John Torrey 1820.

A

COMPENDIUM

OF

PHYSIOLOGICAL AND SYSTEMATIC

BOTANY.

WITH PLATES.

BY GEORGE SUMNER, M. D.

The beauties of the wilderness are HIS,
That make so gay the solitary place.
Cowper.

HARTFORD,
OLIVER D. COOKE.
....
1820.

P. B. GOODSELL, PRINTER.

TO

THE RIGHT REVEREND

THOMAS C. BROWNELL, DD. LLD.

BISHOP OF CONNECTICUT,

THIS LITTLE VOLUME

IS RESPECTFULLY INSCRIBED,

BY HIS OBEDIENT SERVANT

AND FRIEND,

THE AUTHOR.

PREFACE.

OF the elementary works on Botany to which the student finds easy access, the *Introduction* of Dr. Smith, with the notes of the American editor, is justly preferred to every other. It comes from the pen of a lively writer, who ranks pre-eminent among the botanists of the present day ; and it teaches us, as we pursue the path of science, to cull the flowers on the way : but it is made " the vehicle for many observations, criticisms, and communications," which are uninteresting to most of his readers. Its numerous references to expensive English works, and to foreign plants, which are alike unknown in this country, add rather to the expense than to this excellent *Introduction*. The *Principles of Botany*, by Professor Willdenow, of Berlin, and the *Physiological Botany* of Mr. Keith, maintain a high rank among the elementary works of their kind, but having never been republished in this country, they are comparatively rare.

The author deems it necessary to observe, that many of the following pages have been selected from these and other works, and that the arrangement which he has pursued is very similar to that of Dr. Smith, though several alterations are adopted, which it is thought will be regarded as improvements. The " Imperfect plants" are arranged in a separate chapter, the natural orders of Jussieu are explained, and a general summary taken chiefly from Mirbel constitutes the concluding chapter. The technical English terms, which occur in the several* *Floras* recently published in the this country, are defined and illustrated by a reference to well known plants, but the Latin terms, and the criticisms which are found in most elementary works of this kind have been omitted.

This Compendium was designed as an Introduction to the study of American plants, and it is published for the convenience of those who wish to pursue it.

It was designed as a substitute for the more expensive volumes of Smith, Barton, Willdenow and Keith, and it has been compiled for the convenience of those who wish to consult the Floras which have, within a short time, been published in various sections of the United States; other merits it does not claim.

Botanical students who wish to obtain an accurate knowledge of the various plants that meet their view, will often find it necessary to compare them with others, to which they are nearly allied. Hence the indispensable utility of an herbarium which shall contain a collection of dried plants, usually arranged according to the system of Linnæus or Jussieu. The student who wishes to form such a collection will require some instruction.

When their flowers are fully expanded, the plants should be gathered, placed between folds of paper, and subjected to a moderate pressure until they are thoroughly dry. When the specimens are numerous or juicy, the papers should be frequently removed, and others are to be substituted for those which have imbibed the moisture of the plants, and the more faithfully this direction is followed, the more perfectly will the specimens retain their original colour. Most plants should be gathered when they are entirely dry, but the Mosses may be collected at any season, thrown into a vessel of water and then laid between the folds of moistened writing paper, and subjected to pressure as in other cases. The Mushrooms are preserved with the greatest difficulty, and hence some have resorted to models, and some to coloured engravings for the illustration of that obscure class of vegetables. When the specimens are thoroughly dry they are to be arranged according to some method, and the papers to which they are attached should contain the name, locality, time of flowering, and whatever else is interesting respecting the plants which are in this way preserved.

An herbarium is frequently injured by insects as well as by moisture ; and it is remarkable that plants of an acrid nature, are of all others most frequently devoured. Some essential oil is one of the best preservatives against this misfortune ; and we thus resort to the same armature which nature employs for the preservation of the tender flower. And with all his care it is necessary to caution the student against disappointment. Many plants turn black in spite of our exertions, while others retain their freshness with comparatively little care. Yellow, scarlet, and green, are among the lasting colours ; but the blue, the pale red, and the white, part with their beauty and their freshness together.

The student should also be provided with a magnifier, which will enable him to inspect the flowers of the Grasses, and others equally minute ; and a close tin box of any convenient size and shape, will enable him to preserve the specimens which he gathers, several days ; and even then, they do not wither, but become black and mouldy.

But instruments will be of little use, unless he resorts to books, for instruction. The *Plants of Boston*, by Dr. Bigelow ; the *Manual of Botany*, for the Northern States, by Mr. Eaton ; the *Flora of Philadelphia*, by Dr. Barton ; the *American Genera*, by Mr. Nutall, and the *Botany of the Southern States*, by Dr. Elliott, have all been recently published in the United States.

Nor should I omit to mention the *Catalogue of North American Plants* by the late Dr. Muhlenburg, and the

Grasses, which he has more fully described. The last mentioned work, however, as well as the Flora of Mr. Pursh, are in Latin. The student who wishes to examine the productions of our Forests, in a more alluring dress, will derive much gratification from the perusal of the splendid volumes of Michaux, entitled the *American Sylva.*

CONTENTS.

INTRODUCTION.

THOSE who are about to commence a study which has hitherto been regarded merely as an ornamental branch of education, may reasonably enquire what advantages they are to derive from their botanical pursuits; what reward for the fatigue of patient and long continued research?

It is scarcely necessary to point to the examples of many illustrious men, who have devoted their time to the cultivation of botanical science. They have erected a noble fabric, and the student who enters its portals, feels interested to know, by whom the materials were collected, and by whose exertions they have been thus judiciously arranged. He is surrounded by monuments of their ingenuity, and pauses to enquire, in what section of the world, and at what period, lived the men whose names are thus honorably preserved from oblivion.

Of these men, some have been distinguished for the accuracy of their descriptions, some for the extent of their acquirements, and some for the intrepidity, with which they braved danger and endured privations. Those only who have most successfully endeavoured to advance the interest of our science, and to promote the welfare of mankind, will claim from us the tribute of a brief, yet respectful notice.

Like other branches of natural history, this is comparatively of modern origin. Previous to the sixteenth century, a few plants only were known, and these were such as the credulity of former ages had endowed with extraordinary virtues, and many of them were regarded with a degree of veneration to which they were poorly entitled. The wisdom of him, whose knowledge extended from the proud Cedar of Lebanon, to the humble moss which invested the walls of Judea, had not been revealed to his successors, and it was long, long before the mantle of Theophrastus, the father of the science, rested on the shoulders of a worthy son.

About the middle of the sixteenth century, several works were published, in which were delineated many of the European plants, and their authors are still distinguished in the annals of botany. Among them we recognize Fuschius of Germany, and Lobel of England ; names associated in the mind of the florist, with some of the most splendid of his treasures.* Among them Clusius also ranks preeminent. He is said to have been one of the greatest men of his age, who prosecuted the study of botany with more zeal and perseverance than any of his predecessors ; and with a diligence which his followers have never surpassed. He visited almost every section of Europe, encountered many hardships, suffered much from sickness, and at last fell a victim to his bold and untimely exertions. "His works shew us the great botanist, being enriched

* The Cardinal flower *Lobelia Cardinalis* is universally admired for the rich hue of its blossoms ; and on account of the beauty of the *Fuschia*, it has been introduced into the gardens of Europe. They are both American plants.

with neat distinct figures, and masterly descriptions. It was a pity that a man of so great merit, should have suffered so much, and even become the first martyr for botany.*"

Contemporary with these lived Conrad Gesner, a native of Switzerland. At an early age Gesner turned his attention to the charms of his native mountains, whose romantic scenery, whose rich and varied productions, have excited the admiration of every beholder. Every year did the persevering Gesner visit some portion of the Alps, collecting the plants which fell in his way; and frequently did he receive from his distant friends and admirers, the useful and the rare productions of other countries. In this way his herbarium became rich and extensive. He it was, who first described the tobacco plant, which was soon afterwards introduced into Europe by Sir Walter Raleigh, and has since become an important article of luxury and of commerce. But this skilful observer of nature is more particularly distinguished, as the first who proposed to divide plants into classes, so as to secure the advantages of system; and Cæsalpinus should be remembered as the first, who carried into effect the proposal of Gesner. His system however was too imperfect to gain many adherents, and botanists continued to describe plants, without order, and very often without precision.

About two hundred years since, lived John and Caspar Bauhin. These brothers were natives of Lyons in France, and "the effect which their skill and assiduity had on the state of the science, was such as to form an era in its history. The sagacity of the elder brother detected the errors of his predecessors, and his

* Wildenow.

General History of Plants, containing the result of fifty years patient and acute observation, was enriched with masterly descriptions, declared by the immortal Haller to have been at that day unequalled."*

The younger Bauhin soon pursued the steps of his brother, with the same praise worthy diligence, but with greater facilities for acquiring information ; and though less critical, and less accurate, he was more popular than his brother, and his career was more brilliant than that of any preceding botanist. He performed a most acceptable service, by designating the different names which other writers had applied to the same plant, and his work is still a key to the repositories of ancient botany.

But the extensive writings of the Bauhins did not give to botany the regular form which it has since assumed, for the system of Cæsalpinus, memorable only as the first production of its kind, had been neglected, perhaps forgotten by his successors, and the subject was entirely overlooked, till revived by Morrison of Scotland. He was soon followed by Rivinus a German botanist, whose system, founded upon the number and regularity of the petals, was so simple and so easily learned, that it found several adherents on the continent of Europe. It had been the practice of the systematic writers who preceded Rivinus, to separate trees from herbs, and to aim at an arrangement purely natural ; but he rejected the former, because it marred the uniformity of his plan, and renounced the pursuit of affinities as uncertain and abstruse. The simplicity of this system was one of its greatest excellencies ; but unfortunately, the variableness of the or-

* Edinburgh Encyclopedia.

gans on which it was founded, was an insurmountable objection to its general use.

And though it was received by some of the German botanists, that of Ray, possessing still greater excellencies, was more generally adopted in England. Its author, who was a clergyman of the English Church, was equally distinguished for his piety and learning, for his very eminent talents and indefatigable industry ; a happy combination of excellencies, from which great improvements might be confidently expected. He published a *General History of Plants*, embracing nearly 20,000 species and varieties, and at the commencement of the eighteenth century, completed a system, " in which the order of nature where it could be traced, is carefully pointed out, and the affinities of plants delineated with a masterly hand."*

The merits of his arrangement were unquestionably very great, and when we compare it with those of an earlier date, we shall not wonder that it was generally adopted in the native country of its author.

Contemporary with Ray lived Tournefort of France, who at an early age manifested a partiality for the same pursuits, and was afterwards distinguished for the intrepidity with which he collected plants, and the success with which he arranged them. After investigating the natural productions of Aix and the neighbouring Alps, he was led by the spirit of discovery to the summit of the Pyrenees, and over the hills of Spain, where he twice encountered the robbers, who had sought in those sequestered retreats, an escape from justice, and a repository for their plunder. Finding him loaded with dried herbs and poor bread, they wil-

* Smith.

lingly relinquished their spoil, and permitted the enterprising traveller to return without further molestation to his native country. Under the patronage of Louis his king, he visited Greece and many of the provinces of Asia, and as he rambled over classic ground, he gathered the same treasures, which had centuries before been described by Theophrastus. After this he returned to Paris where he published his *Institutions*, an excellent work requiring no higher praise, than that "it became the torch which illumined the early path of Linnæus, and was the source of that more powerful light which the writings of the latter afterwards diffused."

But we must pass by the names of Kæmpfer, Celsius, Dillenius, and Vaillant, names long distinguished in the annals of botany, though eclipsed by the superior splendour of one who was about to appear. His name was Charles Linnæus ; and it commands more than cold respect, it has the veneration of the scientific world. He was born at a small village in Sweden, on the 3d of May 1707, and exhibited, during the first years of his life, a prediliction for those studies which he afterwards pursued with unequalled success. His father being himself a clergyman destined him for the church, but

"Lightly he rambled over meadow and mount,
And neglected his task for the flowers on the way."

The consequent deficiency of his academical acquirements soon became known, and the father, disappointed by the perverseness of his wayward son, was about to devote him to a more humble occupation, when the interposition of a neighbouring physician placed the young Linnæus in the road of usefulness and glory.

The friendship of Rothman enabled him to pursue his studies three years at Wexico, after which, poor and without a friend, he entered the university of Upsal.

But merit like his could not be overlooked, and it was not long ere Celsius, the first botanist in Sweden, was charmed with his zeal and intelligence, and relieved him of the burden of poverty with which he was encumbered. He was afterwards invited by the Academy of Sciences at Upsal, to explore the cold regions of Lapland, and the alacrity with which this proposal was accepted, and the faithfulness with which the objects of his journey were secured, were equally creditable to the zeal and perseverance of Linnæus. Previous to his Lapland tour, the inhabitants of Torneo were frequently distressed by the loss of their cattle, two hundred of which are said to have annually perished on a single mountain. He went to their pastures to ascertain the cause of this calamity, and found it to proceed from the young leaves of the Water Hemlock, a poisonous plant, which grew abundantly in the marshy grounds of that country. He told the inhabitants how the loss of which they complained might be avoided without difficulty or expense, nor is it surprising that he should consider this as the most interesting event of his journey. What better compensation for its fatigues, what more heartfelt satisfaction could he receive, than that which he derived from the consciousness of saving the impoverished Laplander from the loss of his cattle and the horrors of famine.

After his return to Sweden, he visited Holland for the purpose of receiving a medical degree, and there he became acquainted with Boerhaave, the most eminent physician of his age, and with Clifford, scarcely less distinguished for the extent of his botanical treasures.

By the latter he was employed as an assistant, and during the years which he spent in this happy situation, he planned the system, which with some variations has been received by most of his successors, and published among other works, a description of the plants which he had formerly gathered in Lapland, and also of those which were collected in the garden of his friend. Having in the mean time visited the most richly stored gardens of England and France, he returned after an absence of nearly four years, to his native country; where through the kindness of an eminent Swedish statesman, he at length obtained the great object of his ambition, the botanical chair at Upsal. In this situation he was unusually popular, and his increasing fame attracted students from every quarter, among whom were several, who imbibed, and diffused throughout the civilized world, a taste for the science over which Linnæus presided.

"The father who had been so often grieved at the perverseness of his son's disposition for hunting after plants and worms, and who had therefore concluded that he was fit only to be a maker of Swedish brogues, fortunately lived to see him, not only professor of botany, but dean of the College of Physicians at Upsal, caressed by the grandees of Sweden, and honored by all the literati of Europe."

At the age of forty-six, by the government of his own country he was created knight of the Polar Star, and soon afterwards, he was elected a member of the Royal Academy of Sciences at Paris, and of the Royal Society at London. "Botanical studies we have seen, were the first to engage the youthful mind of Linnæus; in these he persevered through life with delight, and on the advancement which he lent to the science of Botany, will his future fame chiefly rest. So ardent did his passion for plants remain even after his health had began to decline, that disease was sometimes put to flight by the mere acquisition of botanical treasures. He was lying ill of the gout, and unable to move, when Kalm arrived from America; but the sight of the transatlantic rarities brought home by this zealous collector, so much roused his spirits that he soon found the use of his limbs and conquered the malady."*

And when in consequence of the infirmities of old age and sickness he was unable to perform the duties of his office, he found in his only son an able assistant, and a worthy successor. The brilliant career of the latter however was of short duration, and the Linnæan treasures, since his death, have been transferred from Sweden to England; and fortunately for the science, they are in the possession of the most distinguished botanist† of the Island.

To trace the progress of systematic botany from the days of Linnæus, would be to transgress the limits of this Introduction. It will scarcely be deemed necessary to mention the names of Thunberg his successor, Vahl his favorite pupil, Gmelin, and Pallas of Russia, Wildenow the very distinguished professor at Berlin, Murray, and Hoffman of Germany, Curtis, Withering, and Smith, of England, Decandolle of Geneva, Jussieu, Lamark, and Desfontaines of France. Much credit is due to these, and also to the worthy president of the Royal Society, for his early zeal in promoting a science, of which, he is at once the most judicious and the most liberal patron. Nor should we omit the names of

* Edinburgh Encyclopedia.
† Sir J. E. Smith, President of the Linnæan Society.

the unfortunate Loefling, who fell a victim to his exertions in South America, of Jacquin and Swartz, who visited the West India Islands in order to investigate their natural productions ; of Brown, who with the same view resided several years at New-Holland, and of Humboldt and Bonpland, two enterprising travellers, who spent five years exploring the fertile regions of equinoctial America.

I turn from these men, learned and respected, to speak of those botanists, who have investigated the productions of our own land. Among them I notice with pleasure the venerable name of John Bartram. His occupation was that of an industrious farmer, but he pursued with equal diligence the avocations of a naturalist. His inquisitive eye was always exercised in the examination of vegetables, which he surveyed through the various stages of their growth, and the beauty of their structure did not fail to impress his reflecting mind. Not satisfied with the survey of his own paternal fields, he visited most of the provinces of this country, and in this favorite pursuit, was neither discouraged by difficulties, nor impeded by danger. He explored forests marked by no human footstep but of the savage warrior, and extended his researches to Florida, where even at this day, danger treads on the heel of the bold adventurer who dares pursue the steps of the persevering Bartram. He returned, and on the banks of the Schuylkill three miles from Philadelphia, commenced the formation of his garden. It was the first effort of the kind which had ever been made on this side the Atlantic, and it was eminently successful. There he collected in the compass of a few acres, those plants which he had sought with so much diligence and fatigue, and enjoyed the luxury of a paradise which his own hands had formed. Mr. Bartram is represented by one who knew him best, as "a man of modest and gentle manners, frank, cheerful, and of great good nature, a lover of justice, truth and charity. He was himself an example of filial, conjugal and parental affection. His humanity, gentleness and compassion were manifested on all occasions, and were even extended to the animal creation."*

The name of Bannister should not be omitted; for Ray has termed him a most learned man, and consummate botanist. He resided in Virginia, where he formed a catalogue of plants, with descriptions generally correct and sometimes elegant, and one of his successors has given perpetuity to his name by associating it with a family of climbing plants.

He was soon followed by Clayton, the correspondent of the learned in Europe, and the author of the Flora of Virginia. This was one of the earliest works which was arranged by Gronovius according to the Linnæan system, and the student, who has an opportunity to compare it with those of a more recent date, will acknowledge his obligation to the Swedish reformer for the introduction of specific names.

We are reminded of Houston, who first described many of the Canadian plants, by the humble but very common Bluetts,† which during the spring months whiten the hilly pastures of New England. Kalm, though a gleaner in the same field of discovery, was equally meritorious and perhaps still more fortunate. He was the pupil of Linnæus, who having spent three years on this continent, returned with those treasures

* Barton's Medical and Physical Journal.
† *Houstonia Cerulia* frequently named Eye-bright.

which so animated his master as to dispel the anguish of his malady and relieve him from a tedious confinement. Kalm was a Swedish divine, who was afterwards elected professor at Abo, and the American Laurel * which has been dedicated to his memory, is a splendid monument of his worth as a botanist.

Many of the plants of the New England states were first enumerated by Cutler, while those of the south and west were brought to light by the labours of Walter and Fraser.

We may well feel gratified to gaze on forests which excel all others in the variety and usefulness of their productions. They had charms to tempt the intrepid Michaux, from a climate the most salubrious, a soil the most productive, from the pleasures of refined society, from the bosom of his family, and the circle of his friends. They had allurements to retain him twelve years in this happy exile, during which time he explored every recess from Georgia to Maine, at one time investigating the productions of nature, at another the improvements of art, always seeking and always ready to communicate useful information. From him, probably for the first time we learn that the single family of Oak comprehends within the limits of our own country, more species than the whole amount of the trees of Europe. One hundred and forty trees have been enumerated in our forests, of which ninety-five are employed in the arts, while those of France contain less than twenty, only seven of which have been used for building. The vain champion of reason and philosophy, whose name deserves not to be remembered, once rested an argument on the diminutive productions of our soil.

* *Kalmia.*

He little knew how much it surpassed in many respects the favourite abode of his kindred philosophers. Michaux has not only told us what trees enrich the different sections of our country, but he has mentioned the various uses to which they are appropriated, on which account his work is one of the most interesting, as well as most valuable, in the whole range of botany. His object in visiting this country, was to ascertain what of its vast productions might with advantage be transferred to France, and when this was accomplished he returned to Europe. The publication of his work was entrusted to his son,* who had accompanied him in these researches, and he soon afterwards fell a victim to his exertions, while exploring the fruitful regions of Madagascar. The diligent enquirer after truth, the devoted patriot may imitate but will never surpass the example of the elder Michaux.

Among American botanists none have ranked higher than the late Dr. Muhlenburg of Lancaster. While performing his parochial duties this venerable clergyman is said to have been extensively useful to his poor parishioners, by teaching them the healing efficacy of their native plants. How delightful must have been his employment, whose life was devoted to the attainment of useful information, which diffused the smiles of gladness around the abode of misery, and made him the ever welcome visitor of his friends. Such was the employment of a man whose works—whose opinions—whose hints—whose very doubts have contributed to the advancement of botanical science.

* F. A. Michaux, whose splendid work on the forest trees of North America has been recently published in Philadelphia.

As a public teacher however, he was less distinguished than the late Professor Barton of Philadelphia. Like the pupils of Linnæus, his were numerous ; and many of them having imbibed his spirit, have cultivated, with zeal and success, the science which contributed to the usefulness and pleasure of their benevolent instructor.

But while these men were employed in collecting, describing, and arranging the plants of different countries, and accelerating the progress of systematic botany, others with equal zeal, devoted their time to the study of vegetable physiology.

Among them were Grew of England, and Malpighi of Italy ; both distinguished for the originality and correctness of their observations, which were for a long while adopted, without alteration or improvement. They were succeeded by Dr. Hales, a clergyman of the English Church, and a member of the Royal Society, whose work is described as a perfect model of experimental investigation, and whose character is at least equally excellent ; for he was " pious, modest, indefatigable, and born for the discovery of truth."

He was soon followed by Duhamel of Paris, and Bonnet of Geneva, the former a most worthy botanist, whose physiological observations are ingenious and instructive ; the latter, distinguished for his luminous experiments on the uses of leaves.

Nor should we omit to mention the excellent Gærtner, a German physician, whose work is a monument of the author's accuracy and patience, and a repository of information respecting the structure and physiology of the seed. And it would be equally unjust to pass by the names of Mirbel and Knight, for in the following pages, we shall have frequent occasion to derive instruction from their publications, and to refer to their discoveries and opinions.

Mr. Knight is a worthy English gentleman, residing near London, nor is he less distinguished for his practical improvements in the culture of plants, than for the philosophical opinions which led to their adoption.

Mirbel, the equally worthy professor of botany at the Athenæum in Paris, has published a treatise on vegetable physiology, which is altogether the most interesting, as well as the most complete, in this department of our science.

Let us close this rapid sketch of its advancement, with a few observations respecting the utility of the Science, which so many illustrious men have made at once, their "time's employment, and their leisure's charm."

The objects, to which our attention is invited, are both interesting and important; interesting, for they clothe the earth with verdure and beauty; and important, because from them we derive all the comforts and conveniences of life. Nor is it necessary to prove, for it has been established by the experience of ages, that the science, which reveals the nature and uses of objects like these, may be of great practical utility.

More important, and more deserving our attention at the present time, is its influence on the mental powers; giving energy to the weak, purity to the vicious, and contentment to the troubled mind; at once the source of innocence, tranquillity, and joy. Many have attempted to delineate the most eligible course of education, and the claims of history to enlighten, of poetry to charm the human mind, and of the sciences to give it capacity and strength, have long been duly estimated and improved. All have their peculiar excellencies, which become more or less conspicuous, according as they promote the enjoyment of their respective pursuers, and enable them to accomplish with facility the duties of life.

More recently chemistry has become a favourite branch of instruction, and it has strong claims to our attention. Its intimate connection with the arts, the precision of its language, and more especially the brilliancy of its experiments, exhibiting little less than creative power, have thrown around the labratory of the chemist, a lustre and a charm, sufficient to arouse the most listless observer.

But while chemistry unfolds the latent energies of creation, and arms us with the power of the elements, natural history displays the treasures of a world, and makes them subservient to our enjoyment and use. Interesting in all its relations, whether we pursue it for pleasure, or employment, for amusement, or instruction, we are sure of our reward. And especially when we turn our attention to the vegetable kingdom, whose magnificent treasures give life and gaiety to millions of animated beings, treasures, without which plenty has no overflowing cup, and joy no flowery wreath, we shall no longer despise the science which displays them to our view. Then we shall justly value it, as the source of innocent amusement, of practical information, and of mental improvement.

As an innocent amusement, it will afford recreation to the man of business, and employment, happy employment to the man of leisure. To both it will yield that serene satisfaction, that cheerful independence, which look for happiness, not to fickle worms of the dust, but to the great source of light and life. And having once learned to read the volume of nature, it is always open and before them ; and every plant becomes a monument of pleasure, displaying its interesting organs, revealing its useful properties, and associated with pleasant recollections. A single example will serve to illustrate the truth of this observation. In almost every section of the United States, is found a weed, which to the eye of a common observer, presents no idea of usefulness or beauty ; but it reminds the botanist of the same plant, which, presented by the Roman warrior, became the sacred pledge of friendship, the same Vervain with which their sacrifices were garnished, the same which formed a garland for their priests, and a wreath for their temples. He remembers, that gathered on a moonless night, it was employed by the Druids to remove diseases, conciliate friendships, and secure the accomplishment of every wish ; and though as an amulet it has lost its charm, and its reputation as a remedy, it is still a welcome intruder for the ideas which it recalls. Associations of this kind render botany at all times pleasing and instructive. But as the source of useful information, it has still stronger claims. Perhaps the victim of disease is at this moment, trampling under feet the very plant, which if properly applied would restore him to health. I need not say how pleasant it is to know the properties of those plants, by which we are immediately surrounded. Their history and application to the various purposes of domestic economy, should be investigated by every man who would be extensively useful to those around him.

By the botanic researches of Bartram and his companions, the Magnolia and the Azalea, as well as numerous other ornaments of our forests, were transferred to the princely gardens of Europe. By the labours of Michaux his country was enriched with resources more valuable and more lasting, than the monuments of Italian and Grecian art, which victory enabled her armies to transfer to Paris.

But plants cannot be successfully cultivated without a knowledge of their natural habitation and wants, and therefore we find that gardening, the most elegant, and agriculture the most useful of all arts, are improved only in those countries in which botany is made subservient to their advancement. And when a knowledge of this science is more generally diffused throughout our own country, we may expect to see it more frequently enriched with fields, and adorned with gardens, which while they bestow honor on their possessors, shall prove a pleasant recreation to the old, and a useful study to the young, exerting their salutary influence on both. Nor should its influence on the moral character be entirely disregarded. The late President Dwight was an eminent champion of the virtue which he practised. Often did he direct the attention of his pupils to Sweden, to point out the influence of natural history on the moral character of man. In that country botany is taught in the schools, and the habitation of her excellent children presents a heart cheering picture of domestic felicity, combining the piety of her divines with the patriotism of her undaunted heroes. Their piety and their patriotism both flow from the same source, for while they examine the productions of their country, they become attached to its soil, and while they contemplate the works of their Maker, they inspire the glowing spirit of devotion.

Botany deserves our highest regard as the source of mental improvement. Nothing so powerfully attracts the notice of the young observer, as the various, the gay, though fleeting beauty of flowers; yet these interesting objects, like the characters of Algebra, serve to produce an accuracy of discrimination, which is the foundation of correct taste, the essence of sound judgment, and the object of every judicious system of education. And an intimacy with natural objects serves to cherish those finer feelings, which give delicacy to taste, and brilliancy to fancy, feelings which are often buried amidst the rubbish of severer sciences. On this account it is peculiarly suited to the culture of the female mind. There we look for the glow of fancy, sprightliness of thought, correctness and delicacy of taste, and there, if properly cultivated, we are sure to find them.

Such are the benefits which may be derived from the culture of botanical science. It relieves from the weariness of an idle, the fatigue of a busy, and the troubles of a contentious world. Its pleasures pure, rational, and lasting, are meted out with a liberal hand, neither stained by passion nor deformed by guilt.—Pure, for they flow from the contemplation of sinless objects, monuments of goodness and power, whose perfections in the the language of the Lyric Bard, perpetually

> "Offer notes divine,
> To our Creator's praise."

They are also abundant. He must be rich to whom the world pays tribute, rich indeed if that tribute be happiness. Such is the wealth of the Botanist, and there is no field so barren but it yields fruits for him, no plant so contemptible but he views it with pleasure. He finds animation and intelligence wherever he goes, new charms in every object, and new beauties in every scene. Earth teems with gladness, and in the solitude of the wood he finds interesting companions, untarnished by the rude touch, unknown to the vulgar eye.

Called to visit distant lands, familiar objects like the companions of his childhood greet his arrival on the foreign shore, where new scenes introduce new pleasures, and give to the fatigue of his journey the fascinating form of amusement. Animated by the spirit of Linnæus he climbs the highest mountains with alacrity, with glowing zeal penetrates the untrodden forest, and returns with cheerfulness to his home; but his journey is not yet ended, for he has there collected materials whioh will yield him pleasure and employment, while the cold blast of winter is whistling round his dwelling.

Thus we shall find, whatever be our situations and pursuits, whatever be the trials and the pleasures that await us, that natural history, and especially our own favourite science, multiplies the sources of innocent enjoyment, extends our bounds of usefulness, and enables us to encounter the storms of life with fortitude and success.

These are not the visionary speculations of youth and inexperience, for experience and wisdom have united their testimony in favour of Botanical pursuits. "The study of Natural History has been for many years the occupation of my leisure moments, and it is a merited tribute to say that it has lightened for me many a heavy, and smoothed many a rugged hour; that beguiled by its charms, I have found no road rough or difficult, no journey tedious, no country desolate or barren. In solitude never solitary, in a desert never without employment, I have found it a relief from the languor of idleness, the pressure of business, and the unavoidable calamities of life."

The author of our Southern Flora has here spoken the language of every lover of natural science, and his pleasures are within the reach of every individual in society. And there is not an individual who will not find them uniformly connected with some practical advantage. Is he a disciple of Hume? let him forsake the wretched dogmas of his master, turn from the sophistries of reason, the cold and cheerless realms of infidelity, to contemplate the works of his God; and he will be compelled to acknowledge it was truly said, the Botanist cannot be an Atheist. Is he a minister of the Gospel? the Bible is his book, the volume of nature its best appendix. Both proceed from the same source, and we are required by the same authority to search the scriptures, and to consider the lillies of the field. Is he a physician? I need only remind him of the language of the beloved Rush, to arouse his attention to the vegetables of his country. Is he pursuing the pleasures of youth? how many of our amusements at that interesting period of life have an intimate connexion with natural objects, and when those objects are consecrated by science and friendship, the fields become more verdant, the flower garden more inviting, and every scene more charming.

If such be its happy influence on youth, what may we not expect when old age has folded us in his mantle. In the evening of life, when the horizon of friendship is illumined by here and there a solitary star, memory shall invite us to scenes of past enjoyment, where every flower will excite the recollection of some happy event, or reflect the image of some absent friend, absent perhaps in the regions of immortality, contemplating the more splendid works of the same Almighty hand.

The object of this work is to present a compendious view of the science which is recommended by such powerful examples and by its own intrinsic worth. It will involve the consideration of the life, growth, texture and secretions of plants. It will involve an account of the different organs whose presence is required in the constitution of an individual plant. It will involve a particular examination of those organs which are necessary for the perpetuity of the race : and lastly, it will present an explanation of those systems, which are to be our guide in studying the plants which meet our view, and in the investigation of their natural affinities.

COMPENDIUM

OF

BOTANY.

CHAPTER I.

VEGETABLE LIFE

AND

DISTINCTIONS BETWEEN PLANTS AND ANIMALS.

Natural History is the name of the science which examines and developes the nature, properties, and mutual relations of natural objects, comprehending the Mineral, Vegetable, and Animal Kingdoms, under the three divisions of Mineralogy, Botany, and Zoology.

Minerals are readily distinguished, being destitute of organization and life, subject only to chemical and mechanical laws. But the other kingdoms of nature are so intimately blended, possessing properties which like the colours of the rainbow emerge into each other, that many have attempted to define their respective limits without success. They are both organised, and equally under the controul of a living principle, whose laws, the greatest efforts of human ingenuity have not been able to expound. This principle of life, it is said, consists in a power to resist putrefaction, and to a certain extent to maintain a temperature different from that of surrounding bodies. It is obvious that this definition is alike applicable to animals and plants. Both possess the power to resist chemical agency, both preserve their own temperature, which is sometimes higher and sometimes lower, than that of the surrounding atmosphere. It is needless to mention that the temperature of animals is commonly greater, though it is equally true that it is sometimes less than that of the air they inspire. Plants though in an inferior degree possess the properties which distinguish them from inanimate matter. He who has escaped from the almost intolerable heat of paved streets, knows how much the green and living grass, can contribute to his comfort.

Near a volcano in the island of Tanna, the surface of the earth which is but 10 degrees below that of boiling water, is decorated with leaves and flowers comparatively cool ; and the roots of the Chaste tree were discovered by Sonnerat, receiving nourishment from a rivulet which was nearly as warm. Yet the source from which it derived its nourishment, had little or no effect on the temperature of the plant. Under different circumstances, especially during the impregnation of their flowers, plants possess the property of generating heat. And from the simple elements which are absorbed by their roots, they form combinations which transcend, if they do not subvert, the established laws of chemical action. Thus by a process which we can neither imitate nor explain, they convert the insipid fluid which they derive from the earth, into substances, as distinguished for their various yet peculiar qualities, as for the important uses to which they are subservient.

Darwin, whose exuberant genius too often soared above the field of sober observation, has attributed to vegetables a sensibility capable of enjoyment and suffering, with the power of volition, subject to the passion of love and the necessity of sleep.

The irritability of vegetables, on which depends the absorption and circulation of their fluids, was ingeniously demonstrated by an experiment of Von Uslar. He destroyed the life of a plant by electricity, without affecting its organization, after which an incision of its branches was not followed by an effusion of fluids, though previous to the experiment it bled abundantly. It may also be exhibited by two transverse sections of a twig, from each extremity of which a fluid may be observed to escape.

Sensibility differs from the preceding property of vegetable life, by its supposed association with pleasure and pain. A little attention to this subject will convince us, that plants distinguish heat from cold, darkness from light, and the other sensible properties of the atmosphere which promote, from those which retard vegetation. Thus when plants are placed by our windows, we see them present the upper surface of their leaves to the light; and when their position is reversed, a new arrangement of the leaves takes place, by which the same surface is again exposed to the rays of the sun. Some flowers which shine with distinguishing lustre in the morning, shrink from the dazzling brightness of a noon day sun; some court his meridian glory, while others at the approach of darkness, expand their tender blossoms, loading with perfume the breezes of evening. Thus too, we find the leaves of some plants closing around their tender blossoms, to protect them from the injurious effects of cold and moisture; and others exquisitely sensible to the touch of extraneous bodies. The flowers of the Barberry, a shrub which grows abundantly in every section of the United States, evince a susceptibility of impression from external objects, at once curious and surprising. The leaves of the Sensitive, so often the innocent source of interest and amusement, exhibit the same phenomena in a still more remarkable degree.

Dr. Smith, to whom I shall frequently have occasion to refer, and from whom on a subject like this it is generally unsafe to differ, thinks that vegetables possess some degree of sensation, and consequently an inferior degree of happiness. He says that such a supposition, accords with all the best ideas we can form of the Divine Creator, nor could the consequent uneasiness which plants must suffer, no doubt in a very inferior degree from the depredations of animals, bear any comparison with their enjoyment on the whole. Whatever opinions we adopt on this subject, until our knowledge is more extended, sensibility must not be regarded as the peculiar attribute of either kingdom.

Some have attempted to draw the line of distinction, by limiting to animals the power of locomotion; but they forget that while the corals are attached to the rocks of the ocean, the *fuci* are seen to swim on its waters.

Plants like men are much under the power of habit. The following examples are sufficient to evince the extent of this power. Several plants which are natives of warm climates where their existence is prolonged for several successive years, have been removed to less temperate regions. They are unable to endure the cold of their new situations, and consequently must change their habits of growth ere they can be cultivated with success. To secure this object some of them pass through the successive stages of their existence with astonishing velocity, and accomplish in a single summer what they had been accustomed to require years to perform. Our garden Nasturtion was originally a shrub which flourishes without cultivation on the banks of the Peruvian streams; yet, transferred to this country, it has become an annual plant, which arrives at maturity in a few short months. The habits of other tender plants are with more difficulty subdued, and they to be successfully cultivated must be gradually transferred from their native soil. In the latter case the habit and the power they acquire to accommodate themselves to their new situation, overcome the natural impediments to their growth, which under different circumstances would have been irresistible. Therefore it is, that plants whose seeds were ripened in northern latitudes, are less liable to injury from frost, than they would have been if their seeds had been brought from a temperate climate. By thus gradually accustoming it to a diminution of temperature, Rice was at one time cultivated with advantage in New Jersey, though without these precautions it rarely comes to maturity even in Virginia.* The habits of the Indian corn aided by climate and culture have suffered still more remarkable changes. After having been for several years raised in Canada it arrives at perfection in a few weeks, and on that account is employed by us as an *early corn.* But that which has been repeatedly cultivated in Virginia will not ripen even in New-England, yet originally the small early Canadian, and the luxuriant Virginia corn were the same, both in habit and in every other known property. They probably originated from the same identical seed. Numerous other examples might be mentioned, but enough has been done to justify the conclusion, that vegetables as well as animals are under the dominion of habit.

Yet some there are, who deny the existence of vege-

* Barton's Medical and Physical Journal.

table life, who attribute the phenomena of which we have been speaking to a power which the artist possesses, to the agency of chemical and mechanical causes. We have seen that they possess most of the properties which distinguish living from inanimate matter, and that like animals they owe their existence to a power which we can neither comprehend nor explain.

This analogy might be traced still further, and we at last should be obliged to resort to a criterion which for want of a better has of late been defended with great ingenuity by Mirbel, and adopted by the most eminent naturalists of Europe. The food of animals is found to consist of organized materials, whose peculiar properties were produced by the action of life. With the single exception of salt, which is used as a condiment and not as food, I believe this is a rule of universal application, and that there is not an article of food which has not been the tenement of life. Vegetables on the other hand are nourished by inorganic materials, by earth, by air, and by water. They constitute the great manufactory of life, in which the dead elements of creation are converted into living solids, capable of sustaining the lives of animals. In this respect the former possess a power denied to the latter, and if they could speak, they would tell us how entirely, how immediately we are dependent on them for existence. Is not then the position tenable, that life is the same wherever it is found, and that it derives its peculiar modifications from the form and structure of the tenements which it inhabits ? Even in the same body it assumes a great multiplicity of forms, and enables the eye to see, the ear to hear, and the tongue to taste and tell, while other organs equally important and equally alive are almost denied the power of sensation.

To a person accustomed to contemplate only the higher orders of plants and animals, it will appear easy to draw the line of distinction and to point out the characteristics of each. To him the criterion of Mirbel will appear as hypothetical as it is really just, and he will never find it necessary to resort to such an expedient, to determine whether he is examining the organised remains of animal or vegetable life. But when he descends to the inspection of those inferior orders of beings, in which simplicity of organization is combined with powers of life almost extinguished, he then finds it difficult to determine to which kingdom, those organs and that life belong.

In such cases the resources of modern chemistry have furnished us with an additional guide. The peculiar phosphoric odour exhaled during the combustion of animal substances, indicating the presence of nitrogen, has been rarely detected during the decomposition of vegetables, and we may safely infer the animal nature of those organs by whose combustion it is produced. Plants then are organized and living beings, springing from seeds or gems, and nourished by inorganic substances which they absorb from the atmosphere and the earth. Medicine reveals their healing efficacy—chemistry detects the elements of which they are composed, and agriculture and gardening teach how they may be cultivated with the greatest advantage.

But Botany assumes a more elevated station, and points out to her enquiring followers the great variety of their external forms, the curious arrangement which their internal structure presents, their habits, their history, their mutual relations and natural affinities.

CHAPTER II.

GERMINATION.

The living principle whose character can be traced only in its operations, sometimes remains inactive for years. Such at least is its situation while enclosed in the seed, where it continues inert till aroused by the application of external agents, or wasted by the destroying agency of time. The former process is termed germination, and it is the source of all that variety and beauty, which plants exhibit, to charm the eye and make glad the heart of man.

Reserving for a future chapter a more minute account of the seed, it will be sufficient at this time to observe, that its coats enclose an *embryo* or *corcle* destined to become a living plant, usually lying betwixt two lateral lobes or *cotyledons*, and frequently accompanied by a farinaceous substance denominated the *albumen*. The latter, which exists abundantly in most kinds of grain, is designed entirely for the sustenance of the young plant, and the lobes, exhibiting more evident traces of organization are chiefly subservient to the same end. In most cases however during germination, they grow out of the earth, assuming the appearance of leaves, but readily distinguished from those of a subsequent growth by their peculiar shape, clothing and duration. In others, they remain beneath the surface of the earth, or are elevated on the side of the young stalk, but in the latter case, they never assume a leaf-like appearance,*

The embryo, to which these parts are merely accessory, consists of two portions, one named the rostel and becoming the root, while the other, termed plumelet, ascends above the surface, to form the stem and the herbage.

If we observe the order of these changes it will be found that the seed first swells from the absorption of moisture ; its coats burst and decay, the rostel being enlarged by the sustenance which it receives from the lobes, descends and becomes attached to the ground ; after which the cotyledons are elevated above the surface, and at last the plumelet appears emanating from the base of the seminal leaves.

But a better idea of these successive changes may be derived from the following examples, the former being seeds with two cotyledons and the latter with one which remained beneath the earth's surface.

At a season favourable to vegetation, Malpighi planted some seeds of the Gourd, and the following were his observations respecting the developement of the young plants.

At the end of the first day, the seeds were consider ably enlarged—their coats were moist—a small orifice was discernible at their summit, through which the fluids seemed to have been absorbed, and the cotyledons, had already begun to assume the appearance of seminal leaves. At the end of the second day, the em-

* Wildenow describes three kinds of germination peculiar to perfect plants ; in the first the cotyledons, usually two in number, are converted into seminal leaves as in radish ; in the second they remain beneath the surface as in lilies and grasses ; and in the third, they are elevated on a young stalk, having the plumelet at their side as in some species of rush grass.

bryo was somewhat enlarged, the traces of its organization were more evident, and its radicle was distinctly visible. At the end of the third day, the exterior membraneshad become brown, the rostel had burst through it, and the plumelet had begun to expand. At the end of the fourth day, the young plant had considerably enlarged, and the nerves of the seminal leaves which were still enclosed by the coats of the seed, had become very perceptible. At the end of the ninth day the plant had wholly escaped from the seed, though the plumelet was still enveloped in the seminal leaves, yellowish in its appearance but generally assuming a tinge of green. At length its extrication was effected and the rostel converted into a root ; the rudiments of a stem developed ; and on the twentieth day the plant was complete.

The other example will serve to illustrate the growth of seeds with one cotyledon. Some Rye was planted in good soil, and at the end of the second hour its radicle was discernible. At the end of twenty four hours the embryo had escaped from its integuments. On the second day the fibres of the root had augmented but the leaves had not appeared. On the fourth day the first leaf began to appear above ground, at which time its colour was red. On the fifth day it had grown to the length of an inch, and its colour was now green, and on the sixth day the second leaf had appeared.*

These effects are produced by the united influence of air, water and heat.

Homberg, a distinguished philosopher of Europe, planted a variety of seeds under the exhausted receiver of an air pump ; they rarely germinated, and in this

* Keith.

situation never continued to grow. The experiments of Homberg have been repeated with great fidelity by others, who infer that in the cases of germination mentioned by him the vacuum must have been very incomplete. Seeds which have remained for years unchanged buried deep in the earth, are often seen to germinate when raised within the influence of the atmosphere ; and the chesnut and acorn are found to grow better on the surface of the earth than when buried beneath it. Achard proved that seeds grow more luxuriantly in compressed than in rarefied air, and the successors of the illustrious Scheele, have by a series of ingenious experiments ascertained that it is the oxygen of the atmosphere which excites their germination.

Water and heat are also agents of primary importance. The arid sands of Africa are scarcely embellished by a single plant, and the cold of our winter most effectually prevents the germination of the seeds which are scattered over the earth ; but let the rain descend and it will cause the desert to blossom as the rose, and when spring returns diffusing cheerfulness and warmth, it will revive the energies which slumber within the coats of the seed.

The moisture which causes the first enlargement of the seed is chiefly absorbed through the *scar* (a small point by which it was originally connected with the fruit, and easily discernible on the surface of most seeds) but it is also imbibed by the integuments, for the entire exclusion of water from the *scar*, retards but does not arrest the process of germination. In either case the water which is absorbed passes through the vessels of the cotyledons to the rostel of the infant plant, which exhibits the first indications of vitality. Hence we learn how these vessels are tinged when the germinating seed is placed in a coloured fluid, and why the young plant inevitably dies if the cotyledons are prematurely removed.

But the fluids thus imbibed by the seed do not reach its embryo unchanged. They dissolve the farina of the albumen or lobes, a quantity of carbonic acid gas is disengaged, and a fermentation is thus begun which terminates only in the evolution of the new plant, or in the destruction of its vitality. If no oxygen gas be present, the latter consequence ensues, for whether it stimulates the vital principle, supplies the embryo with food, or converts the farina of the cotyledons into a mild and nutritive substance resembling sugar, whatever be its mode of operation, the importance of this agent, nay its necessity to germination has been most fully established.

By removing even a minute portion of its carbon, the farina of seeds is converted into sugar, and from the very luminous experiments of the younger Saussure it has been reasonably inferred that oxygen promotes the germination of seeds, only as it combines with their carbon, and enables it to escape. Thus by a process nearly allied to that of malting, the infant plant is supplied with food, and it is probable that in the former as well as in the latter case, a small portion of heat is disengaged. "I conceive" says Dr. Smith, "the evolution of this heat may powerfully further the progress of vegetation, by stimulating the vital principle of the embryo, till its leaves unfold and assume their functions."—Whether this conceit be true or not, it is certain that germination may be much advanced by the application of artificial heat, and seeds have in this way been made to vegetate in three hours, which under ordinary circumstances, require twelve. Adanson found that many seeds which were transported from Paris to Senegal germinated three days earlier than in their native country. And wherever it is desirable to obtain the earliest productions of the season, seeds ripened in a northern climate should be selected, for though less luxuriant, plants which are thus obtained, reach maturity with a less degree of heat. Since the agency of oxygen became known, it has been ascertained that it may be employed to excite the vegetative power of seeds, which under common circumstances refuse to grow. At least those substances which yield it with facility and in abundance, have been employed with the greatest success to produce this very desirable effect. One of the most effectual of these is, the chlorine of modern chemistry. Humboldt,* to whom we are indebted for this discovery, planted some Cress seeds in sand, and moistened some of them with pure water, and others with water impregnated with chlorine; the latter vegetated in six, the others in thirty-six hours. Jacquin employed the same agent to excite the action of seeds which he had received from the cape of Good Hope, and though every other effort had proved ineffectual, this was crowned with the most flattering success.

It has been a question whether light promotes or retards germination. However important it may be to the luxuriance of the growing plant, I am inclined to believe that its influence on the germinating seed is comparatively trifling. It seems to have been the design of nature, that this operation should be performed in the bosom of the earth, secluded from the light of

* Humboldt mixed about four parts water with two of manganese and one of common muriatic acid, and placed the seeds in this mixture until the rostel was evolved.

day ; and observation has taught us, that in some instances, it proceeds most rapidly in the dark.

The following table will serve to shew how various are the periods requisite for the germination of different seeds, some requiring a greater degree of heat, and some more moisture than others, and some also requiring a longer exposure to all the exciting causes of germination.

	days		days
Wheat and Millet require	1	Purslain	9
Spinage, Beans, Mustard	3	Cabbage	10
Lettuce, Anise	4	Hyssop	30
Melon, Cucumber, Cress seed	5	Parsley,	40 or 50
Radish, Beet	6	Almond, Chesnut, Peach	1 year
Barley	7	Rose, Hawthorn, Filbert	2 y'rs
Orach	8		

No seeds vegetate so rapidly as those of the grasses, and none require a longer period than those of the Rose and others of the same natural order.

But from what has previously been said, we must expect to see a variation of these periods in consequence of the more or less favourable situations in which the seeds are planted.

