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OF
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BY
J. E. TESCHEMACHER.

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To Miss Anne Smith
Cambridge
From her son

St. Michael's Church
St. Michael's Church

St. Michael's Church

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A
CONCISE APPLICATION
OF THE
PRINCIPLES OF STRUCTURAL BOTANY
TO
HORTICULTURE,

CHIEFLY EXTRACTED FROM THE WORKS OF LINDLEY,
KNIGHT, HERBERT, AND OTHERS, WITH ADDI-
TIONS AND ADAPTATIONS TO THIS CLIMATE.

By J. E. TESCHEMACHER.

BOSTON:
CHARLES C. LITTLE AND JAMES BROWN.

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P R E F A C E .

THE combination of practical skill and experience with scientific investigation and knowledge, the former giving results, the latter affording reasons for these results, and sketching the outlines of farther experiments, has always appeared the surest ground of obtaining information of the greatest value on all subjects of natural science.

A concise and simple explanation of some of the prominent facts and laws of vegetable physiology so that they might become known to, and guide those agriculturists and horticulturists, whose time is too much occupied to permit them to go into the detail of the reasoning involved in the numerous experiments scattered through many volumes and periodicals, must be of advantage.

The valuable experiments of Knight, the works of Lindley, Decandolle, Herbert and others, the Compilations of Loudon, and some of the results of the extraordinary attention paid within the last

fifteen years throughout Europe to the laws and operations of vegetable life, added to my own experience and study of this subject, compose the basis on which this little publication is founded.

The subject of Manure, and the properties of soils, do not strictly belong to structural botany, but the few details inserted regarding them cannot be thought misplaced.

The diseases of Plants must be left to the Entomologist as far as the insects which infest them are concerned, and to the Cryptogamist as respects the injuries inflicted by fungi lichens and mosses. Nor are there any channels into which the labors of those who are devoted to such branches, can be diverted with more interest to themselves or value to mankind.

It cannot be denied that many of the advantageous practices in Horticulture and Agriculture have been discovered by the mere practical man, without any deductions from science, or the laws of vegetation. Yet it is probable that had the knowledge of these laws been earlier and more widely disseminated, these advantages would have been sooner known and more generally diffused than they are at present. Many are disinclined to

adopt a new course, and reject the old one to which they have been long attached, without some very palpable and sufficient reasons for the change. But one improvement introduced and properly accounted for, paves the way for others, and the mind is prepared to inquire. In this country, particularly, such a frame of mind is prevalent, and has produced very important results in agriculture; it will do the same in horticulture, now comparatively in its infancy.

It seemed, therefore, that the separation of a few of the principal facts concerning the structure and parts of vegetables from the other masses of botanical knowledge with which they are usually published, and their application to the practice of horticulture could not fail to be favorably received in this community.

A complete treatise on these subjects cannot be expected in a work of this nature, but if the facts and reasoning give rise to new experiments, and produce results favorable to the progress of Horticulture or Agriculture, the object of the publication will be completely answered.

APPLICATION
OF
STRUCTURAL BOTANY
TO
HORTICULTURE.

GENERAL NATURE OF PLANTS.

HORTICULTURE is the application of the arts of cultivation, to the improvement for the use or delight of man, as well as to the domestication, of the vegetable kingdom.

Agriculture and Arboriculture are included in this definition.

Plants are organized bodies, composed of a substance called *Tissue*, which is so delicate and thin as to permit fluids and gases to pass through.

This Tissue exists either in the form of mi-

nute bladders called cells, which are filled with juices and lie close to each other, leaving however intermediate passages where they do not touch — this is Cellular tissue; or in slender tubes called woody fibre which are closed at each end, conical, and placed side by side.

Or in a fibre either rolled up spirally like a wire spring, or forming long cylindrical vessels placed end to end, which finally become continuous and lie close to each other; this is called vascular tissue — from *vas* a vessel.

Cellular tissue when just formed is very lax or coheres loosely and possesses great powers of absorption.

Late microscopic discoveries have enabled botanists to distinguish several varieties of Cellular tissue. Even their names, however, would be misplaced here.

It constitutes the soft and brittle parts of plants, as pith, pulp, the soft part between the veins of leaves, the tender parts of the flower, fruit, &c.

Succulent plants, as the Cactus, have an excessive development of this tissue.

It may be considered the most essential kind of tissue, because, while no plants exist without it, many are composed of nothing else.

Woody Fibre is what causes stiffness and tenacity in certain parts of plants ; hence it is found in the veins of leaves, and in bark, and it constitutes the principal part of the wood.

The most remarkable form of vascular tissue is the *Spiral vessel*, which has the power of unrolling with elasticity when stretched.

Other kinds of vascular tissue are incapable of unrolling, but break when stretched.

Spiral vessels are not found in the wood or bark, and rarely in the roots of plants.

Vascular tissue of other kinds is confined to the root, stem, veins of leaves, petals, and other parts composed of leaves. It is not found in bark.

The common office of the tissue is to convey fluid or air, and to act as the receptacle of secretions.

The cells of Cellular tissue convey fluids in all directions through their sides, and absorb with great rapidity ; when placed in contact with cells of the same species they join together and adhere — as is exemplified in budding and grafting — the cells adhere, then form Woody fibre — but cells of different or widely related species will not form a junction.

This is the operation of grafting or budding,

in which, however, the similar parts of the stock and scion must be brought into close contact, and kept so for some time, and this must be done during the growing season.

Woody fibre conveys fluid in the direction of its length, gives stiffness and flexibility to the general system, and acts as a protection to spiral and other delicate vessels.

Spiral vessels convey oxygenated air.

Other vessels probably conduct fluid when young, and air when old.

As the bodies of which all tissue is composed are perfectly simple, unbranched, and regular in figure, having, when elongated, their two extremities exactly alike, they are more or less capable of conveying gaseous matter or fluids in any direction; and, consequently, a current may be reversed in them without inconvenience: hence, inverted cuttings or stems will grow.

All parts of plants are composed of tissue, whether they be soft, as pulp; or hard, as the bony stone of a Peach.

With regard to Horticultural operations, the parts of plants should be considered under the heads of *Root, Stem, Leaf-buds, Leaves, Flowers, Stamens and Pistils, Fruit, and Seed.*

Root.

The Root is the part that strikes into the earth when a seed begins to grow, and which afterwards continues to lengthen beneath the soil. But some roots do not require the soil, and draw their nutriment from the atmosphere, as the Ivy, Air-Plants, &c., others live on the juices of trees, as the Mistletoe, &c., they are called parasitical.

It is distinguished from the stem by the absence of leaves in any state, of regular leaf-buds; of evaporating pores, or *stomata*; and of pith in Exogenous plants.

Therefore, such underground bodies as those called Tuber of the Potato; Bulb of the Onion; and solid Bulb or Cormus of the Crocus, are not roots.

The office of the root is to absorb food in a fluid or gaseous state; and also to fix the plant in the soil, or to some firm support.

The latter office is essential to the certain and regular performance of the former.

It is not by their surface only that roots absorb food; it is chiefly by their young and newly formed extremities, called *Spongioles*.

Hence the preservation of the spongioles in an uninjured state is essential to the removal of a plant from one place to another, and care should be taken to preserve even the smallest fibres of the roots uninjured.

A Spongiole consists of very young vascular tissue, surrounded by very young cellular substance.

It is therefore one of the most delicate parts of plants, and the most easily injured.

Hence whatever is known to produce any injurious action upon leaves or stems, such as certain gases and mineral or vegetable poisons, will produce a much more fatal effect upon the spongioles.

These spongioles have no power of selecting their food, but will absorb whatever the earth or air may contain, which is sufficiently fluid to pass through the sides of their tissue.

So that if the spongioles are developed in a soil which is of an unsuitable nature, as they will still continue to absorb, they cannot fail to introduce matter which will prove either injurious or fatal to life, according to its intensity.

This may often explain why trees suddenly become unhealthy, without any external apparent cause.

Plants have the power of replacing spongioles by the formation of new ones ; so that an individual is not destroyed by their loss.

But this power depends upon the coöperation of the atmosphere, and upon the special vital powers of the species.

If the atmosphere is so humid as to hinder evaporation from the leaves, spongioles will have time to form anew ; but if the atmosphere is dry, the loss by evaporation will be so much greater than can be supplied by the injured roots, that the whole plant will be emptied of fluid before the new spongioles can form, and death will ensue.

This is the key to the operations of transplantation and propagation by cuttings scions and buds.

As roots are destitue of leaf-buds, and as leaf-buds are essential to the multiplication of an individual, it should follow that roots can never be employed for the purpose of multiplication.

Nevertheless, roots have, occasionally, the power of generating leaf-buds, which being latent, and not according to the usual operations of nature, are called adventitious ; and when this is the case, they may be employed for the

purpose of multiplication; as those of *Cydonia Japonica*, &c.

The cause of this power existing in some species, and not in others, is unknown.

It is therefore a power that can never be calculated upon; and whose existence is only to be discovered by accident.

The immediate cause of the formation of roots is at present involved in obscurity, but the fact is well known that some plants when propagating by cuttings produce roots with much more facility and in a shorter time than others.

Darkness, moisture, and perfect rest, seem necessary for this purpose — as well as a downward circulation of the sap, which is effected by the action of the leaves on the upper part of the stem — nor can the roots exist by themselves without the leaves to create the action of drawing up the juices they absorb — therefore a cutting without leaves will soon perish.

