CONVERSATIONS

ON

VEGETABLE PHYSIOLOGY;

COMPREHENDING

THE ELEMENTS OF BOTANY,

WITH

THEIR APPLICATION TO AGRICULTURE.

BY MRS. MARCET,

AUTHOR OF

"CONVERSATIONS ON CHEMISTRY," "NATURAL PHILOSOPHY,"
&c. &c.

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PREFACE.

THE favourable reception which the former works of the Author have met with, encourages her to offer this volume to the public. In doing so, she cannot but feel diffident of success, as the subject of the present work is one with which she has but recently become acquainted. Yet the source from which her knowledge of the vegetable creation is derived, makes her hope that this new mode of studying Botany may be found interesting and useful.

The reader will perceive that the facts and opinions contained in the following pages are almost exclusively taken from the Lectures of a distinguished Professor of Geneva. To him, indeed, whatever merit may be found in this work is due. The instruction and amusement which the Author derived from his Lectures, led her to think that she might, under the form of Conversation, convey a part of that interest to the minds of others. All she can lay claim to, is having arranged the subject in that form, which has always appeared to her to possess great clearness and advantage, in fixing the attention of young people.

In acknowledging her obligations for the encouragement and assistance which that friend has so kindly given her, she must at the same time consider herself responsible for any errors or inaccuracies, which, either through inattention or want of knowledge, may have crept into the work.*

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* Since the present edition went to press, Professor de Candolle has published a new work on Vegetable Physiology, to which the Author refers her readers for a complete and highly scientific view of the subject. The latest discoveries, which are pointed out in that publication, have been inserted in the following pages.

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Table of Explanation of the Scientific Terms used in this Work.

Achenium, fruit of the fir tree, 57. 260.
Albumen, a substance analogous to white of egg, contained in the seed, 284. 429.
Alburnum, the young layers of white wood, 39. 89.
Amendements, improvement of soil by the admixture of foreign ingredients, 187.
Amnios, nutritive fluid of the germ, or embryo plant, 283.
Annuals, plants living but one year, 203. 340. 375. 410.
Annular section, a ring cut through the bark, 88.
Anthers, a small bag filled with pollen, situated on the summit of a stamen, 245. 260. 354.
Artificial grasses, not permanent grasses, but entering into a course of cropping, as lucerne, clover, 130. 206. 416.
Assolements, the rotation of successive crops, or the cultivation of simultaneous crops, 180. 200. 209. 215.
Azote, a principle abounding in the animal kingdom, and in small quantities in some vegetables, 97. 435.

Bracteæ, or floral leaves, peculiar to some plants, growing very near the flower, and liable to be mistaken for it; being sometimes coloured, as in the Hydrangea, 56.

Calyx, or flower-cup, consisting of sepales more or less soldered together, 241.
Cambium, the returning sap, after it has been elaborated in the leaves, 16. 85. 223. 364.
Carbon, charcoal perfectly pure, 77. 92. 137. 360. 384.
Carbonic acid, the combination of carbon and oxygen, 111. 137. 189. 193.
Carpel, consists of a seed-vessel surmounted by a style, which is crowned by a stigma, 244. 273.
Cellular system, a tissue of cells resembling a honeycomb, and forming one of the elementary organs of vegetables, 11. 37. 41. 330.

Perennials, plants living several years, 204.
Pericarp, covering of the seed, and origin of the fruit, 265.
Petals, the leaves of a flower forming the corolla, 241. 354.
Petiole, footstalk of a leaf, 34. 50. 60. 354.
Pistil, composed in general of several carpels, 244.
Pollen, a powder contained in the anthers, 245.
Pome, a name for all fruits whose seeds are pips, 275.
Primordial leaves, the first regular leaves that expand, 55.
Pseudosperma, fruits of compound flowers, and the gramineous family, consisting of the seed surrounded by the pericarp, 280.

Racemus, flowers growing in long clusters, like currants, 247.
Races of plants, derive their origin from the same species; and the points in which they differ are of so decided a character, that they are continued from the parent plant to its offspring, 344.
Radical leaves, leaves near the root, 56.
Radix, root, 21.
Receptacle, the base whence the pedicels of the umbel radiate, 247. 255.
Resins, volatile oils modified by the action of oxygen; as pitch, tar, and turpentine, 100.
Rhizoctonia, a fungus which attacks the roots of lucerne and saffron, producing the disease called *death*, from its fatality, 373.
Rhizomorpha, a false parasite which attacks wood, and reduces it to a vegetable mould, 370.
Rhizophora, or *mangrove*, a tree whose branches bury themselves in the ground and strike root, 224.
Rust, a disease of grasses, 375.

Seminal leaves, cotyledons expanded, 54.
Sepales, leaves forming the calyx, 241.
Siliques, pericarps of the cruciform family, 272.
Smut, a fungus, under the form of a black powder, attacking the ears of corn, 374.
Spelt, *Triticum Spelta*, a species of wheat, 420.
Spermoderm, the skin or covering of the seed, 259. 282. 421.
Spike, or *Spica*, a mode of flowering, 247.
Spongiole, an expansion of the cellular integument at the extremity of the root, resembling a small sponge, being full of pores, by means of which the root absorbs water from the soil, 17.
Stamens, slender filaments surrounding the pistil, and each supporting an anther, 245 252. 260 304.

Station of plants, the peculiar localities in which they are generally found, 333.

Stigma, a spongy substance situated at the summit of the style, 244.

Stipula, two accessory leaves situated at the base of compound leaves, 52. 59.

Stoma, a pore situated at the extremity of each rib of a leaf, by which the leaf exhales moisture, 51. 71.

Style, a small stalk rising from the seed-vessel and supporting the stigma, 244.

Succulent plants, those which retain moisture, the cellular tissue connecting the vessels of the upper and lower surface of the leaf being thick and fleshy, 226. 228.

Syngenesia, the family of compound flowers, 255.

Testa, the exterior skin of the spermoderm, 282.

Thorns, the degeneration of young shoots of branches, 356.

Torus, or *bed*, a common base on the summit of the flower-stalk, by which the several parts of the flower are connected together, 246. 276.

Tracheæ, elementary organs of plants conveying air, 12.

Triticum Spelta, commonly called Spelt, a species of wheat, 421.

Umbel, pedicels diverging regularly from the summit of the peduncle, so called from the resemblance it bears to an umbrella, 246.

Variations, variations arising from peculiar circumstances, such as soil, temperature, &c., 344.

Varieties, a subdivision of races, in which the points of difference are of so slight a character, that they are continued from one individual to another only when the plant is propagated by subdivision; that is, by grafting, budding, or layers, 344.

Vascular system, the second set of elementary organs, consisting of tubes open at both ends, situated internally, and lodged in a thick coating of cellular integument, 11.

Verticellate, situated around a common axis, 274.

Volatile oils, or *essential oils*, are inclosed in small vesicles, whence they are extracted by pressure; they exist thus in the rind of oranges, the wood of the sandal tree, and in a variety of leaves. These oils differ from fixed oils in not being decomposed by heat, 100, 101.

Whorl, a circle of leaves, 241. 256.

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PLATE I.

THE COMMON PEA.

Pisum vulgaris; Leguminous family, Dicotyledon.

a,	Stem.
b b,	Stipula.
c c,	Petiole, or common leaf-stalk.
d d,	Folioles of the compound leaf.
e e,	Apex of the leaf.
f f,	Tendril, terminating the petiole of the leaf.
g g,	Peduncle or flower-stalk springing from the axilla, and dividing it into two pedicels.
i i,	Pedicels.
k k,	Axilla of the leaf.
l,	The flower.
m m,	The calyx.
n n,	The corolla.
o,	The standard, or superior petal.
p p,	The two wings, or lateral petals.
q,	The carina, or two lower petals soldered together, seen interiorly.
r,	The torus, or base of the flower.
s,	The stamens, nine of which are half soldered together by their filaments.
s[1]	The tenth stamen free.
t t,	The anthers.
v u w,	The pistil — *v*, the ovary; *u*, the style; *w*, the stigma, bearded.
x,	The fruit or pod, of which a portion has been removed in order to show the seeds.
y y,	The seeds attached to the upper suture of the pericarp.
z z,	Firmeules, or ligatures attaching the seeds to the pericarp.

PLATE I.

y^1,	A seed detached.
y^2,	The cicatrice.
y^3,	The seed split open, showing the embryo plant and the two cotyledons.
A,	The radicle.
B B,	The two fleshy cotyledons.
C,	The plumula.

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PLATE II.

WILD TULIP.

Tulipa sylvestris; family Liliaceous, Monocotyledon.

a,	Stem.
b,	That part of the stem which forms the peduncle of the flower.
c c c,	Leaves.
d d,	Flowers with six pieces disposed in two rows, bearing the name of Perigone.
e,	Torus, or base of the organs of the flower.
f,	Filaments of the stamens, bearded at their base.
f^1,	The anthers.
g,	The pistil, composed of the ovary and the stigma, having no style.
g^1,	The ovary.
g^2,	The stigma crowning the ovary, composed of three cells.
C c,	The pistil enlarged and grown into a fruit.
$C\,c^1$,	The fruit cut open, to show the three cells, separated by partitions, and enclosing each two rows of seeds attached to the centre of each cell.
h,	A separate seed.
h^1,	The same cut through lengthwise, to show the spermoderm, the albumen, and the embryon.
i,	The spermoderm.
k,	The albumen.
l,	The embryon.
l^1,	The embryon alone, showing it to be of one piece, or monocotyledon.
m,	The bulb.
n,	The base, representing the trunk or stem.
o,	The roots.
p,	A lateral branch.

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PLATE III.

CHINA-ASTER.

Aster chinensis; Syngenesious family, or Compound Flower.

a, The stem.

b, A branch.

c c, Leaves.

d, A head not blown.

d^{1}, A head in blossom.

e e, Folioles composing the involucre.

f, Floral leaves, approximating to the form of the folioles of the involucre.

g, Ligulate florets situated around the disk.

g^{1}, A single floret remaining on the head, all the others being taken off.

h, Tubular florets situated on the disk or centre of the head.

h^{1}, A single tubular floret remaining on the disk.

g^{11}, A ligulate floret magnified.

i, Tube of the calyx soldered on the ovary.

k, Edges of the calyx terminating in layers or pappus.

l, Ligulate petal terminating in fine teeth

m, Two stigmas.

h^{11}, A tubular floret magnified.

i^{1}, Tube of the calyx soldered on the ovary.

k^{1}, Pappus crowning the calyx.

l^{1}, Tubular petal terminating in fine teeth.

m^{1}, Stigmas.

n, Upper part of the style bearing the stigmas.

n^{1}, The same magnified.

n^{11}, The lower part of the style.

m^{1}, The two stigmas enlarged to see the sweeping hairs.

l^{11}, Tubular petal split lengthwise, and spread open.

o o,	The fine filaments of the stamens.
p p,	The five anthers soldered together, and forming a tube.
q,	The fruit entire, crowned by the pappus.
r,	The fruit magnified.
s,	The cicatrice, by which the fruit adheres to the receptacle.
t,	The border of calyx magnified, showing a single hair truncated, inserted in a ring of teeth, the rest of the hairs being pulled off.
u,	The embryon, in which may be distinguished the radicle and the two cotyledons.
x,	Receptacle of the florets.

Fig. 1.

Fig. 2.

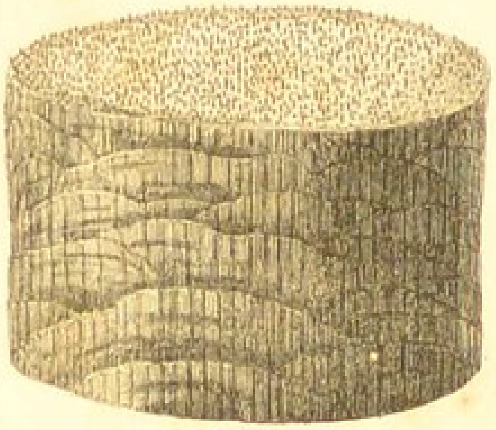

Fig. 3.

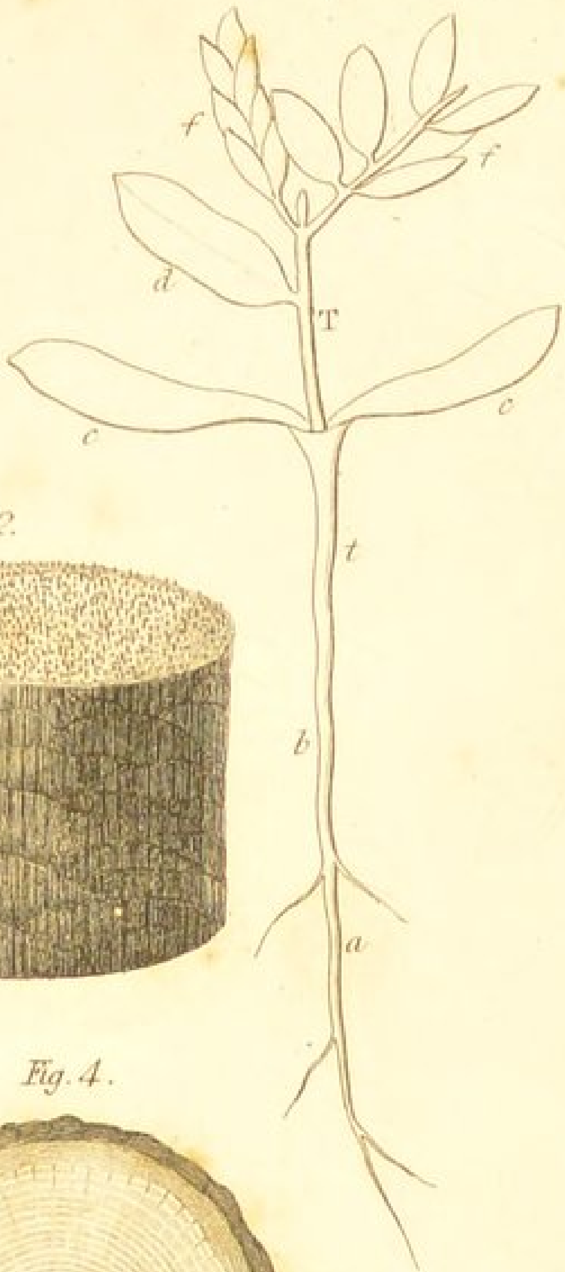

Fig. 4.

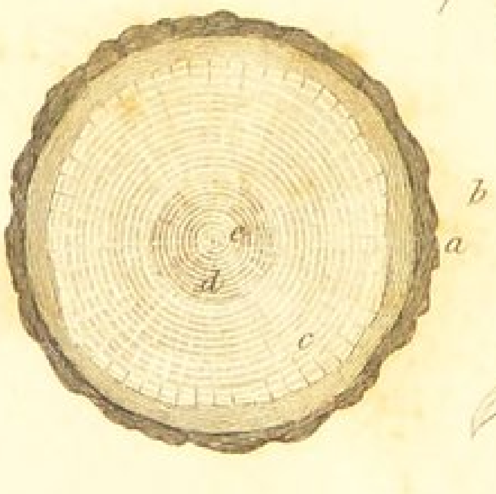

Fig. 5.

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PLATE IV.

Fig. 1.

GERMINATION OF A MONOCOTYLEDON, OR ENDOGENOUS PLANT.

The *Scheuchzeria palustris.*

a, Pivot or radicle.
b b, Accessory roots shooting from the bottom of the stem.
c, Cotyledon, or first leaf.
d d^1, Second and third leaves, called primordial.
e e, Common leaves of the plant.

Fig. 2.

HORIZONTAL SECTION OF THE STEM OF A MONOCOTYLEDON, OR ENDOGENOUS PLANT.

Yucca aloifolia.

Showing the scattered fibres which compose the wood, having neither bark, pith, medullary rays, nor distinct layers.

Fig. 3.

GERMINATION OF A DICOTYLEDON, OR EXOGENOUS PLANT.

Daubentonia punica.

a, Radicle slightly branching.
b, Neck, or vital point between the root and the stem.
t, Portion of the stem below the cotyledons.
T, Portion of the stem above the cotyledons.
c c, Two opposite cotyledons.
d, A simple primordial leaf.
f f, Common leaves.

PLATE IV.

Fig. 4.

VERTICAL SECTION OF THE STEM OF A DICOTYLEDON, OR EXOGENOUS PLANT.

The *Oak.*

a b, The bark, composed of the vertical layers *a*, and the internal bark *b*.

c d e, The wood, composed of the alburnum or young wood *c*, the perfect wood *d*, and the pith *e*.

The circular zones represent the layers of wood, and the lines diverging from the centre the medullary rays.

Fig. 5.

A BRANCH TURNING ITS LEAVES TOWARDS THE LIGHT.

CONVERSATIONS.

CONVERSATION I.

EMILY.

As I wander over these beautiful mountains, and observe the variety of flowers they produce, how much I regret my ignorance of botany!

MRS. B.

It is, certainly, a science particularly adapted to Switzerland: but why should you suffer your regret to be vain? To wish to learn is the first, and often the most difficult, step towards the acquisition of knowledge.

EMILY.

But though I should certainly like to understand botany, I cannot say that I wish to learn it: there is such a drudgery of classification to encounter, before any proficiency can be attained to recompense your labours, that I confess I do not feel courage to make the attempt.

CAROLINE.

And, after all, what is it one acquires? — A knowledge of the class to which a flower belongs, according to the number of its stamens or its pistils; and, perhaps, after hard study you may go so far as to ascertain its Latin name, though you may still be ignorant how it is called in your own vulgar tongue. Botany appears to me a science of rules and names, not of ideas;

and is, therefore, devoid of interest. I am, for my part, quite contented to gather a sweet-smelling nosegay of beautiful garden monsters, as botanists call them, without troubling myself about their scientific names.

MRS. B.

I will frankly own, that, for many years, I entertained the same prejudices against botany, as you do; but having had the good fortune, during a spring I passed at Geneva, to hear a course of lectures on that science by Professor de Candolle, I was entirely converted: and I am now fully persuaded that no natural science is dry, unless it be dryly treated.

EMILY.

None can be more likely to succeed in converting others, than those who have been converted themselves; and if you would indulge us, my dear Mrs. B., with relating what you learned at these lectures, I make no doubt that Caroline would be tempted to listen to you, were it but from curiosity to discover whether her first opinions on the subject were correct, or whether she ought not, at least, to acknowledge that they were hastily formed.

CAROLINE.

Oh! I shall be very thankful to be allowed to remain, provided I am at liberty to depart if I find I do not take an interest in the study.

MRS. B.

I shall not be ambitious of retaining uninterested listeners; and, though I was delighted with the instruction I received myself, I am very sensible that I shall not be able to communicate to you either the same degree of pleasure or of information. I will, however, do my best to relate to you what I can recollect of these lectures.

M. de Candolle, so far from confining himself to the classification of plants, examines the vegetable kingdom in its most comprehensive and philosophical point of view. In describing the structure he investigates the habits and properties of plants, and shows, not only how wonderfully they have been formed to fulfil the purposes of their own multiplication and preservation, but how admirably they answer the higher purpose which Nature has assigned them, of ministering to the welfare of the animal creation; and more especially to that of man. He turns his attention particularly to point out the means by which the science of botany can promote that with which it is most intimately and importantly connected — agriculture. He makes ready the soil and sows the seed for the husbandman; he extracts the healing juices and the salutary poisons for the physician; he prepares materials for the weaver, colours for the dyer; in a word, as he proceeds, there is scarcely an art on which he does not confer some benefit, either by pointing out a new truth, or warning against an old established error. Thus, throughout his course, his principal aim is to promote, by his vast stock of knowledge, the welfare of his fellow-creatures.

EMILY.

Treated in this point of view, botany surely cannot fail to interest us.

MRS. B.

It is rather the physiology of botany which I should teach you; and I shall merely give you such an insight into classification as is necessary to enable you to understand the structure and character of plants.

M. de Candolle entered upon the subject by observing, that, in classing the various productions of Nature, the first great line of demarcation is that which separates the mineral kingdom from organised beings. How would you make the distinction?

CAROLINE.

I should say that nothing was more easy: organised beings have life, and minerals have not.

MRS. B.

Very true; yet I should be tempted to retort upon you that this is a distinction rather of names than of ideas. I believe I have before observed to you, that we know not what life is. We see its effects: they are sufficiently apparent and numerous; and it is only by studying them that we are able to form any idea of that state of being which we call life. The first difference, therefore, to be observed between minerals and beings endowed with life is, that the latter are formed with organs adapted to fulfil the several functions for which they were destined by Nature. These organs differ, not only in form and structure, but more or less in the materials of which they are composed: organised beings are generally of a smooth surface, rounded and irregular; whilst minerals are rough, angular, and, in their crystalline state, of geometrical regularity.

One of the principal functions these organs have to perform is nutrition. Unorganised matter may, in the course of nature, be enlarged or diminished, either by mechanical or chemical changes; minerals may be augmented by the addition of similar particles, or by chemical combination with substances which are dissimilar, but they have no power to convert them into their own nature.

Organised bodies, on the contrary, are increased in size, by receiving internally particles of matter of a nature different from their own, which they assimilate to their substance.

EMILY.

That is to say, that the food by which they are nourished is converted into their own substance?

MRS. B.

Yes; organised beings have also the power of reproducing their species: — minerals may be broken into fragments, but they are alike incapable of receiving nourishment, of growing, or of reproducing.

Let us now proceed to inquire, what is the principal distinction between the two classes of organised beings, the animal and the vegetable creation.

CAROLINE.

Animals are endowed with a power of locomotion, whilst vegetables are attached to the soil.

MRS. B.

That is true, and it will, perhaps, be as well to begin by ascertaining the cause whence this difference arises. Animals are provided with a cavity called a stomach, in which they deposit a store of food, whence they are continually deriving nourishment. This organ is essential to them, as they are not constantly supplied with food: they do not always find it within their reach; they must wander in search of it; and were they not furnished with such a storehouse, they would be frequently in danger of perishing.

EMILY.

But surely we are not in want of continual nourishment: should we die if our stomachs were quite empty?

MRS. B.

No, not immediately; for though the system requires constant renovation, Nature is so careful of the preservation of its creatures, that she not only affords them the means of subsistence, but provides resources in cases of accidental interruption of the supply: after having consumed, or rather, I should say, assimilated the food contained in the stomach, the fat of animals is made to contribute to the nourishment of their organs, and to the support of life. In some, such as the dormouse and the polar bear, this provision is carried to such an extent, that they pass several of the winter months in a state of inanition; during which period, the only sustenance they receive is from the abundant provision of fat which they make during the summer; and when roused from their lethargy by the return of spring, they are lean and ravenous.

The food of animals is conveyed from the stomach to the various parts of the body by the function which is called *digestion.* The food passes through small absorbent vessels into the blood, and is thence circulated throughout the system.

CAROLINE.

But, Mrs. B., one would think you were going to give us the history of the animal rather than the vegetable creation.

MRS. B.

Only so far as to enable me to point out the distinction between them.

Vegetables have no stomach; they do not require such a storehouse, since they find a regular supply of nourishment at the extremity of their roots: with them, therefore, there is no occasion for accumulation. In order to conceive an idea of the form in which plants receive nourishment, you must represent to yourself a very delicate cobweb network, of such extreme tenuity as to render it invisible until the interstices are filled and distended by the nutriment lodged within them. The food of plants is not, like that of animals, fo a complicated nature; but consists of the simplest materials, — water, and the solid and gaseous matter contained within it.

The second distinction between the animal and vegetable creation is, that the latter are not endowed with sensibility.

EMILY.

But the mimosa or sensitive plant, Mrs. B., when it shrinks from the touch, bears a strong appearance of sensibility.

MRS. B.

I should doubt its being any thing more than appearance. Some ingenious experiments have, indeed, been recently made, which tend to favour the opinion that plants may be endowed with a species of sensibility; and seem to render it not improbable that there may exist in plants something corresponding to the nervous system in animals.

CAROLINE.

The sensitive plant would then, no doubt, be a nervous fine lady at the court of Flora. But, pray, what were these experiments?

MRS. B.

There are certain vegetable substances, such as nux vomica, laurel-water, belladonna, hemlock, and several others, which are known to destroy life in animals, not by affecting the stomach, but merely by acting on the nervous system. These poisons were severally administered to different plants, either by watering them with, or steeping their roots in, infusions of these poisons. The universal effect was, to produce a sort of spasmodic action in the leaves, which either shrunk or curled themselves up; and, after exhibiting various symptoms of irritability during a short time, became flaccid, and the plant in the course of a few hours died.

EMILY.

I should have been curious to have seen an experiment of this nature tried on the sensitive plant.

MRS. B.

It was done. Two or three drops of prussic acid, which, you know, is a most powerful poison, were poured upon a sensitive plant: the leaflets closed and opened again at the end of a quarter of an hour; but they did not regain their sensitiveness for at least six or eight hours. When we see plants thus acted upon by vegetable poisons, which are known to be incapable of destroying the animal fibre, or of injuring the frame except through the medium of the nerves, we may be led to suppose, that certain organs may exist in plants with which we are totally unacquainted, and which bear some analogy to the nervous system in animals.

It is to the vital principle of plants that must be attributed that general excitability which is necessary to vegetation. Here is a slip of elder; when I cut it in two, the fluid you see continues oozing from both of the separated parts: were there no action going on within the stem, only a single drop would flow out at each orifice. There are some flowers, such as those of the Barberry, whose stamens will bend and fold over the pistil, if the latter be pricked with a needle; and there is one instance of a plant whose leaves move without any assignable cause: this is the *Hedysarum gyrans*, which grows only on the banks of the Ganges; it has three leaflets on each foot-stalk, all of which are in constant irregular motion.

EMILY.

I recollect seeing a plant called Sundew (*Drosera*), the leaves of which, near the root, are covered with bristles bedewed with a sticky juice. If a fly settles on the upper surface of the leaf, it is at first detained by this clammy liquid, and then the leaf closes, and holds it fast till it dies.

MRS. B.

The *Dionæa muscipula* affords another example of the same kind: it grows in the marshes of South Carolina. Its irritability is so great, that an insect which settles on it is generally crushed to death by the collapsing of the two sides of the leaf, which is armed with bristles, like that of the Drosera.

CAROLINE.

But all plants are endued with some degree of irritability, if you will not admit of sensibility; for we know that, in general, their leaves turn towards the light, and, when growing in a room, they spread out their branches towards the windows, as if they were sensible of the benefit they derived from light and air.

MRS. B.

Light and air conduce to their well-being, and they are so wisely constructed by Providence as to seek them; but it is independently of all choice or preference. We must consider plants as beings in which the principle of life is reduced to its state of greatest simplicity. As we advance in the scale of creation, we find that the lowest animals are directed by instinct; intelligence increases as we approach towards man, who is guided by reason: but the vegetable world is influenced merely by physical causes, which derive their energy from the principle of life.

EMILY.

But since plants are so inferior in the scale of existence, why is their form so much more delicate and beautifully varied than that of animals? Is it not singular that Nature should be most solicitous for the appearance of her simplest works?

MRS. B.

The most curious details of the structure of a plant are visible in its outward form; whilst those of the animal economy are concealed in the anatomical structure of the internal parts. The organs of plants are chiefly external, and are ornamental at the same time that they perform the several functions for which they were formed.

Plants appear, also, to be susceptible of contracting habits: the mimosa, or sensitive plant, if conveyed in a carriage, closes its leaves as soon as the carriage is in motion, but after some time it seems to become accustomed to it, the contraction ceases, and the leaves expand; but if the carriage stops for any length of time, and afterwards recommences its motion, the plant again folds its leaves, and it is time only which can reconcile it to its new situation.

EMILY.

This shows strong symptoms of sensibility. One would suppose that the plant was alarmed at the new and unknown state of motion; and that its apprehension, like that of an infant, returned every time the novelty recurred.

MRS. B.

You will, perhaps, consider plants as patriotic, when you learn that those which are brought from the southern hemisphere, faithful to the seasons of their native country, make vain attempts to blossom during our winter, and seem to expect summer at Christmas.

CAROLINE.

If you continue talking in this style, Mrs. B., you will certainly make me think that plants are not wholly devoid of sensibility.

MRS. B.

We cannot positively deny it; but the evidence against that opinion is so strong as to amount almost to proof. Had Providence endowed plants with the sensations of pleasure and of pain, he would no doubt, at the same time, have afforded them the means of seeking the one and of avoiding the other. Instinct is given to animals for that express purpose, and reason to man; but a plant rooted in the earth is a poor, passive being: its habits, its irritability, and its contractibility, all depending on mere physical causes.

The properties of plants may be separated into two classes: first, those which relate to their structure; such as their elasticity, and their hygrometric power: these properties may continue after death. Secondly, those which relate to their vitality; such as excitability: which, consequently, can exist only in the living state.

The organs of vegetables are all composed of a membranous tissue, which pervades the whole of the plant; they are distinguished by the name of elementary, and are of three kinds.

1st. The cellular system, consisting of a fine tissue of minute cells or vesicles, of an hexagonal form, apparently closed and separated by thin partitions, somewhat similar to the construction of a honeycomb; or bearing, perhaps, a still nearer resemblance to the bubbles formed by the froth of beer.

EMILY.

This appears very similar to the cellular system in the animal economy, which you described to us in our lessons on chemistry.

MRS. B.

Not exactly; for one of the chief purposes of the cellular system in the animal frame is to contain the fat, a substance to which there is nothing analogous in the vegetable kingdom.

CAROLINE.

And are not plants furnished also with a vascular system?

MRS. B.

Yes; this forms the second set of elementary organs. It consists of tubes open at both ends; these are always situated internally, and are, besides, guarded from injury by being lodged in a thick coating of the cellular integument. Some of these vessels assume the form of a necklace, their coats being at intervals drawn tight together, or strangulated, so as to appear to stop the passage of the fluid they contain.

CAROLINE.

It is doubtless through the vascular system that the sap rises?

MRS. B.

That is not so easily determined, for the organs of plants are so extremely small, that it is frequently difficult, even with the aid of the most powerful microscope, to examine the structure of their parts accurately enough to be able to ascertain their functions. It has long been a disputed point, whether the sap ascended through the vascular or the cellular system of organs; but the latest opinion, and that which M. de Candolle is inclined to favour, is, that neither of these systems convey the sap, which, as he conceives, rises throughout the plant wherever it can find space, and chiefly through the interstices which separate the cells.

EMILY.

Indeed! It appears to me very extraordinary that the sap, which performs so essential a part in the economy of vegetation, should not flow freely through appropriate vessels, but be left to find its way as it can between them.

MRS. B.

The sap, when first sucked up by the roots, consists of little more than water, holding various crude materials in solution: it is, therefore, more important that the regular organs should be reserved for its elaboration, and its preservation after that process. M. de Candolle conceives that the cells are the most excitable organs of plants; that they alternately expand and contract, and, by so doing, not only enlarge and diminish their own dimensions, but those of the interstices which separate them, and by this action propel the sap.

The third system of elementary organs is the tracheæ; so called from their conveying air both to and from the plant: they are composed of very minute elastic spiral tubes.

CAROLINE.

But, surely, plants do not breathe, Mrs. B.?

MRS. B.

Not precisely in the same manner that we do; but air is so essential an agent, both chemically and mechanically, in promoting their nourishment and growth, that it is scarcely less necessary to their existence than to that of animals. Indeed, it is the opinion of M. de Candolle, that the function of transmitting air is not confined to the tracheæ, but extends throughout the vascular system.

The whole of the vegetable kingdom consists of masses of these several elementary organs, with the exception of fungi, mosses, and lichens, whose vessels are all of a cellular form, without any vascular system whatever.

EMILY.

That affords a strong argument against the passage of the sap through the vascular system.

MRS. B.

Certainly. The fibres of plants are composed of collections of these vessels and cells closely connected together. The root and stem of plants consist of such fibres: if you attempt to cut them transversely, you meet with considerable resistance, as you must force your way across the tubes, and break them; whilst, if you slit the wood longitudinally, you separate the vessels without breaking them, and have only to force your way through the elongated cellular tissue which connects them.

EMILY.

The difference is very observable; but I wonder that the cells, being formed of a delicate membrane, are not squeezed and crushed to pieces in the stems of plants, especially when they become hard wood.

MRS. B.

The cells, by the growth of the stem, are frequently drawn out of their original form, and elongated; but the vascular system, which is of the greatest importance, is internal, and lodged in a bed of cellular integument, so that the pressure of the bark or surrounding parts is not sufficient to crush it.

The layers of wood which you may have noticed in the stem or branch of a tree cut transversely consist of different zones of fibres, each the produce of one year's growth, and separated by a coat of elongated cellular tissue, without which you could not well distinguish them.

The cuticle, which is the external skin or covering of the plant, consists of an expansion of the cellular tissue; and is furnished with pores for evaporation.

CAROLINE.

This is, I suppose, neither more nor less than what is commonly called the bark?

MRS. B.

On the contrary, it is both *more* and *less* than the bark. *More*, because the cuticle is extended over every part of the plant; it covers the leaves and flowers, with the exception of the pistil and anthers, as well as the stem and branches: *less*, because the bark consists of three distinct coats, of which the cuticle forms only that which is external. The cuticle of a young shoot, after it has been for some time exposed to the atmosphere, becomes opaque, dries, and distended by the lateral growth of the branch, splits, and after a year or two falls off. A second membrane is then formed by the desiccation or drying up of the external part of the cellular integument; but it differs from the former in being thicker, and of a closer texture. It is not furnished with pores, having no other function to perform than to inclose a layer of air, and preserve the internal parts from injury. This covering is distinguished from the former by the name of epidermis.

These general, though, perhaps, rather desultory observations will, I hope, prepare you for our next interview; when I propose to take a full-grown plant, examine its structure, and explain the nature of those organs by which it is nourished and preserved. We shall begin with the roots, and then proceed up the stem to the leaves and flowers.

EMILY.

I should have expected that you would have commenced by the birth of the plant; that is to say, the germination of the seed.

MRS. B.

If the plant derives life from the seed, the seed equally owes its origin to the parent plant; and as the preparation of the seed, by that beautiful and delicate system of organs, the flower, is one of the most curious and complicated operations of the vegetable economy, I think it will be better to reserve it for the latter part of our studies.

CAROLINE.

That is very true so far as regards the formation of the seed; but its bursting, and the sprouting of the young plant, appears to be the natural commencement of the history of vegetation.

MRS. B.

The germination of the seed is a process so intimately connected with its formation and composition, that it is a reciprocal advantage to treat of them together, or, rather, in immediate succession, instead of separating them by the intervention of the whole history of vegetation.

CONVERSATION II.

ON ROOTS.

MRS. B.

We are now to examine the structure of those organs, whose office it is to nourish and preserve the plant.

In the nutrition of plants, six periods are to be distinguished : —

1. The absorption of nourishment by the roots.
2. The transmission of nourishment from the roots to the different parts of the plant.
3. The development of the nourishment.
4. The action of the air on plants.
5. The conversion of nourishment into returning sap or cambium.
6. The secretion of various juices from the sap.

We shall begin by the absorption of nourishment by the roots.

Plants being, as we have observed, deprived of locomotion, cannot go in search of food : it is necessary, therefore, that Nature should provide it for them in their immediate vicinity. Those simple elements, which are almost every where to be met with, water and air, constitute this food. Water not only forms the principal part of it, but serves also, as a vehicle to convey what solid nutriment the plant requires ; and as a vegetable is unfurnished either with a mouth to masticate, or a stomach to digest, solid food can be received only when dissolved in water. In this state it is absorbed by the roots ; for the root not only supports the plant by fixing it in the soil, but affords a channel for the conveyance of nourishment. If it does not fulfil this double office, it is not a root, but a subterraneous branch.