Philosophers have in vain attempted to determine why plants invariably assume an erect position, why as the rostel descends towards the centre of the earth, the plumelet always rises above its surface. Art may force a young shrub to the horizon but its branches will still ascend as if they spurned a contact with the earth which supports them ; and if a germinating seed be made very gradually to revolve, the spiral form of its rostel will show that it has uniformly aimed to descend. Delahire supposed that plants become erect in consequence of the volatile nature of their fluids, the explanation of Mr. Knight rests upon mechanical principles, while others have imputed it to the same inherent perceptive intelligence which leads the duckling to the water, and the young partridge to the wood. Mr. Knight found that if seeds be made to germinate on a rapidly revolving wheel, their plumelets converge towards its axis, while the radicles proceed in an opposite direction, and therefore, he concludes that the same principle which causes a heavy body to fall when unsupported, gives to the rostel its descending direction. The subject however is still involved in obscurity, for it seems paradoxical to say, that the Oak towers above the horizon in consequence of the same gravity, by which, when decayed it is precipitated to the ground.

The germination of the Misletoe is very different from the process which has here been described. Destined to live upon the resources of other vegetables, its rostel penetrates their bark, and according to the observations of Duhamel, its seed will vegetate even when its cotyledons have been removed. Nor does its rostel exhibit that invincible tendency downwards, which has been noticed among the phenomena of ordinary generation, but its young stem and young roots grow in every direction, apparently with the same facility.

"The preservation of the vital principle in seeds, is one of those wonders of Nature which pass unregarded from being every day under our notice. Some lose their vegetative power by being kept out of the ground ever so little a while after they are ripe, and in order to succeed, must sow themselves in their own way and at their own time. Others may be sent round the world, through every vicissitude of climate, or buried for ages deep in the ground, till favourable circumstances cause them to vegetate."*

The forester who removes from his plains the Pines with which perhaps for ages they have been occupied, is surprised soon after, to behold them covered with the barren oak, for he knows not, where or how the germs of such a multitude of shrubs have been preserved. And where other vegetables have been burnt, he sees the Fire weed, which Phœnix-like, springs up and appears to thrive only on the ashes of the dead. The earth which is thrown from cellars and wells is soon covered with thistles and other plants, whose seeds have been deposited in such a situation as to prevent their growth, during a period which no man can estimate.

These and other examples of the kind, have led to the popular, though erroneous belief, that the vegetables which thus appear, derive their existence from the earth, and not from the germination of seeds.

"Great degrees of heat, short of boiling, do not impair the vegetative power of seeds, nor do we know any degree of cold that has such an effect. Those who convey seeds from distant countries should be instructed to keep them dry; for if they receive any damp sufficient to cause an attempt at vegetation, they necessarily die, because the process cannot as they are situated go on. If therefore they are not exposed to so great an artificial heat as might change the nature of their oily juices, they can scarcely according to the experience of Mr. Salisbury, be kept in too warm a place. By the preservation of many seeds so long under ground it seems that long continued moisture is not in itself fatal to their living powers, neither does it cause their premature germination unless accompanied with some action of the air."*

* Smith.

CHAPTER III.

VEGETATION.

As soon as it has escaped from the integuments of the seed, the young plant becomes capable of abstracting from the atmosphere and the earth, the nutriment necessary to its complete developement; and our next enquiry relates to the food which it absorbs, and to the agents by which its growth is affected. By the aid of chemistry the soil and the Atmosphere have been analyzed, and when we compare the ingredients of which they are composed, with those which enter into the composition of vegetables, it will be found, that the latter do not select the principles which the former contain in the greatest abundance. *Carbon, oxygen* and *hydrogen*, the two last by their union forming water, constitute the bulk of most plants. Yet it appears, that the proportion of these and the other ingredients, is various in different plants, and hence it is obvious, that they would not grow with equal luxuriance in the same soil, sustained by the same food, and exposed to the same privations. Hence we learn, why some vegetables flourish in clayey, some in flinty earth, while others thrive better in a calcareous soil than in either of these: why some are found invariably on the margin of the sea, while others shun, as the pestilence of death, the vapours of the "salt sea foam." And hence we learn, why some thrive only in water, others on the dry and sandy plain, why some grow luxuriantly in the valley, while others bud and bloom only on the mountain's dreary summit. From water, air and the soil, plants derive their food; heat and light enabling them to convert it to their own use.

1. WATER.—Of the various substances by which vegetables are nourished, water is perhaps the most important. It preserves the vigour and freshness of plants, which droop and wither when deprived of their necessary supply, and it restores to health the leaf that fades in consequence of its privation. * "Many plants will grow, and thrive, and effect the developement of all their parts, if the root is merely immersed in water, though not fixed in the soil. Lilies, Hyacinths, and a variety of plants with bulbous roots, may be so reared, and are often to be met with, so vegetating; and others will also vegetate, though wholly immersed. Most of the marine plants are of this description. It can scarcely be doubted therefore, that water serves for the purpose of a vegetable aliment.

But if plants cannot be made to vegetate without water; and if they will vegetate, some, when partly immersed, without the assistance of soil; and some, even when totally immersed, so as that no other food seems to have access to them; does it not follow that water is the sole food of plants, the soil being merely the basis on which they rest, and the receptacle of their food? This opinion has had many advocates; and the arguments and experiments adduced in support of it, were at one time thought to have completely established its truth. It was indeed the prevailing opinion of the seventeenth century, and was embraced by sever-

* This chapter is selected chiefly from the Physiological Botany of Mr. Keith.

al succeeding philosophers, that water, by virtue of the vital energy of the plant, was sufficient to form all the different substances contained in vegetables.

But more recent experiments have proved that this opinion is untenable, for it appears that in those cases in which mere water supplies the wants of vegetation, its invigorating effects are partially owing to the substances which it holds in solution. While we maintain, therefore, that water is not the sole food of plants, and is not convertible into the whole of the ingredients of the vegetable substance, even with the aid of the vital energy; we must at the same time admit that plants, though vegetating merely in water, do yet augment the quantity of their carbon. In this situation some plants thrive, others are feeble, and languish for the want of more solid nutriment; and in all cases it is desirable to know whether the vegetables we cultivate, grow most luxuriantly in a moist or in a dry soil. The texture and form of their leaves and roots, and the peculiar situation, in which, when unrestrained by culture, they are found to delight, will furnish useful hints to those who are pursuing this enquiry.

2. ATMOSPHERE.—When it was found that water is insufficient to constitute the sole food of plants, recourse was next had to the assistance of the atmospheric air; and it was believed that the vital energy of the plant, is at least capable of furnishing all the different ingredients of the vegetable substance, by means of decomposing and combining in different ways, atmospheric air and water. But as this extravagant conjecture is founded on no proof, it is consequently of no value. It must be confessed, however, that atmospheric air is indispensably necessary to the health and vigor of the plant, as may be seen by looking at the differ-

ent aspects of plants exposed to a free circulation of air, and plants deprived of it; the former are vigorous and luxuriant; the latter weak and stunted. It may be seen also, by means of experiment, even upon a small scale. If a plant is placed under a glass, to which no new supply of air has access, it soon begins to languish, and at length withers and dies; but particularly, if it is placed under the exhausted receiver of an air pump, as might be expected from the failure of the germination of the seed, in similar circumstances.—According to the experiments of Saussure, plants of peas, though completely developed and furnished with their leaves, died in the space of three days, when put into the exhausted receiver of an air pump, whether in the shade or the sun. But even in this situation, plants with thick and succulent leaves, seem capable of supporting vegetation, at least if exposed to the sun. A plant of the Prickly Pear, *Cactus opuntia* lived more than a month in this state, without showing any symptoms of decay, except that the epidermis seemed dry, which again recovered its freshness, however, in the atmospheric air.

But although we admit the great utility of atmospheric air, and even its absolute necessity to the support of vegetable life, we must not attribute to it more than is due, and conclude without proof, that air, together with water, forms the whole of the vegetable aliment And yet in support of this doctrine, it has been said, that many plants do evidently effect the developement of their parts, without the aid of any other nourishment beyond that of air, rains, and dews; and the Mosses and Lichens, and some other tribes of plants, have been quoted as affording examples.

It must be admitted no doubt, that plants of slow growth, and tenacious of life, such as many of the Mosses, and some of the succulent plants, do indeed effect the developement of their parts, without the aid of any other nourishment beyond what they derive from the atmosphere. But plants of rapid growth, such as annuals, can never effect that developement, without the aid of nourishment derived from the soil. Saussure tried the experiment upon Beans, Peas, and cresses, by placing them in pure sand, and moistening them with distilled water. They grew indeed, and some of them even flowered, but never produced perfect seeds. It is plain, therefore, that some essential principle of nourishment was wanting, which is furnished by the soil; and that atmospheric air and water, are not the only principles constituting the food of plants.

3. VEGETABLE EXTRACT.—When it was found that atmospheric air and water are not, even conjointly capable of furnishing the whole of the aliment necessary to the developement of the plant, it was then alledged that, with the exception of water, all substances constituting a vegetable food must at least be administered to the plant in a gaseous state. But this also is a conjecture unsupported by proof; for even with regard to such plants as grow upon the barren rock, or in pure sand, it cannot be said that they receive no nourishment whatever besides water, except in a gaseous state. Many of the particles of decayed animal and vegetable substances, which float in the atmosphere and attach themselves to the leaves, must be suffered to enter the plant in solution with the moisture which the leaves imbibe; and so also similar substances contained in the soil must be supposed to enter it by the root; but these substances may certainly contain vegetable nourishment; and they will perhaps be found to be taken

up by the plant in proportion to their degree of solubility in water and to the quantity in which they exist in the soil. Now one of the most important of these substances is vegetable extract.

When plants have attained to the maturity of their species, the principles of decay begin gradually to operate upon them, till they at length die and are converted into the dust from whence they sprang, thus resembling the animal to whom they afford support. The substance to which they are finally converted has been denominated vegetable mould. And this, as might be expected, constitutes a considerable proportion of the soil. The chance then is, that it is again converted into vegetable nourishment, and again enters the plant. But it cannot wholly enter the plant because it is not wholly soluble in water. Part of it, however, is soluble and consequently capable of being absorbed by the root, and that is the substance which has been denominated extract. But the quantity of extract that may be separated from pure mould formed by nature upon the surface of the globe is not in general very considerable. And yet it frequently seems to be more than sufficient for the purposes of vegetation; for a mould containing an excessive quantity was found by Saussure to be less fertile than that which contains an ordinary share. But if the quantity of extract must not be too much, neither must it be too little. Plants that were put to vegetate in mould deprived of its extract, as far as repeated decoctions could deprive it, were found to be much less vigorous and luxuriant than plants vegetating in mould not deprived of its extract; and yet the only perceptible difference between them is, that the former can imbibe and retain a much greater quantity of water than the latter.

From this last experiment, as well as from the great proportion in which it exists in the living plant, it evidently follows that extract constitutes a vegetable food.

4. SALTS.—Most plants are found by analysis to contain a certain proportion of salts ; such as nitre and muriate of soda or common salt. How do they acquire them ? In the earlier periods of phytological investigation, when every effect was attributed to the agency of the vital principle as exerted upon the air and water, which the plant inhales or absorbs, it was thought that the salts contained in vegetables are formed in the process of vegetation ; but this is also one of those extravagant conjectures of which further research has exposed the absurdity. The salts which have been detected in vegetables are known to exist in the soil. It is most likely therefore that the root absorbs them in solution with the water by which the plant is nourished. For the fact is already ascertained that plants are capable of taking up salts by the root, at least when presented to them in a state of artificial solution ; and if so, there is then reason to presume that they are also taken up by the roots of plants vegetating even in their natural habitations.

But if salts are thus taken up by the root of the vegetating plant, does it appear that they are taken up as food ? Some plants, it must be confessed, are injured by the application of salts, as is evident by the experiments of Saussure ; but others are as evidently benefitted by it. Clover and Lucern have their growth much accelerated by the application of gypsum, though many other plants are not at all influenced by its action. The Nettle, and Borage will not thrive except in such soils as contain nitre ; and plants inhabiting the sea coast, as was observed by Duhamel, will not thrive in a soil that does not contain muriat of soda.

It has been thought, however, that the salts are not actually taken up by the root, though converted to purposes of utility by acting as astringents in stopping up the orifices of the vessels of the plant, and preventing the admission of too much water ; but it is to be recollected that the salts in question are found by analysis in the very substance of the plant, and must consequently have entered in solution. It has been also thought that salts are favourable to vegetation only in proportion as they hasten the putrefaction of vegetable substances contained in the soil, or attract the humidity of the atmosphere. But gypsum is not deliquescent, and if its action consists merely in accelerating putrefaction, why is its beneficial effect confined but to a small number of plants ?

Some writers have contended that the salts which are found in vegetables are merely accidental in their occurrence, and not necessary to the health or perfection of the individual ; because they are found to exist in but a very small proportion, both in the soil and plant ; but as there are many species in which some salts are to be met with constantly and uniformly, at least if they have vegetated in a soil in which they are found to thrive, we can scarcely regard their occurrence as being merely accidental, or as producing no beneficial effect upon the plant. But the proportion of salts lodged in the soil, is not so small as is generally believed ; and it is abundantly sufficient for all the purposes of vegetation. It may even in some cases contain too much ; for it is to be recollected that saline substances are beneficial to vegetation only when applied in very small quantities. If they are administered in great abundance they destroy the plant.

And the argument against their utility that has been drawn from the small proportion in which they are found to exist in the plant itself, is altogether inadmissible; because it is very well known that some particular ingredient may be essential to the composition of a body, and yet constitute but a very small proportion of its mass.

5. EARTHS.—As most plants have been found by analysis to contain a portion of alkaline or earthy salts, so most plants have been found to contain also a portion of earths; and as the two substances are so nearly related, and so foreign in their character to vegetable substances in general, the same enquiry has consequently been made with regard to their origin.

It seems to have been the opinion of Lampadius that the earths contained in plants are merely the effect of vegetation, and altogether independent of the soil in which they grow; and extravagant as the opinion is, it has been made to assume the semblance of resting upon experiment. Saussure has exposed the absurdity of this opinion, and the fallacy of the experiments which led to its adoption; and it is at present more generally believed that the earths are absorbed with the water in which they are dissolved.

It is probable, however, that plants are not indebted merely to the soil for the earthy particles which they contain. They may acquire them partly from the atmosphere. Margray has shown that rain water contains silica in the proportion of a grain to a pound; which, if it should not reach the root, may possibly be absorbed along with the water that adheres to the leaves.

But although the earths are thus to be regarded as constituting a small proportion of vegetable food, they are not of themselves sufficient to support the plant, even with the assistance of water. Giobert mixed together the different earths in such proportions as are generally to be met with in fertile soils, and moistened them with water. Several different grains were then sown in this artificial soil, which germinated indeed, but did not thrive ; and perished when the nourishment of the cotyledons was exhausted. It is plain, therefore, that the earths, though beneficial to the growth of some vegetables, and perhaps necessary to the health of others, are by no means capable of affording any considerable degree of nourishment to the plant.

6. MANURES.—As the object of the preceding pages, has been that of exhibiting a brief view of the different species of vegetable food, whether it be regarded as derived from the soil or the atmosphere ; so our next object will be to show how the food necessary to the support of the vegetating plant may be supplied when defective, or restored when exhausted. But this unavoidably involves the subject of manures, or artificial preparations of vegetable food, so important to the advancement of agriculture, and consequent interest of mankind.

With regard to the food of plants derived from the atmosphere, the supply is pretty regular, for the proportion of its elements is not found to vary on any part of the surface of the globe, and if human aid were even wanted, it does not appear that it could be of much avail. But this is by no means the case with regard to soils, which are less regular in their composition, and at the same time, more within the reach of human management. On this subject however, we can only refer to those practices which have been pursued with advantage, both in this country and in Europe. If the soil be wet or marshy, it is drained and burned; if exhausted from the repeated culture of any vegetable, the crop is changed; if still unproductive the earth is plowed and suffered to repose. If any one asks how the fertility of a soil is restored by these means, it will be sufficient for the object of this work to reply that, in the case of draining, the amelioration is effected by means of its carrying off all such superfluous moisture as may be lodged in the soil, which is well known to be prejudicial to plants not naturally aquatics, as well as by rendering the soil more firm and compact. In the case of burning, the amelioration is effected by means of the decomposition of the vegetable substances contained in the turf, and subjected to the action of fire, which disperses part also of the superfluous moisture, but leaves a residue of ashes favourable to future vegetation. In the case of the rotation of crops, the fertility is not so much restored as more completely developed and brought into action; because the soil, though exhausted for one species of grain, is yet found to be sufficiently fertile for another, the food necessary to each being different or required in less abundance.

In the case of the repose of the soil, the restored fertility may be owing to the decay of vegetable substances that are not now carried off in the annual crop, but left to augment the proportion of vegetable mould; or to the accumulation of fertilizing particles conveyed to the soil by rains; or to the continued abstraction of oxygen from the atmosphere.

In the case of fallows, it is owing undoubtedly to the action of the atmospheric air upon the soil, whether in rendering it more friable, or in hastening the putrefaction of noxious plants; or, it is owing to the abstraction and accumulation of oxygen. And in the case of plowing and trenching, it is owing to the increased facility with which the roots can penetrate to a proper depth.

But it often happens, that the soil can no longer be ameliorated by any of the foregoing means, and in this case, there must be a direct and actual application made to it, of such substances as are fitted to restore its fertility. And hence the indispensable necessity of manures, which consist chiefly of animal and vegetable remains, that are buried and finally decomposed in the soil, from which they are afterwards absorbed by the root of the plant, in a state of solution."

7. HEAT.—Besides the qualities of the earth, there are other agents, which maintain an unbounded influence over the vegetation of plants. One of these is heat, and without it no plants have been made to grow, though some require a greater degree of it than others. They all require sufficient while vegetating, to prevent the congelation of their fluids, and the temperature at which this takes place, their freezing point determines the extent of their power to resist the operation of cold. The vital energy of equinoctial plants, is not calculated to resist its agency, and therefore they cannot endure the temperature of freezing water. They require to be protected during the winter, and if originally brought from the southern hemisphere, they ought to be exposed to a good degree of artificial heat, or they lose their native beauty and fragrance. But the vegetables of Polar regions possess an astonishing power of resisting the operation of cold, which enables them to brave the inclemency of every season,

and to extend the empire of their existence beyond the limits of perpetual snow. They are furnished with buds, which guard the tender leaves and flowers from injury, till the period of their evolution arrives, after which their power of self preservation is lost, and they are injured by the cold which they are no longer prepared to resist.

8. LIGHT.—Another agent is light; without which, plants may be made to grow, but no longer exhibit the verdure, the texture, or any of the properties of health. Hereafter we shall probably learn, that while the atmosphere is contaminated by the respiration of animals, its purity is restored by the vegetation of plants. But secluded from the light, vegetables are no longer capable of converting a portion of the fixed air to their own use, or of supplying the atmosphere with oxygen, on which its importance to animal life, chiefly, if not entirely depends. By the action of light, the carbon of the fixed air is interwoven with the very texture of the plant, whereby it acquires a greater degree of firmness, and becomes more valuable in the arts. Through its agency, the aromatic and essential secretions are formed, and hence we find them existing in perfection, only in countries which are favoured with the perpetual light of summer, or on elevated mountains, where the rays of light meet with no obstruction. There we find the Nutmeg, the Clove, the Cinnamon and the Peruvian barks, all designed to increase the comforts, or diminish the sufferings of humanity; and all owing their chief excellencies to the *light* of the sun.

When prepared to investigate the geographical distribution of the vegetable kingdom, we shall learn the powerful effects of these united causes. Feeble and exhausted in Polar regions, vegetation acquires strength as we approach towards the equator; where its powers can be estimated, only by the magnificence of its productions. There the light of the sun is more vivid, its heat more permanent and intense, while the soil is equally fertile, and the atmosphere equally pure.

In southern Georgia, an island of the frozen ocean, only two plants have been discovered, and but thirty have been found to grow without cultivation, in the more temperate climate of Spitzberg. How contemptible are these productions, when compared with those of our own climate, or the still more fertile fields of Madagascar! But deprive Madagascar of its heat, and it becomes a second Greenland. Exclude the light of the sun, and like the dark caverns of the earth, it will produce only a few plants, and those of a sickly hue. Destitute of rain, it will be like the deserts of Africa, and unsupplied with air, it will exhibit no vestige of life. We must therefore expect, as we recede from the equator, to meet with a constant succession of new plants, but as we advance, we shall find them less numerous snd perhaps of inferior beauty and size. And as we ascend above the surface of the ocean, we must be prepared for a similar, though more rapid succession. This was long ago established by the observations of Tournefort, and it has more recently been verified, by the researches of Humboldt and Decandolle; but an account of their observations must be reserved for a subsequent chapter.

CHAPTER IV.

TEXTURE OF VEGETABLES.

When we reflect upon the vast variety of productions which the analysis of vegetables discloses to our view, and that even the same plant presents substances essentially different from each other ; it must be obvious that for each of these substances there is an appropriate system of vessels. And when we examine the transverse section of a woody stem, it presents several varieties of structure, distinguished from each other by colour–taste--density and strength, embracing all the different arrangements which are to be found in the growing plant, and some of them in their most perfect form. It presents externally the BARK, composed of *Epidermis—Cellular Integument* and *Cortical Layers ;* it presents the WOOD, exhibiting, especially in old trees, two distinct portions, which are readily distinguished by their peculiar density and colour ; and in the centre of these it presents the PITH ; very abundant in young shoots, but gradually disappearing with age.

This is the arrangement which we find, and this we shall adopt, in the prosecution of our enquiries respecting the texture of vegetables.

SECTION 1.

EPIDERMIS.

The exterior covering by which every part of a living plant is surrounded, is named its Cuticle or *epidermis.*

The various examples which it exhibits, some distinguished for their delicacy and others for their singular beauty, invite to an examination which the importance of the organ demands.

"In the root and trunk, it is coarse and hard, or it is a crust of considerable thickness, forming a notable portion of the bark, and assuming some peculiar shade of colour which it seems to acquire from age; while in the leaves, flowers, and tender shoots, it is a fine, colourless, and transparent film, not thicker than a cobweb. But its want of colour is discoverable only when detached; for, when adherent, it is always tinged with some peculiar shade, which it borrows from the part immediately beneath it. Hence the green colour so prevalent in the leaf and tender shoot, which the epidermis merely transmits, and the beautiful variety of tints displayed in flowers and fruits. In the permanent parts of woody and perennial plants, the old epidermis often disengages itself spontaneously, as in the Currant, Birch, and Plane tree, in which it seems to be undergoing a continual waste and repair; and in such plants it is again regenerated, even though destroyed by accident. But in herbaceous plants, and in the leaf, flower, and fruit of other plants, it never disengages itself spontaneously, and is never regenerated if once destroyed."*

According to the elder Saussure, who studied this organ chiefly in the leaves and flowers of the Jessamine and Foxglove, it is composed of two layers, the interior being a net work interspersed with numerous glands, the other consisting of a fine transparent mem-

* Keith.

brane, capable of being partially detached but destitute of organization.

The glands, noticed by Saussure, are regarded by Hedwig as mere apertures, or pores, perforating the pellicle that forms the epidermis. "They are contained within a peculiar area, which is sometimes round, sometimes oval, and sometimes rhomboidal. [*Figs.* 1 and 2 are designed to represent a magnified view of these areas as exhibited by the garden pink and lily.] They are generally oblong, though they are often so much contracted as to change their form. The areas communicate with one another by means of certain vessels originating in their circumference, and forming part of the general net-work which is composed of two distinct but adherent layers. Finally, they are regarded as being organs of perspiration, and their peculiar areas, which consist also of two distinct but not adherent layers, are regarded as forming receptacles for perspirable matter."*

The magnitude and number of these pores is unquestionably various in different plants, and by observing how soon the branches wither when removed from their original connexion, we can estimate the aggregate number and size of the orifices, through which their fluids escape. By observing also how soon the faded branch revives after it is plunged into water, we can determine the comparative magnitude and number of those orifices, through which its fluids are absorbed; and we shall find that while our aquatic vegetables wither in a few moments, owing to the rapid discharge of their fluids, others are so constructed as to retain their moisture several days. We shall likewise find that

* Keith.

some which absorb water with facility, exhale it very sparingly, a fact, which renders them well adapted to sustain the privations which they were designed to encounter. The Houseleek is a plant of this description, and therefore we frequently see it flourishing on walls, where other vegetables would wither and die. The Aloe and Ice plants, those splendid ornaments of the sandy desert are other examples, whose cellular texture is filled with fluids, which the peculiar formation of their epidermis enables them to absorb and retain.

The epidermis usually appears like a simple membrane, but those of the Paper Birch and Currant, are composed of several layers which may easily be separated from each other, and the number of its epidermidal coats has acquired for an American shrub, the popular name of Nine bark.* But there are cases in which the several layers are obviously so incorporated as to form in the aggregate only an individual epidermis. This may be exemplified in the rind of an apple, of which the layers are two in number, the exterior being thin and transparent, the other being more succulent and tender, and tinged with a peculiar shade, giving colour to the fruit. In most cases when recently formed, it is transparent as well as porous, so as to admit the free access of light and air, while it excludes every substance which would prove injurious to vegetation. Not only does it protect the young tree from external injury, but it preserves our choicest fruit from premature decay, and without it the leaf would lose its verdure, the flower its fragrance, and their transitory beauty would become still more evanescent.

* Barton's Elements.

To Wheat, to Rye, and to most kinds of grass, the epidermis is of still greater importance, for at once it supports their stalks, and secures them from injuries, to which, without this defence they would have been continually exposed. The beauty and strength of those straws which are employed in the manufacture of bonnets, and the durability of such as are used in the formation of thatched roofs, may be traced entirely to their exterior covering. In these, and still more abundantly in the epidermis of the Rattan and Scouring Rush, Sir Humphry Davy has discovered the existence of flinty earth, and in some cases the quantity is so great as to give fire when struck with steel. It is the flint which enters into its composition that renders the Rush so noxious to animals, so useful in the arts, and it is this which makes the ashes of burnt straw one of the best materials, which can be employed in giving its finest polish to marble.

The epidermis is sometimes clothed with wool or down, when it becomes an effectual security against the extremes of heat and cold. Thus protected, a few plants linger around the ruins of the volcano, long after they are deserted by their less fortunate companions. The young leaf of the American poplar, *Populus grandidentata*, affords a fine example of this downy covering, which disappears whenever the enclosed texture becomes so firm as no longer to require it for defence. The wooly covering of the Mullein is more generally known, and its very close analogy to the fur of animals, would warrant the inference that they are designed to answer the same important purposes.

Thus various are the forms of the epidermis, an organ merely of defence, admirably designed to secure from harm the tender vessels which it encloses, and to form in the language of an interesting writer, "a fine but essential barrier betwixt life and death." Possessing in a very inferior degree the properties of organization, and the powers of life, it is frequently the most durable portion of the vegetable structure, and serves to enclose the remains of those organs, for whose defence, when living, it was chiefly designed.

SECTION 2.

CELLULAR INTEGUMENT.

Immediately beneath the epidermis of leaves and young stems, we find a soft juicy coat which is named *cellular integument.* It exists in all herbaceous plants, occurs in pulpy fruits, and is particularly conspicuous in the leaves and flowers. In the seed lobes, it is usually white, in the leaves it is green, while in the flowers and fruit it assumes almost every variety of hue.

The organ in question has been examined with peculiar care by Mirbel, and no one else has delineated its structure with so much perspicuity, and minuteness. When divided by a transverse or vertical section it presents an assemblage of hexagonal cells, resembling those of the honey comb, each side being common to two cells, and the whole arranged with the most perfect symmetry. "But if the cells happened to be compressed by any foreign force, the hexagon then assumed an elongated appearance. The partitions of the cells were found to be extremely thin and transparent, and their organization too fine to be distinguished even by the highest magnifiers. But they were generally perforated with holes or pores, forming the medium of communication between the different cells, and bordered with a sort of small and glandular ring. The whole of the tissue was extremely delicate, but particularly in the several parts of the flower, where the slightest touch stained it, and the slightest pressure destroyed it. It was also speedily destroyed by maceration in water. If the cells happened to be empty it was transparent and colourless, but if filled with juice it was generally green, though sometimes brown, yellow, or red, communicating its acquired colour to the epidermis, whether in the leaves, petals, or other parts of the plant."*

The mere empty cells form the *cellular membrane*, and the same cells when filled with their appropriate and frequently coloured juices, constitute the *Parenchyma* or pulp, which forms the great mass of succulent plants and pulpy fruits. No plants are destitute of this integument, for it is the seat of operations indispensably necessary to healthy vegetation ; but these operations will be more fully explained in our chapter on the uses of leaves.

SECTION 3.

CORTICAL LAYERS.

If a stem of the Currant or a branch of the Lime tree be divided transversely, we find within the cellular integument a series of concentric or *Cortical Layers*, corresponding in number to the age of the stem or branch we examine. In some instances they constitute

* Keith.

the entire bark, and in all they are its most essential portion.

The exterior and old " layers are coarse and loose in their texture, exhibiting individually a conspicuous and indurated, but very irregular net-work, composed of bundles of longitudinal fibres, not ascending the stem directly but winding more or less around the axis of the plant.

As the layers recede from the circumference, the net-work which they form is finer though still very irregular, and their texture more compact. But although irregular, the meshes of the different layers often correspond, forming an aperture that extends as far as the meshes coincide, but diminishing in size as it penetrates towards the centre. In the trunks of aged trees, such as the Oak and Elm, the apertures thus formed, widen into large gaps and chinks, exhibiting still in their distribution the rough traces of the net-work of the original layer, now laid bare by the decay of the epidermis and cellular integument."*

But in the bark of young trees and young branches, these apertures are occupied by a cellular substance, more or less indurated, which pervades the fibres of the net-work and binds them together, but these fibres being less perishable than the intervening substance remain entire long after it has wasted away.

The inner layer, that which lies contiguous to the wood is termed *Liber*, from its having been employed in ancient manuscripts. It is more delicate than the others and also more important; whether we regard its uses in the economy of vegetation, or its subserviency to the wants of man.

* Keith.

From the inner bark of the Mulberry, the natives of Otaheite manufacture their garments, and though whimsical in their appearance, they are wrought with great ingenuity. By a more refined process, the *Liber* of the Flax is converted into fine linen, the "white robe of innocence," which in the natural as well as in the moral world, is obtained only through the exertions of man and the bounty of his Creator. But even in its natural state this organ is sometimes extremely beautiful; of this we have a remarkable example in the Lace bark of Jamaica, whose net-work is scarcely inferior to the finest lace; and at the same time soft, flexible, and shining as silk. It is obtained from a shrub* which grows in the West India Islands where it is said to be employed as an article of dress.

We see therefore that the cortical layers are composed of two distinct portions—longitudinal fibres forming a network—and cellular substance occupying the intervening spaces. The texture of the former varies from the delicate fibres of the lace bark, to the coarse meshes of the oak, but in all cases the net-work is more durable than the intervening pulp, and more capable of resisting the operation of chemical agents. But the cortical layers of the Pine tribe present no net-work, the *Liber* being composed of parallel adhering fibres and the outer layers appearing like plates of dried cellular integument, each separated from the other by an intervening membrane or epidermis.

The cellular texture which is so easily destroyed by the action of air and water appears to contain the peculiar secretions of plants frequently in their most perfect state. Of this we have a very common exam-

* *Daphne Lagetto.*

ple in the bark of the Oak, whose layers in a living state are closely connected with each other by the cellular texture, but in consequence of long exposure this texture is destroyed and the separate layers only remain. But with this substance, the astringency of the Oak is gone. And if the bark of the Cinnamon be for a while subjected to the action of boiling water; the woody fibres of the net-work remain uninjured but it loses its exquisite flavour which probably resides in the intervening pulp.

SECTION 4.

WOOD.

The texture of the Wood which constitutes the great mass of trees and shrubs, was investigated with peculiar care by Duhamel, and the same subject has been more recently pursued by Mirbel and Knight, with their usual ingenuity and success.

An old stem of the Currant, when transversely divided, exhibits a series of concentric layers intersected by plates which diverge from the pith to the bark, like the rays of a circle.* A transverse section of the Oak presents a similar arrangement, but here the circular layers are considerably thicker and the divergent plates far more conspicuous than in the preceding example. And if we would pursue the examination still farther, the Ash, the Elm, and the Lilac, will serve to shew that the arrangement so obvious in the Oak, prevails also in other woody stems. The central layers are usually most durable and complete, for those of the circumference being still under the control of a living principle, retain a portion of their peculiar juices,

* *Figs. 7 and 8.*

which can be suddenly dissipated only by the application of heat. This external portion of wood which is named *sap* by the workmen, is for obvious reasons to be rejected whenever durability and strength of materials are required. By Duhamel it was named Alburnum in consequence of its being uniformly white, whereas the central layers are frequently of a different colour. In the Guiacum they are black, in the Oak and Laburnum they are brown, and in other examples they are of a reddish hue. The exterior and unripe portion is converted into perfect wood, much sooner in vigorous trees than in others, and this change is sometimes effected earlier on one, than on the other side of the same tree, in consequence of its more vigorous growth.

The term Alburnum which Duhamel employed in a more extensive sense, is usually restricted to the external layer, whose texture is softer and more abundantly stored with juices than the others. From this peculiarity of external character, it was at one time thought to be a substance essentially different from that of the layers it invests. By the ancients it was regarded as analagous to the fat of animals, and intended perhaps to serve as nutriment during the winter. But it is now known to be merely wood in a less condensed state, being yet lighter and softer than the interior layers, but acquiring strength and solidity with age. It does not however acquire its utmost degree of solidity till after a number of years ; but when divested of its bark it is converted into perfect wood in a single summer.*

It is generally believed that each of the concentric layers is the growth of a single year, and that the age of a tree may be known by the number of circular lay-

* Keith, Vol. I. p. 331.

ers which compose its trunk. It has even been asserted that we may know what winters have been peculiarly severe, by the hardness of the annual plates, and what summers have been mild and serene by their superior thickness. Duhamel having discovered some exceptions to the truth of this general proposition was led to reject it entirely, but his observations are not deemed sufficient to invalidate an opinion which most botanists have adopted. " It is very true that there may be occasional interruptions in the formation of the wood from cold or fickle seasons, and in some trees the thin intermediate layers, hardly discernible in general, which unite to form the principal or annual ones, may, from such fluctuation of seasons, become more distinct than is natural to them. Such intermediate layers are even found more numerous in some trees of the same species and age than in others. But as there is always a most material difference between summer and winter, so I believe there will always be a clear distinction between the annual rings of such trees as shew them at all. Trees of hot countries indeed, as Mahogany, and evergreens in general, have them but indistinctly marked ; yet even in these they are to be seen."*

The divergent plates sometimes termed *silver grain* in allusion to their singular brightness, are particularly numerous in the Maple and large in the Oak. They seem to bind together the annual circles, and to increase the strength of timber which without these connecting bands, would have been easily shattered to pieces : nor is it uncommon to see the former separated from each other, in consequence of the destruction of their silver grain. Each of these concentric layers is divisi-

* Smith.

ble into others, which at last may be reduced to a net-work of longitudinal fibres similar to those which exist in the bark. The Hemlock tree *Pinus Canadensis*, after a long exposure to the atmosphere exhibits a good specimen of layers thus subdivided, nor is it easy to distinguish the component layers from the annual circles. The same thing may be observed in the stem of the Cabbage, which has been exposed to the weather until its divergent plates are decomposed; leaving its concentric layers distinct from each other like the tubes of a telescope.

When minutely examined, the plates of silver grain are found to be composed of parallel fibres closely crowded together, and appearing like compressed cellular membrane. We see therefore, that wood is composed of longitudinal fibres forming a net-work, and cellular tissue extending in a transverse direction, the two sets of fibres being interwoven so as to make the entire structure very compact, and thus corresponding to the description of Grew, who compared one to the warp and the other to the woof of a web.

After it was ascertained that a new layer is annually deposited, it became a question whether it was formed by the bark, the wood, or according to the speculations of Linnæus from the pith. But the experiments of Duhamel and Hope, have put this question forever at rest. The former introduced plates of tinfoil between the bark and wood of growing trees, carefully binding up their wounds, and suffering them to remain several years without further molestation. He found in all cases, the layers of new wood exterior to the tin.

Dr. Hope's experiment is equally decisive. He made a longitudinal incision on the branch of a Willow, so as to detach the wood from the bark, leaving the latter in the form of a hollow cylinder, by the side of the naked stem, and both portions retaining their original connexion with the trunk and superior branches. After a few years this tree was examined, and "the cylinder of bark was found lined with layers of new wood, whose numbers added to those of the wood from which it had been stripped, made up the number of rings in the branch above and below the experiment." But the stem from which the bark had been removed remained unaugmented. It appears therefore that two layers are annually deposited on the inner surface of the bark, similar at first and closely united, but gradually assuming a distinct character, and at last receding from each other in the form of wood and bark. At the commencement of a second Spring, they are contiguous but readily detached from each other, but ever afterwards are they separated by the intervention of the more recent layers.

SECTION 5.

PITH.

The pith is a soft spongy substance occupying the centre of the stem, and extending from the root to the extremity of the young branches. In the Ash it is uninterrupted and compact, in the Garget *Phytolacca decandra*, it is composed of transverse partitions intersecting the tube of the stem, which in that plant is unusually large ; and in some of the Thistles, it more resembles the web of a spider attached to the sides of the tube, but neither regularly disposed nor so large as to occupy its entire cavity. In the Hemlock and other

Umbelliferous plants it forms a fine delicate lining, remarkable in some cases for its brilliancy, and in many of the grasses it presents a similar appearance. But in the *Zizania* or wild Rice, one of the largest grasses in New-England, it forms in addition to this lining, distant partitions which interrupt the cavity of the stem.— When young the pith is usually green, becoming of a snowy whiteness when old, though in a few cases it becomes yellow or brown.

Its texture is precisely similar to that of the cellular integument, being composed of cells which are seen to the best advantage in the centre, for there they are least compressed by the surrounding layers of wood. These cells, which are unusually large in the Elder, are filled with fluids when young, but in old branches the fluids are gone and the empty cells only remain.

The pith is sometimes interspersed with fibres of a very different texture. They occur in the old stems of the Elder, and are still more conspicuous in the stalk of the Indian Corn. In the former case, they are distinguished by their peculiar colour from the pith in which they are imbedded, and the formation of these fibres has been regarded as the commencement of the process, by which the pith is converted into perfect wood.

Of its uses in the economy of vegetation, but little is known. Its structure being similar to that of the cellular tissue, it is probably subservient to the same purposes, though some writers have assigned to it more important functions. Among them was Linnæus, by whom it was regarded as the source of nutriment, and the seat of vegetable life. Others, and among them is Mr. Knight, regard it as a reservoir of moisture, to supply the leaves when exhausted by excessive exhalation. But it has been observed that the pith of a whole branch does not in many cases, contain sufficient moisture to supply an hour's perspiration of a single leaf; and an opinion, whose absurdity is thus easily demonstrated, must be forever relinquished.

SECTION 5.

VEGETABLE FIBRE.

In the pith of the Indian Corn, we have seen a number of large insulated fibres, passing longitudinally throughout its whole extent. In the leaf stalk of Celery, in the stem of the common Brake, and also in most herbaceous plants, we meet with similar fibres. Viewed with a microscope, they are found to be a bundle of very slender fibres firmly connected together, and forming a thread, which is usually elastic and frequently strong. This thread is capable of repeated subdivisions, but no art can divide the component fibres to which it may easily be reduced.

In a similar way the net work of fibres which compose a portion of the wood, and those of the silver-grain, by which the former are intersected, may be repeatedly subdivided, and it is found that they differ not only in structure and arrangement, but also in their degree of strength. "This is obvious, from the well known fact that wood may be easily split, in the direction of its longitudinal fibres, but not in the direction of the transverse plates, owing evidently to the strong and tough fabric of the former and to the slender and delicate contexture of the latter."*

* Keith.

The firmness of wood, and consequently its value as timber, depends on the number and density of its longitudinal fibres. In the *Guiacum* and Mahogany they are numerous and compact, in the Poplar they are few, and the wood of the former is extremely hard, while that of the Poplar is soft and spongy. But even in the same plant these fibres are not uniform throughout, acquiring their utmost degree of solidity only by age, and being soft and tender in the more recent layers of wood and bark. And the delicate fabric of these recent layers, exhibits a difference, equally worthy of observation. If for example, the bark is wounded, its fibres will soon reunite, and no traces of the wound are perceptible; but when the wood is injured, its fibres are never reunited and the injured part is never regenerated. We here see one of those admirable provisions of Nature, which it is impossible to contemplate without delight. The bark being exposed to frequent injuries, is capable of restoring itself to health, but the wood being comparatively secure, needs not and possesses not this preservative power.

But even these fibres, so slender that the naked eye can scarcely detect them, are found to be tubular, and they constitute the channel through which the fluids of the vegetable pass from one organ to another. They form in the aggregate bundles of hollow cylinders of which Mirbel has given a very satisfactory description, accompanied with some instructive hints relative to the peculiar functions of each variety.

SECTION 7.

VESSELS.

1. *Simple Tubes.—Fig.* 4 *a.* These are larger than the other varieties, and have no lateral perforations. They occur chiefly in the bark, sometimes in the alburnum or in the fibres of herbaceous plants, but they are particularly obvious in vegetables which contain thick and resinous juices. The peculiar colour of these juices, which on account of their consistence could not readily pass through a channel of less diameter, will frequently enable us to detect the simple tubes.

2. *Porous Tubes.—Fig.* 4 *b.* These resemble the preceding in their general aspect, but the membrane which forms them is not in this case entire; being pierced with small pores which are arranged in parallel transverse rows. They occur chiefly in woody plants, and are particularly abundant in the hard texture of the Oak, but their uses are not very satisfactorily determined.

3. *Spiral Tnbes..—Fig.* 4 *c.* If a young shoot of the Elder or Snowball is gently broken, its two fragments will appear to be connected by transparent fibres, which when closely examined, evèn to the naked eye exhibit a spiral form. *Fig.* 5.

These are the coats of the spiral tubes uncoiled by the separation of the fragments, and if the latter are still farther separated, these fibres at last are broken, retract and assume their original form. In this state they have been compared to the *Trachea* or windpipe of animals, but they more closely resemble the elastic wire of suspenders which forms a complete tube except when forcibly extended and then it represents the spiral vessels in their uncoiled state. These tubes occur chiefly in the stems of herbaceous plants, in young shoots of trees and shrubs, and in leaves of every description. They have rarely been detected either in the mature wood or in the root, and the stems and leaf-stalks of Liliaceous vegetables exhibit them to the best advantage.* Of the nature and uses of these vessels, but little is known. Some have described them as the tubes through which the sap is propelled. Others as air vessels which accompany the tubes through which the sap passes in its ascent towards the leaf. We know that healthy vegetation requires the presence of atmospheric air and it is reasonable to suppose, that like the other substances by which plants are nourished, this is furnished with an appropriate system of vessels, and surely nothing could be better calculated to answer this intention, than the spiral tubes which we have seen in the leaves and their appendages.

4. *False Spiral Tubes—Fig.* 4 *c.* These appear somewhat intermediate between the two preceding, having transverse fissures, analagous to the pores of the one and between these fissures rings which are not unlike the spiral coat of the other. They occur more frequently in herbaceous plants, and are particularly abundant in the soft texture of the Vine, and it is probable that they are formed by the partial union of the Spiral rings. This idea has been confirmed by inspecting the Flowering Rush in which they are of a mixed character the same vessel exhibiting the arrangement of each variety being at once porous, spiral, and also intersected by transverse fissures. *Fig.* 4 *d.*

5. *Small Tubes* are the only ones which remain to be

* No plants which I have examined, exhibit them so distinctly, as the Skunk's Cabbage, which is well named and figured in the American Medical Botany of Dr. Bigelow.

noticed. They are composed of an assemblage of elongated cells which have collectively been compared to a bundle of tangent reeds, and individually to a straw of wheat whose cavity is occasionally interrupted by the joints. "The membrane of which they are formed is often pierced with a great number of pores ; but is at the same time thick and strong, being cut with difficulty in a transverse direction, though in a longitudinal direction it is divisible without effort. M. Mirbel says the solidity of the vegetable depends upon the number of interrupted or cellular tubes. They are not discov erable in the embryo, nor even in the young plant at a very early period, but only when the parts have been fully developed, in which stage they are discoverable in most plants without much difficulty, pervading the ramifications of the branched *Lichens*, and the stems of the Mosses ; surrounding the fibrous tubes of herbaceous plants, and constituting also longitudinal fibre ; and intermingling themselves even with the fibrous tubes of woody plants, and constituting part of the ligneous layers, as well as the prominent ridges with which the surface of vegetables is marked. In the finer and more delicate parts of the plant they are also equally prevalent, but here they assume a different aspect, and acquire a degree of consistence resembling that of the cellular tissue."*

Thus it appears according to the observations of Mirbel and others that the structure of vegetables is entirely vascular being an assemblage of tubes and cells which are formed by the foldings of a membrane so colourless, transparent and fine that no one has been able to discover any traces of its organization. The form

* Keith.

of the cells is somewhat diversified, varying in consequence of the pressure of the juices with which they are filled, as well as of the more substantial organs by which they are surrounded ; usually, however, they are hexagonal, and the student who has no other means of gaining an adequate idea of their form and arrangement may profit by the illustration of Grew, who happily compared them to the bubbles that float on the surface of fermenting liquors.

CHAPTER V.

SAP AND SECRETIONS.

In a former Chapter we have enumerated the various substances by which plants are nourished, and we have now seen through what pores this nutriment is absorbed, in what cells it is elaborated, and through what vessels it passes from one organ to another. We are next to trace this food, which is abstracted from the soil only in a fluid state, through its various changes, to learn in what way it contributes to the developement of new organs, and to the formation of the vegetable secretions.

The water in which the roots of a plant are immersed is gradually absorbed, and during the season of vegetation, it ascends through the vessels of the stem with great rapidity and with great force, but still limpid, tasteless and inert, possessing only the properties of the pure water from which it was derived. This fluid constitutes the *Sap*. In some plants and at certain seasons it is particularly abundant. If wounded in the spring previous to the expansion of their buds, the sap of the Vine, Maple or Birch, flows profusely, but at mid-summer, after the leaves are fully developed, the " *tears* of the Vine" are comparatively few. It is not unusual in this country to collect one or two hundred pounds of sap from a single Maple of ordinary size, and we are told that a Birch tree when wounded, has been known to discharge a quantity equal to its own weight.

Yet, at mid-summer when the whole energies of the vegetable are exerted, these trees scarcely bleed at all.

The flowing of the sap is usually regarded as the effect of its accumulation in the vessels, at a season when there are no leaves through which, in the form of vapour it may escape. Dr. Smith however regards it as the effect of heat, operating on the irritability of the plant, and he considers it as the first step towards the revival of vegetation from the torpor of winter. To this hypothesis there are very serious objections, for many trees bleed in the autumn after the leaves begin to fade and fall, as well as in the spring before the buds are open.

During the season of vegetation, the motion of the sap is uninterrupted, and the energy with which it moves, is in some cases very great. Dr. Hales found that it ascends in the stem of the Vine, with force sufficient to elevate a column of water more than forty feet. By what means is it thus forcibly propelled ? The capillary attraction of the tubes, the influence of temperature and the winds, have all been regarded as the agents by which the sap is elevated, but they all appear inadequate to produce the effect. Nor is the hypothesis of Mr. Knight in any degree satisfactory. Having ascertained that the silver grain of the Oak is susceptible of quick changes from variations of temperature, he thinks that these changes may alternately contract and enlarge the diameter of the tubes, and thus forcibly propel the fluids which they contain. But the action of heat operating on the silver grain, would as much promote circulation through a dead and leafless branch as any other. The inherent irritability of the vessels, furnishes the only satisfactory explanation, for it is the only adequate cause of the sap's ascent. And of the sufficiency of this, there can scarcely be a doubt, for we have already learned,* that when the life of a plant is destroyed by electricity, though its texture is uninjured, it ceases to bleed, and its fluids remain stationary. But still they are exposed to all the other agents which have been thought to accelerate their motion.

The ascending sap is usually insipid and inodorous, being according to the experiments of the French chemists but slightly impregnated with those substances, by which plants are nourished, and from which their secretions are formed.

As soon as the leaves expand, this excess of moisture is exhaled, chiefly through the pores of their epidermis, and the fluid thus perspired appears scarcely different from pure water, being the residue of sap deprived of the elements of those secretions which are formed during vegetation; and though it escapes unseen, its amount is in some cases very considerable. A small plant of the Sunflower was found to exhale more than a pound in the course of a day, and the Corneil tree of Europe, perspires still more freely.