Although roots are generated under ground, and sometimes at considerable depths, yet access to a certain quantity of atmospheric air appears indispensable to the healthy execution of their functions. This is constantly exemplified in plants growing in the earth at the back of an ill-ventilated forcing house, where the

roots have no means of finding their way into the earth on the outside of the house.

The spongioles and newly formed parts of the root contain considerable nitrogen, a supply of this gas therefore seems necessary to their health. Manure which contains nitrogen in abundance must therefore be of consequence to them. It has lately been asserted that those seeds which contain most nitrogen vegetate the earliest.

It is supposed by some that the introduction of oxygen into their system is as indispensable to them as to animals.

It seems more probable that the oxygen of the atmosphere, combining with a certain quantity of carbon, forms carbonic acid, which they absorb and feed upon.

It is at least certain that the exclusion of air from the roots will always induce an unhealthy condition, or even death itself. This may be one of the reasons why stiff, clayey, tenacious soils are so seldom suited to the purposes of the cultivator, until their adhesiveness has been destroyed by the addition of other matter, such as sand or manure.

After the juices have circulated through a plant and performed their destined offices, what

remains unfit for its further nourishment returns to the spongioles, is by them thrown off—this substance so thrown off is unsuitable and even poisonous to this species of plant, but is not so to other species; it may even be suitable to them.

Hence soil may be rendered impure, (or, as we inaccurately say, worn out) for one species, which will not be impure for others.

This is the true key of the theory of rotation of crops.

This also may serve to explain in part why light soil is indispensable to so many plants, and heavy or tenacious soil suitable to so few: for in the former case the spongioles will meet with little resistance to their elongation, and will consequently be continually quitting the place where their excrementitious matter is deposited; while, in the latter case, the reverse will occur.

It will also be one of the reasons why an orchard planted too thickly of the same trees cannot thrive, the trees by their roots soon absorb all the nutriment from the earth, and only those on the borders can send out their roots to a distance for fresh juices, those in the centre have little else to feed on but the sub-

stance thus cast off by themselves and by the others around. And why young apple trees planted on the site of an old apple orchard cannot thrive, the earth is full of the poisonous matter thrown off by the roots of the old trees ; but probably young cherry or peach trees would succeed. Likewise it accounts for the natural rotation of trees which has been discovered to exist in the ancient forests of this part of the globe ; for the necessity of repotting plants grown in green-houses every one or two years, and for many other circumstances in horticulture for which hitherto sufficient reasons had not been given.

Much of the healthy action of the root depends on the warmth and moisture of the soil. A late German writer, Mr. Writgen, has made it appear probable that much more depends on this than on the geological nature or chemical state of the soil, and when it is considered that the salts usually found in the earth are more readily soluble in a warm moisture than in a cold one, and also that heat is favorable to decomposition and the production of gases — it seems likely there is truth in this position.

During the summer in the temperate parts of Europe, the earth at one and two feet depth is

one to one and a half degrees higher in temperature than the atmosphere, but in tropical climates the earth is many degrees hotter. The system of applying bottom heat to accelerate the junction of the parts of plants that have been grafted, budded, or inarched, is successful from its exciting the healthy and rapid action of the roots in absorbing juices and supplying them in abundance to the stock.

The root is never entirely dormant except when frozen; during the winter it is slowly collecting juices for the supply of the spring; where the period of rest or winter is long, the store of juices is large, and vegetation in the spring is rapid and luxuriant. This accounts for the quick growth in northern climates where plants commence vegetation and mature their fruit in the short space of three months.

STEM.

The stem is that part of a plant which is developed above-ground, and which took an upward direction at the period of germination of the seed.

It consists of a woody axis, covered by bark having pores on its surface, bearing leaves with

leaf-buds in their axils, and producing flowers and fruit.

The points where leaves are borne are called *Nodi*, knots; the spaces between the leaves are *Internodia*, Internodes.

The more erect a stem grows, the more vigorous it is; and the more it deviates from this direction to a horizontal or pendulous position, the less is it vigorous.

Some stems are developed under ground, such as the Tubers of the Potato and the Cormus of the Crocus, but they are known from roots by the presence of leaves, and regular leaf-buds upon their surface, as the shoots from the eye of the potato.

Stems increase in diameter in two ways.

Either by the addition of new matter to the outside of the wood and the inside of the bark; when they are *Exogenous*; ex. Oak.

Or by the addition of new matter to their inside; when they are *Endogenous*; ex. Cane. Palm.

In Exogenous stems, the central portion, which is harder and darker than that at the circumference, is called *Heart-wood*; while the exterior, which is softer and lighter, is called *Alburnum* or *Sap-wood*.

The inside of the bark of such stems has also the technical name of *Liber*.

The Heart-wood was, when young, Alburnum, and afterwards changed its nature, by becoming the receptacle of certain secretions peculiar to the species.

Hence the greater durability of Heart-wood than of Sap-wood. While the latter is newly formed empty tissue, almost as perishable as bark itself, the former is protected against destruction by the introduction of secretions that become solid matter, which is often insoluble in water, and never permeable to air. •

The secretions by which Heart-wood is solidified are prepared in the leaves, whence they are sent downwards through the bark, and from the bark communicated to the central part of the stem.

The channels through which this communication takes place are called *Medullary Rays*, or *Silver Grain*.

Medullary rays are plates of cellular tissue, in a very compressed state, passing from the pith into the bark. They are what form the cross grain of most of our ornamental woods.

The wood itself is composed of tubes consisting of woody fibre and vascular tissue, imbedded longitudinally in cellular substance.

This cellular substance only developes horizontally; and it is to it that the peculiar character of different kinds of wood is chiefly due.

For this reason the wood of the stock of a grafted plant will never become like that of its scion, although, as will be hereafter seen, the woody matter of the stock must all originate in the scion.

The stem of an Exogenous plant may therefore be compared to a piece of linen, of which the weft is composed of cellular tissue, and the warp of fibrous and vascular tissue.

In the spring and autumn a viscid juice is secreted between the wood and the liber, called the *Cambium*.

This Cambium appears to be the matter out of which the cellular horizontal substance of the stem is organised.

In Endogenous stems, such as the Palm, the portion at the circumference is harder than that in the centre; and there is no separable bark.

Their stems consist of bundles of woody matter, imbedded in cellular tissue, and composed of vascular tissue surrounded by woody fibre.

The stem is not only the depository of the peculiar secretions of species, but is also the

medium through which the sap flows in its passage from the roots into the leaves.

In Exogenous stems it certainly rises through the alburnum, and descends through the bark.

In Endogenous stems it probably rises through the bundles of wood, and descends through the cellular substance; but this is uncertain.

Stems have the power of propagating an individual only by means of their LEAF-BUDS. If destitute of Leaf-buds, they have no power of multiplication, except fortuitously.

LEAF-BUDS.

Leaf-buds are rudiments of branches, enclosed within scales, which are imperfectly formed leaves.

All the leaf-buds upon the same branch are constitutionally and anatomically the same.

They are of two kinds; viz. *regular* or *normal*, and *adventitious* or *latent*.

Regular leaf-buds are formed in the angle of the leaf and the stem, called the axil, at the origin of the leaf—all bodies growing in that angle, are called axillary.

They are capable of propagating the individual from which they originate.

They are at first nourished by the fluid lying in the pith, from which it is probable they take their rise, as may be seen in a cross slice of the pine made at a knot, or just at the axil, but they finally establish for themselves a communication with the soil by the woody matter which they send downwards.

Their force of development will be in proportion to their nourishment; and, consequently, when it is wished to procure a young shoot of unusual vigor, all other shoots in the vicinity are prevented growing, so as to accumulate for one shoot only all the food that would otherwise have been consumed by several.

Cutting back to a few eyes is an operation in pruning to produce the same effect, by directing the sap, as it ascends, into two or three buds only, instead of allowing it to expend itself upon all the others which are cut away.

It is better in many cases of flowering plants and fruits to rub off all buds but those wished to be left, before they become branches.

When leaf-buds grow, they develop in three directions; the one horizontal, the other upward, and the third downward.

The horizontal development is confined to the cellular system of the bark, pith, and medullary rays.

The upward and downward developments are confined to the woody fibre and vascular tissue.

In this respect they resemble seeds; from which they differ physiologically in propagating the individual, while seeds can only propagate the species.

When they disjoin from the stem that bears them, they are called *bulbs*.

In some plants, a bud, when separated from its stem, will grow and form a new plant, if placed in circumstances favorable to the preservation of its vital powers.

But this property seems confined to plants having a firm, woody, perennial stem.

Such buds, when detached from their parent stem, send roots downwards and a stem upwards.

But if the buds are not separated from the plant to which they belong, the matter they send downwards becomes wood and liber, and the stems they send upwards become branches. Hence it is said that wood and liber are formed by the roots of leaf-buds.

If no leaf-buds are called into action, there will be no addition of wood: and, consequently, the destruction or absence of leaf-buds is accompanied by the absence of wood; as is proved by a shoot, the upper buds of which are destroyed and the lower allowed to develop. The lower part of the shoot will increase in diameter; the upper will remain of its original dimensions.

The quantity of wood, therefore, depends upon the quantity of leaf-buds that develop.

It is of the greatest importance to bear this in mind in pruning timber trees; for excessive pruning must necessarily be injurious to the quantity of produce.

If a cutting with a leaf-bud on it be placed in circumstances fitted to the development of the latter, it will grow and become a new plant.

If this happens when the cutting is inserted in the earth, the new plant is said by gardeners *to be upon its own bottom*.