CAROLINE.

But will not a branch, if placed under ground, become a root, and absorb nourishment? I have seen the gardener fasten down branches of laurel and other shrubs, leaving only the extremity above ground; and these layers strike root, and become, in the course of time, separate plants.

MRS. B.

Striking root implies, that roots will (under certain circumstances) grow from a branch, but the branch itself cannot be converted into a root; for at the extremity of each fibre of a root there is an expansion of the cellular integument called a spongiole, from its resemblance to a small sponge, being full of pores, by means of which the roots absorb water from the soil. Now, a branch, being destitute of this apparatus, cannot supply the plant with nourishment.

CAROLINE.

True: it cannot feed without a mouth; — but I thought that there were pores in every part of a plant.

MRS. B.

The pores in those parts of a plant above ground are almost wholly for the purpose of exhalation. The roots have no pores except in the spongioles at their extremities, which, as I have observed, are for the purpose of absorption. It would be very useless for them to be furnished with evaporating pores, since they are not exposed to the atmosphere, where alone evaporation can take place.

EMILY.

The tendrils of vines, then, and of other climbing plants, which serve to fix them against a wall, or the trunk of a tree, cannot be considered as roots; since they are unable to supply the plant with nourishment, although they answer the purpose of sustaining it.

MRS. B.

Certainly, these plants are furnished with roots which pump up nourishment from the soil; but there are some parasitical plants, such as the *Viscum album* or mistletoe, and the *Epidendron Vanilla*, which, having no immediate communication with the earth, strike their fibres into the stems or branches of a tree, and derive their nourishment from this richly prepared soil; but as the absorption in this case is not carried on by the regular mode of spongioles, these fibres do not bear the name of roots.

A root is never green, even when exposed to the light, an element which is essential to the developement of the green colour in other parts of the plant.

The root, then, by means of the little spongioles attached to its extremities, sucks up whatever liquid comes within its reach; in proportion as it grows, its fibres spread themselves over a greater extent of soil, and come in contact with a greater quantity of moisture; and the plant, whose branches extend above ground, in proportion as the root spreads beneath, requires a more abundant supply of food.

EMILY.

And do the roots take up every kind of liquid, or have they any means of selecting what is suitable for their nourishment?

CAROLINE.

How would it be possible for them to make a choice, having neither reason nor instinct to direct them? For I conclude that the little spongioles are not endowed with the sense of taste, to enable them to discriminate between different sorts of food.

EMILY.

True; but without endowing the vegetable creation with reason, instinct, or even sensibility, Nature might possibly have so constructed the absorbent pores, that, either by mechanical or chemical means, they should reject what was unfit, and receive only what was good for the plant.

MRS. B.

The only provision which Nature appears to have made with this view is, to have formed the pores of the spongioles of such small dimensions, that they are incapable of absorbing a liquid which is thick or glutinous; for, if the particles with which the fluid is loaded are not extremely minute, they cannot make their way into the plant, the interstices between the cells being too small to admit them. I do not mean to say that these absorbing pores have any power to reject a dense or viscous fluid, but that they will be clogged and obstructed by it, and the absorption consequently cease.

Water which has flowed through the manure of a farm-yard, and abounds with nutritive particles, is much used on the Continent for watering gardens; yet, unless copiously diluted with pure water, it is found to be deleterious, choking the plant with an excess of food. But when the liquid is sufficiently limpid, the spongioles suck it up with equal avidity, whether it contain salubrious nourishment or deadly poison.

EMILY.

Oh, my poor plants! Why did not Nature grant them some means of preservation from such dangers?

MRS. B.

Nature has bountifully diffused throughout the soil such fluids as are adapted for the nourishment of the vegetable creation: no streams of poison flow within their reach. It is unnecessary, therefore, to guard against a danger which does not exist. It is merely from the experiments of the chemist and the physiologist that we learn that the roots of plants will absorb liquids, of whatever nature, presented to them, provided they be sufficiently limpid. The spongioles act chiefly by capillary attraction, and suck up moisture just as a lump of sugar absorbs the water into which it is dipped. As a proof of this it has been shown, that if roots, saturated with moisture, be transplanted into very dry earth, the latter will absorb the moisture from the roots.

CAROLINE.

If so, why do not the roots continue to absorb moisture when the plants are dead, as well as when they are living? A sponge, or a lump of sugar, have no vital principle to stimulate them to draw up liquids.

MRS. B.

Neither does absorption immediately cease upon the death of a plant, as the blood ceases to circulate upon the expiration of animal life; but when the vital energy is destroyed, that susceptibility of expansion and contraction, which enabled them to propel the fluid upwards, ceases, and it can no longer ascend into the roots, but remains stagnant in the spongioles, which soon become saturated. Disease and putrefaction follow; and that nourishment, which was designed to sustain life, now serves only to accelerate decay. The fluid is, however, still performing the part assigned to it by Nature; for if it be necessary to supply living plants with food, it is also necessary to destroy those which have ceased to live, in order that the earth may not be encumbered with bodies become useless, and that their disorganised particles may contribute to the growth of living plants. By this beautiful provision of Nature, the putrefaction of dead leaves, straw, &c. which reduces these bodies to their simple elements, prepares them to become once more component parts of living plants.

CAROLINE.

I do not know whether this is botany, Mrs. B.; but it is totally different from the dry classification of flowers. It elevates the heart while it enlightens the mind, and leads quite as much to religious contemplation as to scientific knowledge.

MRS. B.

The physiology of plants, of which we are now treating, forms one branch of the science of botany, and one which is certainly replete with interest: but from every natural science, and every branch of it, from the arrangement and classification of the organs of the flower as well as from the history of vegetation, the well-disposed mind will draw lessons of piety; and he must study Nature with very contracted views, who does not raise his thoughts from the admiration of the creation to that of its all-wise and beneficent Creator.

Botanists distinguish several kinds of roots. The *radix fibrosa*, or fibrous root, is the most common, and most simple in its form: it consists of a collection or bundle of fibres, connected by a common head, and often merely by the base of the stem. The roots of many grasses and most annual herbs are of this description: during their short existence, which is limited to one summer, they continue growing, both by forming new fibres and by elongating the old ones. These fibres are occasionally covered with a sort of shaggy down, which, as it generally occurs in loose or sandy soils, is considered as a provision of Nature for the purpose of fixing the plant more firmly in the ground.

EMILY.

Of what description are the roots of those weeds, such as couch-grass, which seem to be interminable?

If you attempt to eradicate them, you meet with a succession of bunches of fibres springing from a root which grows horizontally, and appears to be endless.

MRS. B.

This is the *radix repens*, or creeping root. The long horizontal fibre is, in fact, not a root but a subterraneous branch, for it has no spongioles: the real roots are the small bunches of fibres which spring from it. Such a root is very tenacious of life, as any portion, in which there is an articulation will grow: it decays at its origin, and continues growing at its extremity.

EMILY.

Then we must not seek for its origin, but its extremity, in order to eradicate it.

MRS. B.

You cannot destroy it without digging up the whole of the subterranean stem: it is this which renders it so difficult to eradicate.

CAROLINE.

Yet surely not more difficult than the Ox-eye, and many other weeds, whose strong penetrating roots seem to strike to the very centre of the earth; for, however loosened by digging, they are scarcely ever pulled up entire.

MRS. B.

The root of these plants is called *fusiform*, or spindle-shaped. It also bears the name of the tap-root and the pivot-root; the first from its tapering so considerably towards the end; and the latter owing to its fixing the plant immovably in the earth. This root is but scantily provided with the means of acquiring food, having sometimes not more than a single fibre furnished with a spongiole at its extremity. To compensate for this disadvantage, it is of so moist and fleshy a nature as to afford an ample store of provision for the plant.

CAROLINE.

But, with such limited means of suction, how can this store-house be replenished?

MRS. B.

The surface of the ground immediately exposed to the drying powers of the sun and wind, retains less moisture than the deeper and more sheltered strata of the soil; besides, the store is laid up during the season of abundance, and measured out, as the necessities of the plant require, during that of dearth. Here, you see, are a variety of compensations for its circumscribed power of absorption.

A very simple experiment will convince you, that the spindle-shaped root, as well as those of every other description, absorb water only by the spongioles at their extremities. If you immerse a young radish in a glass of water, so that every part of it shall be covered except the taper end of the root, you will find that it will soon die; while if you immerse only the extremity of another radish in water, you will preserve it alive. The whole body of the root serves to fix and support the plant in the soil; but it is the extremity alone which absorbs nourishment.

It sometimes happens that this species of root, whether from want of vigour or some mechanical impediment, is checked in its growth, and wears the appearance of being cut or bitten off. It has hence obtained the name of *radix præmorsa*, or abrupt root; but it is, in fact, nothing more than the *radix fusiformis* originally mutilated, and modified by that mutilation in successive generations.

EMILY.

Is not the Devil's bit Scabious of this description?

I recollect hearing a curious story of its acquiring this mutilated form. In the age of sorcery and credulity it was affirmed, that the devil, out of spite to mankind, bit off the end of a plant which was endowed with so many excellent properties.

MRS. B.

The name of the plant is, no doubt, derived from this ridiculous story; but I should be rather inclined to suppose that it was an allegorical compliment to the virtues of the plant, than that such absurdity could obtain belief in any age.

EMILY.

Bulbous roots, such as those of the hyacinth, the lily, and the onion, are also solitary roots, Mrs. B.; but they seem to fix the plant in the soil rather from their mass than their depth, for they are very superficial; and it is no doubt from the difficulty of finding water, that Nature has added to their root a tuft of small stringy fibres (which are doubtless furnished with spongioles) to multiply the points of absorption.

MRS. B.

The bulbous root, *radix bulbosa*, is improperly so called; for the tufts or fibres pendant from the bulb are alone the roots. The bulb itself, you will learn, when you come to examine its structure, constitutes the stem of the plant: no wonder, therefore, that it is superficial.

EMILY.

How curious! a globular subterraneous stem?

MRS. B.

If you prefer giving it the name of bud rather than of stem, you may with equal propriety, for it contains the whole embryo plant; but, as we are not at present treating the subject either of stems or of buds, we must reserve this explanation for a more appropriate period.

CAROLINE.

And are the roots of potatoes of this description?

MRS. B.

The potato is not the real root of the plant, (though usually so called) but a species of mucilaginous, farinaceous excrescence, growing upon subterraneous branches, which have no means of deriving nourishment from the soil; and it is very remarkable, that this salubrious and nutritious substance is produced by a plant, the real fruit of which is of a poisonous nature. The potato appertains to the class of tuberous or knotted roots, *radix tuberosa*, which are of various kinds, comprehending all such as have fleshy knobs or tubers. This sort of root belongs to perennial plants, though the knobs are frequently either annual or biennial. In all cases, they are to be considered as reservoirs of nourishment, which enable the plant to support the casual privations of a barren or dry soil.

Some plants, of which Timothy grass is an instance, acquire tubers when situated in a soil subject to vicissitudes of drought and humidity, and lose them if transplanted to one regularly supplied with moisture.

EMILY.

It is wonderful to observe in what an admirable manner roots find means of compensation for local inconveniences!

MRS. B.

The object of nature throughout all these varying forms of roots and subterranean branches is the same — to establish a reservoir in which the vital force of the plant and its material resources are husbanded.

The root of she *orchis* is well deserving our notice from its singularity. It consists of two lobes, somewhat similar to the two parts into which a bean is divided. One of these perishes every year, and another shoots up on the opposite side of the remaining lobe. The stem rises every spring from between the two lobes; and, since the new lobe does not occupy the same place as its predecessor, the orchis every year moves onwards, though to a distance only of a few lines.

CAROLINE.

Thus, in the course of a certain number of years, the orchis may walk all round a garden, provided the gardener does not interrupt it in its progress.

MRS. B.

There are some plants which, like the Indian fig tree, shoot out roots from the stem many feet above ground: they grow downwards, bury themselves in the soil, and new stems ultimately spring up from them; but the epidermis of these roots is never green, like that of young branches.

EMILY.

I recollect reading an account of a tree which bears some analogy to this fig tree. It was situated at the top of a high wall, and its roots grew down the side of the wall till they reached the ground, a distance of about ten feet, and then buried themselves in the soil.

MRS. B.

This account is given by Lord Kaimes of a plane tree, situated among the ruins of the New Abbey monastery in Galloway. But the analogy with the fig tree is only apparent, this singular growth of the roots being merely the result of local inconvenience.

CAROLINE.

I once heard of a curious experiment performed on a willow tree. It was dug up, and reversed, the head of the tree being planted in the ground, and the roots stretched out like naked branches in the air. In the course of time, the roots were transformed into branches, and the branches into roots.

MRS. B.

Such a transformation could not really have taken place, because it would be impossible for the buried branches to acquire spongioles; but roots could shoot from them as well as branches from the uncovered roots, and it is thus the change was accomplished. It is, however, a bold experiment, which does not often succeed.

The duration of roots is either annual, biennial, or perennial. To the first belong plants whose existence is limited to one summer, such as barley and other kinds of corn, and a vast number of garden and field flowers. The biennial root produces the first season only leaves, and the following summer flowers and fruit, or seed; after which it perishes. The perennial belong to plants which live to an indefinite period.

A root consists of a collection of fibres composed of vascular and cellular tissue, without tracheæ or vessels destined for the transmission of air; but there is so great an analogy between the structure of the root and that of the stem, that I shall reserve what observations I have to make on this subject till our next meeting, when I propose to examine the nature of the stem.

CONVERSATION III.

ON STEMS.

MRS. B.

Every plant has a stem.

CAROLINE.

That is to say, trees and shrubs; for there are many plants, such as violets, anemones, fern, and a variety of others, which have large bunches of leaves growing from the roots out of the ground: the flowers, it is true, have each a stem, but the plant itself seems to have none.

MRS. B.

I must repeat my assertion: — every plant has a stem, through which the sap circulates, and from which the leaves and flowers spring. This stem, it is true, is not always apparent; it is sometimes concealed under ground, sometimes disguised under an extraordinary form. The stem of the tulip is contained within the bulb or onion, which is commonly, but improperly, called its root; that of the fern is subterraneous. A very curious plant grows in some of the valleys of the Alps, called willow-grass (*saule en herbe*). You sometimes meet with a plain covered with it, and you would not imagine whence it derives its origin: it is nothing less than the head, or rather, I should say, the extremities, of the branches of large willow trees.

EMILY.

Do you mean a tree which has been accidentally overthrown and buried, the leaves of which have sprouted above ground?

MRS. B.

No; it is a willow which is annually buried alive. Every spring it struggles to rise above ground, and every autumn it disappears beneath the soil. Let us suppose the seed of a willow springing up at the foot of a mountain, and that the earth which is annually carried down by the rains from this mountain should be sufficient to bury the young plant. The following spring it would again shoot out with redoubled vigour; for the growth of the plant having been checked by the fall of the soil, the sap, which should have been expended in the produce of foliage, being accumulated in the little stem, will be sufficient to afford nourishment for a double shoot; two little branches will therefore now appear. This, like its predecessor, flourishes but for a season, and in the winter is buried. The two stems the following spring produce four, which expand their leaves, and in the autumn are consigned to the earth; the third year eight stems arise; the fourth, sixteen; and the plant goes on thus doubling its sprouts every year, and the surface of the soil rising, till at length a plain is formed covered with verdure, consisting of the leaves of the willow-tree.

CAROLINE.

What a singular growth! — How much I should like to walk on one of these curious meadows!

MRS. B.

They are, as you may suppose, not very common, since it requires peculiar local circumstances to produce them: the vicinity of a mountain which annually sends down earth sufficient to bury the young shoots, though not so deeply as to prevent their rising from their tomb every spring. The age of these willows has been ascertained by digging down the side of the plain and observing how often the shoots have been renewed; the lower you descend, the more you find the branches increase in size while they diminish in number, till at length you reach the original and single stem.

CAROLINE.

But what is the difference between a subterraneous stem and a root?

MRS. B.

The structure of the root and of the stem is in some respects different, and their functions totally so: the former merely sucks up nourishment from the soil and transmits it to the leaves; the latter is supplied with organs to distribute it, variously modified, to the several parts of the plant, the leaves, the flowers, &c.

There is a point or spot separating the stem from the root, called the neck, which may be considered as the seat of vitality. If the root of a young plant be cut off, it will shoot out afresh; if the stem be cut away, it will be renovated; but if this vital spot at which the root and the stem are united be injured, the plant will infallibly perish.

EMILY.

I think it should be called the *heart* rather than the neck of the plant, since it is so essential to its existence.

CAROLINE.

Is not the neck equally so? Animals will not survive decapitation any more than plants. But it is true the situation of the neck does not quite correspond with that of the animal frame, unless you call the roots the body of the plant, and the whole that is above ground the head.

MRS. B.

I do not think the huge trunk of a venerable oak would yield that title to its roots, and the extremity of its branches crowned with verdure would lay exclusive claim to the dignity of head.

The stems of plants are divided into two classes: those which grow internally, and increase from the centre, and those which grow externally and increase from the surface. M. de Candolle distinguishes them by the characteristic appellations of *endogenous* and *exogenous;* a distinction first introduced by a celebrated French botanist, M. Desfontaines. We have no corresponding terms in English: in our country these two classes of plants retain the denomination given them by Linnæus, of *monocotyledons* and *dicotyledons.*

CAROLINE.

These are hard-sounding names, Mrs. B.: I hope their explanation will make them intelligible.

MRS. B.

I believe you will find no difficulty in understanding them. The class of plants whose stems grow internally, and are called endogenous by the French, are by us termed monocotyledons, from another characteristic of this order of plants; viz., from their seed, during germination, being converted into one thick leaf, or lobe, which yields nourishment to the young plant until it is strong enough to suck it up from the soil. This leaf is called a cotyledon; and *monos* is a Greek word, which signifies *one.*

The other class, whose stems grow externally, and are termed exogenous by the French, are by us called dicotyledons, and comprehends all those plants whose seeds in germinating split into two parts, forming two nutritive lobes, or seminal leaves; and hence they bear the name of dicotyledons, which signifies two cotyledons.

EMILY.

I have seen lupins, peas, and beans germinate in this way; but do not recollect having observed any seed germinate with only one cotyledon.

MRS. B.

They are much less common in these climates, at least in plants of sufficiently large dimensions for their cotyledons to be observable.

There is a third class, denominated *acotyledons*, which have no cotyledons and no vascular system, such as fungi, lichens, &c.; but of these we shall not treat at present.

Let us first examine the structure of the stems of the monocotyledons, or endogenous plants. Of this description are the date, the palm, and the cocoa-nut tree, the sugar-cane, and most of the trees of tropical climates.

Their stems are cylindrical, being of the same thickness from the top to the bottom; whilst those of Europe, you know, always become more slender and taper towards the summit of the tree, approximating to the conical form.

CAROLINE.

I thought that endogenous plants were those which grew in our own country, in opposition to exotics, or plants of foreign countries; but, by your account, it is just the reverse, for endogenous plants grow in countries most distant from us.

MRS. B.

You confound the word *endogenous* with *indigenous*: the latter signifies to grow within the country; the former is a French word, not yet introduced into the English language, signifying to grow internally, or within itself.

CAROLINE.

Within itself! How can the stem increase in size internally? One would think that the new layers of wood growing in the interior part of the stem would burst the external coats.

MRS. B.

The more the external coats are pressed by the new growing wood, the closer and more compact they become, and the greater the resistance they offer to the internal layers; till at length a period arrives when the outer coats are so hardened and distended as to yield no longer: the stem has then attained its full growth in horizontal dimensions, and offers a broad flat circular surface to view, which has scarcely risen in height above the level of the ground.

EMILY.

How singular a mode of growing! In this first stage it must resemble the stump of the trunk of a tree which has been cut down; but how does it grow up afterwards?

MRS. B.

The following spring, there being no room for a new layer of wood to extend itself horizontally, it shoots up from the centre of the stem vertically; fresh layers every year successively perforate this central shoot, till, from the innermost, it becomes the outermost layer of wood; hard, compact, and of the same horizontal dimensions as the base: the second period of growth is then completed; and thus the stem continues growing, for a certain number of years, horizontally, and then it takes a sudden start upwards.

EMILY.

The stem, then, does not begin to rise until it is as large in circumference as at full growth? How I should like to see one of these broad flat stems!

MRS. B.

You may see them growing in hothouses; and though we have none in the open air in these climates, we have many smaller plants of the same description. Corn and all gramineous plants, the liliaceous tribe of flowers and bulbous roots, are all endogenous.

CAROLINE.

But lilies, tulips, and all flowers which spring from bulbous roots have long stems, thick at the lower end, and tapering towards the flower.

MRS. B.

You again confound the stalk of the flower with the general stem of the plant. Both flowers and leaves, with but few exceptions, have each a separate stem or foot-stalk; that of the flower is called by botanists a peduncle, or pedicel; that of leaves a petiole. These are perfectly distinct from, and independent of, the general stem of the plant. The stems of bulbous plants are contained within the bulbs, as I have already informed you.

CAROLINE.

This mode of growing puts me in mind of the pushing out of an opera glass, the sliding cylinders of which are contained one within the other.

MRS. B.

It is true that there is some analogy between them. The leaves and fruit of this class of plants grow from the centre of the last shoot, and form a sort of cabbage at the top of the tree, which, if cut off, the tree perishes.

EMILY.

But what becomes of the bark of these trees? How does that resist the pressure of so many successive layers of wood?

MRS. B.

Endogenous plants have no real bark; the external coats of wood are so much hardened as to render such a preservative unnecessary.

EMILY.

But the palm and cocoa-nut tree, which I have seen at Mr. Loddiges's hothouse, have a very rough external coat, greatly resembling bark.

MRS. B.

This is formed of the basis of decayed leaves. A circle of leaves annually sprouts from the rim of the new layer of wood; and, when they fall in autumn, leave these traces of their past existence. When a European woodcutter begins to fell a tree of this description, he is quite astonished at its hardness. "If I have so much difficulty with the outside," says he, "how shall I ever get through the heart of the wood?" But as he proceeds, he discovers that the trees of the tropical regions are softest in the centre; this circumstance renders it very easy to perforate them, and makes them peculiarly appropriate for masts of vessels, pipes for the conveyance of water, and such like purposes.

These plants have usually no branches; if we except one species of palm-tree, which shoots out two or three branches together.

The family of the gramineous plants, that is to say, the grasses and corn, have a knot at the base of each leaf, whence the shoot grows.

CAROLINE.

I have observed that the straw of corn is hollow, but closed at certain intervals, forming externally a sort of ring; and it is from these rings that the leaves and branches shoot.

MRS. B.

The sugar-cane, which grows in this manner, is the largest of the gramineous plants.

Lilies are also of this description.

The Yucca of the tropics differs from our liliaceous plants only by having a longer stem; in these temperate climes vegetation has not sufficient vigour to develope all the energies of the plant, and the stem grows only laterally, never shoots upwards, but lies concealed in the bulb. Were it transplanted to a tropical climate, as soon as it had attained its lateral growth, it would shoot upwards in the manner I have described.

The structure of *exogenous plants*, or *dicotyledons*, to which the trees of our temperate climes belong, is much more complicated. Here, then, are two reasons for our submitting them to a more accurate investigation.

The stem is composed of two separate parts: the one ligneous, the other cortical; in other words, it is formed of wood and bark.

The wood consists in the first place of the pith, a soft medullary substance, which occupies the centre of the stem, and is almost always of a cylindrical form. This soft pulpy body does not grow or increase in size with the tree, but retains the same dimensions it originally had in the young stem.

CAROLINE.

I thought that it rather diminished; for if you cut a young branch or stem, the growth of one season, the pith is very considerable, while little or none is to be discovered in the trunk of a full-grown tree.

MRS. B.

The pith which fills the shoot of one season is scarcely perceptible in a large tree; the quantity, however remains the same. Its dimensions may be contracted by the pressure of the surrounding coats of wood, which sometimes so condenses and hardens it as to prevent its being distinguished from them.

Some trees have a much greater quantity of pith than others; the elder, for instance, abounds with it. The quantity of pith in the branches depends also upon their nature: if the branch is barren, it contains much more than if it is destined to bear fruit, but in the same individual stem or branch the quantity never alters.

The pith consists of cellular tissue. If this membrane be of a very fine texture, it is susceptible of extension as the branch lengthens; but if it be coarse, and the cells large, when the branch grows, it cracks and separates into parts. This is distinctly visible in a branch of jessamine, if you slit it open so as to exhibit the pith.

CAROLINE.

Here is one which we may examine. I will slit it longitudinally: look, Emily, the pith it separated into parts, as if it had been forcibly torn asunder.

MRS. B.

It is the growth of the stem which rends the pith in pieces, but it is not thus destroyed until it has fulfilled the purpose of its destination, which is to nourish the young wood during the first period of its existence.

EMILY.

Then it acts the part of a cotyledon, or nurse to the young wood. But when it is become dry, what is to perform this office to the new wood which is annually formed?

MRS. B.

Every new layer of wood is lined with a layer of cellular tissue, which is, in fact, the pith of the wood to which it is attached. These internal coatings not only separate the several layers of wood, but are also interwoven and incorporated with them, and may be seen in the form of rays, which appear to issue from the central pith, and proceed to the external layer of wood: these are called medullary rays: they are visible in wood, but are remarkably distinct in the root of the carrot.

CAROLINE.

But these fibres or rays, which appear all to proceed from the centre, cannot be continuous, since they originate annually in each fresh growth of wood.

MRS. B.

Very true; but they are so minute, and so numerous that the termination of those of one year's growth, and the commencement of those of the following year, cannot be distinguished. This gives them the appearance of being continuous; but, were it really so, their distance from each other would increase in proportion as they diverged from the centre; yet you see in the carrot they are as close, and consequently much more numerous, in the external layers of wood, than in those nearer the central part. In one sense, indeed, they may be considered as continuous; as it is conjectured that the growth of the new wood originates from the extremities of the medullary fibres of the preceding year: this would tend to give regularity to the distribution and direction of the successive rays, and an appearance of continuity. A succession of these horizontal rays, perfectly regular, form vertical planes along the stem; which may be tolerably well represented by those circular brushes which are made to clean the inside of bottles.

EMILY.

The wood of exogenous plants, growing externally has not the same difficulties to encounter as that of endogenous plants.

MRS. B.

The difficulty is rather reversed than diminished, the pressure being from the external upon the internal parts. The first layer surrounding the central pith grows freely during a twelvemonth, but the following year it is enclosed by a new layer; and notwithstanding the accession of nourishment it receives from the roots, and the additional space it would, if unconfined, occupy, it is pressed and squeezed by the new layer into a narrower compass than it occupied the preceding year. In this distressing situation, what is to be done? Compelled to yield laterally, it makes its way where there is no pressure; that is to say, vertically: thus the stem grows in height at the same time that it increases in thickness. The first layer of wood having, therefore, found a vent for that new portion of its substance which could not be contained in the contracted space in which it was confined by the growth of the second layer, this portion grows freely during the second year; when a third layer shooting up around and compressing the second, this in its turn escapes from bondage, but, rising vertically, it encloses and confines the first layer.

CAROLINE.

Then the second layer which was the prisoner now becomes the gaoler of a new prisoner; but the latter does not excite my commiseration, for it doubtless profits by the experience of the first layer and rises above the fetters with which it is encircled.

MRS. B.

Yes; the first layer thus makes a shoot upwards every year, and the new ones follow its course in regular succession. This mode of growing, you must observe, renders the form of the stem conical, the number of layers diminishing as the stem rises.

These layers of wood attain a state of maturity, when they become so hard by continued pressure as to be no longer susceptible of yielding to it. Previously to this period, the layers bear the name of *alburnum*, signifying white wood; for wood is always white until it reaches this degree of consistence. The length of time requisite to attain a state of maturity varies extremely, according to the nature of the wood. In some trees five years are sufficient for this purpose; in others ten or twenty are necessary; and the Phyllyrea requires no less a term than fifty years to convert its alburnum into perfect wood. When once the first layer has attained this point of maturity, the others naturally follow in succession, according to their respective ages.

EMILY.

But are those dark-coloured woods, such as mahogany and rose-wood, ever white?

MRS. B.

Yes; and, what is still more remarkable, ebony, a wood which is completely black, is white until it has attained this state of maturity. Here is a small piece of a branch of ebony cut transversely; you see that the interior parts are perfectly black, and are surrounded by a ring of white wood or alburnum. The difference between the alburnum and perfect wood is less marked in woods of a lighter colour, but it is always sufficiently so to be distinguishable. Look at this trunk of chesnut-tree, which has been recently cut down with a saw.

CAROLINE.

I not only see plainly where the perfect wood is separated from the alburnum, but I can distinguish every layer of wood. I follow them in imagination in their successive shoots upwards to extricate themselves from the pressure of the new layers, by counting the number of layers at the base of the tree; then, Mrs. B., shall I be able to ascertain its age?

MRS. B.

Yes; and you may do more: for if you take the the trouble to count the number of layers at each end of one of those pieces of wood which have been sawed into logs for fuel, you will learn how many years that portion of the tree was in growing.

EMILY.

There are thirty layers at one end, and twenty at the other; consequently the tree must have been ten years growing the length of this log. I little thought I could ever have taken so much interest in, or derived so much knowledge from, a log of firewood.

MRS. B.

You will always find the works of Nature to be objects of interest and admiration, however common-place may be the purposes to which they are applied.

The annual layers of wood are distinguishable not only by their different degrees of hardness and density, but also by their being separated by layers of the cellular system, which constitutes the pith of each layer of wood; so that, when you examine the trunk of a tree, you perceive zones of woody fibre and zones of the cellular system.

EMILY.

Can the age of endogenous plants be ascertained in the same manner?

MRS. B.

No; the annual layers of wood are not sufficiently distinct from each other.

CAROLINE.

But the ring annually formed by the vestiges of leaves affords a still better record of their age; for it is not necessary to cut down the tree in order to ascertain it.

MRS. B.

For a certain period they may answer this purpose; but these vestiges are obliterated by time, and in an aged tree are no longer distinguishable towards the base of the stem.

The vegetation of the bark is precisely the inverse of that of the wood; that is to say, it is *endogenous*, its layers growing internally like those of the palm-tree: the new soft coat of bark, therefore, lies immediately in contact with the new soft layer of wood.

EMILY.

But if a fresh layer of bark grows every year, why is the bark so much thinner than the wood? I should have supposed that they would have been of equal dimensions.

MRS. B.

The outer coats of bark, when they become too hard to be further distended by the pressure of the internal layers, crack, and, becoming thus exposed to the injury of the weather, fall off in pieces: it is this which produces the ruggedness of the bark of some trees. In others, the rind, though smooth, peels off, after cracking, like that of the cherry, the birch, and particularly the plane tree. Those trees whose external coat of bark is least liable to peel off, such as the oak and the elm, become more scarred and rugged, in proportion as the tree grows older, and is longer exposed to the action of air, water, insects, and parasitical plants: sooner or later these various causes effect the destruction of the outer bark; and the other layers, as they become external and exposed to the same sources of injury, experience, in due course of time, the same fate; whilst the layers of wood, being protected and sheltered by the bark, vegetate in security.

CAROLINE.

Yet it is not uncommon to see the trunks of very old trees in a state of total decay, whilst the bark remains uninjured.

MRS. B.

That is the case when the wood is, by any accident, exposed to the inclemencies of the weather, which it is not calculated to resist. This happens, sometimes, by the lopping or breaking off of large branches, considerable pieces of bark falling off, or any circumstance by which the rain can gain admittance to the wood.

There are some trees whose bark is of so elastic and yielding a nature, that it does not harden for a considerable number of years. The bark of the cork tree, for instance (which is the part commonly called *cork*), does not begin to harden till after the age of seven years: care is taken to strip it off for the use of the arts before that period. The bark of the plane tree is, on the contrary, of so hard and inflexible a texture, that it cannot expand, but splits and falls off every season. These two species of trees, the cork and the plane tree, form the two extremities in the scale of varieties of texture in the nature of bark. The cuticle, or external coating of bark, is not confined to the stems and branches, but spreads itself over the leaves, and every part of the surface of the plant which is of a green colour.

EMILY.

But the bark of trees is not of a green colour, Mrs. B.

MRS. B.

You should recollect that the cuticle is a covering which lasts seldom more than a twelvemonth. In those parts of a plant which are of longer duration, such as the stem and branches of trees, the cuticle decays and peels off; and its place is supplied, as I have already told you, by the epidermis, a coating formed by the desiccation of the external part of the cellular tissue which has been left exposed to the air. The epidermis, therefore, is not green.

Aquatic plants form the only exception, as they have, properly speaking, no epidermis.

If you pass a silver wire or blade completely through the bark of a tree, the new internal layers, as they are annually formed, will gradually push it outward, till at length the internal coat becoming external, the wire will fall off.

CAROLINE.

That is, no doubt, the cause why inscriptions on the bark of trees, are, in the course of time obliterated: the new bark does not grow over them, it is true, but growing under them, the inscription becomes distended, and when the bark gives way, it will most readily split and fall off where the inscription has already wounded it.

EMILY.

If, however, the inscription be made so deep as to penetrate the layers of wood, the new layers of bark, instead of injuring, will preserve it.

CAROLINE.

But of what use will be its preservation whilst it is so buried as to be totally lost to the sight?

MRS. B.

Buried treasures are sometimes brought to light. Adanson relates, that, in visiting Cape Verd in the year 1748, he was struck by the venerable appearance of a tree, 50 feet in circumference. He recollected having read in some old voyages an account of an inscription made in a tree thus situated. No traces of such an inscription remained; but, the locality having been accurately described, Adanson was induced to search for the inscription by cutting into the tree, when, to his great satisfaction, he discovered it entire, under no less a covering than three hundred layers of wood.

CAROLINE.

Three hundred years, then, had elapsed since the inscription had been made! How much he must have been gratified by the discovery! — But did not this venerable tree suffer from such deep wounds?

EMILY.

Probably not; for, according to the size of the tree, though he cut so deep, he was still far distant from the centre.

MRS. B.

The centre is not the most dangerous part, for in exogenous plants this is the oldest and hardest part of the wood: the vital part of the stem is situated between the young layers of wood and those of the bark; or perhaps the vitality may be exclusively confined to the inner coat of the bark; for if the young layer of wood be destroyed by frost, the tree suffers but little; whilst, if the inner coat of bark be frozen, the plant infallibly perishes. In the trunk of a tree which has been cut down, it is very easy to trace the effect of frost on any layer that has been injured by it, the wood appearing withered and wrinkled. M. de Candolle observed a frost-bitten part of this description in a tree cut down in the forest of Fontainebleau, in the year 1800; and, by counting the superincumbent layers of wood, he ascertained that it must have happened in the year 1709, one which was remarkable for the severity of the frost.

EMILY.

But since the layers of wood grow with so much regularity, whence come those knots and waving lines, which constitute the beauty of polished wood?

MRS. B.