But the sap does not ascend indiscriminately, through every portion of the stem. A tree may be divested of its bark, and it will produce its usual supply of leaves, and an increased quantity of fruit. Mr. Knight removed the pith from a young shrub, and it continued to grow with its former luxuriance. The nutriment therefore does not ascend through the bark or pith. Nor does it pass through the central portion of the woody stem, for its vessels are nearly consolidated, and they are not, even during the bleeding season, filled with a limpid fluid. But one channel remains, and it is the alburnum of trees and shrubs, or the analagous portions of herbaceous plants, and hence we learn why the

* Page 25.

operation of girdling, by which the vessels of their alburnum are divided, not only arrests the vegetation, of trees but destroys their life.

This opinion is also confirmed by experiments with coloured infusions, which tinge the vessels through which they pass, and give us a better opportunity of tracing their progress. In this way Mirbel ascertained that the *small tubes* are the channels through which the sap ascends, because they and they only are tinged with the infusion, and he adds in confirmation of his own correctness, that they are filled with a limpid fluid during the bleeding season.

Mr. Knight has pursued this enquiry still further, and finds that the sap enters the leaf-stalk, through the centre of those fibres by which it is attached to the branch, and that it passes on to the surface of the leaf, through vessels which appear to be a continuation of the small tubes of Mirbel. In the cellular tissue of the leaf, the sap is renovated, its superfluous moisture escapes through the pores of the epidermis, and the peculiar juice of the vegetable, sometimes denominated *Cambium*, is formed. It is green in the Periwincle, orange in the Bloodroot, and white in the Poppy and Milkweed, being the great principle from which the various organs of the plant are developed, and ofttimes the seat of its medical virtues. Like the sap it passes in an appropriate set of tubes, which arise from the expanded surface of the leaf, pass through its footstalk exterior to the central tubes, and penetrate the stem or branch to which the leaf is attached. From the experiments of Mr. Knight, we learn through what portion of the stem, and through what system of vessels, it descends to the root. Having detached a ring of bark from the trunk of a young tree, he found that the sap continued to rise, and the portion above the incision augmented as usual, while the portion below the ring scarcely augmented at all. "But if a bud was protruded under the ring, and the shoot arising from it allowed to remain, then the portion of the trunk below that bud began immediately to augment in size, while the portion between the bud and incision remained nearly as before. When two circular incisions were made in the trunk so as to leave a ring of bark between them, with a leaf growing from it, the portion above the leaf died, while the portion below the leaf lived ; and when the upper part of a branch was stripped of its leaves, the bark withered as far as it was stript. Whence it is evident that the sap which has been elaborated in the leaves and converted into proper juice, descends through the channel of the bark, or rather between the bark and alburnum to the extremity of the root, effecting the developement of new and additional parts.

But not only is the bark thus ascertained to be the channel of the descent of the proper juice, after entering the trunk ; the peculiar vessels through which it immediately passes, have been ascertained also. In the language of Mr. Knight they are merely a continuation of the external tubes already noticed, which after quitting the base of the footstalk he describes as not only penetrating the inner bark, but descending along with it, and conducting the proper juice to the very extremity of the root. In the language of M. Mirbel, they are the large or rather simple tubes so abundant in the bark of woody plants, though not altogether confined to it ; and so well adapted by the width of their diameter, to afford a passage to the proper juice."*

* Keith.

The practice which was adopted by Mr. Knight for the illustration of vegetable physics, has been pursued both in Europe and in this country for a very different object. If a ring of bark is detached in the spring from the trunk of the Olive, the quantity of its fruit is very considerably increased. If a branch of the Vine is treated in a similar way, it has been ascertained that its fruit arrives at maturity, three or four weeks earlier than usual. By adopting this plan, those tender Grapes which could not otherwise be cultivated with success at Paris, have been brought to perfection.* The practice has also been adopted in this country, and it is not uncommon to see Apple and other fruit trees, with a portion of their bark detached. It has indeed superceded the old rude practices, of filling their trunks with nails, and boring to their pith, in order to increase the quantity of their blossoms and fruit.

The observations of Mr. Knight teach us in what way the removal of a small portion of bark, may add to the fertility of the fruit tree. By intercepting the descent of the Cambium, a larger supply of food is collected in the extreme branches, and thus the fertility of the tree, and the luxuriance of its young branches, are at once promoted. And the same observations teach us, that whatever impedes the descent of the Cambium, will sooner or later interrupt the progress of vegetation, for the root being deprived of its customary nourishment, loses its vigour and ceases to abstract from the earth, an adequate supply of those materials, by which old organs are nourished, and new ones are formed. They also teach us that the fluids of a leafless

* Desfontaine's Arbres, &c.

tree, cannot circulate, except through the lateral orifices of its vessels ; for the small tubes through which the sap is elevated, and the simple ones through which the Cambium descends, have no direct communication with each other, except on the leaf's expanded surface. It is obvious, therefore, that the vascular system, at least that portion of it through which the fluids circulate, must in every case be co-existent with the leaf, annual in deciduous trees, and perennial in all others.

But the renovated sap as it descends from the leaf, contains not merely woody fibre for the increase of the vegetable : it has acquired other substances on which its flavour and medical virtues depend. We shall enumerate those only which are most important.

STARCH, whose properties are well known, is a very common product of vegetable secretion, being particularly abundant in every kind of grain, and existing in large quantities in Potatoes and other nutritive roots. In the form of *Sago*, it is obtained from the pith of some of the East Indian Palms, and *Salop* which also is a peculiar modification of starch, is procured from the roots of various species of *Orchis*.

GLUTEN.—After the Starch is extracted from flour, there remains a darkish adhesive substance, named gluten, or vegetable glue. Exposed to a moderate degree of heat, it yields large quantities of fixed air, which renders the pastry of flour porous and light ; and hence its utility in the manufacture of bread. Yeast, in whatever mode it is formed, contains gluten, whose decomposition affords fixed air and whose tenacity retains it.

GUM.—Another product of vegetable secretion is mucilage or gum. It is commonly procured from those trees and shrubs which, in their uncultivated state, are armed with thorns. These organs are their only security against the attacks of animals, whose fondness for mucilage, would cause them to wound the trees which afford it. The different species of *Mimosa*, the *Astragalus Tragacantha*, as well as the Plumb, in their native situations, are in this way defended, and from them the most perfect examples of gum are obtained. It is also procured from the *Lichens* which cover some tracts of land, and abound on the bark of decaying trees; and the gum which is thus obtained, has been substituted for the more costly productions of Arabia and Crete. The leaves of various species of Mallows, and the seeds of Quinces, furnish familiar examples of mucilage nearly allied to the preceding.

SUGAR.—To the secretion of plants, we owe the existence of Sugar. It has long been employed by the Chinese, and previous to their invasion by the Spaniards, the natives of this continent, were in the habit of extracting it from the stalk of the Corn, which they cultivated for food, and from the Virginian Aloe, *Agave Virginica*, which grows spontaneously at the South. In one of the Mexican cities, the Spaniards found a large supply of sugar which had been in this way procured. It was unknown in Europe until the fifth century, when one of the Fathers describing the province of Chorassan, mentioned among its charms the "valley of Saporem, where the precious sugar was made." It has now become an essential article of food, employed to a greater or less extent by all the nations of Europe, and by all the civilized world. In tropical countries it is commonly obtained from the expressed juice of the *Saccharum Officinarum* or Sugar Cane, but the Maple of the North, yields it equally pure and scarcely less abundant. It exists also in the roots of some, and in the esculent fruit of many plants, communicating a sweet and usually an agreeable taste.

ACIDS exist in many plants, and when sufficiently abundant, they communicate their own peculiar taste to the organs which contain them. Thus for example the leaves of the Sorrel, and the fruit of the Lemon tree, are both sour. Chemistry has ascertained the existence of several peculiar acids, which exist in the leaves and other parts of different plants; they have usually a sour, sometimes an astringent taste, but they are better known by their effects on the vegetable colours. The *Prussic acid*, which may be obtained by distilling the leaves and kernel of the Peach tree, possesses the flavour of bitter almonds, and is, when used to excess, a poison of the most virulent kind. This should teach us caution in the use of the distilled water of the Peach, which possesses to a greater or less extent, the dangerous properties of the acid in question. The *Tartaric acid* exists in the juice of the grape, and constitutes the principal ingredient of the well known salt, *Cream of tartar*. It is deposited on the bottom of wine casks, where it is found in sufficient abundance to supply the apothecary with a very important medicine. The *Malic acid* exists in the juice of Apples, Barberries, Plumbs, Currants and Strawberries, and it is essentially different from those which communicate a sour taste to the Sorrel and Lemon. Jellies contain the peculiar acids of the fruit from which they are procured, united with sugar, and in some cases with mucilage or starch, and the agreeable healthy qualities of most fruits depend on the vegetable acid which they contain.

TANNIN.—If nutgalls or grape seeds are pulverized and dissolved in cold water, the solution when evaporated, presents the tannin principle in a very pure state. It is yellowish, very astringent, brittle, and abundantly soluble either in alcohol or water. Its combinations with iron are black, and by its union with gelatine, it forms an insoluble compound. On account of its astringency, it is of very great utility in medicine, and the virtues of the Peruvian bark, *Cinchona Officinalis*, so celebrated as a febrifuge and tonic, are supposed to reside chiefly in this principle. Its combinations with iron form the basis of writing ink, and by its union with gelatine, leather is formed, and hence we perceive the utility of those barks which the tanner employs; they being in all cases strongly impregnated with the tannin principle. In this country the bark of the Hemlock, *Pinus Canadensis*, is preferred to every other, but various species of Willow and Oak are scarcely less valuable, in the manufacture of leather.

EXTRACT.—That portion of the vegetable which is soluble in water, but becomes insoluble when exposed to the atmosphere, is denominated extract. It is a very common product of vegetable analysis, and it appears that its properties are not well defined, for the extracts which are obtained from different plants, do not appear to be precisely the same. Some of them are employed in medicine, others in the arts. They supply us with most of the colours used in dyeing, and having a powerful affinity to the fibres of linen and cotton, they communicate an almost indelible tinge to the various textures with which they unite. The most frequent of these colours are blue, red, yellow and brown.

BLUE.—Indigo presents a beautiful example. It is obtained from the leaves of the Indigo plant, *Indigofera tinctoria*, which is cultivated extensively in India and at the south. When the plant is about six months old, these leaves are gathered and macerated in water, till they begin to ferment; they are then removed, and the colouring material, which is extracted by the water, is soon afterwards deposited. It is green at first, but in consequence of exposure to the atmosphere, it gradually becomes blue. Similar to this is the Woad, *Isatis tinctoria,* with which the ancient Britons stained their bodies, that they might appear more terrible to their enemies in battle. The culture of this plant has been strongly recommended to the American farmer, and as a dyeing material, it is scarcely inferior to the preceding.

RED colours exist in various plants. Madder, which is obtained from the dried roots and stems of *Rubia tinctorum*, is not only beautiful but very penetrating, for it tinges the bones of animals, when mixed with their food. From different species of *Lichen* a similar colour is obtained; and this is the origin of the Litmus, much celebrated as the chemical test of alkalies and acids. From the flowers of the *Carthamus tinctorius*, usually but improperly named Saffron, a red colour is extracted, from which rouge is manufactured, by mixing it with the powder of talc. The celebrated Campeachy, and Brasil woods, whose names allude to the countries from which they are imported, are well known, and important colouring materials.

YELLOW is also obtained from different plants, particularly from the bark of *Quercitron*, and some species of Sumach. The Anatto of commerce, "is obtained from the *Bixa orellana*, a tree that grows in South America, and produçes fruit twice in a year. The seeds are bruised and kneaded with a little oil into a paste, known by the name of *rocou*, from the decoction of which in water, it is precipitated by alum with which it forms a yellow lake."

The BROWN colour of vegetables, is equally abundant. It is obtained very frequently from the bark of the Butternut and Walnut trees, from the Sumach and various species of Oak, as well as from the nutgalls which are found on the leaves of the latter.

VEGETABLE OILS.—Fixed oils are usually extracted from the seeds, sometimes from the pulpy fruits of their respective plants. Some of them are used as food, some as medicine, and others in the preparation of the most durable paints which the artist employs.

OLIVE OIL is extracted from the pulpy fruit of the Olive *Olea Europea*, a shrub which grows naturally in the south of Europe, and the Almond which also grows in Italy and Spain, yields an oil equally well known, though perhaps less extensively employed. The secretions of the same vegetable are frequently various, but it is worthy of observation, that the cotyledons of its seeds are always nutritive and mild. The Poppy, so famed for its narcotic properties, will serve to exemplify the truth of this remark, for the oil which is extracted from its seed, is tasteless, inodorous and mild, being used like Olive oil for food, and possessing nothing of the narcotic properties of the plant from which it is obtained.

VOLATILE OILS are also extracted from various plants. They exist in the bark of the Cinnamon, in the leaves of Mint, Partridge-berry and Geranium, and in the flowers of *Clethra*, Jasmine and Rose. From these they may usually be obtained by distillation or expression, but the fragrance of the Jasmine is best preserved by steeping its flowers in fixed oil, till it has acquired their rich perfume.

"The odour of plants," says Dr. Smith, "is unquestionably of a resinous nature, a volatile essential oil, and several phenomena attending it well deserve our attentive consideration. Its general nature is evinced by its ready union with spirits or oil, not with water, yet the moisture of the atmosphere seems, in many instances, powerfully to favour its diffusion. This I apprehend to arise more from the favourable action of such moisture upon the health and vigour of the plant itself, thus occasionally promoting its odorous secretions, than from the fitness of the atmosphere, so circumstanced to convey them. Both causes, however, may operate. A number of flowers which have no scent in the course of the day, smell powerfully in the evening, whether the air be moist or dry, or whether they happen to be exposed to it or not. This is the property of some which Linnæus has elegantly called *flores tristes*, melancholy flowers, belonging to various tribes as discordant as possible, agreeing only in their nocturnal fragrance, which is peculiar, very similar and exquisitely delicious in all of them, and in the pale yellowish, greenish, or brownish tint of their flowers. The sweet smell of new hay, (sometimes termed the gramineous flavour) is found not only in several Grasses, but in Woodruff, Mellilot, and other plants widely different from each other in botanical characters, as well as in colour and every particular except smell.

Their odour has one peculiarity, that it is not at all perceptible while the plants are growing, nor till they begin to dry. It proceeds from their whole herbage, and should seem to escape from the orifices of its containing cells, only when the surrounding vessels, by growing less turgid, withdraw their pressure from such orifices. When this scent of new hay is vehement, it becomes the flavour of bitter almonds."

Both the fixed and volatile oils become concrete in consequence of the absorption of oxygen, constituting Wax in the former case and Resin in the latter. *Wax* is found under various modifications, communicating a glossy surface to many leaves, and existing in the form of a yellow powder on the anthers of almost every flower. From the latter, bees extract it, and though at first yellowish and somewhat aromatic, it soon becomes white and inodorous, if exposed in thin layers to the influence of the atmosphere and light. Wax assumes various degrees of solidity, and different terms have been employed to express the peculiar hardness. Thus when obtained from the Chocolate Plant, *Theobroma Cacaco*, it is yellow and soft, forming the butter of Cacao, and this is the substance from which the peculiar flavour of Chocolate is derived. But when obtained from the Bayberry, *Myrica cerifera*, it assumes a more concrete form, and constitutes the well known bayberry tallow, which, in this section of the country, is frequently employed as a substitute for bees wax. Wax is extremely inflammable, and exposed to a moderate degree of heat, it is dissipated in the form of vapour. In consequence of its disengagement in this invisible shape, it sometimes forms a combustible atmosphere around the plant that yields it, and if in a dry season, a candle is brought near to the *Fraxinella*, its atmosphere is immediately inflamed, and the wax, which is particularly abundant in that plant, furnishes a satisfactory explanation of the phenomenon.

RESIN. From the various species of Pine, there exudes a balsam, which concretes in the form of tears. It differs somewhat according to the peculiar tree from which it is obtained, and by distillation it is separated into two distinct ingredients: Oil of turpentine, which is volatile, and Resin, which is not. If a quantity of pine wood is collected, covered with turf, and then set on fire, the resinous juice which would have been dissipated in the open air, may be collected in a suitable receptacle beneath. In this way, tar and pitch, two well known articles of commerce, and both of a resinous nature, are usually procured.

Some of the most common examples of resin, are Copal from a species of Sumach, Mastick from the *Pistacea*, a tree which grows in the island of Chios, and Sandarach from the common Juniper. From the *Amyris Gileadensis*, a shrub which grows in Palestine and Arabia, is obtained a resin long celebrated for its medical virtues. It is the Balm of Gilead, so frequently alluded to in sacred history, and it is still highly prized by the Turks, who prohibit its exportation.

On the epidermis of many vegetables, we find a soft blueish powder which may easily be removed. It is denominated the *Bloom*, and occurs on Plumbs, Cabbage leaves, and several other plants, always resisting the action of water, but like the other resins readily soluble in alcohol.

No kind of wood is so durable as that in which the resinous secretion abounds. It is rarely injured by those insects which devour the hardest timber, and the insolubility of resin most effectually secures it from the destroying agency of water. As a proof of this fact, it has been observed that the Cypress gates of Constantinople, erected by the Emperor Constantine, were found undecayed a thousand years after they were built. It is owing to this secretion that Pine is more durable than the hardest Oak, though at the same time it contains much less of the woody fibre, on which the value of timber usually depends.

The BITTER PRINCIPLE is afforded by many of our native plants. Two species of Gentian, whose flowers are the brightest ornaments of our meadows, and the bark of several of our forest trees, possess bitter qualities, and have been successfully employed as medicines. The beautiful *Coptis*, whose yellow roots have acquired the name of Gold-thread, has been long in use as a domestic remedy, and it owes its efficacy and colour to this secretion.

The NARCOTIC PRINCIPLE.—There is a class of plants, which the Botanist recognizes by their lurid aspect, and the physician, by their narcotic and poisonous qualities. Opium, which is extracted from the Poppy is most frequently employed; but Henbane, Nightshade, Belladona and Stramonium, all produce their "drowsy syrups," equally powerful, and equally to be avoided on account of their noxious qualities.

But these poisons shrink into insignificance, when compared with the reputed properties of the Upas tree of Java. In the midst of a desert, several leagues from the habitation of man, it was approached by none but the condemned criminal, whose punishment was remitted, if he returned with a branch of the fatal tree.—Nothing could sustain its noxious exhalations, not even a kindred plant, so that for twelve miles around, the earth was a barren waste, and occasionally, as if to render the prospect more cheerless, the bones of other victims served to remind the unfortunate visitor of his approaching fate. Such were its reputed properties; but since Java has been frequently visited by Europeans, the Upas tree has been approached with impunity, and examined with care, and it appears to abound in a poisonous secretion, but no longer capable of diffusing pestilence over an extensive territory.

CAMPHOR, is obtained by distilling the wood and bark of *Laurus camphora*, and according to Sir Humphry Davy, it exists in Sassafras, Marjoram and Sage. Its properties and appearance are well known.

The ELASTIC GUM, more frequently termed India rubber, is obtained from the *Urceola*, *Jatropha*, and other trees of warm climates. When their bark is wounded, it exudes in the form of a milky juice, which becomes black in consequence of being dried in the smoke. The fluid which exudes so abundantly from different species of Silk weed *Asclepias*, is said to be a variety of elastic gum.

When wood is exposed to the action of an open fire, it burns with a yellow flame, and disappears in the form of vapour and smoke, or remains in the form of ashes, but exposed to an intense close heat, it is converted into *charcoal*. From the latter product, wood derives its strength as timber, and its value as fuel; the soil its fertility, and the growing plant its food;—but it cannot with propriety be classed with the vegetable secretions. The same remark is applicable to the alkalies and earths which are found in the ashes of plants, and in the soil by which they are nourished, constituting an essential ingredient of both; and formed with the "primæval mountains of the globe," but not as has been fondly imagined, a product of vegetation.

We have now examined the most important of the vegetable secretions, and the examination is one of the deepest interest. It has presented to our view the root, absorbing from the earth, a tasteless, limpid, and inodorous fluid, possessing the properties of mere water; it has enabled us to trace this fluid through an appropriate system of vessels, till it reaches the leaf, to observe the new properties which it there acquires, and the various substances into which it is converted, at once yielding the flinty earth of the epidermis for its own protection, and the grateful perfume of its flowers for our delight; to see it forming resin, a security from moisture and decay, and gum, which is soluble and easily converted into the food of plants and animals; forming at one time, medicines to relieve, at another, the poison to destroy; to see it yielding the sweetest as well as the most bitter draught, and contributing to the formation of organs, which delight us with every variety of colour, and beauty, and fragrance.

CHAPTER VI.

DURATION, SURFACE, &c.

In the preceding chapters, we have seen the embryo of the seed unfolded, and by the combined influence of air, water, and heat, assuming the form of a perfect plant. We have learnt by what agents its growth is promoted, by what substances it is nourished, through what vessels its aliment passes, and into what productions this aliment is converted. It is impossible to pursue this inquiry without interest, for it reveals the nature and extent of those operations which are constantly going on in the tender vegetable frame, converting the dust of the earth into wholesome nutriment, and supplying us with the ordinary comforts of life.

But the paths of Systematic Botany, are equally delightful, for they lead us to an acquaintance with those plants, which frequently fall under our observation, and teach us how to discriminate and how to arrange them. The delineation of an entire vegetable, presents to our view, the root, the stem, and its branches, the leaves and their various appendages, organs which assume almost every shape, and enable us by attending to their varieties, to discriminate between kindred plants. It also exhibits the flower and fruit, with their respective appendages, organs by which the perpetuity of the vegetable kingdom is ensured, and on which the Botanist establishes characters, of the most unquestionable nature.

It is our design, to present an isolated view of these various organs, accompanied with a few observations respecting the utility of each, in the economy of vegetation. The terms with which this portion of our subject is beset, present a formidable aspect to the eye of the student, especially if he has been taught to consider the language of Botany, as a burden of pedantic learning, which may without inconvenience be spared.

In order to avoid an unnecessary repetition, those terms which are equally applicable to different organs, and sometimes employed to express the general character of the plant we examine, will be here defined and illustrated, by a reference to well known examples. They relate chiefly to duration, surface and numbers, but embrace others of a miscellaneous nature, which do not fall within the limits of the succeeding chapters.

DURATION.—With respect to duration, plants are *annual*, ⊙* when they live only one year; *biennial*, ♂* when they live only two years, producing flowers and fruit but once; and *perennial*, ♃* when they produce flowers and fruit several years in succession. The Sun flower is an example of the first variety, the Foxglove of the second, and trees and shrubs are all included under the last division. These distinctions are not always absolute; for a biennial plant may be made to live several years, by removing the flower-buds before they expand, and a perennial plant of warm climates, frequently becomes annual, when transported to less temperate regions. If the stem of a perennial plant annually dies to the ground, it is said to be herbaceous, and ranks with annuals, from which it is some-

* These signs are frequently employed, instead of the terms to which they are annexed, in order to express the particular duration of any plant.

times with difficulty distinguished. If its stem is small, woody, and subdivided into numerous branches, from the summit nearly to the ground, it is said to be *fruticose* or *shrubby*, and the Lilac is a very common example. When the branches annually perish, leaving the main stalk alive, and when the whole shrub is extremely slender, as in *Pyrola*, and Partridge berry, it is said to be *suffruticose*. If a plant extends itself laterally, and covers the earth so as to form a turf, it is *cæspitose* or turfy, and the Moss-pink *Phlox subulata*, is an example.

If its cellular texture is abundant, and filled with juices, as in the Ice plant it is said to be *succulent*. If it thrives only in water it is said to be *aquatic*, and the Pond Lilly is an example; if on the margin of the sea, it is *maratime*, and the Marsh Rosemary is an example; if in sea water, it is *marine*, and the numerous Sea weeds are examples. Those plants are said to be *native*, which have flourished in any particular district, without the aid, and beyond the recollection of man, and those are *exotic* which were brought from a foreign country, and cannot be preserved except by cultivation. When a foreign plant thrives, and extends itself without culture, it is said to be *naturalized*. The Dandelion, which is a native of Europe, has become extensively naturalized on this continent, and no plant is more common or better known.

SURFACE.—When the surface of a plant is smooth, without visible hairs or bristles, it is said to be *glabrous*, and the leaves of Snake head, *Chelone glabra*, and also of the Elder, are good examples. The term *even* also denotes smoothness, and is opposed to roughness and irregularity of surface.

When the surface is so smooth as to glitter or shine, it is said to be *polished*: the leaves of the Holly and the stalk of the Maiden hair furnish examples.

When the surface is covered with a resinous or adhesive substance, such as occurs on the stem of some species of Catchfly, *Silene*, and on the flowers of the White Honeysuckle, *Azalea viscosa;* it is said to be *viscid*.

When covered with soft tubercles like the Ice plant, it is *papillose*, and *verrucose* or warty when these tubercles are large.

When covered with a resinous secretion, sometimes denominated *bloom*, it is said to be *glaucous*, and the stem of the Raspberry, and the fruit of the Plumb tree furnish examples.

Some plants are *hoary*, either from the presence of close silky hairs, or of a scaly powder analagous to bloom, communicating in either case a whitish appearance. Wormwood and Hoary Basil, *Pycnanthemum incanum* are examples. Where the surface is beset with numerous fine glossy hairs, it is said to be *Silky*, and *Villous* when these hairs are white, long and soft. It is termed *Tomentose*, or downy, when covered with soft hairs so interwoven as to be scarcely discernible, as in Velvet Leaf, *Sida Abutilon*. When these hairs are of a rust colour, the plant is sometimes termed *ferruginous*.

It is *pilose*, or hairy, when beset with long, single hairs, as, in Norway Cinquefoil, *Potentilla Norwegia*. It is *woolly*, as in the Mullein, *hispid* as in Borage, *hirsute* as in Ground Laurel, *Epigea repens*, and *Scabrous* or rough to the touch from inequality of surface, as in the leaves of the Black Mulberry and Elm.

It is *striated*, when marked with fine parallel lines, as in the straws of many grasses, and it is *furrowed*, when these lines or depressions are deeper as in the stem of wild Parsnip, and other umbelliferous plants.

It is often desirable so express the number of particular organs, and no terms occur more frequently than those which are employed for this purpose. Like other technical names, they are sometimes derived from the Greek, and sometimes from the Latin language ; Thus

A plant with		A flower cup with	
One leaf is	uni-foliate	One leaf is	mono-phyllous
Two leaves	bi-foliate	Two	di-phyllous
Three leaves	tri-foliate	Three	tri-phyllous
Four leaves	quadri-foliate	Four	tetra-phyllous
Many leaves	multi-foliate	Many	poly-phyllous

These terms conjoined with others to be hereafter explained, occur in the technical description of almost every plant, and the student who has once learned them, will have removed a very formidable impediment to his future researches.

CHAPTER VII.

THE ROOT.

"The root, is that part of a plant by which it attaches itself to the soil in which it grows, or to the substance on which it feeds, and is the principal organ of nutrition." This definition does not apply to those plants which float in the water without any attachment, but it embraces every kind of root, which the student, whose observations are not extended to aquatic vegetables, will probably find.

It applies to the *branching root*, by which trees, shrubs, and many perennial plants are nourished and supported. Like the stem, it is subdivided into numerous branches, some of which penetrate deep into the earth, and others creep extensively beneath its surface. But in whatever way it is subdivided, its branches always terminate in minute filaments or *radicles*, which alone abstract nutriment from the earth.

It applies to the *fibrous* root, *Fig.* 9, which consists merely of slender fibres, that convey nourishment to the basis of the stem, as in most grasses and annual plants.

It applies to the *creeping* root, *Fig.* 15, which extends horizontally beneath the earth's surface, occasionally sending up stems at a distance from the parent plant, as in Mint.

It applies also to other varieties. One of these is the *tuberous* root, which consists of one or more fleshy knobs, like the Artichoke and Potatoe. When two or more of these knobs are connected at their base, they constitute the *palmate* root, *Fig.* 13, and the *fasciculated*, when several are bundled together. Various species of *Orchis* present examples of the two last varieties.

When the root descends perpendicularly, gradually tapering downwards, as in the Radish, Carrot, and Parsnip, it is termed *fusiform* or spindle-shaped.

When it terminates abruptly, as if its lower extremity were bitten off, it is termed *abrupt* or *præmorse*, and when several small knobs or grains, are strung together along the sides of radical fibres, as in the English Saxifrage, and Wood Sorrel, *Fig.* 10, they constitute the *granulated* root.

BULBS, are subterranean organs, somewhat analagous to buds, having numerous radical fibres attached to their inferior surface, and constituting the *bulbous* root. Bulbs themselves do not exactly fall within the limits of the definition which stands at the head of this chapter. But as they are usually regarded and described as roots, it will not be improper to mention the three varieties which most frequently occur. The first is scaly, as in the Lily, *Fig.* 11, the second is tunicate or coated, as in the Onion, *Fig.* 12, the third is solid, as in *Crocus*, or English Saffron.

Of these several varieties, the fibrous root is most simple, consisting merely of fibres, which diverge in every direction in search of nourishment, and to secure a firm attachment to the soil. Most annual plants are furnished with a fibrous root of this description, and by a wise provision of Nature, the more they are stripped of their leaves, the more vigorous will be the growth of their roots. In this respect they are peculiar, for all other vegetables, when robbed of their foliage, not only suffer, but frequently perish in consequence of their privation. Were it otherwise, the grazing cattle would destroy the verdure of the pastures, which they now contribute to beautify and adorn, by rendering the turf more compact and close. Fibrous roots sometimes creep extensively under the surface of the earth, whereby their opportunities of receiving sustenance, as well as their tenacity of life, are much increased. Sometimes they are remarkably *downy*, which also secures the double object, of a firm attachment to the ground, and a rapid absorption of its fluids. It will be recollected that these downy fibres, are but extensions of those vessels, through which the sap is conveyed from the root to the leaf; and observation has taught us, that they are appropriated to those grasses, which inhabit barren plains, where other plants would be unable to exist. The sandy shores of Holland, once as much disturbed by the winds as the waves they enclose, have, through the agency of these roots, been converted into a fertile soil, which furnishes the inhabitants of the low lands with the fruits of the earth, and forms an effectual barrier against the waters of the ocean.

The fibres of some parasitical plants, "are peculiarly thick and fleshy, not only for the purpose of imbibing more nourishment, but also to bind them so strongly to the branches of trees, as to defy the force of winds upon their large and rigid leaves."*

The roots by which trees and shrubs are supported, appear to be merely elongations of their stems, subdivided into numerous branches, and terminating in minute radicles or absorbents. These extremities re-

* Smith.

semble the fibrous roots of grasses, and are subservient to precisely the same ends, for the main body as well as its large branches, serve only to convey towards the leaf, the nourishment, which its minute extremities have derived from the earth. Like the stem to which it is attached, the former is composed of concentric circles corresponding to the age of the tree, and contains the same vessels which pervade the other parts of the vegetable texture ; but the extreme radicles are always of annual growth, and the delicacy of their texture, renders it difficult to transplant vegetables after they are formed. The proper period therefore to remove trees and shrubs, is late in autumn, after the radicles have ceased to absorb moisture from the earth, or in the spring, before a new system of absorbents is formed. It may be done with safety in mid-winter, when the whole energies of the vegetable are torpid, but during the season of vegetation, which requires the constant abstraction of nutriment from the earth, it is a work of more difficulty and danger. The analogy between the ascending stem and the branching root, is more close, and better established, than at first view, we should be prepared to expect; and their only difference is derived from the different organs with which they are connected. This is established by an experiment which has frequently been performed, and may without difficulty be repeated. A shrub was bent to the horizon in such a manner that half of its branches were covered with earth, and a similar proportion of its roots were exposed to the action of air and light, without any protection but that of a thin coat of Moss, which was removed in a few days. In this position the shrub remained for a considerable while, after which, the remainder of the stem was buried beneath, and the whole root raised above the surface of the ground. Thus reversed, it continued to grow, the former roots being crowned with leaves, and in a few years decorated with flowers, while the former branches put forth radical fibres, whereby the shrub derived its nourishment from the earth.

It is obvious that when a plant is thus reversed, the course of its fluids must be changed, for the sap still continues to ascend through the wood, and the cambium to descend through the vessels of the bark ; though according to the observations of Mr. Knight, the new wood is deposited *above* the leaf-buds, and not as in ordinary vegetation *below* them. In this case it is probable that the plant retains a portion of its original disposition, which however, gradually wears away with age, and at last the fluids circulate, and the plant grows exactly as in its natural position.

If any one will take the pains to examine the roots of many of our native Violets, he will find that they terminate abruptly, appearing as if they had been bitten or broken off ; and he will then have a correct idea of the abrupt root, which is by no means peculiar to the Violets. An English plant, furnished with a similar root, is termed *Devil's-bit* ; and from an old writer whose name is recalled by some of the most beautiful of our late flowers,* we learn why it bears so singular an appellation. He says upon the authority of " old fantasticke charmers, that the divel did bite it for envie, because it is an herbe that hath so many good vertues and is so beneficial to mankinde." Unfortunately for the patients of the present day, the en-

* *Gerardia*, dedicated to the memory of Gerard, whose *Herbal* is a monument of his industry and zeal.

vious spirit of the devil has been so much gratified as to leave in the remainder of the herb, no healing virtue for them.

Bulbs are by some writers classed with roots, while others regard them as an interesting variety of subterranean bud. Certain it is, that they enclose the embryo of future plants, till the period of their evolution arrives, and in this respect they perform the office of buds. Many of them are also composed of concentric scales, nearly allied to those which secure the tender leaves and flowers of northern trees, from the cold of the winter to which they are exposed. But it is equally true that they bear a close analogy to the tuberous root, and whatever opinions we adopt respecting their nature and rank, whether we class them with roots or with buds, the plants to which they are attached will always be regarded with peculiar interest. They are amongst the earliest harbingers of spring, and certainly the most splendid ornaments of the garden. Among them are the Lily, Snowdrop, Tulip, Hyacinth, with about forty more interesting plants, equally deserving the fostering care of the cultivator. While examining the internal arrangement of these roots even at mid-winter, we cannot fail to observe with what care the plants of another season, already conspicuous and perfect, are preserved from injury. From their inferior surface, radicles descend into the earth, which like the fibrous extremities of other roots, are designed for the immediate absorption of nourishment. The bulbs are evidently designed to preserve the living powers of the plant, and to supply it with sustenance when its other resources are exhausted. Their structure would lead to this opinion, and their habits would confirm it. Thus the root of the common Herds-grass, *Phleum pratense*, when growing in pastures that are uniformly moist, is merely fibrous, but in dry situations, or such as are occasionally wet, it becomes bulbous, and thus secures a store of nutriment by which its vital powers are supported, while the fibrous roots are deprived of their usual supplies. If once more transferred to a soil uniformly and thoroughly moist, it again becomes fibrous and resumes its former luxuriant growth. In this case it has been supposed that "the herb being in the first instance starved, by a failure of the nutrimental fluids hitherto conveyed by the water of the soil, its growth would be checked, and when checked, the same growth could not, as we know by observation on vegetation in general, be instantaneously renewed. A sudden fresh supply of food would therefore cause an accumulation of vital energy in the root, which would consequently assume a degree of vigour and a luxuriant mode of growth not natural to it, and become bulbous. Thus it acquires a resource against such checks in future, and the herb is preserved alive, though in a very far less luxuriant state than when regularly and uniformy furnished with its requisite nourishment."* And accordingly we see that those plants which in their native situation find only a precarious supply of water, are supplied with bulbous roots for their preservation. Like the thick-leaved plants, many of them were brought from Africa, and their texture is happily designed to encounter the privations of those countries which they are intended to adorn.

Nearly allied to bulbs are the tuberous roots which consist of a single knob, or of several, connected by intervening radicles. These knobs preserve the vital energy as well as the nutritive fluids which they re-

* Smith

ceive from the leaves of their respective plants, till the former is aroused into action, and the latter are demanded for use. Like that of the alburnum their growth depends on the renovated sap, which has passed and repassed through the vessels of the stem. We see therefore the intimate connexion betwixt the leaf and the root, and perceive why the luxuriance of the one should indicate the comparative size and fruitfulness of the other.

Bulbous and tuberous plants are usually propagated by separating their roots, and this is the easiest, but not in all cases the most eligible mode of cultivation. When it is pursued, the roots are to be transplanted either in autumn or spring, for at these seasons having no radical fibres to connect them with the earth, their removal does not impede the process of vegetation. There is an exception to this rule, which it would not be deemed necessary to mention, if it did not relate to some of the most interesting of our native plants.—The *Orchis*, and others of the same natural order, have been named as furnishing examples of the palmate or bituberous root. These roots are usually biennial, the oldest portion, bearing the herb and flower of the present season, while its young companion is preparing to succeed it, and to produce the leaves and flowers of another year. When the plant is in full bloom, it may be removed with entire safety, for at this time the radical fibres of the youngest bulb are not formed, and consequently it has no necessary connection with the earth. After this however, as the flower fades, the oldest portion of the root decays and then new fibres are formed, (and the other bulb) which are to supply the plant with nourishment until it blooms again, and these fibres are in all cases an insuperable barrier to removal. Still more difficult is it to transplant others of this family which have three pairs of these bulbs that flower in succession, and it is probable that such plants have never been removed except in connexion with their native earth.*

"If a pair of these knobs is separated, and then immersed in water, the one will be found to sink and the other to swim. This is a phenomenon that seems to have puzzled the simplists of antiquity not a little ; and to have given rise to many idle and superstitious conjectures. It was thought that the knob that swims must necessarily have possessed some peculiar and potent properties, and accordingly some potent properties were very liberally ascribed to it. If prepared in a particular manner and worn about any one's person, it was believed to have the singular property of exciting, by means of proper management, a violent attachment to the wearer in the breast of any one he pleased. And this belief is still a vulgar error among the ignorant and superstitious ; though the sinking of the one knob, and the swimming of the other, have been accounted for from the regular operation of natural causes, and the mystery and magic charm of the phenomenon altogether dissolved.

From the swimming knob which was generated in the course of the preceding year, the plant of the present year, together with the sinking knob, has sprung ; but by this means the substance of the first has become exhausted, and specifically lighter than water, and on this account it swims. The other which is still firm

* Dr. Smith observes, that they have "not been found to survive transplantation," but it has been stated in reply, that inclosed in a ball of their original earth, they may be removed with safety, and that the experience of Scotch gardeners has demonstrated the truth of the latter assertion.

and solid, is of course specifically heavier than the water, and on this account it sinks ; but in the succeeding year it also will produce a new plant and knob, and being itself exhausted it will swim, and fade and decay in its turn."*

With respect to direction, roots exhibit some variations worthy of our attention. The spindle shaped are generally perpendicular, gradually tapering as they proceed downwards, but the fibrous and branching roots are more frequently horizontal, sometimes near the surface, and sometimes deep in the earth, accommodating themselves to the climate and soil in which they grow. An experiment has often been made of planting seed in sand over a bed of rich earth, and it is found that the root descends several inches below its usual situation, apparently in search of the more congenial soil beneath it. Wildenow placed a Strawberry plant in some sand close to the rich soil of a garden, and it exhibited some evidence of the same selective property, by growing towards the good soil in which it continued to flourish long after the main plant had decayed. A more singular case has recently occurred in Scotland. A seed of the Plane tree was accidentally deposited on the ruinous wall of a monastery in Galloway, where it germinated, and the young tree grew for a while with considerable luxuriance, though the wall on which it stood was ten feet from the ground. Its small store of nourishment was soon exhausted, and the young tree ceased to grow, but as if it had perceived the rich supply of food at the bottom of the wall, it sent down some strong fibres which soon reached the earth. When these roots had become attached to the surrounding soil so as to supply the young tree with nourishment, it

* Keith.

again began to grow, and continued to flourish till it was blown over by the wind. Those who observed the singular situation of this tree, and marked its very unusual progress, have attempted to explain by what law of nature, or by what perceptive power inherent in the plant itself, the descent of its roots, so necessary in this situation, was produced.

Some have inferred that the young tree perceived the store of food at the bottom of the wall, and like Israel of old, sent its messengers to a distance, to avoid the famine by which it was threatened. Others have referred it to that general law of nature, by which all roots descend towards the centre of the earth, until they meet with resistance; and those who have observed the descent of the radical fibres of Hyacinths, when growing in pure water, will be inclined to adopt the latter opinion. But still they will admire that wonderful provision, by which a Plane tree, on a high wall in Galloway, would provide for its own security, as successfully, as if it had been blessed with an ordinary share of human intelligence. And with respect to the experiment of Wildenow, it has been justly observed, that the Strawberry plant advanced towards the rich soil in its neighbourhood, because in that direction, it met with a better supply of nourishment, for the radical fibres thus situated, grew luxuriantly, while those which remained in the sand, soon perished from the want of sustenance.

It seems almost unnecessary to observe, that roots are situated beneath the surface of the ground, but to this rule *Parasitic plants* furnish us with an exception. They either derive their nourishment from the air, or in the true spirit of prodigality, subsist on the resources of their neighbours, to which, in various ways they closely adhere. The *Lichens* which cover the epidermis of many trees, the Blight which destroys the fruit, and the Beech drops which are attached to the roots of the tree whose name they bear, are all examples of parasitic plants.

The seed of Dodder or Love-vine, easily recognized by the golden hue of its threadlike and leafless stems, first germinates in the earth, and as its plumelet rises, it seizes upon the first plant in its vicinity, sends forth fibres which penetrate the bark of its supporter, after which the root and lower part of the stem die, leaving the vine to derive its sustenance entirely from the plant to which it adheres. Others of this class are never found on the earth, but their seeds are deposited on living trees, where they germinate and grow. The Spanish Beard is found loosely attached to the forest trees of the South, to which it has been observed by travellers to communicate a melancholy aspect. This plant was named *Tillandsia* by Linnæus, "for it brought to his mind the fate of the student, who in going by sea from Stockholm to Abo, experienced so severely the terrors of the deep, that he chose to walk back, rather than again trust himself to so cruel a deity as Neptune." This was Tillands, afterwards professor of Botany at Abo, and Linnæus named in honor of its prototype, this plant of tropical America, which cannot endure water.*

The sacred Misletoe, once venerated for its all-healing virtues, is another example. It never grows on the earth, and probably the observance of this fact, inspired the superstitious Druid with a belief, that it was

* Lapland Tour.

the immediate gift of Heaven, sent down to avert the calamities to which he was exposed.

The observations of Duhamel, respecting the germination of this singular parasite, have been formerly noticed. Equally interesting are the experimerts of Decandolle, instituted in order to ascertain the nature of its connexion with the trees on which it is found, and the degree of energy with which it absorbs their fluids. According to that learned naturalist, if a branch of the Apple tree to which the Misletoe is united, be introduced into coloured water, the latter becomes tinged even brighter than the portion of tree to which it adheres. By a reversion of this experiment, he found that the coloured fluid descended through the stem of the parasite, tinged its radical fibres, and penetrated to the wood of its supporter. His next object was to ascertain if the leaves of the Misletoe, like those of other plants, had the faculty of elevating the sap through its stems, and he found that they increased this faculty in a six fold degree.*

The last object of Decandolle, was to determine whether fluids were absorbed with the greatest rapidity, when they passed through a portion of the supporting tree, or immediately into the stem of the shrub, and it appeared that in the latter case, unless the branch is uncommonly vigorous, no fluids are absorbed.

Fruit trees are frequently invested with a minute tribe of parasitic plants, which are regarded as a sign of old age and decay. The experiments of Decandolle teach in what way they may prove destructive, and

* The experiments were these; two stems of nearly equal size, one naked and the other leafy, were introduced into tubes filled with water, closed, and sealed at their superior extremity, and having their bases plunged into mercury. The elevation of the mercury denoted the ratio of their absorption.

point to the most effectual mode of preservation. Let the trees "mossed with age" be divested of those vegetables which rob them of their nourishment, and hasten their destruction, and they will recover their former health and again become vigorous and productive.

But there is a class of parasitic vegetables, whose roots do not abstract nourishment from their supporters. One of the most extraordinary of these is the *Epidendrum*, or Flower of the Air, which grows abundantly on the banks of the Ganges. It is said to vegeate for years, hung upon the ceiling of the Indian's cottage, with no other nourishment than what it derives from the air of the room, to which its blossoms communicate a most delightful fragrance.

All these varieties of roots are formed to secure the same end, to fix the plant securely in the earth, to supply it with food, and to preserve its vital though dormant energies, at a season when they could not be safely aroused into action; and at the same time, to secure its resources against the vicissitudes of moisture and dryness, to which the vegetables of many countries are perpetually exposed. And a small share of attention to the structure and form of each variety, will enable us to pursue the best mode of cultivation, and to designate the quality of the soil to which they are respectively suited. Of those which descend deep into the earth, there are several varieties, and all require to have the ground deeply furrowed, before they can be cultivated with advantage. Barren and thin soils are best suited to the wide spreading roots, which creep extensively on their surface; dry and sandy plains are adapted to those which penetrate deep for nourishment; and are supplied with bulbs for its preservation, or with downy radicles for its abundant absorption. No one can advantageously introduce a new plant, till by the examination of its various organs, he has learned to what situation it is best adapted, nor can he be a successful florist, who is not at the same time an observing botanist.

CHAPTER VIII.

TRUNKS.

A knowledge of the various kinds of stalks by which the herbage is elevated above the surface of the earth is often of great practical utility, for these varieties are the basis of botanical distinctions, always convenient and sometimes indespensable.

1. STEM.—This term is strictly confined to that universal trunk, which sustains leaves, flowers and fruit ; being herbaceous in most annual stems, and woody in trees and shrubs. In the White Lily, it is *simple* and undivided, but in most vegetables, it is branched, and the arrangement which its branches assume, gives to every plant its peculiar habit and form.

With respect to *Direction* and mode of growth, the stem is erect as in Sun-flower ; *procumbent* or trailing on the ground, as in Moss Pink, *Phlox subulata* and Carpet weed ; *repent* or creeping when it trails on the earth, emitting radical fibres from its inferior surface, as in Trailing Arbutus and Creeping Crowfoot, *Ranunculus repens ; reclined* when the superior extremity of an erect stem is bent down so as to form an arch with the horizon, as in Raspberry ; *ascending* when the extremity of a procumbent stem is erect. When a creeping stem sends out roots only from its joints, as in Strawberry, it is termed *sarmentose*. Weak stems frequently attach themselves to other bodies for support. The Vine and the Passion flower, *Fig* 20, climb by their spiral tendrils, and the common creeper by its radiating fibres. The last is properly a *radicant* or rooting stem, *Fig.* 18. It sends out numerous fibres which penetrate, but derive no nourishment from the plant to which it adheres. The Poison Ivy, *Rhus radicans*, is a good example of this variety. The *Voluble* stem twines around other plants for support, and if it follows the apparent motion of the Sun, as in the Honeysuckles, *Fig.* 19, it is said to twine from left to right, and from right to left, when as in Bindweed *Convolvulus Sepium*, it pursues the opposite direction. Some stems are *straight* as in the Lily ; some *diffuse*, having irregular spreading branches ; and some are *flexucse* or zigzag, forming obtuse angles at every joint, as in various species of *Smilax* or Green-Briar. When a stem is regularly and repeatedly divided into pairs, *Fig.* 16, as in common Chickweed, and Stramonium, it is said to be *dichotomous* or forked.

With respect to *Form*, the stem is usually *terete* or round ; sometimes it is *compressed*, having its two opposite sides flattened ; and sometimes it is *ancipital*, or two edged, forming two opposite and acute angles, as in the Blue-eyed Grass. In other cases it is triangular, square, or pentangular, but these terms require no explanation. When the angles of a stem are extended into a flat leafy border, as in the Sweet Pea and many of the Thistles, it is said to be *winged*, but sometimes a decurrent leaf causes the stem to appear winged when in reality it is not.

The *Branches* of a stem are *alternate*, when between two on one side there arises an opposite and intermediate branch ; and they are *opposite*, when two branches arise at equal distances from the base of a stem. When opposite branches alternately cross each other at right angles, as in the Lilac, they are said to be brachiate or *decussate*. When several branches arise from a common stem at the same distance from its base, as in the Spruce and White Pine, they are termed *verticillate.* When the terminal buds produce flowers only, and the lateral ones leaves and branches, the stem is said to be *abruptly branched.* The American Honeysuckle, *Fig.* 17 is an example, and it is easy to tell how many times it has produced flowers, by ascertaining the number of its abrupt or determinate subdivisions. They are *distichous*, when the branches arise promiscuously from all parts of the stem, and spread only in two directions as in the Hemlock tree and Silver-Fir, and they are *fastigiate*, when the branches arising from different parts of the stem, terminate at equal distances from the ground.

In some plants the branches are few and *scattered*, in others they are *crowded*, so as almost to conceal the stem.