But if it happens when the cutting is applied to the dissevered end of another individual, called *a stock*, the roots are insinuated into the tissue of the stock, and a plant is said to *be grafted*; the cutting being called a *scion*.

There is, therefore, little difference between cuttings and scions, except that the former root into the earth, the latter into another plant.

But if a cutting of the same plant without a leaf-bud upon it be placed in the same circumstances, it will not grow, but will die.

Unless its vital powers are sufficient to enable it to develope an adventitious leaf-bud.

A leaf-bud separated from the stem will also become a new individual, if its vital energy is sufficiently powerful.

And this, whether it is planted in earth, into which it roots, like a cutting, or in a new individual to which it adheres and grows like a scion. In the former case it is called *an eye*, in the latter *a bud*.

Every leaf-bud has, therefore, its own distinct system of life, and of growth.

And as all the leaf-buds of an individual are exactly alike, it follows that a plant is a collection of a great number of distinct identical systems of life, and consequently a compound individual.

Regular leaf-buds being generated in the axils of the leaves, it is there that they are always to be sought.

And if they cannot be discovered by ocular

inspection, it may nevertheless be always inferred with confidence that they exist in such situations, and may possibly be called from their dormant state into life.

Hence, wherever the scar of a leaf, or the remains of a leaf, can be discovered, there it is to be understood that the rudiments exist of a system of life which may be, by favorable circumstances, called into action.

Hence, all parts upon which leaves have ever grown may be made use of for purposes of propagation.

From these considerations it appears that the most direct analogy between the Animal and Vegetable Kingdoms is with the Polypes of the former.

Adventitious leaf-buds are in all respects like regular leaf-buds, except that they are not formed at the axils of leaves, but develop occasionally from all and any parts of a plant.

They are occasionally produced by roots, by solid wood, or even by leaves and flowers.

Hence, roots solid wood, or even leaves and flowers may in particular cases be used as means of propagation.

But as the development of adventitious buds is extremely uncertain, such means of propaga-

tion can never be calculated on; and form no part of the *science* of cultivation.

The cause of the formation of adventitious leaf-buds is unknown.

From certain experiments it appears that they may be generated by sap in a state of great accumulation and activity.

Consequently, whatever tends to the accumulation of sap in an active state may be expected to be conducive to the formation of adventitious leaf-buds.

When a hard woody plant is cut down after transplantation, adventitious leaf-buds will start from all parts of the stem. They originate and are pushed out from the centre, and are caused by the accumulated sap.

The leaf-bud and the flower-bud are the same in the earliest stage of their organization, but soon after, the change takes place which is visible in most fruit trees as soon as the sap begins to flow.

The determination of these buds to leaf or blossom-buds, no doubt depends on the quantity and quality of the sap stored up during the winter. When excessive vigor is produced in trees, it is favorable to the production of leaf-buds, and consequently of wood. On the con-

trary, when rapid and vigorous vegetation is checked, blossom-buds, and consequently, fruit will be in abundance—thus, fruit is seldom borne on the thick vigorous shoots of the peach, &c., but generally on the slender ones.

If an unproductive tree is transplanted, it often becomes productive from the check given.

In India and China, trees are brought to bear fruit by cutting the roots or exposing them to dryness.

LEAVES.

Leaves are expansions of bark, traversed by veins.

The veins consist of spiral vessels enclosed in woody fibre; they originate in the medullary sheath and liber; and they are connected by loose cellular tissue which is full of cavities containing air.

This cellular tissue consists of two layers, of which the upper is composed of small cells perpendicular to the outer skin, and the lower of small cells parallel with the outer skin.

These small cells are arranged so as to leave numerous open passages among them for the circulation of air in the inside of a

leaf. Cellular tissue of this nature is called *cavernous*.

The skin covering the leaf called *cuticle*, is formed of one or more layers of depressed cellular tissue, which is generally hardened, and always dry and filled with air.

Between many of the cells of the cuticle are placed apertures or pores called *stomata*, which have the power of opening and closing as circumstances may require.

It is by means of this apparatus that leaves prepare the sap which they absorb from the alburnum, or new wood, converting it into the secretions peculiar to the species.

Their cavernous structure enables them to expose the greatest possible surface of their cellular tissue to the action of the atmosphere.

Their cuticle is a non-conducting skin, which protects them from great variations in temperature, and through which gaseous matter will pass readily.

Their stomata are pores that are chiefly intended to facilitate evaporation ; for which they are well adapted by the power they possess of opening or closing as circumstances may require.

They are also intended for facilitating the

rapid emission of air, when it is necessary that such a function should be performed.

The action and functions of stomata being of such vital importance, it is absolutely necessary to the health of a plant that they be not choked up with dust or dirt or injured by insects, the cleaner therefore the leaves of a plant are kept the more it will flourish.

Leaves growing in air are covered with a cuticle.

Leaves growing under water have no cuticle.

All the secretions of plants being formed in the leaves, or at least the greater part, it follows that secretions cannot take place if leaves are destroyed.

And as this secreting property depends upon specific vital powers connected with the decomposition of carbonic acid, and called into action only when the leaves are freely exposed to light and air, it also follows that the quantity of secretion will be in direct proportion to the quantity of leaves, and to their free exposure to light and air.

The leaf therefore is a beautiful contrivance for exposing a large surface of crude sap to the influence of the external air and solar light, by the operation of which it is rendered capable

of being converted into the different substances required for the growth of the plant and the production of its fruit and seed.

The light of the sun striking on a leaf causes

1. Decomposition of carbonic acid, by which carbon in different vegetable forms enters into the composition chiefly of the solid parts of the plant — this is in proportion to the intensity of the light to which it is exposed ; hence, plants grown in the shade are weak, and *vice versa*.

2. Extrication of nitrogen.

3. Insensible perspiration or evaporation ; hence this does not take place during the night.

The health of plants depends much on the proper adjustment between the quantity of juices taken up by the roots, and the perspiration of the leaves. If they are exposed to too much solar light, the perspiration is greater than the roots can supply, and the leaves flag : when transplanted, if watered in the evening, the roots become supplied with moisture and juices, the perspiration ceasing during the night, this action recovers its equilibrium, and the leaves are seen erect in the morning.

The quantity of light or shade which can be borne by a plant, depends on the number, form

and action of the stomata, and as these vary considerably in different plants, it is evident that some are created to prefer shade, others to prefer light.

In this climate where the atmosphere is so pure and free from mist and vapor, where solar light is so intense during the summer, attention to these principles is peculiarly requisite. On this subject, more will be found under the considerations of light, air, perspiration, and transplantation.

The usual position of leaves is spiral, at regularly increasing or diminishing distances; they are then said to be alternate.

But if the space of the stem called the axis, that separates two leaves, is reduced to nothing at alternate intervals, they become opposite.

And if the spaces that separate several leaves be reduced to nothing, they become verticillate or whorled.

Opposite and verticillate leaves, therefore, differ from alternate leaves only in the spaces that separate them being reduced to nothing.

FLOWERS.

Flowers consist of two principal parts, the interior or those destined to form and perfect the seed, called Stamens and Pistils, and the exterior or those destined to envelope, protect and ornament the former, called Floral Envelopes.

Of these, the latter constitute what is popularly considered the flower; although the former are the only parts that are absolutely essential to it.

Some flowers have only one envelope, some none, as the willow.

However different they may be in appearance from leaves, they are all formed of those organs in a more or less modified state, and altered in a greater or less degree by mutual adhesion.

The Floral Envelopes consist of two or more series called *whorls* of transformed leaves; of which part is calyx, its leaves being called sepals, and part corolla, its leaves being called petals.

The stamens and pistils are also transformed leaves.

The calyx is always the outermost, the corolla is always the innermost whorl; and if there is but one floral envelope, that one is called calyx.

Usually the calyx is green, and the corolla colored and more highly developed; but the reverse is frequently the case, as in *Fuchsia*, *Ribes sanguineum*, &c.

A Flower being, then, an axis, or stem surrounded by leaves, it is in reality a stunted branch; that is, one the growth of which is checked, and its power of elongation destroyed.

That flowers are stunted branches is proved, *firstly*, by all their parts, especially the most external, occasionally reverting to the state of ordinary leaves; *secondly*, by their parts being often transformed into each other; and, *thirdly*, by the whorls of flower-buds being dislocated and actually converted into branches whenever any thing occurs to stimulate them excessively.

Their most essential distinctive character consists in the buds at the axils of their leaves being usually dormant, while those in the axils of ordinary leaves are usually active.

But an extraordinary case is recorded by Mr. Knight of potatoes growing in the angles (axils) of the sepals and of the petals of the flower.

For this reason while leaf-buds can be used for the purpose of propagation, flower-buds cannot usually be so employed.

Being stunted branches, their position on the stem is the same as that of developed branches.

And as there is in all plants a very great difference in the development of leaf-buds, some growing readily into branches, others only unfolding their leaves without elongating, and many remaining altogether dormant, it follows that flower-buds may form upon plants of whatever age and in whatever state.

But to produce a general formation of flower-buds it is necessary that there should be some general predisposing constitutional cause independent of accidental circumstances.

This predisposing cause is the accumulation of sap and of secreted matter, as has been before explained.

Therefore whatever tends to retard the free flow of sap, and causes it to accumulate, will cause the production of flower-buds, or fertility.

And on the other hand, whatever tends to produce excessive vigor causes the rapid motion and dispersion of sap, or prevents its elaboration and causes sterility or want of flower-buds.