If the sap, in rising through the young wood, meets with any casual obstruction to its passage, it naturally accumulates in that spot, and forms what is called a knot. This consists of distended vessels, containing a magazine of food, which has previously been elaborated in the leaves, and which gives birth to a germ or shoot; but it frequently happens that, before this germ has attained strength to force its way through the bark into the open air, a new layer of wood rises over and encloses it. Sometimes it is only temporarily buried; and the following season it acquires sufficient vigour to break through its prison. Thus, if the shoot go on annually forcing its way through the soft wooden wall which rises up to oppose its progress till it reaches the surface of the stem, it becomes the origin of an external shoot or branch. If, on the contrary, it is exhausted by this series of struggles, it perishes; and leaves, in memorial of its efforts, the knots, waves, and streaks which embellish its tomb. This shoot, which had increased in size whilst traversing the several layers of wood, diminishes as soon as it grows externally, and protrudes in the air, being thickest in the stem, and tapering towards its extremity; so that a shoot, if traced from its origin, exhibits the form of a double cone, the base of which is at the surface of the stem.

EMILY.

But whence did this shoot derive its origin? The accumulation of sap can merely favour its growth, but cannot have given it existence.

MRS. B.

This is a question not very easily answered; but the opinion most prevalent among botanists is, that germs or latent shoots exist throughout the stems and branches of plants, and that those only are brought into a state of active vegetation which are fully supplied with food, so that those which chance to be situated in a knot or storehouse of food, are sure to be developed.

CAROLINE.

Do the stems and branches of exogenous plants grow, like their roots, merely at their extremities?

MRS. B.

No; they increase throughout their whole length.

If you make marks at certain distances on a root, you will find that these distances are not altered by growth; but if you make similar marks on a stem or a branch, the distances will increase, showing that it grows in its whole extent.

EMILY.

It must be so, since a new layer of wood grows annually at the base.

And pray, through what part of the stem does the sap rise?

MRS. B.

That is a question which has been long and much disputed. Some naturalists have maintained the opinion that it ascended through the pith; others, that it rose through the bark: and they have reciprocally proved each other to be mistaken in their conjectures. A third road was, therefore, sought for; and, by colouring the water with which a plant was watered, it has been traced within the stem, and found to ascend almost wholly in the alburnum or young wood, and particularly in the latest layers.

CAROLINE.

That is very natural. The perfect wood has in a manner finished its active career: it can itself acquire but little nourishment; and its indurated texture would be ill adapted to the conveyance of the sap, whilst the young layers, being in the full vigour of growth, and their cellular system flexible and elastic, are much better calculated to transmit it; besides, it is in these, you say, that the young shoots take their origin.

MRS. B.

The sap does not impart nourishment to the plant during its ascent: it is therefore more probable that its rising through the new wood is owing to that being the softest and most permeable. By means of the coloured medium I have mentioned, it was observed that the sap naturally ascended in straight lines, but that, if it encountered any obstacle, it could move obliquely, or even spread itself laterally.

A great variety of experiments have been made in order to ascertain the degree of velocity with which the sap rises; but as the rapidity of its ascension depends in a great measure upon the means which the plant has of parting with it by exhalation, we cannot well follow its progress, without having previously made acquaintance with the excretory organs of plants — the leaves, whose office it is to exhale that portion of the sap which is superfluous.

CAROLINE.

The whole of the sap, then, is not required for the nourishment of the plant?

MRS. B.

That nourishment is a more complicated operation than you are aware of: all the water which enters into the plant is not retained by it; part of it passes through the leaves into the atmosphere, and the atmosphere, in its turn, contributes to the nourishment of the plant. But we must not anticipate; and, at our next interview, we will examine the structure and agency of the leaves of plants.

CONVERSATION IV.

ON LEAVES.

MRS. B.

There is nothing more beautiful in the vegetable creation than the gradual formation and development of a leaf. It consists of the flattened expansion of the fibres of the stem from which it shoots, connected together by a layer of cellular tissue called the pabulum, and the whole is covered by a delicate coating of cuticle, which is almost always of a green colour. A plant may, indeed, be considered as a continued series of these fibres, sometimes closely bound up in the form of stems, at others spread out into that of leaves.

CAROLINE.

Yet surely, Mrs. B., there are many parts of a plant which can neither be referred to leaves nor stems? The blossom, the fruit, and such occasional appendages as thorns and tendrils, cannot come under either of these denominations.

MRS. B.

I beg your pardon: they all originate in leaves. Even the seed, when first ushered into life, comes cradled in a folded leaf; but as in assuming the form of a seed-vessel it loses that of a leaf, we must not allow it to encroach upon the present subject of our conversation, that of leaves properly speaking, which retain their original form throughout the whole of their transitory existence.

CAROLINE.

Well, it must be confessed that this borders on the marvellous; but I shall take it on your authority till the time comes for you to explain it more fully.

MRS. B.

It rests upon much better authority than mine: it is sânctioned not only by the opinion of M. de Candolle, but also by the celebrated Mr. Brown, who was the first to develope this theory in England. In Germany, so long as thirty years ago, the venerable poet Goethe wrote a small treatise on the metamorphoses of plants; and if this little work has not met with the attention it deserves, it is probable that, being written by a poet, it has been considered rather as the effusion of an ardent imagination, than as the deductions of a philosopher. But, whatever be the changes which leaves may undergo, it is our present business to treat of them in their state of leaves.

If, when a leaf shoots, the fibres which attach it to the stem or branch spread out immediately, the leaf is termed *sessile* or continuous; for it cannot be separated from the stem without the fibres being torn asunder: the leaves of corn, grasses, and all gramineous plants, are of this description.

EMILY.

But it is much more common for leaves to be attached to the branch by a foot-stalk.

MRS. B.

With exogenous plants it is; and the trees and shrubs of our temperate climate are almost all of that class. Such leaves are said to be articulated: the fibres when they first separate from the stem remain bound together, forming the *petiole* or foot-stalk; thence they expand in numerous ramifications, constituting the ribs of the leaf. Let us now examine this leaf of a horse-chestnut: I cut it transversely at its base, and you may perceive with the naked eye the larger vessels which convey the sap into the leaf. At the other extremity of the foot-stalk they are also visible. They are five in number, corresponding with the five leaflets of which the horse-chestnut leaf is composed.

The fibres of leaves spread out in various directions: the principal one, dividing the leaf from the base to the summit, is called the dorsal, or midrib; others branch out from this laterally; and a third class consists of still smaller ramifications issuing from these last: they all terminate at the surface of the leaf by a pore called *stoma*, a Greek word, signifying mouth.

CAROLINE.

These are, no doubt, the exhaling pores which send off the superfluous moisture?

MRS. B.

Yes; but we must patiently labour through a forest of foliage, before we can return to the physiological operations of the plant.

Leaves are usually divided by botanists into five classes, according to the direction of their ribs: —

First, the pennated are those in which the smaller ribs expand from the principal rib like the feathers of a quill: the leaves of the pear and the lime tree are of this description.

The second class is palmated. In these, the ribs diverge from the petiole like the fingers from the palm of the hand, as you see in this vine-leaf. They are not, however, always five in number, since they vary in different plants, and even sometimes in different leaves of the same individual.

The third class is called target-shaped, or *peltate*, being shaped like a buckler; such is the nasturtium.

The fourth class is *pedatum*, having the form of the foot: the hellebore is of this class.

The fifth class has simple ribs, proceeding from the base to the extremity of the leaf; corn, grasses, and all the gramineous tribe, are comprised within it. These leaves are always *sessile*.

The outline of the leaf, is of much less importance than the direction of its ribs. The indentures, or teeth of leaves, are formed by the termination of its ribs.

In the gramineous tribe, the leaves are smooth at the margin, and have no indentures; the ribs run on each side along the margin like a small seam, and terminate at its pointed extremity, whence all the exhalations take place.

When the indentures of some leaves reach so far as half-way down, they are said to be pinnatifid; and when the leaves, though separate, grow from one foot-stalk, so that one of them cannot fall off, or be separated from the other without being torn asunder, the leaf is said to be dissected.

CAROLINE.

There are a great variety of leaves of this description: the rose, the acacia——

MRS. B.

No; these are compound leaves, and differ from the dissected by being articulated, each leaflet having a separate foot-stalk, which, when the leaf dies, detaches the leaflet from the general foot-stalk, and they fall separately.

At the base of the foot-stalk of compound leaves there generally grows a small organ, called *stipula*: it consists of two accessary leaves, as you see here in the rose-leaf, the willow, and indeed in most exogenous plants. Sometimes the stipula is attached to the foot-stalk, at others to the stem: it withers easily, and often falls off before the other leaves; for which reason it is not always to be met with on branches of a certain age.

In this branch of rose-tree you see that there are stipulæ to all the younger shoots, while the older ones have already lost them. In the pea the stipula is larger than the common leaves. [See Plate I.]

When the ribs of leaves are expanded upon the same plane, the leaf is thin; in succulent plants, which retain moisture and evaporate but little, the cellular tissue, which connects the vessels of the upper and lower surface of the leaf, is thick and fleshy.

The two surfaces of a leaf generally differ in appearance: in the upper surface the ribs are the least prominent, and the leaf is consequently the smoothest, and of the deepest green. The under surface is more hairy, and abounds with *stomas* or pores; the upper has fewer, or is sometimes wholly without them, excepting in aquatic plants, whose leaves float on the water; their upper surfaces being alone exposed to the air, are alone supplied with *stomas*.

But, whether the two surfaces be similar or not, it is very certain that their functions are different; for if you reverse the leaf of a plant, and prevent it from resuming its natural position, it will wither and die.

EMILY.

But corn and grasses grow vertically, Mrs. B., and can scarcely be said to have an upper and an under surface; though, it is true, they are greener and smoother on one side than on the other.

MRS. B.

All the gramineous family have a more equal distribution of pores on either surface; for growing nearly erect, and being therefore equally exposed to the air, each surface can probably perform the same functions, and these plants can bear the reversion of their leaves better than any other.

Floating aquatic plants, on the contrary, having no pores on their lower surface, infallibly die if they are reversed without power of resuming their natural position.

CAROLINE.

It would be superfluous for aquatic plants to be furnished with pores on their under surface, since they could not evaporate into water.

MRS. B.

Nor can they elaborate the sap without exposing it, by means of the pores, to the atmosphere: but we must complete the anatomical examination of the structure of the leaf, before we enter upon its physiological functions.

The first appearance of leaves which the young plant puts forth on the germination of the seed is formed by the lobes of the seed itself, which we have already noticed under the name of cotyledons.

EMILY.

I have often observed them in lupins, when they first shoot above ground, and wondered that the tiny plant should be able to supply food to such thick substantial leaves.

MRS. B.

It is, on the contrary, these leaves which yield their substance to the tiny plant; and as soon as they have completed this function, and the whole of their pulpy nutriment is consumed, they wither and fall off.

But all cotyledons are not of a succulent nature: some are thin, like other leaves, and are more commonly called seminal or seed leaves.

EMILY.

How, then, can they feed the young plant?

MRS. B.

By immediately elaborating the sap, which the nascent root draws up from the soil. Seminal leaves are furnished with stomas for this purpose, while fleshy cotyledons have none; in the latter, the conversion of the cotyledons into leaves is but very imperfect: they frequently remain under ground, and do not assume either the form or colour of a leaf.

EMILY.

The cotyledons of peas and beans are of this description; in those of lupins the conversion is more complete, though they remain succulent.

CAROLINE.

Since the fleshy cotyledons have no stomas, I know not what they have to do in the open air: merely acting the part of a magazine of food, they are more at hand to supply the young plant with it under ground than above it.

EMILY.

But is it not wonderful that a young plant should be able to absorb sap, and elaborate it from the first moment of its existence?

MRS. B.

Not more so than that a young chicken should pick up grains of corn as soon as it has thrown off its egg-shell. Nature has probably given more firmness and stability to the roots of plants, which are obliged immediately to provide their own food, in the same way as she has to the beaks of young birds. The embryo plant has often another resource, but which does not belong to our present subject.

The first regular leaves which expand are called primordial, and are not unfrequently of a different character from the common leaves of the plant.

When the leaves shoot very near the ground, so as to appear to grow from the roots, they bear the name of radical leaves; they sprout, however, from the base of the stem, for roots never give birth to leaves.

Bracteæ or floral leaves are, on the contrary, leaves peculiar to some plants, which grow very near the flower, and are often mistaken for blossom, not being always of a green colour. The Hydrangea, for instance, has a great abundance of pink or lilac bracteæ, which I doubt not but that you have supposed to be the flower of that plant.

CAROLINE.

Are then those beautiful blossoms of the hydrangea not its flowers?

MRS. B.

To a superficial observer they bear, it is true, a much greater resemblance to flowers than to leaves; but, if examined attentively, you will find they possess few of the regular organs of the flower, and could produce neither fruit nor seed. The lime-tree shoots out a profusion of bracteæ of a pale yellow colour; and I doubt not but that you have also confounded them with the blossom which lies concealed beneath them. The coloured leaves of the *red-topped Clary*, which exhibit various tints of red, purple, and green, are also of this description. There are many bracteæ which do not differ either in colour or form from the other leaves of the plant, and are distinguished only by their situation with regard to the flower. Such is the tuft of leaves on the summit of the flower called the crown imperial, and that which grows from the top of the pine-apple: the scaly covering of this fruit consists also of the remnants of degenerated bracteæ.

CAROLINE.

And pray, Mrs. B., is not the scaly cone of the fir-tree of the same nature? I have often observed it when the seeds have fallen out, and it wears the appearance of an aggregation of short, thick, stiff leaves, forming a cone of cells somewhat resembling a bee-hive.

MRS. B.

You are quite right; except in calling the fruit which is lodged in these cells seeds: their botanical name is *achenium*.

Both the fir-cone and the pine-apple are aggregated fruits, separated by bracteæ; but in the succulent pine-apple almost all vestiges of the intervening bracteæ are obliterated.

EMILY.

When the crown of the pine-apple is pulled off, the summit of the fruit, I think, exhibits some marks of cells formed by bracteæ.

MRS. B.

That is true; and they are, you may have observed, empty: the pressure of the base of the crown having prevented the fruit from growing, the bracteæ are not wholly obliterated.

Leaves are arranged on the stem in a great variety of ways: sometimes in opposite pairs, and the successive pairs crossing each other at right angles; at others, several leaves shoot from the same spot, and spread out in a circle. They are sometimes alternate on the stem, and appear irregularly scattered; but Nature allows nothing to be scattered by chance: upon a careful investigation, order and method will be discerned in the minutest of her works; and, in the arrangement of leaves on the stem, she has been studious to prevent their covering each other too closely, both light and air being required to enable them to perform their functions.

EMILY.

Is it not surprising that Nature should have bestowed so much pains upon so insignificant a part of the creation as a leaf? However beautiful and curiously constructed it may be, it lasts but one season, and then is shaken off by the first blast of wind, and trodden under foot.

MRS. B.

It does not fall till it has performed the part which Nature has assigned to it; and when you are acquainted with the importance of its functions in the vegetable economy, you will probably be induced to treat it with somewhat more respect.

CAROLINE.

Leaves, when they first shoot, are generally enclosed in small scaly buds, evidently designed to protect them from inclemency of weather. Now these scales differ totally in form and appearance from the leaves they shelter; and I think, Mrs. B., that you would be at a loss to assign them the same origin?

MRS. B.

Nothing more simple. All leaves begin to shoot without any external covering; but when, in early spring, they quit the protecting branch in which they were embosomed, to encounter the cold air, they are chilled and checked in their growth, and, instead of expanding in the natural shape, they contract, harden, curve inwards, and are finally transformed into a species of scales, which shelter the internal leaves: under so friendly a covering, these vegetate freely. In the mean time the season advances, the air becomes warmer, and the young leaves, having been protected from its former inclemency, are now cherished and developed by its genial influence.

EMILY.

What a beautiful provision for the security of a leaf!

MRS. B.

If you follow up the development of the bud of the ash or the maple, you will observe that the external scales are short, hard, reddish, and rather hairy. In proportion as they are more internal, they become membranaceous, pale-coloured, and elongated; embryo leaves then appear at their extremities; and these, shortly after, assume the form of leaflets, so very different in shape and structure from the external scales, that it is difficult to conceive they have had the same origin.

EMILY.

The more feeble and delicate the leaves of a plant are, the greater, I suppose, will be the number of those which degenerate into scales; therefore, the thicker and warmer will be the covering for the leaves which are ultimately to be developed.

CAROLINE.

And these, being of the same delicate texture, require such additional clothing. What an admirable effect produced from so simple a cause!

MRS. B.

These scaly leaf-buds are not universal, some leaves being of so hardy a nature as not to require a covering, especially when growing in a warm climate; they are then said to grow naked; but being closely folded or rolled up in a small compass when first they shoot, they wear the appearance of a smooth bud without scales.

The horse-chestnut, in its native climate of India, unfolds its young leaves to the genial atmosphere, without risk of their suffering from exposure; while, in this colder country, many successive leaflets are arrested in their growth, and condemned to degenerate into scales. If you examine the buds on this branch, you will see what numbers have changed their form, and are reduced to play a subordinate part in the system of vegetation.

The scales of some buds are formed from the rudiments of stipulæ; others derive their origin from petioles or footstalks ; which, instead of growing long and slender, expand and assume the form of scales, and envelope the embryo shoot. The scaly part of the buds of the walnut and the pear are formed from stipulæ. 9/-

EMILY.

I have often examined these buds with great interest, and admired the ingenious manner in which the leaves were so closely packed, in order to be contained within them. Do the same buds produce both leaves and flowers?

MRS. B.

Buds vary in this respect not only in different plants, but sometimes even in the same individual: some sprouting into flowers and fruits; others into leaves only, and branches; and there are buds of a third description, which are developed into both fruit and leaves. The first kind is full and round; the second, smaller and more pointed; and the third, both in size and shape, forms a medium between the other two.

CAROLINE.

How essential it must be for a gardener to be able to distinguish these buds! For he would have a very poor crop of fruit, if, in pruning a tree, he were to lop the branches which contained most of the fruit-buds, and retain those which had more leaf-buds. Are these three species of buds common to all trees?

MRS. B.

No; the buds of the horse-chestnut, which are so large, scaly, and glutinous, are all of the mixed kind; those of the apple and pear are of the two distinct species.

Endogenous plants, or monocotyledons, scarcely ever produce more than a single bud annually; the cabbage of the palm-tree is its bud, and the leaves and flowers are folded within it. The flowers and foliage of the cocoa-nut and date trees are developed in the same manner.

Bulbous plants (the endogenous plants of our temperate climate) are of the same description. I have already observed, that their stem is contained within the bulb; but you have yet to learn that this bulb is in fact the bud or cabbage, containing not only the stem, but also the leaves and flowers. The scales formed from the rudiments of undeveloped leaves are particularly distinct in bulbous roots, especially in the onion.

EMILY.

Thus then a lily, a tulip, or a hyacinth, are all contained within their bulbs, which we have been accustomed to consider merely as their root. But these flowers have each a stem, besides that which you say remains undeveloped within the bulb.

MRS. B.

The shoot which you consider as a stem is the peduncle or footstalk of the flower, not the stem of the plant; the leaves which grow from the stem shoot from beneath the footstalk. The bud or cabbage of the palm-tree, when fully formed, shoots up a footstalk on which the flower expands, while the leaves spread out at its base. The difference between these plants of the tropical and of the temperate zones is, that the stem of the palm-tree being developed, the cabbage is situated at its summit; whilst, in our more temperate climate, the vegetation of the bulbous plants is not sufficiently vigorous fully to develope their organs, and the stem remains in a latent state within the bulb.

CAROLINE.

How can those plants bud whose stem and branches die annually, such as dahlias, pæonies, and China asters, &c.?

MRS. B.

The new stem and branches shoot from a bud formed at that vital spot called the neck of the plant; in perennials the stem dies down to this spot, but if that perishes, the whole plant dies. It is situated either on a level with, or rather below, the ground; and the bud being but little exposed to the weather, is not provided with the same warm covering as most of those which sprout in the air above ground.

CAROLINE.

That is to say, being protected by their situation, their first leaves do not degenerate into scales.

And pray, do all these various kinds of buds originate in some little accumulation of sap in the stem, in the manner you have described to us?

MRS. B.

This accumulation of sap is the origin of a bud, so far only as it enables a germ or embryo shoot to grow, by affording it an ample supply of food.

Buds commonly shoot at the articulation of a leaf, because the branching off of the vessels offers some little impediment to the flowing of the sap; a small portion of it is arrested in its course, and forms a deposit of food, which a neighbouring germ quickly applies to its own use, and is thus ushered into life.

EMILY.

Such germs must exist then in a latent state in every part of the stem, and wait only for fresh sustenance to make their appearance externally.

MRS. B.

In all probability they do; for wherever there is an accumulation of sap, a germ is sure to be developed.

EMILY.

When I plant a slip of geranium, I take care that it should have at least one leaf; because, though quite ignorant of the cause, I know by experience that the shoot would spring from the articulation of the leaf.

MRS. B.

In geraniums there is also another species of articulation, consisting of knots in the stem, which answers the same purpose, by interrupting in some measure the circulation of the juices, and affording a small supply of stagnant sap. Pinks and carnations, reeds and rushes, the stems of corn and grass, in a word, all endogenous plants, are intersected in a similar manner.

CAROLINE.

Then when carnations and pinks are propagated by layers, the shoots take place at those intersections of the stem.

EMILY.

Excepting the geranium, the leaves of all the plants you have mentioned are, I believe, sessile; the intersections in the stems must therefore supply the place of articulations in furnishing the buds with food.

MRS. B.

Precisely so. The leaves of endogenous plants are more rarely articulated than those which are exogenous. These intersections, however, not unfrequently occur in the latter, as with the geranium, the vine, and several other dicotyledons.

In our conversation on stems, you may recollect my observing, that a number of years frequently elapsed before the buds formed on the trunk or branches of a tree attained sufficient strength to force their way through the successive layers of new bark which annually enclosed them; while others vigorously pushed through this barrier the first year. Buds usually begin to be formed in the month of August, and remain in a latent state during the winter, when they are commonly called *eyes*: the following spring they shoot, and make their appearance externally; but they cannot properly be called buds till scales are formed by the degeneration of the outward leaves of the shoot.

It is heat which determines the period of budding in a plant. A branch turned towards the south, or placed in a greenhouse, will shoot long before the rest of the tree; the budding begins to appear first near the extremity of the branches where the wood is most soft and tender.

EMILY.

I should have imagined that the base of the branch which the sap first reaches would have budded earliest.

MRS. B.

In the larch, and many other trees whose branches are equally hard throughout, this is the case; but the superior facility of piercing through the tender part of a branch more than makes up for the earlier supply of food.

The scales of buds are often coated with a sort of glutinous varnish, which resists moisture; some are lined with a species of down or fur, to preserve the internal shoot from cold.

CAROLINE.

These, at least, cannot result from the degeneration of leaves. Such a beneficent provision for the protection of the shoot seems to indicate, that the bud is possessed of a distinct organ, specifically designed for its security.

MRS. B.

Such is no doubt equally its destination, whether it originate in the abortion of another organ, or whether expressly created for that purpose; nor is it difficult to refer the formation of down or varnish to the same origin. The scales of buds can absorb from the sap only a portion of what was destined to nourish them had they been developed into leaves, and the remainder may be converted into a species of glutinous resin or varnish. Then the young leaves, when examined in the bud before they are developed, wear the appearance of small filaments of cotton, which, when spread out, exhibit the minute skeleton of a leaf. It is, therefore, you see, not at all improbable but that these bodies derive their origin from the rudiments of leaves.

It would be difficult to suggest a mode of folding or rolling which Nature has not adopted in enclosing these embryo leaves in the bud. The leaves of the vine are folded like a fan; in other plants they are doubled from the top to the bottom; in others folded down the middle; some are laid one within another; others closely packed side by side; and there are an equal number of modes of rolling them up in the buds.

In some plants the petioles or footstalks retain the nourishment they should transmit to the leaves, so as to prevent the latter from being developed; they remain therefore in an embryo state; the petiole, in the mean time, gorged with nutriment, becomes thick, corpulent, and clumsy, flattening as it expands, and wearing rather the appearance of a leaf than of a stalk. The acacia of New Holland has this singular conformation.

CAROLINE.

I have seen tropical plants in hothouses of this description: the prickly fig is, I believe, one of them. But how do these leafless plants disburden themselves of the superfluous moisture which leaves exhale?

MRS. B.

The dilated petioles, which usurp the place of leaves, perform also, though but imperfectly, their functions, and have pores adapted for that purpose: they are not, however, leaves, any more than the tail of a kangaroo is a leg, or the trunk of the elephant an arm, though they respectively perform the office of these members. When common organs assume in certain species an uncommon form, they may be useful for purposes different from those for which Nature originally designed them;

but they should not on that account obtain the name of the organ they but imperfectly imitate.

Leaves are usually deciduous, that is to say, last but one season: there are but few exceptions of plants whose leaves last two, three, and sometimes as long as four years. Evergreens change their leaves annually; and the plant remains green during winter only because the old leaves do not decay till the spring, after the young leaves make their appearance.

EMILY.

Is it not singular that the leaves of evergreens should wither and fall in the spring, when the weather becomes warm, the sap most abundant, and vegetation in full vigour?

MRS. B.

A leaf withers when the vessels which should bring it nourishment are no longer capable of performing that function. In autumn, the vessels of the petiole become obstructed by a deposit of hard matter, which disables them from transmitting sap, and, being no longer moistened by the passage of this fluid, they dry up and wither; while the pabulum of the leaf, consisting of an expansion of the cellular system, which is of a soft, moist nature, preserves the leaf some little time after the petiole has ceased to perform its functions.

CAROLINE.

Like an animal deprived of sustenance, which you told us feeds on its own fat, before it perishes.

MRS. B.

The circulation of sap in evergreens being more uniform throughout the year, the deposit of hard matter does not obstruct the passage of the sap till towards the spring, when the vigorous sap is directed towards the buds, and the old leaves drop off as the young ones expand.

The petioles of some leaves, such as the aspen and the poplar, are flattened, and adhere less firmly to the stem ; hence they tremble at every breath of wind, and fall off more readily than those of a cylindrical form.

With regard to the most important functions of the leaves, the chemical changes they operate upon the sap, we must reserve them for our next interview, when I intend to give you an account of the sap, and of the interesting part it performs in the vegetable system.

CONVERSATION V.

ON SAP.

MRS. B.

Now that you have made acquaintance with the *root*, the *stem*, and the *leaves*, we may proceed to trace the sap in its ascent through the several organs, observe the various transformations it undergoes in the leaves, and, following it in its descent, examine the manner in which it feeds and restores the several parts of the plant.

CAROLINE.

This seems to me to comprise the whole history of vegetation.

MRS. B.

In a general point of view it does, but we shall yet have many details to enter into; besides, what I have hitherto said relates only to the nourishment of plants: their re-production is of no less importance, and we have not yet once alluded to the flower, the principal and most beautiful of their organs, and that in which the seed originates.

EMILY.

But this sap, Mrs. B., which I imagined to be diffused through the plant as it rose, seems to be disposed of in a very different manner: part you say is exhaled by the leaves, and part descends through the bark; what then remains to nourish the plant?

MRS. B.

All that is necessary for that purpose is selected and retained. If you consider that the sap which rises in the roots consists simply of water, holding in solution a variety of crude ingredients, such as lime, silex, magnesia, soda, and potash, you will acknowledge that something more is required than the mere effusion of this heterogeneous fluid through the plant in order to nourish it. The sap traverses the stem, rising, as I have already said, through the alburnum, and some small portion of it through the perfect wood. A great variety of experiments have been made, with a view of ascertaining the degree of rapidity with which the sap ascends. M. Bonnet raised some plants in a dark cellar, in order to blanch their stems, that he might be able to trace the ascent of the coloured water with which he nourished them. He found that this tinted sap rose only four inches in two hours; but the plants, owing to the disadvantageous circumstances under which they were cultivated, were weak and sickly; in subsequent experiments on more healthy subjects, the sap was seen to ascend three inches in the course of an hour. Some time afterwards Mr. Hales immersed a fresh cut branch of a vigorous pear-tree in a tube full of water, and found that the sap rose in it eight inches in six minutes.

EMILY.

And how do you account for so remarkable a difference in the result of these experiments?

MRS. B.

Chiefly from the improved mode of performing them. The velocity with which sap rises varies, however, very considerably, and depends upon the nature of the plant, the degree of temperature, and above all, the quantity of solar light; which last is absolutely required, to enable the superfluous water in the leaves to evaporate.

During the spring there is a more than usual absorption of sap, for the purpose of nourishing the young buds which are to be developed; and it is worthy of remark, that the sap which feeds these buds passes through different channels from that which serves to nourish the plant generally at a more advanced period of vegetation. Instead of rising through the young wood, it ascends nearly in the centre of the stem in the parts contiguous to the medullary channel, and is thence transmitted through the wood to the buds.

EMILY.

And pray what is the cause which produces the rising of the sap in spring?

MRS. B.

Heat is the circumstance most favourable to the absorption of sap, as it is heat which, by expanding the buds, makes room for it and draws it up. An experiment has been made by placing two pieces of vine in two similar vases of water, and then introducing the stem and branches of one of them, through a hole in the wall, into a hothouse: the buds of this latter plant were rapidly developed, and the water in the vase as rapidly absorbed; whilst the buds of the other made only the usual progress, and the water diminished in the same slow proportion.

If plants are pruned in the spring, the sap will rush out often with violence: in vineyards, this flowing of the sap, when plants are cut, is called the tears of the vine. Mr. Hales made an experiment by cutting off the upper end of the branch of a vine, and enclosing the wounded extremity of the lower part (which remained on the stem) in a tube; the sap flowed from it with such violence, and in such abundance, as to rise to the height of forty-three feet in the tube, thus sustaining the weight of one atmosphere and a half.

CAROLINE.

What a prodigious force! If you make an incision into the stem of a tree in the spring, the sap will of course flow out?

MRS. B.

No, not at least with violence, for the spring sap rises with force only in shoots of one year's growth, and will consequently flow rapidly from none but these; and in making the incision, you must penetrate to the centre in order to reach the full channel of the spring sap; then the instant your instrument touches the pith, you will hear the sap gush, and see it follow the instrument as you draw it out.

We must not, however, bestow the whole of our attention on this nursling sap, but return to that which rises through the alburnum to feed the mature plant. The greater part of this sap reaches the leaves without undergoing any change; but as soon as it arrives there, a considerable portion of its water exhales by the *stomas*, leaving the nutritive particles which it held in solution deposited in the leaf.

EMILY.

And pray, what is the proportion of the quantity of water evaporated by the leaves to the quantity absorbed by the roots?

MRS. B.

It varies exceedingly, according as circumstances are more or less favourable to evaporation. A plant can evaporate only in proportion to its absorption: the quantity, therefore, depends not only on the abundance or deficiency supplied from the soil, but also on the number of ramifications of the roots; that is to say, of mouths to suck up water. On the other hand, these mouths, however numerous, and abundantly supplied, can continue to receive water only in proportion as the exhalation by the leaves carries off what has already been taken in, so as to make room for more. Thus, while water enters at one extremity of the plant, it must find its way out at the other.

EMILY.

But what is it that promotes the flowing out, or, in other words, the evaporation of the water by means of the leaves?

MRS. B.

The most essential circumstance is *light*.

CAROLINE.

You surprise me: I should have thought that heat would have been more necessary than light to produce evaporation.

MRS. B.

Heat, it is true, increases it mechanically: but without light no exhalation from the leaves will take place; and it will be inconsiderable, unless the sun's rays fall upon the plant.

CAROLINE.

Is it not very singular that light should be most favourable to the ascension of the sap which passes through the alburnum, whilst heat is most congenial to that which rises through the centre of the stem? What is the reason of this difference? For both saps, I conclude, must be of the same nature, since the spongioles suck up whatever is sufficiently fluid to enter their pores.

MRS. B.

Being derived from the same source, they were, no doubt, originally of the same nature; but when separated into different channels a difference arises. The nursling sap, we shall find, undergoes a preparation in its passage towards the buds, and their expansion, produced by *heat*, is alone required to draw it up; while the sap which passes through the alburnum must not only throw off a considerable quantity of its water by the leaves, but also undergo a chemical change, for both of which processes the aid of the solar rays is absolutely required.

Let us first consider the simple evaporation by the leaves. The quantity of water exhaled by plants is to that which they absorb generally in the proportion of two to three; one third only, therefore, remains in the plant, and becomes a part of its substance; the rest may be considered simply as a vehicle which Nature had employed to convey a due quantity of nourishment into the plant, and which, after having fulfilled its object, disappears.

EMILY.

Is the water, then, which is evaporated perfectly pure?

MRS. B.

It does not contain above a ten-millionth part of the foreign matter which it held in solution when absorbed.

This exhalation is not visible, because the water is so minutely divided as to be dissolved by the atmosphere as soon as it comes in contact with it.

CAROLINE.

It may then be compared to our insensible perspiration.

MRS. B.

True; and it is called by many botanists the perspiration of plants, and it sometimes happens (as is the case also with animal perspiration) that it becomes sensible. This occurs only in plants whose leaves have simple ribs uniting at a point at the extremity of the leaf. The sap is accumulated by the absorption of the roots during the night, and that portion of it which is destined to be evaporated flows towards this sole aperture, and may be seen there in the form of a minute drop, if observed before sunrise, for it is reduced to vapour by the first solar rays; the subsequent evaporation being equal to the absorption, no accumulation takes place, and no fluid is perceptible. This effect may be seen on the leaves of corn, which, with all the gramineous family, have simple ribs.

CAROLINE.

Plants, then, must increase in weight during the night, since they absorb by the roots, without exhaling by the stomas?

MRS. B.

They do so; and whenever, through any accidental cause, the stomas are obstructed or diseased, the plant becomes dropsical, from the accumulation of water, which it cannot discharge. Plants growing in vases in a room are very subject to this malady, owing to their not having sufficient light to promote the evaporation required.

EMILY.

Yet if you expose a nosegay in a room to the sun's rays, it withers.

MRS. B.

Because the sun produces a degree of evaporation which the poor mutilated flowers are unable to support; for though the stalks may be immersed in water, the organs of absorption are wanting, and the quantity of water they suck up is quite inadequate to the evaporation. Since, therefore, you have deprived them of the power of absorption, you must diminish, at least, that of exhalation, and, by keeping them from too much light, endeavour to preserve the sap which they already contain.

EMILY.

I should be curious to know what quantity of water a plant exhales in a day.

MRS. B.

It has been ascertained by Mr. Hales, that a full-blown helianthus, or sunflower, placed under advantageous circumstances in regard to light and temperature, evaporated twenty ounces of water per day, which is seventeen times more than that evaporated by a man, supposing their surfaces equal. This experiment was made by weighing, first, the water in the vase in which the sunflower was placed, then the plant itself; and, after due time being given to the experiment, the water and the plant were again weighed. The plant had absorbed as much water as the vase had lost; but it was not found to have increased in weight so much as the water in the vase had diminished by twenty ounces, which affords a conclusive proof that these twenty ounces had been evaporated. Of course, suitable precautions had been taken in order to prevent any immediate evaporation from the water contained in the vase.

Fleshy fruits, such as apples, plums, peaches, &c. have few or no pores: they therefore retain the moisture they receive from the sap, which enables them to remain long on the tree, after coming to a state of maturity, without drying up and withering. Whilst dry fruits, such as peas or beans, wither in consequence of the number of their pores by which they exhale moisture. There is the same difference between thick fleshy leaves, such as those of the cactus and other succulent plants, and dry leaves, such as those of the pine and the fir, which are at the opposite extremity of the scale; common leaves bear a medium between the two, but, in the same space in which a common leaf contains six or seven stomas, the leaf of a pine has sixty or seventy.