When the extremities of the branches are inclined towards the main stem they are *compact;* when extending in a horizontal direction, they are *diverging;* and when they form an obtuse angle with the superior portion of the stem, they are *divaricate.* Some branches are *erect*, as in the Lombardy Poplar; others are *pendant*, as in the Weeping Willow and Elm, and their stems are said to be *reflected.*

When a stem is occasionally intercepted by knots, as in the Garden Pink, it is said to be *jointed;* but if these joints are much contracted, as in some species of *Cactus*, *Fig.* 25, the stem is *articulated;* when the firm texture of the exterior portion extends to the centre, it is *solid;* when filled with pith, it is termed *pithy;* and when it forms a complete cavity, it is *fistulous*, or hollow. Plants whose leaves and flowers spring immediately from the ground, *Fig.* 22, are termed *stemless*, and the

Dandelion and many of the Violets, furnish us with examples. The latter being allied to other species, that are furnished with stems are said from occasional luxuriance, to assume the character of their allies, but the former remains stemless in every situation.

Stems are usually garnished with leaves, and termed *leafy* ; and occasionally beset with scales, and termed *scaly*, *Fig.* 21 ; but in a few instances, having neither leaves nor scales, they are said to be *naked*, as in Dodder and Glasswort. In the latter case the succulent stem supplies the place of leaves ; in the former the living vegetable to which it clings, furnishes the parasite with food, already prepared for its own nourishment.

The student who examines these forms, will not fail to observe the various sizes of stems, some being slender and unresisting, others large and powerful. He will notice without the aid of botany, the magnitude of the Oak, the majestic form of the Elm, and the towering height of the Tulip tree, and as he compares them with those humble herbs that scarcely raise themselves above the surface of the ground, he will see how manifold are the productions, which he is to examine. But in southern latitudes, we find trees more majestic than the Elm, and more lofty than the Tulip tree ; for there, vegetation is more rapid, and new organs are developed without interruption.

The *Adansonia* which grows on the banks of the Senegal in Africa, is said to be thirty feet in diameter, and to require a chain six rods in length to enclose it. —Its branches spread sixty feet in every direction, and when excavated by old age and decay, its hollow trunk becomes the abode of several families.

A still more singular stem is presented by the *Rhi-*

zophora, which grows within the tropics of Asia and America. It sends forth its numberless branches which descend perpendicularly to the ground, where they take root. From these, other branches arise and pursue the same course, as if to extend the dominion of the tree from which they all originate, and at last it covers the country for a mile around, with a forest of numberless branches, having the appearance of a close clipped bower.*

Those who have observed the progress of the vegetable growth, and seen trees of various sizes produced by the annual deposition of a thin layer of wood ; will be prepared to find a correspondence between the magnitude and age of the stems they examine. And unless the growth has been particularly rapid, this may be considered as a correct criterion, for the Oaks and the Elms are among the oldest of our forest trees, and the *Adansonia* is probably not merely the largest, but the oldest vegetable in existence. Indeed, the only limit to the growth of woody stems, is found in their perishable nature, which prevents them from retaining, beyond a limited period, strength sufficient to support their own weight. The centre or heart wood being dead, will in the course of a few centuries at least, begin to decay, but at the same time, new layers of alburnum are deposited as before. The progress of decay is more rapid than that of renovation, and at last, the hollow trunk being unable to support its own branches, is precipitated to the ground by their growing weight, or overturned by the winds, which it has buffeted probably for ages. The durability of the perfect wood, and the strength of the alburnum, must therefore determine the age to which any tree can arrive.

* Wildenow.

We have noticed the articulated stem of the *Cactus*, from the summit of which, new branches arise, readily distinguished by the intervening and contracted joints, and furnishing an example of the *proliferous* stem.—These are mostly tropical plants, though one species occurs frequently in New-England, and others thrive on the banks of the Missouri. Destitute of leaves, they are beset with rigid spines, and form, when properly arranged, an impenetrable hedge; but in spite of their armature, the wild antelope of the plains, finds means to render them subservient to its wants.*

The arrangement presented by the transverse section of a woody stem, the annual layers, the silver grain by which they are intersected, the vessels through which the fluids pass, and the cellular texture which binds them together, rendering the whole solid and compact, have been already noticed. The arrangement presented to our view, by the transverse section of annual stems is somewhat different, their cellular texture being more abundant, and the vessels through which the sap passes being variously arranged, but assuming in each plant a determinate form, peculiar to its tribe. A transverse section of the Date Palm, exhibits "over the whole surface, a great number of black spots, dispersed without any regular order, upon a white ground, larger in the centre and smaller in the circumference, but the largest not being more than the third of a line in diameter. These spots are the divided extremities of bundles of longitudinal fibres, passing from the base to the summit of the stem, in a direction parallel to its axis."† Such is the arrangement presented not merely by the Date Palm, but by an ex-

* Nuttall. † Keith.

tensive tribe of plants, easily recognized by their peculiar features, and furnishing, by their solitary seed lobes, a discriminate character on which the botanist chiefly relies.

No forest trees are more lofty than the Palms, and few attain a greater age ; yet they are regarded as perennial herbaceous plants, and exhibit the same internal structure. Their leaves spring immediately from the ground, and those which are most recent, being interior to the others, must of course rise above them, before they are unfolded. When one system of these leaves has performed its office, another appears above it, and thus its power of lateral extension being limited by the exterior and old bundles of leaf-stalks, all the energies of the plant are directed to the elongation of its stem ; which being unbranched and very lofty, gives a peculiar cast to the scenery of those countries in which the Palm trees abound. In northern latitudes they never occur, but the White Lily, which belongs to the same natural division of plants, may serve to elucidate this subject. "Its stems, though of only annual duration, are formed nearly on the same principle as that of the Palm, and are really congeries of leaves, rising one above another, and united by their bases into an apparent stem."*

2. CULM.—This term is applied to the stems of grasses and grass-like plants. They are usually tubular and jointed, the joints being larger than the intervening straws, and interrupting the continuity of the cavity which they form.

When they form an angle at each of the joints, they are termed *geniculate*, as in the Bent and White top,

* Smith.

Agrostis alba; but when radical fibres are emitted from these joints, and attach themselves to the earth, as in the Fiorin grass, *Agrostis stolonifera*, the culm is said to be *stoloniferous.* Compared with other stems, these are more frequently triangular, jointed, and hollow, and in this climate, they are almost without exception, of annual duration.

The flint which exists in the stems of grasses, and their consequent utility in the arts, has been formerly noticed. The primary design of this deposition, is probably to secure the flower and the seed from destruction, for while animals greedily devour the herbage of grasses, they leave the culm and consequently the seed unmolested.

From the Leghorn straw, hats of a most durable kind are made, and recently, one of the most common of our grasses, has been made subservient to the same useful purposes.

In northern countries, grasses are never large, being always destroyed at the approach of winter, but as we proceed towards the equator, they attain to a greater size and a greater age. There we find the useful Cane and the still more lofty Reed, both surpassed by an Asiatic grass, *Panicum arborescens* whose culm we are told, is sometimes eighty or an hundred feet in length.*

The peculiar stem of the Palm tree was formerly regarded as a distinct variety, and denominated Stipe, but as the term has been restricted to other organs and other plants, there is no reason why it should retain a place in this chapter. The peculiar stalks of leaves and flowers are rather to be regarded as appendages, and as such they will be described.

* Barton's Elements.

CHAPTER IX.

LEAVES.

Leaves are membraneous or succulent organs, usually of a green colour, arising immediately from the root, or attached to the stem and its branches. The point by which a leaf is attached to the plant is termed its *base*, the opposite extremity is the *summit*, the intermediate portion of the leaf is its *expansion*, and the boundary of the expansion is its *margin*. The superior surface is more even, and usually of a deeper green ; and the other exhibits more prominently the fibres of the diverging vessels.

PETIOLE.—The base is frequently prolonged into a footstalk or *Petiole*, by which the leaf is removed to a greater or less distance from the place of its attachment. The leaf stalk of the Vine is nearly cylindrical, but we more frequently find its superior surface compressed or *channelled*, and this circumstance will enable the student to distinguish the foot stalks of compound leaves, from the young branches with which, without regarding this distinction, he would be liable to confound them. The interesting St. Pierre, has with his usual ingenuity, attempted to prove, that the channel of the petiole is designed to convey the water which falls on the leaves, towards the roots of their respective plants. He even says that the form and capacity of this groove, will indicate the quantity of moisture which any individual plant may require, and his hypothesis is supported by many plausible arguments. The motion of the trembling Aspen, when every thing around it is quiet and at rest, has caught the attention of many an observing eye. The leaves of this and other species of Poplar, have their petioles so *compressed*, as to admit of a lateral tremulous motion when exposed to the slightest breath of air.

We discriminate between the Orange and the Lemon by the *winged* leaf stalk of the former, and it is not merely a convenient but a necessary mark of distinction.

The petiole of the Grasses forms an entire *sheath*, (*vagina*,) and the late Dr. Muhlenburg in his Grasses of America, has rarely failed to describe it under the latter denomination.

The leaf-stalks of the common Pea terminate in a tendril, and those of the Traveller's Joy, *Clematis Virginica*, perform the office of tendrils, by twining like them around their supporters.

The continuation of the petiole through the leaf is termed its *midrib*, and its various ramifications, which are most conspicuous on the under surface, constitute the *nerves* and *veins*.

In the examination of leaves we are to learn their different positions and modes of insertion, as well as the varieties of form, texture, and surface.

1. POSITION.

Radical Leaves spring immediately from the root, as in the Dandelion and English Cowslip, *Fig.* 22.

The leaves of the Stem, sometimes differ from those of the Branches, and then it is necessary to distinguish them by terms which denote their respective insertions. The flower is sometimes accompanied by leaves of a different size or shape from the others, and these are termed *Floral* leaves. The stalk of Parnassia, having only a solitary leaf is said to be *Unifoliate*, and the Lily of the Valley having two is *Bifoliate*, but it is rare to see leaves so few, or their number so invariable.

When the petioles are inserted into opposite points of a stem, as in the Lilac, they are said to be *Opposite*, and when they arise successively from the different sides of a stem, as in the Cherry and Pear trees, they are said to be *Alternate*.

Stellate or *Verticillate* leaves, *Fig.* 45, grow in a circle around the stem, as in the common Red Lily, Indian Cucumber, and *Galium*.

When several leaves are inserted together as in the Hackmatack, they are said to be *Fascicled* or *Tufted* ; and *Imbricated* when they overlap and enclose each other, like tiles on a house top, as in White Cedar and Juniper.

When opposite leaves alternately cross each other at right angles as in Bone-set, they are *Decussated*.

Distichal or Two-ranked leaves spread in two directions, as in the Hemlock tree, but if leaves thus disposed arise from two opposite points of a stem, they are said to be *Bifarious*.

Those leaves are *Floating*, which we see on the surface of the water, as in Pond Lilies ; those are *Immersed* which are beneath it, as Water Violet and *Valisneria* ; and those are *Emersed*, which are seen rising above its surface.

Some leaves are *Appressed* towards the stem, some *Depressed* close to the ground, as in the Carpet weed ;

some *Erect ;* some obliquely *Ascending ;* some *Horizontal ;* and some *Relining* downwards ; but these are distinctions which are rarely observed.

2. INSERTION.

A *Petiolate* leaf has a footstalk inserted into its base, as in the Maple, Poplar and Vine, *Figs*. 31, 32 and 48.

When the Petiole is inserted into the inferior surface of a leaf, at a greater or less distance from its margin, it is said to be *Peltate,* as in Nasturtion and Water shield, *Fig*. 27.

A *Sessile* leaf arises immediately from a stem, branch or root, without the intervention of a footstalk, as in the clustered and two leaved Solomon's seal.

Clasping leaves embrace the stem with their base, as in the New England Aster, and Clasping Bell-flower.

When two opposite leaves are united at their base, as in Fever-root and Bone-set, they are said to be *Connate ;* and *Perfoliate* when a stem passes through a solitary leaf, as in most of the Bell-worts. *Fig*. 26.

Sometimes we find examples which appear intermediate between the two preceding, but all necessary precision is obtained in these cases, by using the term Connate-perfoliate. To the leaves of the Bone-set and *Chlora perfoliata*, *Fig*. 16, such a term is strictly applicable.

When leaves form a sheath for each other or for the stem, as in the *Iris*, and some of the Grasses, they are said to be *Sheathing*. In the latter, however, the sheath is usually an expanded petiole, and not according to the common acceptation of the term, a portion of the leaf itself.

When the base of a leaf is extended down the side of a stem, so as to form a leafy border or wing, it is said to be *Decurrent*, and the Mullein, some of the Thistles, and Peas are familiar examples. *Fig.* 23.

3. FIGURE.

With regard to form, leaves are *Simple*, as in the Lilies and Grasses, or they are *Compound*, as in the Parsley and Rose. The petiole of the simple leaf terminates in a single expansion, which is either entire or divided, but in the latter case the incisions never extend to the midrib. The footstalks of compound leaves are more frequently subdivided, and the expansions or leaflets in which they terminate, are distinguished like simple leaves by their peculiar form. Of these forms, the following with annexed examples, are more particularly important.

An *Orbicular* leaf, whose entire margin is in the circumference of a circle is of rare occurrence, and "precise examples are scarcely to be found." When there is but a slight deviation from this form, leaves are said to be *Subrotund*, or roundish, and the Round leaved Winter green is a good example.

The *Ovate* or Egg-shaped leaf, *Fig.* 28, occurs more frequently, having its base broader than its summit as in the Periwincle and Sage.

The *Obovate* is also egg-shaped, but has its summit broader than its base as in the fragrant Clethra.

The *Eliptic* or oval leaf, is intermediate between the two preceding, having its two extremities equally broad, as in the Lily of the Valley and Water shield. *Fig.* 27.

The term *Oblong*, is somewhat indefinitely applied to those leaves which are several times longer than broad.

The *Spatulate* leaf, *Fig.* 29, so named from its resemblance to a well known instrument of the surgeon, has a round and somewhat broad extremity, with a long slender base. The Rose Campion and Marsh Rosemary are well known examples.

A *Cuneate* or Wedge shaped leaf, has a broad extremity tapering to a point at the base as in Carpet Weed and Purslane.

An oblong leaf tapering towards each extremity, as in our field Lilies is termed *Lanceolate. Fig.* 30.

Linear leaves are narrow, having their sides parallel, as in the common Garden Pink and most Grasses. A short acute linear leaf, is termed *Subulate* or Awlshaped, and the Moss Pink is a good example ; very slender linear leaves are also called *setaceous*, *capillary*, or *filiform*, from their resemblance to bristles, hair or thread.

Acrose or Needleshaped leaves are linear, riged, and generally evergreen, as in the Pines.

A *Deltoid* or *Triangular* leaf has three prominent angles, one of which is formed by its acute summit, as in the Lombardy Poplar and White Birch.

A *Rhomboid* or Diamond-shaped leaf has four prominent but somewhat oblique angles, its opposite sides being nearly parallel, as in Purple Trellium and Althea.

Other leaves are *Angular*, as in the Moon-seed and Colts-foot, but in these cases it is seldom necessary to ascertain the exact number of angles, nor are they sufficiently constant to furnish marks of distinction.

The *Cordate*, or Heart shaped leaf, *Fig.* 31 occurs frequently, and its figure is well known. When its two lobes approach each other so as to form an apparent cavity above, it is then termed *Cuculate* or hooded, and one of our common Violets, *Viola cucullata*, whose specific name alludes to this circumstance, will serve as an example. When the petiole is inserted into the pointed extremity of a heart shaped leaf, it is said to be *obcordate*, as in the Wood sorrel, *Fig.* 42, though the equivalent term, inversely heart-shaped, is frequently employed.

A *Reniform* or kidney shaped leaf has a rounded extremity, and usually a circular excavation at its base, as in Canada Snake-root and Gill. *Fig.* 32.

The *Crescent* form, of rare occurrence, and happily illustrated by a reference to the figure of the new moon, may have its stem inserted into the concave or opposite portion.

The Arrow shaped or *Sagittate* leaf, *Fig.* 34, has two lobes projecting from its base, one on each side of the petiole to which they are nearly parallel, as in Arrow-head and Scratch-grass *Polygonum sagittatum.*

The Halbert or *Hastate* leaf, *Fig.* 33, has also two projecting lobes, which are nearly at right angles with the leaf stalk, as in Sorrel, and *Polygonum hastatum.* By Wildenow the *Auricled* leaf is regarded as a peculiar variety of the hastate, having its lobes smaller and round, but Dr. Smith speaks of them as the two lateral leaflets, liable occasionally to be united to the terminal one of a compound leaf. Wildenow's application of the term is most usually adopted.

A leaf is *Unequal*, *Fig.* 35, when the midrib does not divide it into two equal portions. Such are the leaves of the Elm and Lime trees, which last are also describ-ed as *Oblique.*

The leaves of a stem not unfrequently present a different form from those of the branches, and sometimes they are different on the same branch or stem. The

Chinese Mulberry is a very striking example of this diversity, having scarcely two leaves of the same form. Students should be aware of this, or they will not understand why the Leaves of the Sassafras are described as ovate and lobed, while those of the Moon-seed are cordate and angular.

The following varieties of simple leaves are divided by incisures, more or less deep, into several lobes or segments, forming a connecting link between the entire and the compound leaves.

In the *Sinuate* or Scolloped leaf, *Fig.* 36, these incisures are curved, and the segments are either rounded or acute. The Oaks furnish us with numerous examples.

A *Runcinate* leaf *Fig.* 37, is cut into numerous transverse acute segments, which point towards its base as in the Dandelion.

The segments of a *Lyrate* leaf are transverse, the terminal one being rounded and much larger than the others. It occurs in the wild and cultivated Radish.

The *Palmate* leaf, *Fig.* 38, so named from its resemblance to the open hand, has five or seven projecting segments or fingers ; as in the Castor-Oil plant and Blue Passion flower.

The *Lobed* leaf, *Fig.* 39, has curved or rounded segments, with incisures less deep than in the succeeding variety. The Noble Liverwort and Sassafras are good examples.

The *Cleft* leaf has straight incisures and segments terminating acutely ; and the *Parted* has incisures extending very nearly to its base. *Fig.* 40. The Cranesbill will serve to exemplify each variety.

In using these terms, it is often necessary to express the number of lobes or segments, and hence we have *trilobate* or three-lobed, *trifid* or three-cleft, and *multifid*, or many-cleft.

Laciniate leaves are irregularly divided into numerous lobes or segments. In consequence of their irregular and indeterminate form, they are also called jagged or *incised.*

It has been observed that those submersed leaves which are exposed to the action of running water, are frequently subdivided, while those which float on its quiet surface are large and entire.

Pinnatifid leaves, *Fig.* 41, are transversly divided into several oblong, parallel segments, which are gradually smaller, as we proceed from the base to the summit of their respective leaves. When these segments are also transversely divided, as in Yarrow, the leaf is said to be *Bipinnatifid.* When these segments are extremely narrow, and like comb teeth, the leaf is termed *Pectinate.*

4. COMPOSITION.

A Compound leaf is *Digitate*, when several leaflets arise from the summit of a simple petiole, as in the Horse Chesnut, and Hemp.

It is *Binate* or *Conjugate*, when the number of these leaflets is two ; if they are three, as in the Clover and Strawberry, it is *Ternate*, *Fig.* 42, and if they are five as in Five finger, it is *Quinate.*

It is *Pinnate*, *Fig.* 43, if several leaflets arise from the side of a petiole, as in the Rose and Sensitive plants. In the first there is an odd or *terminal* leaflet, in the last there is none, and the Rose is said to be *oddly*, and the Sensitive *abruptly pinnate.* These leaflets are sometimes opposite and sometimes alternate, and hence we find leaves, *alternately* or *oppositely pinnate.* If these leaflets alternate with others of a smaller size, as in Agrimony, the leaf is *interruptedly pinnate. Fig.* 44.

When a leaf stalk is divided, and the leaflets arise only from the superior side of its two branches, the leaf is said to be *Pedate, Fig.* 46, *Viola pedata* and *Arum dracontium* are examples.

When a petiole is divided, and each division supports a compound leaflet, it is said to be *Decompound.* Such leaves are usually *Biternate, Fig.* 50, or *Bipinnate.*

When the secondary branches of a petiole support compound leaflets, it is said to be *Thrice compound,* and if the leaflets are ternate, as in *Panax trifolium,* the leaf is *thrice ternate.*

5. SUMMIT.

The Summit of leaves is *Acute,* as in the Willows, or *Acuminate* being still more slender and pointed, as in the Lombardy Poplar, or it is *obtuse* as in the round, ovate and wedge shaped leaves, which terminate in the segment of a circle.

The *Truncate* leaf terminates abruptly, as if its extremity had been removed by a transverse incision; and the Tulip tree, *Fig.* 48, is a good example.

If the extremity of a leaf is tipped with a bristle-like point, as in Marsh Rosemary, it is said to be *Mucronate,* and if it is tipped with a tendril it is *Cirrhose.*

If it has a small acute notch at its summit, it is *Emarginate,* but if the notch be broad and shallow it is *Retuse.*

6. MARGIN.

The margin of leaves is *Entire,* as in Lilies; *Spinous* or beset with prickles, as in the Holly and Thistle; *Ciliate* or fringed like the eye lashes, as in Moss Pink; and *Dentate* or beset with numerous distant teeth, as in the Arrow-wood, *Viburnum dentatum.* The leaves of the Beech tree are both Ciliate and Dentate. *Serrate* leaves are beset with teeth like a saw, all of which point toward their summits. The Rose, Apple and Peach leaves are examples.

Crenate leaves are like the edge of a common dining plate, having rounded projections inclining to neither extremity, as in Penny wort and Gill. *Fig*. 32.

When the teeth or projections are very minute, the terms *Denticulate*,*Serrulate* and *Crenulate* are employed.

When the projections of a serrate leaf are beset with minute serratures, it becomes *Doubly-serrate*, and the same rule is extended to the dentate and crenate leaves.

A *Repand* leaf, *Fig* 47, is bordered by numerous angles, which appear as if formed by the excision of a small segment of a circle.

Sometimes a leaf appears as if it had been irregularly cut, notched or eaten, and then it is termed *Erose*.

When the margin is rolled backwards a leaf is said to be *Revolute*, and *Involute* when its border is turned towards its superior surface.

7. SURFACE.

With respect to Surface, Leaves are *Dotted*, or as they are sometimes termed *Punctate*, as in the Orange, Lemon, and different species of *Hypericum*. When the veins are tighter than the intermediate substance of a leaf it is said to be *Rugose* or wrinkled, as in the Foxglove and Sage. If the inequalities thus produced, are greater than in the last named example, as in the Cabbage, a leaf is said to be *Bullate* or blistery.

A *Plaited* leaf is folded like a fan, and the American Hellebore is a good example. When the surface of a leaf near its margin is waved obtusely up and down, it is said to be *Undulate ;* and *Curled* when the border is so much expanded as to be in regular folds, as in the Curled-leaved Mallows.

When the middle of a long and narrow leaf is furrowed or depressed it is said to be *Chanelled*, as in Narcissus and Hyacinths. And when the midrib is prominent, on the inferior surface of a leaf, as in the Indian Corn, it is said to be *Keeled.*

A leaf is *Veined* when the vessels arise from it midrib, as in the Cherry and Elm.

It is *Nerved*, when arising from the petiole, its vessels are continued from the base to its summit, as in Ladies Slipper and Solomon's seal. When these nerves are three, a leaf is termed *three-nerved* or *three-nerved at the base*, when as in the Burdock and Sunflower, the two lateral nerves pass for a considerable distance along the margin of the leaf. When these nerves arise above the base of a leaf it is said to be *triply-nerved*, as in *Ceanothus Americanus.*

When the vessels of a leaf intersect each other so as to form a net-work, a leaf is said to be *Reticulate.* This is well seen in the Rattle snake Plantain, *Neottia pubescens*, whose white veins present a very obvious contrast with the dark green colour of the intervening cells.

The surface of a *Lineate* leaf is slightly marked longitudinally with depressed parallel lines.

When no vessels are apparent on the surface of a leaf it is said to be *Nerveless* or even, as in Marsh Rosemary.

All leaves that are not green are said to be *Coloured*, as in the Three-coloured Amaranthus, and Beet.

Variegated.—Dr. Smith applies this term to the white and yellow spots which are the effect of disease. The Ladies Striped-grass, so well known in almost every garden, loses it variegated appearance when transferred to the fields, though its luxuriant growth in the former situations, seems to indicate that it is not exclusively the effect of disease. The same observations are applicable to the *Aucuba* or Golden Plant of Japan, and therefore it is probable, that an unnatural exposure, perhaps to the action of light, may have produced this effect.

An *Aculeate* leaf is covered with spines as in *Rhexia*. When the serratures of a leaf terminate in sharp prickles it is said to be *aculeate-serate*.

A leaf destitute of every kind of pubescence is said to be *Naked*.

8. SUBSTANCE.

With regard to Substance, *Membranaceous* leaves are thin, flexible and almost transparent, as in Penny wort. *Coriaceous* are thick and firm like leather, as in Laurel and Oleander, and *Succulent* or fleshy leaves are filled with pulp, as in the Ice plant and Aloe.

The Onion is an example of a *Tubular* leaf, and that of the Water Lobelia, has two contiguous cavities or cells. *Fig*. 51.

A thick oblong blunt leaf with a cartilaginous margin is said to be *Lingulate* or *Tongue-shaped.* It occurs but rarely.

An *Ensiform* or sword-shaped leaf, is two-edged, erect, tapering to a point, with two convex or gibbous surfaces, neither of which can be said to be superior. The Blue flag, and other species of *Iris* furnish examples.

Sempervireut leaves retain their verdure through one or more winters, as in the Laurel, Pine, and other evergreens, but in Northern countries, leaves are more usually *Deciduous*, falling at the approach of winter.

When the character of a leaf cannot be otherwise precisely delineated, botanists qualify or combine the terms which have been thus briefly defined. It is not uncommon, for example, to find leaves which are intermediate between the ovate and the lanceolate forms, and they are said to be ovate-lanceolate. Nor is it unusual to find them with foot-stalks so very short, that a student is unable to decide whether they are Sessile or not; but here the term sub-petiolate or sub-sessile is used, and in this, as well as in all cases, the term *sub*, implies that the character in question is obscure or not well defined.

" By the judicious use of such means," says Dr. Smith, " all necessary precision is attained. Perhaps no mind, though ever so intent on the subject can retain all the possible terms of description and their various combinations, for ready use at any given moment.

There are few natural objects, to which a variety of terms are not equally applicable in description, so that no two writers would exactly agree in their use. Neither is Nature herself so constant as not perpetually to elude our most accurate research. Happy is that naturalist, who can seize at a glance what is most characteristic and permanent, and define all that is essential, without trusting to fallacious though ever so specious distinctions."

9. MAGNITUDE.

The Magnitude of leaves varies almost as much as their forms. In the mosses which abound in cold climates, they are extremely minute; and the forest trees of the North are adorned with leaves which appear diminutive, when compared or rather when contrasted with the foliage of Equatorial plants. There we find the leaves of the Banana, perhaps the same which were employed by our first parents, to supply the want of a more artificial dress; they being in the opinion of many writers the "Fig leaves" of sacred history. In Ceylon, a country alternately exposed, for many months in succession, to the rays of a vertical sun, and the inclemencies of an unceasing storm, is found the singular Talipot, a single leaf of which is sufficiently large to shelter twenty men from the vicissitudes of the climate in which they dwell. This tree is venerated by those who find beneath its branches so kind a shelter, and travellers consider it, as the greatest blessing which Heaven has bestowed on the country. And when we regard its subserviency to the wants of the human race, it is not surprising that by the ancients, the wide spreading tree, decorated with leaves and occasionally beautified with flowers, should have been held sacred as the very temple of the deities they worshipped.

10. DURATION.

The Duration of leaves is also various. In this climate they are mostly deciduous, and every autumn return to their original dust, and enrich the soil from which they derived their own nourishment. But the trees of Equinoctial regions are perpetually verdant, and the same leaves which have been noticed as unusually large, are equally remarkable on account of their longevity, as they rarely fade till they are six years old ; yet these very trees, when removed to a colder region, are in some cases annually stripped of their foliage. In its native country, the far famed Cydon, and also when cultivated in the South of Europe the Quince tree is evergreen, though here, as we have had an abundant opportunity to see, it annually parts with its leaves. On the other hand the Currant, which was originally an inhabitant of the northern countries of Europe, when transferred to the Island of St. Helena was soon crowned with perennial leaves, but it there produces less fruit than in its native country.

11. TEXTURE OF THE LEAF.

In examining the texture of the leaf, we shall find the vessels of its petiole diverging in various directions, imbedded in cellular substance, and enclosed by an exterior membrane or *Epidermis.* The latter is transparent and delicate, but at the same time sufficiently firm to answer the object for which it was designed, to secure from injury the vessels of the leaf, and to expose its fluids to the necessary agency of air and light. It is sometimes covered with wool or hair, which seems to afford an additional security against the vicissitudes of climate. Plants thus protected are capable of enduring a greater degree of heat than any others, and they abound chiefly in the hottest sections of Europe and America. More frequently, however, the epidermis of leaves is covered with a transparent varnish, which adds to their brilliancy, and secures them from the destructive influence of moisture. The trees of Abyssinia are furnished with leaves of this description, for they are exposed to the violence of long continued rains, which nothing but this armature could enable them to resist. But whether covered with varnish or down, it contains minute orifices or pores through which vegetables discharge the excess of their fluids, and abstract nourishment from the air.

Beneath the epidermis, we find the vessels of the leaf, the tubes which ramify in every direction, and the cells which occupy the intervening spaces. Two systems of the former are always to be found, one to distribute the fluids which descend through the petiole, and another, to re-convey the elaborated sap to every portion of the vegetable structure.

Between these vessels, which are usually most prominent on its inferior surface, we find the *cellular substance* of the leaf, which is not merely the seat of vegetation, but the source of those charms, which render the summer's landscape more interesting and more lovely, than the bleak scenery of winter. The green substance of the leaf consists entirely of these cells, which are filled with fluids here exposed to the action of different agents, acquiring new properties and forming the vegetable secretions. In this texture, the medicinal and nutritive qualities of leaves reside, and they supply cattle with their daily food, and insects, which usually manifest a partiality for the leaves of one plant, and avoid every other. Thus the Cochineal insect thrives only on the *Cactus*, and the silk worm clings to the leaf of the Mulberry, but they both die when denied access to the leaves or cellular texture of their respective plants. These vessels constituting the cortical net, consist of two layers corresponding to the two surfaces of the leaf. Holman detected and separated them in the leaf of the Pear tree, and Linnæus pursuing the same inquiry discovered their points of union, and ascertained that the fabric of the inferior layer is more delicate than the other. It is said that Hedwig discovered similar layers in the mosses which he examined, and moreover, that in the leaf of the Orange tree, he detected an additional layer. "But no language is able to convey an adequate idea of the delicacy and intricacy of the web. It must be inspected as it exists in the contexture or rather in the decay of the leaf, whole leaves being found reduced to a skeleton of fibres in the winter or spring, lying at the roots of trees in situations where they have not been dispersed by the wind."* *Figs.* 57 and 58 represent the cortical net.

12. USES OF LEAVES.

Wearied with the examination of the diversified forms of leaves, the student turns with delight to the contemplation of their uses, and in the pursuit of the latter inquiry, he finds an adequate compensation for the fatigue of the former.

It was the opinion of an ancient writer, that leaves were designed to protect fruit from the intense heat of summer. In proof of its correctness, he observed that leaves always appear before the fruit, continue till it ripens, when they fall, as if the sole end of their existence was accomplished. If however, a branch be prematurely stripped of its leaves, its green fruit will never arrive at maturity. It was also observed, that in

* Keith.

those countries where the heat is always intense, trees never part with their leaves. The correctness of an opinion, confirmed by arguments like these, was for a while unquestioned, but subsequent observations have shewn, that leaves are subservient to other and more important ends. It is true, they defend the fruit from the intense heat of summer, and at the same time, protect animals and even men from the parching rays of noon-day. And in cultivating the plants of warm climates, naturally pleased with a greater degree of heat, it is often expedient to remove the leaves, so as to expose the flowers and fruit to the full influence of the sun. This practice, fatal if carried too far, when judiciously adopted, will restore to their native flavour, the Melon, the Orange, and the Grape.

It has long been known, that leaves are organs of Exhalation, from which an invisible vapour continually escapes, capable of being collected, condensed, and accurately examined. The fact is illustrated by a very simple experiment, and we all know that when a branch is separated from its parent stock, it will shortly droop, wither and die. Its weight is diminished, for it is no longer filled with those fluids on which its firmness and elasticity depend. They have been discharged through the pores of the leaves, which, being cut off from all further supply, are sooner or later entirely exhausted. But if a leafy stem be placed in a small vessel of water, its freshness will be preserved a much longer time, though the perceptible and rapid diminution of the water, will prove that the leaves have been the outlet, through which it has escaped. If the same branch be placed in a close tin box, its freshness will be still longer preserved. Here are no fluids for the stem to absorb, but by confining the air which is already saturated with vapour, we prevent its further escape from the leaves, which must of necessity cease to transpire. They retain the same fluids with which they are already supplied, and though they perform none of the actions, they exhibit the appearance of perfect health. Thus they may be preserved for weeks, and thus the botanical traveller, who expects to derive every advantage from his journey, will collect and preserve the plants that meet his eye, till he has leisure to examine them.

The quantity of vapour thus exhaled, though various, is commonly greater than at first view we should be prepared to expect. When the sun is bright, and the atmosphere dry and warm, leaves perspire more copiously, than when clouds obscure the brightness of the one, and diffuse a moisture through the other. In the former case, the mown grass is converted into hay in a few hours, in the latter, it is so tenacious of its fluids as to baffle every effort of the farmer to hasten the process.

In general, succulent plants exhale more sparingly than others. It seems to have been the design of Nature, that they should inhabit the burning sands of the Torrid Zone, and the peculiarity of their native situation, makes it necessary for them to preserve the fluids, which, with so much difficulty they procure. But plants with thin membranaceous leaves which generally occupy moist situations, where they are supplied with an abundance of water, perspire very copiously. The Sunflower, which is very frequently met with in the United States, was found to exhale two pounds in the course of a day ; and in the same space of time the Cornelian Cherry, a shrub with thin and almost transparent leaves, growing in the hedges of

Europe, is said to lose a quantity equal to twice its own weight. On a warm summer's day, at a time when there had been no rain for several weeks, Dr. Watson placed some grass under a large vessel, and in two minutes it was covered with moisture which ran down its sides. By collecting it on muslin, he ascertained the amount of this exhalation ; and from the result of his experiments, he was led to conclude, that in the course of a day, an acre of land transpires nearly two thousand gallons of water. The rapidity with which plants wither, will teach us how fast their roots absorb, or their leaves exhale, and in cultivating rare plants, this simple experiment will enable us to determine, what quantity of water they require. But in the performance of this experiment, the condition of the atmosphere, must be taken into consideration. Nor should it be entirely overlooked by the practical gardener, whose operations frequently fail, because they are performed at an untimely hour. Every person who has been engaged in transplanting, knows it may be accomplished with more success, on some days than on others. If removed when the air is warm and dry, plants are apt to wither, and unless carefully managed, they will shortly perish beyond the power of recovery : but under different circumstances, and at a proper time, the same thing is performed without difficulty or danger.

The fluid which is exhaled by the leaves, may be collected, by introducing a branch into a capacious glass vessel, but it possesses no very peculiar properties. In all plants it is nearly uniform, being the residue of the sap, after the separation of its more essential secretions. Occasionally it is combined with a volatile oil, which communicates to the atmosphere around, the peculiar fragrance of the plant which exhales it. When the temperature suddenly changes, the insensible perspiration is sometimes condensed, in the form of tears. This was observed by the Roman Poet, whose mythology had transformed the mournful sisters of Phæton into Poplars, and the fluids which glittered on their leaves, were the tears which bespoke their anguish.

It may frequently be observed on the leaves of those plants, which delight in moist shady situations, and fade rapidly whenever they are removed. The *Impatiens fulva*, termed on account of its elastic capsules Touch-me-not, is one of this kind. I have frequently seen it when every other plant around was dry ; yet its leaves glittered with the vapour, which in the form of tears, had been condensed on their surface.

Very different from condensed vapour, are the exudations, which frequently appear on the leaves of different plants ; and which are either an effusion of healthy secretion, or an indication of disease. The Honey-dew, which is seen on the leaves of the Beech, is occasioned by dampness of the atmosphere, and denotes its unhealthy condition ; but Manna frequently covers the leaves of the healthy Ash, from which tree it is usually obtained, as we procure sugar from the Maple. Sometimes this effusion possesses adhesive properties, sometimes it is intensely bitter, and in some cases highly inflammable.

Leaves are organs of Absorption. The use of a tin box to preserve their freshness has already been noticed. If it contains a minute quantity of water, it will restore to the vigour of health, the fading and the dying leaf. This renovation arises from its power to imbibe moisture from the atmosphere of the box in which it is confined ; a power which most leaves possess, though in very different degrees. This was abundantly proved by the experiments of Bonnet. He placed the leaves of various plants on the surface of water, in order to ascertain the relative absorbing power of different leaves ; and also, of the different surfaces of the same leaf. His experiments, so easily performed, have been repeated by others, and their results are too curious to be unknown. A singular difference has been observed, between the leaves of trees and herbaceous plants, the former absorbing chiefly by their inferior, and the latter by their upper surface. One of the plants which Bonnet employed, was the Purple-leaved Amaranth ; and though it lived not a week, with its inferior surface on the water, it retained its vigour several months, when its position was reversed. On the other hand he placed the upper surface of the Mulberry leaf on the water, and it continued healthy about six days, when it began to droop. He placed by its side another leaf, from the same tree, with its inferior surface on the water, and in that position it remained six months, before it lost its vigour and health. To prove that absorption really converts the vapour of the atmosphere to its own use, we have only to place one of two leaves, which are connected together, in a proper situation to imbibe moisture, and the fluid absorbed, is frequently sufficient to support them both. When speaking of Parasitic plants, I mentioned the *Epidendrum* or Flower of the Air, which trails over the walls of the Indian's cottage, and is prized by him for the perfume of its blossoms. Yet this plant is sustained entirely by the moisture which its leaves imbibe from the air of the same room, through which it diffuses its delightful fragrance.

A knowledge of the exhaling, and absorbing power of leaves, is often of great practical importance. It teaches us that plants droop, in consequence of the excess of the former, and are to be revived by diminishing their discharge, or increasing their absorption. The former is accomplished by confining the air around them ; and the latter, by sprinkling water over the leaves ; and when plants have recently been removed, such management is frequently required.

Leaves are Organs of Respiration. By the aid of the microscope, Dr. Grew ascertained the existence of air cells in the substance of leaves. He also observed the spiral coated vessels, which are particularly numerous in the leaf, as well as in the substance of the alburnum. His discoveries led to the conclusion, that leaves absorb air, that their cells receive, and their vessels convey it, to every part of the growing plant. The next experiments were performed with an Air-pump ; by which abundance of air was procured from the leaves, and other parts of vegetables, and the truth of former speculations, more firmly established. It was also demonstrated by Bonnet, whose experiments on absorption, we have already mentioned, that when leaves are placed in water, and exposed to the influence of the sun, air escapes from their surface. But we owe to the labours of Priestly more than to all others. Aided by the resources of modern chemistry, this distinguished veteran of science, first exhibited in its true light, the influence of vegetation on the air we breathe, and presented to the scientific world, a simple yet satisfactory explanation of phenomena, which had eluded the investigations of all his predecessors.

It is well known, that when animals cease to breathe, they immediately perish. The air by which they are sustained, is no less essential to the healthy existence of plants. But to comprehend and explain this subject, in all its interesting relations, we must premise a few observations respecting the constitution of the atmosphere. It is composed of three invisible fluids, two of which possess very peculiar properties. One of these is oxygen or vital air, the great supporter of combustion and animal life, without which neither can for a moment exist. Combustible bodies introduced into a portion of this gas, burn with increased splendour; its volume is diminished, and they acquire an additional weight, proportioned exactly to the quantity of gas absorbed. Its union with inflammable bodies, is usually attended with an evolution of heat and light, constituting in ordinary language, combustion or fire; but sometimes this union is effected without the appearance of flame.

If 30 grains of powdered charcoal are inflamed in 100 cubic inches of this gas, both the charcoal and the oxygen disappear, a combination of their elements is effected, and a new product is formed, possessing very different properties from either. This is carbonic acid gas, or fixed air, and it constitutes an essential, though a very small portion of the atmospheric air. The respiration of animals is one of its most fruitful sources, and hence we find that the atmosphere of a close and crowded room soon becomes contaminated, and unfit to sustain the ordinary functions of life; and this contamination arises entirely from the repeated respiration of confined air, by which it is deprived of its oxygen, and impregnated with carbonic acid.

A diligent inquirer after truth, would ask how the purity of the atmosphere is preserved, while millions of animals are continually breathing out their noxious exhalations. Even the light which guided the immortal Priestly through his evening labours, was contaminating the air, while it enabled him to point out the renovating cause—while it assured him and us, that every part of the creation is controlled by the Wisdom of an Infinite Mind. By a series of experiments conducted with his accustomed ingenuity, he ascertained that growing plants imbibe carbonic acid and expire oxygen gas. The leaf of a Vine was introduced into a phial of the former, and in less than two hours the fixed air disappeared, and oxygen gas was found in its place. If leaves be introduced into an inverted tumbler of water, and exposed to the influence of the sun's rays, bubbles of air will appear on their surface. They consist of nearly pure oxygen gas, but if the same experiment is performed in the dark, the air evolved does not possess the same degree of purity. Thus we learn the mutual dependence of the two living kingdoms of nature upon each other, the beauty and harmony of creation: Man expires the food of plants—plants exhale what has been emphatically denominated the *breath of life.*

After the experiments of Priestly, it was supposed that respiration deprived the air of that oxygen, which is restored by the vegetation of plants. This theory, so satisfactory, and apparently so well established, has been received till lately without a doubt. Within a few years, however, Mr. Ellis has performed some experiments, which lead him to reject the opinions of Priestly, and to insist on the one effect of organized living existence; and he maintains that the germinating seed, the vegetating plant, and the respiring animal, all produce the same changes, all increase the carbonic acid and diminish the oxygen of the atmosphere. Whatever credit is due to this gentleman for the ingenuity of his experiments, they do not appear to justify his conclusions, and his opinions are yet to be established by additional proof, or else entirely rejected; for they are not consistent with the observations of many of his predecessors, and of some who have succeeded him. They do not explain why the air we breathe is constantly pure, notwithstanding the unequivocal and decidedly bad effects of respiration. They point to no renovating cause; and if true, they must subvert one of the most beautiful explanations of modern science; one which has long been sanctioned by high authority, and will long be remembered with delight, even if it should be proved erroneous. Speaking on this subject, Sir Humphry Davy makes the following observations. "It cannot be supposed that the production of oxygen from the leaf, which is known to be connected with its natural colour, is an exertion of diseased action, or that it can acquire carbon in the day time, during its most vigorous growth, and when all its powers for obtaining nourishment are exerted, merely for the purpose of exhaling it at night." He concludes that in proportion to the exigencies of any plant, will be the rapidity of its absorbing carbon; that if one be made to grow in pure water, and another be placed in carbonaceous earth, the leaves of the former will derive from the atmosphere, what the roots of the latter absorb from the ground; and finally that when the leaves of vegetables perform their healthy functions, they purify the air. And their influence on the temperature of the atmosphere, is one of those extraordinary provisions of Nature, which claims the attention and the gratitude of man. Were it not for this, the summer's wind would become a Sirocco, and the breeze of health would be converted into a pestilential blast. We have already recited the observations of Sonnerat, who found plants comparatively cool, although the heat of the earth from which they derived their nourishment, was scarcely less than that of boiling water.

But to promote these effects, *Light* is an agent of indispensible importance. We already know that when it is excluded, leaves become sickly and pale, their stems lose their natural elasticity and strength, for the former derive no nourishment from the air, and the latter no sustenance from the leaf. The fluids are retained, no oxygen escapes, there is a deficiency of alkali, on which the green colour of the leaf is supposed to depend, and of carbon, which alone gives firmness to the wood. But when light is admitted, it enables the leaf to convert the carbon of the air to its use, which as it descends through the vessels of the bark, becomes alburnum, and at last forms perfect wood. It also enables the leaf to exhale its excess of fluids, and of oxygen, thereby increasing the proportion of that alkali, on which its green and healthy colour depends. But the beneficial influence of light upon leaves is confined entirely to their superior surface, which always courts the full influence of the sun, and turns as if to welcome his congenial rays. Those who have cultivated plants, must have observed how uniformly they mantain this position, and if disturbed, how soon they resume it; and if a Vine leaf be suspended by a thread, it is still susceptible of impression from the sun's light, and retains the power to follow him in his course.

The pinnate leaves are more under the dominion of light than any others. They expand in the morning, and at the approach of darkness close around each other, and sometimes around the full blown flower, as if for mutual protection and support. This is the *sleep of plants*, but what analogy it bears to the sleep so essential, and so refreshing to the animal kingdom, is left for others to determine. These are the leaves which have already been mentioned, to prove that sensibility is one of the properties of vegetable life. The Sensitive plant, which shrinks from the slightest touch, is nearly allied to several others which possess similar degrees of this extraordinary power. The leaves of the Fly-trap *Dionœa muscipula*, *Fig.* 53, exhibit no marks of sensibility until the unfortunate fly ventures to light on its surface, when it instantly closes and confines the insect prisoner, as long as he continues to struggle for escape. On the banks of the Ganges is found a plant exhibiting such powers as to excite the astonishment of every beholder. It is the *Hedysarum gyrans* or the Moving plant of India. If as he passes by the playful Indian impedes its motion, no sooner does it regain its liberty than its operations are renewed with increased activity, as if it were necessary to redeem the time which had been lost. I have seen this plant in a green-house, and though no breath of air disturbed the peace of its companions, its winged leaves disdained to rest, but exhibited the most astonishing example of industry I ever saw.

The degree of vapour in the atmosphere has a powerful effect upon the leaves of some plants, so that they indicate with almost unerring certainty the approach of rain. We are yet on the threshhold of discovery. When we shall have advanced a few steps farther, those plants which now appear to have been formed in vain, will display their useful qualities, they will enable the physician to combat disease, and the traveller to avoid the impending storm.

The leaf of *Sarracenia** *Fig.* 54 presents one of those

* The *Sarracenia purpurea* frequently named Adam's Cup, or

anomalies which excite the attention of the most indifferent observers. It is tubular, and the lid which is attached to its dilated margin, is covered with rigid hairs, uniformly projecting towards its base. If we examine the interior of this leaf, we shall find it partially filled with water, and stored with insects, which having been entangled by its marginal hairs, were precipitated into the cavity, where they perished. What is the design of this singular arrangement ? By Catesby who resided several years in South Carolina, it was said to furnish insects and flies with a secure retreat against the attacks of birds and reptiles, but unfortunately for his hypothesis, it was rather a fatal than a safe retreat. By Linnæus it was supposed to preserve a supply of water in its cavity, till a dry season rendered its expenditure necessary for the growth of the plant. It has been replied to this, that the old leaves which require the least water, are furnished with the largest supply, and that even in the dryest season, this quantity is never entirely exhausted.

Abandoning the opinions of Catesby and Linnæus, Dr. Smith has adopted another which seems to have been founded on a single observation, made in the Botanic garden at Liverpool. An insect was observed by the gardener, drawing the flies which he could manage, into the tube of the leaf, where he supposed they were deposited as food for the aggressor, for it was found that the other leaves were also partially filled with water, and contained several dead or drowning flies. In most cases I am persuaded they are not forced into their hollow tomb, but having ventured too far

Side Saddle flower, is occasionally found in the low marshy grounds of New-England.

upon the hairy border, they are unable to return, and at last fall into the water, where they perish. Here unquestionably they may be of use to the plant, by furnishing it with nourishment, which is absorbed by its hollow leaf, for the air evolved by decaying insects is favourable to vegetation. Dr. Smith therefore concludes that the design of this singular construction is to entrap and retain the small insects which become food for their larger companions, and nourishment for the plant which contains them, and he thinks it curious, "that an European insect should find out an American plant in a hot house, in order to fulfil that purpose."*

It would be useless to find fault with this hypothesis, or to mention others which have been defended with equal ingenuity, for none of them rest on the substantial basis of observation and experiment. It remains to be ascertained, whether the water which the leaf contains is derived from its root or from another source, whether it is pure, or impregnated with any of the vegetable secretions, whether the insects with which it is stored, are forced into its cavity or become victims to their own temerity, whether they furnish birds and insects with food, and whether the plant is less vigorous, when all foreign substances are excluded from the cavity of its singular leaves. When these questions are all answered, there will be time enough to speculate; but until the subject is more thoroughly investigated, no theory can rest on a substantial foundation.