Transplantation with a partial destruction of roots, age, or high temperature accompanied by a dry atmosphere, training obliquely or in an inverted direction, a constant destruction of the extremities of young growing branches, will all cause an accumulation of sap, and secretions; and consequently all such circumstances are favorable to the production of flower-buds.

But a richly manured soil, high temperature, with great atmospheric humidity, or an uninterrupted flow of sap, are all causes of excessive vigor, and are consequently unfavorable to the production of flower-buds.

There is a tendency in many flowers to enlarge, to alter their colors, or to change their appearance by a transformation and multiplication of their parts, whenever they have been raised from seeds for several generations, or domesticated.

The causes of this tendency are probably various, but being entirely unknown, no certain rules for the production of varieties in flowers can be laid down, except by the aid of hybridising.

It often happens that a single branch produces flowers different from those produced on

other branches. This is technically called a *sport*.

As every bud on that branch has the same specific vital principle, a bud taken from such a branch will produce an individual, the whole of whose branches will retain the character of the sport.

Consequently, buds by accidental variety may be made permanent, if the plant that sports be of a firm woody nature.

As flowers feed upon the prepared sap in their vicinity, the greater the abundance of this prepared food, the more perfect will be their development.

Or the fewer the flowers on a given branch the more food they will severally have to nourish them, and the more perfect will they be.

The beauty of flowers will therefore be increased either by an abundant supply of food, or by a diminution of their numbers (thinning), or by both. The business of the pruner is to cause these by his operations.

The beauty of Flowers depends upon their free exposure to light and air, because it consists in the richness of their colors, and their colors are only formed by the action of those two agents.

Hence, Flowers produced in dark or shady confined situations are either imperfect, or destitute of their habitual size and beauty.

Double Flowers are those in which the stamens are transformed into petals; or in which the latter, or the sepals, are multiplied. They should not be confounded with *Proliferous* and *Discoid Compound Flowers*. This difference will be explained immediately.

Although no certain rules for the production of double flowers can be laid down, yet it is probable that those flowers have the greatest tendency to become double, in which the parts are habitually multiplied.

Plants whose flowers have naturally numerous stamens and pistils, are those which usually become double, these being the parts generally transformed into petals.

Double Flowers are therefore least to be expected in plants with fewest stamens.

Whenever the parts of a Flower adhere by their edges, forming what are called one sepalled (*gamosepalous*) calyxes or one petaled (*gamopetalous*) corollas, or where the stamens are combined either into one or few parcels, the tendency to multiplication seems checked, but this is by no means general, as we have double

Campanula which is one petaled and double Hibiscus and Camellia where the stamens are combined.

Proliferous Flowers are those in which parts that usually have all their axillary buds dormant, accidentally develop such buds; as in certain Roses, in which a branch grows up from the centre of a rose, or as it is technically said the carpellary leaves develop leaf-buds in their axils, so that the flower becomes a branch, the lower leaves of which are colored and transformed, and the upper green, and in their ordinary state.

Discoid compound Flowers are those in which the central florets of a flower-head acquire corollas, like those of the circumference, one side strap shaped, as in the Dahlia; the cultivated varieties of which should be called discoid, and not double.

These two last are so essentially different from double flowers, that whatever laws may be supposed to govern the production or amelioration of double Flowers, can have no relation to proliferous or discoid compound Flowers.

STAMENS AND PISTILS.

The Stamens and Pistils are known to be modifications of leaves, because they very frequently are transformed into petals which are demonstrably such; and because they occasionally revert to the state of leaves. In the double poppy the stamens change into petals, in the double anemone and ranunculus the pistils undergo the same transformation.

The stamens bear at their summits an organ, called the *anther*, which contains a powder called *pollen*.

When the anther is full grown it opens and ejects the pollen, either dispersing it in the air in consequence of the elasticity with which it opens; or depositing it upon the summit of the pistil called stigma; or exposing it to the action of wind, or such other disturbing causes as may liberate it from its case.

The pollen consists of exceedingly minute hollow balls, or cases, containing myriads of particles called granules, which are the fertilising principle of the stamens.

The pistil has at its base one or more cavities or *cells* called in a ripe state seed ves-

sels, in which bodies called *ovula* are placed ; and at its summit one or more secreting surfaces called *stigmata*.

The ovula are the rudiments of seeds.

If the fertilising powder of the pollen come in contact with the stigma, the ovula in the cells of the pistil are vivified, and become seeds.

Late microscopic discoveries render it almost certain that the granules of pollen are the true seeds deposited in the ovula by means of tubes or elongations of the skin of the hollow balls of pollen — there partly developed and secured by various coverings called integuments, until the proper period and circumstances arise for their farther growth in the earth — and that the present idea of vivification by pollen and the sexes of plants is either not correct or not properly understood.

In wild plants a stigma is usually acted upon only by the pollen of the stamens which belong to it.

In this case the seeds thus vivified will, when sown, produce new individuals, differing very little from that by which they were themselves produced.

And, therefore, wild plants are for the most

part multiplied from generation to generation without change.

But it is possible to cause deviations from this law, by artificial means.

If the pollen of one species is placed upon the stigma of another species, the ovula will be vivified ; and what is called a *hybrid* plant will be produced by those ovula when they shall have grown to be seeds.

Hybrid plants are different from both their parents, and are generally intermediate in character between them.

Reasoning from analogy it was formerly thought that hybrids were sterile and could not perfect seeds, experience however teaches that this is not the case ; but in woody and other plants where hybridisation has produced fine varieties either of fruit or flowers, these varieties are usually propagated by buds, cuttings, and scions.

The power of hybridisation will probably when experience shall have matured and science arranged more numerous results, become the most correct test of botanical divisions into genera. Great care is requisite in making experiments on hybridisation to cut out the anthers of one of the plants experimented

on previous to their bursting, to apply the pollen of the other when in perfection, and to place the plant where none others of the genus are in the vicinity.

The tropical warmth of the sun in this country, is very favorable for maturing the pollen of all plants, particularly those from tropical regions, thus facilitating such experiments.

It usually happens that the hybrid has the constitution and general aspect of the polliniferous parent; but is influenced in secondary characters by the peculiarity of the female parent. See more on this subject under article FRUIT.

This should always be borne in mind in procuring new hybrid plants.

Really hybrid plants must not be confounded with such as are spurious, in consequence of their origin being between two varieties of the same species, and not two species of the same genus.

Hybrid plants, are often more abundant flowerers than either parent.

This is, probably, connected with constitutional debility.

FRUIT.

Fruit, strictly speaking, is the pistil arrived at maturity.

When the calyx adheres to the pistil and grows with it to maturity, the fruit is called *inferior*; as the Apple.

But when the pistil alone ripens, there being no adhesion to it on the part of the calyx, the fruit is called *superior*; as the Peach.

The fruit is, therefore, in common language, the flower, or some part of it, arrived at its most complete state of existence; and, consequently, is itself a portion of a stunted branch.

The nature of its connection with the stem is therefore the same as that of the branches with each other, or of leaves with their stem.

A superior Fruit consisting only of one, or of a small number of transformed leaves, it has little or no power of forming a communication with the earth and of feeding itself, as real branches have.

It has also very little adhesion to its branch; so that but slight causes are sufficient to detach

it from the plant, especially at an early age, when all its parts are tender.

Hence the difficulty of causing Peaches and the like to *stone*, or to pass over that age, in which the vascular bundles that join them to the branch become woody, and secure them to their place.

For the same reason they are fed almost entirely by other parts, upon secreted matter which they attract to themselves, elaborate, and store up in the cavities of their tissue.

The office of feeding such fruit is performed by young branches, which transmit nutriment to it through the bark.

But as young branches can only transmit nutriment downwards, it follows that unless a fruit is formed on a part of a branch below a leaf-bud, it must perish.

Unless there is some active vegetation in the stem above the branch on which it grows; when it may possibly live and feed upon secretions attracted by it from the main stem; thus in pruning the peach and other trees with *superior* fruit in the spring it is always necessary to leave one or two leaf-buds above the flower-bud.

But inferior fruit, consisting always of the calyx in addition to the pistil, has a much

more powerful communication with the branch ; each division of its calyx having *at least* one bundle of vascular and fibrous tissue, passing from it into the branch, and acting as a stay upon the centre to prevent its breaking off.

Such fruit may be supposed much more capable of establishing a means of attracting secretions from a distance ; and, consequently, is less liable to perish from want of a supply of food.

It is therefore not so important that an inferior fruit should be furnished with growing branches above it, instance, Apple, Pear.

Fruit is exclusively fed by the secretions prepared for it by other parts ; it is therefore affected by nearly the same circumstances as flowers.

It will be large in proportion to the quantity of food the stem can supply to it : and small in proportion to the inability of the stem to nourish it.

For this reason, when trees are weak they should be allowed to bear very little, if any fruit ; because a crop of fruit can only tend to increase their debility.

And in all cases each fruit should be so far separated from all others as not to be robbed of its food by those in its vicinity.

We find that nature has herself in some measure provided against injury to plants by excessive fecundity, in giving them a power of throwing off flowers, the fruit of which cannot be supported.

The flavor of fruit depends upon the existence of certain secretions, especially of acid and sugar; flavor will, consequently, be regulated by the circumstances under which fruit is ripened.

The ripening of fruit is the conversion of acid and other substances into sugar.

As the latter substance cannot be obtained at all in the dark, is less abundant in fruit ripened in diffused light, and most abundant in fruit exposed to the direct rays of the sun, the conversion of matter into sugar occurs under the same circumstances as the decomposition of carbonic acid.