EMILY.

Aquatic plants which live wholly under water, you told us, were not provided with stomas; but now that I comprehend the nature of their functions, I do not understand why the plants should not derive benefit from them: for while the roots absorbed the water holding ingredients in solution, the stomas would evaporate it in a pure state, leaving all its riches behind.

MRS. B.

The plant has not power to exhale water into water: it requires the assistance of the air to dissolve it and carry it off. Those aquatic plants which rise to the surface are abundantly furnished with stomas to disburden themselves of their excessive supply of water.

Let us now turn our attention to the nature of the sap which remains in the leaf, after having disengaged its superfluous moisture. It consists of about one third of the water originally absorbed by the roots, but augmented and enriched by the acquisition of all the nutritive particles which the evaporated water has deposited.

CAROLINE.

In this state it is certainly better calculated to nourish the plant; and from this ample store I suppose the the various organs select and assimilate the food they each require.

MRS. B.

The preparation of the food is not yet completed; the sap undergoes another and very important change, in some measure analogous to that which the blood undergoes in the lungs, to prepare it for assimilation. This operation is also performed in the leaves, which may be considered as the laboratory in which the sap is submitted to a regular chemical process.

EMILY.

This, indeed, bears a very striking resemblance to the chyle, which is the sap of animals, and which is converted into blood, fitted to go through the general circulation, and nourish the several parts of the body.*

MRS. B.

The analogy is perhaps even stronger than you imagine; for this process, which in animals is performed

* See Conversations on Chemistry, vol. ii. p. 286.

by means of breathing atmospherical air, in vegetables is performed by the same air acting on the sap when it comes in contact with it at the stomas: the leaves may therefore be considered as the lungs or organs of respiration of plants.

EMILY.

How curious! their stomas then are so many little breathing mouths. And does the oxygen of the atmospheric air carry off carbon from the sap, as it does from the chyle?

MRS. B.

On the contrary, carbon or charcoal is the principal ingredient of wood and of all vegetable matters: the object to be aimed at is therefore to increase, instead of to diminish, the quantity contained in the sap; and the chemical process to which this fluid is submitted in the leaves, though analogous to that performed by the lungs, so far as it prepares the sap for being assimilated to the plant, is rather opposed to it in respect to its chemical results.

We animals, the most favoured part of the creation, endowed with the faculty of locomotion, require to be of a lighter structure than our tough woody neighbours who are attached to the soil. In order to move about with facility, it is necessary that we should disencumber ourselves of part of the carbon we consume in feeding on vegetables; and a man exhales, in breathing, no less than 11 oz. of charcoal per day; whilst the vegetable kingdom, far from suffering from excess of carbon, requires its store to be augmented, in order to promote its fixity and durability.

EMILY.

Ah! this is what I have heard spoken of as one of the most beautiful dispensations of Providence: the vegetable creation purifies the atmosphere, by absorbing the carbon with which it has been contaminated by the breath of animals.

MRS. B.

Just so; but let us examine these wonders a little more narrowly, and trace the steps by which they were brought to light.

M. Sennebier covered a plant which was growing in a pot of earth with a glass bell full of water; and, in the course of a few hours, found a quantity of air within the bell. Whence came this air? Did it proceed from the plant or the water in which it grew? He repeated the experiment with water which had been boiled, for the purpose of depriving it of its air, and in this instance no air was produced in the bell.

CAROLINE.

Of what nature was this air?

MRS. B.

Dr. Priestley ascertained that it consisted of oxygen gas, and conceived that it was produced by the decomposition of the water, which, you know, is composed of oxygen and hydrogen; but then he could not understand why boiled or distilled water, which contains as much oxygen as rain or spring water in their natural state, should not produce this air in the glass bell.

At length M. Sennebier, in the prosecution of his experiments, discovered the mysterious origin of this air to be in the carbonic acid, which water, in a natural state, always contains. I hope you have not so far forgotten your lessons of chemistry, as not to recollect that carbonic acid is composed of oxygen and carbon: the plant absorbs this gaseous acid. It is decomposed in the leaves by the sun's rays: the carbon, which it is essential to the plant to retain, is deposited within it; and the oxygen, which it does not require, flies off by the stomas.

CAROLINE.

Then the little vegetable mouths breathe out pure oxygen, and retain the carbon: this is just the reverse of the operation performed in the lungs.

MRS. B.

You may prove this by a very neat experiment. Place two glass jars over the same water-bath, with a means of communication through the water; fill one of them with carbonic acid, and put a sprig of mint in the other. After some time, a vacuum will be produced in the upper part of the jar of carbonic acid; and a quantity of oxygen gas, corresponding exactly to the quantity of carbonic acid which has disappeared, will be found in the jar containing the sprig of mint. Now this can be accounted for only by supposing, that the carbonic acid has been absorbed by the mint, decomposed by its leaves, the carbon retained, and the oxygen evaporated.

M. de Saussure has succeeded in measuring the quantity of carbon which plants thus acquire. He transplanted fourteen periwinkles into vases, seven of which he watered with distilled water, and the remaining seven with water in its natural state. After some days he analysed these plants, and found that the former had not acquired any fresh carbon, whilst the latter had gained a considerable quantity of it; their wood being one sixth heavier than that of the former.

EMILY.

And the periwinkles, which had increased in weight, had, I suppose, alone given out oxygen by their stomas.

MRS. B.

No doubt; but, in making these experiments, attention must be paid to expose the plants, not only to broad daylight, but, if possible, to the full force of the sun's rays; for solar light is absolutely necessary to the process of decomposing the carbonic acid. During the night the vegetable laboratory is employed in a very different process; for, in the dark, plants absorb instead of exhaling oxygen.

CAROLINE.

You alarm me, Mrs. B.: this is a sort of Penelope's labour, to destroy during the night the work done in the day. And how is the atmosphere to be purified by these means?

MRS. B.

It is true that this apparent inconsistency requires some explanation. You must observe, that the solid nutritive particles dissolved in the sap, whether of animal or vegetable origin, are combined with a considerable quantity of carbon. The sap therefore contains carbon in two states: in the one gaseous, combined with oxygen, and mixed with the water of the sap; in the other combined with different solid ingredients, but dissolved in the water of the sap. The carbonic acid, we have already observed, is decomposed in the leaves, the carbon is retained, and the oxygen thrown off; but what do you suppose becomes of the carbon contained in the animal and vegetable matter which the sap holds in solution?

CAROLINE.

I suppose it is assimilated to the substance of the plant, together with the other nutritive ingredients which the sap holds in solution.

MRS. B.

No, that cannot be; for, in order to render carbon fit to be assimilated, it appears to be necessary that it should previously be combined with oxygen, and afterwards separated from it.

CAROLINE.

Is there not something paradoxical in this? How can it be necessary that the carbon should be combined with oxygen, merely for the purpose of being separated from it?

MRS. B.

It is very possible that this chemical process may produce a more minute subdivision of the particles than any mechanical operation could effect, and thus prepare it for being assimilated to the plant.

CAROLINE.

Oh, then, now I guess it. During the night the leaves absorb oxygen, to combine with this carbon, and convert it into carbonic acid ; and, when the sun rises, this acid is decomposed, the carbon deposited in a state fit to be assimilated, and the oxygen escapes.

MRS. B.

You are right ; and as the decomposition of the carbonic acid, which existed in that state in the sap, takes place at the same time, these two operations, being both similar and simultaneous, are confounded together. But, so far as regards the purification of the atmosphere, it is necessary to distinguish them ; for, in the first instance, the oxygen exhaled is merely a restoration to the atmosphere of oxygen which had been taken from it during the night ; whilst, in the latter, the oxygen evolved, being drawn from the soil with the sap, is so much clear gain to the atmosphere.

CAROLINE.

Well, I breathe freely again, since I know that the atmosphere positively acquires oxygen from the vegetable kingdom. The portion absorbed during the night, I suppose, is but inconsiderable.

MRS. B.

Not so trifling as you seem to imagine ; but, since the whole quantity is restored to the atmosphere during the day, you need not apprehend any dangerous results from its abundance. The Stapadra, the plant which absorbs least, takes in a quantity nearly equal to its own volume during a night ; and the apricot-tree, which is at the other extremity of the scale, absorbs eight times its own volume of oxygen gas.

Succulent plants absorb the least, having the fewest stomas ; and, after them, plants which grow in marshes; then evergreens; and, finally, those plants which shed their leaves in autumn absorb the greatest quantity.

EMILY.

It is this, I suppose, which renders it unwholesome to keep plants in a bedchamber?

MRS. B.

It is ; but, besides this, I should tell you that those parts of plants which are not green, such as the brown stems and branches of a tree, and also the flowers, absorb oxygen both night and day, but in such very minute quantities, as not sensibly to affect the air.

The principal change which is produced in the sap by its elaboration in the leaves is the formation of gum, which consists of one atom of carbon combined with one atom of water. Gum constitutes the foundation of the returning sap, and appears to form the essential ingredient of the food of plants ; almost all the vegetable materials consisting of this mucilaginous substance variously modified.

Our conversation has been rather difficult to-day ; let me hear if you can repeat the substance of it.

EMILY.

The sap rises in plants through two different channels : that which is destined for the nourishment of buds, in shoots of the first year, passes near the pith, and is thence conveyed through the wood to the buds ; that which is to feed the plant in general rises through the alburnum, and is elaborated in the leaves in this operation.

MRS. B.

Very well ; and in what does this elaboration consist, Caroline ?

CAROLINE.

The quantity of water is diminished by evaporation, and the quantity of carbon is increased.

MRS. B.

How is this latter effect produced?

CAROLINE.

The sap contains carbon in two states: first, in that of carbonic acid; secondly, combined in animal and vegetable matter. In the first state the sun's rays decompose the acid, the carbon is deposited, and the oxygen which flies off purifies the atmosphere; in the second state, oxygen is absorbed during the night, and combines with the carbon, with which it forms carbonic acid; this, during the day, is decomposed, and the oxygen restored to the atmosphere. Thus vegetation serves as a counterpoise to the deleterious effect of the respiration of animals.

EMILY.

And should we not add to the contamination of the air by combustion, Mrs. B.? for oxygen is also absorbed in that process.

CAROLINE.

The air of a forest must then be much more wholesome than that of a town, where so many human beings and animals are continually breathing out carbonic acid, and where such numberless combustions are robbing the atmosphere of oxygen.

MRS. B.

No; the constant motion of the air so rapidly restores the equilibrium, that it has been found, by the most accurate chemical experiments, that the air of a crowded city contained precisely the same quantity of oxygen as the finest air of the country. I do not mean to say that the atmosphere is as pure in a large town; but this arises from the smoke, and a variety of exhalations, which do not circulate so rapidly as the oxygen gas.

The air in a forest is, on the other hand, far from being considered as healthy; the trees impede the circulation more than the houses in a town, the latter being, in some measure, ventilated by the currents of air which flow through the streets.

CAROLINE.

But, then, consider the pure breath of the green leaves in a forest.

MRS. B.

The exhalations arising from the stagnant waters, and the putrefaction of the dead leaves which remain floating in the confined air, more than counterbalance that advantage, and render a dense forest an unwholesome spot to inhabit.

CONVERSATION VI.

ON CAMBIUM, AND THE PECULIAR JUICES OF PLANTS.

MRS. B.

HAVING traced the sap in its ascent to the extremity of the leaves, and converted it, by the changes it undergoes in that chemical laboratory, into a homogeneous liquid adapted to the nourishment of the plant, we must now, following it in its descent, observe in what manner it performs this office.

The sap, thus changed, assumes the name of Cambium, or returning sap, and descends chiefly through the liber, or most internal layer of bark, and a small portion through the alburnum, or young wood.

CAROLINE.

Having compared the ascending sap to chyle, Mrs. B., we may find a still greater analogy between the cambium and blood, into which chyle is converted, after having passed through the heart and lungs, and been rendered fit to nourish the animal frame.

MRS. B.

We have already observed, that the chemical changes which take place in the leaves, in order to convert the sap into cambium, are in many respects analogous to those which take place in the heart and lungs, in order to convert the chyle into blood.

EMILY.

True: in both cases the atmosphere is the agent; with this difference, however, that it carries off carbon from the animal system, while it is the means of accumulating carbon in that of vegetables.

CAROLINE.

But if the cambium descends through the liber, how does it find its way in endogenous plants, which have no bark?

MRS. B.

Its passage in monocotyledons has not been well ascertained. It is probable that the fibres of the wood are the medium through which the sap both ascends and descends. As the vessels of plants are so minute as barely to be discernible by the aid of a microscope, it appears impossible to examine them with accuracy. And a still greater difficulty attaches to the investigation of the vessels of endogenous plants; those which grow in our climates being too small to enable them to acquire that degree of vigour which is requisite for a complete development of their organs.

CAROLINE.

We shall not have the same difficulty to account for the descent of the cambium, as we have had for the ascent of the sap; since it obeys the laws of gravity, and descends by its own weight.

MRS. B.

That is a general cause of the descent of cambium, no doubt; but in the weeping willow, and many other trees whose branches are pendant, some additional cause is required to produce the motion of the cambium, since it must rise to return into the stem. It has been ascertained that agitation facilitates and accelerates this motion, and consequently increases the vigour of vegetation; for the more rapidly this nutritive fluid circulates through the several organs, the more frequently it will deposit its nutritive particles in them. Mr. Knight has made a variety of interesting experiments on this subject. He confined both the stem and branches of a tree, in such a manner that it could not be moved by the wind. The plant became feeble, and its growth much inferior to that of a similar tree growing in a natural state. Mr. Knight confined another tree, so that it could be moved only by the north and south winds, and obtained the singular result of an oval stem; the sides accessible to the wind growing more vigorously than those sheltered from its influence. Every species of restraint, and especially such as tend to render plants motionless, impedes their growth. Stakes by which young trees are propped, nailing them to walls or trellises, greenhouses, or confined situations where the salutary air has not free access, check and injure the vigour of vegetation, and render plants diminutive and weakly.

CAROLINE.

But if young trees were unsupported, they would in all probability be blown down by the first violent wind.

MRS. B.

The stake, it is true, is often necessary ; but then it must be considered as a necessary evil, and remembered that, whenever it can be avoided, the plant will thrive better without it. It should never be fastened so tightly as to prevent all motion, for the exercise which the wind gives to young trees is no less salutary than that which a mother gives to her infant ; but it is true that the wind is often a rough nurse, over whom it is prudent to keep a watchful eye.

CAROLINE.

Nailing fruit-trees against walls must then be prejudicial to their growth ?

MRS. B.

No doubt; but the advantages resulting from the shelter afforded by walls and the heat reflected by them more than compensate for the bad effects of confinement — for such fruits, at least, as require a higher temperature to ripen them than is to be met with in our climate; but, when the temperature is genial to the plant, standard trees, growing freely in their natural state, produce the finest fruits. Greenhouses and hothouses, however confined, are asylums necessary in winter for the culture of plants of a warmer climate; for though gentle breezes may be beneficial to fan delicate plants, we must shelter them from the inclemency of boisterous winds.

The cambium, we have observed, descends almost wholly through the liber, or most internal and youngest layer of the bark; if, therefore, you cut a ring completely through the bark, this fluid will be arrested in its course, and, accumulating around the upper edge of the intersected bark, cause an annular protuberance. The descent of the cambium thus being obstructed, it will accumulate in that part of the tree above the intersection, afford it a suberabundance of nourishment, creating a proportional vigour of vegetation, and a corresponding excellence and profusion of produce.

EMILY.

Would it not then be a good mode of improving the produce of fruit-trees?

MRS. B.

This operation, which is called *ringing*, has been tried on the branches of fruit-trees, and, I understand, often with success; but I should conceive that the tree must be ultimately injured by the operation; for, if you confine to one part of a plant the food which was destined for the nourishment of the whole, you interfere with the order of that wisest and best of agriculturists — Nature. When interrupted, however, in her original course, she is fertile in expedients to accomplish by collateral means her destined purposes. I observed that some small portion of the cambium descended through the alburnum, which is contiguous to the liber. When the annular section is made on a branch, a much more considerable quantity forces its passage through this channel, and, by affording the young wood an unusual supply of nourishment, renders it harder and heavier below than above the intersection.

CAROLINE.

But if the vegetation of the tree above the annular section is improved, and the wood beneath it better nourished, what part of the plant suffers by this operation?

MRS. B.

Not any part during the season the annular section is made: the evil is reserved for a later period, as I shall explain to you.

The cambium being thus diverted from its course, the greater part being forcibly detained above the annular section, and what little makes its escape descending through another channel, the bark is wholly deprived of its natural sustenance; the consequence of which is, that the new layers, both of alburnum and of liber, which should be annually produced by the descent of the cambium, are not formed.

The following season, therefore, the sap, instead of rising through the soft and tender vessels of the newly-formed alburnum, must ascend through the alburnum of the preceding year, under the additional disadvantage of its being unusually hardened by the superabundant quantity of nourishment it has received.

This artificial mode of rendering alburnum hard and mature, suggested the idea of stripping timber-trees of their bark a year or two previous to their being cut down, in order to harden the young external layers of wood, by forcing the whole of the cambium to find a passage through them, and thus convert the alburnum into perfect wood before the natural period. The experiment, when first made, appeared to answer the most sanguine expectations. The cambium, instead of forming new layers of tender wood under shelter of the bark, forced its way through the alburnum, giving it in one season the hardness and consistency of perfect wood. But it was afterwards discovered that the wood thus artificially matured, by being stripped of its bark, and exposed naked and defenceless to the inclemency of the weather, to the encroachment of lichens and creeping plants, and to the attacks of insects and reptiles, receives injuries, which more than counterbalance the advantages of a precocious maturity, and render it much less fit for building.

Let us now turn our attention to the composition of the cambium, and trace the steps by which it subsequently becomes a component part of the plant.

After it has been elaborated in the leaves, it consists of a rich mucilaginous juice, impregnated with the salts and other mineral substances which have been deposited by evaporation.

CAROLINE.

This precious nutritive fluid has no doubt vessels appropriated for its conveyance?

MRS. B.

No: M. de Candolle is strongly of opinion that the returning sap descends through the intercellular interstices, in the same manner as the ascending sap rises through them.

EMILY.

Then do they not meet and interrupt each other in their course?

MRS. B.

They follow in a great measure different routes; the rising sap traversing chiefly the young wood, whilst the cambium descends principally through the contiguous layer of bark; they do not, therefore, often encounter and interfere with each other. But a considerable portion of the returning sap is arrested in its passage by the cells contiguous to which it passes. These cells imbibe it and deposit it on the inner surface of their coats, to which it adheres, and becomes as it were incrusted, and in that state it is reserved in store for future use.

EMILY.

But will not these hard incrusted deposits require to be softened and dissolved, in order to render them fit to nourish the plant?

MRS. B.

The deposited cambium is not only dissolved, but again elaborated in these cells. A plant may be considered as a chemical laboratory from one extremity to the other: compositions and decompositions are going on in almost all its organs; and, after the leaves, these processes are most open to our observation in the cellular system. Observe, that if the cells are not impervious to the cambium, they must be still more so to the rising sap, from its greater fluidity. I have said that the greater part of this sap reached the leaves, but not the whole; a portion being arrested in its course, and imbibed through the coats of the cells. Here, then, we have the limpid ascending sap in contact with the incrusted materials of the descending sap ready to act chemically on each other.

CAROLINE.

And the cell is the alembic, or the furnace, or what chemical apparatus you will, no doubt well adapted to the process it has to perform?

MRS. B.

Certainly; for the products of the operation are new chemical compounds—fecula, sugar, lignine, and sometimes fixed oil. These bodies are the immediate materials of the vegetable kingdom: they are prepared by one set of organs, and then transmitted to another, which they are destined to nourish.

CAROLINE.

Then it is the cambium which contains these materials, and the fecula, sugar, and lignine are produced by them?

MRS. B.

Yes; and each is suited to the wants of the organs it is destined to nourish. Fecula is the farinaceous part of seeds; sugar is a component part of fruits, and often of stems and roots, as in the sugar-cane and beet-root. Lignine is the principal component of wood.

CAROLINE.

I thought that carbon was the essential ingredient of wood?

MRS. B.

So it is, as well as of all vegetable matter; but it is a simple substance, which enters into the composition of all those you mentioned. How this takes place we cannot tell: we are not able to penetrate into the laboratory whilst it is in action, because we can only examine plants chemically after their death; but it is not improbable that the vascular system, which is so intimately connected with the cellular tissue, may assist them in these chemical metamorphoses.

CAROLINE.

Especially if, as you suppose, these vessels convey air; for we know what an important part the gases perform in the chemical laboratory.

MRS. B.

The absorption of the rising sap by the cellules takes place more especially in the spring, when the sap which is destined for the support of the first burst of vegetation rises near the pith, and thence transudes laterally through wood, till it reaches the circumference of the stem or branch. In this transversal passage it is absorbed in considerable quantities by the cells, laden with materials, which have been elaborated in the leaves of the preceding summer, and have been stored up in these magazines during the winter. Here the nursing sap is prepared for the nourishment of the millions of buds which are ready to burst into foliage.

EMILY.

This obviates a difficulty which perplexed me. Since the rising sap is incapable of affording nourishment until it has been elaborated in the leaves, I could not understand how the buds of spring could be fed before the leaves were unfolded; but now I see that their food is prepared from the cambium of the preceding year, which has been stored up for their use; and which the first sap that rises in the spring dissolves, and converts into that nursing fluid which we have compared to milk.

MRS. B.

I have a few more observations to make to you on the component parts of the cambium.

We have observed, that about two thirds of the water absorbed by the roots is evaporated by the leaves, one third only remaining in the plant. This latter portion exists in vegetables in two states: in the one it retains its liquid form; in the other it is decomposed, and enters into a chemical combination with various parts of the plant, so as to be identified with its solid tissue, and in such a manner that desiccation will not make it re-appear.

EMILY.

But by a chemical analysis would you not discover it?

MRS. B.

No; because it no longer exists in the form of water, but is resolved into its constituent elements, oxygen and hydrogen.* I trust you recollect that water is a combination of these two principles.

M. de Saussure weighed the water with which he watered a plant; and, after the most careful investigation by mechanical means, both by preserving the water evaporated, and obtaining, by desiccation, that which remained in the plant, he could not discover above five sixths of the water he had given to the plant.

EMILY.

And is it known under what form this sixth portion of water exists, in its new combinations in the plant?

MRS. B.

The oils and resins with which plants abound contain a very large proportion of hydrogen. There are other vegetable substances which abound with oxygen; the water, therefore, which so totally disappears, is doubtless resolved into its two constituents, oxygen and hydrogen, supplying the oils and resins, and the other juices, with such proportions of these elements as they respectively require.

Carbon is obtained by plants from three different sources: — from the carbonic acid contained in the sap; from animal and vegetable matter dissolved in that fluid; and from the atmosphere.

CAROLINE.

Having so many means of procuring carbon, no wonder that plants should lay in so large a store of it.

MRS. B.

What part of a plant would you imagine contained the most carbon?

* See Conversations on Chemistry, vol. i. p. 227.

CAROLINE.

I should think the wood, which burns so well, because it consists almost wholly of charcoal.

EMILY.

And yet the leaves in which the carbon is deposited, when separated from the oxygen, should contain more of that ingredient than the wood.

CAROLINE.

In that case leaves should be used for fuel in preference to wood.

MRS. B.

Emily is right: the green parts of plants contain the most carbon; and dry leaves make an excellent combustible, but they are too bulky to form a convenient one.

After the leaves, the bark, especially when green, abounds most with carbon; and, lastly, the wood: the alburnum or white wood contains the least.

CAROLINE.

Green wood, then, should be most combustible; and yet it is noted for burning badly.

MRS. B.

By green wood is commonly meant wood not sufficiently dried. Whatever quantity of carbon wood contains, it cannot prove a good combustible, unless the water, and other juices injurious to combustion, be first evaporated.

The alburnum, when well dried, burns briskly, because it contains a greater quantity of hydrogen than perfect wood; and it is the combustion of hydrogen, you may recollect, which produces flame: but, owing to its deficiency of carbon, alburnum gives out less heat.

The ascending sap, we have observed, contains also a great variety of earthy and alkaline particles; such as magnesia, lime, silex, potash, and soda. When the evaporation from the leaves takes place, these bodies are deposited, and become constituent parts of the cambium, and are thus conveyed to their several destinations.

The most soluble of the earthy salts, such as lime and magnesia, are naturally most abundant in the sap; and when a plant is burnt, the earths, being incombustible, form the materials which constitute its ashes.

The alkaline salts, potash and soda, being also of a soluble nature, are conveyed in considerable quantities into the sap; when this undergoes evaporation, a large portion of these salts is deposited in the leaves, the rest remains in solution in the cambium, is incorporated with the plant, and, after combustion, may be discovered in its ashes.

The silicious particles contained in the plant being, on the other hand, nearly insoluble, enter very little into the composition of the cambium, the greater part remaining in the leaves, where it has been deposited by the evaporating sap; and the fall of the leaf is attributed to the accumulation of this hard earthy matter, which in the course of time clogs and hardens their vessels, so as to render them impervious to the juices requisite to their vegetation. The vessels composing the petiole, in which they are so closely bound together, are more especially liable to suffer from these obstructions: unable any longer to transmit nourishment to the leaf, the petiole dries, withers, and falls off; and the plant is thus disburdened of a useless substance, the accumulation of which would be prejudicial to its growth.

CAROLINE.

It must be confessed, that it is rather a serious remedy to destroy the organ in order to get rid of the inconvenience with which it is afflicted.

MRS. B.

You must consider, that when Nature constructed these organs in so frail and delicate a manner, it was with the intention that they should be annually renewed: it becomes expedient, therefore, to get rid of the old leaves, in order to make way for the new ones.

Azote, an ingredient chiefly of the animal kingdom, is to be found also, in very small quantities, in vegetables: they obtain it both from the atmosphere, of which it forms the chief constituent part, and from manure.

From the cambium, with all the component parts of which you are now acquainted, a great number of different juices are secreted, such as oil, resins, milk, &c.

CAROLINE.

Just as tears and saliva are, in the animal economy, secreted from the blood.

MRS. B.

There is, it is true, a considerable analogy between the animal and vegetable secretions: they are both drawn from the general nutritive fluid, and each by the means of glands; but, owing to the extreme minuteness of the organs of plants, the vegetable anatomy is very much behind that of the animal kingdom.

EMILY.

In small herbs this must necessarily be the case; but in large forest-trees I should have supposed that the organs, when full grown, would have been of greater magnitude than those of animals.

MRS. B.

No; the organs of the oak are not larger than those of mosses. Nor is this singular, if you consider that the leaves and fruit of forest-trees are not, in any respect, proportioned to the size of the plant: — you do not forget the fable of the Pumpkin and the Oak. Every leaf and every flower must contain a system of organs, adapted to the various operations it has to perform, without any reference to the general size of the plant. In the animal economy we are still unable to discover the mode in which the glands draw their secretions from the blood: how much less, then, can we expect to penetrate the secret, in a system where the organs themselves are frequently so minute as to elude our sight, the largest not being more than one twentieth of a line in diameter, and there are some, so small as not to exceed the one hundred and fiftieth part of a line in dimension!

Many ingenious hypotheses have been proposed to account for the secretory action of the glands, both in the animal and vegetable economy, but none have hitherto proved satisfactory. That which appears least objectionable, is the agency of electricity; but it must be owned that the chief argument in favour of this agent is, that we are not yet sufficiently acquainted with its powers to prove the hypothesis which rests upon it to be erroneous.

The chemistry of vegetables, on the other hand, is more advanced than that of the animal kingdom; because the great and mysterious secret, *life*, performs a less important part in the vegetable than in the animal economy.

The secretions separated from the cambium by the glands are of two descriptions; the one, destined to remain in the plant, is distinguished by the name of internal secretions, and is elaborated by glands of a cellular form; the other, intended to be conveyed out of the plant as useless or detrimental to it, is secreted by glands of a vascular form.

CAROLINE.

Both are very appropriate to their respective uses; the one like a prison to keep the secretion within, the other like a channel to convey it out of the plant; and pray what are the internal secretions?

MRS. B.

The internal secretions are milk, resins, gums, gum resins, manna, essential oils, and fixed oils.

EMILY.

These are substances with which we made acquaintance in learning chemistry.

MRS. B.

True; but we are now to examine them rather in a different point of view; and I do not think I then mentioned the secretion of vegetable milk. There are three species of this fluid:—the first is that which contains opium, and is extracted from the juice of poppies, lettuces, and some other plants; it is almost always white, but sometimes assumes a reddish or yellowish hue.

The second contains caoutchouc, or elastic gum; which, however different in appearance in the artificial state in which we are acquainted with it, is naturally white and liquid. It is obtained from several different species of trees in tropical climates, but principally from that which bears the name of Hevea. When an incision is made in the stem, it flows from the wound, and is collected on the surface of small moulds of clay in the form of bottles, to which, being of a glutinous nature, it adheres. It acquires consistency and blackens in drying, and, when the coating of caoutchouc is of a sufficient thickness, it is beaten to pulverise the mould, which is then shaken out.

The third species of vegetable milk resembles that of the cow, and is the produce of a tree in America, thence called the Cow-tree. Baron Humboldt informs us, that it grows in rocky and unfruitful districts, little calculated for the pasturage of cattle. On the barren side of a rock it rises with coriaceous and dry leaves, which are, during many months of the year, not moistened by a single shower. The branches appear dead and dry; but, when the trunk is pierced, there flows from it a sweet and nourishing milk. At sunrise, this vegetable fountain is most abundant. The natives are seen hastening from all quarters, furnished with large bowls to receive the milk, which grows yellow, and thickens at the surface. This tree is of the family of the Sapoteæ.

CAROLINE.

What a delightful resource it must be to the people of that country, who may repose beneath its shade, while they refresh themselves with the grateful beverage it produces! Does it also yield fruit?

MRS. B.

Every tree yields fruit of some kind, otherwise it could not continue its species; but that of the Cow-tree is as yet unknown.

Resins are volatile oils, peculiarly modified by the action of oxygen. Pitch, tar, and turpentine are the most common and the most useful juices of this description; they exude from the pine and fir trees, and are of a thick viscous consistence. Copal, mastic, and frankincense are resins of a more refined nature: the two former, dissolved in oil, form excellent varnishes: and frankincense, you know, is the perfume burnt in all the Roman Catholic churches. The resinous juices flow always in a descending direction: when an incision is made in a tree which yields them, they trickle from the upper edge of the wound. Of course, being secreted from the cambium which flows downwards, they must follow the same direction.

Gum, we have observed, constitutes the basis of the cambium: it is secreted from it, in its simple mucilaginous form in all leguminous plants, and a great number of trees bearing stone-fruits, such as the cherry, the peach, and the apricot: from these last it exudes whenever an accidental fissure is made in the stem.

Gum arabic is obtained from the acacia of Arabia by incisions made in the stem.

Gum tragacanth exudes naturally from the stem of the *Astragalus*. This secretion, which accumulates during the night, when little or no evaporation takes place, swells the wood which presses against the bark, and, this dry coating not being susceptible of a similar distention, the gum forces its way through it.

Gum resins appear to be a mixture of the two vegetable products from which their name is derived, and are common to all umbelliferous plants.

Manna is a saccharine secretion, which abounds in the small-leaved ash of Calabria. It is to be found also, in lesser quantities, in several other trees, such as the larch and the willow.

The essential or volatile oils bear a strong resemblance to resins; they are enclosed in small vesicles, whence they are extracted by pressure. They are imprisoned, in this manner, in the rind of the orange and the bark of the cinnamon tree, in the wood of the sandal tree, and in a great variety of leaves, such as those of the geranium and the orange, and in flowers of almost every description. In a word, there is scarcely any part of a plant from which essential oil may not be extracted, excepting the seed, from which it is absolutely excluded.

Fixed oils, on the contrary, are almost exclusively contained in the seed, where they constitute the most appropriate nourishment for the embryo plant. There is, I believe, but one exception to this rule, the olive, where the oil abounds not only in the seed, but also in the pulp of the fruit, whence it is expressed to supply our tables, or for the purpose of combustion. Nut oil, linseed oil, and all the fixed oils, are not, like the essential oils, enclosed in appropriate vessels, but are lodged in every interstice of the seed. We shall speak more fully of this when we come to examine the organisation of this asylum of the embryo plant.

Let us now proceed to the excretory secretions: they are of much less importance than the preceding, and consist chiefly of vapours and gases exhaled from flowers. Among these we distinguish the vapour of the Fraxinella, which is elaborated by glands sufficiently large to be visible, and is very combustible.

EMILY.

I recollect having seen it burn, by approaching a taper to it; but is not this vapour similar to the exhalations of the odour of plants?

MRS. B.

No; the odours of plants are undoubtedly an excretory secretion, but are not generally of a combustible nature. They are of various descriptions, but it is difficult to determine in what manner to class them, as they affect the olfactory nerves of different people in so different a manner: they have been attempted to be distinguished by the name of aromatic, stimulating, penetrating, sweet. Flowers, with some few exceptions, (such, for instance, as the rose and the violet,) exhale their perfume only as long as the plant is living; that which proceeds from the bark, or other parts of the plant, continues to be emitted after death.

Flowers having an ambrosial smell, exhale it only in the evening, after sunset; those which have the odour of musk are always of a yellowish purple colour, and of a dull appearance, corresponding, it is said, with the deleterious nature of their perfume.

The smell of flowers, in general, is considered to be more insalubrious to a person sleeping than awake. Whether it be, that, in the latter case, the animal frame has a more energetic power of resistance to deleterious effects, or from some other cause, is not ascertained.

EMILY.

May not this difference arise from plants giving out oxygen during the day, and absorbing it during the night?

MRS. B.

No; the spasmodic effect produced on the nervous system by the perfume of flowers is quite independent of those operations; and it is whether sleeping or waking, in the daytime or the night, that the difference I mentioned has been observed.

Besides the water which plants exhale from the leaves, there are several peculiar juices elaborated by glands situated on the surface of the leaves. These glands are attached to hairs somewhat resembling those which grow at the orifice of the pores of our skin; and the gland is situated either at the base or point of the hair.

EMILY.

How extremely minute must those glands be which can be supported on so slender and frail a stem!

MRS. B.

You may thence form some idea of the diminutive size of the vegetable organs in general. When the secretory gland is situated on the summit of the hair, the liquid it secretes is of an innocent nature; when situated at the base, the secretion is acrid, caustic, and poisonous.

CAROLINE.

This is, no doubt, the case with nettles, which pour their noxious secretions on the skin, and raise it into blisters.

MRS. B.

The poison must penetrate beneath the cuticle in order to produce this effect; the hair is the instrument which gives the wound, and the poisonous juice is then poured into it.

EMILY.

This is just like the sting of a serpent, who inflicts a wound, and then ejects his poison into it. But what is the reason that nettles do not sting when wetted with rain?

MRS. B.

Because the hair, when softened by moisture, has not sufficient strength to perforate the skin; and, unless a puncture be made, the secretion cannot insinuate itself beneath the skin, and no sting is felt. Stinging plants can also be handled with impunity after death, if dried; for, though in this case the instrument may be capable of wounding, the poisonous juice is no longer fluid, and cannot flow into the puncture.

EMILY.

Then should we not feel the wound, although we might escape the smarting of the blisters?

MRS. B.