The leaf of the *Nepenthes distillatoria*, *Fig.* 55, a plant that grows among the bogs of India, presents a similar anomaly. A pitcher-shaped appendage attached to its superior extremity is partially filled with water, but the

* Smith's Introduction.

cavity being furnished with a moveable lid apparently designed to exclude the rain, there can be no doubt that the fluid it contains is derived from the vessels of the leaf and not from any foreign source.

Frond.—When the leaf and stem are so incorporated as to form but one organ, whose parts do not even in decay spontaneously separate, they present by their union an example of the Frond. Such examples are rare, unless we descend to the inspection of the inferior classes of plants, and its various arrangements as exhibited by them will be noticed in a subsequent chapter.

As applicable to the more perfect plants, it is peculiar to the Palms, and the tall Palmetto of the south, will serve to exemplify this singular arrangement. But its application to them has of late grown into disuse, and as the stalk of the Palm, formerly denominated the stipe, now ranks with stems, so must its peculiar foliage be regarded as a variety of leaves.

CHAPTER X.

APPENDAGES.

There are various appendages to the parts already enumerated, which are either organs of defence or support. Sometimes they are evidently designed to defend the leaf and tender shoot from cold. Sometimes they are a security from other injuries, but in a few cases their uses in the economy of vegetation, remain to be ascertained. Their forms are much diversified, and they all occasionally furnish discriminative characters, to which the botanist often finds it necessary to resort.

1. BUDS.

About mid-summer, the progress of vegetation seems to be suspended, and for several days, the vital energies of the tree, are exerted in the formation of buds. We no longer observe the vigorous growth of spring, but if we examine the young branches, we shall find the newly formed buds at the base of the leaf stalk, immediately above the place of their insertion. After the fall of the leaves, they are more conspicuous, and during the winter we may perceive a gradual enlargement, corresponding to the developement of the tender germs which they enclose. Their situation like that of the leaves, is either alternate or opposite, there being in the former case a solitary bud at the summit of the branch, and in the latter three terminal buds, the central one being larger than the others. Their form is not unlike that of a Pear, and their organization exhibits a happy combination of utility and beauty, well meriting the attention of the student. On their exterior surface we find a series of concave scales, enclosing each other like the tiles of a house. The outer of these are hard and dry, the other more delicate and resembling in their texture the leaves which they enclose. These scales are frequently connected together by a resinous substance, which water is unable to penetrate, and this armature is particularly obvious on the large buds of the Horse-Chesnut. Having removed the scales we find the leaves or flowers, or perhaps both enclosed in down, which like the fur of animals is designed as a security against the influence of cold.

The buds of the Walnut and Horse-Chesnut are unusually large, and the examination of either of these will enable us to form an accurate idea of their general structure and use; one of the latter was dissected by a German botanist for whose patience I have great respect, at the time when it did not exceed the size of a pea. He found it covered externally by about 20 scales, which were cemented together by the resinous adhesive substance so conspicuous in the buds of that tree. Within the scales he found the embryo enveloped in down, and pursuing the inquiry he distinctly saw twenty-eight leaves surrounding a spike of sixty flowers. The scales, resin and down, all conspire to produce the same effect, though the first appears particularly designed to guard against external injury from birds and animals, while the down serves as a protection from cold, and the resin from moisture and air.

United, they enable the tender embryo to brave the vicissitudes of a northern climate, and protect it from other injuries till the period of expansion arrives. In the northern section of the United States, we find but few trees or shrubs capable of enduring the cold of winter without this security.

In Sweden we are told there is but one shrub destitute of buds, and that from the peculiarity of its situation, is always protected from the inclemencies of the Swedish winter. But in warmer climates, the tender shoots do not require this protection, and accordingly, we find that the Orange, Lemon and Mimosa, and other shrubs, natives of tropical regions, are not furnished with the " winter cradles" of northern plants. If they are, whatever may have been their natural situations, whatever may be the degree of heat to which they have been accustomed, they will probably endure the cold of our winters and flourish without protection in the open air.

Botanists distinguish three varieties of buds, one to enclose the leaves and their branches, one to contain the rudiments of the future flower, while the other possesses an intermediate or rather combined character, and performs the office of both. The flower and leaf buds are easily distinguished by their forms, the former being round and short, the latter slender, long and pointed. The Peach presents examples of each variety, the leaves and flowers being distinct ; and the buds of the Lilac enclose them both together. The leaf bud will grow luxuriantly when placed on the earth, but in the same situation the other uniformly dies.

It has been recently discovered, and it is a discovery of no small practical importance, that these varieties of buds are convertible into each other. Mariotte deprived a Rose tree of its branches and leaves, suffering nothing to remain but the buds, which would have produced flowers, the ensuing spring. They continued to grow, but when the period of their expansion arrived, instead of flowers they put forth branches and leaves.

An accident which occurred in one of the Royal gardens of England first demonstrated the possibility of increasing the proportion of flower buds. A West India plant* which had for several years been cultivated in the green house grew luxuriantly, but refused to produce flowers. " At length it was accidentally left without water, in the dry stove at Kew, and in consequence of this unintentional neglect, the luxuriant growth of its branches was greatly checked, and a flower came forth at the extremity of each. By a similar mode of treatment, the same effect has since frequently been produced. Several plants, especially with bulbous roots, which blossom abundantly in their native soils, have hitherto defied all the art of our gardeners to produce this desirable effect ; yet future experience may possibly place it within our reach by some very simple means. In general, whatever checks the luxuriant productions of leaf-buds, favours the formation of flowers and seeds. That variety of the Orange Lily which is most prolific in buds, seldom forms seeds, or even those organs of the flower necessary to their perfection. So likewise the seeds of Mints, a tribe of plants which increase excessively by roots, have hardly been detected by any botanist ; and it is asserted by Doody, that when the elegant little *Ornithopus perpusillus* does not produce pods, it propagates itself by grains or tubercles of its root, though in general the

* *Solandra grandiflora.*

root is annual. But such propagation is only the extension of an individual, and not a re-production of the species as by seed. Accordingly, all plants increased by buds, cuttings, layers, or roots, retain precisely the peculiar qualities of the individual to which they owe their origin. If those qualities differ from what are common to the species, sufficient to constitute what is called a variety, that variety is perpetuated through all the progeny thus obtained. This fact is exemplified in a thousand instances, none more notorious than the different kinds of apples, all varieties of one common stock."*

The Bulbs which have been formerly described are closely allied to Buds. This affinity is less obvious, when the bulb occurs in its most usual position, beneath the surface of the ground, than when it arises from the bosom of the leaves, or in the vicinity of the flowers. The Bulb-bearing Loose-strife presents an example of the first, and the Meadow-garlic of the second variety; and in both cases it remains attached to the parent plant, till the embryo it encloses has reached maturity. It then falls to the ground, strikes root, and a new plant is developed. In their situation these bulbs are analagous to buds; in their destiny they appear more like bulbs, and are to be regarded as a connecting link between the buds of trees, and the radical bulbs of herbaceous plants.

2. STIPULES.

The leaves and their petioles are frequently accompanied by small leaf-like appendages, which, in the

* Smith.

technical language of the botanist, are termed *Stipules.* They are usually found in pairs at the base of the petiole, *Fig.* 20, and this Dr. Smith regards as their most natural position.

In the Myrtle-leaved Pea-vine they are semi-sagittate, resembling a section of the arrow-shaped leaf; in the Willow, they are frequently lunulate, having the appearance of the crescent-shaped leaf; in the Silver weed they are ovate; in the common Pea they are round; and in other plants they assume other figures designated by terms which have been defined in a former chapter.

In the examples which have been enumerated, the stipules are in pairs, exterior to the leaf; and in some of them, and also in the Rose, they are laterally united to the petiole at its base. In other plants, the stipules are internal and simple, as in the Knot-grass, and other species of Polygonum. In these it is frequently tubular, forming a sheath for the stem above the insertion of the petiole; and to this peculiar variety of the stipule, those who are fond of minute distinctions have applied the term *Ochrea.*

In the natural order of Grasses it is also solitary, forming a membranous scale, which arises from the summit of the sheath, and like it encloses the culm. This form of the stipule is denominated *ligula*, a term which Dr. Smith regards as superfluous, and of course to be rejected. It is however still retained by several writers, and not unfrequently occurs in the delineations of American grasses. Usually the stipules are persistent, and fall only with the leaves, but in the Tulip-tree they are deciduous and fall as soon as the leaves are fully expanded. The presence and figure of this organ are often the basis of botanical distinctions and Jussieu in distributing the vegetable kingdom into natural orders, has frequently derived from them his secondary characters.

In their functions these organs are auxiliary to the leaves, serving like them for the elaboration of the sap; and in some of the Pea vines it has been observed that the latter occasionally disappear, leaving only the stipules to supply their place.

3. TENDRILS.

These are filiform appendages by which weak stems are attached to their supporters. They usually arise from the branches, being opposite to the leaves in the Vine, and axillary in the Passion flower. In a few instances they arise from the leaf, and very rarely from the petiole and flower stalk. In the Traveller's Joy, *Clematis Virginica*, the petiole itself performs the office of tendrils, and twines like them around other objects for support, and in the *Annona hexapetala*, the flower stalk forms a hook and grasps the neighbouring branches serving to suspend its very heavy fruit. The young tendril usually proceeds in a straight direction till it has found something to cling to, after which it assumes its spiral form and brings the young vine closer to the objects which sustain it. Some turn from right to left, some from left to right, while a few possess the property of twining in either direction. In the Ivy, *Fig*. 18, they are not spiral, being merely fibres which arise from the stem and penetrate the bark of the neighbouring trees, or if denied access to other vegetables they cling to the naked wall, "attaching themselves firmly as the stem elongates, which thus often climbs to the summit of the loftiest trees or to the battlements of the loftiest towers, covering the decayed trunk with a borrowed foliage, and giving beauty even to the mouldering ruin."*

Those of the common Creeper are branched, and their minute extremities cling powerfully to the hardest, smoothest rocks, and therefore it is admirably calculated to screen the cheerless wall from our view. It is in fact, the only Ivy of which we can boast, for that of which the poets sing, is not an American plant. The tendrils of the laughing Vine, have long been considered the fittest emblem which joy could wear, probably because some votary of cheerful mirth, had associated the juice of the grape with the tendril which supports it.

4. PUBESCENCE.

This term includes all the down and hairs with which the surface of plants is invested. Sometimes it appears like dust or powder scattered over the surface of the vegetable; sometimes like fine silky down, communicating a silvery whiteness as in the common Silver-weed, *Potentilla anserina*; sometimes it is velvet like, as in the leaf of *Sida Abutilon*; and sometimes it assumes a woolly appearance, the hairs being curled and matted together, as in the leaf of the Mullein; sometimes these hairs are few and scattered as in leaves of Noble Liverwort; sometimes they are long and shaggy, sometimes they are short and pungent, arising from small eminences as in many of the rough-leaved plants.

None of the appendages are more affected by cultivation than these, and therefore it has been established

* Keith.

as a general principle, that except in cases of necessity, no marks of specific distinction should be drawn from them. They enable us by observing the peculiar arrangement which they assume in some of the Mints to discriminate between species, which we should otherwise be apt to confound. Nor is it uncommon for writers to notice as one of the striking features of the plants they describe, whether it be pubescent or not ; that term being employed to express the different kinds of hairs which have been enumerated in the present section.

5. GLANDS.

These are minute organs of various forms usually attached to the leaf or its foot stalk. They occur in the substance of the leaves of the Myrtle, Lemon, and common St. John's-wort, causing them to appear dotted when exposed to the light. They occur on the petioles of the Nectarine, Snow-ball, and Passion-flower, between the serratures of the leaf in the Almond, and on its superior surface in the Sun-dew. In the latter they are filiform, and tipped with a clear transparent secretion, which glitters like dew in the sun. In Roses, *Fig*. 59, particularly in the Moss Rose, these glands are elevated on a slender stalk, and contain a secretion, which communicates to many species of that interesting family of plants, their peculiar and delightful perfume. Glands sometimes furnish marks of specific distinction, to which it is often convenient and sometimes necessary to resort. They enable us to discriminate betwixt the Almond and the Peach, the leaves of the former being glandulous while those of the Peach are not.

6. ARMATURE.

In addition to the preceding, there are appendages, which seem more evidently designed for the security of the plants on which they occur. One of these is the *Sting* of the Nettle, a plant which thrives around the dwellings of man, as if to defy his attacks, it being admirably prepared to resist them. The hairs or stings by which the Nettle is covered, are tubular, very slender and pointed, but expanding towards their base, so as to form a receptacle for the secreted fluid, *Fig.* 60. By this sting we are wounded, but the pain which ensues, is caused by the venomous fluid, which is conveyed through the cavity of the sting into the wound.

Another variety of armature is the *Prickle*. It arises from the bark being sometimes straight, sometimes hooked, and sometimes forked. The Rose, the Bramble and the Raspberry furnish examples of these several varieties.

Some plants are guarded by *Thorns*, which in many instances appear to be diminutive stems, assuming their peculiar form, from the want of cultivation. The wild Pear tree is covered with thorns, but when transferred to the more congenial soil of the garden, they are found to disappear. Linnæus imagined that such trees were divested of their natural ferocity, and therefore in the pursuit of his favourite analogy, he said they were *tamed*. Certain it is that they fall under the more immediate protection of man and no longer require their original armour, and whenever they disappear by culture, it may be presumed they are abortive buds, which in a more favourable situation would have been converted into luxuriant branches.

But in some cases the thorns do not disappear even under circumstances favourable to vegetation. Such are the spines which beset the Gooseberry, and such are the thorns of many shrubs which are used in the construction of hedges.

CHAPTER XI.

FLOWER STALK AND INFLORESCENCE.

The stalk which bears the flower and fruit, springs immediately from the earth, as in Dandelion, or arises from the stem and its branches. In the former case it presents an example of the *Scape* which like the radical leaves, is appropriated chiefly to stemless plants. In the Hyacinth it is naked, in the Colts foot it is scaly, in the *Valisneria* it is spiral, in the Dandelion it is tubular, and in the sweet flag it terminates in a leaf-like expansion, and is denominated leafy.

When the flower-stalk arises directly from the stem or its branches it is named the Peduncle. When it arises from the side of the stem it is lateral, when from the summit it is terminal, and when from the bosom of the leaves it is axillary. It is one-flowered in the Tulip, two-flowered in *Linnœa*, and many flowered as in the Cowslip *Fig*. 22 and Lilac.

In the latter, and indeed in numerous other examples, the flower-stalk is branched, and the peculiar arrangement which the flowers assume, technically named the Inflorescence depends on the number, proportion and distribution of these pedicels or branches. If the flowers are solitary, or in pairs, their origin alone will occupy our attention, " but when many grow together, their aggregation forms a feature in the habit of the plant, peculiarly striking and peculiarly interesting to the botanist, as forming the most elegant and the most invariable of all specific distinctions.

1. The UMBEL *Fig*. 62.—The umbel is a mode of flowering in which a number of flower-stalks issuing from a common centre diverge like the rays of an umbrella, bearing their flowers on the summit, and raising them about the same height. The Carrot, Parsnip, and Hemlock, are familiar examples, which with all other plants affecting this mode of inflorescence are denominated umbelliferous or umbellate.

If the rays of the umbel are undivided so that each individual ray supports but a single flower, as in the Silkweeds *Asclepias*, the umbel is said to be simple, but if the rays of the primary umbel are themselves subdivided, so as to form and support secondary umbels, as in the preceding examples, the umbel is then said to be compound."*

2. CYME. *Fig*. 63 —The flowers of the cyme are supported on peduncles, which issue from the common centre and rise to the same height; the intermediate subdivisions being irregular. The Elder, Snow-ball and other species of *Viburnum* present familiar examples of the cyme.

3. CORYMB. *Fig*. 64.—In the preceding varieties of inflorescence, the flower stalks proceed from the same point, in which particular they differ from the corymb. The flower-stalks of the latter arise from the sides of a common stem, being proportionably shorter as they originate near its extremity, so that its flowers are finally disposed on a level with each other. It is easy for the student who has the examples before him, to become acquainted with these varieties, by observing wherein they differ, and how they correspond with each other, by observing the flower-stalks

* Keith.

of the umbel proceeding from the same point, and, if at all, regularly subdivided ; by observing those of the cyme, also arising from the same point but irregularly branching, while those of the corymb, arise from a common stem, some nearer to its extremity than others, but terminating on the same level. And if he will examine the flowers of the Apple and Pear, he will find they differ only in their respective arrangements, the Apples being disposed in an umbel, and the Pear furnishing a good example of the Corymb.

4. FASCICLE.—An assemblage of flowers more densely arranged than in the corymb, but otherwise disposed in a similar way, constitutes the fascicle. The Sweet-William presents examples which correspond with the above definition, but they might be conveniently classed with the corymbose flowers.

5. SPIKE. *Fig.* 65.—The spike is an assemblage of flowers arising from the sides of a common stem. In some cases the flowers are sessile, as in the Herdsgrass, but the term applies also to flowers which stand on short stalks as in Common Lavender, and different species of Orchis. " The spike generally grows erect. Its mode of expansion is much more progressive than that of the raceme, so that a long period elapses between the fading of the lowest flowers, and the opening of the upper ones. The flowers are commonly all crowded close together, or if otherwise they form separate groups, perhaps whorls, when the spike is said to be either interrupted or whorled ; as in some Mints."

The spike is either simple and undivided, as in Agrimony, or it is compound, as in some species of Lavender.

The term Spikelet, is applied exclusively to grasses that have many florets in one calyx, and the filiform receptacle to which these florets are attached is denominated the Rachis.

6. RACEME. *Fig*. 66. A Raceme or cluster differs from the spike only in the length of its individual flower-stalks which are also in this case attached to the sides of a common stem. The Currant is a fine example of a cluster, which more frequently than any other falls within our observation. It is unilateral in the Scull-cap *Scutellaria lateriflora*; terminal in the Cohush *Actæa Americana*; lateral in the Currant, and compound in the Woody Nightshade.

7. HEAD. *Fig*. 67.—This is an assemblage of flowers upon the extremity of the branch or stem, and arranged in a globular, oval or cylindrical form. It occurs in the Globe Amaranth, and in several species of the *Trifolium* or Clover.

8. WHORL. *Fig*. 68.—An assemblage of flowers surrounding the stem or its branches constitutes the whorl. It occurs in the Mint, and in many of the Labiate plants.

9. PANICLE. *Fig*. 69.—When the flowers are arranged on a stalk variously and repeatedly subdivided, as in the Oat, their inflorescence constitutes the Panicle. In the grasses the branches of the panicle are somewhat verticillate, being diffuse or loosely spreading, or dense and crowded; sometimes nodding and sometimes erect.

.10. THYRSE.—The flowers of the Thyrse are arranged like those of the panicle, the branches of the pedincle being short and the flowers more compact, as in the Lilac and Prim.

11. AMENT or CATKIN. *Fig*. 71.—Like the Spike, the flowers of the Catkin are arranged along the side

of a common filiform receptacle, as in the Walnut and Birch. In the Ament the flowers stand on chaffy scales, which scales are deciduous in the White Birch, and persistent in the Pine, growing with the seed, and forming the *cone*, *Fig*. 72. In the Plane tree the catkins are globular, in the Hop they are oval, in the Birch they are cylindrical ; being sometimes covered with wax, sometimes smooth, and sometimes hairy. The European and the American forests present numerous examples of the catkin, while the spike usually occurs in the herbaceous plants.

12. SPADIX.—A columnar receptacle, usually arising from a sheath, and supporting a number of sessile flowers, constitutes the Spadix. In Dragon root *Arum triphyllum*, the flowers are attached only to its base ; in *Pothos fœtida*, they crown the summit of the column which sustains them.

In each of the above examples, the Spadix rises from the bosom of a singular spathe, *Fig*. 101 ; but in the Indian corn it is enclosed by leaves, popularly denominated the husks ; in the Sweet-flag it is naked, and in the Palms it is branched.

CHAPTER XII.

FLOWER.

By Linnæus the Flower and Fruit were classed together, and defined to be a temporary part of vegetables, destined for the reproduction of the species, terminating the old individual, and beginning the new. These constitute the reproductive organs, by which the species have been hitherto preserved from extinction, and by which alone they will be renewed, so long as seed time and harvest continue. "A plant may be destitute of stems, leaves, or even roots, because if one of these parts be wanting, the others may perform its functions, but it can never be destitute of those organs by which its species is propagated. Hence, though many individual plants may be long without blossoms, there are none, so far as nature has been thoroughly investigated, that are not capable, in favourable circumstances, of producing them, as well as seeds; to whose perfection the blossoms themselves are altogether subservient."* No part of the vegetable displays such a variety of colours, or exhales a more pleasant perfume than the flower: it gives to most ornamental plants their greatest charm, and is the peculiar object of the florist's attention. But as we require not the aid of Botany to discover that the perfume is delightful, and the colour rich or gay, so we need not the aid of technical names to express their very obvious qualities. It is conven-

* Smith.

ient for the student who wishes to gain any adequate idea of these organs, to dissect different flowers, and bestow upon each part a separate examination. He will find externally the calyx usually of a green colour, and often wanting; the Corolla, or as it is sometimes termed, the Blossom, assuming various shades of colour, exhibiting a more delicate texture than the preceding, and like it sometimes wanting; the stamens, which are filiform organs arranged interior to the corolla, and are never wanting; and the pistils, arising from the centre of the flower, and containing the rudiments of the fruit.

1. CALYX.

The external covering of the flower, which often serves the purpose of a temporary bud, is denominated the calyx. It secures the more tender organs within it from injury, and probably like the leaves serves to elaborate the sap which goes to the nourishment of the flower stalk. The following are the most important varieties of calyx.

Monophyllous, when it is composed of a single leaf, as in the English Cowslip, *Fig.* 22.

Parted, when divided into segments, by incisions which extend nearly to its base, as in the Lime tree.

Cleft, when divided as in the preceding case, but with incisions less deep, as in the Cherry and Peach trees.

Toothed, when the margin of the calyx is beset with teeth, as in the Soapwort and Pink.

Polyphyllous, *Fig.* 76, when the calyx is composed of several distinct leaves or scales, as in the Magnolia. In all these cases, it is necessary to ascertain the number of the teeth, segments, or leaves, unless they are numerous and indeterminate.

Double, Fig. 84, when it is composed of two distinct rows of leaves or scales which enclose each other, as in the Mallows. If the exterior scales are very small, the calyx is said to be *calyculate.*

Common, Fig. 73, when it encloses several florets, as in the Dandelion and Sun flower.

The calyx is *cylindrical*, as in the Garden Pink ; *prismatic*, in the Monkey-flower ; *urceolate*, as in the Rose ; *ventricose* or inflated, as in the Catch-fly ; *turbinate* or top-shaped, as in the Syringa ; *imbricate, Fig.* 73, as in the Asters ; dry and *scariose*, as in Everlasting ; *hooked*, as in the Burdock ; and *spinous*, in the Thistles. It is *persistent*, in the Syringa, and remains attached to the fruit ; *deciduous*, in the Lime-tree, falling with the other parts of the flower, and *caducous*, in the Poppy, falling before them.

GLUME. *Figs.* 82, 83.—The peculiar Calyx of grasses is denominated *glume*, and the pieces of which it is composed are termed its *valves.*

In studying the grasses it is necessary to observe the number of the valves which compose the calyx, and the number of flowers which the calyx encloses.

SCALE.—In some cases the calyx consists of a mere scale to which the more essential parts of the flower are attached, and by which they are protected previous to their expansion. Several of these scales being attached to a filiform receptacle, constitute the catkin, *Fig.* 71, and when permanent, they at last form a cone, as in the Pines, *Fig.* 72.

For the sake of accurate discrimination, it is sometimes necessary to observe the form of the scale, and also its peculiar arrangement and duration.

"The knowledge of the uses of leaves," says Dr. Smith, "may throw some light upon that of the calyx. Besides protection of the flower from external injuries, which is one evident use of this part, it appears highly probable, that it may often contribute to the growth and strength of the stalk which supports it, as the leaves do to that portion ofthe branch below them. The stalk often swells considerably during the growth of the flower, especially just below the calyx, becoming more woody; an alteration frequently necessary for the support of the ripening fruit. When the calyx falls very early, as in the poppy tribe, I cannot find that the flower-stalk is subsequently enlarged, nor in any manner altered; while in genera without number, whose calyx is permanent, the stalk becomes not only more woody, but often considerably thickened."

Involucre Fig. 62. Nearly allied to the calyx are those leaf-like appendages, which frequently enclose the rays of the Umbel. To these leaves, botanists apply the term Involucre; and by Linnæus they were regarded as a common calyx, placed at a distance from the flowers. He adopted this opinion from necessity rather than choice, being compelled to resort to the involucre, for those characters which are usually derived from the calyx; but this necessity has been removed, and the involucre now ranks as a floral leaf, being restricted by some writers to the umbelliferous plants, and applied by others to similar organs occurring in some of the Cornels and Grasses.

When the leaves arise from the base of the primary branches of the umbel, they constitute the *general involucre*, but when they arise from the base of the secondary branches and enclose the partial umbels, the involucre is said to be *partial*. In Lovage both are present, in Parsnip neither ; and when present, they either entirely invest the peduncle, or are *dimidiate*, being attached to one side, leaving the other naked.

Spathe Fig. 101.—" The Spathe is a floral leaf issuing from the upper extremity of of the stem or scape, and enveloping one or more flowers by the union or convolution of its edges, which open as the flower expands. The term is restricted by some Botanists to such plants only as produce their fructification on a spadix, as the *Arum* or Palms ; but by others it is used with greater latitude, being applied also to the sheath which invests the unexpanded flowers of the Narcissus and similar liliaceous plants, in which application of the term there seems to be no impropriety. Linnæus indeed regarded and arranged the Spathe as a species of calyx ; but for reasons analagous to those excluding the involucre from the rank of calyx, the spathe is excluded from that rank also."*

In Narcissus, it encloses a solitary flower, in Jonquil several, and in *Arum*, it contains an assemblage of sessile flowers surrounding the base of the spadix.

In most cases the spathe consists of a single leaf, which in *Arum triphyllum* is inflected and striped, in *Calla palustris* white and spreading ; spongy and spotted in Skunk's Cabbage ; and membranaceous in Snow drop and in most liliaceous plants.

The leaves which enclose the ears of Indian Corn, (in New England termed the husks) are to be regarded as a singular variety of spathe closely investing the spadix until its seeds are mature.

Bracte or Floral leaf. This is a leaf-like appendage to the Peduncle or flower. When it closely invests

* Keith.

the flower and assumes the appearance of the calyx, it is somewhat difficult to decide, whether it be a bracte or not. In such cases if it falls with the other parts of the flower; it is to be regarded as a calyx, but if it remains attached the the fruit till the leaves begin to fade as in the common Fennel flower *Nigella Damascena*, it is considered to be a bracte.

This organ assumes a great variety of forms, being green in the Orchis, yellowish in the Lime tree, purple in Clary, and scarlet in *Bartsia coccinea* or Painted cup. The coloured bracte of the latter is very conspicuous in our meadows during the spring months, and is usually mistaken for the blossom, which in that plant is without beauty and secluded from our view.

The floral leaf of the Lime tree, *Fig.* 104, serves to distribute the seed; that of the *Atractylis cancellata*, *Fig.* 61, is spinous, and encloses and protects the calyx.

2. COROLLA.

This term is applied to the interior covering of the flower, which is more conspicuous than the calyx, more slender in its fabric, and more richly coloured. It is white in the Blood-root; yellow in the Butter-cups; orange in the Pleurisy-root and *Orchis ciliata;* scarlet in the Cardinal flower; purple in the Crane's-bill; and blue in Borage and Spider-wort.

If the calyx invests a single corolla, as in the Peach and *Convolvulus*, the flower is said to be *simple;* but when it encloses an assemblage of corollas, as in the Dandelion and Thistle, the flower is said to be *compound;* and the individual corallas are denominated *florets.*

The corolla is monopetalous or composed of one coloured leaf as in Stramonium, or is polypetalous being composed of several as in the Pond Lilies and Magnolia. In the former case, we find the tube, the orifice, and the border ; in the latter, the claw by which the petal is attached to the receptacle, and the border, which corresponds to the expansion of the monopetalous corolla. In either case, we find flowers that are regular, *Figs.* 76 and 77, the petals being equal in size and similar in form ; flowers that are unequal, the petals being similar, but of different sizes ; and flowers that are irregular, *Figs.* 79 and 81, the petals or their segments being unequal and dissimilar. The tube is long and slender, as in the sweet-scented *Mirabilis*, or it is twisted as in Periwincle ; the throat is closed as Borage and Comfrey, or it is naked as in Gromwell, and the border or limb is plaited, as in *Convolvulus*, and reflected as in the Lilies. Petals furnished with a claw as in the Pink and wall flower, are said to be *renguiculate.*

A monopetalous corolla is,

Campanulate or bell-shaped as in the Bell-flowers.

Funnel-shaped as in the Stramonium.

Ovate as in Uva-ursi and Partridge berry.

Urceolate or Pitcher shaped, as in Whortle-berry.

Salver-shaped, having a slender tube and flat border, as in Moss Pink and Lichnidia.

Rotate or wheel shaped, as in Loose strife and Borage.

Tubular as in Fever-root and Trumpet Honeysuckle. In the Rotate corolla, the tube, if present, is very short, and in the tubular corolla, there is a deficiency of the border.

Labiate or *Ringent*, *Fig.* 81, when the segments are irregular resembling the lips of an animal. If these lips are closed, as in Snap-dragon and other species of *Antirrhinum*, the Corolla is termed *personate*. In these cases the upper lip is usually concave or vaulted, the other being larger and frequently cleft, but when this arrangement is reversed as in Figwort, the corolla is said to be *resupinate*.

A polypetalous corolla is

Cruciform, when composed of four petals which are arranged in the form of a cross, as in Cabbage and Wall-flower.

Liliaceous, *Fig*. 77 when it is composed of six petals, usually naked, and so arranged as to appear bell-shaped.

Rosaceous, when it consists of five petals which are (usually) inserted into the Calyx, without the intervention of claws, as in the Apple and Rose.

Papilionaceous, *Fig*. 79, when it consists of four petals, irregular and assuming the shape of a butterfly. The Pea furnishes an example, and the large petal which encloses the others is the *Standard*, the two lateral petals are the *Wings*, and the other which is interior and appearing in some instances like the keel of a boat, is denominated the *Keel*.

The florets of a compound flower are *Tubular* as in *Cacalia*, *Fig*. 73, and *Ligulate* or strap shaped as in Dandelion. They not unfrequently both occur in the same flower, as in the Asters.

The petals are usually *deciduous* and fall with the other parts of the flower, sometimes they remain in a *withered* condition, as in the *Orchis* and Cucumber, sometimes they continue fresh and are termed *persistent*, and sometimes they are *caducous* dropping as soon as the flower expands.

" The whole use and physiology of the Corolla have not yet been fully explained. As a protection to the tender and important parts within, especially from wet, its use in many cases is obvious, but by no means in all. Linnæus imagined it to serve as wings, to waft the flower up and down in the air, and so to promote the functions of the Stamens and Pistils, as will hereafter be described; nor is this opinion unfounded.

Sprengel has ingeniously demonstrated, in some hundreds of instances, how the Corolla serves as an attraction to insects, indicating by various marks, and perhaps by its scent, where they may find honey, and accommodating them with a convenient resting place or shelter while they extract it. This elegant and ingenious theory receives confirmation from almost every flower we examine. Proud man is disposed to think that

"Full many a flower is born to blush unseen,"

because he has not deigned to explore it; but we find that even the beauties of the most sequestered wilderness are not made in vain. They have myriads of admirers, attracted by their charms, and rewarded with their treasures, which very treasures would be as useless as the gold of a miser to the plant itself, were they not thus the means of bringing insects about it. The services rendered by such visitants will be understood when we have described all the parts of a flower.

Besides the above purposes, I have always conceived the Corolla to fulfil some important office to the essential parts of the flower with respect to air, and especially light. It not only presents itself in a remarkable manner to the sun-beams, frequently closing or drooping when they are withdrawn, but it is so peculiarly distinguished by beauty or brilliancy of colour, that one cannot but think its functions somewhat different from those of the leaves, even with regard to light itself. And when we consider the elaborate and peculiar secretions of a flower, the elastic and inflammable *pollen*, the honey, and the exquisitely volatile perfume, as we know from the curious discoveries of modern chemistry how great a share light has in the production of such, we cannot but conclude that the petals must be of primary importance with respect to their secretion by its means."*

Like the calyx, the corolla is sometimes wanting, and hence we have the distinction of *naked* and *apetalous* flowers. But it is not always easy to determine when a flower has but one envelope, whether it be a calyx or corolla. The green colour and coarse texture of the former, and the vivid hues and slender fabric of the latter, appear in most cases abundantly sufficient to decide the question. But the calyx is not always green, nor is the corolla always gay and lively; and the exceptions are so numerous as to invalidate every rule established on such a variable basis.

"Another rule of distinction suggested by Ray was, that the corolla is deciduous, and the calyx permanent; and the rule is, no doubt, of pretty general application; but is loaded with far too many exceptions to be a good one. In the Poppy the calyx falls before the blossom, and in the Hyacinth and Star of Bethlehem the corolla is persistent.

It had been an opinion of Cæsalpinus, that the calyx is merely a continuation of the outer bark of the plant or flower-stalk; and upon this foundation Linnæus establishes a test, apparently sufficient to distinguish the calyx from the corolla in all doubtful cases. For, improving upon the notion of Cæsalpinus, he apprehend-

* Dr. Smith.

ed that as the calyx is a continuation of the outer bark of the flower-stalk, so the corolla is a continuation of the inner bark. And hence, if of these two organs only one is present, we have but to ascertain in what part of the bark it originates, in order to say which it is. This summary and decisive test looks indeed very beautiful in theory ; but the observations of the acute and sagacious Hedwig have shown that it is not founded in fact.

Linnæus does not indeed impose it as a rule of practice, being furnished with what he might, perhaps, regard as a better ; though the distinction is both clearly and confidently stated in his work. But it has been since adopted, with all its imperfections upon its head, as the grand test of discrimination in this doubtful case, even by the celebrated Jussieu himself, the first botanist of the present age. In consequence of the adoption of this opinion, Jussieu has been led to regard as a calyx, the beautiful blossom of the Tulip, and other liliaceous plants, which has been, by the common consent of all other botanists whatever, regarded as a corolla."*

The student therefore, who in the study of natural orders, seeks the guidance of that learned naturalist, will bear in mind, that what other writers term the corolla, is the *petaloid calyx* of Jussieu. By applying his own terms as he has defined them, we shall avoid much unnecessary confusion ; and it becomes immaterial whether the splendid blossoms of liliaceous plants rank with the calyx or corolla.† And indeed it has been

* Keith.

† Jussieu has defined the corolla to be that covering of a flower which is invested by the calyx ; rarely naked, being a continuation of the *liber* or inner bark of the flower-stalk, not of the epidermis ; crowning, but not united to the fruit ; its petals or segments usually equalling, and alternating with the stamens.

justly observed, that in these plants the two organs are usually united into one, the exterior being green and coarse like the calyx, and the other delicate and coloured as in the Bethlehem Star.

NECTARY.—This term is applied to that part of the flower " which contains, or which secretes honey." In some instances, it is merely a depression or groove in the tube of the corolla ; in others it is distinct from the petals, being attached to different parts of the flower, and assuming a great variety of shapes.

In the cruciform flowers, the nectary is glandular, and situated at the base of the stamens ; where it may be detected by its green colour. In the Violet and Orchis it is a production of the corolla, assuming the form of a *spur*. The petal to which the spur-shaped nectary is attached is termed *calcarate*.

In *Ranunculus* it is a scale attached to the base of the petal ; and in Nasturtion it is a production of the coloured calyx.

In the Monk's hood the situation as well as the form of these organs is very singular ; one of its petals being concave conceals a pair of *hooded* nectaries, *Fig.* 88, from which a slight pressure causes the honey to exude.

Other appendages are regarded as nectaries, though it has not been ascertained that they secrete or contain honey. One of these is the arch or vault, which closes the orifice of the tubular corolla, as in Borage and Comfrey ; another is the beard, which is very conspicuous in the Iris, *Menyanthes* and Partridge-berry, arising in each case from the inferior surface of the corolla ; another is the corollet, which surmounts the blossoms in the form of a crown. In Narcissus this crown is bell-shaped, its border being in some of the species beautifully tinged with red. The nectary of the Passion-flower, *Fig*. 20, is composed of several filiform appendages, which arise from the base of the flower in three concentric circles, and form a triple " crown of glory."

In the Grasses the nectary is very delicate and often transparent, being filiform in many of the Rushes, *Figs*. 74 and 75, and resembling a scale in other examples: These are the Involucellate filaments, (*Setæ*) frequently described by Mr. Nuttall in his " Genera of North American plants". The same writer has used the term *Lepanthium* to designate the petaloid nectaries of Linnæus. He applies it to the crown of the Narcissus, to the hooded nectaries of the Silkweeds, *Fig*. 87, to the hornlike appendages of the Columbine and Larkspur, and to the singular organs which have been already noticed in the concave petal of the Monk's hood. He also applies it to the nectaries of *Parnassia*, which arise from the petals, and terminate in three filaments, as in *Parnassia Caroliniana* or in several *Fig*. 80, as in *Parnassia palustris*. Each of these filaments is tipped with a yellow summit, which the inexperienced botanist would be apt to confound with the adjacent stamens, but if he traces them to their origin his mistake will be at once corrected. The nectary furnishes a receptacle for the honey which is secreted by the flower ; but there has been much diversity of opinion respecting the uses of this secretion. Some regard it as the food by which the surrounding organs are nourished, or by which the unripe seeds are perfected ; but others, and among them Dr. Smith, believe " that the sole use of the honey with respect to the plant is to tempt insects who in procuring it scatter the dust of the anthers, and fertilize the flower."

3. STAMENS.

These are the slender filiform organs, which occur immediately within the corolla. In the Mountain Balm there are two ; in the Holly there are four ; in the Lily *Fig.* 58 there are six ; in the American Laurel there are ten ; and in the Peach, Magnolia and Rose, there are numerous stamens ; and the number of these, often determines to which of the Linnæan classes any plant belongs. Examined separately, each stamen is usually found to consist of two parts ; the summit or *anther*, and the *filament*, by which it is elevated above the calyx. corolla, or base of the flower ; the former being essential, and the latter a subservient organ, which like the corolla is occasionally wanting.

The *Filaments* are usually smooth and slender ; but in Spider wort they are covered with down ; in Bethlehem star they are lanceolate, and in some few plants they are so expanded as to resemble petals. The broad filaments of one species of *Clematis*, have by some writers been mistaken for the narrow petals of an *Atragene*, but its plumose seeds, and the whole aspect of the plant, establishes its identity with the former. When the filaments are enclosed in the tube of the corolla, they are said to be *inserted*, as in Lichnidea ; *exserted*, when they pass beyond it ; and *declinate* when they curve towards the inferior side of the flower, as in the *Hemerocallis* or Day Lilies.

In the Barberry, the filaments are sensitive, springing forwards towards the centre of the flower, when touched on their inner surface near the base. In all cases they are evidently designed to elevate the anthers above the base of the flower, to expose them to the winds, and like the petiole of the leaf, to facilitate the motion of the organs with which they are connected.

The *anther*, which is the only essential part of the stamen is generally of a membranous texture ; consisting of two cells which open laterally, as in the Lily, or at the summit as in the *Pyrola* and the Heaths. In the stamens of most flowers, each filament is tipped with a solitary anther ; but in *Fumaria*, there are three anthers to each filament, and in the Theobroma, (the plant from which chocolate is procured) there are five. When the stamen is destitute of a filament, the anther is said to be sessile. In Parnassia when the flower first expands, the anthers are all sessile ; but they gradually and successively rise above the germen, in consequence of the growth of their respective filaments. The anthers are said to be connivent, when they approach and even come in contact with each other, as in Violets ; adnate when they are firmly united to the filament ; and versatile, when loosely attached to its summit, and turning with the slightest breath of air.

" The *Pollen* or dust, is contained in the Anther, from which it is thrown out chiefly in dry warm weather, when the coat of the latter contracts and bursts. The Pollen, though to the naked eye a fine powder, light enough to be wafted along by the air, is so curiously formed, and so various in different plants as to be an interesting and popular object for the microscope. Each grain of it is commonly a membranaceous bag, round or angular, rough or smooth, which remains entire till it meets with any moisture, being contrary in this respect to the nature of the anther ; then it bursts with great force, discharging a most subtle vapour. In the Orchis family, and some other plants, the pollen is of a glutinous nature, very different from its natural aspect. This forms yellow elastic masses, (*Pollinia*) often stalked, in each cell of the anther, and the cells are either parallel and close together, or removed from each other to the opposite sides of the style. In *Asclepias*, the pollen is borne in 5 pair of glutinous masses, exactly as in the Orchis, by 5 glands upon the stigma. Some obscurity arises from each mass of pollen being received into a cell, (*Antheridium*) formed by a peculiar valvular apparatus that encircles the organs of impregnation, and bears a great resemblance to stamens."*

4. PISTIL.

Between the stamens we find the pistils, equally essential in the economy of vegetation, and equally necessary to the completion of the flower. In the Lily there is one, and the flower is monogynous ; in grasses, and in the garden Pink, there are two, and the flower is digynous ; in the Elder there are three, and the flower is trigynous ; and in the Magnolia there are several, and the flowers are polygynous. Each pistil consists of three distinct portions, the Ovary or Germen, the Style and the Stigma.

"The *Ovary* or *Germen* is the lower extremity of the pistil, supporting the style and stigma ; and containing the rudiments of the future seed. If it is situated immediately upon the base or receptacle of the flower, as in *Arbutus*, it is said to be sessile ; if it is supported upon a pedicle elevating it above the base of the flower, as in the Poppy and Caperbush, it is

* Smith.

said to be stipitate; if it is situated below the insertion of the calyx, as in the Rose and Apple it is said to be inferior; if it is situated above the insertion of the calyx and enclosed within it, it is said to be superior, as in the Primrose; and if it is situated partly above and partly below the insertion of the calyx, it is said to be semi-superior, as in *Saxifraga nivalis*. In the genus Adoxa it is inferior with regard to the corolla, and half inferior with regard to the calyx.

The figure of the germen is roundish, as in the Cherry; or egg-shaped as in the Pink; or oblong, as in the Goat's-beard; or prism-shaped, as in Wall-flower; or turbinated, as in Fescue-grass; or compressed as in the Vetch. In its structure it is simple, as in the Apple and Pear; or double, as in Galium; or divided into four, as in Labiate flowers. It consists also of one cell, as in the Hazel; or of two, as in Wall flowers; or of several, as in the Spurge and Beech. The surface is generally smooth or slightly pubescent; but sometimes it is set with rough hairs, and sometimes with glands."*

The *Style*, which is a prolongation of the germen, generally arises from its summit, as in the Lily; and sometimes from its side, as in the Rose. It is either *simple*, as in the Tulip; or *multiplicate*, as in the Grasses; in which two styles usually arise from a single germen. In the Cherry it is deciduous, falling with the petals, but in the Geranium it remains attached to the fruit, and is said to be persistent.

At the summit of the style we find the *Stigma*; which is plumose, in the Grasses, *Fig.* 82; petaloid, in the Iris; peltate, in Water Lilies; and radiate, as

* Keith.

in the Poppy. In the two last examples it is sessile, the style being wanting; but the stigma as well as the germen is essential.

5. RECEPTACLE.

That part of the flower by which the others are connected, and to which they are often immediately attached, is denominated the *receptacle* or base. In simple flowers it is inconspicuous and cannot be seen with advantage, until the calyx, the petals, and the other organs are removed; and it is interesting only as the connecting point in which they are all united.

The receptacle of the compound flowers, *Fig*. 100, is more interesting, and in studying the plants of that natural family, we shall find a knowledge of its several varieties very convenient, and often indispensable; for the most satisfactory generic characters have been established on the peculiarity of the common receptacle. It may be examined after the seeds have been scattered by the wind, or if the florets are forcibly removed, the base to which they were attached becomes exposed to our view; the central portion which is more frequently occupied by tubular florets, being called the *disk*, while the margin whose florets are more frequently ligulate, constitutes the *ray*. It is conical and naked as in the Daisy; chaffy and flat as in the Sun-flower; convex as in Tansey; cellular as in the Cotton Thistle; dotted as in the Dandelion; and villose or hairy as in common Thistles.

When the calyx is inserted into the receptacle beneath the Germen, as in the *Parnassia*, *Fig*. 85, it is said to be inferior or detached; and when it is inserted above the germen, *Fig*. 66 as in the Apple and Mock-Orange, it is said to be adherent or superior.

When the Corolla is inserted into the receptacle beneath the germen, as in Foxglove and Stramonium, it is termed *hypogynous*. When it is inserted into the calyx and surrounds the germen, as in the Currant, it is termed *perigynous*, and when it is inserted upon the germen, as in the Trumpet honeysuckle, it is termed *epigynous*.

The stamens are *hypogynous* as in the Poppy and Tulip tree ; *perigynous* as in the Currant and Rose ; and *epigynous* as in Sassaparilla and in the umbelliferous plants. When they arise from the corolla they are said to be *epipetalous*.

A flower furnished with both calyx and corolla is said to be complete ; destitute of a calyx it is said to be naked ; and without a corolla it is *apetalous* or incomplete. When the stamens and pistils both occur in one flower it is perfect or *united ;* when they occur only in different flowers of the same species as in the Indian Corn, the flowers are separated or *diclinious*, that which bears the stamens being unfertile or barren and that with pistils being fertile and bearing the seed. When barren and fertile flowers both occur on the same plant, they are said to be *monœcious*, if they grow on two separate plants as in the Poplar they are *diœcious ;* but when united and separated flowers occur in the same species " making a sort of compound household," they are said to be *polygamous*.

A compound flower has numerous sessile florets situated on a common receptacle and enclosed in a common calyx. These florets are monopetalous and superior, each standing on the germen or seed, and usually five cleft at the summit. They enclose five stamens whose anthers are united into a cylinder, and hence the compound flowers are usually termed *Syngenesious*.

An aggregate flower has a common receptacle whose florets are usually on short stalks and are enclosed in a partial calyx and have their anthers separate. The Scabious, well known in the gardens, and the Teasel, whose hooked seeds are employed by clothiers, furnish examples of the aggregate flower.

The filiform receptacle (*rachis*) of the Grasses, and the common base to which the scales of the catkin are attached, have been noticed in a former chapter; and the columnar receptacle of the *Arum* (*spadix*) furnishes an example of a peculiar variety of inflorescence but not of an aggregate flower.

CHAPTER XIII.*

FUNCTIONS OF THE STAMENS AND PISTILS.

"The Stamens and Pistils of flowers have, from the most remote antiquity, been considered as of great importance in perfecting the fruit. The Date Palm, from time immemorial a primary object of cultivation in the more temperate climates of the globe, bears barren and fertile flowers on separate trees. The ancient Greeks soon discovered that in order to have abundant and well-flavoured fruit, it was expedient to plant both trees near together, or to bring the barren blossoms to those which were to bear fruit; and in this chiefly consisted the culture of that valuable plant. Tournefort tells us that without such assistance dates have no kernel, and are not good food. The same has long been practised, and is continued to this very day in the Levant, upon the *Pistacia* and the Fig.

About the year 1676, Sir Thomas Millington, Savilian Professor at Oxford, is recorded to have hinted to Dr. Grew that the use of the Stamens was probably to perfect and fertilize the seed. Grew adopted the idea, and the great Ray approved it. Pontedera, however, at Padua, an university long famous, but then on the decline, and consequently adverse to all new inquiry and information, in 1720 published his *Anthologia*, quite on the other side of the question.

Linnæus, towards the year 1732, reviewed all that had been done before him, and clearly established the

* This chapter with a few alterations is taken from the "Introduction" of Dr. Smith.

fact so long in dispute. He determined the functions of the Stamens and Pistils, proved these organs to be essential to every plant, and thence conceived the happy idea of using them for the purpose of systematical arrangement. In the latter point his merit was altogether original; in the former he made use of the discoveries and remarks of others, but set them in so new and clear a light, as in a manner to render them his own.

We have already mentioned, the two modes by which plants are multiplied, and have shown the important difference between them. Propagation by seed is the only genuine reproduction of the species, and it now remains to prove that the essential organs of the flower are indispensably requisite for the perfecting of the seed.

Every one must have observed that the flower of a plant always precedes its fruit. To this the Meadow Saffron, *Colchicum autumnale*, seems an objection, the fruit and leaves being perfected in the spring, the blossoms not appearing till autumn; but a due examination will readily ascertain that the seed-bud formed in autumn is the very same which comes to maturity in the following spring. A Pine-apple was once very unexpectedly cited to me as an instance of fruit being formed before the flower, because the green fruit in that instance, as in many others, is almost fully grown before the flowers expand. The seeds however, the essence of the fruit, are only in embryo at this period, just as in the germen of an Apple blossom.