Therefore, if fruit be produced in situations much exposed to the sun, its sweetness will be augmented.

And in proportion as it is deprived of the sun's direct rays that quality will diminish.

Fruit produced under circumstances of great moisture and diminution of solar light, as in seasons of continued rain where the sky is

much clouded, will be larger, but the flavor will be less sweet and agreeable — this is often the case with the large strawberries.

So that a fruit which when exposed to the sun is sweet, when grown where no direct light will reach it will be acid; as Pears, Cherries, &c.

Hence acidity may be corrected by exposure to light; and excessive sweetness, or insipidity, by removal from light.

Judicious pruning, therefore, so as to admit all the possible light and air to the fruit, is advantageous, but care must be taken that it be not pursued to the injury of the plant.

It is the property of succulent fruits which are acid when wild to acquire sweetness when cultivated, losing a part of their acid.

This probably arises from the augmentation of the cellular tissue, which possibly has a greater power than woody or vascular tissue of assisting in the formation of sugar.

As a certain quantity of acid is essential to render fruit agreeable to the palate, and as it is the property of cultivated fruits to add to their saccharine matter, but not to form more acid than when wild, it follows that, in selecting wild fruits for domestication, those which are acid

should be preferred, and those which are sweet or insipid rejected.

Unless recourse is had to hybridism; when a wild insipid fruit may be possibly improved, or may be the means of improving something else.

It is very much upon such considerations as the foregoing that the rules of training must depend.

The effect of removing a ring of bark from the fruit-bearing branch, is to increase considerably the size of the fruit above the ring, by retaining the juices of the wood which are prevented from returning, the communication being cut off. But if the ring is too wide or the branch on which it is practised too small, a morbid state of early maturity is produced, and the fruit is worthless. The breadth of the ring should be in proportion to the thickness of the branch, and in fruit-bearing trees should be performed as soon as the flowers are apparent in the spring.

Hybridisation has been had recourse to with much success to improve fruits, but although the results have been thus good, sufficient care has not been taken to note down the detail of the experiments so as to arrive at any fixed

laws capable of affording unerring rules of action.

Mr. Knight says he had observed generally a strong prevalence of the constitution and habits of the plant whose pistil was fertilized by the pollen of another. Mr. Herbert, in discussing a hybrid *Cytisus*, thinks that the plant with the pistil influences the leaf, and that with the pollen the flower and fruit. This gentleman in his work on *Amaryllidaceæ*, has given a most interesting and detailed account of many years experience on Hybridisation.

The experience of Van Mons in raising new varieties of fruit trees from seed, has been eminently valuable and successful, and no doubt would throw light on this subject.

SEED.

The seed is the ovulum arrived at perfection.

It consists of various coverings enclosing an *embryo*, being the granule of pollen deposited there, which is the rudiment of a future plant.

The seed is nourished by the same means as the fruit; and, like it, will be more or less perfectly formed, according to the abundance of its nutriment.

The plant developed from the embryo in the seed, will be in all essential particulars like its parent species.

Unless its nature has been changed by hybridising.

But although it will certainly, under ordinary circumstances, reproduce its species, it will by no means uniformly reproduce the particular variety by which it was borne.

So that seeds are not the proper means of propagating varieties.

Nevertheless, in annual or biennial plants, no means can be employed for propagating a variety, except the seeds; and yet the variety is preserved.

This is accomplished solely by the great care of the cultivator, and happens thus.

Although a seed will not absolutely propagate the individual, yet as a seed will partake more of the nature of its actual parent than of any thing else, its progeny may be expected, as really happens, to resemble the variety from which it sprung, more than any other variety of its species.

Provided its purity have not been contaminated by the intermixture of other varieties.

By a careful eradication of all the varieties

from the neighborhood of that from which seed is to be saved, by taking care that none but the most genuine forms of a variety are preserved as seed-plants; and by compelling by transplantation a plant to expend all its accumulated sap in the nourishment of its seeds, instead of in the superabundant production of foliage, a crop of seed may be procured, the plants produced by which will, in a great measure, have the peculiar properties of the parent variety.

By a series of progressive seed-savings upon the same plan, plants will be at length obtained, in which the habits of the individual have become as it were fixed, and capable of such exact reproduction by seed, so as to form an exception to the general rule; as in Turnips, Radishes, &c.

But if the least neglect occurs in taking the necessary precautions to ensure a uniform crop of seed, possessing the new fixed properties, the race becomes deteriorated, in proportion to the want of care that has occurred, and loses its characters of individuality.

In all varieties those seeds may be expected to preserve their individual characters most distinctly which have been the best nourished; it is, consequently, those which should be se-

lected in preference for raising new plants, from which seed is to be saved.

When plants have been propagated for a series of years by suckers alone, which are adventitious buds arising from the root, their power of producing seed seems somewhat impaired, this is the case with many herbaceous plants and bulbs, but if a single seed be found by which to raise a new plant, the faculty of bearing seed becomes renewed.

When seeds are first ripened, their embryo is a mass of cellular substance, containing starch, fixed carbon, or other solid matter in its cavities; and in this state it will remain until fitting circumstances occur to call it into active life.

These fitting circumstances are, a temperature above freezing point, a moist medium, (earth) darkness, and exposure to air.

It then absorbs the moisture of the medium in which it lies, decomposes water from which it inhales oxygen, and undergoes certain chemical changes; its vital powers cause one extremity of it to ascend for the purpose of finding light, of decomposing its carbonic acid, by parting with its accumulated oxygen, and forming leaves and branches, and the other extremity to descend for

the purpose of finding a constant supply of crude nutriment and becoming roots.

Unless these conditions are maintained, seeds cannot germinate ; and, consequently, an exposure to light is fatal to their embryo, because oxygen will not be absorbed in sufficient quantity to stimulate the vital powers of the embryo into action, for the purpose of parting with it again, by the decomposition of the carbonic acid that has been formed during its accumulation.

The length of time which seeds preserve their power of growing, or vitality as it is called, differs in different plants. Some lose their vitality in a single year, others preserve it for many years—the best authenticated account of this latter power is of some raspberry trees now growing in the garden of the Horticultural Society of London, which were raised from seeds taken out of the stomach of a skeleton found in one of the tumuli or ancient tombs at Dorchester England, *thirty feet below the surface*. With the skeleton were found some coins of the Emperor Hadrian—so that they must have been sixteen or seventeen hundred years old. The raspberry has also vegetated from seeds taken from raspberry jam, in this case

they must have borne the heat of cooking for a length of time. This plant, as is well known, is a native of the colder parts of this continent; the integuments or coverings of the seed must therefore have been formed with wonderful powers of protection against extremes of heat, cold, and age.

Pine seeds and many others vegetate very rapidly in lime just slacked. This action produces warmth, and the lime immediately attracts the excess of carbonic acid from the seed, this, as before observed, being one of the chief conditions of vegetating.

The business of saving seed for gardens as a trade, is quite new in this country, and many hundred dollars are annually expended in importing seeds from Europe. The vitality of some is injured by the voyage.

It will be seen by the foregoing information that it would be useless to compete with European seedsmen, unless this branch were followed as a business, so much attention, so many precautions are requisite to procure true, full, and plump seeds of vegetables or flowers. But it is equally certain if this attention were paid so as to ensure an infallible character after proper trials to the seeds grown, that the alpine purity

of the atmosphere, the quantity and intensity of solar light, by ripening all the juices, and particularly the pollen of plants, would enable the seed-growers of this country to excel by far those of Europe.

But unless done thoroughly, it is no use to make the attempt, as a grower once disappointed in the quality of his seed will scarcely ever try the same source again.

SAP.

The fluid matter which is absorbed either from the earth or from the air is called sap.

When it first enters a plant it consists of water holding certain principles, especially carbonic acid, in solution.

These principles chiefly consist of animal or vegetable matter in a state of decomposition, and salts, and are energetic in proportion to their solubility, or tendency to form carbonic acid by combining with the oxygen of the air.

Sap soon afterwards acquires the nature of mucilage or sugar, and subsequently becomes still further altered by the admixture of such soluble matter as it receives in passing in its

route through the alburnum or newly formed woody tissue.

When it reaches the vicinity of the leaves it is attracted into them, and there, having been exposed to light and air, is converted into the secretions peculiar to the species.

It finally, in its altered state, sinks down the bark, whence it is given off laterally by the medullary rays, and is distributed through the system.

The cause of the motion of the sap is the attraction of the leaf-buds and leaves.

The leaf-buds, called into growth by the combined action of the increasing temperature and light of spring, decompose their carbonic acid, and attract fluid from the tissue immediately below them; the space so caused is filled up by fluid again attracted from below, and thus a motion gradually takes place in the sap from one extremity to the other.

Consequently the motion of the sap takes place first in the branches and last in the roots.

For this reason a branch of a plant subjected to a high temperature in winter will grow while its stem is exposed to a very low temperature.

But growth under such circumstances will not be long maintained, unless the roots are secured from the reach of frost: for, if frozen they cannot act, and will, consequently, be unable to replace the sap of which the stem is emptied by the attraction of the buds converted into branches, and by the perspiration of the leaves.

Whatever tends to condense the sap, such as a dry and heated atmosphere, or an interruption of its rapid flow, or a great decomposition of carbonic acid by full exposure to light, has the property of causing excessive vigor to be diminished, and flower-buds to be produced.