The instrument is so minute, that the wound it inflicts would not be felt were the skin not inflamed by the poison.

The nectar of flowers, the bloom on fruits, and the viscous coating of aquatic plants, which protect them from the water in which they grow, may all be considered as excretory secretions; but we will postpone their examination till we enter upon the subject of flowers and fruits.

We have now traced the sap, from its first entrance into the roots, throughout the whole frame of the plant; we have examined its component parts, the chemical changes it undergoes in the leaves, its subsequent descent under the form of cambium, and the various peculiar juices which are secreted from this nutritive fluid, as it returns from the extremity of the leaves into the roots.

EMILY.

But is the whole of the sap consumed in the performance of these several operations, and does no part of the cambium return through the roots into the earth?

MRS. B.

M. de Candolle has long entertained the opinion that a small residue exudes from the roots into the ground. A plant, he observes, being under the necessity of absorbing whatever comes within reach of its roots, must necessarily take up some particles of matter which are not adapted to its nourishment, and which, after passing with the sap through the general circulation, in all probability returns into the roots, and from thence into the soil.

EMILY.

Then, though plants can make no choice as to what they absorb, their organs must be, in some measure, capable of selecting what they shall assimilate to their own substance, since they reject particles which are not adapted to their nourishment.

MRS. B.

Without allowing them the discrimination of the chemist, we may, at least, conjecture that the laboratory of each plant is so constructed as to act only on bodies congenial to its nature. This theory of exudations is strongly corroborated by a circumstance which has long been known in agriculture. In planting, it is found that trees of a different family from those which previously occupied the ground thrive better than a repetition of the same trees. Now this is easily explained, if we admit that plants exude into the soil; for the exudations which would be deleterious to individuals of the same family may afford nourishment to plants of another description.

CAROLINE.

Then the new planted tree would feed on the very substances which its predecessor had rejected. This theory, I am convinced, must be true, it affords such a striking proof of the wise economy of Nature, which enables beings, incapable of either distinguishing or selecting their food, to incorporate that which is alone appropriate to them. But have no experiments been made with a view to elucidate this point?

MRS. B.

A question so interesting in vegetable physiology could not but attract the attention of naturalists; but their researches have proved unsatisfactory till very recently, when M. Macaire, by a course of simple but ingenious experiments, appears to have ascertained the fact. He dug up some plants in full vegetation; and having carefully removed the earth from their roots, and washed them in distilled water in order to prevent any particle of foreign matter from adhering to them, he immersed them in vases of pure rain water, taking care to support the plant, so that no portion of the stem should sink into it. He found the plants continued healthy, and put forth both leaves and blossoms. After some time he examined, by means of chemical tests, the water in which the roots had been immersed, and found it to contain a substance, which he conceived to have been exuded by the roots.

CAROLINE.

After the precautions he had taken, it could not, I think, have had any other origin.

MRS. B.

M. Macaire attempted to obtain similar results from cut branches and roots, but without success; hence, he concluded that plants exude only when in an active state of vegetation.

In a third experiment the roots of thriving plants were immersed, some in sea water, others in lime water; and after having absorbed a considerable quantity of these liquids, they were taken out and plunged in pure rain water; when it appeared that they exuded the lime and the salt profusely; showing that though plants have no choice with regard to absorption, they have the power of rejecting what is not conducive to their nourishment.

But the most interesting and conclusive of these experiments consisted in immersing the roots of a plant in water which had previously been saturated with the exudations of another individual of the same family : it soon began to droop and wither; thus proving that it could derive no nourishment from the substance which its predecessor had exuded.

EMILY.

But unless these exudations had some poisonous effect on the fresh plant, why should it not have derived nourishment from the water in which its predecessor had vegetated ?

MRS. B.

Because its predecessor had, in all probability, consumed all the nourishment the water afforded. Pure rain water can supply the plant with no other food than carbonic acid, and that in such small quantities, that after one plant has vegetated in it some little time, the stock would be exhausted; therefore, unless the fresh plant could feed upon the exudations it must perish.

CAROLINE.

I wish a fresh plant of another family had been substituted; for if it had vegetated in this exhausted water, it would have afforded conclusive evidence that it derived nourishment from these exudations.

MRS. B.

This is exactly the experiment which M. Macaire made, and he had the satisfaction to see that it was quite successful; for the fresh plant of a different family not only vegetated, but seemed to acquire additional vigour from the water which had been saturated by the exudations, and exhausted of carbonic acid by its predecessor.

EMILY.

But you have not yet told us what constitutes a family of plants; and how they are distinguished from each other.

MRS. B.

That subject must be reserved for the classification of plants; it will suffice for the present to know, that the vegetable kingdom is divided into a great number of families, each of which has its peculiar characteristics.

CAROLINE.

And one of their distinguishing properties appears to be, that the exudations of plants of one family afford nourishment to those of another.

MRS. B.

You must not extend the theory so far as to suppose that this reciprocity of benefits is extended to all plants.

It is only certain families that bear this relation to each other. Thus the growth of corn, which is of the gramineous family, is greatly promoted by the exudations of the artificial grasses, which are of the leguminous family.

CAROLINE.

And I doubt not but that the vegetation of the blue corn flowers and scarlet poppies, which are so common in corn fields, is promoted by the exudations of the corn.

MRS. B.

That may, perhaps, be true; but if so, the poppy makes a very ungrateful return, its exudations being of so poisonous a nature as to be prejudicial to plants of every description. Nor are these noxious qualities confined to the poppy. The exudations of the Euphorbiaceæ are so acrid and venomous, as to be highly injurious to all vegetation.

Having now concluded our examination of the structure of a plant, and of the mode in which it is nourished, we shall proceed to observe in what manner it is affected by the outward bodies with which it is in contact, such as light, heat, the atmosphere, the soil, &c. This will enable you to acquire some information respecting the culture of plants; and though I do not aim at making you adepts in agriculture, yet I consider the application of botany to that science as the most useful and the most interesting point of view in which it can be studied.

CAROLINE.

And it must be much more amusing than the common mode of studying the classification of plants.

MRS. B.

Classification is very necessary in science. It is impossible, without its aid, to acquire clear ideas in any branch of knowledge; but it is true that in botany it is sometimes too exclusively considered; and the student is apt to forget that classification is but the means, not the end, to be attained.

M. de Candolle's mode of classification is more simple than that of any preceding botanist. But we shall not treat of it till we have examined the various organs of the flower on which it is founded.

CAROLINE.

And when are we to learn the history of the flower, Mrs. B.? — that part of botany which I once thought comprised the whole of the science?

MRS. B.

The flower is the asylum, in which the seed, destined for the reproduction of the plant, is lodged. We shall examine the flower and the seed, therefore, in immediate succession, when we enter on the subject of the reproductive powers of plants.

CONVERSATION VII.

ON THE ACTION OF LIGHT AND HEAT ON PLANTS.

MRS. B.

In examining the effect of external bodies on plants, we shall begin with light, which may be considered as acting on them in four different ways. The first rays of the rising sun seem to awaken the vegetable creation from its state of repose.

CAROLINE.

You do not mean to infer that plants sleep during the night, Mrs. B.?

MRS. B.

I doubt whether the term sleep be literally appropriate to that state of relaxation and inaction which appears to afford them repose during that season. The leaves and flowers usually change their position as soon as it grows dark; in many plants the leaves droop; in others they close, as well as the petals of the flowers, and are opened by the first rays of the morning sun. The leaves then recommence their chemical operations, the spongioles draw up a provision for their labours, every function which had ceased or diminished during the night is again renewed, and the whole plant re-animated. It is this effect, produced by light on plants, which I call being awakened.

Secondly, the direct rays of the sun are necessary to enable plants to decompose carbonic acid gas in any sensible quantities. We have already observed, that in this process the oxygen of the carbonic acid is exhaled by the leaves, and the carbon deposited in the plant: now, it is this deposit which produces their green colour. M. Sennebier is of opinion, that carbon is not positively black, but of a dark-blue colour. The cellular tissue of plants is of a yellowish white; consequently, when those minute blue particles are lodged within the yellow cells, the combination of the two colours produces green, in which the blue or yellow tint prevails, in proportion as the carbon or cellular tissue predominates.

CAROLINE.

That is very curious, and accounts for the pale delicate tint of the spring verdure, when but a small quantity of carbon has been deposited in the leaves; and for the deeper shades which plants acquire in summer and autumn, when they have accumulated a greater stock of carbon.

But what is it that produces the change of colour at the fall of the leaf, and, indeed, often takes place previous to their fall, when many of the leaves become red or yellow.

MRS. B.

Some ingenious experiments have lately been made on this subject by M. Macaire. He ascertained that, late in the autumn, when leaves begin to change their colour, they absorb oxygen during the night, but lose the power of giving it out during the day: hence he inferred, that the accumulation of oxygen destroyed the green colour, and produced the various tints which the autumnal leaf assumes.

EMILY.

We know the power that oxygen has in changing the colours of metals: it is not, therefore, surprising that it should produce effects somewhat similar on plants; but if it is oxygen which makes the dying leaves red or yellow, may it not also be the cause of the various hues of living flowers? M. Macaire should have prosecuted his researches in order to discover this.

MRS. B.

He did so; and the result led him to think, that it is to the various quantities and modes of combination of oxygen that the different colours of plants are to be attributed.

The third mode by which light acts on plants, is by facilitating, and consequently increasing, their absorbent powers. Tell me now, what do you suppose would happen from great intensity of light?

EMILY.

To answer your question properly, one ought to be acquainted with the plants of tropical climates, where light as well as heat is so much stronger than in our latitudes.

CAROLINE.

It would be more easy to study the plants which grow on the summits of the mountains in this country; they are so much more exposed to light than those in the valleys or the plain; and I recollect observing, that they are generally of a deeper green, which is no doubt owing to the greater deposit of carbon.

EMILY.

I have remarked, also, how much deeper the green colour of vegetation is in Italy than in England.

MRS. B.

In the tropical climates this difference is still more remarkable. But what is very extraordinary, Baron Humboldt met with some green plants, growing in complete darkness at the bottom of one of the mines of Freuberg. The mine abounded with hydrogen. Now, whether this gas be endowed with the power of producing the green colour, or whether it may enable the leaves to decompose carbonic acid without the aid of light, is a problem which we must leave to more able chemists to solve. What increases the difficulty is, that carburetted hydrogen gas is a poison no less deleterious to vegetables than to animals.

Another effect of intensity of light, is to render plants remarkably firm and hard, owing both to the accumulation of carbon, and to the increased vigour of their powers of absorption, which enables them to incorporate a greater quantity of the earthy matter floating in the increased quantity of sap they suck up.

CAROLINE.

But, on the other hand, they must contain a greater quantity of liquid, which would produce a contrary effect.

MRS. B.

You must recollect that intensity of light increases the power of evaporation, as well as that of absorption; the plant, therefore, retains no superabundance of liquid, although it acquires more of the solid particles which it held in solution. The compactness and hardness of plants in some degree impedes their growth; their vessels, deficient in elasticity and flexibility, are not so capable of being elongated by the fluids which circulate within them. Mountainous plants are therefore more diminutive than those of the plain.

EMILY.

But this is far from being the consequence of exposure to light in hot climates, where the vigour of vegetation greatly surpasses that of our more moderate temperature, and the plants are in general of much larger dimensions than with us.

MRS. B.

It is to the intensity of heat, rather than of light, that they owe their superiority. When these two causes act simultaneously on plants, they concur in promoting vegetation. The intensity of heat distends the vessels hardened by the deposit of vegetable matter, and gives increased impetus to the rising sap; which, being imbibed in considerable quantities by these firm yet still elastic vessels, occasions a power of vegetation and a degree of magnitude unknown in our less genial climes.

The mountain plant, on the contrary, is peculiarly exposed to cold; the chilled and languid sap can with difficulty penetrate the indurated cells; the circulation of all the juices is checked, and the growth proportionally diminished.

CAROLINE.

And yet the flowers on mountainous plants appear to me unusually large.

MRS. B.

That is an observation which has been frequently made; but I am inclined to think it is an illusion, produced by the comparatively small size of the rest of the plant.

There is a third cause of the greater hardness of plants exposed to intensity of light. By assimilating a larger quantity of carbon, the plant at the same time decomposes and incorporates a larger quantity of water. It is not known how this operation takes place; but the water, no longer in a liquid form, increases instead of diminishing the solidity of the plant.

CAROLINE.

I should be curious to examine also, the effects of a deficiency of light, such as occurs with plants cultivated within doors, in confined situations, in the shade of forests, &c.

MRS. B.

In the first place, they are pale from not having a sufficiency of carbon to develope their colour. In consequence of this deficiency of carbon, their fibres, being soft and feeble, are easily stretched out, and grow to a great length; as you may possibly have seen potatoes, when sprouting in a dark cellar, shoot out weak slender branches, six or eight feet in length.

A deficiency of light diminishes the power of evaporation still more than that of absorption, so that the plant retains an excess of liquid, and becomes literally dropsical. This state of saturation diminishes both its smell and its flavour. Advantage is taken of this circumstance to soften the flavour of vegetables when too strong; that of celery, for example, is tempered by burying the stem in the ground, and sheltering it from the light, the leaves alone being suffered to appear above ground. In these, the green colour is developed, while the stem remains perfectly white.

CAROLINE.

But since it is the leaves which occasion the deposit of carbon, I should think the purpose would be more effectually accomplished by covering them up with earth also, or by stripping off the stem. Besides, by depriving the plant of its means of evaporation, you would also increase the retention of sap, and render the plant more tender and less strongly flavoured.

MRS. B.

But such extreme measures would check vegetation, and render the plant diseased, if not actually destroy it.

It is with the view of making lettuces white and tender that they are tied up, so that the external leaves are alone exposed to the light.

CAROLINE.

It is not necessary for the gardener to perform such an operation on cabbages; for Nature takes this precaution herself and keeps the heart quite white and tender. Endive is artificially whitened, and its flavour softened, by being covered with tiles; the green leaves of endive, which have not been thus sheltered from the light, are very unpleasant to the palate from their bitterness. But vegetables thus blanched, though tender, are generally crisp, not soft.

MRS. B.

That crispness would have been converted into a hardness approaching to woody fibre, if the plant had not been sheltered from the light. The crispness is very agreeable to the palate in lettuces and endive when eaten raw, and it becomes perfectly soft by cooking; whilst those parts of a vegetable in which the woody fibre begins to be developed, by the deposit of carbon, after cooking remain tough and stringy. You must have noticed this difference in every dish of cardoons and of celery which is served at table: those parts from which the light has been completely excluded are quite soft and tender, whilst those which have been partially exposed to it, are tougher and more fibrous.

It was supposed by the ancients, and, indeed, taught by their great naturalist, Aristotle, that the verdure of plants was developed by the atmosphere, and that it was the exclusion of air which prevented the roots from assuming that colour.

EMILY.

What would be the consequence of depriving a plant entirely of light?

MRS. B.

The leaves would become dropsical and fall off: fresh leaves would, indeed, sprout; but these, having no power to decompose carbonic acid, would be completely etiolated. Deprived of carbon, and in a great measure of the earthy matter deposited by evaporation, the new shoots would be soft and feeble, but considerably elongated by the absorption of fluid which they have not power to throw off.

M. Bonnet of Geneva cultivated some peas in a cellar totally dark, and they were completely blanched.

EMILY.

Pray, can you tell me why plants turn their leaves and flowers, and even stretch out their branches, towards that side on which the light predominates?

MRS. B.

Some have imagined that this preference resulted from a sort of instinct; others have gone so far as to discover in it an indication of sensibility.

EMILY.

I begin to take such an interest in plants, since you have made me better acquainted with them, Mrs. B., that I should be delighted to find they were raised somewhat above the mere passive mechanical beings, in which Nature carries on her chemical and physical processes without their interference.

MRS. B.

In all organised beings, life plays so considerable a part, as effectually to distinguish them from mere impassive matter; but, in regard to the instinct and sensibility of the vegetable creation, I fear we must abandon the subject to poets, who have often treated it with much beauty. The inclination of plants towards the light we soberminded botanists account for in a far less romantic manner.

I must relate to you an experiment made by M. Texier, which shows that, far from being endowed with feeling, plants are mechanically compelled to turn towards that quarter which is most conducive to their well-being. M. Texier having placed a plant in a dark cellar, where it was supplied by openings on the one side with light, and on the other with air, at liberty to prefer either, both leaves and branches in a short time extended themselves towards the light. This partiality may be thus explained: — Those parts of a plant most exposed to the light becoming harder and less susceptible of elongation than the parts more in the shade, the two sides being unequal, the one is obliged to yield to the other; the soft, yielding, elongated side to that which is harder and more contracted. If one side of a branch be more elongated it will take a curved form, as may be seen in plate IV. fig. 5., where the dark line represents the accumulation of carbon and contraction of growth, and the fine line, the softer texture and greater elongation; and thus you see that the plant mechanically assumes a position in which it may receive the greatest benefit from an element so essential to its welfare.

CAROLINE.

This is extremely curious; and it accounts for the tendency of plants towards the light in a manner so simple and clear, that, mechanical as it is, I cannot doubt its correctness.

MRS. B.

Let us now proceed to examine the effect of temperature on plants.

Heat excites and accelerates the circulation of the juices of plants, as it does those of the animal frame; but this effect varies in different kinds of plants, and even in different individuals of the same kind. It is the accelerated motion of the sap, during the warmth of spring, which determines the period of the budding of the plant; and, as the temperature of the season increases, produces a greater absorption by the roots, of evaporation by the leaves, brings out the blossom, and, finally, ripens the fruit.

The action of heat in these operations is not merely mechanical, but produces effects on the living plant very analogous to those which it does on animals.

When, on the contrary, the temperature of the soil is as low as the freezing point, the spongioles finding no fluid to imbibe, the plant, deprived of sustenance, languishes; and should this privation continue any length of time, it dies of want.

EMILY.

Whilst, on the other hand, if the heat be so intense as to evaporate all the water of the soil, the plant will be equally deprived of nourishment.

MRS. B.

The effect is similar, though produced by so opposite a cause. The plant will in the last case, however, perish sooner; for, besides being deprived of sustenance, it will evaporate its own moisture. But let us first enquire into the effects of a low temperature on plants. Water may freeze within the plant, but it is less liable to congelation after, than before being absorbed by the roots; not only because it is better sheltered from the external cold, but because the motion of the sap is unfavourable to congelation.

If the stem of a tree freezes, the elasticity of the vessels requisite to propel the juices is destroyed, and the plant dies both from cold and hunger. But if merely the leaves and buds be frozen, they alone are destroyed; and the sap, which the stem continues to transmit to the branches, enables them to throw out new buds and leaves.

CAROLINE.

So, a man would still live, were his nose or fingers frozen. The analogy, however, will go no further, for he has not the power of throwing out new ones.

What degree of heat will plants support?

MRS. B.

It varies extremely, depending on a variety of circumstances. The *Vitex agnus castus* has been known to strike root in water, at the temperature of 170° Fahrenheit.

When one of the hothouses of the Botanical Garden of Paris was burnt, all the plants within it perished excepting the flax of New Zealand, which resisted a degree of heat that even consumed its leaves.

The temperature of some few plants becomes greater at the moment of flowering: that of the *Arum maculatum* rises from fourteen to twenty-one degrees, when its blossom expands between three and five o'clock.

EMILY.

Do plants, like unorganised bodies, partake of the temperature of the surrounding atmosphere? I should have imagined that they must be warmer; for, since some portion of the water which a plant absorbs remains incorporated in it under a solid form, in changing its state from fluid to solid, it must give out its latent heat, which would raise the temperature of the plant.

CAROLINE.

But you forget, Emily, that two thirds of the water which the plant absorbs is evaporated, and, by changing its form from liquid to vapour, cold must be produced. Now, as the quantity which assumes the form of vapour is much greater than that which becomes solid, the temperature of the plant should ultimately be lower than that of the atmosphere in which it grows.

MRS. B.

Each of your opinions have been sanctioned by different naturalists; but, however exact these calculations may be in the laboratory, they can give us but very little insight into the chemistry of vegetation, where that mysterious principle *life* performs so essential a part.

EMILY.

Yet, is it not easy to ascertain by the thermometer whether plants differ in temperature from the atmosphere?

MRS. B.

It appears by that test, that the trunk of a tree is colder in summer, and warmer in winter, than the air by which it is surrounded; and the larger the stem, the more this difference is manifest. But the reason of this is very simple; the roots draw their nourishment from a depth of soil, well sheltered from both extremes of heat and of cold: the water they absorb remains throughout the year of a moderate temperature; and the stem, which serves as a channel to transmit this water to the branches, naturally acquires the temperature of the fluid it conveys. The sap thus tends to cool and refresh the plant during the heat of summer, and to keep it warm during the severity of winter; but should this severity be so intense or of such long duration as to penetrate into the deep recesses of the soil, whence the sap is drawn, the temperature of the tree will gradually descend to that of the atmosphere.

CAROLINE.

The stem has still another defence from the cold, in the several layers of bark; which we may, I suppose, consider as so many warm coats to preserve the internal temperature of the tree?

MRS. B.

Certainly. The bark is a bad conductor of heat, and, like flannel-clothing, serves equally to keep in warmth during winter, and to exclude heat in the summer.

Notwithstanding all these precautions, which Nature has so wisely taken to preserve the equable temperature of plants, the water within the stem is sometimes frozen; and, as water when converted into ice occupies a larger space than in its fluid state, it bursts the vessels in which it is contained, and injures, if it does not destroy, the texture of the plant.

EMILY.

But should this occur after a dry season, so that the cells which contain the water be not filled, there will be room for its expansion in freezing.

MRS. B.

True; freezing may then take place without considerable injury to the plant; it is only when the parts become disorganised, from the fracture of the vessels of the cellular system, that the plant itself is said to be frozen. The more water, therefore, plants contain, the more liable they are to injury from frost; and, accordingly, we find that aqueous plants are those most easily frozen. What parts of a plant should you suppose most liable to be attacked by the frost?

CAROLINE.

Those which contain the greatest quantity of water: the leaves, where that liquid is conveyed to be evaporated; and the buds, where, during spring, the sap is brought in such abundance for their nourishment. Besides, the leaves and the buds are most exposed to the air, while the stem and branches are well defended from its inclemency by their warm clothing, the bark.

MRS. B.

You have judged rightly. If the frost be so inveterate as to attack the stem, it is the alburnum, as being the most moist and tender, which first suffers; afterwards the liber, the internal coating of bark. If this freezes, death must ensue, as the vessels which convey the cambium are lodged in this coating. The external layer of bark is the driest of any part of the plant, being constantly subjected to the inclemencies of the season. It is often injured, and in the lapse of time decays and peels off; but it is never frozen.

EMILY.

Plants must be more liable to freeze in the spring than in the autumn, at an equal temperature, because they contain more water at that time.

MRS. B.

True. In autumn the absorption of sap diminishes, in the spring it increases, both in quantity and celerity of motion, in order to provide for the budding of the plant; and if in this season a frost should prevail, there is great danger of the plant falling a sacrifice to it.

Plants of different species vary much in their power of resisting cold. Oaks do not freeze at 56° below the freezing point of Fahrenheit; beech will support 79°, an intensity of cold which congeals mercury. M. de Candolle found snowdrops in blossom on Mount Saleve beneath the ice; and Captain Parry, in his polar expeditions, discovered many plants, in full leaf and ready to blossom, encased in ice.

It is remarkable that those plants, which are the greatest sufferers by extreme cold, are at the same time most liable to injury from intense heat. But this apparent inconsistency admits of solution. We have observed that aqueous plants are easily frozen; they also evaporate abundantly; therefore, when exposed to extremes of temperature, they will be either frozen or dried up.

Plants which secrete a viscous juice do not easily freeze: the tenacity of this thick, sticky fluid prevents, or at least impedes, that arrangement among the particles which is necessary to produce congelation. Freezing, you know, is a species of crystallisation; and it is requisite that each particle of liquid should be free so as to place itself in that order which is essential to the formation of such regular bodies as crystals.

CAROLINE.

The rising sap then must freeze more easily than the descending sap or cambium, as the latter is thicker and more viscous.

MRS. B.

Yes; and there is also another reason why the sap is more liable to freeze than the cambium: the former moves more quickly, so that its particles more easily place themselves in the order of crystallisation.

EMILY.

Might not recourse be had to the expedient of stripping the plant of its leaves, in order to diminish the velocity of the rising sap, when in danger of freezing? For then by depriving a plant of the organs of evaporation you would lessen its power of absorption.

CAROLINE.

But by taking them away you would prevent the plant from acquiring that consistency which, by the formation of the sap in the leaves, enables it to resist congelation; you render it dropsical by the accumulation of water; and aqueous plants, Mrs. B. has told us, are most liable to freeze.

MRS. B.

Emily's expedient has been tried, but not without danger of the consequences you suppose would ensue from it.

Fleshy fruits, such as oranges, apples, and pears, require a great quantity of sap to supply them with sustenance, and this occasions a great absorption by the roots. These plants are, consequently, particularly liable to injury from frost; and, when there is any danger of this it is a useful precaution to gather the fruit, in order to secure the tree. In the south of France, the oranges are gathered on the first appearance of a frost; and should this operation not be completed before it sets in, it frequently happens that the side of the tree on which the fruit remains is frozen, whilst that on which it has been gathered escapes uninjured.

CAROLINE.

Then, in cases of such urgency I think they should begin by gathering the fruit on the north side of the tree, as being most exposed to the cold.

EMILY.

Some fruits, like the peach, are coated with a soft down; which, I suppose, answers the purpose of warm clothing?

MRS. B.

Yes; it is, perhaps, even a better preservative from the cold than the coatings of the epidermis. This soft down encloses and confines the particles of air on the surface of the fruit on which it grows. Air, you may recollect, is a very bad conductor of heat, and especially air in a tranquil state; that which is imprisoned by the down affords, therefore, the most useful shelter to the plant.

EMILY.

I have often experienced the advantage of a precaution of this nature, by holding up my fur-tippet before my mouth when encountering a sharp frosty wind.

MRS. B.

Yes; you must observe, also, that the air is tempered by the warmth of the breath you exhale before being inhaled by the lungs; so that, in fact, you breathe a tepid instead of a frosty air. This is the effect produced by the respirators now so much used by invalids.

A layer of air is also imprisoned between the epidermis and the bark, which is, perhaps, a still better preservative to the plant than the bark itself: it is a delicate under-garment, which the stem wears beneath its more cumbrous clothing of epidermis.

CAROLINE.

The epidermis itself, was, I thought, a delicate covering to the internal layers of bark.

MRS. B.

That depends upon the nature of the plant, and the part to which it belongs. The epidermis of the leaves and buds is delicate, but that of the stem and branches of a venerable oak is of a very different description: the bark in general which covers the trunk consists almost wholly of carbon; which, being a very bad conductor of heat, answers the double purpose of confining the internal heat in winter, and excluding the external heat of summer.

The epidermis itself is sometimes single, sometimes double or triple, but more commonly consists of a number of layers. So many as one hundred and fifty have been counted in the epidermis of a tropical plant; and so great a number still remained that the calculation was abandoned from the difficulty of completing it.

At our next interview we shall examine, how far plants will admit of being naturalised to a climate differing in temperature from that in which they are indigenous; and what are the precautions necessary to be taken in transplanting them to a foreign country.

CONVERSATION VIII.

ON THE NATURALISATION OF PLANTS.

MRS. B.

In estimating the effect of diversity of climate on plants, the point most important to be considered is the difference of temperature. The nature of the soil, the air, water, and light, are circumstances comparatively trifling, compared with the abundance or deficiency of heat.

EMILY.

I should have imagined that the quality of the soil and the quantity of water would have been of still greater consequence than the temperature.

MRS. B.

When we wish to naturalise a foreign plant, art may do much in rendering the soil analogous to that in which it originally grew, in affording it a due quantity of water, in sheltering it from, or exposing it to the light. The nature of the air varies very little in any latitude, but its temperature most remarkably; and over this art has little or no control.

CAROLINE.

You forget our hothouses, Mrs. B., where we produce whatever temperature we choose.

MRS. B.

True; but the plant cultivated, or I should rather say forced, in such an artificial atmosphere remains a foreigner, and cannot in this way become accustomed to the climate of the country.

If you compare the mean temperatures of different countries, you will be surprised to find how much more they resemble each other than you would first imagine. For instance, those of England and of Switzerland do not vary above two or three degrees; yet they frequently will not admit of the cultivation of the same plants. In Switzerland it is hotter in summer than in England, owing to its latitude; whilst the local elevation, and the numerous mountains covered with snow, render it colder in winter. The more equable temperature of England, throughout the year, enables every species of laurel, and even Rhododendrons, to support the winter with impunity. In Switzerland the common laurel, if it escape being frozen, suffers so much as greatly to injure its vigour and beauty: the contrast of a strong vegetation in summer, suddenly checked by the severity of winter, ill accords with its nature. The Laurustinus and the Portugal laurel are unknown in Switzerland, except as greenhouse plants; whilst, on the other hand, the fruit of the vine, which we can but imperfectly ripen in England, in Switzerland affords a luxuriant vintage.

EMILY.

I am often inclined to envy the Swiss their oleanders and pomegranates, which blossom so beautifully in the open air, and require the shelter of a greenhouse only in winter; while we produce very inferior plants of the same description even in our hothouses.

CAROLINE.

Yet the temperature of Switzerland must be lower than its latitude would indicate, owing to its elevated situation ; for, being nearly in the centre of Europe, whence almost all the great rivers have their source and flow into the sea, it must be the spot most raised above that level.

MRS. B.

Independently of the degree of elevation above the level of the sea, the climate of a country is liable to be affected by a variety of circumstances. One of these, which, however remarkable, naturalists have not hitherto been able satisfactorily to account for, is, that in countries of similar elevation and latitude the temperature is always higher in those situated on the western than on the eastern side of a continent. It is warmer, for instance, at Nantes, on the western shore of France, than at Quebec, on the eastern shore of America, both being very nearly of the same latitude. At Quebec, snow-shoes and sledges are in general use during several months of winter, and booths are built upon the frozen river St. Lawrence ; whilst at Nantes frost and snow are little known, and of short duration.

The prevalence of hot or cold winds, such as the *sirocco* in the south of Italy, the *mistral* in the south of France and the *bise* in the valleys of Switzerland, should always be taken into consideration in estimating the temperature of a climate.

EMILY.

But pray tell me, how far can plants accustom themselves to a climate which is not natural to them ?

MRS. B.

It varies extremely, according to the nature of the plant. The horse-chesnut, which is so well naturalised to our nothern regions that it braves even the inclement skies of Sweden, was originally brought from India : where it grew, it is true, on mountains, but of no very considerable elevation. Some plants succeed only partially on being transplanted to a foreign country.

Thus the artificial grasses, such as clover and cinquefoil, thrive very well as grasses; they are cut down when in blossom. The heat of summer being seldom sufficient to ripen their seed, we are under the necessity of importing it from warmer climates, in order to renew them.

EMILY.

I thought that the artificial grasses were cut down at that early period of their growth, as being then most tender, and best suited for the nourishment of cattle.

MRS. B.

That is true; but were we able to ripen the seed, we should cultivate a portion for that purpose, instead of annually renewing it from the Continent.

CAROLINE.

Why have these grasses obtained the name of artificial?

MRS. B.

Because they require continued cultivation from seed. They are not perennial, but must be constantly resown; whilst most of the grasses of our pastures and meadows spread by the root.

There are many plants which will not admit of transplanting to a colder country: thus the orange and the olive have made no progress northward since the time of the Romans, but are still confined to the same limits.

CAROLINE.

The orange-tree bears our climate under shelter of a greenhouse extremely well.

MRS. B.

There are few plants which cannot be cultivated with some degree of success, by the artificial temperature of a greenhouse or a hothouse; but I am speaking of their being naturalised, so as to admit of being raised in the open air.

When you make the experiment of introducing a new plant from a warmer climate, you must treat it with great care, and endeavour, by gentle gradations, to wean it from its native country, and accustom it to our more inclement skies. You should begin by placing it in a hothouse; the following year a greenhouse may be tried; and, if it does not appear to suffer from this change, it may be finally exposed to the open air. While the plant undergoes this species of education, you have the advantage of studying its habits, the nature of the soil most favourable to its growth, the quantity of water it requires, the degree of light to which it should be exposed, the wind which it will support, and a number of minute circumstances, which will indicate the situation and treatment most congenial to it, on transplanting it into the open air. This knowledge of the habits of plants is highly essential to the success of the cultivator.

EMILY.

Undoubtedly. If it were found that they required much moisture, it would be proper to plant them in hollows rather than on rising round; when the plant is tender and delicate, so that light, heat, and shelter become essential to its preservation, a southern aspect should be selected, that it may derive every possible advantage from the sun, and be sheltered from the north wind.

MRS. B.

You must also pay attention to plant it rather deep in the earth, in order that its roots may be supplied with water of a moderate temperature, and that the neck or vital part of the plant be sheltered from the inclemency of the weather. Then it should be transplanted in the spring, in order that it may be gradually accustomed to a diminution of temperature, instead of being suddenly exposed to the severity of winter.

Besides, if removed into the open ground in the spring, it will be hardened and defended against future cold by the deposit of carbon during the summer. It is desirable, also, that it should have a rich vegetable soil round it, in order to afford it plenty of nourishment.

CAROLINE.

In Switzerland, they plant rhododendrons and kalmias in pots of remarkably black earth.

MRS. B.

The bog or peat-earth of England, though less rich, is of the same nature, consisting chiefly of vegetable remains, and this is commonly used for such plants. There are whole districts in Belgium of this nutritive vegetable soil, which are converted into nursery gardens for raising kalmias, rhododendrons, and other plants of this description, where they grow and prosper in the open air. In England the rhododendron succeeds perfectly well in our gardens, though the soil is less rich in carbon than the bog-earth of Belgium ; but the moisture of our climate is particularly favourable to that, as well as to every species of laurel, and to evergreen plants in general.

In transplanting from a colder region, very few precautions are required : an elevated situation is desirable, and a sufficiency of water to provide for the more abundant evaporation to which the plant is subjected.

Plants brought from a warmer climate should be watered but moderately, because the power of evaporation is checked by the diminution of temperature. This is particularly to be observed in autumn, when the cold weather first sets in.

EMILY.

This direction, I should suppose, would be applicable to plants of every description, none of them being capable of evaporating so much during winter as in summer.

MRS. B.

True; but it is not equally applicable to those which preserve their leaves. Such greenhouse plants, for instance, as geraniums and orange-trees, which retain their organs of evaporation throughout the winter, will admit of being watered more abundantly than others.

EMILY.

Do you approve of sheltering delicate shrubs by covering them with straw or matting during the winter?

MRS. B.

If the spot in which they grow be elevated, and the soil dry, it may be done with advantage; but in low damp situations such a precaution might occasion decay, particularly in evergreens, as the covering would prevent the evaporation of any superabundant moisture by the leaves. In such cases, it is better to leave the plant exposed, taking care only to shake off the snow, which, if melted by the sun during the day, runs down the stem and branches, and insinuates itself into any little crevice it may chance to find in its passage, or is absorbed by the buds and tender parts of the plant as it trickles over them. Then at night, if this water freezes it injures, if it does not destroy, the texture of the parts with which it comes in contact.

CAROLINE.

It must surely be desirable to plant such trees against a wall in a southern aspect, even under the inconveniences to which such a state of confinement subjects them.

MRS. B.