It was very soon ascertained that flowers are invariably furnished with Stamens and Pistils, either in the same individual, or two of the same species, however defective they may be in other parts; of which *Hippu-*

ris, the most simple of all blossoms, is a remarkable example. Few botanists indeed had detected them in the *Lemna* or Duckweed, so abundant on the surface of still waters, and Valisneri alone for a long time engrossed the honour of having seen them. In our days however they rewarded the researches of the indefatigable Ehrhart in Germany, and on being sought with equal acuteness, were found in England.

Plants indeed have occasionally abortive stamens in one flower and barren pistils in another, and the Plantain-tree, *Musa*, is described by Linnæus as having five out of its six stamens perfected in such blossoms as ripen no fruit, while those with a fertile germen contain only a single ripe stamen, five being ineffective. This only shows the resources, the wisdom, and the infinite variety of the creation. When the roots are luxuriantly prolific, the flowers are in some measure defective. Nature, relaxing as it were from her usual solicitude, and allowing her children to repose, and indulge in the abundance of good things about them. But when want threatens, she instantly takes the alarm ; all her energies are exerted to secure the future progeny, even at the hazard of the parent stock, and to send them abroad to colonise more favourable situations.

Most generally the access of the pollen is not trusted to any accidental modes of conveyance, however numerous, elaborate, and if we may so express it, ingenious, such modes may be ; but the Stamens are for greater security lodged in the same flower, under the protection of the same silken veils, or more substantial guards, which shelter their appropriate pistils. This is the case with the majority of our herbs and shrubs, and even with the trees of hot countries, whose leaves being always present might impede the passage of the pollen.

On the contrary, the trees of cold climates have generally separated flowers, blossoming before the leaves come forth, and in a windy season of the year ; while those which blossom later, as the Oak, are either peculiarly frequented by insects, or, like the numerous kinds of Fir, have leaves so little in the way, and pollen so excessively abundant that impregnation can scarcely fail.

The pollen and the stigma are always in perfection at the same time, the latter commonly withering and falling off a little after the anthers, though the style may remain to become an ufeful appendage to the fruit. The Pansy, the *Martynia*, and many plants besides, have been observed to be furnished with a stigma gaping only at the time when the pollen is ripe. The beautiful Jacobean Lily, *Amaryllis formosissima*, is justly described by Linnæus as provided with a drop of clear liquid, which protrudes every morning from the stigma, and about noon seems almost ready to fall to the ground. It is however re-absorbed in the afternoon, having received the pollen whose vapour renders it turbid, and whose minute husks afterwards remain upon the stigma. The same phenomenon takes place several successive days.

In opposition to similar facts, proving the synchronous operation of these organs, Pontedera has, with more observation than usual, remarked that in the umbelliferous tribe the style frequently does not appear till the anthers are fallen. But he ought to have perceived that the stigma is previously perfected, and that the style seems to grow out afterwards, in a recurved and divaricated form, for the purpose of providing hooks to the seeds. It is also observable that in this family the several organs are sometimes brought to perfection in different flowers at different times, so that the anthers of one may impregnate the stigmas of another, whose stamens were abortive, or long since withered. The same thing happens in other instances. Linnæus mentions the *Jatropha urens* as producing flowers with stamens some weeks in general before or after the others. Hence he obtained no seed till he preserved the pollen a month or more in paper, and scattered it on a few stigmas then in perfection. There can be no doubt that, in a wild state, some or other of the two kinds of blossoms are ripe together, throughout the flowering season, on different trees.

A similar experiment to that just mentioned was made in 1749 upon a Palm-tree at Berlin, which for want of pollen had never brought any fruit to perfection. A branch of barren flowers was sent by the post from Leipsic, twenty German miles distant, and suspended over the pistils. Consequently abundance of fruit was ripened, and many young plants raised from the seeds.

Tournefort and Pontedera supposed the pollen to be of an excrementitious nature, and thrown off as superfluous. But its being so curiously and distinctly organized in every plant, and producing a peculiar vapour on the accession of moisture, shows, beyond contradiction, that it has functions to perform after it has left the anther. The same writers conceived that the stamens might possibly secrete something to circulate from them to the young seeds; an hypothesis totally subverted by every flower with separated organs, whose stamens could circulate nothing to germens on a different branch or root; a difficulty which the judicious Tournefort perceived, and was candid enough to allow.

Both the conjectures just mentioned vanish before one luminous experiment of Linnæus, of all others the most easy to repeat and to understand. He removed the anthers from a flower of *Glaucium phœniceum;* stripping off the rest of that day's blossoms. Another morning he repeated the same practice, only sprinkling the stigma of that blossom, which he had last deprived of its own stamens, with the pollen from another. The flower first mutilated produced no fruit, but the second afforded very perfect seed. His design was to prevent any one in future from believing that the removal of the anthers from a flower was in itself capable of rendering the germen abortive.

The usual proportion and situation of stamens with respect to pistils is well worthy of notice. The former are generally shortest in drooping flowers, longest in erect ones. The barren blossoms usually stand above the fertile ones, (and no plant is better calculated to exhibit this arrangement than the Indian Corn) that the pollen may fall on the stigmas. This is the more remarkable, as the usual order of Nature seems in such plants, as well indeed as in compound, and even in umbelliferous flowers, to be reversed, for the pistils are invariably central, or internal, in every simple flower, and would therefore, if drawn out into a monœcious spike, be above the stamens.

Many curious contrivances of Nature serve to bring the anthers and stigmas together. In *Gloriosa*, the style is bent, at a right angle from the very base, for this evident purpose. In *Saxifraga*, and *Parnassia*, the stamens lean one or two at a time over the stigma, retiring after they have shed their pollen, and giving place to others; which wonderful economy is very striking in the garden Rue, whose stout and firm filaments cannot be disturbed from the posture in which they may happen to be, and evince a spontaneous movement, unaffected by external causes. The five filaments of the Cock's-comb, are connected at their lower part by a membranous web, which in moist weather is relaxed, and the stamens spread for shelter under the concave lobes of the corolla. When the air is dry, the contraction of the membrane brings them together, to scatter their pollen in the centre of the flower. The elastic filaments of *Parietaria*, for a while restrained by the calyx, as those of the lovely *Kalmia*, are by the minute pouches in the corolla, relieve themselves by an elastic spring, which in both instances serves to dash the pollen with great force upon the stigma.

But of all the flowers, that of the Barberry-bush is most worthy the attention of a curious physiologist. In this the six stamens, spreading moderately, are sheltered under the concave tip of the petals, till some extraneous body, as the feet or trunk of an insect in search of honey, touches the inner part of each filament near the bottom. The irritability of that part is such, that the filament immediately contracts there, and consequently strikes its anther, full of pollen, against the stigma. Any other part of the filament may be touched without this effect, provided no concussion be given to the whole. After a while the filament retires gradually, and may again be stimulated ; and when each petal, with its annexed filament, is fallen to the ground, the latter on being touched shows as much sensibility as ever.

I have already mentioned that any moisture causes the pollen to explode, consequently its purpose is liable to be frustrated by rain or heavy dews. Linnæus observes that husbandmen find their crops of rye to suffer more from this cause than barley, because in the latter the anthers are more protected by the husks ; and the Juniper-berries are sparingly, or not at all, produced in Sweden when the flowering season has been wet. The same great observer also remarks, what yearly experience confirms, that Cherry-trees are more certainly fruitful than Pear-trees, because in the former the opening of the anthers is, in each blossom, much more progressive, so that a longer period elapses for the accomplishment of the fertilization of the germen, and there is consequently less chance of its being hindered by a few showers.

To guard against the hurtful influence of nocturnal dews or drenching rains, most flowers either fold their petals together, or hang down their heads, when the sun does not shine; by which, their internal organs are sheltered. In some which always droop, as the Snowdrops, the Fritillary, the Crown Imperial, various species of *Campanula*, and others, while the over-shadowing corolla keeps off rain, the air has free access underneath to blow the pollen to the stigma. Nor is this drooping caused by the weight of the flowers, for the fruit in most of them is much heavier, and yet stands erect on the very same stalk. The papilionaceous flowers in general spread their wings in fine weather, admitting the sun and air to the parts within, whereas many of them not only close their petals at night, but also derive additional protection from the green leaves of the plant folding closely about them. The common Bindweed, as well as the *Anagallis arvensis*, and many others, are well known to shut up their flowers against the approach of rain; whence the *Anagallis* has been called the Poor Man's Weather-glass. It has been observed by Linnæus that flowers lose this fine sensibility, either after the anthers have performed their office, or when deprived of them artificially; nor do I doubt the fact. I have had reason to think that, during a long continuance of wet, the sensibility of the *Anagallis* is sometimes exhausted ; and it is evident that very heavy thunder-showers often take such flowers by surprise, the previous state of the atmosphere not having been such as to give them due warning.

That parts of vegetables not only lose their irritability, but even their vital principle, in consequence of having accomplished the ends of their being, appears from an experiment of Linnæus upon Hemp. This is a diœcious plant, and Linnæus kept several fertile-flowered individuals in separate apartments from the barren ones, in order to try whether they could perfect their seeds without the aid of pollen. Some few however remained with the barren-flowered plants, and these ripened seed in due time, their stigmas having faded and withered soon after they had received the pollen. On the contrary, the stigmas which had been out of its reach continued green and vigorous, as if in vain expectation, nor did they begin to fade till they had thus lasted for a very long while. Since I read the history of this experiment, I have found it easy in many plants to tell by the appearance of the stigma whether the seed be fertilized or not. The above experiment is the more important as the abbe Spallanzani has recorded one made by himself upon the same species of plant, with a contrary result. But as he has said nothing of the appearance of the stigmas, his experiment must yield to that of Linnæus in point of accuracy ; and even if his account be otherwise correct, the result is easily explained. Hemp, Spinach, some Nettles, &c. naturally diœcious, are occasionally not completely so, a few latent barren or fertile flowers being frequently found among those of the other sort, by which provision is made against accidents, and the perfecting of a few seeds, at any rate secured.

In general, germens whose stigmas have not received the pollen wither away without swelling at all, but some grow to a considerable size, and in such the substance of the seed, its skin, and even its cotyledons, are often to be found, the embryo only being wanting. In a Melon or Cucumber it is common to find, among numerous perfect seeds, many mere unimpregnated husks. Gardeners formerly attempted to assist Nature by stripping off the barren flowers of Melons and Cucumbers, which, having no germen, they found could not come to fruit, and were, therefore, as they supposed, an unnecessary encumbrance to the constitution of the parent plant. But finding they thus obtained no fruit at all, they soon learned the wiser practice of admitting air as often as possible to the flowering plants, for the purpose of blowing the pollen from one blossom to the other, and even to gather the barren kind and place it over that destined to bear fruit.

The œconomy of various aquatic plants throws great light upon the subject before us. Different species of *Potamogeton* Pondweed, float entirely under water, often at some considerable depth, till the flowering season arrives, when they rise near the surface, and throw up their flowering spikes above it, sinking afterwards to ripen and sow their seeds at the bottom. The White Water Lily *Nymphæa alba*, is very truly described by Linnæus as closing its flowers in the afternoon and laying them down upon the surface of the water till morning, when it raises and expands them, often, in a bright day, to several inches above the water. And to use the language of Alpinus the celebrated stories of the *Lotus* turning to the sun, closing its flowers and sinking under water, at night, and rising again in the morning, are conformable to what every body has observed in the *Nymphæa*.

But the most memorable of aquatic plants is the *Valisneria* which grows at the bottoms of ditches in Italy, and is not unfrequently found in the rivers of the United States. In this the fertile flowers stand on long spiral stalks, and these by uncoiling elevate them to the surface of the water, where the calyx expands in the open air. In the mean while plenty of barren flowers are produced on a distinct root, on short straight stalks, from which they rise like separate white bubbles, suddenly expanding when they reach the surface, and floating about it in such abundance as to cover it entirely. Thus their pollen is scattered over the stigmas of the first-mentioned blossoms, whose stalks soon afterwards resume their spiral figure, and the fruit comes to maturity at the bottom of the water. All this Micheli has described, without being aware of its final purpose ; so different is it to observe and to reason !

Some aquatic vegetables, which blossom under water, seem to have a peculiar kind of glutinous pollen, destined to perform its office in that situation.

The fertilization of the Fig is accomplished in a striking manner by insects, as is that of the real Sycamore, *Ficus Sycomorus*. In this genus the green fruit is a hollow common calyx, or rather receptacle, lined with various flowers seldom both barren and fertile in the same fig. This receptacle has only a very small orifice at the summit. The seeds therefore would not in general be perfected were it not for certain minute flies continually fluttering from one fig to the other, all covered with pollen, and depositing their eggs within the cavity.

The stamens and pistils of the *Aristolochia Clematitis* are enclosed in its globular base, the anthers being under the stigma, and by no means commodiously situated for conveying their pollen to it. This therefore is accomplished by an insect, which enters the flower by the tubular part. But that part being thickly lined with inflexed hairs, though the fly enters easily, its return is totally impeded, till the corolla fades, when the hairs lie flat against the sides, and allow the captive to escape. In the mean while the insect, continually struggling for liberty, and pacing his prison round and round, has brushed the pollen about the stigma.

The ways in which insects serve the same purpose are innumerable. These active little beings are peculiarly busy about flowers in bright sunny weather, when every blossom is expanded, the pollen in perfection, and all the powers of vegetation in their greatest vigour. Then we see the rough sides and legs of the bee laden with the golden dust which it shakes off, and collects anew, in its visits to the honeyed stores inviting it on every side. All Nature is then alive, and a thousand wise ends are accomplished by innumerable means that "seeing we perceive not;" for though in the abundance of creation there seems to be a waste, yet in proportion as we understand the subject we find the more reason to conclude that nothing is made in vain."

It is well known that in consequence of cultivation, the stamens are often converted into petals, and the preceding observations teach us why full or double flowers are so rarely fertile. They teach us too, why the botanist, who studies the character of the plant in the essential organs of the flower, flies from the gaudy productions of the garden, in which those organs are obliterated, to the modest but more interesting ornaments of the field. It has been observed that the flowers of Grasses and other plants, whose seeds are employed as food, though nourished by the richest soil, never become double. In this respect they are very unlike those blossoms which are cultivated for ornamental purposes.

CHAPTER XIV.

FRUIT.

After the fertilization of the flower, the calyx, petals, stamens, and style, usually begin to fade. The germen however remains attached to the plant, continues to expand until it reaches maturity, and then it constitutes the Fruit. This term, which in common language is employed in a more limited sense, denotes seed vessels of every description, and seeds, whether naked or enclosed in a pericarp. It is either simple, as in the Currant; or multiplicate, as in the Labiate plants. Its covering is merely a thin epidermis, as in the Apple, a bark, as in the Orange, or a shell, as in the Filbert.

1. SEED VESSELS.

The Pericarp or seed vessel is designed to convey nourishment to the seed, to enclose and defend it from injury, while recent, and when ripe to liberate, and often to scatter its contents to a distance.

It often separates spontaneously into several distinct portions or *valves*, whose number, though constant in the same species, is various in different plants. When the valves are detached, we find a central pillar or column, which is denominated the axis of the fruit, and is sometimes the receptacle of the seed. These valves when united, either form one entire cavity, as in the Garden Pink; or several, as in the Stramonium, whose seed vessels are divided by several transverse *partitions*, and form four distinct *cells*. The partitions sometimes arise from the margin of the valves, sometimes from the inner surface, sometimes from the central column, and sometimes they are formed by the inflection of the borders of the valves.

When the cell or the seed vessel contains one seed, it is *monospermous;* if two, it is *dispermous;* if many, it is *polyspermous.*

The following are the most important varieties of the pericarp.

Capsule, *Fig.* 89 This is a dry membranaceous or woody seed-vessel, usually separating when ripe into a determinate number of valves. The Iris furnishes an example. The peculiar capsule of the Ash and Maple, *Fig.* 90, which is winged, but destitute of valves, is denominated by Gærtner, *Samara;* and the capsule of the Silk-weeds having one cell and a solitary valve, is denominated *follicle;* both terms however are considered unnecessary.

Silique, *Fig.* 97. This is a long dry seed vessel, formed of two valves separated by an intervening membranous partition, to which the seeds are attached, as in cruciform flowers. When the silique is very short, as in Shepherd's-purse, *Fig.* 75, it is denominated *silicle.*

Legume, *Fig.* 99. This is composed of two oblong valves without any intervening partition, and its seeds are usually attached to one of its margins, as in the common Pea. In the Tamarind it is filled with pulp, in which the seeds are enveloped. When a legume is internally divided by several transverse partitions into cells, and has valves which do not finally separate, as in Hedysarum, it is denominated a *Loment.* But many writers do not employ the latter term.

Pome, Fig. 93. The Pome or Apple is a pulpy seed vessel, without valves, and enclosing a capsule. The Apple and Pear are examples.

Berry, Fig. 91. This is a pulpy seed vessel, containing one or more seeds enveloped in the pulp. It becomes soft and juicy, as it approaches maturity, in which respect it differs from the capsule ; and though when young it is sometimes difficult to distinguish them, the distinction is made with ease when they have become fully ripe. The Orange and Lemon are regarded as berries with a thick coat ; and the Melon, Cucumber, and Gourd, are usually considered as varieties of the Berry ; though Gærtner separated them, and applied a different name, (*Pepo.*)

Externally the Apple and Berry are alike, but in the interior of the latter we find no capsule to separate the seeds from the pulp of the fruit, they being imbedded in its substance as in the Gooseberry and Currant. Such is the texture and arrangement of most berries but in the Linnæa and *Trientalis* the berry is dry and juiceless, and is distinguished from the capsule only by its want of valves. When several berries each with one seed are united together as in the common Raspberry, they constitute the compound berry. There are several spurious kinds of berries whose pulp is not properly a part of the fruit, but originates from some other organ. Thus in the Mulberry as well as in the Strawberry Spinach, the calyx after flowering becomes coloured and very juicy, investing the seed like a genuine berry.

In the Juniper a few scales of the fertile Catkin become succulent and coalesce into a globular berry with three or more seeds, and in the Yew ; some have thought it a calyx, others a peculiar kind of receptacle, which becomes red and pulpy embracing the seed. In the Strawberry, *Fig.* 96, what is commonly called the berry, is a pulpy receptacle studded with naked seeds. In the Fig, the whole fruit is a juicy calyx, or rather common receptacle, containing in its cavity innumerable florets, each of which has a proper calyx of its own that becomes pulpy and invests the seed, as in its near relation, the Mulberry. The paper Mulberry of China is indeed an intermediate genus between the two, being as it were a Fig laid open but without any pulp in the common receptacle."*

Nut, Fig. 94.—The nut is distinguished by its hard firm texture from the preceding varieties of seed vessels. It rarely separates into valves, and never spontaneously separates into more than two pieces. The Filbert and Chesnut are well known examples of nuts, one enclosed in a leaf-like and the other in a prickly calyx.

Drupe, Fig. 92.— Sometimes the nut is enclosed in pulp, forming a seed vessel which externally resembles the berry, and is denominated the drupe. The Cherry and Peach furnish examples. Sometimes the shell of the Drupe is separable into distant parts, each enclosing a seed ; each division is termed *Pyrena ;* and hence we find fruit described as dipyrenous, tripyrenous &c, according to the number of parts into which it is subdivided.

Strobile, Fig. 72.—The Strobile or cone is the common receptacle and scales of the Catkin, indurated and much enlarged as in the Pine, being usually conical, ovate or spherical. " In the mature state of the fruit, the scales, which are now closely imbricated, cover the

* Smith.

seeds or nuts so completely as to assume the appearance of forming only one compact whole, and thus the strobile hangs upon the tree during the whole of the winter season, protecting the enclosed scales ; but the heats of the succeeding summer have no sooner arrived than the scales, formerly close and compact, begin now to shrink and separate, detaching themselves from one another by the whole of their connected surface, and thus forming a passage for the discharge of the seeds."

Occasionally the pericarp is wanting, when the seeds are said to be naked. This however is not in all cases strictly true, for they are frequently enclosed in the permanent calyx; which supplies the deficiency of an additional capsule.

2. SEEDS.

We have in the course of our inquiry seen the bud, designed during the winter to protect the rudiments of the flower ; we have seen all the efforts of the last named organ directed to the security and fertility of the germen, and we have seen how admirably this germen is planned for the protection of the unripe seeds.

The seed therefore, to which all the other parts of the fructification are subservient, next presents itself to our view. On this subject, botanists look to the excellent Gærtner for instruction ; for his work "presents a most finished model of analysis, and at the same time exhibits the most durable monument that could have been erected, of the indefatigable industry and profound research of its author : so minute in his investigations that nothing has escaped him, and so faithful in his delineations that no one has ever surpassed him."

The unripe seed is attached to its receptacle by a system of vessels which convey to it nourishment sufficient to effect the developement of its different parts. When the seed reaches its maturity these vessels are broken, and the place to which they were attached remains conspicuous on the surface of most seeds. It is denominated the Scar, (*Hilum*,) and near it we frequently find a minute orifice through which the water is absorbed during germination.

The exterior coat of the seed (*Testa*) is usually firm; and being formed previous to the internal organs, it communicates to them its peculiar figure. In the mature Apple it is brown, in the common Bean it is white, in the Indian corn it is straw-coloured and glossy, in the Rice it is pellucid, and in the Fumitory it is black and shining. During germination this integument bursts in consequence of the enlargement of its contents. It is not unfrequently lined with a delicate membrane which more immediately invests the enclosed organs, being in some cases entirely distinct from the exterior covering of the seed, and often inconspicuous, in consequence of its intimate union with the adjacent parts. In examining the internal structure or kernel of the seed, we find, what botanists denominate, the Albumen, Vitellus, Cotyledons and Embryo.

The *Albumen*, so named from its resemblance to the white of a boiled egg, occurs in many seeds, and is particularly abundant in the Grasses, Lilies and Palms. It often encloses the Embryo, and has, by some writers, been denominated the *Perisperm*, in allusion to its peculiar situation, but in many cases this name is not appropriate. During germination the albumen is dissolved, and converted into the first aliment of the young plant. It is according to Gærtner, always distinct from the embryo, and easily detached from it, being *external* in the umbelliferous plants, *internal* as in *Mirabilis*, and *unilateral* as in Knotgrass and Pink.

It is *farinaceous* as in Mirabilis and in most of the Grasses, and constitutes the nutritive portion of grain. Seeds with this kind of albumen frequently have the embryo external, and as they contain no oil, they never become rancid. More frequently the albumen is *carnose* or fleshy, as in the Lime tree ; and sometimes it is *corneous*, being very hard, and resembling a horn. "It is wanting in several tribes of plants, as those with compound or with cruciform flowers, and the Cucumber or Gourd kind, according to Gærtner. Some few leguminous plants have it, and a great number of others which, like them, have cotyledons besides. We are not however to suppose that so important an organ is altogether wanting, even in the above mentioned plants. The farinaceous matter, destined to nourish their embryos, is unquestionably lodged in their cotyledons, whose sweet taste as they begin to germinate, often evinces its presence, and that it has undergone the same chemical change as in Barley. The albumen of the Nutmeg is remarkable for its eroded variegated appearance, and aromatic quality ; the cotyledons of this seed are very small."*

Vitellus.—This occurs between the embryo and albumen, and is so closely connected with the former, that it cannot easily be detached. It does not escape from the shell during germination, nor does it become a seminal leaf, but like the albumen it is entirely converted into the nourishment of the young plant. In some of the aquatic plants *Ceratophyllum* and *Nelumbo*

* Smith.

it more resembles the cotyledons, but as it remains enclosed in the seed during germination it is regarded as a vitellus.

" The hypogean or sub-terrestrial cotyledons, are not to be passed over unnoticed ; for although on account of their regular form, and the radicle being always placed without the lobes, and not covered by their substance, they neither can, nor ought to be separated from the rest of the true cotyledons ; yet on account of their incapacity for germinating and the coalition of their lobes into one body, as in the Horse Chesnut, they differ so very little from the vitellus, that there is the closest bond of affinity between these parts ; and in general, nature, in producing these parts of the seeds, seems to proceed from the very simple texture of the albumen, insensibly to the more organic structure of the vitellus, and from this to the more perfect fabric of the cotyledons."*

In the Grasses, this organ assumes a different form ; and appears like a mere scale, to which the embryo is attached on one side, and the albumen on the other.

The *Cotyledons*, are that portion of the seed which encloses the embryo, and during germination, appear in the form of leaves above the surface of the ground, *Fig.* 110. Each seed is usually furnished with two cotyledons, but in the Hemlock, *Pinus Canadensis*, there are three, and in other species of Pine they are still more numerous. In some cases the seed is said to contain but one cotyledon, and the Grasses and Lilies are referred to as examples ; in others it is said to be without lobes, and the Mosses, and other imperfect plants are of the number. On this subject, however,

* Gærtner.

botanists maintain very discordant opinions. Willdenow defines the cotyledons to be the entire substance of the seed; not including the embryo. "Nature" he says "provided plants with their cotyledons, that they might nourish the young plant in its tender infancy. Never yet have I noticed a single instance where this wise measure of nature was omitted. I examined purposely all those plants which were said to want the cotyledons, and always met with them. That in some plants the existence of the cotyledons was altogether denied, and others were said to have one only, others two, and several plants more than two, arose partly from inaccurate observation, partly from mistaking a plant of the embryo for a cotyledon."

Willdenow obviously includes in his idea of cotyledons the vitellus which most writers regard and describe as distinct. They rarely occur in the same seed, and it is probable that the latter is designed to supply the place of the former, until the first leaf of the young plant is unfolded; and that the number of cotyledons, though constant in the same, is various in different seeds.

The *Embryo*, by Linnæus denominated the *Corcle* is the most essential part of the seed, to which the others are subservient, and without which it cannot be made to vegetate. It is usually central, being enclosed by the lobes or albumen, as in the umbelliferous plants, or it is excentric as in Coffee, and external as in the Grasses; it is straight as in the Apple; curved as in the Kidney Bean, *Fig*. 111; erect as in the Dandelion; reversed as in Parsnip; oblique as in Persimmon, *Fig*. 108; and horizontal as in the Date Palm. Each embryo is composed of two portions, the *rostel* or radicle which is first evolved during germination, and the *plumule* or plumelet which rises above the ground and forms the stem and the herbage.

There are various appendages to the seed, of which the following are particularly worthy of notice.

Pellicle.—This adheres closely to the surface of some seeds so as to conceal their colour entirely from our view, as in Convolvulus.

Arillus.—This is a partial or entire covering of the seed attached merely to its base. It is soft and pulpy in Euonymus, membranaceous and elastic in the Sorrel, cariaceous and divided in the Nutmeg, and like paper in Coffee. Mace which envelopes the Nutmeg forms a *partial* arillus, but the minute seeds of the Orchis are completely invested by a similar coat, giving them a light and chaffy appearance. To this head Dr. Smith refers the loose husky covering which invests the seeds of *Carex* which has besides this, an additional coat not found in the seeds of other grasses.

Pappus or *Down.**—This term is applied to the chaffy, feathery or hairy crown of many naked seeds arising from the partial calyx, and remaining till the blossom has faded.

In the Dandelion and Salsify it is elevated on a stalk and termed stipitate ; in the Thistle it is sessile ; in the Cacalia it is pilose resembling hairs ; and in Salsify it is plumose or feathery. In Burr Marygold it is formed of several barbed bristles which cling to our clothes as soon as the seeds are mature. " The use of this organ," says Dr. Smith, " is evidently to transport seeds to a distance from their native spot, either by resigning them to the power of the wind, or by attaching them

* The French, and some English writers copying them, term it Aigrette.

to the shaggy coats of animals. In due time the feathery down separates and leaves the seed behind it, which happens sooner in the Thistle than in most other plants, and hence the vacant down of that genus is frequently seen wafted in light masses over a whole country, which has not escaped the notice of Poets."

Some writers apply the same term to the feathery crown of seeds which are enclosed in a capsule, as in the Oleander and Silk-weeds, and to the down which envelopes the seeds of the Cotton grass and Willows. Similar to these is the down which covers the seeds of the Cotton Plant, and is enclosed like that of the Silk-weed in a Capsule, which opens as the seeds are matured.

Tail, *Fig*. 105.—This is the permanent style which remains attached to some seeds, and assumes a feathery or hairy appearance as in the Traveller's Joy and other species of *Clematis*.

Beak, *Fig*. 102.—This term is applied to an elongation of the seed vessel, as in *Geranium*, Crane's-bill, and to the slender summit of some naked seeds as in Sweet Cicily and other umbelliferous plants.

Awn, *Fig*. 63.—The awn is usually an appendage to the flower and seeds of grasses, but is sometimes applied to the beak of naked seeds. It is usually attached to the corolla, and arises from its base as in Foxtail Grass, or from its extremity as in Rye ; being straight as in Hair-grass, contorted and spiral as in the Oat, and plumose in the Feather-grass. The contorted Awn possesses the property of an hygrometer, coiling in dry weather and again extending itself when the atmosphere is filled with vapour.

Wing.—This is a membraneous appendage to seeds or their capsules, *Fig*. 90. The Catalpa furnishes an example of the latter, and the Ash and Maple of the former. The seeds of *Bignonia*, present still more perfect examples of winged seeds, enclosed in a capsule, and the naked seeds of many umbellate plants have an *alated* or winged margin.

Seeds are sometimes furnished with spines, hooks, and various other appendages all designed for their security while living, and for their subsequent dispersion.

" In general, however, smoothness is characteristic of a seed, by which it best makes its way into the soft earth, though it is sometimes barbed, or at least its covering, as in the Feather grass, that it may not easily be withdrawn again by the powerful feathery appendage of that plant, which after having by its circumvolutions forced the seed deeper and deeper, breaks off a joint, and flies away."*

The *Dispersion* of seeds is so intimately connected with these appendages. that the examination of the one imperceptibly leads to the contemplation of the other. Destitute of this inherent power, they would fall around the parent stem in such a situation as to prevent their growth, and probably to terminate the existence of the tribe. The means of dispersion are all too curious, and the subject is too important to be passed by unnoticed.

Water is one of the vehicles by which they are conveyed to a distance from their original habitation.

By the currents of the ocean, the seeds of West India vegetables are frequently conveyed to the coast of Norway where they refuse to grow merely in consequence of the unfavourable climate in which they are deposited.

* Smith.

In this way the plants of Germany find access to Sweden, and those of Spain and France are scattered over the shores of England.

In these cases the difference of climate is not so great as to prevent the growth of seeds which have thus emigrated from their native country. On the banks of the Connecticut we frequently meet with plants which probably descended with its current from the mountains among which it takes its rise ; plants whose seeds ripened in Canada, and emigrated to a more temperate climate.

Winds also contribute to the dissemination of seeds. We have seen how well many of them are adapted to expose a large surface to its action, and we have often observed them sailing through the air, in pursuit of a new and distant home. It is scarcely necessary to refer to the winged capsules of the Maple and the Ash, which, in connexion with the seeds are propelled by the wind to a distance from their respective trees. Nor is it necessary to say how effectually the same object is secured by the winged seeds of the Catalpa and Pine, which, in a similar way are elevated and propelled through the air.

Some seeds, like those of the *Staphylea*, are enclosed in an inflated calyx, more resembling a balloon than a sail, but equally effectual in diffusing over the globe the seeds which they enclose. But the feathery crown which invests the seeds of Compound flowers affords a more beautiful specimen of mechanism than any of these, and it is brought into operation through the agency of dry air at the very moment best suited for their dispersion. Aided by this, the *Erigeron* of Canada has travelled from America to Europe, and thence it has been diffused over the eastern continent.

Aided also by this, the Dandelion, a native of Europe, has diffused itself over every part of our country; neither impeded by the broadest rivers nor intercepted by the loftiest mountains, it has already passed the Allegany and become a tenant of the woods of Ohio. The minuteness of some seeds facilitates their dispersion by the wind, and it is found that those which are most minute are most extensively diffused. It is chiefly on this account that Mosses and Ferns are more widely scattered than those whose seeds are large. Swartz found in Jamaica the same Moss which he had been accustomed to gather when climbing the mountains of Europe, and there too the same Ferns which he had frequently seen in France, though the other plants were all new and peculiar.

Indeed, it seems that there is no place so remote, but seeds like these are capable of reaching it; no mountain so high, but they lodge on its very summit; no cavern so deep, but they penetrate its unmeasured recesses; where, surrounded by many impediments to vegetation, they germinate, and at last fill the atmosphere with the seeds of another race.

When the seeds of Balsamine are ripe, the capsule suddenly opens, and scatters its contents abroad; and the seeds of the common Crane's-bill are thrown to a distance, by the elasticity of the beak, to the base of which they are attached.

The seed-vessels usually open when the atmosphere is dry, and the sky unclouded, that no vapour may collect on the wings of the seed, and impede its progress. But to this rule the Ice-plant furnishes a remarkable exception. The ornament of a sandy desert, where few other plants are capable of existence, its seeds would be planted in vain, if at an untimely season ; and accordingly its capsules open, when the rain would cause others to close ; and its seeds are dispersed at the only time when their germination could be effected.

Here too we should mention the seed of the Walking or Animated Oat, *Avena sterilis*, whose awn is made to move by the slightest variation of atmospheric vapour. It is not unfrequently found at a distance from where it was originally deposited, marching with constant step till it has penetrated the earth ; and even then its progress is arrested only by the equal moisture, which causes its seed to germinate, and fixes it to the soil.

Allied to the Walking Oat—equally alive to the varieties of moisture, is the beak of the *Erodium moschatum*, or Musk Geranium. While it remains attached to the style, it is straight, but coils up after it is ripened, whenever it is placed in a dry situation ; but water has the power of extending it to its former shape. The hairs with which the seed is invested, facilitate its entrance into the earth, and prevent its return ; so that the whole economy of the seed is too curious to be overlooked.

The fruit of many plants being the food of animals, they in various ways scatter the seeds abroad. The Squirrel fills his storehouses with a stock of winter's food ; but he is either destroyed, or forgets where his treasures were deposited, till they are no longer desirable food. Here his nuts are permitted to germinate, and the very means which threatened to destroy, are made to preserve the trees to which they belong. Birds also lay up a store of food for themselves and their young. While the Hollanders were in possession of the Spice Islands, they endeavoured to destroy the Nutmegs which they could not defend; and before they relinquished any of their possessions, they carefully rooted out this, their most valuable production. But notwithstanding the vigilance and the jealousy of the Dutch, birds disseminated the seeds of the Nutmeg over these very islands, evidently indicating, that nature will not acknowledge the improper restrictions, which man would make supreme.

The hooks of the Sanicle and Cleavers attached to the fleeces of the flock, are frequently carried to a distant town, where they germinate and grow. "When young," says Mirbel, "I accompanied Raymond in his excursion to the Pyrenees, where that learned naturalist pointed out to me these deserters from the plains below. They grew on the remains of ruined hovels, where they kept their stations in defiance of the severity of the winters, and remained as memorials to attest the former presence of man and his flocks."

The seeds of aquatic vegetables adhere to the feathers of the birds who visit them, till at last they are deposited in some distant lake. There is no place so remote, but the Water Lily gains access to it; though its seeds cannot, like those of other vegetables, gradually extend their dominion from one place to another.

But more than birds and animals—more than wind and tide, man contributes to the dispersion of seeds. Of this we shall be convinced, as we learn the history of many well known vegetables, as we trace them from one country to another, and observe in what way they have been thus extensively diffused. The wars which led many of the European nations to the Holy Land, brought back many of the esculent vegetables which are seen on our tables, and many of the flowers which adorn our gardens. Commerce has enriched different nations by an interchange of their most valuable productions, and science has discovered in the remotest sections of the earth, vegetables which are now diffused through countries where they were formerly unknown. The common Stramonium, now a weed throughout all Europe and in various parts of the United States, was brought from Abyssinia by a class of empyrics who pretended that its seeds were a sovereign remedy for various diseases. Buck-wheat and most kinds of grain were received through Italy from the eastern nations, while the various kinds of cultivated fruit were derived from Greece, ultimately perhaps from the provinces of Asia. Persia is the native country of the Peach ; Arminia of the Apricot ; and from these nations they have travelled through Europe and at last reached this country. The Potatoe was carried from America to Ireland by Sir Walter Raleigh, and from thence it has found its way to almost every section of the eastern continent. These are but a few of the many examples which might be mentioned, to prove how much man has contributed to the dissemination of seeds. The fertility of the vegetable kingdom will warrant the conclusion, that its numerous species have all been preserved in the midst of the dangers which assailed them ; dangers too, which they have no eyes to see, and no voluntary power to avoid.

The patience of Ray enabled him to ascertain the number of seeds, which were produced by a single plant of the Tobacco, and they amounted to 300,000. Dodart with a perseverance equally worthy of our admiration, ascertained that in one year a single Elm produced more than half a million of seeds, yet compared with the fertility of other plants, the Tobacco and Elm are unproductive, for it exceeds the powers of man to estimate the number of seeds which are enclosed in a capsule of a Moss or on the single leaf of a Fern.

Whenever they are less numerous, they are defended from injury by the hardness of their external coat, by the thorns with which they are invested and by the acrimony of their juices.

Thus productive, and thūs defended, it is probable that no family of plants now in existence, will prematurely cease to be. We now see how various and yet how essential are the means which nature employs for the dissemination of plants. Seeds are literally scattered over the whole face of the globe, but their dispersion is neither the effect of accident or chance. The mountain has its favourite plant whose seeds are endowed with the power of reaching its summit, while those which delight in the valley, are carried by opposite means to their destined abode. The seeds of mountain plants are sometimes the food of birds, through whose agency they reach the place most favourable to their germination. Sometimes they rise on the wings of their feathery crown, sail through the air, till they reach their final home, on the brow of some neighbouring hill. And is it not delightful to observe the various means which are employed for their dispersion, to see some furnished with wings which enable them to fly more like things of life than tenements in which it slumbers ; to see those domestic plants which linger around the dwellings of man furnished with seeds whose hooks attach them to the dress of every visitor, by which they are scattered at a distance from their original locality, though near the walks and around the habitations which they delight to honor ; to see the seeds of aquatic plants enclosed in a shell by which they can swim, or covered with an adhesive substance by which they are attached to the birds who visit them, in short, to see that neither plant nor sparrow will fall without the notice of Him who gave them life and existence.

CHAPTER XV.

IMPERFECT PLANTS.

There is an extensive tribe of plants to which the foregoing terms do not apply. Linnæus, finding their flowers invisible, at least to the naked eye, denominated them *Cryptogamia ;* and other writers, in consideration of their simple and often defective structure, term them *Imperfect.* They are usually distributed into Ferns, Mosses, *Hepaticæ*, *Algæ*, and *Fungi*, which we shall examine in the above mentioned order.

1. FERNS.

These are usually distinguished with ease from the more perfect plants, having their leaves, branches, and stems so united, as to constitute one organ, and usually having the fructification on the back of the leaf. That part which is analagous to the stem of other plants, or perhaps to the peticle of a compound leaf, is denominated the *Stipe ;* and the various parts united, whether in a Fern or in other plants, constitute a *Frond.*

Their floral organs are very minute, and entirely unlike the gay blossoms which adorn the landscape and beautify the shrubs that bear them. The existence of these organs, taken collectively, is established by the production of seeds which grow on the back of the frond, or on a separate spike, or at the base of the stipe, or in the axils of the leaves.

When the fructification is in scattered patches, on the back of the leaf, as in *Polypodium*, *Fig*. 24, the Fern is said to be *dorsiferous*, in allusion to the situation of the floral organs. Examined with a microscope, the fruit is found to consist of a capsule usually surrounded by an elastic transverse ring, which opens when ripe for the discharge of the seeds. These capsules are usually accompanied by an additional integument, named *Indusium*. It is a thin membrane, *Fig*. 113, enclosing the unripe fruit, and originates sometimes from the veins, and sometimes from the margin of the leaf. In distinguishing the genera of Ferns, Linnæus resorted to the situation and shape of the capsules ; but Dr. Smith has found the presence of the *indusium*, and the mode in which it bursts, the best criterion for determining the genera of Ferns ; and in connexion with the other characters, it is "the only sure ground on which the botanist can rely."

But the floral organs are not always confined to the back of the frond, nor are the leaves and stems always thus intimately incorporated. In *Equisetum* or the Horsetail, *Fig*. 114, the fruit is attached to peltate receptacles, *Fig*. 115, which are collected into a spike, and terminate the stem ; and its numerous seeds are enfolded by four pollen-bearing filaments, *Fig*. 116, somewhat analagous to those which occur in the flowers of the more perfect plants.

In *Lycopodium* or Ground Pine the capsules are sometimes found in the axils of the leaves and sometimes at the summit of the stem. This family of plants is entirely unlike those ferns whose herbage constitutes a frond, and it ranks with them, only because no one has been able to detect those organs which serve to characterize the more perfect plants. In most of the

Floras which have been published in the United States. Ferns alone, of the cryptogamic plants are included.

Their herbage is frequently very beautiful ; and the polished Stipe of the Maiden Hair presents an example of the glittering surface which is not surpassed by any of the more perfect plants. The *Lycopodium* is an interesting trailing vine, which retains its verdure during the winter when it is often employed to decorate our dwellings and our churches, serving at least to dispel the gloom of one season, by reminding us of the gaiety of another.

2. MOSSES.

Mosses constitute a second order. Though too minute to attract the notice of the passing observer, when examined with attention, they exhibit a beauty of structure which we cannot fail to admire. They are furnished with leaves and stems presenting a miniature of the lofty forest trees, and like them usually having their floral organs distinct. Sometimes however the stem is wanting ; and when present, it has been observed to sink into the soil, and as the old root decays and is converted into mould, so the old stem annually descends into the earth, emits radical fibres, and is converted into a root.

The leaves of Mosses are very minute, being often transparent. They arise from every side of the stem, and are linear, oval, lanceolate, pointed, and imbricate, varying like other leaves, and having their different forms designated by the same terms. According to Hedwig, the floral organs of the Mosses usually occur on separate plants, but in some cases they are *monœcious*, having barren and fertile flowers distinct, but on the same plant. The former are the stars, which terminate the branches *Fig.* 130, or the buds that sit in the bosom of the leaves ; and the latter are the urn shaped capsules, *Figs.* 117 and 129 which are usually elevated above the rest of the plant, and concealed when young, by an exterior membrane.

The fertile flowers of Mosses present an arrangement well worthy of our attention. "They are not furnished with any integument that can be decidedly called a calyx, though the leaves immediately surrounding them, are generally different both in size and structure from the other leaves of the plant ; in the genus *Hypnum*, they are so very obviously different, as to have obtained the proper appellation of the *Perichœtium*, or fence, being an assemblage of loose imbricated scales, rather than real leaves.

But if they are not to be regarded as the real calyx, or part of the real leaves, they are at least to be regarded as floral leaves, both from their contiguity to the flower, and analogy to the floral leaves of other plants. In their original distribution, they form a peculiar bud, from the centre of which the flower issues, presenting when first visible, the appearance of a fine and minute point, projecting from the bosom of the leaves.

As the process of fructification advances, the parts of the flower begin to assume a different appearance ; the fine and pointed substances expanding into a cone, invested by a thin membranaceous integument, which is adherent at the summit and base, and finally separates into two distinct portions. The under portion, which is placed within the *perichœtium*, remains as before attached to the base of the fructification, and is termed the *sheath ;* while the upper portion adheres to the summit of the capsule, and invests it, in the form of an extinguisher, *Fig.* 129 *a.* In this state it has been called a calyx by some botanists, and by others a corolla; but its resemblance to either is so slight, as scarcely to justify the terms. It is more generally known, however, by the appellation of the *Calyptra*, or veil; a term sufficiently expressive, of at least part of its functions, masking as it does a globular or urn-shaped vessel, which is the capsule of the Mosses. In some species this capsule is sessile, but in most cases it is elevated upon a fine slender foot-stalk; and is erect or drooping, smooth or striated; being in a young state green or white, but at maturity becoming yellow, or red, or brown. The mouth of the capsule is externally covered with a lid, (*operculum*) *Fig.* 129 *d*, assuming in different species a variety of forms, and detaching itself horizontally when ripe. When this lid is removed, the mouth of the capsule is seen, invested with a fringe (*peristomium*) *Fig.* 118, which is usually double, occasionally single, and very rarely wanting; *Fig.* 129 *c.* The number of the teeth of this fringe, though variable in different genera, is uniform in the same; and it is worthy of observation, that this number is in all cases a multiplicate of 4, being 4, 8, 16, 32, and 64. Within the urn, there is a slender *column*, which passes through its whole extent, and perforates both the lid and the veil. This organ was regarded by Hedwig as the style of the Mosses. As the urn and column are concentric, there is an intermediate and cylindrical cavity, filled with a powder usually brown or yellow, and sometimes dotted or prickly. By sowing this powder, Hedwig reared a crop of young Mosses, in all respects similar to the parent plants; thus proving beyond the possibility of a doubt, the nature of the dust which he planted.

Such is a short sketch of the herbage and fructification of the Mosses, according to the observations and discoveries of Hedwig, and of the theory founded upon them, namely : That the Mosses are formed with all the organs necessary to the constitution of a flower, and producing perfect seeds ; a theory that seems at least to be founded in fact, and that has obtained the approbation of most succeeding botanists.

Mosses are very tenacious of life, and flourish in the coldest climate and at the coldest season of the year ; and it is said that after they have been preserved a century, their freshness may be restored by the mere application of water. Their uses in the economy of vegetation, are greater than is commonly suspected. "Nature," says Willdenow, "always takes care to use one plant for the benefit of another ;" and those which decay are taxed to support those which are to succeed them. This remark is peculiarly applicable to the Mosses. They vegetate on naked barren rocks, to which their seeds have been wafted by the wind, deriving their nourishment from the atmosphere, and preparing the way for plants of a greater magnitude. Sometimes they flourish only on the summit of lofty mountains abstracting moisture from the clouds which encircle them, contributing to the formation of fountains, rivulets, and at last majestic streams. Wherever they vegetate Mosses improve the soil, and when it becomes capable of sustaining other plants, these disappear as if the sole end of their existence was to fertilize the ground. They overspread the trunks of trees which in the winter they protect from cold and in the summer from the parching rays of the sun, nor do they, like other parasitic plants, derive nutriment from the trees which support them. Shrubs covered with Moss can be removed to a distance with greater safety than when protected in any other way, and according to the observations of Gleditsch, they grow with as much luxuriance when nourished merely by Moss as when in the most fertile soil. Some Mosses thrive only in marshy situations which they annually enrich by the deposition of new mould. The Hercynian forest, once an impenetrable morass, has through the agency of the Grey Moss *Sphagnum palustris*, been converted into a fertile soil, and the yellow corn now waves over the fields which have been forming for ages. Thus we owe to insignificant mosses the largest rivers, the draining of extensive marshes, and the fertility of some barren fields.*

3. HEPATICÆ.

These are small herbaceous plants whose herbage constitutes a frond, and whose fruit like that of the Mosses is enclosed in a capsule. The veil, however, by which this capsule is sometimes enclosed, usually opens at the summit, nor is it furnished with a *lid*, analagous to the one we have seen in the fructification of Mosses. This is a small and by no means interesting tribe of plants. The student who wishes to gain an idea of their singular structure, will find the common Brook Liverwort, *Marchantia polymorpha* an example well calculated to exhibit the frond, but the peltate receptacle on which its fructification is borne is very different from the capsules of the other genera. In *Jungermannia*, *Fig*. 119, the capsule is four-valved, and when the seeds are mature, these valves separate

* Willdenow.

for their escape. They are not at present of much utility in medicine or the arts, but their name confirms the opinion that they were formerly employed as medicines in affections of the liver.

4. ALGÆ.

This term, originally applied to marine plants, has been employed in a more extensive sense, and embraces among others, the Lichens which cling to the rock, and the *Byssi* which appear chiefly to delight in the damp atmosphere of the cellar. The Lichens, constituting a very extensive order, have been investigated with great success by the learned Acharius of Sweden, whose works " form a new æra in this department of our science, and will probably be the basis of all subsequent improvement."* The Lichens have nothing analagous to the root, unless we are willing to regard as such, the fibres which issue from the inferior surface of the frond. And in many cases the place of these fibres is supplied by a cement which attaches the plant so closely to the smooth rock, that we can separate them only with difficulty. The frond, *Fig.* 121, (denominated *thallus* by Acharius,) is either a leaf-like expansion, or it is branched, and like a shrub in miniature, or it is a mere crust or powder, presenting in each case a simple structure and consisting chiefly of gelatine and mucilage. With regard to the fructification of Lichens, Hedwig and Gærtner, both men of primary authority, maintain very different opinions.