While, on the other hand, whatever tends to dilute the sap, such as the free and rapid circulation of it, a damp atmosphere, or a great accumulation of oxygen in consequence of the imperfect decomposition of carbonic acid, has the property of causing excessively rapid growth, and an exclusive production of leaf-buds.

Condensed or accumulated sap is, therefore, a great cause of fertility.

And thin fluid, not being elaborated, is a great cause of sterility.

The conversion of sap into different kinds of secretion is effected by the combined action of *Air, Light, and Temperature.*

Mr. Knight is of opinion, founded like all his opinions, on well conducted experiments, that the motion given to plants by the wind, enables their fluids to circulate more freely and is thus beneficial.

AIR AND LIGHT.

When an embryo plant is formed within its integuments, it is usually colorless, or nearly so ; but, as soon as it begins to grow, that part which approaches the light (the stem) becomes colored, while the opposite extremity (the root) remains colorless.

The parts exposed to the air absorb oxygen at night, absorb carbonic acid and part with oxygen again in daylight ; and thus in the day-time purify the air, and render it fit for the respiration of man.

The intensity of this latter operation is in proportion to the intensity of solar light to which leaves are directly exposed.

Its cause is the decomposition of carbonic acid, the extrication of oxygen, and the acqui-

tion by the plant of carbon in a solid state ; from which, modified by the peculiar vital actions of species, color and secretions are supposed to result.

For it is found that the intensity of color and the quantity of secretions are in proportion to the exposure to light and air, as is shown by the deeper color of the upper side of leaves, &c.

And by the fact, that if plants be grown in air from which light is excluded, neither color nor secretions are formed, as is exemplified in blanched vegetables ; which, if even naturally poisonous, may, from want of exposure to light, become wholesome, as Celery.

When any color appears in parts developed in the dark it is generally caused by the absorption of such coloring matter as pre-existed in the root or other body from which the blanched shoot proceeds, as in some kinds of Rhubarb when forced.

Or by the deposition of coloring matter formed by parts developed in light, as in the subterranean roots of Beet, Carrots, &c.

What is true of color is also true of flavor, which equally depends upon light for its existence ; because flavor is produced by chemi-

cal alterations in the sap caused by exposure to light.

The same thing occurs in regard to nutritive matter, which in like manner is formed by the exposure of leaves to light. Thus the Potato when forced in dark houses contains no more farinaceous matter than previously existed in the original tuber ; but acquires it in abundance when placed in the light, and deposits it in proportion as it is influenced by light and air. Thus, also, if Peaches are grown in wooden houses, at a distance from the light, they will form so little nutritive matter as to be unable to support a crop of fruit, the greater part of which will fall off. And for a similar reason it is only the outside shoots of standard fruit trees that bear fruit. Considerations of this kind form in part the basis of pruning and training.

Light is the most powerful stimulus that can be employed to excite the vital actions of plants, and its energy is in proportion to its intensity ; so that the direct rays of the sun will produce much more powerful effects than the diffused light of day.

Hence, if buds, that are very excitable are placed in the shade, their excitability will be checked.

And if buds that are very torpid are exposed to direct light, they will be stimulated into action.

So that what parts of a tree shall first begin to grow in the spring may be determined at the will of the cultivator.

This is the key to some important practices in forcing.

This should also cause attention to be paid to shading buds from the direct rays of the sun in particular cases: as in that of cuttings, whose buds, if too rapidly excited, might exhaust their only reservoir of sap, the stem, before new roots were formed to repair such loss.

As plants derive an essential part of their food from the air by the action of light, it follows that in glass-houses those which admit the greatest portion of light are the best adapted for purposes of cultivation.

And as it has been found by experiment, that light passes more freely through a curvilinear than through a plane roof, and through glass forming an acute angle with the horizon than through perpendicular glass, it follows that a curvilinear roof is best, and a plane roof with glass perpendicular sides the worst adapted to the purposes of the cultivator.

For the same reason common green glass is less fitted for glazing forcing-houses than white crown glass.

Poisonous gases in very minute quantities act upon vegetation with great energy. A ten-thousandth part of sulphurous acid gas is quickly fatal to the life of plants ; and hence the danger of flues heated by coal fires, and the impossibility of making many species grow in the vicinity of houses heated by coal fires, or in large towns.

Heating by hot water is now so well understood, and so simplified by the method of first heating the air in a large reservoir, or air chamber, from which it circulates to any required part, either of a green house or dwelling house, that no one erecting a glass structure for plants would now think of heating on the old principle of the fire flue.

PERSPIRATION.

It is not, however, exclusively by the action of light and air that the nature of sap is altered. Evaporation from the leaves is constantly going on during the growth of a plant, and sometimes is so copious, that an individual

will perspire its own weight of water in the course of 24 hours.

The loss thus occasioned by the leaves is supplied by crude fluid, a large portion of which is water, absorbed by the roots, and conveyed up the stem with great rapidity.

The consequence of such copious perspiration is the separation and solidification of the carbonised matter that is produced for the peculiar secretions of a species.

For the maintenance of a plant in health, it is indispensable that the supply of fluid by the roots should be continual and uninterrupted.

If any thing causes perspiration to take place faster than it can be counteracted by the absorption of fluid from the earth, plants will be dried up and perish.

Such causes are, destruction of spongioles, an insufficient quantity of fluid in the soil, an exposure of the spongioles to occasional dryness, and a dry atmosphere.

The most ready means of counteracting the evil consequences of an imperfect action of the roots is by preventing or diminishing evaporation.

This is to be effected by rendering the atmosphere extremely humid.

Thus, in curvilinear iron hot-houses, in which the atmosphere becomes so dry in consequence of the heat that plants perish, it is necessary that the air should be rendered extremely humid, by throwing water upon pavement, or by introducing steam.

And in transplantation in dry weather, evergreens, or plants in leaf, often die, because the spongioles are destroyed, or so far injured in the operation as to be unable to act, while the leaves never cease to perspire.

The greater certainty of transplanting plants that have been growing in pots is from this latter circumstance intelligible ;

While the utility of putting cuttings or newly transplanted seedlings into a shady damp atmosphere, is explained by the necessity of lessening evaporation produced by solar light.

The admission of air or ventilation, as it is called, is not generally well understood by gardeners. Much light has been thrown on this subject, since the invention of the air tight boxes of Mr. Ward, in which, owing to the total exclusion of currents of air (ventilation) the evaporation from the surface of the earth and plants is constant, according to the heat,

and the atmosphere is thus kept uniformly moist, not, as in green houses, moist all night and dried by ventilation all day. The only way of growing plants to perfection in rooms, is in these Ward's boxes—and the plants in most glass structures would thrive better with much less ventilation. The greater the heat the more moisture is required. The custom of gardeners seems preposterous, to deluge the floors of green houses with water to create a damp atmosphere, and then ventilate freely, which dries it up. This capricious change is very injurious to plants.

It is thought by some geologists, that the gigantic growth of the plants of former ages, of which such beautiful specimens are daily discovered in coal mines, was favored by the extreme heat and moisture with which the surface of the globe was then covered.

Mr. Knight, in a forcing house devoted to experiment, never gave air to his grapes until nearly ripe, even in hottest and brightest weather, farther than just necessary to prevent the leaves being destroyed by excess of heat, and employed very little fire heat. Many hot houses are now built in Europe without any means of ventilation. It must be remembered,

however, that dampness, unaccompanied by warmth and light, will produce fungi and all their injurious concomitants.

CUTTINGS.

When a separate portion of a plant is caused to produce new roots and branches, and to increase an individual, it is a cutting.

Cuttings are of two sorts, — cuttings properly so called, and *eyes*.

A cutting consists of an internodium, (space between bud and bud) or a part of one, with its nodus and leaf-bud.

When the internodium is plunged in the earth it attracts fluid from the soil, and nourishes the bud until it can feed itself.

The bud, feeding at first upon the matter in the internodium, gradually elongates upwards into a branch, and sends organised matter downwards, which becomes roots.

As soon as it has established a communication with the soil, it becomes a new individual, exactly like that from which it was taken.

As it is the action of the leaf-buds that causes growth in a cutting, it follows that no cutting without a leaf-bud will grow ;

Unless the cutting has great vitality and power of forming adventitious leaf-buds, which sometimes happens.

An eye is a leaf-bud without an internodium.

It only differs from a cutting in having no reservoir of food on which to exist, and in emitting its roots immediately from the base of the leaf-bud into the soil.

As cuttings will very often, if not always, develop leaves before any powerful connection is formed between them and the soil, they are peculiarly liable to suffer from perspiration.

Hence the importance of maintaining their atmosphere in an uniform state of humidity, as is effected by putting bell or other glasses over them.

In this case, however, it is necessary that if air-tight covers are employed, such as bell glasses, they should be from time to time removed and replaced, for the sake of getting rid of excessive humidity.

Layers differ from cuttings in nothing except that they strike root into the soil while yet adhering to the parent plant.

Whatever is true of cuttings is true of layers, except that the latter are not liable to suffer by

evaporation, because of their communication with the parent plant.

As cuttings strike roots into the earth by the action of leaves or leaf-buds, it might be supposed that they will strike most readily when the leaves or leaf-buds are in their greatest vigor.

Nevertheless, this power is controlled so much by the peculiar vital powers of different species, and by secondary considerations, that it is impossible to say that this is an absolute rule.

Thus Dahlias and other herbaceous plants will strike root freely when cuttings are very young ; and Heaths, Azaleas, and other hard wooded plants, only when the wood has just begun to harden.