It is attended with several advantages, which, in the initiation of tropical plants to our climate, often more than compensate the injury resulting from confinement. A southern wall not only affords shelter from the north wind, but becomes a source of heat, by the transmission of the sun's rays to the plant.

EMILY.

The white walls of France and Switzerland must reflect a great deal of heat; but I should not have supposed that our brown bricks in England would have produced much effect, for they must absorb more heat than they reflect.

MRS. B.

The rays, whether reflected or absorbed by the wall, are alike beneficial to the tree planted against it; for no sooner does the temperature of the wall become elevated by the absorption of heat, than it radiates this heat, which is thus transmitted to the tree in contact with it.

The injurious effects of the confinement of the branches must, however, be taken into consideration; for, besides that the movement which follows from the free access of air adds to the health of a tree, it also increases its power of evaporation — a power which it is very desirable to encourage, as it is necessarily diminished in a climate of a lower temperature than that in which the plant was placed by Nature; especially in England, where the atmosphere is impregnated with moisture. It is owing to this circumscribed power of evaporation that wall-trees are less hard in their texture, and contain less carbon, than standard trees.

EMILY.

Let me try if I can recapitulate the several circumstances to be attended to in transplanting from a warm to a cold climate. In the first place, you must make the plant pass through the various gradations of the hothouse and greenhouse, previously to exposing it to the open air: you must then plant it, in the spring, deep in a richly carbonised soil, and cover up the vital point of junction between the stem and the roots. It must be placed in a southern aspect, or against a south wall, and watered with great moderation: the fruit must be gathered before the frost sets in ; and the plant may be covered with matting in winter, if situated on an elevated spot and in a dry soil.

MRS. B.

I believe you have enumerated all the directions I have given you on this point.

I shall add a few remarks on greenhouses and hot-houses, as necessary to the cultivation of such plants as cannot be familiarised to our climate. They should both be situated, as far as is practicable, in a southern aspect.

EMILY.

But when this is not attainable, which do you think best, — a south-east or south-west aspect ?

MRS. B.

The first has the advantage of affording the earliest relief to a plant which has suffered from the cold during the night ; the latter that of sheltering it from the severe east wind : upon the whole, I should be inclined to choose the south-west.

Vertical windows have the advantage of not retaining the snow, the disadvantage of admitting less light and heat ; and in England, where we are not much troubled with snow, and require all the heat we can obtain in winter, the inclined windows are certainly preferable, and are almost universally adopted ; whilst on the Continent, where less heat is required, vertical windows are more common.

In southern countries, the house must not be built deep, in order to admit the sun's rays to every part ; and as they fall more obliquely in northern climates, a greater depth of building is admissible : the roof should project and be coved, so as to collect the rays of the sun and reflect them into the house.

In order to protect hothouses and greenhouses from dampness, they must be warmed and aired at the same time : the heat both dissolves the moisture and prevents the plants from suffering from the external air while the windows are open ; and the current of air carries off any moisture which is not dissolved.

The finest hothouses are in Russia, where the wealth of the higher classes enables them to indulge in luxuries. In their cold climate, hothouses and greenhouses are considered as necessary articles of comfort. Mr. Loddiges' establishment at Hackney exhibits a very complete model of hot and green houses : they are warmed by vapour, and, when necessary, watered by the tepid water into which the steam is condensed. The building is one thousand four hundred feet in length, and divided into compartments, each of a different temperature.

EMILY.

What effect has the tan which is used in hothouses?

MRS. B.

It produces heat, by undergoing a degree of fermentation; but it also generates moisture, and heat and moisture favour the propagation of fungi and of worms; and the plants would be injured should their roots spread out below the pots, and penetrate into the tan.

The smaller and lower the house, the more favourable it is to young and delicate plants: the heat always rises, so that in large and elevated houses the small plants of the lower range are situated in an atmosphere of cold air. It is for this reason that cuttings and seedlings are generally raised in beds covered with glass, where they receive as much heat in as small a space as possible.

CONVERSATION IX.

ON THE ACTION OF THE ATMOSPHERE ON VEGETABLES.

MRS. B.

This morning we shall turn our attention to the manner in which the atmosphere affects the vegetable world. It acts in two ways: both mechanically and chemically.

CAROLINE.

But in a very different manner from what it does on animals: we only breathe the air; plants may in some measure be said to feed on it, since they absorb carbon from the atmosphere.

EMILY.

They also absorb oxygen from that source; but it is true they restore it with ample interest, and purify the air we animals have contaminated by our breath. But since carbon is so beneficial to vegetables, I should like to try the experiment of enclosing a weakly, debilitated plant in an atmosphere of carbonic acid, to see whether the abundance of such nourishment would not restore its vigour.

MRS. B.

The quality of the food would be excellent; but nothing is good when administerod in excess. Such an experiment would resemble the attempt to restore pulmonary patients to health by making them respire pure oxygen gas: at first it seemed to be attended with beneficial effects; but the deleterious consequences occasioned by great excitement of the lungs was soon discovered, and the experiment abandoned. We cannot be too cautious in our proceedings when we venture to deviate from the paths which Nature has pointed out.

The chemical action of the atmosphere on vegetables we have already so fully investigated in our preceding conversations, that, although it is no less applicable to our present subject, it would be but repetition to return to it. I have not, however, yet mentioned, that the electricity of the atmosphere appears to affects plants; it is at least an undoubted fact, that vegetation is accelerated during a storm.

EMILY.

May not that arise from the agitation produced by the wind? — Branches being tossed to and fro must greatly hasten the circulation of the sap, and promote its nutritive effects; the evaporation from the leaves must also be considerably increased by the wind blowing them about, and carrying off the vapour the instant it is formed.

MRS. B.

That may possibly be a concurring cause of the phenomenon, but it is not sufficient wholly to account for it. M. de Candolle mentions the remarkable growth of the branch of a vine during a storm, of no less than an inch and a quarter in the course of an hour and a half: now the tree grew against a wall, so as to be little accessible to the wind.

The French, during their occupation of Egypt, made use of the tall elastic stems of the palm trees, when agitated by the wind, to draw water from the Nile. In that flat country the wind blows continuously; and the stems, thus put in motion, raised the pistons of the pumps, which fell again by their own weight.

CAROLINE.

How very ingenious, and at the same time how simple!

MRS. B.

The quantity of water contained in the atmosphere is a point of a great importance to plants. Water, you may recollect, exists in the atmosphere in two different states: in the one it is so completely dissolved, that the air feels perfectly dry to us, and affords no moisture to the vegetable part of the creation. It is heat which enables the air to perform this solution; therefore the higher its temperature the more water it can dissolve.

CAROLINE.

Then though the atmosphere is driest in the torrid zone, it contains the most water: — that appears very paradoxical.

MRS. B.

It is nevertheless true, whenever the air cools, its power of retaining water in solution diminishes.

CAROLINE.

This must happen, then, not only when the weather changes from hot to cold, but every evening after sunset?

MRS B.

Accordingly, we continually see misty vapours floating in the atmosphere in the evening, and the ground more or less covered with dew: all this is water precipitated by the diminution of temperature of the air. In the morning, when the sun has sufficiently warmed the atmosphere to enable it to dissolve these fogs and vapours, they disappear.

The other state in which water exists in the air is that of a fine subtle vapour, diminishing its clearness, and producing a sensation of humidity.

EMILY.

The latter state, I should suppose, would be the most advantageous to vegetation; for plants almost always require water.

MRS. B.

It is to the dampness of our climate that we owe the fine verdure of our meadows and lawns, for which England is so celebrated, and which are in vain attempted to be imitated on the Continent; unless it be in some very elevated spots, where the grass is nurtured by the mountain mists. It is to this cause, also, that we are indebted for the prosperity of our laurels, and a variety of evergreens: yet a damp climate has its attendant disadvantages, even as regards the vegetable creation. Fogs and vapour diminish the quantity of light, and, consequently, the numerous benefits which result from it; such as absorption, evaporation, the deposit of carbon, and the developement of colour. In this point of view, therefore, a very moist climate injures the beauty and vigour of vegetation.

Trees growing on mountains, where they are much exposed to vapour, are very liable to suffer from what is commonly called a white frost. The clouds and mists, so prevalent in those elevated regions, bedew their branches with a light coating of watery vapour, which easily freezes during the night; the morning mist attaches itself to this thin layer of ice, and shoots into minute frosty crystals, called a white frost.

CAROLINE.

The white frost, which we so commonly see on the grass, is formed, I suppose, by the freezing of the dew.

MRS. B.

Yes; and it is, you know, so slight as to disappear soon after the sun has risen above the horizon.

Moisture is particularly inimical to blossoms: if it comes in contact with the anthers, it destroys them, and the flower bears no seed. This disease often affects the vine, and not unfrequently corn, to the great injury of the vintage and the corn harvest.

There are some plants to which the sea breezes are so essential, that they cannot be cultivated in any other situation than on the shores of the ocean.

EMILY.

These plants, doubtless, require sea-salt; and yet the vapour which exhales from the sea is perfectly fresh; the clouds thus formed are never impregnated with salt: how, therefore, can plants obtain it?

MRS. B.

Not from the vapour exhaled by the sea, but from minute drops of salt water, thrown into the air by the motion of the waves, and carried by the wind to the shores. *Salsola kali*, or kelpwort, is a plant of this description: if grown in an inland situation, it contains not a particle of soda, the alkali from which it derives its value; for this can be obtained only from *muriate of soda*, or sea-salt. During the late war between France and Spain, the French being greatly distressed for soda, which they had imported chiefly from Spain, attempted to cultivate kelpwort on the hills bordering the sea-shore in the south of France. When planted on the southern side of the hill, sloping towards the sea, the crop succeeded perfectly; and the price of soda having risen very high, one single harvest repaid the purchase of the land on which it was raised. Such great profits induced agriculturists to extend the culture of soda to the northern side of the hill, where not being exposed to the briny particles, it failed completely, and the plant contained no other alkali than potash.

EMILY.

This explanation solves a difficulty which had often perplexed me. The sea air is, you know, much recommended to invalids as a tonic; and the fogs and mists, so prevalent on the sea-shore, do not appear to be attended with the debilitating effects produced by inland fogs: this must doubtless be owing to the tonic qualities of the briny particles with which the sea air is impregnated.

CAROLINE.

We can seldom walk out on the beach without our dress suffering from the damp sea air; and the salt with which this air is loaded is often so strong that we can even taste it. But this prevails only within some few hundred yards of the shore: on rising upon the downs it is no longer perceptible; and yet it is the air of these downs which is reckoned so particularly invigorating.

MRS. B.

The saline particles are generally too ponderous to be carried to such a height; but there you experience the salubrious effect of mountain air. The salt is not requisite to render it tonic: it is only when you descend on the opposite side into the inland country, that you perceive the want of those invigorating qualities for which the sea air is so celebrated.

It is remarkable that kelpwort exudes a portion of the alkali which it receives from the atmosphere into the ground, the soil on which it has been cultivated being found to contain more than when such a crop has not been raised upon it. This is owing, probably, to the quantity it absorbs being greater than the plant requires.

EMILY.

This, then, affords an exception to the general nature of the exudation of plants by the roots, as it must constitute appropriate nourishment for other plants of the same species.

CAROLINE.

And is not the air also useful as a vehicle to transport small seeds from one country to another?

MRS. B.

Yes; there is scarcely any resemblance between the plants of Europe and of America, excepting in *Cryptogamous* plants, because the seeds of lichens, of mosses, and of fungi, of which this family is composed, are so small that they float in the air, and are transported by the wind from one continent to the other.

The wind also performs the part of a careful sower, dispersing the seeds which fall from the plant with regularity over the soil.

CAROLINE.

I wish it would distinguish between weeds and flowers, and confine itself to the dispersion of useful seeds; but it seems to delight in the propagation of weeds: if any thistles or groundsel are to be found in a garden, the wind is sure to carry their seeds all over it.

MRS. B.

The distinction between weed and flower is not so easily made as you may imagine. In botany we know not what weeds are; every plant has its use for some purpose or other.

We have already fully treated of the temperature of the atmosphere, which is the point of greatest importance in vegetation. I have only to add, that plants which grow in the plain, in countries of high latitudes, if transported to a warmer climate, must be cultivated in elevated situations. In Chili, for instance, potatoes grow at an elevation of nine thousand feet higher than they will grow in these climates.

EMILY.

Then with reference to the growth of plants, the degree of latitude is the inverse of the degree of elevation from the level of the sea?

MRS. B.

The one serves as a compensation for the other. It is not, however, every species of plant which can take advantage of this sort of compensation; but the greater number will grow equally well at a high latitude in the plain, or in a low one on a mountain.

In an estimate made of the greatest elevation at which several species of trees will grow in the south of France, it appears that

The Larch grows at an elevation of 7200 feet.
The Birch .... 6000 feet.
The Beech .... 4000 feet.
The Cherry .... 3000 feet.
The Walnut .... 2400 feet.
The Vine 1800, or even so high as 2400 feet, if the situation be particularly favourable.

Among the *Cerealia*,

Rye .... 6000 feet.
Wheat .... 5400 feet.
Turkey Corn .... 3000 feet.

EMILY.

I recollect woods of birch-trees on the mountains of Scotland, where they had to struggle against the difficulties both of elevation, of latitude, and of situation; but, it is true, they were ragged and dwarfish.

MRS. B.

And yet their elevation was far below 6000 feet; for Ben Nevis, the highest mountain in Scotland, does not rise more than 4370 feet above the level of the sea. The larch, which is much more hardy, has been planted upon the mountains of Scotland with great success, and clothes their once barren sides with a delicate foliage.

The olive-tree will not grow in a higher latitude than the southern provinces of France; and there it is only under the most favourable circumstances of soil and aspect that it can be cultivated, at the height of 1200 feet.

CAROLINE.

We have seen it in Italy growing almost to the summits of the mountains. I own that I was disappointed with the Italian olive. We associate so many pleasing and poetic ideas with the olive-branch, that I expected it to rival the beauty of the laurel; but, far from that being the case, the colour of the olive is so dingy, that it looks more like a willow covered with dust.

MRS. B.

I cannot see what reason there is to expect much resemblance between the emblems of glory and of peace. The branching of the young olive-tree is, however, remarkably elegant, and the lightness of the foliage makes up for the want of vivacity of colour; and, when mixed with plants of a more lively green, it affords a very agreeable variety.

EMILY.

I recollect that the olive-groves of Tivoli gave me the impression of the most ancient trees I had ever beheld: their venerable trunks are torn, riven, and twisted into a thousand fantastic forms; a profusion of young branches, decked with light foliage, shoot from these aged stems, and, waving their silvery tints in the sun, seem to smile and say, We are your contemporaries, but the antiquated parent whence we spring once put forth branches under the shade of which Cicero and Mecænas reposed.

CONVERSATION X.

ON THE ACTION OF WATER ON PLANTS.

MRS. B.

Water may be considered as acting on plants in several different ways; the first and most important of which is, its being the vehicle of their nourishment. The greater the quantity of nutritive particles which water contains, the more favourable it is to vegetation, unless it should be so far saturated as to be too dense to pass through the pores of the spongioles. In that case the plant is reduced to the state of Tantalus, and perishes of famine in the midst of plenty.

We have already observed, that of three particles of water which enter a plant, one only remains within it; and this either retains its natural liquid state, analogous to the water of crystallisation in minerals, or is decomposed, to contribute to the formation of oils or other peculiar juices of vegetables.

In the second place, water acts mechanically on plants, by dilating them, and rendering them supple. The woody fibre absorbs water abundantly, but not the bark. The former is often so swelled by this absorption as to burst and split the bark.

CAROLINE.

This is no doubt one of the causes of the roughness of the bark of many trees, such as the oak and the elm, which are seamed and severed into small parts.

MRS. B.

Yes; these, in the course of time, dry and fall off. In other trees the bark remains smooth, but peels off when split by the swelling of the wood.

EMILY.

But how can the wood absorb water if it does not pass through the bark?

MRS. B.

By the internal vessels. If the trunk of a felled tree lie on the ground in a damp spot, with the roots and branches cut away, so as to leave the vessels exposed at both ends, it will absorb so much water as frequently to make it sprout small branches and leaves.

EMILY.

I recollect seeing an instance of this in Kensington Gardens: the log was lying partly immersed in water at the bottom of a dell, and the whole of it was sprouting with verdure.

MRS. B.

Thirdly, water conveys air into plants; and the more it is impregnated with air, whether atmospheric or carbonic acid, the better it is adapted to promote their growth. Thus the water of large rivers which flow rapidly, and pass over a great extent of country, is much more favourable to vegetation than that of small rivulets, which have not been a sufficient length of time in contact with the atmosphere to become impregnated with air: yet this latter is preferable to the water of a lake, which has little or no current; for it requires a considerable degree of motion, to mix water and air together in the quantity which is required by plants. Large lakes, such as that of Geneva, it is true, are considerably agitated by the wind: the waves then swallow up a certain quantity of air; but when tranquil they contain much less than river water.

CAROLINE.

Yet is not the water of ponds preferred to that of rivers for watering plants, although it is so tranquil as frequently to become stagnant, and to be covered with a green slime, which shows that it can have been little agitated by the wind?

MRS. B.

This green scum is a vegetable production, affording food to numerous swarms of the insect tribe, flies, worms, snails, &c. In a short space of time this little ephemeral population, as well as the vegetables which nourished it, perish, and putrefaction succeeds, as you may frequently have discovered by the offensive effluvia exhaled by ponds and marshes of this description; but these corrupted waters, though they may appear to us disagreeable and deleterious, are very beneficial to the vegetable creation. Saturated with the decayed remnants of both animal and vegetable matter, and replete with carbonic acid, they convey these rich materials for fresh vegetation into the roots of the living plant.

CAROLINE.

The only danger, then, is lest the fluid be too abundantly laden with food, and the plant be gorged with it.

MRS. B.

As plants are not capable of acquiring the virtue of temperance, Nature has wisely provided against their suffering from excess, by giving them mouths of such very small dimensions, that they cannot take in more than is good for them. The only danger, therefore, is, lest the fluid should be too dense to obtain entrance at the roots.

The water least fit for plants is that of springs: and, when obliged to use it, we should endeavour to remedy the double defect of a deficiency both of air and of temperature, by leaving it exposed during some length of time to the atmosphere. If the reservoir in which it is contained be situated in the neighbourhood of a farm-yard or stables, the water will become impregnated with carbonic acid produced by the manure. Advantage may also be taken of such a vicinity to enrich the water of the reservoir, by conveying a small stream through the manure into it.

EMILY.

But spring-water is not always of a lower temperature than the atmosphere: during a frost it is evidently warmer, being sheltered from the cold by the depth whence it rises.

MRS. B.

Plants do not then require water: it is in summer that this artificial aid is wanted, and never at a season when the temperature of spring-water is higher than that of the atmosphere.

EMILY.

How beautifully the watering of the vegetable creation is contrived! the rain falling in small drops through the atmosphere, acquires its temperature, and becomes impregnated with air.

CAROLINE.

Yet rain-water, as it consists of pure vapour exhaled from the surface of the globe, can hold no nutritive particles in solution.

MRS. B.

You must observe that, when rain falls on a plant, it merely refreshes the foliage, by washing off the dust, and cleansing the evaporating pores, which may have been clogged during the drought. Rain cannot feed the plant as it falls from the clouds: the absorbent pores, you know, are not exposed to its influence: in order to perform this second function it must penetrate into the earth in search of food, and, dissolving whatever it meets with appropriate for that purpose, convey it to the roots of the plant.

Attention should be paid to the proper time and season for watering plants. They do not require it at all in winter, when planted in the open air; because, during that season they cease growing, and, consequently, stand in no need of nourishment; indeed, they often absorb more water from the wet soil in winter than is good for them. Greenhouse and hothouse plants should be watered with great moderation in winter: it is only requisite when their leaves begin to droop and wither. As spring approaches, the quantity of water must be increased, in order to feed the young buds, which call up additional sap; but the increase must be made with precaution, the earth being still moist with the winter rains. Plants at this season should be watered in the morning, in order that they may not be overloaded with moisture during the night, which would be dangerous should a frost chance to occur: besides, by watering in the morning, you provide for the evaporation of the day.

EMILY.

Yet our gardener generally prefers watering in the evening, if he does it only once a day.

MRS. B.

In the midst of summer the plant, exhausted by evaporation during the heat of the day, requires water in the evening to revive it; there is then no danger of its suffering from frost during the night. In Switzerland, where heat and light are much more powerful than they are with us in England, it is generally necessary in summer to water plants both morning and evening: the earth is dry; and it is difficult to provide for the immense increase of the absorbing and evaporating functions.

There are some plants which grow perfectly well on the Alps, because they are, throughout the summer, watered by streamlets supplied by the melting snow: these same plants perish on the Jura, or any other mountain which is free from snow in summer, because they are not furnished with so regular a current of water.

In autumn, trees which bear pulpy fruits, such as the peach and the plum, require a great deal of water to fill out and to ripen the fruit, while those which are of a dry nature, such as nuts and dates, do not need so much. The precaution of watering in the morning is equally necessary as in the spring, lest the plant should be surprised by a frost during the night.

CAROLINE.

Grasses and herbs, I suppose, require more water than trees; for, consisting chiefly of leaves, they must undergo a greater evaporation.

MRS. B.

Yes; and annual grasses the most of any.

Seeds which are beginning to germinate, should be watered very sparingly; for the seed, feeding at first on its own proper substance, is rather in want of air than of water; but as soon as it has put forth roots, and a stem has sprung up, it will require a more plentiful supply until the time of flowering, when it must again be restricted, because the blossom is nourished by its own peculiar juices elaborated by the leaves; and when the seed ripens, if it be of a dry nature, still less water must be given.

The quantity of water depends, also, upon the nature of the cultivation. You must consider what is the produce you wish to favour: if it be a meadow, leaves and not flowers will be your object; therefore you must water profusely; since abundance of water is favourable to leaves, and prejudicial to flowers. If it be a field of corn, on the contrary, you must water sparingly, in order to produce the grain. Rye is cultivated sometimes with a view to the grain, and sometimes chiefly for the straw; in the first case you should water but little, in the latter abundantly.

The siliceous soil of Ireland is very favourable to the culture of corn: this earth not being retentive of water, the abundant rains of that country do not injure the crops. A similar soil in France will not admit of the cultivation of corn; because the climate being much hotter, the corn requires more water, and can be raised only with success on an argillaceous or clay soil, which retains the water.

EMILY.

In watering fruit trees, I have observed the gardener dig a trench round the tree, at some little distance from the stem, and pour the water into that, instead of watering close to the tree.

MRS. B.

A judicious gardener will apply the nourishment to the mouths of the plant it is to feed. Now these, you know, are situated at the extremity of the roots; and as the roots spread out beneath the soil, pretty nearly to the same extent as the branches above ground, the tree should be watered at the distance of the extremity of the branches from the stem; the closeness of garden culture usually prevents a trench being dug so far from the tree, but the nearer you approach to it the better. Observe how admirably Nature teaches us this lesson: the head of the tree, in the form of a dome, protects the stem from the rain, like an umbrella: all around the soil is exposed to the rain, and the water penetrates the earth just where the extremities of the roots are situated to receive it. In addition to this, the greater part of the rain, which has washed and refreshed the leaves, trickles down from the ends of the branches, and reaches the ground in the appropriate spot.

CAROLINE.

How beautifully contrived! I shall not in future take shelter from a shower, beneath a tree, without thinking of it.

EMILY.

What strikes me with the greatest wonder, in Nature, is the ease and simplicity of the means employed: it is always a natural consequence — a thing of course; it would require efforts to prevent, rather than to produce such results: the facility with which they are accomplished does not draw our attention; but when we do observe and study them, we cannot but feel their infinite superiority to the most complicated contrivances of art.

MRS. B.

The greater and more comprehensive the mind that contrives, the more simple, in general, are the means employed; you may admire, therefore, but you can scarcely wonder at the perfection of the economy of Nature.

In order to form correct ideas on the theory of watering, we must distinguish between the means which are natural and those which are artificial. The former consists in rain, dew, and the melting of snow, but as this last belongs only to the Alps or other countries where the mountains are constantly covered with snow, I shall not enter into any details upon it. Since it is beyond the power of science to increase or diminish the quantity of rain by a single drop, or to hasten or retard, by a single minute, the period of its falling, we must limit our efforts to the study of the signs of the times and seasons of approaching rain, in order to modify our culture, so that it shall receive advantage rather than injury from it.

EMILY.

Does not the barometer indicate the approach of rain with tolerable accuracy?

MRS. B.

Far from it: according to the most exact calculations, it is found that the descent of the mercury is followed by rain only seven times out of eleven.

CAROLINE.

Then you have the hygrometer?

MRS. B.

That is of little use as a sign of approaching rain: it indicates merely the degree of moisture of the spot in which it is situated, and gives us no insight into the state of the upper regions of the atmosphere.

Wind blowing from places where a greater degree of evaporation takes place is one of the most unquestionable precursors of rain. This is the case with winds blowing from the sea; thus the west wind comes loaded with vapour from the Atlantic Ocean, which it deposits on the continent of Europe.

EMILY.

But why does the south wind bring us rain? we may consider that as coming from the dry heated continent of Africa, for the Mediterranean Sea is too insignificant to impregnate it with vapour.

MRS. B.

The climate of Africa being considerably hotter than that of Europe, a greater evaporation takes place there; the atmosphere dissolves and contains much more water than our colder regions are capable of holding in solution; the air, therefore, as it advances northward, becomes loaded with a precipitation of vapour, which congregates into clouds, and falls to the earth in the form of rain.

CAROLINE.

That is very curious; and a north wind, on the contrary, being able to maintain more vapour in solution in our climate, than it did in the colder countries whence it blows, scarcely ever brings us rain. I have heard that swallows flying low, flies stinging, fowls rolling themselves in the dust, and cattle feeding voraciously, are all signs of approaching rain; pray, are these merely rustic prejudices, or will they admit of an explanation?

MRS. B.

Swallows fly low before rain to catch the insects, which then come nearer to the ground for shelter; they may, also, approach the earth in search of worms, which make their appearance above ground in times of rain: then a species of fly, which stings, frequently makes its appearance on the approach of wet weather; fowls may possibly cover themselves with dust in order to preserve them from the wet; and cattle may, instinctively, lay in a store of food as a provision against the time they must abandon their pasture to seek shelter from the rain; but I do not pretend to advance these opinions as any thing more than conjectures.

The second mode which nature employs to water plants is the dew. I hope you recollect the very ingenious theory of Dr. Wells on that subject?

EMILY.

I fear but imperfectly.

MRS. B.

I advise you to look it over*; at present I shall only say, that it is founded on Professor Prevost's Theory of Radiant Heat. In proportion as a body radiates, its temperature must necessarily be lowered, unless it be supplied with heat from some foreign source: during the day the sun affords this supply very amply, but after sunset the earth, as well as every object upon its surface, cools by radiation. The atmosphere, which radiates much less than the solid earth, preserves its temperature longer; but the stratum of air which is immediately in contact with the ground is cooled by it, and deposits upon it that portion of vapour which the diminution of its temperature prevents it from longer

* See Conversations on Chemistry, vol. i. p. 98. 12th ed.

holding in solution. This precipitation is the dew, which you perceive on the grass, after sunset.

EMILY.

Since it proceeds from the cooling of the surface of the earth, why is it not equally precipitated on gravel walks and pavement?

MRS. B.

Because the stones of which these are composed are not good radiators, and therefore preserve their temperature longer; and if they do not cool quicker than the air with which they are in contact, no deposition of dew will take place. Minerals, and especially metals, are bad radiators; they require no dew: Nature reserves this mode of watering for the vegetable creation: to plants she gives the power of abundant radiation, both to enable them to throw off the heat with which they have been oppressed during the day, and to call down those refreshing showers of dew which restore their vigour. This is another example of the wise provision which is thus made for the benefit of the vegetable kingdom, and of the simplicity of the means by which it is accomplished.

CAROLINE.

I imagined that the dew fell from a considerable height; for trees afford a shelter from it: you seldom find any dew beneath a tree.

MRS. B.

The radiation of the earth is stopped by the canopy of the tree and reflected back to the ground, thus preventing it from so rapidly cooling as to occasion a deposit of dew. For the same reason, when the sky is covered with clouds, the heat is reflected back to the earth by them, and little or no precipitation of dew takes place; while, on a clear night, the radiation goes on uninterruptedly, the earth cools rapidly, and an abundant dew is deposited.

EMILY.

How admirably this provision is proportioned to the wants of the vegetable creation! A clear sky, which leaves it exposed throughout the day to the ardour of the sun's rays, insures it an abundant supply of refreshing dew in the evening.

CAROLINE.

I have seldom perceived this radiation of heat in England; but in Switzerland it is very sensibly felt on a summer's evening, from trees, walls, and other buildings which have been heated by the sun during the day.

MRS. B.

It is for this reason that, in hot climates, the public walks are less planted with trees, than those of more temperate regions; in the former you can walk out only after sunset, when the neighbourhood of trees is attended with every disadvantage. They prevent the free circulation of the cool evening air. They reflect back the heated radiation of the earth, and are, themselves, a source of heat by their own radiation.

EMILY.

In our more temperate climate, when we frequently walk out during the day, trees afford us a grateful shelter from the sun, and in the evening they have the advantage of retaining the heat and preventing the deposit of dew.

CONVERSATION XI.

ON THE ARTIFICIAL MODES OF WATERING PLANTS.

MRS. B.

We shall now proceed to examine the artificial modes of watering, which may be divided into three classes.

1st. By watering-pots or engines.

2d. By filtration.

3d. By irrigation.

The first mode applies merely to horticulture, for the use of watering-pots can scarcely be extended beyond the garden and greenhouse; the plain spout is calculated for watering the roots, that pierced with holes imitates the rain, and is therefore more appropriate for washing the leaves, and for watering seeds, young sprouts, or delicate plants which require to be watered sparingly.

If the soil be light, or the plants situated near the high road, or exposed to the smoke of a town, they require more water to refresh the leaves; for when the stomas are choked, evaporation is checked, and vegetation injured: in order to render plants healthy, they must not only be nourished, but kept clean.

EMILY.

Greenhouse and hothouse plants being sheltered from the dust, will, I suppose, not require so much precaution?

MRS. B.

But then you must consider that they are exposed to the dust arising from their cultivation within doors, and deprived of the natural means of getting rid of it, the wind, which in the open air prevents the dust from accumulating on their surface: this artificial mode of raising plants, therefore, requires more attention to cleanliness than when grown in the open air; and gardeners frequently use a bellows as a substitute for the wind.

CAROLINE.

Is it not a good way of keeping greenhouse plants moist in the summer to bury them in their pots in the earth?

MRS. B.

Yes, provided they are taken up occasionally, in order to cut off the roots, which shoot through the aperture at the bottom of the pot; for if this operation be delayed till they are housed in the autumn, the roots will be so bulky as to render their amputation dangerous.

CAROLINE.

Yet is it not the nourishment which the plant obtains from the soil, by shooting its roots through this opening, which gives it so much vigour?

MRS. B.

True, but the small fibres which sprout out after cutting away the projecting roots are sufficient for this purpose. The main object of the hole at the bottom of the pot, is in order that the water may filter through; without this resource it would become stagnant around the roots, and rot them. The opening is, you know, partially closed by a piece of tile, leaving only room sufficient for the water to escape which is not absorbed by the roots; but when the plant is too sparingly supplied with water, the roots insinuate themselves through the aperture to search for it in the soil beneath.

Watering by filtration is adapted to two classes of plants; those which suffer from excess, and those which suffer from scarcity of water: it may be performed in two ways; the one by enclosing the pot which contains the plant in a larger vase full of water, and then burying the double vessel in the earth, the water will filter from the outer into the inner vase, which must, of course, not be glazed, but of a porous texture. The other mode is to place a pot of water contiguous to that which contains the plant, and connect them by means of a skein of worsted which will act as a syphon, and transfer the water to the vase in which the plant grows.

In the Island of Corfu I have heard that it is usual to water the orange trees by surrounding them, at the distance of the extremities of the roots, with very porous pots of water; the water oozes through into the ground, and is sucked up by the spongioles.

Meadows are commonly watered by filtration, small trenches are dug, into which water is occasionally made to flow, and thence it filters into the adjacent soil: these trenches need be but little below the surface of the soil, for the water to penetrate to the roots of the grass.

EMILY.

The trenches are, I suppose, left open in order that the water may derive the benefit of exposure to the air?

MRS. B.

They are sometimes buried in the soil, and at others left open. The first have the advantage of economising the soil, as the ground above them may be cultivated; loss is also prevented by evaporation; yet I think the open trenches preferable, both on account of exposure to the air, and as affording facility for repairs, which are often required.

3dly. Watering by irrigation is performed by means of small channels similar to those used for watering by filtration, but which are made, at pleasure, to overflow the adjacent ground. In order to accomplish this, it is essential to be furnished with an ample supply of water; if it can be obtained from a superior elevation the operation will be greatly facilitated.

When, on the contrary, it is necessary to raise the water from rivers or wells, various mechanical means are resorted to. The current of a river may be used to turn a wheel furnished with small buckets, which, during one revolution, filled with water, raise it, and pour it into the reservoir prepared to supply the channels of irrigation ; when there is no current, horses may be employed to turn the wheel.

The hydraulic ram is another mode of raising water. M. de Candolle mentions one, which, put in motion by a fall of water of twenty feet, raised a body of eight cubic feet per minute to the height of one hundred and sixty feet.

EMILY.

I should think a steam-engine would afford the most effectual means of raising water ; is it not used for this purpose ?

MRS. B.

Very frequently, for draining mines ; but it would, I conceive, be too expensive a mode of raising water for the purpose of agriculture ; at least, I never heard of it being so applied.

The rain-water which falls from the roofs of houses is frequently turned to account ; from its being soiled, it is the better calculated for the nourishment of plants. Sometimes, and this is an excellent method, these washings of roofs are collected into tanks, dug in the ground, and carefully lined with a coarse cement impermeable to water. They are roofed over and covered with earth, so that nothing appears above ground but a small pump, by means of which the water is raised for the garden and for common household purposes.

CAROLINE.

But surely, Mrs. B., it cannot be clean enough to drink?

MRS. B.

It deposits all that it has washed from the roofs and is pumped up perfectly clear, but still it is only rain-water, and therefore insipid and heavy, wanting both the air and the salts which make spring water so much pleasanter to the palate.

Artificial modes of watering were first practised by the Moors of Spain; their labours in that department were very extensive. Near Alicant they constructed a wall between two hills in order to retain the water which flowed through the valley, for the purpose of irrigating the adjacent country. This wall, which is still in existence, is only twenty-four feet in length at the base, that being the breadth of the valley; but the hills receding as they rise, it is two hundred and sixty feet long at the top, and sixty-seven feet in depth; which is much more than is required to withstand the force of the waters it confines; but the Moors were not versed in the laws of hydraulics.

There are various modes of irrigation: the inundations are sometimes flowing, sometimes stagnant; sometimes transitory, at other times permanent, according to the nature of the crop. Of the latter description are the rice plantations: this plant requires such abundance of water, that the inundation is drawn off only when the grain begins to ripen.

EMILY.

I remember, in Lombardy, seeing the green tops of the rice peeping through their watery bath, and looking not very unlike the green scum which frequently covers pools of stagnant water.

MRS. B.