The former contends that he has detected in the interior of the frond, small cells, which contain particles

* Smith.

of pollen, and in the shields or targets, *Fig.* 122, he found a number of oval bodies, arranged in perpendicular columns, which were regarded as seeds. But Gærtner maintains, that these substances are a peculiar kind of gem, which he denominates *propago*, and describes as being "simple gems without leaves, or regular form, sometimes naked, and sometimes covered with an envelope, which separating at length from the parent plant," are dispersed like seeds. Gærtner's views of the subject are most probably correct.

Lichens are described by Acharius as forming a natural order, distinct from the other imperfect plants; in which the whole body performs the functions of an universal receptacle or *thallus*, of various shapes, without distinct root or stem, and furnished with vegetative organs, by which the species is propagated. These organs abound in the substance and on the surface of the flowers, being sometimes scattered and sometimes collected in nests, and existing in a separate organ (*apothecium*) *Fig.* 122, which he regarded as a partial receptacle, and to which other writers have applied the terms saucer, shield, and cup.

"The aquatic or submersed *Algæ* form a distinct and peculiar tribe. Some of them abound in fresh water, others in the sea, and hence the latter have been denominated sea-weeds. The chief genera are *Ulva*, well defined by its seed organs being dispersed under the cuticle throughout the membranous or gelatinous substance of the frond; *Fucus*, whose seeds are collected together in tubercles, or swellings of various forms and sizes; and *Conferva*, commonly known by its capillary and jointed frond. They are in general merely fixed by the roots, their nourishment being imbibed by their surface ; many of them float without any attachment."*

These plants, notwithstanding their simple structure, and humble aspect, are all, important in the economy of vegetation. Like the Mosses, they abstract nourishment from the atmosphere, and by their decay enrich the soil over which they spread, and cover with a fertile mould, the rocks to which they are attached.

The Rein Deer of the North is supported by the branched coralline lichen, *Cenomycerangiferina* which grows luxuriantly beneath the Lapland snows, at a season when the vegetation of all other plants is absolutely arrested.

The Iceland Moss, *Cetraria Icelandica* thrives in a country where no kind of grain reaches maturity, and is pulverized by the inhabitants who use it as food. It is indeed the best food which consumptive patients can use, and for them, it is imported into the United States. Probably some of our own Lichens might answer the same valuable purposes. We know that the Lungwort *Pulmonaria* has possessed a high reputation, and further investigation may establish its efficacy as a medicine.

Many of the Lichens have been employed in the arts ; some as affording colouring materials and others as yielding mucilage, which has been substituted for the more costly gums of Crete and Arabia.

5. FUNGI.

The only remaining order of imperfect plants embraces the Fungi or Mushrooms. Destitute of leaves

* Smith.

and flowers, they appear to want every property which would entitle them to rank with other vegetables. In taste, they approach near to the lower tribe of animals, and by many writers they have been arranged with zoophites, and regarded as animated beings. But more enlightened observation and more accurate research, have pointed out their analogy to some of the preceding orders. The names of Micheli, Hedwig and Persoon, rank high among the botanists who have devoted their time to the investigation of this department of botany. They have in the language of a late writer, demonstrated that Mushrooms are organized vegetables which consist of fibres, vessels and roots, that they have organs appropriated to the formation of seeds (or gems) and that without these no reproduction can take place. In short, they spring up, flourish, and decay, like other organized beings, after having transmitted the principles of that vitality which they possess, to a new race exactly similar to themselves.

The examination of Fungi presents to our view the *wrapper Fig.* 127, which envelopes the fungus when young and in its mature state remains close to the ground ; the *cap* or summit, *Fig.* 125 which is usually oval, and supported on the peculiar stem of the Fungus, which stem is denominated the *Stipe.* The inferior sur face of the cap is beset with gills as in *Agaricus Fig.* 125 ; with pores as in Boletus 123 ; and with prickles as, in Hydnum, *Fig.* 128 ; and these gills, prickles and pores, are the seat of the reproductive organs. The stipe is either central or lateral, solid or hollow, sometimes connected with the gills and sometimes separate, and these are characters to which it is often necessary to resort.

Persoon has arranged them according to the situation of the organs of fructification. In one order the seeds or gems are internal as in the common Puff-ball; in the other they are imbedded in an appropriate membrane, as in the Mushroom.

These plants notwithstanding their simple organization have been converted to useful purposes. The powder of the Puff-ball, *Lycoperdon*, is employed as a styptic and is remarkable also for its property of strongly repelling moisture. If a vessel is filled with water and a little of the powder sprinkled over its surface, the hand may be plunged to the bottom of the vessel without coming in contact with the water. The Moshrooms are well known articles of seasoning and of food, which are frequently employed, and, with safety, unless gathered by an unskilful hand.

We have now examined the various orders of the imperfect or cryptogamous plants. Some late wrtters apply the term *agamous* to some of the tribes which Linnæus and others associated with the Mosses and Ferns. They apply it to those plants whose floral organs have never been detected, being propagated by peculiar gems (*propagula*) which shew themselves in the form of a powder on the surface of the plant; are at no period enclosed within a germen, and have been deemed with great probability mere fragments of the external texture of the vegetable. They have no parts of an herbaceous nature, but include the Algæ, the Hepaticæ and the Fungi, * plants destitute of leaves, and often without a stem.

* Mirbel.

CHAPTER XVI.

CLASSIFICATION.

By a recent publication it appears, that 50,000 plants have been collected, named and described ; a number so formidable, a subject so vast, that without the aid of science, it would be impossible for one mind to comprehend the whole. No where else are system and knowledge so intimately blended ; for here they are so inseparable that he who denies the necessity of the one must relinquish all pretensions to the other. Without system, all would be chaos and confusion ; and the study of plants and the investigation of their character and relations would be interesting only, as it led to the contemplation of beautiful objects. Without system, our subject would be no longer worthy of pursuit ; it would neither exercise nor enlarge the mind, nor would it strengthen the memory. Of the various modes of arrangement that of Tournefort is distinguished for its beauty ; that of Linnæus for its simplicity ; that of Jussieu for its analogy to nature.

Tournefort, the most learned botanist of his age, the favourite of Louis his king, the pride and the boast of his country, rendered himself immortal by reducing to order the plants which were at that time known. His classes are founded on the forms of the corolla, and they were more natural, more easily understood, and more usually studied than any others.

Were it desirable, we might in a little while become acquainted with his classes. for each of them comprises one of the various forms of the corolla which have already been enumerated. But unfortunately for Tournefort and his system, the various forms were not sufficiently distinct, and it was frequently difficult to say under which class an individual plant should be arranged It therefore received different names, some of which being extremely barbarous, would have deterred all but the most devoted lovers of natural history from pursuing this its most interesting portion.

In a few years it would have been discarded had not Linnæus appeared, its prince and its saviour, to redeem it from the corruptions of former, and to guard against the innovations of future ages. With an eye which could at a single glance discern the peculiar features of any object; with firmness to encounter, and with talents to overcome, the greatest difficulties, he planned, he accomplished more than all his predecessors, and his works which remain at this day unrivalled, will probably long continue unequalled.

The number, situation, and proportion of the stamens were the foundation of his primary divisions. These organs, so constant, so essential to the completion of the flower, so necessary for the preservation of the vegetable kingdom, were happily selected to furnish each of his *Classes* with an obvious immutable character. The *Orders* into which his classes are subdivided, are established on a basis equally constant, on the number and situation of the pistils, or on some other circumstance equally obvious and invariable. But this system, like that of Rivinus is *artificial*, and though it enables us with great facility to learn the name of any unknown plant; it does not pursue the order of nature, nor does it, like that of Jussieu, exhibit the affinities of the vegetable kingdom.

"Independently of all general method of classification, whether natural or artificial, plants, as well as animals, are distinguished into *Genera*, *Species* and *Varieties*.

By Species are understood so many individuals, or, among the generality of animals, so many pairs, as are presumed to have been formed at the creation, and have been perpetuated ever since; for though some animals appear to have been exterminated, we have no reason to suspect any new species has been produced; neither have we cause to suppose any species of plant has been lost, nor any new one permanently established, since their first formation notwithstanding the speculations of some philosophers. We frequently indeed see new Varieties, by which word is understood a variation in an established species; but such are imperfectly, or for a limited time, if at all, perpetuated in the offspring.

A Genus comprehends one or more species, so essentially different in formation, nature, and often many adventitious qualities, from other plants, as to constitute a distinct family or kind, no less permanent, and founded in the immutable laws of the creation, than the different species of such a genus.

Thus the various species of Rose compose a beautiful genus, known to every one who ever looked at a plant, merely by a certain combination of ideas, but essentially distinguished by clear and decisive characters. The species of *Iris* form also a numerous genus, and the Willows another; while the interesting *Linnæa* is too singular and distinct to be associated with any known plant besides and constitutes a genus by itself.

The first great and successful attempt to define the genera of plants was made by Tournefort, and in this his transcendant merit will ever be conspicuous, though his system of arrangement should be entirely forgotten. Not that he has excelled in verbal definitions, nor built all his genera on sure foundations; but his figures, and his enumerations of species under each genus, show the clearness of his conceptions, and rank him as the father of this branch of botany.

Linnæus first insisted on generic characters being exclusively taken from the flowers and the fruit, and he demonstrated these to be sufficient for all the plants that can be discovered. He also laid it down as a maxim, that all genera are as much founded in nature as the species which compose them; and hence follows one of the most just and valuable of all his principles, that *a genus should furnish a character, not a character form a genus;* or, in other words, that a certain coincidence of structure, habit, and perhaps qualities, among a number of plants, should strike the judgment of a botanist, before he fixes on one or more technical characters, by which to stamp and define such plants as one natural genus.

In methodical arrangement, whether natural or artificial, every thing must give way to generic distinctions. A natural system which should separate the species of a good genus, would, by that very test alone, prove entirely worthless; and if such a defect be sometimes unavoidable in an artificial one, contrivances must be adopted to remedy it; of which Linnæus has set us the example, as will hereafter be explained.

Generic characters are reckoned by Linnæus of three kind, the *factitious*, the *essential*, and the *natural*, all founded on the fructification alone, and not on the inflorescence, nor any other part.

The first of these serves only to discriminate genera that happen to come together in the same *artificial* order or section; the second to distinguish a particular genus, by one striking mark, from all of the same *natural* order, and consequently from all other plants; and the third comprehends every possible mark common to all the species of one genus.

The *factitious* character can never stand alone, but may sometimes, commodiously enough, be added to more essential distinctions, as the insertion of the petals in *Agrimonia*, indicating the natural order to which the plant belongs, which character, though essential to that order, here becomes factitious.

The *essential* character comprehends all the distinctions requisite to discriminate each genus from every other in the system, only avoiding a repetition at every step of the characters of the artificial class and order, which stand at the top of each page, and are not always essential to the character of the genus. This is the kind of generic character now universally adopted, and indeed the only one in common use. The learned Jussieu has given it the sanction of his approbation and adoption, as far as its plan is concerned, throughout his immortal work, subjoining in a different type such characters and remarks as belong to the habit, or refer to other circumstances.

The *natural* character seems to have been, at one time, what Linnæus most esteemed. Its disadvantages are, that it does not particularly express, nor direct the mind to, the most important marks, and that it can accord only with such species of the genus as are known to the author, being therefore necessarily imperfect. This kind of character is, however, admirable for the illustration of any difficult natural order.

Specific characters should be constructed on similar principles to the generic ones, as far as regards certainty, clearness and conciseness. The genus being first well defined, we are to seek for characters, not mentioned among the generic marks, for distinguishing the species. A specific difference for the solitary species of any genus, is therefore an absurdity. Linnæus at first intended his specific definitions should be used as names; but the invention of trivial names happily set aside this inconvenient scheme. On this account however he limited each to twelve words, a rule to which all philosophical naturalists have adhered, except in cases of great necessity. Nor is the admission of one or two words beyond the allotted number reprehensible, provided the whole sentence be so neatly and perspicuously constructed, that the mind may comprehend it, and compare it with others at one view; but this can hardly be done when the words much exceed twelve.

Nomenclature is no less essential a branch of methodical science than characteristic definitions; for, unless some fixed laws, or, in other words, good sense and perspicuity, be attended to in this department, great confusion and uncertainty must ensue.

In all ages it has been customary to dedicate certain plants to the honour of distinguished persons. Thus *Euphorbia* commemorates the physician of Juba a Moorish prince, and *Gentiana* immortalizes a king of Illyria. The scientific botanists of modern times have adopted the same mode of preserving the memory of benefactors to their science; and though the honour may have been sometimes extended too far, that is no argument for its total abrogation. Some uncouth names thus unavoidably deform our botanical books; but this is often effaced by the merit of their owners, and it is allowable to model them into grace as much as possible.

Linnæus has in several instances drawn a fanciful analogy between botanists and their appropriate plants, thus—

Bauhinia, after the two distinguished brothers, John and Caspar Bauhin, has a two-lobed or twin leaf.

Scheuchzeria, a grassy Alpine plant, commemorates the two Scheuchzers, one of whom excelled in the knowledge of Alpine productions, the other in that of Grasses.

Dorstenia, with its obselete flowers devoid of all beauty, alludes to the antiquated and uncouth book of Dorstenius.

Hernandia, an American plant, the most beautiful of all trees in its foliage, but furnished with trifling blossoms, bears the name of a botanist highly favoured by fortune, and allowed an ample salary for the purpose of investigating the Natural History of the Western world, but whose labours have not answered the expense. On the contrary

Magnolia with its noble leaves and flowers, and

Dillenia with its beautiful blossoms and fruit, serve to immortalize two of the most meritorious among botanists.

Linnæa, " a depressed, abject, Lapland (and American) plant, long overlooked, flowering at an early age, was named by Gronovius after its prototype Linnæus."

Specific names should be formed on similar principles to the generic ones ; but some exceptions are allowed, not only without inconvenience, but with great advantage. Such as express the essential specific character are unexceptionable ; but perhaps those which express something certain, but not comprehended in that character, are still more useful, as conveying additional information, for which reason it is often useful that vernacular names should not be mere translations of the Latin ones.

Botanists occasionally adapt a specific name to some historical fact belonging to the plant or to the person whose name it bears, as *Linnæa borealis* from the great botanist of the north ; *Murræa exotica* after one of his favourite pupils, a foreigner ; *Browallia demisa* and *elata*, from a botanist of humble origin and character, who afterwards became a lofty bishop, and in whose work upon water I find the following quotation from Seneca in the hand-writing of Linnæus : "Many might attain wisdom, if they did not suppose they had already attained it." In like manner *Buffonia tenuifolia* is well known to be a satire on the *slender* botanical pretensions of the great French zoologist, as the *Hillia parasitica* of Jacquin, though perhaps not meant, is an equally just one upon our pompous Sir John Hill. I mean not to approve of such satires. They stain the purity of our lovely science. If a botanist does not deserve commemoration, let him sink peaceably into oblivion. It savours of malignity to make his crown a crown of thorns, and if the application be unjust, it is truly diabolical."*

* Smith's Introduction.

CHAPTER XVII.

SYSTEM OF LINNÆUS.

The arrangement of Linnæus, with some variations, to be hereafter explained, has been adopted by the most eminent botanists of the present age, and it is perhaps the most perspicuous, if not the most perfect system which has been presented to the world.

CLASSES.

This system is composed of 24 classes, distinguished from each other by the number, situation, proportion, and connexion of the stamens. The first eleven of these classes are distinguished merely by the *number* of the stamens.

1.	*Monandria* has	1	as in *Canna* and Strawberry Blite.
2.	*Diandria*	2	*Collinsonia* and Lilac.
3.	*Triandria*	3	*Iris* and Carpet weed.
4.	*Tetrandria*	4	*Cornus* and Partridge-berry.
5.	*Pentrandria*	5	*Azalea* and Currant.
6.	*Hexandria*	6	*Amaryllis* and Lily.
7.	*Heptandria*	7	*Trientalis* and Horse-Chesnut.
8.	*Octandria*	8	*Rhexia* and Willow-herb.
9.	*Enneandria*	9	*Laurus* and Rhubarb.
10.	*Decandria*	10	*Kalmia* and Pink.
11.	*Dodecandria*	11 to 20	*Asarum* and Mignonette.

The twelfth and thirteenth classes embrace plants whose flowers have numerous unconnected stamens, and they are distinguished from each other by their insertion.

12. *Icosandria* has numerous stamens inserted into the *calyx* as in *Spirea* and Strawberry.

13. *Polyandria*, has numerous stamens inserted into the *receptacle*, or base of the flower.

The fourteenth and fifteenth classes are distinguished by the number and proportion of the stamens.

14. *Didynamia* has four stamens, of which two are long, and two are short, as in *Gerardia* and the Labiate flowers.

15. *Tetradynamia*, has six stamens of which four are longer than the two others, as in *Iberis* and Wall flower.

In some flowers the stamens are *connected* into one or more parcels.

16. *Monadelphia* has them united by their filaments into a tube, as in *Geranium* and Mallows.

17. *Diadelphia* has its stamens united into two bundles, as in *Vicia*, *Lathyrus*, and most of the Papilionaceous flowers.

18. *Polyadelphia* has its stamens united into several bundles, as in the *Hypericum*, and in the Orange and Lemon.

19. *Syngenesia* has the stamens united by their anthers into a tube, as in *Cacalia* and Dandelion.

20. *Gynandria* has the stamens united to the pistil, and inserted either in the style or germen, as in *Orchis* and Ladies' slipper.

In the preceding classes the stamens and pistils occur in the same flower, but in some instances they are separated, either on the same or on different plants.

21. *Monoecia* has stamens on the same plant with the pistil, but not in the same flower, as in *Ricinus* and Oak.

22. *Dioecia* has stamens on one plant, and pistils on another, as in *Valisneria* and Poplar.

23. *Polygamia* has stamens and pistils either in the same flower, or in different flowers of the same plant, or in different plants, as in *Ficus* and Ash.

24. *Cryptogamia.*—This class embraces the imperfect plants whose floral organs are invisible or wanting.

ORDERS.

The orders of the first thirteen classes are founded on the *number* of pistils.

1. *Monogynia has*	1	as in Lily.
2. *Digynia*	2	Pink and Grasses.
3. *Trigynia*	3	*Staphylea* and Sumach
4. *Tetragynia*	4	Holly.
5. *Pentagynia*	5	*Statice* and Pear.
6. *Hexagynia*	6	Rare.
7. *Heptagynia*	7	Very rare.
8. *Octagynia*	8	Rare.
9. *Enneagynia*	9	Rare.
10. *Decagynia*	10	Poke.
11. *Polygynia*	*many*	*Clematis* & Columbine.

The 14th class is subdivided into two orders, *Gymnospermia*, having (usually four) naked seeds as in the Marjoram and Balm ; and *Angiospermia* having numerous seeds in a capsule, as in Snapdragon and Foxglove.

The 15th class has two orders, distinguished like the preceding by the fruit. The seeds of the first, *Siliculosa*, are enclosed in a *silicle*, as in the Shepherd's-purse. The seeds of the second, *Siliquosa*, are in a *silique*, as in the Wall flower and Cabbage.

The orders of the 16th, 17th and 18th classes are founded on the number of the stamens.

The orders of the 19th class are known by the interblending of florets, which are united or separate, fertile or barren.

1. Polygamia Equalis has them all united, and all fertile.
2. Polygamia Superflua, has united discal florets, while those of the ray produce pistils only, and all *fertile.*
3. Polygamia Frustranea has united discal florets, while those of the ray, whether they produce pistils or not, are *unfertile.*
4. Polygamia Necessaria has discal florets with stamens only, while those of the ray have only pistils.
5. Polygamia Segregata has several florets, each with a proper calyx and united anthers, all included in one common calyx.

The orders of the 20th, 21st and 22d classes are distinguished by the number of their stamens.

The 23d class has three orders. *Monoecia* has the different kinds of flowers all confined to one plant. *Dioecia* has its several kinds of flowers on two plants, and *Trioecia* has them on three separate plants.

The orders of the 24th class are Ferns, Mosses, *Hepaticæ*, *Algæ* including the *Lichens*, and *Fungi.*

Monandria.—The class Monandria contains two orders exemplified in *Salicornia* and *Blitum*, both American plants. It is by no means extensive, and if we except the *Scitamineæ* natives of tropical regions it is by by no means an interesting or important class.

Diandria has three orders, but one of which occurs in the United States, unless we choose to separate *Anthoxanthum* from the genus to which it belongs. It comprehends the *Jasmineæ* of Jussieu, and a few of the Labiate flowers such as Rosemary and Sage.

Triandria has three orders ; *Iris*, *Ixia* and *Crocus* occur in the first, as well as the *Cyperoideæ ;* most of the Grasses occur in the second ; and *Holosteum* and Carpet-weed will exemplify the third.

Tetrandria has four orders ; *Houstonia*, *Mitchella*, *Linnæa*, and *Frasera* occur in the first, all dedicated to the memory of worthy botanists, two of whom resided in this country. *Galium* and Scabious will also serve to illustrate this order. The second and third orders are extremely rare, and in the fourth we meet with but few plants of interest. The Holly is one.

Pentandria has seven orders. The first, (*Monogynia*,) is probably the most extensive in the system of Linnæus ; embracing more than sixty genera within the limits of the United States. Among these are the Lurid and the Rough-leaved plants, the former exemplified in Stramonium, and the latter in Borage. *Azalea*, *Phlox*, *Convolvulus* and *Ipomœa* are among the most interesting Genera which fall within the limits of this extensive order. In the second, we find the umbellate plants ; in the the third, the Elder and *Viburnum ;* in the fourth, *Parnassia ;* in the fifth, *Aralia*, Marsh Rosemary and Flax ; and in the sixth, we have *Zanthorhiza*, or Yellow Root.

Hexandria has six orders. The first includes the Lilies ; the second has *Oryza*, or Rice ; the third has *Trillium* and *Gyromia ;* the fourth has *Saururus ;* the fifth has *Wendlandia ;* and the sixth (*Polyginia*) has *Alisma*, or Water Plantain.

Heptandria embraces but two genera within the limits of the United States, the Horse Chesnut and *Trientalis*, both of the first order. Africa furnishes a single genus with two, and another with seven pistils. The class *Heptandria* is probably the smallest in the Linnæan system.

Octandria has four orders. The first presents us with *Vaccinium* and Cranberry ; *Epilobium*, or Willow herb, and the Maple. *Chrysosplenium*, or Golden-Saxifrage, occurs in the second order, and *Polygonum* in the third.

Enneandria has three orders. In the first, we find *Laurus*, a very important genus, from which Camphor and Cinnamon are obtained. The Sassafras, Spice-bush and several other species of *Laurus* occur in the United States. In the second order, (*trigynia*) we meet with Rhubarb, but of the third, (*hexagynia*) there is no American example.

Decandria has six orders. In the first, we meet with *Kalmia*, *Rhododendron*, *Pyrola* and *Arbutus* ; in the second, we find Saxifrage *Dianthus* or Pink, and *Hydrangea*. *Silene* occurs in the third order, *Micropetalon* in the fourth ; *Sedum* and *Lychnis* in the fifth, and *Phytolacca* or Poke in the sixth.

Dodecandria.—By several late writers this class has been abolished, and the plants which were formerly arranged here have been transferred to other classes. Some however have retained it. *Lythrum*, *Euphorbia* and *Halesia* are American examples.

Icosandria has three orders. The Cherry, Plumb, and Peach with rosaceous flowers, together with the Myrtle and Clove, occur in the first order. In the second, (*Di pentagynia*) Dr. Smith, and others following him include those plants which have from two to five styles. It is exemplified in the Apple, Pear and Ice-plant. The last order (*Polyginia*) includes the Rose, Strawberry and several plants of the same natural order. How admirably says Dr. Smith does the fruit serve us in *Rosa*, *Rubus*, *Dryas* and *Geum* to discriminate those, whose leaves, flowers and habit all stamp them as distinct! A student cannot do better than to study this order and these genera as an introduction to the knowledge of more obscure ones; and the beautiful plants which compose it, mostly familiar to every body, are easily obtained.

Polyandria has three orders. In the first we find the Poppy, Bloodroot, Lime tree, *Cistus* and *Nymphæa*. The second, (*Di-pentagynia*) has Larkspur, Monk's hood, Columbine and Fennel flower; and the third, (*polygynia*) has *Magnolia*, Tulip tree, *Anemone*, *Clematis* and *Ranunculus*, most of which are cultivated as ornamental plants.

Didynamia has two orders. *Gymnospermia*, having four naked seeds; includes the Mints, Lavender, Marjoram and Basil; and *Angiospermia*, having its seeds in a capsule, is exemplified in *Gerardia*, *Bartsia* and Trumpet-flower, all American plants.

Tetradynamia.—The first order of this class having its fruit a silicle, is exemplified in *Draba*, *Thlaspi* or Shepherd's Purse, Honesty and Candy-tuft; and the second, having its seeds in a silique, embraces the Cabbage, Mustard, Radish and Wall-flower, all of which are familiar examples.

The class *Monodelphia* has eight orders. In Triandria we find *Sisyrinchium* and the Tyger flower: Pentandria is illustrated by the Musk Geranium, *Erodium;* Heptandria by the Cape Geraniums, *Pelargonium;* Decandria by Acacia, and Crane's-bill; and Polyandria which is a very splendid order embraces the *Malvaceæ* of Jussieu.

The class *Diadelphia* has four orders. Pentandria is illustrated by *Petalostemon*, Hexandria by

Corydalis and Fumitory; Octandria by *Polygala;* and Decandria by *Glycine*, Vetch, Locust, and most of the Papilionaceous flowers. In this class the Legume presents the most indubitable marks of distinction. A few genera have their stamens all united, but as they possess every other character, which would entitle them to rank in the present class, botanists have never ventured to separate them.

The class *Polydelphia* has three orders, distinguished by the number and insertion of the stamens. This class has been rejected by many late writers, and most of the plants which it embraces, range under the twelfth and thirteenth classes of the Linnæan system.

The class *Syngenesia* has five orders. In the first, (*equalis*) the florets are all perfect and fertile, being ligulate as in the Dandelion, and tubular as in the Thistle. The second order (*superflua*) contains discoid and radiate flowers. The marginal florets of the former are either obsolete or inconspicuous, and the whole are so arranged as to form a flat or conical surface, as in Tansey, Everlasting, and *Artemisia*. The marginal florets of the latter are ligulate, forming conspicuous and diverging rays as in the Daisy, Aster and *Chrysanthemum*. The third order (*frustranea*) has its marginal florets unfertile though sometimes furnished with the rudiments of pistils, and this alone will serve to distinguish it from the preceding orders. The Sunflower, Sweet-Sultan, and Blue-Bottle are common examples. Dr. Smith is inclined to abolish this order and to rank those genera which have the rudiments of pistils in their radiant florets, with their near relations in the preceding order.

The fourth order (*necessaria*) has stamens in its discal florets, and pistils in those of the ray, so that both are indispensable to the production of fertile seed. It is exemplified in the Garden Marygold. *Iva* and *Polymnia* are American genera.

The fifth order, (*Segregata*) has its florets enclosed in a partial calyx, and all included in one general calyx. It is associated with the preceding orders by its united anthers, but distinguished with facility by the calyx, which is inferior, and not like the chaffy pappus superior to the seed. Globe Thistle and *Elephantopus* are the only examples to which we can refer. This class includes the compound flowers, which are particularly abundant in the United States. The orders are with some difficulty distinguished by the inexperienced botanist, but the common calyx, the pappus, and the receptacle furnish abundant marks for distinguishing the Genera.

The class *Gynandria*, with stamens or sessile anthers united to the pistil, has seven orders ; only four of which occur in the United States. In the first, we find the *Orchideæ* of Jussieu, whose glutinous pollen is found in yellow masses, *pollinia*, enclosed in two antheroid cells ; and these cells are either contiguous or removed from each other to the opposite sides of the style. The best division of the *Orchideæ* is founded on the structure of the anther, " which is sometimes parallel to an unadhering stigma, and fixed, and permanent, at others, crowning the column, and generally moveable, lid-shaped and deciduous."*

Some writers regard the column merely as a style, but Mr. Brown describes it as formed by the incorporation of this organ with three filaments, two of which are usually sterile, as in *Orchis*.

In the second order (*diandria*) we find *Cypripedium*

* Journal of Science, &c.

distinguished from the preceding by its having a pair of very distinct double celled anthers, and by its large inflated nectary. In the order *Hexandria* we find *Aristolochia;* and the Virginia Snake root, well known throughout the country will serve as an example. Other species of this singular genus occur in the Southern states.

Monoecia.–Several late writers have abolished this and the two following classes, and when the structure of the accessory parts of the flower is the same, Dr. Smith is inclined to admit the change as an improvement. "But with respect to those Monoecious or Dioecious genera whose barren flowers are decidedly unlike the fertile ones, the former being in a catkin, and the latter not, as in the Chesnut and Oak, I conceive nothing more pernicious or troublesome can be attempted than to remove them to the classes of united flowers. They meet with no allies there, but, on the contrary, form so natural an assemblage by themselves, as to be unanimously kept separate by the authors of every natural system that has appeared."*

In the first orders of this class we meet with a few aquatic plants and a few Grasses. In the fourth we find the Birch and Nettle, *Amaranthus* in the fifth, *Zizania* or wild Rice in the sixth, and in the remaining orders, the Oak and many other of the forest trees.

The class *Dioecia* having eight orders is illustrated by *Valisneria, Menispermum, Dioscorea,* Persimmon and Poplar.

The class *Polygamia,* having different flowers on the same, and on different plants, has been abolished by many writers. Dr. Smith proposed to unite it with

* Smith's Introduction.

the two preceding, and Pursh, adopting this plan, has arranged them all in one class, termed *Diclinia* in allusion to their separate flowers.

" Such are the principles of the Linnæan Classes and Orders, which have the advantage of all other systems in facility, if not in conformity to the arrangement of nature ; the latter merit they do not claim. They are happily founded on two organs, not only essential to a plant, but both necessarily present at the same time ; for though the Orders of the 14th and 15th Classes are distinguished by the fruit, they can be clearly ascertained even in the earliest state of the germen.

Like all human inventions, however, this system has its imperfections and difficulties. If we meet in gardens with double or monstrous flowers, whose essential organs of fructification are deformed, multiplied, or changed to petals ; or if we find a solitary barren, or fertile blossom only ; we must be at a loss, and in such cases could only guess at a new plant from its natural resemblance to some known one. But the principal imperfection of the System in question consists, not merely in what arises from variations in number or structure among the parts of a flower, against which system could provide, but in the differences which sometimes occur between the number of Stamens, Styles, &c. in different plants of the same natural genus. Thus, some species of *Cerastium* have only 4, others, 5 Stamens, though the greater part have 10. *Lychnis dioica* has the Stamens on one plant, the Pistils on another, though the rest of the genus has them united in the same flower ; and there are several similar instances ; for number in the parts of fructification is no more invariable than other characters, and even more uncertain than such as are founded on insertion, or the connexion of one part with another. Against these inconveniences the author of this System has provided an all-sufficient remedy. At the head of every Class and Order, after the genera which properly belong to them, he enumerates, in italics, all the anomalous species of genera stationed in other places, that by their own peculiar number of Stamens or Styles, should belong to the Class or Order in question, but which are thus easily found with their brethren by means of the index.

It is further to be observed that Linnæus, ever aware of the importance of keeping the natural affinities of plants in view, has in each of his artificial Orders, and sections of those orders, arranged the genera according to those affinities; while at the head of each class, in his System, he places the same genera according to their technical characters; thus combining, as far as art can keep pace with nature, the merits of a natural and an artificial system.

From the foregoing remarks it is easy to comprehend what is the real and highly important use of the *Genera Plantarum* of Jussieu arranged in Natural Orders, the most learned botanical work that has appeared since the *Species Plantarum* of Linnæus, and the most useful to those who study the philosophy of botanical arrangement."

* Smith.

CHAPTER XVIII.

NATURAL SYSTEM OF JUSSIEU.

It is more than forty years since the arrangement of Jussieu was approved by the Royal Academy at Paris. Other systems had determined some of the natural affinities, but they offer at the same time numerous disparities which render them very defective. Linnæus and Adanson, one in his *Fragments*, and the other in his *Families*, had done much, and the elder Jussieu had arranged in natural groups the plants of the Royal gardens at Paris, but he was too diffident to publish an arrangement which he regarded as incomplete. Adopting the same principles, his relative and successor has traced with unrivalled success the order of nature, and detected the affinities for which others had sought in vain. His three primary divisions are founded on the form of the embryo. The first embraces those plants whose seeds are destitute of lobes, and are named *acotyledons* ; the second includes all plants with a solitary lobe and termed *monocotyledons*, while plants whose seeds are furnished with a pair of lobes are comprehended in the third division.

The number of the petals and the relative situation of the different parts of the flower, furnish a character for each of his classes ; while the orders into which these classes are distributed, are less determinate, being established on the structure of more variable organs.

1. ACOTYLEDONS.

The first division, containing but one class, is subdivided into six orders, and includes in addition to the Imperfect or Cryptygamous plants, a few aquatics of very simple structure, associated together in the order *Naiades*, whose character is by no means well defined.

2. MONOCOTYLEDONS.

This division embraces three classes, the first having its stamens inserted beneath the germen, the second having them inserted into the calyx or corolla, and the third having them united to the pistils.

Class 1. Stamens Hypogynous.

Calyx inferior, Corolla wanting, Germen simple, Leaves alternate and sheathing.

1. *Aroideæ.*—Flowers on a spadix, usually situated on the summit of a leafless stalk ; exemplified in *Arum*, *Calla*, *Pothos* and *Acorus*.
2. *Typhæ.*—Flowers aggregate, monoecious ; calyx three leaved ; style simple. Examples, *Typha* and *Sparganium*.
3. *Cyperoideæ.*—Flowers united or monœcious, each enclosed in calycine valves. Germen simple, surmounted by two or three stigmas. Seed naked or arillate, sometimes enclosed in bristles or hairs arising from its base. Culm terete, or three sided, usually knotless. Sheath of the leaves entire. This order embraces Grasses of a coarse texture, exemplified in the Rushes, Sedge, and Cypress grass.

4. *Gramineæ.*—Flowers usually in a panicle or spikelet, enclosed in a glume or valves. Stamens usually three. Germen simple, surmounted by two styles, and plumose stigmas ; Embryo minute, partially surrounded by a large farinaceous albumen. Roots fibrous and capillary. Culm cylindrical, hollow, jointed, simple and herbaceous, sheath of the leaves parted. The vegetable kingdom does not present a more natural or a more useful tribe of plants than the Grasses. They thrive in every section of the globe, clothing the earth with verdure, and supplying the cattle with herbage, and man with his "daily bread."

Class 2. Stamens Perigynous.

1. *Palmæ.*—Flowers diclinious arranged on a spadix. Calyx, six-parted, without a corolla. Stamens six or more. Germens, one or three. Fruit a drupe, of one or three monospermous cells. Seed hard. Embryo in the cavity of a large corneous albumen. The Palms have a simple cylindrical stem, terminated in a tuft of persistent, palmate, or pinnate leaves.
2. *Asparagi.*—Calyx, (Corolla Desfontaines) six-parted. Stamens six. Germen simple, usually superior. Embryo at the base of a corneous albumen. Leaves usually alternate. This order is exemplified in the following American genera : *Convallaria, Trillum* and *Gyromia.*
3. *Junci.*—Flowers in a spathe. Calyx inferior six-parted, (the three interior segments usually large and petaloid.) Germen and fruit simple or compound, exemplified in Swiderwort, Arrow-head and *Alisma.*

4. *Liliaceæ.*—Corolla* naked, six-parted or hexapetalous. Stamens epipetalous. Germen superior, surmounted by one style and three stigmas. Capsule with three valves, and three polyspermous cells. Lilies and Tulips are examples.
5. *Bromeliæ.*—Calyx six-parted, the three interior segments resembling petals. Stamens six. Germen simple, surmounted by a simple style, and three stigmas. Fruit three-celled. Leaves sheathing. Flowers in a spike or panicle, each in a spathe. *Agave*, *Bromelia* and *Tillandsia* are examples.
6. *Asphodeli.*—Corolla six-parted, tubular. Stamens six. Germen superior, simple. Style one. Stigma simple or trifid. Capsule with three valves, and three polyspermous cells. Leaves alternate, usually radical. *Aletris*, *Aloe* and *Hyacinthus* are examples.
7. *Narcissi.*—Stamens six. Germen inferior. Amaryllis, Snowdrop and Jonquil are examples, distinguished from the Liliaceæ by the situation of the germen.
8. *Irides.*—Stamens three. Germen inferior. This order is distinguished from the preceding by the number of its stamens.

Class 3. Stamens epigynous.

1. *Musæ.*—Calyx superior, two-parted. Stamens six. Germen inferior. Fruit three-celled. No examples of this order occur in the United States.
2. *Cannæ.*—Stamen one ; filament attached to the base of the style. Germen simple. Style simple and filiform. Capsule inferior, polyspermous, with three cells, and three valves. This order includes

* Desfontaines.

Scitamineæ or spicy plants, distinguished from the remaining *Cannæ* by the structure of the anther.

3. *Orchideæ.*—Corolla superior, organs of fructification connate. Pollen (in one or two anthers) accumulated in masses of determinate forms. Capsule one-celled, with three polyspermous receptacles attached to the axes of the valves. Seeds minute, with an albumen, but no vitellus.* *Orchis* and *Cypripedium* are examples.
4. *Hydrocharides.*—This order is not sufficiently defined, but embraces those plants with epigynous stamens, which could not be referred to the preceding classes. *Valisneria* and *Hydrocharis* are examples.

3. DICOTYLEDONS.

Class 1. *Flowers apetalous. Stamens epigynous.*

1. *Aristolochiæ.*—Calyx of one leaf. Stamens determinate, attached to the germen. Style simple. Stigma divided. Germen inferior. Cells of the capsule polyspermous. *Aristolochia* and *Asarum* are American examples.

Class 2. *Flowers apetalous. Stamens perigynous.*

1. *Æleagni.*—Stamens attached to the superior part of the tube of the calyx. Germen inferior. Style simple, surmounted by a solitary stigma. Fruit either a monospermous capsule, or a fleshy drupe. *Nyssa* or Tupelo is an American example.
2. *Thymeleæ.*—Calyx of one leaf, tubular and coloured. Stamens attached to the superior part of the tube. Germen superior. Fruit monospermous. Embryo

* Brown.

without albumen ; radicle superior. *Dirca* and *Daphne* are examples.

3. *Proteæ.*—Calyx four or five parted. Stamens four or five, inserted into the segments of the calyx. Germen simple, superior. Seed naked, or included in a capsule of one cell. Embryo without albumen ; radicle superior. This order embraces trees and shrubs of tropical regions, with alternate persistent leaves, and with flowers equally remarkable for their variety and splendour. No example of this order occurs in the United States.

4. *Lauri.*—Calyx persistent, coloured. Stamens disposed in two rows, and adhering to the base of the calyx : anthers adnate. Germen superior. Fruit a monospermous drupe. Embryo without albumen ; radicle superior. Stems woody. Leaves alternate, usually perennial and aromatic. Sassafras and Spice-bush, both species of *Laurus* occur in the United States.

5. *Polygoneæ.*—Calyx coloured and deeply parted. Stamens determinate, adhering to the base of the Calyx. Germen superior. Seed naked, or enclosed by the Calyx. Embryo surrounded by the farinaceous albumen. *Polygonum* and *Rumex* are common examples.

6. *Atriplices* —Calyx deeply parted. Stamens attached to the base of the calyx. Germen superior. Seed solitary, frequently naked. Embryo exterior to the farinaceous albumen. *Atriplex, Blitum* and *Salicornia* are examples.

Class 3. Flowers apetalous. Stamens hypogynous.

1. *Amaranthi.*—Calyx coloured, persistent, deeply parted, and enclosed by scales. Stamens distinct, or

united by their filaments. Germen superior. Fruit a capsule of one cell. Embryo enclosing the farinaceous albumen. *Amaranthus*, *Celosia* and *Gomphrena* are examples.

2. *Plantagines.*—Calyx of one leaf, tube petaloid. Stamens four, inserted into the base of the tube. Embryo enveloped by a corneous albumen. *Plantago* is the only example which this country affords.
3. *Nyctagines.*—Calyx tubular, sometimes calyculate. Germen one. Seed one, often enclosed by the persistent base of the calyx. Albumen surrounded by the Corcle. *Mirabilis* and *Boerhaavia* are examples.
4. *Plumbagines.*—Calyx tubular. Corolla inserted with or upon the petals. Capsule monospermous. Embryo surrounded by the farinaceous albumen. Stem herbaceous or shrubby. Leaves alternate. *Plumbago* and *Statice* are examples.

Class 4. Corolla monopetalous, inserted beneath the germen.

1. *Lysimachiæ.*—Corolla regular. Stamens commonly five, equal in number, and opposite the lobes of the corolla. Fruitwith one cell, polyspermous. Examples. *Lysimachia*, *Primula* and *Anagallis*. Many plants which Jussieu referred to this order are included by Decandolle in the order *Globulariæ*.
2. *Pediculares.*—Calyx monophyllous, persistent. Corolla irregular. Germen superior. Capsule with two cells and two valves centrally united to the partition. Seeds minute. Ex. *Bartsia*, *Veronica* and *Polygala.*
3. *Acanthi.*—Calyx monophyllous, persistent. Corolla irregular. Capsule with two cells and two

valves, opening with an elastic spring. Ex. *Acanthus Ruellia* and *Justicia.*

4. *Jasmineæ.*—Calyx monophyllous. Corolla regular. Stamens two. Fruit two-celled. *Syringa, Chionanthus, Fraxinus* and *Olea* are examples.

5. *Vitices.*—Calyx and Corolla tubular. Stamens usually four, didynamous. Seeds in a berry or capsule. Ex. *Vitex, Verbena* and *Lantana.*

6. *Labiatæ.*—Calyx tubular, five-parted or bi-labiate. Corolla irregular. Stamens didynamous. Germen four-lobed. Seeds four, naked, attached to the receptacle at the base of the calyx. Embryo straight without albumen. This order embraces thirty genera in the United States, exemplified in *Mentha, Stachys* and *Teucrium.*

7. *Scrophulariæ.*—Corolla irregular. Stamens two; or four, and didynamous. Capsule with two cells, and two concave valves, with the seed bearing partition united to their margin. Seeds numerous and small. Albumen fleshy. *Digitalis, Gerardia* and *Mimulus* are examples.

8. *Solaneæ.*—Calyx five-parted, persistent. Corolla regular five-cleft. Stamens five, epipetalous. Embryo curved or spiral. Albumen fleshy. *Datura, Atropa* and *Solanum* are examples.

9. *Borragineæ.*—Calyx five-parted, persistent. Corolla regular. Stamens five. Germen simple or four lobed. Seeds four, naked, and attached to the base of the style, or enclosed in a vessel. Embryo without albumen. Leaves alternate and rough. Borage, *Lycopsis* and *Lithospermum* are examples.

10. *Convolvuli.*—Calyx five-parted. Corolla regular. Stamens five epipetalous. Capsule with 2, 3 or 4

cells. Embryo in a mucilaginous albumen; radicle inferior. Stem sarmentose. Leaves alternate.

11. *Polemonia.*—Corolla regular, five-lobed. Stamens five, inserted into the tube of the corolla. Germen surmounted by one style, and three stigmas. Capsule enclosed by the persistent calyx, three-celled and three valved. Embryo in the centre of a corneous albumen, radicle inferior. *Phlox*, *Cantua*, and *Polemonium* are American examples.

12. *Bignoniæ.*—Calyx divided. Corolla irregular. Stamens four, didynamous, and accompanied by a sterile filament. Capsule two-celled, two-valved. Embryo without albumen. *Chelone*, *Bignonia* and *Catalpa* are American examples.

13. *Gentianæ.*—Calyx monophyllous, divided. Corolla regular, its border parted. Stamens epipetalous equalling the divisions of the corolla. Capsule of one or two cells, and two valves, polyspermous, the seeds attached to the margin of the valves, and the partitions formed by their inflection. Leaves opposite, entire, and sessile. *Gentiana*, *Frasera* and *Spigelia* are American examples.

14. *Apocyneæ.*—Calyx five-parted. Corolla five lobed, (with an internal nectary or Lepanthium.) Stamens five, inserted into the corolla, and alternating with its lobes. Two seed vessels. Seed frequently comose. Embryo straight, surrounded by a minute fleshy albumen. *Vinca*, *Nerium* and *Asclepias* are examples.

15.—*Sapotæ.*—Calyx divided, persistent. Corolla regular. Stamens opposite the segments of the Corolla. Germen one. Fruit a berry or drupe, with one, or several monospermous cells. Seed hard and shining, marked by a lateral scar. Stem shrubby. Leaves alternate and undivided. This order embraces milky plants, of which *Bumelia* is the only American example.

Class 5. Flowers Monopetalous. Corolla Perigynous.

1. *Guaiacanæ.*—Stamens adhering to the Corolla. Fruit a capsule or berry of several monospermous cells. Embryo in a fleshy albumen. This order embraces trees and shrubs, with alternate leaves and axillary flowers. *Halesia*, *Hopea*, and *Styrax* are American genera.
2. *Rhododendra.*—Calyx persistent, five-parted. Stamens determinate, inserted into the corolla, or attached to the base of the calyx. Germen superior. Capsule many-valved, each valve by the introflexion of its margins, constituting a polyspermous cell. This order embraces shrubs with alternate leaves and splendid flowers, most of which are natives of the United States. *Kalmia*, *Azalea*, *Rhododendrum* and *Rhodora* are of the number.
3. *Ericæ.*—Stamens adhering to the base of the corolla or inserted into the calyx. Anthers crested. Fruit a capsule or berry, having numerous polyspermous cells. *Arbutus*, *Andromeda*, *Clethra* and *Pyrola* are common examples.
4. *Campanulaceæ.*—Calyx persistent. Corolla attached to its summit. Stamens usually five, inserted below the corolla. Capsule polyspermous. Cells numerous, opening by lateral pores. *Campanula* and *Lobelia* are referred to this order.

Class 6. Flowers monopetalous. Corolla epigynous. Anthers connate. This class embraces the compound flowers and is subdivided into three orders, distinguished by the structure of the florets.

1. *Chicoraceæ.*—Florets all ligulate and united or fertile. Leaves alternate, flowers commonly yellow. *Leontodon* and *Lactuca* are examples.
2. *Cinarocephalæ.*—Florets all tubular. Leaves alternate, often spinous, colours of the flowers various. *Carthamus*, *Arctium* and *Centaurea* are examples.
3. *Corymbiferæ.*—Flowers mostly radiate, the discal florets being tubular, and those of the ray being ligulate. This is a very extensive order, embracing more than fifty genera within the limits of the United States. *Helianthus* and *Aster* are examples.

Class 7. Flowers Monopetalous. Corolla epigynous. Anthers distinct. Calyx monophyllous. Corolla monopetalous. Stamens determinate. Filaments inserted into the corolla. Germen simple, inferior.

1. *Dipsaceæ.*—Capsule monospermous, resembling a single seed. Embryo without albumen. Radicle superior. Stem herbaceous. Leaves opposite. Flowers aggregate, enclosed in a common polyphyllous calyx. *Dipsacus* and *Scabiosa* are examples.
2. *Rubiaceæ.*—Stamens four or five, alternating with the segments of the corolla. Fruit usually two naked seeds ; or two celled and polyspermous. Embryo small, slender, laterally involved in a large corneous albumen. Leaves entire, verticillate or opposite with intermediate stipules. *Galium*, *Houstonia*, *Mitchella* and *Gardenia* are examples.
3. *Caprifolia.*—Stamens usually five, alternating with the divisions of the corolla. Fruit a berry or capsule, usually crowned by the persistent calyx. Embryo in a cavity at the summit of a fleshy albumen. Leaves opposite and without intermediate stipules.

Linnœa, *Triosteum* and *Diervilla* are American examples.

Class 8. *Flowers polypetalous. Stamens epigynous.* Calyx monophyllous, superior. Stamens alternating with the petals. Germen inferior, simple. Styles two or more. Germen minute, oblong, in the summit of a hard or ligneous albumen.

1. *Araliæ.*—Seeds in a capsule or berry. *Aralia* and *Panax* are American genera.
2. *Umbelliferæ.*—Stamens and petals 5. Styles and Stigmas two. Fruit parted by a perpendicular section into two naked seeds. Leaves alternate, and usually compound, with sheathing petioles. This order includes the umbelliferous plants. Exemplified in Parsley and Hemlock.