The former is, probably, owing to some specific vital excitability, the force of which we cannot appreciate ; the latter either to a kind of torpor, which seems to seize such plants when their tissue is once emptied of fluid, or to a natural slowness to send downwards woody matter, whether for wood or not, which is the real cause of their wood being harder.

If ripened cuttings are upon the whole the most fitted for multiplication, it is because their

tissue is less absorbent than when younger, and that they are less likely to suffer from either repletion or evaporation.

For to gorge tissue with food, before leaves are in action to decompose and assimilate it, is as prejudicial as to empty tissue by the action of leaves, before spongioles are prepared to replenish it.

For this reason pure silex, in which no stimulating substances are contained (silver sand,) is the best adapted for promoting the rooting of cuttings that strike with difficulty.

And for the same reason cuttings with what gardeners call a *heel* to them, or a piece of the older wood, strike root more readily than such as are not so protected. The greater age of the tissue of the heel renders it less absorbent than tissue that is altogether newly formed.

It is to avoid the bad effect of evaporation that a proportion of the leaves are usually removed from a cutting, when it is first prepared.

The method of striking cuttings in double pots, the outer filled with earth in which the cuttings are placed with the ends inserted in the earth touching the sides of the inner one,

which is kept filled with water has for the above reason been attended with success.

The directions for propagating by cuttings in European publications, generally state the month for placing them in the earth ; these directions would be apt to mislead in this country, where the difference of temperature ripens wood at a different period.

Cuttings will strike at any period of the year when the young wood is sufficiently ripe and the plant is continuing its growth, but not when it is in a state of rest.

SCIONS.

A scion is a cutting which is caused to grow upon another plant, and not in earth.

Scions are of two sorts, scions properly so called, and *buds*.

Whatever is true of cuttings is true also of scions, all circumstances being equal.

When a scion is fitted on to another plant, it attracts fluid from it for the nourishment of its leaf-buds until they can feed themselves.

Its buds thus fed gradually grow upwards into branches, and send woody matter downwards, which is analogous to roots.

At the same time the cellular substance of the scion and its *stock* adheres so as to form a complete organic union.

The woody matter descending from the buds passes through the cellular substance into the stock, where it occupies the same situation as would have been occupied by woody matter supplied by buds belonging to the stock itself.

Once united, the scion covers the wood of the stock with new wood, and causes the production of new roots.

But the character of the woody matter sent down by the scion over the wood of the stock being determined by the cellular tissue, which has exclusively a horizontal development, it follows that the wood of the stock will always remain apparently the same, although it is furnished by the scion.

While the preparations of the juices being effected by the leaves of the scion, the produce thereof will be the same as the species from which the scion was taken.

Some scions will grow upon a stock without being able to transmit any woody matter into it; as some Cacti, which have only a small central development of woody tissue.

When this happens, the adhesion of the two

takes place by the cellular substance only, and the union is so imperfect that a slight degree of violence suffices to dissever them.

And in such cases the buds are fed by their woody matter, which absorbs the ascending sap from the stock at the point where the adhesion has occurred; and the latter, never augmenting in diameter, is finally overgrown by the scion.

When, in such instances, the communication between the stock and the scion is so much interrupted that the sap can no longer ascend with sufficient rapidity into the branches, the latter die; as in many Peaches.

This incomplete union between the scion and its stock is owing to some constitutional or organic difference in the two.

Therefore care should be taken that when plants are grafted on one another their constitution should be as nearly as possible identical.

As adhesion of only an imperfect nature takes place when the scion and stock are, to a certain degree, dissimilar in constitution, so will no adhesion whatever occur when their constitutional differences are very decided.

Hence it is only species very nearly allied in nature that can be grafted on each other.

As only similar tissues will unite, it is necessary in applying a scion to the stock that similar

parts should be carefully adapted to each other ; as bark to bark, cambium to cambium, and alburnum to alburnum.

The second is more especially requisite, because it is through the cambium that the woody matter sent downwards by the buds must pass ; and also because cambium itself, being organising matter in an incipient state, will more readily form an adhesion than any other part.

The same principles apply to *buds*, which are to scions precisely what eyes are to cuttings.

Inarching is the same with reference to grafting that layering is with reference to striking by cuttings.

It serves to maintain the vitality of a scion until it can form an adhesion with its stock ; and must be considered the most certain mode of grafting.

It is probable that every species of flowering plant, without exception, may be multiplied by grafting.

Nevertheless, there are many species and even tribes that never have been grafted.

It has been found that in the Vine and the Walnut this difficulty can be overcome by attention to their peculiar constitutions ; and it is probable that the same attention will remove supposed difficulties in the case of other species.

It is certain that scions thrive better on some stocks even of the same species than others, and that this depends somewhat on the soil in which the stock grows; this is a subject however on which there has been so much discussion, and on which practical experience has yet so much to develop, that no certain general rules can be laid down, particularly in this country.

From what has been said on perspiration it seems that the practice of budding on the northern side of stems must be correct.

Mr. Knight often applied two ligatures to his buddings on Peach trees, one above the bud across the transverse incision, the other below, this last was taken off as soon as the bud adhered, the upper one was left on, thus obstructing the flow of the sap upwards and throwing it into the bud, which then vegetated early and produced blossoms the following spring. As soon as the new shoot had attained about four inches in length the upper bandage was removed and the sap suffered to flow freely. By following this practice with roses, and by judicious heading down, I have obtained very large and healthy bushes on the top of a single straight stem the third year.

TRANSPLANTATION.

Transplantation consists in removing a plant from the soil in which it is growing to some other soil.

If in the operation the plant is torpid, and its spongioles uninjured, the removal will not be productive of any interruption to the previous rate of growth.

And if it is growing, or evergreen, and the spongioles are uninjured, the removal will produce no further injury than may arise from the temporary suspension of the action of the spongioles, and the noncessation of perspiration during the operation.

So that transplantation may take place at all seasons of the year, and under all circumstances, provided the spongioles are uninjured.

This applies to the largest trees as well as to the smallest herbs.

But as it is impossible to take plants out of the earth without destroying or injuring the spongioles, the evil consequences of such accidents must be remedied by the hindrance of evaporation.

Transplantation should therefore take place only when plants are torpid, and when their respiratory organs (leaves) are absent; or, if

they never lose those organs, as evergreens, only at seasons when the atmosphere is periodically charged with humidity for some considerable time.

Old trees in which the roots are much injured form new ones so slowly, that they are very liable to be exhausted of sap by the absorption of their very numerous young buds before new spongioles can be formed.

The amputation of all their upper extremities is the most probable prevention of death; but in most cases injury of their roots is without a remedy.

Plants in pots being so circumstanced that the spongioles are protected from injury, can, however, be transplanted at all seasons, without any dangerous consequences.

On the subject of transplantation much difference of opinion exists, particularly as to the most favorable period of performing this operation. Lindley has several pages of argument in favor of transplanting in the autumn as soon as the fall of the leaf indicates a recession of the sap, and of course a stillness of vegetation. I have planted many trees in England and agree with him that November and December are the most preferable months — but it is not clear that the same arguments are true in this climate.

Trees are not generally taken up with the same care here as there, and even if they were, the roots and small fibres are still usually much wounded and injured. If transplanted in September or October just previous to the frost entering the ground, there is not time for these injuries to heal before the action of the severe frosts of our winters, which is sure to penetrate to them as the earth is loosened all round by transplanting; this action of the frost on the lacerated roots must of course be in many cases fatal. Again in March and April, particularly the former, the most drying winds of the year prevail in England, which is unfavorable to transplantation as increasing the evaporation. Here the earth in those months is usually extremely moist from the melting of the snow, &c. Hence it would appear that these months are more favorable for the operation of transplantation here than in England — and it seems probable that there is less chance of failure in this climate by transplanting early in the spring than in the autumn; still I have now before me several trees transplanted in November which have stood this severe winter, and are now in full leaf and beauty. Also the spongioles of the roots of trees transplanted in autumn are better settled in the earth, absorb

the juices quicker and develop their foliage earlier and more abundantly than those moved in the spring; therefore there is a gain of time. From these considerations it may be more correct to transplant all hardy trees and those very tenacious of life in the autumn; immediately after the first frost, but all tender trees as Pears, Peaches, &c., it is safer to transplant in the spring. Evergreens, as the Fir, *Arbor vitæ*, &c., are better moved in the spring also.

With respect to the age of the tree when transplantation should take place, there is no doubt that young trees are the best even for immediate beauty and effect. In moving a large tree great expense and care are requisite, and even then it is probable that considerable pruning must take place to restore the equilibrium between the roots and the branches, by which operation the tree remains an unsightly object for years, and probably does not recover its original size before a young tree would produce nearly the same effect, the young one remaining a beautiful object all the time.

Therefore except in cases of extremely rare specimens, it is better to abandon the idea of transplanting old trees.

Many plants of *Rhododendron maximum* and *Magnolia glauca* are annually brought in the

spring from their native spots in this vicinity for sale; the purchasers generally select the largest and finest, of course the oldest specimens, for which the highest price is paid. They then wonder they will not grow. If such were planted in a moist shady spot and headed down they might have a fair chance of surviving, but younger plants would be far preferable.

Hardy herbaceous plants, the ornament of the open garden in summer, if kept in pots can be transplanted at any time of the year. The nursery men who would make a practice of keeping them in this state, would sell many to their summer visiters, who are delighted with the specimens seen in flower, but afterwards forget them.

MANURES.

This subject is difficult to reduce to the few observations permitted by the size of this work.