Nor does it appear to be less pernicious: for the cultivators of these rice fields are often afflicted with a frightful cutaneous disease, which terminates frequently in madness and self-destruction. This disease, called the *Pelagra*, is supposed to proceed from feeding on maize, or Indian corn, improperly prepared. Its origin was for a long time an inexplicable mystery; and it is only lately that Dr. Sette observed that it was confined to those districts in which the maize, instead of being preserved in the ear, was kept, like wheat, in separate grains, ready to be ground into flour. This led him to suspect that the grain might have acquired some deleterious property in that state; and, on examining it with a microscope, he discovered that that part of the grain, by which it had been attached to the husk, was covered by a species of mould of a poisonous nature; there is, therefore, every reason to believe that this fatal disease arises from feeding on maize in this corrupt state; and if so, it might be easily guarded against.

EMILY.

What a fortunate discovery! The remedy is so simple, it is merely to adopt the usual mode of preserving maize in France and Switzerland, by hanging it up to dry in the ear.

MRS. B.

Certainly, if this should prove to be really the cause of the disease. We have hitherto considered only the various modes of giving water; but it sometimes happens that the earth is too moist: it is necessary, therefore, for the purposes of agriculture, to be acquainted with the best mode of taking it away. This operation may be performed in several ways. When circumstances will admit of the construction of a reservoir in a lower situation to receive it, the water may be carried off by subterraneous ducts. These conduits should be filled with pebbles, sufficiently large to leave a free passage for the water to flow between them.

CAROLINE.

But of what use are the stones? why not leave the channel quite free and open?

MRS. B.

The stones may be considered as forming a sort of loose wall which serves to support the duct, by preventing the top and sides from falling in: the water would soon wear them away, were they not thus defended, and the passage be obstructed.

The operation of draining a marsh is of much greater importance. A marsh is a space of ground on which the water remains too long, either for want of means to run off laterally, or because a layer of clay soil prevents it from filtering downwards.

CAROLINE.

I should have thought that this abundance of water would have been favourable to the culture of many species of plants.

MRS. B.

It is true that marshes cannot be said to be inimical to vegetation in general, for these spots abound with plants; but they are of an aqueous nature, unfit either for the use of man or cattle. They afford, however, an ample repast for the creeping things of the earth; and when we condemn noxious weeds and stagnant marshes, we should remember that, though man is lord of the creation, this world was not made for him alone, and that the reptile and the worm have also their share of its enjoyments. When it is required to drain a marsh of small extent, it may be done by planting it with willows, alders, and poplars. These trees being of very rapid growth absorb a considerable quantity of water, the greater part of which they evaporate into the atmosphere. The poplar has also the advantage of affording very little shade; it does not, therefore, interfere with the action of the sun and air, agents which perform very prominent parts in the operation of draining.

Very extensive marshes will not admit of being drained merely by planting. In this case, the mode resorted to is to raise a bank of earth around the marsh, which answers the purpose of a dam, and prevents the water from running into it; for, if once you accomplish this, the ground is soon dried by the mere process of evaporation. If the marsh be occasioned by a clay soil, this earth, which does so much harm by retaining the water after it has entered the marsh, will do as much good from the same impermeability when raised in the form of a bank to prevent the water from entering. In digging for this purpose, the earth must be thrown up towards the marsh, so as to leave the trench or ditch external; the water will then run off by this ditch instead of filtering through the dam raised on the other side. The dam should be formed in the shape of a hog's back, and pressed down hard towards the base, in order to prevent the water in the ditch oozing through. The dam or dyke may be planted with trees, the roots of which will help to keep it together, and the evaporation by the leaves will assist in draining it; but care must be taken to thin the branches, in order to give free access to the sun and wind; nor must they be allowed to grow high, lest, being more easily blown about, their roots should be loosened, and thus the dyke be injured instead of preserved. On the side next the ditch it is advisable to plant reeds.

EMILY.

But how are you to get rid of the water which fills the ditches?

MRS. B.

That depends, in a great measure, upon the locality:

it must be carried off to the nearest running water, or to the sea; without a resource of this kind, it would be vain to attempt draining. If we can succeed in preventing the external waters from gaining admittance, that which the marsh contains is so soon dried up by evaporation, that care must be taken not to overshoot the mark, and leave an insufficiency of moisture for the purpose of cultivation.

CAROLINE.

Some attempts of this kind appear to have been made towards draining the Pontine marshes; a canal of water borders each side of the road, which is flanked by a bank of earth planted with trees; and when we passed, I was sorry to see that they were cutting most of them down.

MRS. B.

It was probably found, that more injury was produced by their shade, than benefit derived from the evaporation of their leaves. But this attempt at draining the Pontine marshes is of a very circumscribed nature, and attended with little success; although the vicinity of the sea affords facility for carrying off the water.

It is a very laborious undertaking to drain marshes which are situated below the level of the sea, as is generally the case in Holland, and it requires all the patient persevering industry of the Dutch to accomplish it. They begin by making the water run off into canals, and then raise it, by mechanical means, into more elevated channels, till it is higher than the level of the sea.

CAROLINE.

But the level of the sea varies according to the tides, being many feet more elevated at high water than at ebb tide.

MRS. B.

The medium must therefore be taken as the general level; and, raising the most elevated canals above that, let off the water at ebb tide into the sea: the canals are furnished with locks, which are then closed to prevent the water returning when the tide flows. The mode used in Holland to raise the water from the lower to the upper canals consists of a species of small windmills: as the wind blows regularly, though not violently, in that country, they perform their office very well. The same expedient of windmills is adopted in Cambridgeshire and Bedfordshire.

EMILY.

Pray can you explain to us the mode in which the valley of Chiana in Tuscany, which was anciently an unwholesome marsh, has been brought to such a beautiful state of cultivation as it now exhibits?

MRS. B.

The marshes in Tuscany are formed by the waters which flow from the Apennines, and which, not finding a sufficient vent, are arrested in their course, and become stagnant. The Apennines being of a loose sandy texture, the waters bring down with them a great quantity of earth, which they deposit in the lowest parts to which they flow.

CAROLINE.

I recollect that the Arno, when swollen by rain, is quite thick with mud, brought down from the mountains by the torrents which feed it.

MRS. B.

The celebrated Torrecelli took advantage of this deposit of mud to invent a mode of draining the marsh of the Chiana. But before I explain the remedy, it will be necessary to inform you whence the evil arose.

In ancient times, the numerous rivulets which flow from the adjacent hills into the valley of Chiana poured their united waters from thence into the Tiber. Some inconvenience being experienced by the Romans, from occasional overflowing, they constructed a dyke to close this outlet. The waters, thus stopped in their course, formed a lake, which, when gradually raised to a certain elevation, found an issue to the north, precisely in the opposite direction to that in which the water formerly flowed out of the valley. The rivulets, therefore, on entering the valley, were all obliged to change their course. In making this turn, their velocity was diminished; and having no longer power sufficient to carry with them the earthy materials with which they were laden, these were deposited in the lake, in which they accumulated, and, in the course of time, converted it into a marsh. The ingenious and sagacious Torrecelli availed himself of the evil to devise a remedy; and employed the very means which had converted the lake into a marsh, to convert the marsh into dry land.

EMILY.

That was a most happy idea; but how did he accomplish it?

MRS. B.

He caused a mound or bank of earth to be raised towards the base of the hill, around the part where a rivulet changed its course. This was left open on the highest side; so that the water, laden with earth, might have free access to it in its descent; on the lower side a small aperture was made through which the water alone could escape, leaving behind the earthy matter with which it was saturated. In the course of time, the soil within this enclosure was elevated, by the accumulation of earth, above the level of the stagnant waters; and rose, like a peninsula, on the edge of the marsh. A contiguous enclosure was then made, and raised by similar means; a third and a fourth followed in succession. These labours have been going on during the course of two centuries: of late years they have been prosecuted with great activity and sagacity by the celebrated Fosombroni of Florence ; and a few years more will alone be required to complete them. This district is already transformed, from a melancholy and pestilential marsh, into a richly cultivated valley, watered by a clear stream, the result of the torrents purified from their earthy deposits.

CAROLINE.

It is, indeed, quite a metamorphosis : and is not this mode adopted in other countries ?

MRS. B.

It is frequently employed in the environs of Bologna, and in several other parts of Italy. This operation is called in Italian *colmare*, in French *combler*, that is to say, to *fill up*. I once, in travelling, saw it carrying on, in a spot on the declivity of a hill ; for you understand that it can take place only where the ground slopes, so as to enable the waters to run off.

CAROLINE.

When the mountains from which the rivulets bring down the earth are of schist, like the Apennines, this operation must be much more easily effected than when they are of granite, for the harder the earth the less earthy matter the waters can wash down.

MRS. B.

When the mountains are of granite, no deposit of earth takes place to interrupt the course of the streams, and produce a marsh : the evil cannot exist, therefore the remedy is not required. Elaborate and artificial as this mode appears, it is, in fact, precisely that which is employed by Nature to level the inequalities of the globe : the streams are always conveying earth from the mountains to deposit it in the valleys, thus lowering the one and elevating the other. It is thus that the plains in the north of Italy, between the two ridges of the Alps and the Apennines, have been formed. The rivers flowing from these long chains of mountains have deposited their solid contents in the intervening low lands, raised and united the several valleys and levelled them into plains, such as those of Lombardy and Liguria; and had Nature been allowed time to complete her work, they would have been elevated to a height which would have preserved them from danger; but man was impatient to inhabit this alluring paradise, before its creation was completed. Hence, instead of profiting by the gratuitous labours of Nature, who was gradually preparing it for his reception, he has been compelled to repair by artificial means, at the expense of immense toil and trouble, the evils resulting from the interruption given to her operations.

EMILY.

But of what nature are those evils?

MRS. B.

Inundations produced by the quantity of turbid waters, which, in rainy seasons, is frequently so great as to overflow the whole country, and destroy cultivation. The inhabitants, therefore, found it expedient to put a stop to this levelling system of Nature by embanking the rivers, in order to confine the waters within their beds.

CAROLINE.

We observed that in Lombardy and in Tuscany the rivers were generally embanked: but I should have thought that such a measure would have afforded but a temporary remedy; for those very sands which Nature would have employed to raise the general level of the plains, being deposited at the bottom of the rivers, would, in the course of time, so raise their beds, that the waters would overflow the embankments.

MRS. B.

Very true: the only resource was to heighten the embankments in proportion as the beds of the rivers were raised. In consequence of this elevating system of art, in opposition to the levelling one of Nature, the Adige and the Po are higher than the plains which separate the two rivers; and it is thought that it will be ultimately necessary to form new beds for their waters, in order to avoid the ruin they threaten.

The plains of Holland derive their origin from a similar process; but they are exposed to still greater dangers than those of Italy, lying so low as to be menaced not only by the overflowing of the Rhine and the Moselle from the shallowness of their beds, but by inundation of the sea. Every defence which art can afford, such as embankments, dykes, canals, &c., has been achieved by the patient and industrious inhabitants of that country; yet the resistless ocean frequently breaks in upon them, and destroys all their labours.

EMILY.

What a prodigious quantity of earth and sand rivers must carry into the sea. It is well that its bed is too deep to be affected by such deposits.

MRS. B.

It is true there is no danger of their occasioning an overflowing of the sea: important effects, however, are frequently produced on its shores. The impulse of the rivers is diminished on reaching the sea, by that of the waves they have to encounter. Sometimes their waters are partially driven back on the shore, where they form marshes: districts of this description abound on the coast of the Adriatic. Sometimes they deposit their solid contents in one large bank, when their current is first repulsed by the waves of the sea, and form at the mouth of the river a plain or Delta: such is the Delta at the mouth of the Nile.

CAROLINE.

And if we may be allowed to compare small things to great ones, such I suppose is the origin of the Delta or low land, at the mouth of the Rhône, on entering the Lake of Geneva from the Valais.

MRS. B.

The Isle of Camarque, formed by the deposit from the waters of the Rhône at its entrance into the sea, offers a still more striking example. The rivers have sometimes sufficient power to struggle against the resistance of the waves, and do not deposit their mud and sand till they have advanced to some little distance in the sea; and there, broken and divided by the waves, the earthy matter seems to subside into separate spots, forming a number of small islands; hence the origin of those on which Venice is built.

Our conversation has been longer than usual to-day; I have but one more remark to make to conclude this subject.

When it is required to resist the force of an irregular mountain-torrent, a number of small embankments is preferable to one large dyke, however strong; for during violent rains there is some danger of the dyke being carried away, while several small embankments successively break the force of the waters.

CONVERSATION XII.

ON THE ACTION OF THE SOIL ON PLANTS.

MRS. B.

Our last conversation was upon water; to-day we shall change the subject to dry land. It has been asserted, that earth was not absolutely essential to vegetation, because there are some plants which do not require it, which live in water, whence they derive their nourishment: but this class is very insignificant. The earth affords both support and nourishment to plants, or I should rather say, is the vehicle of their nourishment, since that is principally composed of animal and vegetable remains; for the various saline particles which plants pump up from the soil, should rather be considered as flavouring their food, than forming a nutritive part of it: their daily bread is of animal and vegetable origin.

CAROLINE.

And when there is a deficiency of salts to flavour their food, have not plants the power of forming them in their internal laboratory?

MRS. B.

No; the chemical apparatus of their organs is so arranged that it can elaborate only vegetable juices, and is as incapable of forming a salt or an oxide, as an animal is of forming internally the phosphate of lime, with which its bones are hardened.

EMILY.

How, then, are these salts, which are composed of various ingredients, formed?

MRS. B.

The metals intermixed with the earths of which our globe is composed attract oxygen from the atmosphere, and combine with it; and it is thus that the mineral kingdom prepares the oxides, for the use of organised bodies.

In order to support plants, the ground must be neither too compact nor too loose. They can grow neither upon a hard rock nor in a moving sand; for their roots can neither penetrate the first, nor take firm hold on the latter.

EMILY.

Besides, a plant would find no food to nourish it on a barren rock.

MRS. B.

That most patient and perserving of agriculturists, Nature, teaches us how to prepare a soil, even on the hard rock, or the steril lava of a volcano: she commences her operations on these obdurate bodies by means of her elementary agents, air and water. If the rock be of a calcareous nature, the lime is gradually dissolved, a decomposition begins to be effected; and hence the origin of a soil. If it be silicious, the operation is more difficult: but Nature, unrestricted by time, finally accomplishes her object. On this shadow of a soil, a vegetàtion, almost imperceptible from its minuteness, begins to exist: the invisible seeds of lichens, which are always floating in the air, there find an asylum. Minute as these seeds are, they are furnished with admirable means to attach themselves to hard bodies; and, once fastened to the rock, they find sufficient nourishment in the moisture they have absorbed from the atmosphere during their aërial flight to make them germinate, though not sufficient to bring them to perfection, and enable them to produce seeds to continue their species; but when they perish, a new race rises, phœnix-like, from their remains.

CAROLINE.

This is indeed a curious mode of raising plants! What a careful provision even for the most insignificant of the vegetable kingdom!

MRS. B.

It is these remains, mixed up with some of the crumbled particles of the rock, which constitute the first bed of earthy soil, in which the seeds of more robust lichens and mosses sow themselves, and find nourishment; thus a variety of plants, annually increasing in strength and vigour, rise up in succession, till the dry rock becomes covered with verdure, and ultimately clothed with trees. You see, therefore, Caroline, that you have no more reason to despise the humble plants in whose remains a soil originates, than to underrate the germ of a shoot which may produce a stately oak.

There is another process which nature frequently employs to clothe a barren rock; wherever there are fissures the rain insinuates itself, and by freezing in winter often splits the rock, or at least widens the crevices; it is in these humid recesses, where the water has crumbled the rock, that seeds bury themselves, and vegetation commences.

EMILY.

In attempting, then, to cultivate a barren soil, we should follow the same system, and scatter seed in such crevices, which, if they did not arrive at complete maturity, would, by their remains at least, help to prepare a soil.

MRS. B.

This is often done; for instance, in the fissures of the lava of Mount Etna, Indian fig or prickly pear has been sown; the roots of which insinuate themselves into every little cavity, and help to split the block. This plant produces a great quantity of fruit; but its most important recommendation is, that it forms a soil for future vegetation: but to proceed to soils of a less obdurate nature.

A stiff argillaceous soil is difficult to cultivate, on account of the resistance it opposes to the progress of roots. Ground of this description attracts moisture, and is so retentive of water as to be seldom dry, unless during the heat of summer, when it splits; and it is in the crĕvices thus formed that vegetation commences. Such a soil requires frequent ploughing, in order to break down and pulverise the clods: when practicable, earth of a lighter nature should be mixed with it. Plants having large roots will not, in general, succeed in ground of this nature, as they will not be able to penetrate it.

EMILY.

Yet plants with small delicate roots would have still less strength to do so.

MRS. B.

True; choice should therefore be made of plants which have slender, but firm and strong roots: those whose roots are of a dry nature are best adapted to hard, impenetrable soils.

A sandy soil offers difficulties of an opposite description. If the sand be mixed with calcareous matter, these are more easily overcome; for a portion of the lime is dissolved by rain, and its solution gives some degree of stability to the soil: but if the sand be almost entirely silicious, like that of the sea-shore, the evil is well nigh insuperable; for this species of sand is insoluble, and nothing can change its nature. Hence the impracticability of cultivating the sandy deserts of Arabia, Africa, and of various other parts of the world.

EMILY.

Yet, if such deserts existed in Europe, do you not think that means would be discovered to overcome the difficulty?

MRS. B.

I rather doubt it. The wind which blows without restraint over these unsheltered and unstable plains tears up the roots of every tree that is planted.

EMILY.

But small low shrubs would offer but little resistance to the wind.

MRS. B.

These would soon be buried by the whirlwinds of sand. The plants most likely to succeed would be such as are of moderate stature, with spreading roots to fix them in the soil.

When sands are of small extent they may be improved by mixing clay with them; and the first crop should be raised solely with the view of ameliorating the soil.

There are three species of sandy soil: that which forms the banks of rivers; that which composes those extensive plains called steppes; and that which forms sand-hills on the sea-shore. On the borders of rivers, stakes of willow and of alder may be planted with advantage; being abundantly watered, they soon shoot out roots and branches, which grow rapidly. Then, if with the stroke of a hatchet these branches be lopped, so as to make them trail upon the ground, without being completely separated from the stem, they will soon be covered with the loose soil and will strike fresh roots: these numerous roots, shooting out in every direction, are interwoven, and form a species of network, which sustains and gives stability to the soil.

In order to bring steppes into culture, which are not so well supplied with water, the first plants raised must have roots which pierce deep into the earth, so that they may find water beneath the sandy soil. The culture of madder has been successfully employed in the neighbourhood of *Haguenot*, as the precursor of general agriculture. It cannot be too often repeated, that when you aim at bringing bad soils into culture, the first produce must be sacrificed for the benefit of the land, with a view to improve it for future harvests.

CAROLINE.

So far as can be judged from the abundance and magnitude of the crops, Belgium appears to be one of the countries in which agriculture is carried to the greatest degree of perfection.

MRS. B.

The beauty of the produce is no bad criterion of the advancement in the art, especially in that country, where Nature has done little for the husbandman; but the Belgic peasantry are nearly as well versed in agriculture as the learned of other countries. Their soil is in a great measure the work of art, man having taken possession of it before its formation was completed.

CAROLINE.

Nor does it appear that the art of man has yet finished it; for though the cultivated parts yield such rich crops, an extensive sandy desert, called the Campine, still remains on the confines of Belgium and Holland.

MRS. B.

True; but this barren waste is rapidly improving. The mode by which the husbandman commences the process of fertilisation in these sterile plains is by sowing Genet or Broom, which grows up in bushes, the roots of which confine the soil, and give it sufficient stability to enable him to sow Pines with advantage. These are followed by Acacias; the branching roots of which, stretching out in various directions and interwoven together, sustain the soil as it were in osier baskets. But it is not until this succession of forests have flourished and decayed that the soil, enriched by their remains, becomes fit for general culture.

EMILY.

This, then, is the work of a long course of years?

MRS. B.

Certainly; but still the formation of the soil is rapid, in comparison to what it would have been, if left to be completed by the gradual agency of Nature. The sand-hills, which are, in many places, formed on the sea-coast, owe their origin to sand thrown up by the high tide, and which, left by the receding waters, dries, and is carried by the wind farther inland, beyond the reach of succeeding tides. The sand-hills formed in the vicinity of Bourdeaux formerly threatened the destruction of the adjacent country: it was calculated that no less than seventeen villages would be overwhelmed by them in the course of a century; when M. Bremontier was so fortunate as to discover a means of averting this danger. Observing that sand thus thrown up was not devoid of moisture, he scattered over it the seeds of broom and of maritime pine; and, in order to prevent their being swept away by the wind, he covered them with brambles and branches of underwood. The seed sprouted; the broom first rose above ground, and some time after the young pines appeared: the latter, however, made but little progress, seeming to be choked by the rapid growth of the broom: yet in the course of a few years the pines gained the ascendency, and drove their antagonists from the field; or rather, I should say, like cannibals, after destroying the enemy, they fed upon their remains.

In the course of time it became necessary to thin this vigorous forest of pines; and their branches served to shelter the seed scattered on neighbouring sand-hills.

CAROLINE.

I recollect reading in Withering, that the Arundo arenaria, or sea-matweed, which grows only on the very driest sand on the sea-shore, prevents the wind from dispersing the sand over the adjoining fields.

MRS. B.

The Dutch have very probably known and profited by this fact.

Hitherto we have directed our attention rather to the formation of new soils than to the improvement of old ones; but however curious and interesting the former may be, it is the latter which is the point of most importance in agriculture; for it is more frequently requisite to improve the land already under tillage, than to prepare a soil, on ground which has not yet yielded any produce.

Soils may be improved by a variety of different processes: by tillage, by amendments, by manure, and by rotation of crops.

These follow each other in natural succession. Man first begins by cultivating the earth; he next endeavours to ameliorate the soil, in order to render it more propitious to the produce he wishes to raise. After having yielded a certain number of crops, he observes that they degenerate, and concludes that the earth is exhausted of its nutritive principles. He finds the means of renovating these principles by manuring the land; and experience teaches him that a judicious system of cropping answers, in a great measure, the same purpose at a smaller expense.

The principal object of tillage is to break and crumble the earth, in order that the roots of young plants may easily penetrate into it; to expose every part of the soil successively to the action of the air, so that such of the earths or metals, as are destined to be converted into salts by the action of the oxygen of the atmosphere, may be brought into contact with it, as well as such remains of organic bodies as can be dissolved only by oxygen. Various implements of husbandry are employed for this purpose; and it is a continual object of dispute, between the agriculturists of different countries, which answers the purpose best.

EMILY.

But is not the plough the instrument universally used in all civilised countries?

MRS. B.

Most commonly; but the plough itself is of various descriptions; and you have observed the peasants of Tuscany frequently employing the spade, an implement which we reserve for garden culture. They are, indeed, bound by the tenure on which they hold their land to dig it up every third year. The spade undoubtedly performs the operation of turning and subdividing the earth more completely than the plough, but at a much greater expense of labour: and it is an instrument adapted only to light and homogeneous soils; for if the earth be of unequal tenacity, or interspersed with stones, it cannot be used. The pickaxe may in those cases be substituted, as it is a pointed instrument which penetrates more easily. This implement is also of various descriptions; it has a single or a double prong, which is broader or sharper, and forms a greater or lesser angle with the handle, according to the nature of the soil.

CAROLINE.

The hoe, that very useful instrument for weeding or lightly raising the earth, is also used like the pickaxe. But what is the reason that the form of these instruments vary so much in different countries?

MRS. B.

Sometimes from improved models being adopted in one country, which another, through ignorance or prejudice, will not follow; and perhaps, more frequently, from the different nature of the soil. The spade or the hoe must be light or heavy, broader or more pointed, according as the soil is loose or stiff; for the heavier or more tenacious the earth, the less quantity can be raised at one stroke. But the most important of all implements of husbandry is doubtless the plough: it has been celebrated since the times of Moses and of Homer; and it is the form of this instrument which has produced the greatest contention amongst agriculturists. The plough may be considered as a sort of pickaxe, drawn by animals through the soil. In northern climates husbandmen are great partisans of deep ploughing; in southern countries they are no less staunch advocates for light or more superficial ploughing; and they are, perhaps, each equally right in approving their own mode, and wrong in blaming that of their opponents, for the different species of plough are adapted to the soil of their respective countries.

In high latitudes, where there is much moisture and but little heat, it is necessary to turn over the earth more completely, in order to dry and pulverise it, especially when of an argillaceous nature, which is very common in northern countries. In more southern climates, where heat and drought prevail, it is better to plough more lightly, the soil being frequently of a sandy nature, not retentive of water.

EMILY.

But supposing the soil to consist of two layers, the one of sand, the other of clay, the plough should, I suppose, go deep enough to mix them together.

MRS. B.

No doubt their union is as favourable to vegetation as their separation is inimical to it. It signifies not which is uppermost before ploughing; the more they are mixed and incorporated together the better.

CAROLINE.

But supposing there should be a good, rich, vegetable soil on the surface, and layers of sterile ground beneath?

MRS. B.

Then a light plough should be used, and as much care taken to prevent the mixture of the two, as to effect it in the former case; in short, attention must always be paid to the nature and locality of the soil. Ploughing must vary, also, according to the nature of the produce to be raised. Lucern, which shoots out roots four or five feet in length, requires deeper ploughing than corn, whose roots are very superficial. Six or eight inches is a sufficient depth for grain in general.

EMILY.

When new land is first broken up, to bring it under tillage, it will, I suppose, require deep ploughing to pulverise the hard earth.

MRS. B.

That also depends on the nature of the soil. In America, where fine rich vegetable soil is daily brought into cultivation, nothing more is required than to scratch the earth with a plough, and scatter the seed, in order to produce an abundant harvest. But in England, and all countries which have long been cultivated, the good soil is already fully employed; and if any new land is ploughed up, it is of a very inferior description, and it is necessary not only to plough it deeply but repeatedly, and to manure it, before it will yield a crop. The operation of bringing grass land into tillage is on the Continent frequently performed by a pickaxe with a double prong, which breaks the earth more completely than the plough.

Another point to be considered in farming is the quantity of manure to be spread upon the land. If this fall short, and the ploughing has been deep, the nutritive particles may filter down lower than the roots can go in search of them.

The more tenacious and compact the soil is, the closer the furrows must be, and the narrower the ridges of earth turned up, in order more effectually to pulverise it, and afford channels for the water to run off. When the soil is light, broader ridges and more distant furrows suffice: it is even sometimes necessary to beat down the earth, after having ploughed or dug it, in order to render it more compact, especially in nurseries of young trees, whose roots, in a loose soil, are liable to be torn up by the wind.

Deep furrows, or trenches, are very useful where the ground is sloping, either to draw off or retain the water as required. If the soil be too moist, the furrows should be made longitudinally, that is to say, from the top to the bottom of a slope: they will then answer the purpose of conduits to carry off the water. If, on the contrary, the soil be dry, the furrows should be made transversely, and the ridges of earth will act as parapet walls to retain the water.

EMILY.

And what is the best time for ploughing?

MRS. B.

It is very necessary to pay attention to the period of ploughing: it can be done neither in a wet season nor during a hard frost, nor in very dry weather; but as you have the whole season before you, from the reaping of one harvest to the sowing for another, it is not difficult to choose a period of appropriate weather, unless it be in some strong clays, upon which a horse cannot be suffered to tread during the winter. If the ground be intended to lie fallow, the best use which can be made of the repose allowed it, is to plough it in autumn, and again in the spring; but if it is to be sown, the sooner it is ploughed after harvest the better, in order to bury the straw or other remains of the preceding crop, which will enrich the soil, and also prevent the further growth of weeds.

In hot countries the land cannot be ploughed in summer, on account of its dryness; besides it would afford the means of evaporating the small remains of moisture of the newly-turned up earth, and that at a period, when it has its most important functions to perform — those of softening and dissolving the hardest and most insoluble particles, which cannot be done unless the temperature of the water be tepid.

CAROLINE.

But how can it be rendered tepid without exposing it to the sun? — And in that case it will be evaporated.

MRS. B.

Exposure is not necessary: the heat of the atmosphere gradually penetrates the soil, and the water diffused in it acquires the same elevation of temperature. Farmers conceive that the soil is injured by the action of ploughing in summer; but the injury proceeds from impeding the solutions requisite for the following crop. In northern climates, where evaporation is less active, ploughing is not so objectionable in summer.

CONVERSATION XIII.

THE ACTION OF SOIL ON PLANTS CONTINUED — ON THE IMPROVEMENT OF SOIL.

MRS. B.

We may now proceed to examine the various modes of improving the soil by mineralogical processes. The first and most simple of these is to clear it of stones; at least when stones are injurious to cultivation.

CAROLINE.

But are not stones always injurious? For of whatever materials they may be composed, they are such hard insoluble bodies that vegetables can derive no nourishment from them.

MRS. B.

True; and yet they sometimes perform a very useful mechanical part in agriculture. They render a clay soil less tenacious by separating its parts, and thus leave room for water to drain off: they form, as it were, so many natural irregular conduits; and, if under such circumstances you take them away, you must employ them for the construction of artificial ducts to effect the same purpose.

CAROLINE.

This may be the case with stones buried in the earth, but those lying on its surface must surely be always prejudicial to vegetation?

MRS. B.

Generally they are so, but not universally: in some hot countries grass cannot grow, excepting under shelter of loose flat stones. I have seen pastures of this description on the plains of Crace, near Arles. They exhibit the singular spectacle of flocks of sheep feeding on dry stones, as the grass which grows beneath them is not visible; but the sheep find a tender, if not abundant pasture, by nibbling beneath these stones, or by turning them up; while the pebbles, thus overturned, afford shelter to the adjacent blades which are just sprouting, and would be burnt up without such protection.

In some instances the ground in which fruit-trees are planted has been paved with stones, in order to retain the moisture beneath, by preventing evaporation.

In cold countries stones are sometimes considered advantageous as communicators of heat, those of a dark colour especially. They act on the surface of the earth both as reflectors and radiators of heat; and are frequently placed round the stems of plants in a vineyard, in order to give them additional heat. It must be allowed, however, that these occasional uses to which stones are applied in husbandry are to be considered rather as exceptions to the general rule, and that they may be looked upon in most cases as either useless or pernicious.

The improvement of soil by the admixture of foreign ingredients, *amendement*, is one of the most important operations of agriculture.

If the soil be too stiff from excess of clay, it will be improved by sand; and if too loose from excess of sand, it will be improved by clay: but when this mixture is made, the clay must be broken and pulverised, which may be effected by exposing it to the frost, and afterwards drying it. Marl is a natural compound earth, used with great success in the amelioration of soils, which consists of a mixture of clay and calcareous earth or lime, in various proportions.

Argillaceous marl, which contains more clay than lime, is advantageous for a dry sandy soil; while calcareous marl, in which the lime predominates, is suited to a clay soil. The great advantage of marl is, that it swells, cracks, and is reduced to powder by exposure to moisture and air.

EMILY.

Yet marl is not spread on the soil but laid on it in separate heaps?

MRS. B.

Marl in masses would be totally useless to the soil; yet it is necessary to begin by laying it on the ground in heaps, for the more it is heaped the more it swells, splits, and crumbles to dust; in which state it is fit to spread upon the ground.

Marl is often intermixed with other earths; it is sometimes formed into a compost with manure before it is laid on the soil: it should be applied sparingly at a time, and renewed frequently.

CAROLINE.

And what effect does it produce on the soil?

MRS. B.

It subdivides the soil and accelerates decomposition, its calcareous particles disorganising all animal or vegetable bodies, by resolving them into those simple elements, in which state they combine with oxygen; it facilitates this union: hence, though not itself of a nutritious nature, it promotes the growth of plants by preparing their food. The best period for marling ground is the autumn.

Lime is also an excellent *amendement*. It is procured from limestone by exposing it to the heat of the kiln, which evaporates the water and carbonic acid with which it is always found combined in nature, and renders it *quick*, as it is commonly called; that is to say, of a caustic burning nature, having such an avidity for water and carbonic acid, from which it has been forcibly separated, that it seizes upon these bodies, wherever they are to be met with, and disorganises the compounds in which they are contained in order to combine with them.

EMILY.

But since lime is of so destructive a nature, I should have thought that it would have been necessary to add, instead of subtracting, water and carbonic acid, in order to soften its caustic properties, which seem calculated rather to destroy than promote vegetation.

MRS. B.

Were quick-lime applied immediately to plants, it is true that it would prove a poison to them; but, when spread upon the earth, it rapidly attracts water and carbonic acid from the atmosphere, and it is only when thus modified that it promotes vegetation.

EMILY.

Then why force from it, in the kiln, those very ingredients which must be restored to it so soon afterwards?

MRS. B.

In its natural state of limestone it is of too hard and compact a nature to be diffused in the soil; and even quick-lime would be too solid, were it not that through its combination with water and carbonic acid from the atmosphere, it splits and crumbles to powder.

CAROLINE.

I should think that it would simplify the proceeding if the limestone were ground to powder.

MRS. B.

I believe that the experiment was tried in Scotland, in order to save the expense of burning it into quick-lime, but it was not found to be efficacious like the powder of slacked lime. No pounding or grinding, which we can perform by mechanical means, can be compared to the minute division produced by chemical operations.

Lime is particularly adapted to poor cold soils, such as those of marshes, which have not energy to dissolve organic bodies. The quantity to be used must be proportioned to the manure which is laid upon the ground ; for the more organic matter there is to be dissolved, the greater will be the quantity of lime required for that purpose. To mix lime with peat-earth is said to have an immediate and most beneficial effect, and many bogs, having been previously drained, have been converted into fertile land by this means.

The lime procured from fossil-shells is highly esteemed by agriculturists : its excellence results, probably, from its retaining some vestiges of organic remains.

CAROLINE.

The shells of living animals must then be still more valuable for this purpose ?

MRS. B.

They could not be obtained in such abundance ; large strata of fossil-shells are to be found in some soils, whilst of living shells you could procure at most the refuse of the fish-market.

Ashes are very beneficial to the soil : they differ of course in their composition, according to the nature of the substances from the combustion of which they result, but their general ingredients are potash, silex, and calcareous earth. They attract moisture from the atmosphere, and thus accelerate vegetation.

Sulphate of lime, commonly called gypsum, is an excellent *amendement ;* but chemists are not agreed as to the manner in which it acts on vegetation. It is strewed over crops when the leaves are in full vigour, towards the latter end of April or the beginning of May, and it should not be laid on more than once in the year. Clover and saintfoin contain gypsum in their stems to a considerable amount; and when soils are said to be tired of those plants, it is probable that they are no longer able to supply this necessary ingredient. It is on those crops that it is found to be most efficacious.

Having now made you acquainted with the various modes of improving the soil, we are next to consider which are the best means of supplying plants with food.

CAROLINE.

All natural soils, with the exception, perhaps, of burning sands, or arid rocks, must contain nourishment for plants ; otherwise they would not grow spontaneously as they do in wild, uncultivated countries, which often abound with forests and rich pastures.

MRS. B.

True ; but though the earth in its uncultivated state be sufficient for vegetation, yet when by agriculture the land is as it were forced to produce a greater increase for the use of man, we cannot raise those rich and numerous crops, so necessary to the existence of the population of a civilised country, without affording the vegetable creation an artificial supply of nourishment ; for it is an axiom, no less true in the vegetable than in the animal kingdom, that food must be proportioned to the population, in order to maintain it. The mode which art has devised to increase the quantity of food for plants is to spread manure on the soil. This consists of the remains of organised bodies of every description, whether animal or vegetable, in a state of decomposition ; that is to say, resolving itself into those primitive elements which can re-enter into the vegetable system.