Class 9. *Flowers polypetalous. Stamens hypogynous.*

The arrangement of this extensive class into orders not merely natural in themselves, but exhibiting a gradual transition from one to the other, must have been a work of no ordinary difficulty. Stamens within a polypetalous corolla, inserted beneath the germen, constitute the primary character of the class ; which embraces more than twenty orders. Those marks which served as a guide in the distribution of many of the former classes, are here of comparatively small importance. The stamens are variable in their number, union and proportion. The fruit which furnished a character for the monopetalous flowers, is here of less importance, nor will the number of the styles and cells, or the situation of the seeds, furnish invariable marks of distinction. The situation of the embryo in the seed, the presence, or absence, and nature of the albumen, afford characters remarkably constant, and abundantly adequate to the purposes of arrangement. By attending to these, Jussieu has subdivided one of the most extensive classes in his system, into orders which are usually well defined, and in most cases strictly natural.

1. *Ranunculaceæ.*—Stamens indeterminate. Anthers adnate. Germens numerous. Embryo minute, placed at the summit of the corneous albumen. Leaves generally simple and palmate or lobed. *Anemone*, *Ranunculus* and *Clematis* are examples.

2. *Papavaraceæ.*—Calyx usually two-leaved, deciduous. Petals four. Germen simple. Stigma sessile. Capsule one-celled, polyspermous. Seeds attached to a lateral receptacle, each partially invested by a membranaceous covering. *Argemone*, *Papaver*, and *Sanguinaria*, are examples.

3. *Cruciferæ.*—Calyx of four leaves. Petals four, cruciform, and alternating wiih the leaves of the calyx. Stamens six, two short. Style persistent. Fruit a silique. Seeds without albumen. *Lunaria*, *Cheiranthus*, and *Thlaspi*, are examples.

4. *Capparides.*—Germen simple. Fruit a berry or silique. Seeds attached to the sides of the fruit. Embryo without albumen, radicle curved. Leaves alternate. *Cleome* and *Parnassia* are examples.

5. *Sapindi.*—Petals four or five, inserted into a disc beneath the germen. Stamens usually eight. Fruit a drupe or capsule, with two or three monospermous cells. Embryo without albumen. Lobes incurved. *Cardiospermum* and *Sapindus* are examples.

6. *Acera.*—Petals and stamens inserted into a glandular disc beneath the germen. Fruit a many celled capsule, or two or three monospermous capsules, united

at their base. Embryo without albumen. *Æsculus* and *Acer* are examples.

7. *Malpighiæ.*—The plants of this order rank with the *Acera.*

8. *Hyperica.*—Stamens united into several parcels. Germen simple. Styles numerous. Fruit a capsule, with valves inflected, forming numerous cells. Seeds minute. Embryo straight, without albumen. Leaves opposite, simple and entire. *Hypericum* and *Ascyrum* are examples.

9. *Guttiferæ.*—Petals usually four. Fruit one celled. Embryo straight, without albumen. Leaves opposite, coriaceous, glabrous and veined. This order comprehends trees and shrubs, natives of tropical regions, and abounding in a resinous juice. *Clusia* is the only American example.

10. *Aurantia.*—Fruit a berry or capsule, with one or many cells, each enclosing one or two seeds. Embryo straight without albumen. This order contains shrubs with dotted or glandular leaves, exemplified in the Orange and Lemon.

11. *Meliæ.*—Calyx monophyllous: petals four or five, filaments united. Germen simple. Fruit a berry or capsule with many cells, each containing one or two seeds. Embryo straight, without albumen. Stem shrubby, branches alternate. Leaves alternate, without stipules. *Winteriana* and *Melia* are examples.

12. *Vites.*—Calyx monophyllous. Petals four or five. Stamens opposite the petals. Germen simple. Fruit a berry. Seeds hard, lobes plain. Embryo straight, without albumen. Stems sarmentose. Leaves without stipules. Tendrils and peduncles opposite the leaves. *Cissus* and *Vitis* are examples.

13. *Gerania.*—Calyx persistent. Petals five. Stamens ten, filaments united. Germen simple ; style persistent ; stigmas five. Fruit, five capsules, or five cells, usually monospermous. Embryo without albumen. Stem jointed. Leaves with stipules. *Geranium*, *Erodium* and *Oxalis* are examples.

14. *Malvaceæ.*—Petals five, attached to the column, formed by the union of the filaments. Capsules numerous and circularly arranged around the base of the style ; or simple and containing many cells. Embryo without albumen ; lobes incurved ; corrugated. Leaves alternate, accompanied by stipules. *Althæa*, *Gordonia* and *Malva* are examples.

15. *Magnoliæ.*—Stamens numerous, distinct. Anthers adnate. Germens numerous, placed on a common receptacle. Capsules numerous, each containing one or two seeds, sometimes coalescing and forming an aggregate seed-vessel. Embryo straight, at the base of the fleshy albumen. Stem shrubby. Leaves alternate, and accompanied by deciduous stipules. *Magnolia* and *Liriodendron* are examples.

16. *Annonæ.*—Calyx persistent, three-lobed. Petals six. Germens numerous. Berries or capsules numerous, each monospermous. The interior or membranaceous coat of the seed plaited, and enfolding a large solid albumen. Embryo very minute, at the scar or base of the seed. *Annona* and *Porcelia* are examples.

17. *Menisperma.*—Germens numerous. Berries or reniform capsules monospermous. Embryo small, at the summit of a large incurved fleshy albumen. Stem shrubby, sarmentose. Leaves alternate, simple and without stipules. *Menispermum* and *Cissampelos* are examples.

18. *Berberides.*—Stamens and petals equally numerous. Germen simple, fruit a capsule, or berry, of one polyspermous cell. Embryo straight, albumen fleshy. Radicle inferior. Lobes plain. *Berberis, Epimedium* and *Hamamelis* are examples.
19. *Tiliaceæ.*—Petals alternating with the calycine leaflets. Stamens numerous ; filaments distinct. Germen simple. Fruit a berry or capsule, polyspermous.—Embryo enclosed in a fleshy albumen. Leaves alternate, simple and accompanied by stipules. *Bixa* and *Tilia* are examples.
20. *Cisti.*—Calyx five parted.—Petals five. Stamens numerous. Germen simple, surmounted by one style and one stigma. Seeds, valves, and cells of the capsule numerous. Embryo incurved within a slender albumen. Stem shrubby or herbaceous. Leaves opposite. *Cistus* and *Helianthemum* are examples.
21. *Rutaceæ.*—Stamens usually ten. Germen simple. Fruit composed of many capsules united. Seeds attached to the interior angle of the valves. Embryo enclosed in a fleshy albumen. Lobes foliaceous. *Ruta* and *Fribulus* are examples.
22. *Caryophylleæ.*—Calyx tubular. Petals furnished with a claw, and alternating with the calycine segments. Germen simple. Styles and stigmas numerous. Capsule polyspermous. Seeds attached to the central receptacle. Embryo incurved, placed around the central farinaceous albumen. Stem herbaceous and jointed. Leaves opposite and connate. *Dianthus, Holosteum* and *Silene* are examples.

Class 10. *Flowers polypetalous. Stamens perigynous.* Calyx monophyllous. Corolla inserted into the Calyx. In this as in the preceding class, the character of the order is derived from the internal structure of the seed.

1. *Sempervivæ.*—Petals and Calycine segments equally numerous. Stamens determinate. Germens numerous, accompanied by glandular scales at their base. Capsule with one cell and two valves polyspermous. Embryo straight, placed around a fleshy albumen ; radicle inferior. Stem usually herbaceous. Leaves succulent. *Sedum* and *Cotyledon* are examples.
2. *Sxifragæ.*—Calyx 4 or 5 parted. Petals arising from the summit of the calyx and alternating with its segments. Stamens as numerous or twice as numerous as the petals. Germen simple, superior, surmounted by two styles and stigmas. Capsule usually terminating in two beaks, the extremities of the two valves. Seeds numerous, attached to the base of the capsule or to the inflected margin of the valves. Albumen fleshy. Embryo straight ; radicle inferior. *Saxifraga* and *Chrysosplenium* are examples.
3. *Cacti.*—Segments of the calyx numerous. Petals numerous, attached to the summits of the calyx. Stamens indeterminate. Germen inferior, surmounted by one style and several stigmas. Berry polyspermous. Embryo curved, without albumen. *Cactus* is an example. The *Grossulariæ*, originally included with the *Cacti*, have been separated by Desfontaines, and distinguished by the number of petals and stamens, and by the internal structure of the seed, having an embryo accompanied by a fleshy albumen. *Ribes* is an example.
4. *Portulaceæ.*—Petals and Stamens inserted into the base of the calyx.—Germen simple, inferior. Em-

bryo incurved, enclosing a farinaceous albumen. *Claytonia* and *Portulaca* are examples.

5. *Ficoideæ.*—Petals attached to the summit of the calyx. Stamens numerous. Germen simple, surmounted by several styles. Cells of the capsule or berry numerous, polyspermous. Seeds attached to the interior angle of the cells. Embryo placed around a farinaceous albumen. *Sesuvium* and *Mesembryanthemum* are examples.

6. *Onagræ.*—Petals usually four, attached to the summit of the calyx. Stamens determinate. Germen inferior. Capsule or berry polyspermous. Embryo straight without albumen. This order embraces a number of ornamental plants, among which are *Epilobium*, *Œnothera* and *Gaura*.

7. *Myrti.*—Calyx urceolate or tubular. Petals determinate, alternating with the segments of the calyx. Stamens indeterminate. Embryo straight without albumen. Leaves simple and dotted like those of the Orange. *Myrtus*, *Caryophyllus* and *Philadelphus* are examples.

8. *Melastomæ.*—Petals inserted into the summit of the calyx, and alternating with its segments. Stamens determinate and double the number of petals. Filaments bisetos, anthers beaked. Germen superior, enelosed by the urceolate or tubular calyx. Embryo incurved without albumen. Leaves opposite, simple and nerved. *Rhexia* is an American example.

9. *Salicariæ.*—Petals inserted into the middle of the calyx. Stamens determinate. Germen simple superior. Capsule enclosed by the calyx polyspermous, seeds attached to the central receptacle. Embryo straight without albumen. *Lythrum* and *Isnardia* are American genera.

10. *Rosaceæ.*—Petals usually five, inserted into the summit of the calyx and alternating with its segments. Stamens indeterminate. Styles arising from the side of the germen. Seeds attached to the base of the fruit, by a system of vessels which are inserted into a lateral scar near their summit. Embryo straight, without albumen. Leaves alternate, furnished with stipules. *Pyrus*, *Rosa* and *Rubus* are examples.

11. *Leguminosæ.*—In most cases the Corolla is papilionaceous, the stamens united into two parcels, the fruit a legume ; the embryo curved and without albumen. Sometimes the flowers are regular, and the embryo straight, nor are the filaments always united in two bundles : but these are exceptions. The leaves are alternate, usually compressed and accompanied by stipules. *Glycine*, *Lupinus*, *Hedysarum* and *Mimosa* are examples.

12. *Terebintaceæ.*—Petals three or five, inserted into the base of the calyx. Stamens equally or twice as numerous as the petals, inserted with them. Germen superior. Cells of the fruit monospermous. Seeds without albumen usually enclosed in a hard nut. Radicle bent. *Amyris* and *Rhus* are American examples.

13. *Rhamni.*—Divisions of the calyx, petals, and stamens, equally numerous. Germen superior, surrounded by a glandular ring, to which the petals and stamens are sometimes attached. Fruit a berry or capsule, with monospermous cells. Albumen fleshy. Embryo straight. *Ceanothus, Ilex* and *Staphylea* are examples.

Class 11. *Flowers apetalous, diclinious.*

This, which is the last class in the arrangement of Jussieu, embraces five orders, whose flowers are usually separated and without petals. To many plants however, which the learned author included under this head, the essential character of the class does not apply.

1. *Euphorbiæ.*—Stamens inserted into the receptacle. Germen superior. Cells of the fruit numerous, each composed of two elastic valves, and enclosing one or two seeds, which are attached to the central axis, and partially invested by an arillus. Embryo plane, surrounded by a fleshy albumen. *Euphorbia*, *Croton*, and *Ricinus*, are examples.
2. *Cucurbitaceæ.*—Calyx (Corolla of Linnæus and others) superior, five-parted, coloured, and withering. Filaments usually five, inserted into the calyx. Exterior coat of the berry hard. Seeds (if numerous) attached to the sides of the fruit. Embryo plane, without albumen. This order embraces plants with creeping, flexuose stems, axillary tendrils, and alternate leaves, which are usually rough and cordate, or palmate. *Cucumis*, *Sicyos*, and *Bryonia* are examples. Among the plants allied to the preceding, are the *Passifloræ*, which now constitute a distinct order.
3. *Urticæ.*—Flowers in a catkin, or enclosed in a common involucre. Stamens attached to the base of the calyx. Germen superior. Seeds arillate, naked, or enclosed in the pulpy receptacle or calyx. Embryo without albumen. The Nettle, the Fig, and the Mulberry, are examples.
4. *Amentaceæ.*—Barren flowers in catkins ; fertile ones, solitary, aggregate, or in catkins. Germen superior.

Embryo without albumen ; radicle straight. This order embraces trees and shrubs, with alternate simple leaves, accompanied by stipules. Exemplified in the Birch, Willow, Oak, and numerous other forest trees.

5. *Coniferæ.*—Seeds enclosed in the persistent scales of the cone, or in monospermous capsules. Embryo cylindrical, placed in the centre of the fleshy albumen. Seminal leaves divided, appearing as if there were several. Stem shrubby. Leaves persistent. Exemplified in the Pines, Juniper, and Cedar.

Such is the outline of the system of Jussieu. Our limits would not permit us to transcribe his characters ; but it is thought that the preceding sketch, which has been carefully compared with the original work, and with others of a more recent date,* will be equally satisfactory to those who wish to study this department of Natural Science.

* The author whom I have most frequently consulted, is Desfontaines, the learned associate of Jussieu, whose interesting volumes on *Trees*, &c. well deserve an English translation.

GENERAL SUMMARY.

FROM MIRBEL'S VIEWS OF VEGETABLE NATURE.

The food by which plants are nourished, and the agents by which their growth is promoted, have been examined in a former chapter.* To pursue the operation of these causes united, and to exhibit a comprehensive view of the influence of climate and soil on vegetation, requires the aid of extensive observation, and a knowledge of the productions of different countries. The forms of vegetables are extremely various, and certain tribes are attached exclusively to different countries. Some species are confined to the narrowest limits. The *Origanum Tournefortii*, discovered by Tournefort in 1700, in the little island of Amorgos, upon one rock only, was found eighty years afterwards by Sibthorp, on the same island, and upon the same rock; but no one has ever observed it any where else. Two of the *Orchideæ*, grow upon the Table Mountain at the Cape of Good Hope; and Thunberg, who has described them, found them on no other spot.

Mountainous countries afford many of these local species; such as dwell secluded on the heights, without ever migrating to the plains below. Thus we find that the Pyrenees, the Alps, and the Appenines, have their peculiar Floras, and that even some separate mountains of those great chains have species allotted to them alone, and which are not to be found on the adjoining summits.

Speculatively we might presume that all the individ-

* Page 39.

uals of one species would establish themselves under the same or nearly the same degrees of latitude, as they would find a nearly similar climate. But in reality, some species extend themselves in the direction of the longitude, and never swerve to the right or to the left. This is one of those anomalies of which it is not easy to trace the cause.

It may be observed, with the exception of the Lichens, which bid defiance to all climates alike, that a vastly greater proportion of species is calculated to endure a very high degree of warmth, than is calculated to bear severe cold. The progressive course of the proportion demonstrates itself most clearly, if we direct our view from the polar, towards the equinoctial regions.

The general face of the vegetation of a country does not depend solely upon the number, it depends also upon the more or less remarkable characters of the species found there. The chief part of these characters, are fixed ; and are derived from primitive creation, not from the effect of climate. As to the proposition, that certain vegetable forms are necessarily coexistent and dependent upon certain other animal forms in a given climate, we do not presume to controvert it ; but sound reasoning rejects its adoption, as a doctrine, while the connexion and reciprocal control of the phenomena of nature are unknown to us. Cautious and exact observers of those things which are the objects of our senses, let us leave to the fancy of the poet the bold task of unfolding the purposes of the Creator in his works ; while we confine ourselves to the less presumptuous one of describing them as we find them.

Vegetation within the tropics fills the European traveller with amazement, by the majesty and vigour of its aspect. The proportion of the woody to the herbaceous species, is vastly more considerable towards the Equator than in Europe; and the difference is therefore in favour of the equinoctial regions, for trees give the character of grandeur to vegetation. Those of the dicotyledonous class within the tropics, are frequently conspicuous for the height and circumference of their stems, the richness and variety of their foliage, as well as the bright and well-contrasted colours of their blossom. By the irregularity of their forms, they set off to advantage the arborescent monocotyledons of the Palm tribe, which have in general the simple sober forms of our columns, of which they were the models. It is towards the Equator, that the gigantic climbers, which grow to the length of several hundred yards are found; as well as those magnificent herbs of the *Scitamineæ* and *Musæ*, as tall as the trees of our orchards; with flowers and foliage not less pre-eminent in their dimensions. For instance, the *Corypha umbraculifera*, an East Indian palm, with leaves in the form of an umbrella, and more than six yards across; and the *Aristolochia*, that grows on the river of La Madalena, the flowers of which, according to M. de Humboldt, serve the children for hats. The far greater part of the aromatic plants, belong also to the equatorial regions.

By the side of this rich and varied vegetation, that of Europe appears poor and tame. Here the species of trees are few; and all have a port and foliage in which much sameness prevails. Their flowers make so little show, that the generality of people, who think nothing of the flower except the corolla, being ignorant of the use and importance of the other parts, believe that most trees have none at all.

The inferiority of the vegetation of Northern regions will appear in a still stronger light, if we compare the species of the same genera or tribes which grow both in Europe and under the line. In South America, plants of the fern-tribe, with a foliage and frutification not very unlike our common Brake and Polypody, grow like Palms, and have a stalk in the form of a column.

The heaths of the northern parts of Europe are low bushes, with feeble stems and small bloom; those of the coasts of the Mediterranean have also a small bloom, but their stems are taller and more robust; those of the Cape fascinate by the form, splendour of colour, and size of the corolla.

The *Geraniums* of Europe do not approach those of Africa in point of stature or beauty of flower.

Most plants of the Mallow-tribe with us are herbaceous; those of hot climates, either shrubs or trees. A tribe, of so little account in these parts, holds a place among the vegetables of the most note in the equinoctial regions. There it counts among its species the *Baobab* and the *Ceiba*, the colosses of the vegetable creation: besides the "hand-tree" of Mexico, so called from the form and disposition of the stamens of the flower, which represent very tolerably a hand or paw with five fingers.

The *Leguminosæ* or pulse-tribe furnish Europe with many herbaceous species, several shrubs, and one middle-sized tree; all of which, however, have leaves composed of but few leaflets. The same tribe in the hot climates of Asia, Africa, and America teems with lofty trees, graced with leaves of the most delicate texture, divided and subdivided into numberless leaflets, and playing in the wind like plumes.

The *Aroideæ* in Europe never exceed the height of a yard; those of Mexico, the Brazils, and Peru sometimes tower into the air like the Banana, of which they assume the appearance; at others lengthening themselves into supple climbers, they mount to the tops of the highest trees.

Differences as strongly marked are exemplified in *Orchideæ*. In Europe the species are low; their flowers, although equally interesting to the botanist by the singularity of their structure as in other regions, are too insignificant to attract the attention of any who do not make plants an object of their study. In the torrid zone, the case is quite different in regard to this tribe; the greater portion of which consists of species that excite our wonder by the size and brilliancy of their blossom; and many, as the Vanilla, suspend their long branches covered with a foliage of shining green, and terminated by magnificent garlands of flowers from the summits of trees.

The *Apocyneæ*, *Boragineæ*, and many other tribes, are equally examples of contrasts of a like nature. The European nnturalist, whom the ardent thirst of science leads under the Equator, views with ecstacy those fertile regions, which exhibit at every step forms familiar to him, decked in the rich attire bestowed from the hand of a more bountiful and powerful nature.

There are beauties in a land yet wild and savage, which disappear at the approach of civilization. In Europe the soil abounds only in plants which are of use to man. Domestic vegetables, by the aid and protection of the cultivator, have so trenched upon the domain of the wilderness, that space is scarcely left for the existence of those for which man has no call. The primeval forests of the Gauls and Germans have disappeared. Forests at this time of day are mere formal plantations of large extent. They are intersected in all directions by roads and paths, are explored without difficulty; and the wild animals no longer find safe refuge in them. Generations of trees are renewed in quick succession, on a soil which the industry of the proprietor keeps in constant requisition, and it is mere chance, when a single stick is left to end its career by old age. Far in the north there are several forests which still preserve some traces of the primeval vegetation of Europe. In these the oaks, spared by the axe, acquire an enormous size; while others, worn out by age, fall of themselves, are decomposed, and help unceasingly to augment the surface of the soil, covered with high Mosses and thick Lichens, that preserve a prolific moisture.

None however approach in magnificence the forests which shade the equinoctial regions of Africa and America. One is never satiated in admiring there the endless multitude of vegetables brought into near contact with each other, and mingled promiscuously together; so different among themselves, and often so extraordinary in structure and produce; those enormous trees still exhibiting no symptoms of decay, though their age goes back to a period at but little distance from the last revolution of our globe; those towering Palms, contrasting by their simple forms with all that surrounds them; those extensive climbers; those Ratans which, knitting together their long and flexible branches by numberless knots and turns, encircle as one group the whole vegetation of these extensive regions. To clear a path through these, neither fire nor axe is sufficient; the one extinguishes for want of circulation in the air, the other is broken or blunted by the hardness of the wood it meets. The soil cannot afford place to the numberless germs which it developes. Each tree disputes with others, which press from all sides, the soil it wants for its existence; the strong stifle the weak; while rising generations obliterate even the slightest trace of destruction and death; vegetation never flags; and the earth, so far from becoming exhausted, acquires new fertility from day to day. Hosts of animals of every kind, insects, birds, quadrupeds, reptiles, beings as diversified and strange as the vegetables of the place itself, retire themselves under the vast canopy of these ancient thickets, as into a citadel proof against the attack of man.

North America, under the same degrees of latitude as France and England, and with a colder climate, presents a far richer vegetation. There large trees, such as the *Liriodendron* and *Magnolia*, bear the most superb flowers. Those of many other trees and shrubs vie in beauty with the flowers of the torrid zone; the light waving composite foliage of the *Robinias* and *Gleditschias* are the counterparts of the *Mimosas* of the tropics. The single genus of Oak comprehends within the United States more species than Europe reckons within the whole amount of its trees.

In the northern parts of Asia vegetation differs but slightly from that of Europe. We meet with nearly the same genera, and similar types prevail. But in the southern parts the character of the country is changed. Without water, and swept by scorching winds, the drought is extreme. The carpet of soft verdure and the refreshing shade of its northern countries and of Europe are looked for in vain. Most of the plants have thinly-scattered long narrow arid leaves, entire at the edge, and of a gloomy green; several have none at all, or at least such, as instead of leaves may be truly termed thorns. Yet many of the trees and shrubs have a showy blossom. Of the former, the largest in those parts belong to the myrtle tribe, and have a punctured foliage, diffusing an aromatic scent when bruised. There are likewise many shrubs of the pulse-tribe with a composite foliage ; but the leaflets of the leaves are only evolved on the plant's first rising from the seed. As it advances to maturity, the naked footstalks widen into simple lanceolate blades, or become transformed into acicular spines, resembling the leaves of Asparagus. In New Hollaad the *Protaceæ* abound ; so they do at the Cape of Good Hope ; but the *Liliaceæ*, which decorate the African promontory so profusely, are, on the contrary, rare in New Holland. It is a fact as notorious as surprising, that no one vegetable belonging to the countries towards the southern pole produces a single fruit for the food of man.

There are divers conditions, without the performance of which the growth of the different species cannot proceed. An uninterrupted heat is requisite for some ; a moment's decrease in it is fatal to them ; some withstand a considerable degree of cold while their sap is quiescent, but want a high degree of heat when that is once in motion ; some like a moderate temperature, and dread equally the excess of both heat and cold. It is upon the observation of such appearances that the cultivator grounds his practice ; he knows that it would be in vain for him to attempt to grow, without shelter, either the Date or Orange, beyond the 43d degree of northern latitude ; that the Olive will do a little beyond ; that the vine is barren beyond the latitude of 50 degrees, or at least never brings its grape to perfection. He is cautious of exposing in a southern aspect, the species whose sap is readily set in motion by the first gleam of warmth ; he knows that the late frosts destroy them; witness, the vineyards round Paris: the plantations there which escape the injuries of frost, are not those which look towards the south, but those that look towards the north. The sap of the latter is set in motion late, and when the heat reaches them the season is already settled, and no risk is run from the inroad of cold.

Late frosts are peculiarly hurtful to the delicate American and Botany Bay plants, which we are attempting to naturalize in Europe. Many of these will bear a very sharp cold in the heart of winter; but no sooner does the spring advance, and a softer air prevail, than their roots begin to elaborate their juices under ground, their bark to fill with moisture, their buds to swell and open, and a fall in the temperature if but for one moment destroys them.

In proportion as we advance towards the Pole, we are sensible of a change in the appearance of the vegetation. The species which require a mild and temperate climate, are supplied by others which delight in cold. The forests fill with pines, firs, and birches, the natural decoration of a northern land. The birch, of all trees, is the one that bears the severity of the climate the longest; but the nearer it approaches the Pole, the smaller it grows; its trunk dwindles and becomes stunted, and the branches knotty, till at last it ceases to grow at all towards the 70th degree of latitude, the point where man gives up the cultivation of corn. Further on, shrubs, bushes, and herbaceous plants only are to be met with. Wild Thyme, Daphnes, Creeping Willows, and Brambles, cover the face of the rocks. It is in these cold regions that the berries of the *Rubus Rusticus* acquire their delicious flavour and perfume. Shrubs disappear in their turn, They are succeeded by low herbs, furnished with leaves at the root, from the midst of which rises a short stalk surmounted by small flowers. These pretty plants take up their quarters in the clefts of rocks, while the Grasses with their numerous slender leaves spread themselves over the soil, which they cover as with a rich verdant carpet. The Lichen, which feeds the rein-deer, sometimes mixes in the turf: sometimes of itself covers vast tracts of country; its white tufts standing in clumps of various forms, looking like hillocks of snow which the sun has not yet dissolved. If we go farther, a naked land, sterile soil, rocks, and eternal snows, are all we find. The last vestiges of vegetation are some pulverulent *byssi*, and some crustaceous Lichens, which cover the rocks in motley patches.

The principal causes which induce this progression of changes are three: 1st, the excess of duration in the winters, a consequence of the obliquity and disappearance of the solar rays; 2d, the dryness of the air, a consequence of the decrease of heat; 3d, the prolonged action of the light, which illumines the horizon through the whole period of vegetation. I will resume, in as few words as I can, the effects of each of these three causes.

It is well known that too great a degree of cold, by congealing the sap, occasions the rupture of the vascular system in plants, and thereby destroys them; but the deleterious action of cold is not confined to purely mechanical results; it has been proved that heat is a stimulus that cannot be dispensed with in vegetation. Many species secrete juices in warmer regions which are unkhown in their economy in colder climates. The Ash yields manna in Calabria, but loses that faculty as it advances towards the north. The grape in the south of Europe abounds in matter of a sweet quality ; in the north, it contains an excess of acid. So long as the organic functions, which depend upon the degree or duration of heat, can be carried on, the Ash and the Vine continue to grow ; they grow even when those functions are performed incompletely ; but their growth is stinted. They finally disappear at that point where the portion of warmth in the atmosphere, though still equal to prevent the freezing of the sap, is no longer able to stimulate their organs or their frame into action. All other vegetables, whose dimension and duration subject them to the full severity of the frost, share the same destiny at a greater or less distance from the torrid zone, and in proportion as their constitutions require a greater or less degree of heat. So that nothing is found near the Pole but such dwarf shrubs as are sheltered under the snow in winter, or annuals and herbaceous species, endowed with so quick a principle of life, as to rise, flower, and fruit within the space of three months ; or some agamous and cryptogamous species, which adapt themselves to all degrees of temperature, and are consequently the last organic forms under which vegetable life is to be described.

Heat and moisture united are highly favourable to the growth of plants. No countries are more abundant in herbaceous vegetables, or better wooded than Senegal, Guinea, and Cayenne, where both these props of vegetation are in the plenitude of their force. Experiments made with the hygrometer prove that the moisture of the atmosphere increases as we approach the Equator. In hot climates, when the sun sinks below the horizon, the watery exhalations condensed, are returned to the earth in the form of dew, that moistens the surface of the foliage, and feeds those vegetables in which the absorbing powers of the parts above ground suffice for their support. Of this number are the succulent plants, whose fibrous root only serves to hold them in their places; and the moisture of the atmosphere is inhaled and retained by the spongy parts above. Thus in the vast plains that receive the waters from the eastern declivity of the Andes, when the scorching heat of summer has consumed the grasses and other herbaceous kinds which the rainy season had brought forth, we still find some lingering *Cacti*, which, under their dry, thorny coats, conceal a cellular system, by which an abundant sap has been imbibed and preserved. But in countries where the atmosphere holds but little moisture in evaporation, either because the soil is wholly destitute of water, or by reason of the coldness of the temperature, we find no plants at all, or such only as are of dry, hard texture. The sands of Africa, watered by no river, are found to be utterly barren. Spitzberg, Nova-Zembla, Kamschatka, &c. where the influence of the sun is only felt for two months in the year at most, and where, consequently, the air is habitually dry, furnish a very scanty portion of herbaceous plants only, or some dwarf shrubs, with a narrow leathery foliage. It is true that drought is not in these instances the sole cause of the degenerated state of vegetation, but it would of itself be sufficient to produce it: for it is a fact, that plants acquire height of stem and breadth of foliage, only in proportion to the abundance of nutriment they meet with in the atmosphere, and that nutriment is water reduced into vapour, and held in suspension by the atmosphere.

When vegetables are deprived of light, they extend in length, shoot up pale, lank stalks, are of a lax fibre, and of no substance: in short, they spindle themselves out. The way that light acts upon this class of the creation, is principally in separating the elementary parts of the water and carbonic acid contained in them, and in extricating the oxygen of the latter. The carbon of the acid, with the hydrogen and oxygen of the water, form the bases of the gums, resins, and oils, which flow in the vessels or fill the cells. These juices nourish the membranes, and induce the woody state in them ; and they do this in proportion as the light is stronger and its action more prolonged. Thus we see that darkness and light have effects directly opposite upon vegetables. Darkness favours the length of their growth by keeping up the pliancy of their parts ; light consolidates them, and stops growth by favouring nutrition. It should follow that a fine race of vegetables, one that unites in due proportion, size, and strength, depends in part upon the proper reciprocation of nights and days. Now in the northernmost regions, plants go through all the stages of growth at a time when the sun no longer quits the horizon ; and the light, of which they experience the unremitting effect, hardens them before they have time to lengthen. So their growth is quick, but of short duration ; they are robust, but undersized.

The same plants, when transplanted into milder regions, where the atmosphere is moist, and light and darkness follow in regular succession ; if they are but endowed with a frame of sufficient pliancy to support their new mode of existence, are seen to lengthen their stems, expand their branches, as well as multipy, dilate, and soften their leaves.

Vegetation, in ascending above the level of the sea, undergoes modifications analagous to those which attend its progress from the line to either pole ; with this distinction, that in the last case the phenomena succeed by almost imperceptible gradations, while they crowd upon and follow each other in rapid succession on the ascent of mountains. The height of 4 or 5000 yards in the hottest parts of the globe, produces changes as distinct as the 2000 leagues or more, which lie between the Equator and the polar regions. The three causes of the influence of which we have just spoken, all reappear within this space; the heat is diminished, the air is dry, and the duration of light is protracted. To these we must add two others; a decrease of depth in the volume of the air, and a scarcity of those substances which abound in carbon, and are produced by the decomposition of organic bodies.

Many of the less perfect plants grow under circumstances the most unfavourable to vegetation. Neither the total privation or the excess of light, nor the extremes of moisture or dryness, nor scorching heat or the fiercest cold, nor want of mould or scantiness of carbon, prevent these rude species from developing their forms; neither are they of small importance in the general economy of nature. By them the soil is prepared, and they lay the foundation of vegetation.

The rudest of the Lichens, mere coloured crusts of the simplest structure, first fix themselves on the smooth surface of the rock which they erode, break up, and scoop into hollows. These at last are turned into dust. Sorts a degree higher in the scale of organization, together with some elegantly formed Mosses, resembling trees and shrubs in miniature, take their place. By the successive dissolution and regeneration of such vegetation through a long series of years, a thin stratum of mould is formed upon the stone, in which Herbs and Grasses take root and grow. Generations succeed each other, and the mould deepens. Herbs of higher stature, bushes, and even shrubs, take their stand on the newly fertilized rock. At last, the seeds of trees themselves, carried either by animals, the water, or the wind, are seen to germinate, probably to become the first inhabitants of a forest that shall one day extend itself over vast tracts of country.

Lichens will not grow upon sands that are set in motion by the wind ; but the Grasses which are nearly as unformed and rude, afford some turfy species with fine closely fibred roots ; by these they weave themselves together and bind down the sand, which every breeze had used to drive to and fro like the surge of the sea. The soil once made stable, vegetables of every size thrive in it. Hence the industrious inhabitant of Europe has been taught, to use the sea lyme-grass and others of the same nature, to fix the sand of those beaches which threaten to encroach on his fields near the shores of the sea.

The bottoms of the marsh and lake are gradually though slowly raised by aquatic plants. The water gaining in surface what it loses in depth, is sometimes made to overflow at one side or the other ; and even to disappear entirely, when the springs which feed it are no longer able to counterbalance the waste from evaporation, which increases with the surface.

It sometimes happens that certain species, especially of the Bog-Moss, float themselves on marshes and lakes, forming islets and small peninsulas, which are increased from day to day, both in extent and depth, from the accumulated wreck, and remains of the plants which have grown on them. This factitious soil is sometimes clothed by meadows, sometimes by shrubs, and even trees : when now and then it breaks under the weight of the load, and sinks to the bottom of the water. These appearances are by no means uncommon in the north of Europe. The effect they have in changing the face of the soil is greater or less according to circumstances, and in certain districts they may even affect perceptibly the temperature and quality of the atmosphere; but scarcely beyond the spot where they take place. In regard to forests, however, the case is very different; their influence is felt far around. Their usual effect is to cool the atmosphere, to a greater extent even than the degree of latitude. When France and Germany were covered with wood, Europe was much colder than at present; the winters of Italy were longer; the Vine could not be cultivated on this side of Grenoble; the Seine froze every year. The parts of the coast of Cayenne which have been cleared of their wood by Europeans, experience in summer in its full force the overwhelming heat of the sun of the torrid zone, while, in the same season, the interior of the country is cooled to such a degree by forests, that a fire or shelter is found necessary in order to pass the night.

The causes why forests thus lower the temperature, are plain. They detain and condense the clouds as these pass; they pour into the atmosphere volumes of water dissolved into vapour; winds do not penetrate into their recesses; the sun never warms the earth they shade; and the soil being porous, as formed in part of the decayed leaves, branches, and stems of trees, and coated over besides by a thick bed of brushwood and moss, is constantly in a state of moisture. The hollows in them serve as reservoirs for cold and stagnant waters, their declivities give rise to numberless brooks and rivulets; and, as we see, the best wooded countries are ever those which are watered by the largest rivers.

In proportion as man, who finds himself cramped in countries of long standing civilization, extends the boundaries of his domain by stripping the soil of its ancient forests, so the wind and sun disperse the superabundant moisture ; the springs exhaust themselves ; the lakes dry up ; inundations cease altogether, or confine themselves to a smaller extent ; the volume of water carried along by rivers diminishes ; and the atmosphere becomes warmer and drier. These are results that cannot be denied, and, without mentioning the numerous evidences which history offers, it will be sufficient to adduce the United States of America as a proof. It is a fact admitted by all, that the clearing of the woods began two centuries ago in the European colonies, and continued unceasingly to this day, has occasioned a very evident diminution in the quantity of water, and a perceptible elevation in the temperature of the climate. But where, from improvidence or brutal selfishness, man has destroyed the woods of a country without reserve, the soil, bereft of the moisture requisite to the maintenance of vegetation, has been reduced to the most fearful sterility. The Cape Verd islands, once watered by numerous springs, and covered with lofty forests and luxuriant herbage, now present to our view only waterless gullies, rocks bared of their mould, with here and there a patch of parched herbs, some stunted bushes, and a few plants of the succulent kind. The Isle of France, formerly so fruitful, is at this moment threatened with the same sterility, if the wisdom of government does not hasten to set proper bounds to the improvident waste of the woods by the falls now carrying on.

In mountainous countries, above all others, the destruction of trees produces the worst effects. The forests which encircle them above, are the protection of the fields below; but when once the axe is used among them without a due discretion, the rain breaks up and carries off the layer of mould no longer consolidated by roots; large and deep gullies are cut by the descending torrents on all sides; the snow, accumulated on the summits during winter, slides down the declivities, and finding no dam that stops it, enormous masses are precipitated with a dreadful crash to the bottom of the valleys, destroying in their way the fields with their cattle, and the villages with their inhabitants. The rock once laid bare, the rain-water which penetrates its clefts, silently undermines it; the frost cracks and crumbles it away; it falls in ruins, accumulating at the foot of the mountain mounds of rubbish. This is an evil which has no remedy; the forests once banished from the highland tops are never replaced; while the washings and rubble carried down yearly by the rain, soon transform into a desert the populous and flourishing valley below.

The vegetable mould produced by herbaceous plants upon unsheltered land is destroyed by the action of light, heat and oxygen, while that which is formed in the shade of forests, defended from the effects of these destructive agents, increases from day to day, both by the remains of vegetables, as well as of the animals of all kinds which seek refuge in them. This is the reason why newly-cleared land is endowed with such prodigious fertility. In this either rye or oats must be cultivated for the first years, its too abundant richness causing the more precious wheat to grow rank, and produce little grain. But sooner or later, the soil is exhausted, and recourse must be had to manure, to restore the nutritious particles carried off by successive crops. If this is neglected, harvests begin to dwindle, briers and brambles and a thousand wild plants take the places of those which had been produced by agriculture. The flocks diminish rapidly ; for the increase of flocks, and consequently of the human race, depends above all things upon the prosperity of agriculture.

All is connected in the vast system of the globe, and order emanates from the equipoise of conflicting phenomena. Animals carry off the oxygen of the atmosphere, replacing it by carbonic acid gas ; and are thus at work to adulterate the constitution of the air, and render it unfit for respiration. Vegetables take up the fixed air, retain the carbon, and give out oxygen ; and are thus purifying the air tainted by animals, and re-establishing the necessary proportions between its elements. In Europe, while our vegetables, stripped by the severity of the season of their foliage, no longer yield the air contributing to life, the salutary gas is borne to us by trade-winds from the southernmost regions of America. Winds from all quarters of the world intermingle thus the various strata of the atmosphere, and keep its constitution uniform in all seasons and at all elevations. The substances which are produced by the dissolution of animal and vegetable matter, diluted with water, are absorbed by plants, and constitute a portion of the nourishment by which they are maintained ; plants, in their turn, become the food of animals, and these again the prey of others which subsist on flesh. In spite of this perpetual state of war and destruction, nothing perishes, for all is regenerated. Nature has ordained that the two great divisions of organized beings should depend the one upon the other for support ; and that both the life and death of individuals should be equally serviceable in keeping up the races of them.

If we come to consider vegetation as it regards ourselves, we shall find that this great agent of nature, subjected in a certain degree to the control of man constituted in a state of society, is the main source of his prosperity or of his misery. How many countries have the greedy ambition of princes, and the degradation and ignorance of the people, made barren ? Recollect what Asia Minor, Judea, Egypt, the provinces at the foot of Mount Atlas have been, and behold what they are at this day. Recollect Greece, once the country of science and of liberty, now that of ignorance and of slavery ; she can be only recognized in her ruins, and her monuments of the dead. Man had denied his labour to the earth, and the earth her treasures to man : all vanished with agriculture. The traveller who passes that country of so great renown, finds in the place of the fine forests that crowned its mountains, or the rich harvests reaped by twenty busy nations, or the numerous flocks that enriched its fields, only naked rocks and sterile sands, with here and there a miserable village. He seeks in vain for several rivers recorded in history ; they are gone.*

* The preceding summary "from Mirbel," has been abstracted from the Journal of Science, &c.

EXPLANATION OF THE PLATES.

Plate I. Fig. 1. Represents the epidermis of the common Pink, so magnified as to exhibit the exhaling orifices. 2. The epidermis of the Lily magnified to shew the same. 3. The epidermis with areas which contain the evaporating pores of Hedwig. 4. A horizontal section of a woody stem exhibiting a magnified view of its vessels ; *a* represents the simple tubes ; *b* the porous tubes ; *c* the false spiral tubes ; *d* the mixed tubes. 5. Represents the spiral vessels. 6. The same magnified. 7. A transverse section of a woody stem. 8. The same magnified. 9. A fibrous root. 10. A granulated root. 11. A scaly bulbous root. 12. A tunicate or coated bulb. 13. A palmate root. 14. The root of *Utricularia* with numerous air cells, which prevent the plant from sinking in water. 15. A creeping root.

Plate II. Fig. 16. Represents a dichotomous stem with connate perfoliate leaves. 17. *Azalea* with determinate branches. 18. The English Ivy with radicating tendrils. 19. A voluble stem twining from left to right. 20. A Passion flower climbing by the aid of spiral tendrils. Its leaves are cordate ; its stipules in pairs ; its tendrils axillary ; and its radiant nectaries filiform. 21. A scaly stem. 22. The English Cowslip with radical leaves, having its flowers on a scape which terminates in a simple umbel. 23. The winged stem of the Thistle with spinous leaves. 24. *Polypodium vulgare* a dorsiferous fern whose stem furnishes an example of the Stipe. 25. An articulated stem of the *Cactus*. 26. *Uvularia* with a perfoliate leaf.

Plate III. Fig. 27. *Brasenia* with a peltate leaf. 28. Ovate leaf. 29. Spatulate leaf. 30. A lanceolate leaf. 31. *Dioscorea glauca* has cordate leaves which are 9 nerved. 32. Gill has a reniform and crenate leaf. 33. A hastate leaf, 34. A sagittate leaf. 35. An unequal leaf. 36. A sinuate leaf. 37. A runcinate leaf. 38. A palmate leaf. 39. A three-lobed leaf. 40. A parted leaf with incised segments. 41. A pinnatafid leaf. 42. The leaves of wood-sorrel are ternate and obcordate. 43. A pinnate leaf of the Sensitive plant. 44. Interruptedly pinnate. 45. Verticillate. 46. Pedate.

Plate IV. Fig. 47. Represents a repand leaf. 48 The truncate leaf of the Tulip tree. 49. A ciliate leaf. 50. A doubly compound leaf. 51. A bi-tubular leaf. 52. A flower-bearing leaf. 53. The leaf of *Sarracenia purpurea.* 54. The leaf of *Nepenthes distillatoria.* 55. The leaf of *Dionœa muscipula.* 56. The linear leaf of grasses with a stipule arising from the summit of its sheath. 57. and 58. exhibit the cortical net of leaves. 59. Glands on the fruit of the Rose. 60. The leaf of the common Nettle, covered with stings. 61 The flower of *Atractylis* defended by thorns.

Plate V. Fig. 62. Represents an umbel. 63. A cyme. 64. A corymb. 65. A spike. 66. A raceme. 67. A head. 68. A whirl. 69. A panicle. 70. A spikelet, *b*, the involucellate filaments which surround the germen in many of the *Cyperoideœ.* 71. A Catkin. 72. A Cone, *a* represents the scales so dissected as to exhibit the fructification within. 73. A compound flower with an imbricate calyx and tubular florets. 74. The involucellate filaments of *Scirpus*. 75. The same organs in *Schœnus.*

Plate VI. Fig. 76. Represents a monapetalous flower with a trumpet-shaped corolla, and a bell shaped Calyx. 77. A naked flower of the Lily, with 6 petals, 6 stamens and one pistil. 78. The same flower with the petals removed ; *aaa* are the anthers ; *b* the stigma. 79. A papilionaceous flower. 80. The stamens and pistils of the same, the latter with a plumose or bearded stigma. 81. A labiate flower. 82. A flower of Agrostis with a valvular calyx, forked anthers, and plumose stigmas. 83. A flower of the Oat, with a spiral awn attached to the interior valves or corolla. 84. A double calyx. 85. *Parnassia* with its nectaries terminating in filaments and tipped with globose summits. 86. A nectary of *Parnassia palustris.* 87. The nectary or lepanthium of *Asclepias.* 88. Nectaries of *Aconitum.* 89. A three celled capsule. 90. A Samara or winged monospermous capsule. 91. A berry. 92. A drupe. 93. An apple. 94. A filbert nut.

PLATE. VII. Fig. 95. Represents a section of the Cocoa nut. 96. A strawberry. 97. A silique. 98. A silicle. 99. A legume. 100. The receptacle of the Dandelion. 101. *Arum Triphyllum*, whose spathe encloses a spadix. 102. The fruit of Geranium. 103. The pappus of Salsify. 104. The bracte of the Lime tree. 105. The seed of *Clematis*. 106. A seed shewing the scar, to which the vessels of the capsule are attached. 107. The filbert shewing the embryo. 108. The Persimmon with an oblique embryo. 109. A germinating seed. 110. The lobes converted into seminal leaves. 111. The incurved embryo of the Kidney bean.

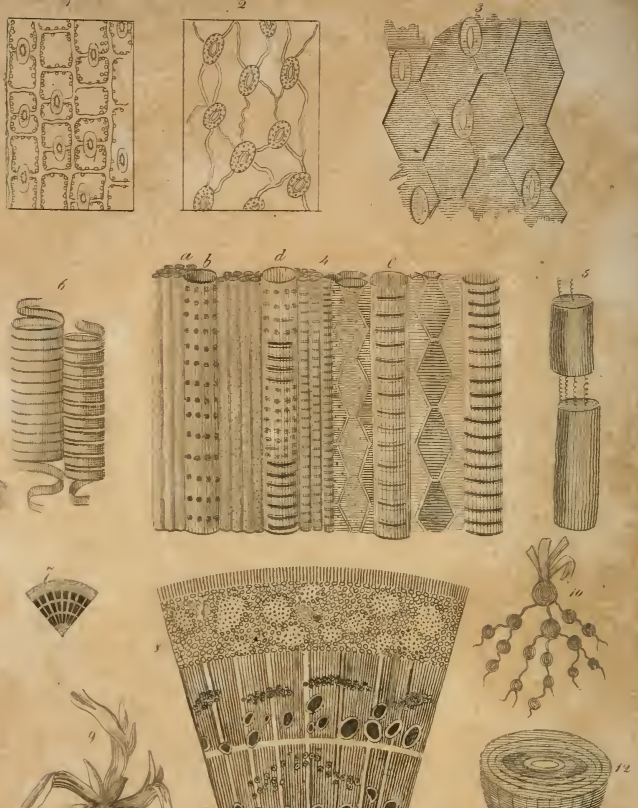
PLATE VIII. *Cryptogamia*, Fig. 112. Represents a section of a fern whose organs of fructification are covered by an indusium. 113. The indusium, and the capsule with its transverse ring. 114. Equisetum with its fructification on a spike. 115. One of its peltate receptacles. 116. Its unripe seeds, surrounded by four stamens. 117. The fertile flowers of *Funaria hygrometica*. 118. The capsule of a Moss magnified to shew its fringe and lid. 119. Herbage and flowers of *Jungermannia complanata*. 120. The same magnified. 121. The herbage (*thallus*) of *Parmelia stellaris*. 122. The shield (*apothecium*) of a Lichen magnified to shew the seeds or gems by which these plants are propagated. 123. *Boletus*, having pores beneath the cap of the Fungus. 124. *Hydnum* with prickles. 125. *Agaricus* with gills which contain the gems. 126. The fructification of *Marchantia*. 127. *Lycoperdon stellatum* a fungus with a stellate volva. 128. *Bryum androgynum*, a moss with unfertile flowers. 129. *Polytricium commune* with its fructification concealed by a veil, *a* represents the veil ; *b* the capsule ; *c* the same with the lid removed ; *d* the lid. 130. The unfertile flowers of the same moss. 131 and 132 the barren and fertile flowers of Mosses according to the representation of Hedwig.

INDEX.

ERRATA.

Preface, page vi, line 3, omit *the*

Page	for	*read*
4	Baukin	Bauhin
125	acrose	acerose
174	renguiculate	unguiculate
202	Lamana	Samara
246	monodelphia	monadelphia
	Wildenow	Willdenow



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12
13
14
15


16
19
21
20
22
24
25
26

IV.


27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46


95
96
97
98
99
100
101
105
104
a
b
102
103
106
107
110
111
108
109

VIII.


112
113
a
b
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
a
b
c
d
130
131
132