The purpose of manure is to supply those juices and gases to the roots of plants, of which the soil has been exhausted by their previous action—and in proportion to the quantity of this supply will plants acquire luxuriance or remain weak. Plants differ however in their capacity of thriving on manure. Vines, roses,

and others can scarcely ever be too much manured—the Pine family will hardly bear any—the Cacti, which naturally vegetate on rocks and in sand, will if manured attain an excessive vigorous growth. The variety of manures and their useful application to different plants are almost infinite.

Loamy clay absorbs heat slowly, retains moisture so tenaciously as to prevent drainage, and is so compact as to hinder the passage of the young spongioles of the root through it. Yet mixed with a large quantity of sand, peat, lime and manure, it becomes valuable; its capability of retaining moisture enabling it to hold the solutions of the peat, lime, and manure until gradually used by the roots, which valuable solutions would quickly run through a light sandy soil without clay, before the roots had time to absorb them.

Silex or the component part of sand, when dissolved by the potash, soda, or other alkaline properties of manure, enters into the tissue of many plants, and largely into all grassy plants; it is supposed to be the chief cause of the stiffness or rigidity of the stem—hence it is valuable as a manure; it also lightens heavy clayey soils. Calcareous earth or lime also enters in appreciable quantity into many plants in the

shape of oxalate or phosphate of lime — bone manure now so much used is phosphate of lime. The salts of potash and soda are likewise found in abundance in plants, hence, besides the power possessed by these and some other salts of dissolving various substances found in the earth so as to make them fit juices for absorption by roots, they themselves are valuable manures in the shape of common salt (muriate of soda) saltpetre, (nitrate of potash) &c., but they should be applied in small quantities. Ulmin or geine, a peculiar substance resulting chiefly from vegetable decomposition and existing in abundance in peat and in common manure, has lately been brought into notoriety in the Geological reports of different States, and represented as the essential part of manure, without a supply of which to vegetables all fruit will fail.

Much direct experiment is still wanting to ascertain the true value and operations of this substance. The small knowledge hitherto possessed on the subject is however rather in favor of the theory.

Those who consider the chemical constituents of a soil as the sole tests of its value for the growth of plants, will be much in error in practice.

Minerals and metals or rather their oxides

exist in plants — as sulphur in the cruciferous family, particularly in mustard, copper in coffee, wheat, and many other plants, iron in tobacco, gold in the sage, &c., but these can only be taken up by the roots as solutions of their oxides, nothing solid being able to pass through the spongioles.

Some manures sensibly affect the colors of flowers as is well known to the tulip growers, even a moderate quantity of manure spoils all their favorite stripes. The change of the pink color of *Hydrangea* into purple is probably produced by some manure containing excess of alkali.

The following statement of the strength of manures on oats, rye, and barley, is extracted by Decandolle from Hermstädt (*Annalen der Landwissenschaft*, *Annals of Agriculture*.)

	Rye.	Barley.	Oats.
Sheeps dung on,	13 fold.	16 fold.	14 fold.
Goats “	13	15	15
Horse “	11	13	14
Cow “	9	11	16
Human fæces	13	13	14½
Pigeons “	9	10	12
Human urine,	13	13	13
Dry bullocks blood,	14	16	12½
Vegetable earth,	6	7	13
Unmanured soil,	4	4	5

These trials were under exactly equal circumstances, but it would have been more satisfactory had the experiment been tried un-

der all equal circumstances except the quality of the natural soil, which should have varied in particulars of composition, tenacity, silicious, calcareous and other natural admixtures.

The refuse from Sugar Refineries has been considered a powerful manure, particularly from those where animal charcoal or burnt and pulverized bone is used in the process — and this refuse has been carried at great expense from the Refineries at St. Petersburg to the South of France for the purpose of manuring the Vineyards. It consists of carbon and phosphate of lime in exceedingly minute division, also of vegetable mucilage, the vegetable coloring matter of sugar which is probably carbon in another state, and a portion of saccharine juice.

The carbon may be converted into carbonic acid and received into a plant for the purpose of being afterwards decomposed and depositing its carbon there, the phosphate of lime we know from the action of bone manure is very powerful, and in this case is so very finely divided that its action must be rapid. Of the effect of the mucilage, I am ignorant, whether being vegetable it is capable of being converted into geine or not, but I suspect not as it re-

sembles the substance thrown off by roots ; the saccharine juice is in sufficient abundance to create the strongest fermentation and heat, so much so that the boards with which a vessel was lined inside while carrying a cargo of this refuse from St. Petersburg to Marseilles were completely converted through and through into charcoal. There is no doubt therefore that it is a most effective manure, but it requires great caution in the use, and to be mixed with a large quantity of earth previous to application, otherwise its heat will completely destroy vegetation. One injurious effect it produced however was to excite the vines so excessively that when it was impossible to obtain this stimulus none other could be found to supply its place, and the vines fell into a state of weakness.

It has lately been subjected to fermentation for the purpose of manufacturing vinegar from it previous to its application to the soil. This of course by abstracting the saccharine juice, leaving a portion of acetic acid in the mass, and perhaps by destroying in some measure the phosphate of lime, much impairs its quality as a manure.

On the much discussed question of the comparative value of manure applied fresh from the stable, or applied after it has lain in a heap for

some months and fermented, it appears that exposure to rain dissolves the salts it contains, which are lost by washing away, and the heat of fermentation dissipates the gases in the atmosphere. Both these are of value to the roots of plants.

On the other hand, on the theory of Geine, the fermentation of manure, kept in a heap, decomposes the vegetable substance and converts it into geine, which is thus in a fit state for immediate application to the roots, while manure, if spread over the earth in a fresh state, does not heat at all and decomposes very slowly, a great proportion of the gases being also lost.

The application of liquid manure to plants, particularly those grown in pots or tubs, is considerably practised, and certainly with great advantage. This liquid manure is usually prepared by steeping manure in water and drawing it off when clear, and of the color of beer or porter. The above argument applies also to this method.

The substances found in plants by analysis are by no means true tests that those substances are required as manure to make them flourish ; thus there may be very little lime found in a vegetable, on analysis, and yet lime as phosphate, (bone manure) carbonate, (common

lime) or even sulphate (gypsum) may be a useful manure for that vegetable—for lime neutralizes acids which may be found in the soil, many of which are injurious; it decomposes and prepares various other substances, as mucilage or gum which readily dissolves and alters phosphate of lime, thus the hurtful exudations of roots partly possessing this mucilaginous nature may perhaps thereby be rendered innocuous or useful, &c. There is indeed perhaps as much or more yet to be discovered on this subject than what we actually know.

Man sows and cultivates many acres of the same plant together, hence arises the necessity of manure and rotation. Nature mixes all her plants in varied and beautiful profusion—hence, no manure or rotation is necessary, the exudations of the roots of one plant become food for another, and the same plants remain growing on the same spots for years, nay ages. Yet when nature does, as in the case of forests, produce the same tree to a large extent—the American forests teach us that there rotation also becomes necessary. It would be a curious experiment to endeavor to ascertain whether the exudations of parasitical plants were beneficial or otherwise to the trees on which they are *said* to feed.

INDEX.

The numbers refer to the pages.

- Acidity, 48.
- Adhesion, 9.
- Alburnum, 19.
- Anther, 41.
- Axil, 22.

- Bell glasses, 69.
- Buds, 26.
- Bulbs, 24.

- Calyx, 34.
- Cambium, 21.
- Carbonic acid, 32.
- Cells, 8.
- Cellular tissue, 2.
- Color, 61.
- Corolla, 34.
- Cuticle, 30.
- Cuttings, 68.

- Darkness, 39.

- Embryo, 51.
- Endogenous, 19.
- Evaporation, 64.
- Evergreens, 80.
- Excrementitious matter, 16.
- Exogenous, 19.
- Eyes, 26.

- Fertility, 36.
- Flavor, 48.
- Floral envelopes, 34.
- Flowers, stunted branches, 35.
- Flowers, 34.
 - double, 39.
 - proliferous, 39.
 - discoid compound, 39.
- Fruit, 45.
- Flues, 64.

- Germination, 55.
- Glass-houses, 63.
- Grafting, 73.

- Heart-wood, 19.
- Hybridising, 50.

- Inarching, 75.
- Insipidity, 49.
- Internodia, 19.

- Layers, 69.
- Leaf-buds, regular, 22.
 - , adventitious, 22, 27.
- Leaves, 29.
- Light and air, 60.

- Liber, 20.
Manures, 81.
Medullary rays, 20.
Nodi, 19.
Nitrogen, 15.
Ovula, 51.
Petals, 4.
Pistill, 41.
Poisonous gases, 64.
Pollen, 41.
Potted plants, 78.
Perspiration, 64.
Root, 11.
Rotation of crops, 16.
Sap, its motion, 57.
——, accumulation of, 59.
Sap-wood, 19.
Scion, 25.
Seed, 51.
Sepals, 34.
Seed-saving, 52, 56.
Silver grain, 20.
Spiral vessels, 9.
Sport, 38.
Spongioles, 11.
Stamens, 41.
Stem, 18.
Sterility, 36, 59.
Stigma, 42.
Stock, 25.
Stomata, 11.
Stoning, 46.
Sweetness, 48.
Tissue, 1.
Training, 62.
Transplantation, 77.
Tubers, 11.
Varieties, 38.
Vascular tissue, 8.
Vivification, 42.
Wood, how formed, 8.
Woody fibre, 8.
Worn out soil, 16.