CAROLINE.

The preparation of food for plants is then precisely the inverse of that for animals, or at least for animals of the human species, for it is necessary that every thing should be decomposed and reduced to the simplest elements, in order to become the nourishment of vegetables. And how is this process performed?

MRS. B.

I have explained it to you in our Conversations on Chemistry: it is by the last stage of fermentation — *putrefaction*. Loathsome as this term may appear to you, yet, when you consider it as the means which Nature employs to renovate existence, and continue the circle of creation, you will think of it with admiration rather than with disgust.

EMILY.

It is very true; the operations of Nature, when philosophically contemplated, are always admirable: those elementary substances, which, in their simple state would be disagreeable to us, by passing into the vegetable system, are converted into the most palatable and nutritious food. When in the resources of Nature we discover such evident proofs of the goodness of the Creator, the philosopher may well exclaim with the poet: —

> "These are thy glorious works, Parent of good,
> Almighty! Thine this universal frame
> Thus wondrous fair; thyself how wondrous then!
> Unspeakable! who sit'st above these heavens
> To us invisible, or dimly seen
> In these thy lowest works; yet these declare
> Thy goodness beyond thought, and power divine."

MRS. B.

This beautiful burst of praise, into which Adam breaks out on the creation at large, is no less applicable to the wisdom and forethought displayed in the arrangement and distribution of its minutest parts.

The principal result of the decomposition, whether of animal or vegetable matter, is carbonic acid; and in this state carbon finds entrance at their roots.

CAROLINE.

But it is not enough to introduce carbonic acid at one extremity of the plant: you must get rid of the oxygen at the other extremity.

EMILY.

This, you know, Caroline, is performed by the leaves when exposed to light and air.

MRS. B.

Manure acts on dry soils also as *amendement* by retaining moisture. Manure which has not completely undergone the process of fermentation, so that the straw is not yet wholly decomposed, is best adapted to strong compact soils: the hollow pieces of stiff straw answer the purpose of so many little props to support the earth, and afford a passage for the air, thus rendering the soil lighter; besides, the fermentation being completed after the manure is buried in the soil, it has the advantage of raising its temperature.

EMILY.

Since the putrid fermentation reduces every animal and vegetable substance into its primitive elements, there are none, I suppose, which may not be converted into manure?

MRS. B.

No, not any; but some bodies are more readily decomposed than others: it is from domestic animals that the best manure is obtained. In maritime districts, fish, when sufficiently abundant, are sometimes used to manure the land. They are easily decomposed, and afford a considerable quantity of nourishment. Even such hard substances as horn, hair, feathers, and bones, are all resolvable into their primitive elements, and make excellent manure; but, owing to their dry nature, require a longer period for their decomposition. Such substances are calculated not for annual harvests, but to fructify the soil for a produce of much longer duration, such as that of olive-trees and of vineyards.

Vegetable manure does not always undergo fermentation previous to being buried in the soil: green crops, such as lupins and buck-wheat, are sometimes ploughed in, for the purpose both of improving and enriching the soil. A green crop contains a considerable quantity of water; and the plants, when buried, serve to lighten the soil previous to decomposition, and subsequently to enrich it for the following crop. This species of manure is particularly calculated for hot countries, on account of the abundance of moisture it incorporates with the soil.

EMILY.

I have seen sea-weed used as manure, which has at least the advantage of being a gratuitous crop.

MRS. B.

Gratuitous in some respects, but the carriage of it is often difficult and laborious. The Isle of Thanet owes its agricultural reputation in a great measure to the power of procuring this manure. And the sea-salt they contain is also favourable to vegetation. Straw is an excellent ingredient for a compost; but it requires being mixed with animal manure, or stratified with earthy matter. Bark and saw-dust are also occasionally used: they should, however, with greater propriety be considered as materials for improving the soil, as they afford but little nourishment.

The grain which produces oil, such as linseed, rape-seed, &c., makes excellent manure after the oil has been expressed: in this state it is called oil-cake, and its unctuous qualities serve to accelerate decomposition; but in England it sells at such a price as to make it a doubtful speculation even to feed cattle with, and it would decidedly be too expensive to be used as manure.

EMILY.

Pray, would not soot make very good manure? It is almost pure carbon, and in so highly a pulverised state, as must render it fit to enter into the vegetable system.

MRS. B.

You forget that it is first necessary to combine it with oxygen; and this is a work of time. Soot has, however, immediately, a beneficial effect on the soil, though not a very permanent one: it is used in large quantities in Hertfordshire, both for grain and pasture, and is spread on the land in March and April, for the crop of the same year.

CAROLINE.

I recollect having observed that the environs of the spots, where charcoal has been prepared in the mountains, are absolutely destitute of vegetation, although strewed with charcoal-powder.

MRS. B.

But were you to visit these same spots some few years afterwards, you would find vegetation more flourishing, more vigorous, and especially greener, than elsewhere, because the charcoal-powder will have gradually combined with the oxygen of the atmosphere, and thus vegetation be supplied with carbonic acid.

The most common manure consists of a mixture of animal and vegetable materials; and this, again, is frequently stratified with mineral substances, such as mud from the streets, dust from the roads, or earth of different descriptions, the whole forming a rich compost. Mud from the beds of rivers, when it can be obtained, is a very valuable ingredient for such a compound, as it abounds with organic remains of fish, shells, reptiles, and decayed plants. Often, however, before being laid upon the land, it requires being well turned up and exposed to the air for some time.

CAROLINE.

What a pity that these valuable materials should be so often lost by being carried by rivers into the sea! The slime of ponds and all stagnant waters must make very rich manure.

MRS. B.

Yes; they may be considered as storehouses of materials, ready to return into the vegetable system.

The elevation of temperature produced by the completion of fermentation of the manure, after it is mixed with the soil, is but inconsiderable, excepting in garden culture, where, accumulated in hotbeds, it often produces a temperature equal to that kept up in a hothouse.

Short manure, that is to say, that which is thoroughly decomposed, and in which the water and other evaporable parts have in a great measure disappeared, contains a considerable quantity of carbon.

Long manure, in which state fermentation is but little advanced, contains a greater proportion of water: the first is, therefore, best adapted to moist, the latter to dry, soils.

EMILY.

But if the fermentation be completed previous to mixing the manure with the soil, are there not many volatile products which escape into the atmosphere, and which might, if buried in the earth, have promoted vegetation?

MRS. B.

No doubt. It is incalculable how many valuable materials are wasted which should have given vigour to vegetation: others are dissolved by moisture, and drained off by rain; but these liquefactions are generally collected and turned to account. To prevent, as far as possible, such losses, dunghills should be sheltered from the atmosphere by sheds: these should, however, remain open on the sides, as air in a moderate quantity is required to promote fermentation.

EMILY.

In which state is it considered most advantageous to bury manure in the soil; when the fermentation is only partially, or when it is completely effected?

CAROLINE.

I should suppose in the former state, in order to prevent the loss by evaporation. When the fermentation goes on in the soil, the elastic as well as the liquid and solid parts are retained; then the act of fermentation raises the temperature.

MRS. B.

The different states of fermentation are suited to different species of crops. The only disadvantage attached to long manure is, that it requires more time to convert it into nourishment for plants. Short manure being already decomposed, is in a state fit for the roots to absorb; if, therefore, the crop requires very prompt sustenance, the former must be used; if not, the latter is in every respect preferable: it is particularly adapted to stiff soils, the straw, previous to its decomposition, rendering it lighter.

EMILY.

It is evident that it must be advantageous to bury either description of manure as soon as it is spread on the soil, in order to prevent loss by evaporation: but how deep should it be laid in the soil?

MRS. B.

That depends upon the nature of the culture; for the manure should be as much as possible within reach of the roots. For this purpose, it should not be buried quite so deep as the extremity of the roots; for, in proportion as it is dissolved and liquefied, it will naturally descend. Due allowance must be made for this; for, if any part subside below the roots of the plants, it is utterly lost, at least for that crop.

EMILY.

It is then, I suppose, better to manure the land in the spring than in autumn, lest the winter-rains should dissolve it too much, and endanger its sinking below the roots of the crop.

MRS. B.

That is the prevailing opinion of agriculturists. With regard to the quantity of manure, it is a commodity so scarce, that it is not likely to be employed in excess. This occurs, however, sometimes in garden culture, and it produces a strong and disagreeable flavour in the vegetables. But the stock of manure is generally so limited, that it has been the study of agriculturists to discover some means of compensation for a deficiency, rather than to apprehend danger from excess. This compensation has been found in a judicious system of crops; but it is too late to enter upon a new subject to-day, and one of so extensive a nature well deserves to have a morning dedicated to its consideration.

CONVERSATION XIV.

THE ACTION OF SOIL ON PLANTS CONTINUED. — ROTATION OF CROPS.

MRS. B.

In the infancy of agriculture, when land was plentiful, because there were few inhabitants, a certain portion of it only was cultivated at one time; and as soon as the soil became exhausted it was abandoned, and the cultivation transferred to another portion; thus new land was successively brought into tillage, till, after a series of years, the agriculturist returned to the spot which had been previously cultivated. This mode, called *ecobuage*, by the French, was first introduced by the Celts, and may still be traced among some of their descendants in Brittany. They usually commenced their operations by burning the natural produce of the ground before they ploughed it. If the soil was stiff and argillaceous, the ashes resulting from this combustion ameliorated it, by increasing the stock of carbon, of sand, and of salts; but if light, such a proceeding was injudicious.

The system of *fallows*, which we derive from the Romans, is an improvement on that of the Celts; the land is allowed only one year's repose occasionally, and during that season it is repeatedly turned over by the plough; every part is thus exposed to the atmosphere, whence it absorbs oxygen, and the weeds being buried by the plough, serve to enrich, instead of exhausting, the soil.

The system of *assolements* we owe to those excellent farmers, the Belgians. It is of two descriptions: the first consists in the judicious cultivation of such a succession of crops, that they shall derive benefit instead of injury from each other; the second is that of raising two crops simultaneously, which shall be mutually advantageous to each other. As we have no precise term to express these processes, I shall use the French word *assolement*.

Those of the first description, which our farmers denominate a rotation or course of cropping, is particularly adapted to northern climates.

EMILY.

And of what nature are the crops which ought to be raised in succession?

MRS. B.

It varies much, according to the soil and climate; but it may be considered as a general rule, that two crops of grain cannot be raised in succession without the latter degenerating; whilst leguminous plants, such as clover and lucern, succeeding a crop of grain, are improved by it.

EMILY.

This system is, doubtless, founded on the theory of the exudation of plants?

MRS. B.

It may now be accounted for by that theory, but it was originally founded on observation and experience, long before the idea of plants exuding into the soil occurred to any one.

CAROLINE.

How, then, could the benefit arising from a judicious succession of crops be explained?

MRS. B.

It was long quietly practised without any explanation: several were, however, attempted, such as, that when the roots of plants in a course of cropping were of different lengths, one crop would seek its nourishment near the surface, while the other would penetrate deeper into the soil, so that the growth of one species of plant would not exhaust the soil of nutriment for the other. There is some truth in this argument with regard to simultaneous crops, but applied to a rotation of cropping it is quite erroneous; for the plough, which turns up the earth between every successive crop, brings the lower parts of the soil to the surface, and mixes the whole so well together, that the nutritive particles are pretty equally diffused throughout.

Another explanation suggested was that the fall of the leaf of the first crop fertilises the soil for a second. This is undoubtedly true to a certain extent; but the foliage can fertilise the soil only by being converted into manure, which would equally afford nourishment for a successive crop of the same family.

EMILY.

It is the theory of exudations which can alone solve the difficulty.

MRS. B.

A third conjecture, approaching nearer to the truth, was, that the two successive crops might absorb different kinds of nourishment; and their growth thus be prevented from interfering with each other.

CAROLINE.

Certainly; if plants of one family feed on the exudations of those of another, they do indeed subsist on totally different kinds of food. The error lies in supposing that they can select their food previous to absorption, instead of rejecting the particles which they cannot assimilate to their own substance, after they have passed through the circulation.

MRS. B.

You are quite right: the crops of grain and those of artificial grasses being of different families, the exudations of the one fructify the soil, and afford nourishment for the other.

These exudations, however, can be considered but as forming a portion of the nutriment of crops: the general food of all the vegetable kingdom is very much of the same nature; and you must recollect that it is manure that affords the grand store of provisions equally good for plants of every description.

EMILY.

But, Mrs. B., there is land in the Vale of Glastonbury, in Somersetshire, which is celebrated for growing wheat many years successively without being manured: and I have heard that in the neighbourhood of the Carron Ironworks, in Scotland, wheat has been raised above thirty years without injury either to the crops or the soil.

MRS. B.

Those soils must not only abound with vegetable nourishment, but the land be particularly well adapted to growing wheat; for the successive crops to be raised without the soil being exhausted.

CAROLINE.

May it not be objected to the theory of exudations, that Nature does not raise plants of different families in succession? The seeds of the parent plant fall to the ground annually, and produce other individuals of the same species, and on the same spot, for centuries; and yet, according to the system of exudations, that spot must be vitiated for such plants, by the long series of exudations of their progenitors.

MRS. B.

Nature, it is true, usually employs simultaneous rather than successive *assolements*. In her spontaneous forests she raises such a prodigious variety of trees and shrubs, and in her meadows such a multiplicity of herbs and grasses, that the different plants mutually supply each other with exudations.

EMILY.

Besides, where Nature acts without restraint, she enriches the soil, not only by the annual fall of the leaf, but, in the course of time, the whole plant, whether grass, shrub, or tree, returns to the soil, to repay the nourishment it had received during its life.

MRS. B.

The soil can never be impoverished by natural vegetation: that of forests, where man does not cut down and carry away the trees, is not more exhausted of nutriment at the present day than it was a thousand years ago.

Those magnificent forests which covered the face of the greater part of America, when it was first discovered, had no other manure than the remains which its vegetable and animal productions afforded; nor can a better be supplied. And when we prepare the soil for corn by ploughing in a green crop of leguminous plants, we only copy Nature.

There is nothing which exhausts either a plant, or the soil in which it grows, so much as the ripening of its seeds. No animal labours with greater effort to support its offspring than the plant to bring its seed to maturity: it pumps up sap with all its powers of suction; yet, if it has much seed to ripen, after having accomplished its task, it frequently perishes through exhaustion from the intensity of its efforts.

Perennial plants have but few and but small grains to ripen, while those of annuals are large, and much more abundant; and it is this difference, perhaps, which constitutes the real distinction between these two classes of plants: the one, exhausted by its efforts, dies after bringing its seed to maturity; whilst the other, having a less laborious task to perform, lives through several successive years.

CAROLINE.

If that constitutes the only distinction, an annual might live several years, were its seed prevented from ripening.

MRS. B.

Instances of this sometimes occur in cold countries, such as Scotland. If the season has not afforded sufficient heat to ripen the corn, and the following winter has not been so severe as to prove fatal to it, it will ripen the succeeding summer; and, indeed, whenever by any artificial means you prevent the seed of an annual from being brought to maturity, it becomes perennial.

But to return to our subject. The succession of crops should be so arranged as to prevent as much as possible the growth of weeds: but what plant is it which deserves so opprobrious a name? for not one issues from the hands of its Creator which is not destined to act some useful part in its own sphere: either its exhalations purify the air; its exudations enrich the earth; its fruit supplies us with food or clothing; its blossoms regale our senses; and even its poisons minister to our diseases. What plant then can justly be called a weed? — The only blame which attaches to weeds is (as Dr. Johnson expresses it) being out of their place; and it is the business of the agriculturist so to fill up the space they would occupy, as to drive them out of the field. This cannot be more effectually accomplished than by the cultivation of artificial grasses, such as clover and lucern, which, when sown thick, produce a shade very prejudicial to the growth of weeds; if sown thin, so as to leave space, light, and air, they, on the contrary, encourage their growth.

There is nothing more favourable to the improvement of land than hoed crops, provided no immediate profit be expected from them, and that we are satisfied if they repay the expenses of cultivation: that is to say, the value of the seed, the hoeing, the ploughing, and the manure.

EMILY.

But why are not these crops sown so thick as to prevent the growth of weeds, and, consequently, the necessity of hoeing?

MRS. B.

They consist of plants whose roots require a great deal of nourishment, such as peas, beans, turnips, potatoes, and carrots; and, if sown thick, the soil would not afford a sufficient supply of sustenance to bring them to perfection.

EMILY.

Yet the weeds which spring up between these plants must rob the soil of a part of its nourishment.

MRS. B.

They do so, but only temporarily; for the dead weeds, after hoeing, return to the soil in the form of manure. The advantage of hoeing is not confined to the destruction of weeds: it loosens the earth so as to admit the air, turns it over, and heaps it around the roots of the plants cultivated.

As hoed crops stand in need of a great deal of manure, they should precede grain, which also requires manure to ripen the seed; and it is from the sale of grain, raised under these advantageous circumstances, that the cultivator will derive his profit.

It must be recollected also, that the more the green crops are increased, the greater is the number of cattle you are enabled to feed, and, therefore, the more considerable is the stock of manure. It is very remarkable, and, however paradoxical it may appear, is nevertheless true, that, since the introduction of *assolements*, meadows diminish, whilst cattle multiply; and corn-fields diminish, whilst grain increases. These miracles are performed by the artificial grasses, the leguminous and other green crops, which not only prepare the soil for grain by their exudations, but enrich it by their remains; which leave no space for weeds, and supply abundant food for cattle.

CAROLINE.

Pray, what is reckoned to be the due proportion of corn to meadow-land in a farm?

MRS. B.

The distribution of a farm should be so arranged that the several portions may mutually contribute to each other's advantage. The farmer should aim at raising every year the same quantity of produce; for though it is true that the vicissitudes of seasons render this end unattainable, yet, by keeping it in view, you will the more nearly approximate to it.

When once the land is laid out to feed the number of cattle required for the work of the farm, and to produce the manure necessary for the soil, no change can take place without disadvantage. If you increase the produce of grain, it must be at the expense of the leguminous crops: the cattle will suffer for want of forage, and the soil from deficiency of manure.

EMILY.

And even the corn the following year will degenerate, for want of that preparation of the soil produced by leguminous crops.

MRS. B.

The Belgians, who are considered as some of the best farmers, lay out their land so as to obtain, as far as possible, equal results annually. They derive their profit from the sale of their corn: this alone goes to market, the forage being all consumed by the farming cattle, and the manure employed on the soil. A Belgic farm consists generally of from thirty to forty acres: the succession of crops is strictly regular, and comprehends a period extending from ten to fifteen years.

In rural economy an intervening crop is occasionally raised between two regular crops: thus, buck-wheat is often sown in that country as soon as the land can be ploughed after wheat, and is gathered in late in the autumn: but a double crop of grain is very exhausting to the soil, and it would be better that these stolen intermediate crops should be of leguminous plants. In England we do not attempt them: our corn is got in too late to admit of sowing for a second produce the same season.

EMILY.

What a prodigious advantage a rotation of crops has over fallows! If leguminous crops do not yield any profit, they defray at least all the expenses of their cultivation, and prepare the soil for a rich harvest of grain; whilst a fallow affords no crop whatever to repay the expense of ploughing and manuring, and does not so well prepare the soil for grain.

MRS. B.

The greater the variety of crops raised in a country, the more we consider that country as advanced in the knowledge of agriculture; for every new plant affords a security against sterility, and the more crops are diversified, the smaller are the chances of suffering from the inclemencies of the season; for what is injurious to the one may be salubrious, or at least not detrimental, to the others. It affords, also, a surer market; for every species of produce will not fall in price at the same time, and thus the chances of loss are diminished. It is also an essential point so to distribute the labour of a farm, that every operation may be made at the most suitable period.

EMILY.

The course of cropping must, I suppose, admit of modification, according to the locality, or the greater demand, for any one species of produce.

MRS. B.

Certainly; in England, for instance, where the beverage of the common people is beer, a greater quantity of barley and hops must be raised than in wine countries. Then, the moisture of the English climate admits of our raising very abundant crops of turnips, peas, and beans: these plants enter with great advantage into our course of cropping.

CAROLINE.

The vicinity of great towns must also influence the nature of the crops: it will be necessary to supply their markets not only with food, but also with bulky produce, the carriage of which is expensive; thus a very great quantity of hay is required to maintain the stock of horses and milch cows of a large town, which are quite independent of a farm.

MRS. B.

So far as regards their labouring for a farm, it is true; but the land profits by their manure: it is in order to supply hay for these animals that you generally see large towns surrounded by grass land. The oxen and sheep destined for food are brought from more distant parts, as they carry themselves to market almost free of expense.

The culture of the vine, especially in temperate climates, where this plant requires a great quantity of manure, necessarily modifies the *assolement;* for the farm must be so distributed as not only to afford manure for the succession of crops, but a large surplus for the vineyard.

EMILY.

This must be difficult to accomplish without making the general culture suffer from such a considerable subtraction; and, indeed, I have observed, that in Switzerland every thing seems to be sacrificed to the culture of the vineyard, that portion of the farm affording the greatest profits.

MRS. B.

And also occasionally producing the greatest losses. It may be considered as a game in which the highest stake is pledged; the greatest pains are therefore taken to increase the chances of winning.

The nature of the soil must also modify *assolements.* The light soils of Belgium and Alsace are very favourable to this system, while stiff tenacious soils offer considerable difficulties: they are, however, well worth the trouble of surmounting, as this mode of culture diminishes the quantity of manual labour which such ungrateful soils require, and which renders their cultivation so expensive.

EMILY.

And what is the most eligible succession of crops?

MRS. B.

The most common is an *assolement* of only four years; the first of which is a hoed crop to destroy weeds: turnips, potatoes, beet-roots, carrots, or any other plants with long roots, are very appropriate for this purpose, as it obliges the farmer to plough deep, in order to prepare the soil for them. After gathering in this crop, the leaves and remnants of the plants are ploughed into the soil, the land is manured, and wheat and clover are sown together.

The clover does not make its appearance till after the corn is reaped. Little advantage is made of the produce of clover the first season, but the following year it yields an abundant harvest. After having mowed it, the ground is ploughed, and the remains of the clover buried; and thus, both by its exudations, and by a part of its own substance, it renovates the soil after the exhaustion it had undergone in ripening the corn, and enables it to produce a second crop of grain the fourth year, which completes the *assolement*.

The rotation of crops must, however, necessarily vary with the soil; that which I have described, from M. de Candolle, is probably best adapted to France; in England, turnips, I believe, are usually followed by barley, clover, and wheat.

CAROLINE.

Pray, why should not trees require an *assolement*, as well as corn and leguminous plants? for the exudations of a tree, during the number of years it lives, must greatly injure the soil for another of the same kind.—Nay, I wonder how the same individual tree can thrive throughout a long life in a soil so deteriorated.

MRS. B.

You must consider, that the roots of a young tree are of small extent, and both seek their food and give out their exudations in the ground immediately surrounding the stem. In proportion to their growth, they extend their researches, spreading wider and piercing deeper into the soil; thus, after having exhausted it of nourishment, and deteriorated it near the stem, they find fresh aliment in a more enlarged sphere.

EMILY.

Then when a tree dies, if another of the same kind be planted in its place, the young roots will find the soil near the stem exhausted of nutritive particles, and vitiated by exudations? and yet, when a dead tree in an avenue is replaced by another of the same species it grows without difficulty.

MRS. B.

If you replaced it by one of another family, there is no doubt that it would thrive better. A tree of the same species is, however, not without resources; for you must consider that the soil nearest the stem of the old dead tree has not been acted upon by the roots for a number of years; and, during this period of repose, it has been able, in a great measure, both to renovate its nutritive particles by the natural manure it receives annually from the fall of the leaf, and to purify itself from exudations of the old tree, these being absorbed by the grasses, underwood, and plants of various descriptions which surround the tree, and which, in return, supply the soil with exudations of a different description, and which are adapted to forest trees: such ameliorations will enable a second tree to live and grow upon the same spot as its progenitor, though certainly not with the same vigour as if it were of a different family.

CAROLINE.

In replacing a tree in an avenue we are not at liberty to choose its species; but in our gardens it is surely wrong to replace an old fruit-tree by another of the same species.

MRS. B.

This is not so easily obviated as you imagine; for it is not sufficient to change the species; you must change the family; and almost all our fruit-trees are of the same family. To remedy this inconvenience, the gardener supplies the young tree with fresh soil, which in a great measure answers the same purpose. This new earth should, if possible, be brought from the neighbourhood of forest-trees, which are of another family. Manure may at the same time be introduced. Nursery gardeners plant fruit and forest trees alternately.

CAROLINE.

When a wood is cut down, another springs up of the same trees; shooting up from the old roots, or growing from the seeds naturally sown. Yet, how can these young plants find sustenance in a soil both exhausted and vitiated by the parent trees?

MRS. B.

You assume as a fact what is only a natural inference. If, when a forest is cut down, a second spring up, it will consist of trees of another family; a forest of oaks, for instance, may be succeeded by one of aspen, or of maple, both of which are of a different family from the oak.

CAROLINE.

I am not talking of replanting the forest, but of that which would naturally spring up if the first were cut down. Now we know that aspen and maple will not grow from acorns.

MRS. B.

It is the acorns which will not germinate in a soil so ill prepared for them; whilst the seed of the aspen, or the maple, which may chance to be here and there intermixed with the oaks, will find a soil so well adapted to them that they will germinate readily and grow rapidly. Thus a wood of aspen and maple will succeed to one of oaks; but, after a long course of years, the old stumps and roots of oak, favoured by the exudations of the forest of a different family, will shoot out, and, in the end, supplant the new forest, and a second forest of oaks will be re-established, but not till after an *assolement* of trees of another family. This takes place in America, when one growth of timber is cut down, another of a different family springs up spontaneously in its place; and if this does not occur in England, it is because we seldom allow vegetation time to sprout up spontaneously. You see, therefore, that Nature occasionally makes successive as well as simultaneous *assolements*.

CAROLINE.

This is very curious. I did not conceive it possible for an *assolement* to take place where human industry did not interfere with the natural course of vegetation. But this succession of crops must change once a century rather than once a year.

MRS. B.

Such crops are doubtless of very long duration. The *assolements* of trees which occur in the course of agriculture are of a more transitory nature: they are generally made with a view to improve new soil, in order to prepare it for cultivation, such as the simultaneous *assolement* of broom and pines in the Campine of Belgium. These shrubs enrich the soil for the future cultivation of grain, both by their exudations and by the manure formed from their leaves.

I have seen a very singular *assolement* in the neighbourhood of the Rhine, consisting of alternations of vine and clover. After a period of twelve years the vines are grubbed up, and clover sown during three or four years.

But the most remarkable *assolement* is that of water. There are some districts in France in which the low grounds are laid under water for the period of a twelvemonth, and this is renewed every seven years.

CAROLINE.

What harvest can be obtained from such a culture, unless it be fish?

MRS. B.

Fish and wild-fowl form, in fact, the only produce while the land is under water. This mode of culture has the advantage of draining the surrounding country, and of favouring the production of aquatic plants, which afford food for a prodigious quantity of worms and insects. All these productions, whether animal or vegetable, leave their relics at the bottom of the sheet of water; and, when it is drawn off, the land remains covered with an abundant stock of the richest manure. There are many ponds of this description in the country of Bresse in the Lyonnois. If the water with which these districts abound were more generally diffused, they would become marshy and unwholesome; for it is the scum of shallow stagnant waters which is deleterious, not the evaporation of deep waters. On the other hand, were these ponds permanent, the deposit they contain of rich manure would either be lost, or could be drawn out only at a great expense; whilst, if you change the locality, by drawing off the water to another spot, the manure remains ready spread on the soil, and the farmer has only to plough it in and sow his seed. The water in the mean time occupies another low land, where it accumulates and deposits its riches: with the assistance of locks, it is thus made to perambulate through the valleys and low lands. Great care is taken to preserve the young fish, and transfer them to their new basins; for these not only supply the markets with food, but enrich the soil for future vegetable produce.

CAROLINE.

It must be very interesting to see ponds of such extent drawn.

MRS. B.

I was once present at the operation of drawing off a sheet of water, of no less than seven hundred acres in extent. It was in the month of October. During the preceding summer, fish had been caught and wild-fowl killed in prodigious abundance; but when the secrets of the prison-house were exposed to view, it afforded a very curious spectacle. The markets of all the neighbourhood were supplied with full-grown fish; the young fry were sold to stock other ponds; and rich and ample were the remnants of animal and vegetable manure which prepared the ground for culture the following season.

Simultaneous *assolements* are as advantageous in warm countries as successive *assolements* are in our northern climates. The circumstance chiefly to be attended to in this mode of culture is, that the two crops should seek their nourishment at different depths: thus the vine and corn may be raised together, the roots of the vine being much longer than those of corn.

EMILY.

In Italy we have seen them continually accompanying each other: strips of corn separating the rows of vines trained on trees; which latter also compose a part of the *assolement*.

MRS. B.

The vine is sometimes twined round the olive, whose roots strike still deeper into the earth. For the same reason, the peach and the almond are often raised in vineyards; while apple and pear trees would not thrive, because their roots are as superficial and as spreading as those of the vine.

CAROLINE.

Their shade might also be prejudicial; while the foliage of the peach and the almond is comparatively light.

MRS. B.

The degree of shade must be regulated by that of the temperature of the climate. In hot countries, leguminous plants succeed well interspersed with trees; because their shade, by diminishing evaporation, retains moisture in the soil. Thus, corn thrives intermixed with turnips and clover: the two latter, when young, requiring the shade which the corn affords; and after it is reaped, the sun is necessary to ripen them.

Wheat and rye are sometimes sown promiscuously: it is an old and, I believe, a very injudicious custom both plants being of the same family; their exudations are noxious instead of advantageous to each other.

Then, as they do not ripen at the same period, when reaped, the one must be over-ripe, or the other not come to maturity. If the intent be to make bread of these two species of corn, it would be preferable to mix the grain after the harvest: indeed, it would be best to keep them separate till after grinding; for, not being of equal size and hardness, a loss is also experienced in grinding them together.

CAROLINE.

It is customary, also, in sowing grasses for forage, to mix a great variety together; is that advantageous?

MRS. B.

It is supposed that the species which is best adapted to the soil will thrive so well as to choke the others; but it would be a more judicious mode of proceeding, to try by experiment, which kind of grass was best suited to the soil, and sow that alone.

On the confines of the cultivation of vineyards, that is to say, in those latitudes where the vine with difficulty ripens, the cultivator aims at producing a large quantity, rather than a superior quality, of wine. For this purpose the vines are frequently trained on trees, which multiplies the fruit at the expense of its flavour.

CAROLINE.

It is singular that the same mode should be resorted to in climates which are too cold, as well as in those which are too hot, for the vine. In Italy they are trained on trees, to afford them shade; but in colder countries, shade must be very prejudicial, more so, I should have thought, than would be compensated by the increase of fruit.

MRS. B.

On the limits of the vine countries, the great demand for common wine, in order to avoid the expense of its carriage from more distant parts, ensures a sale for wines of the lowest description.

Maize, or Indian corn, forms a *assolement* with peas and French beans: it affords a support to these climbing plants; and, being of the grass tribe, its exudations are favourable to leguminous plants.

EMILY.

It is inconceivable what an abundance of produce the earth yields under the influence of a southern sun. In Tuscany we have seen flourishing together, in the most perfect harmony of culture, the olive, the vine, corn, and a variety of leguminous plants.

MRS. B.

And yet the soil of Tuscany is not very favourable to vegetation. It is, indeed, well cultivated, the Tuscans, after the Belgians, being esteemed among the best of agriculturists; and they have, as you observe, the advantage of a most fertilising sun. It is for this reason that they, in common with cultivators in warm climates, aim at producing a numerous simultaneous *assolement;* whilst the Belgians, with the inhabitants of other temperate climates, must content themselves with a succession of crops. The *assolements* of a Belgic farm, we have observed, extend from ten to fifteen years, the farm consisting generally of about forty acres: in Tuscany they are usually circumscribed to fourteen acres, with a soil inferior to that of Belgium; yet the more ardent sun of Italy produces a result nearly similar. In Tuscany the farmer is not obliged to raise his crops in slow succession; they are poured upon him, as it were, from the cornucopia of abundance: oranges, lemons, olives, melons, peaches, corn, and vegetables spring up together, to delight his eyes and to heap his board.

It is remarkable that these two countries, now so distinguished for agriculture, were once no less celebrated for their commerce.

EMILY.

This seems reversing the natural order of things;

for, in general, it is the abundance of agricultural produce which leads to the establishment of manufactures and trade.

MRS. B.

That is certainly the most usual mode of progressive improvement. On the other hand, when a people enrich themselves by commerce, it is a very natural consequence that they should lay out some of their wealth in the improvement of land. Then, it so happened, that, as Europe advanced in arts and civilisation, commerce, which began first to flourish in Tuscany and Belgium, and was, indeed, almost exclusively confined to those countries, became more generally diffused. Political events also tended to diminish the trade of these countries; and, when it fell into decay, agriculture proved a fortunate resource for the wealth and industry of the people. They transferred to this employment not only their capital, but that spirit of speculative enterprise, wisely regulated by those habits of calculation and of order, which distinguished them as merchants: and, when engaged in any hazardous experiments, the regularity of their accounts gave them exact results, and showed them whether they ought to be prosecuted or abandoned. This union of energetic vigour and methodical arrangement has achieved the wonderful enterprises of these excellent agriculturists.

ON THE MULTIPLICATION OF PLANTS.

CONVERSATION XV.

ON THE PROPAGATION OF PLANTS BY SUBDIVISION.

MRS. B.

It is now time to turn our attention from the preparation of the soil to the study of the plants which are to be raised in it.

CAROLINE.

After having provided suitable accommodation for their reception, and an abundant store of food for their subsistence, they will no doubt increase and multiply with rapidity.

MRS. B.

That is not all. If we have taken so much pains to provide for the welfare of the vegetable creation, it is with the interested view of its affording us food and raiment; we shall therefore select for cultivation such plants as are best suited to that purpose.

There are two modes of propagating vegetables: the first consists in subdividing the parts of a plant, so that from one individual several may be formed; the second mode is that of raising new plants from seed.

In order to be able in every case to distinguish these two processes, you must observe that the seed is always contained in an envelope, and that it is prepared by organs exclusively destined for that purpose. These organs compose the flower or blossom. Now the plant which results from the germination of the seed is always of the same species as that in which the seed originated; but varying from it frequently in the quality of its fruit, and not inheriting any of the peculiarities which may have casually distinguished the individual parent-plant.

When, on the contrary, a new plant is raised by separating from the parent-stock a slip or a layer, you not only produce an individual of the same species, but, if I may so express it, a continuation of the same plant, possessing all its peculiarities.

EMILY.

When these are of an advantageous nature, it must be desirable to raise the plant by division; otherwise, I suppose, it is more easily done by sowing the seed.

MRS. B.

The latter mode is much more tardy. A seedling tree of ten years' growth will perhaps not be more advanced than one of five years old raised by a slip; then, when you are provided with a plant which bears remarkably fine fruit, you are sure that, if propagated by division, it will produce fruit of equally good quality; it affords, therefore, the most certain means of improving the species.

CAROLINE.

Reproduction by seed is the mode adopted by Nature; that by division must be the invention of art.

MRS. B.

The latter is also sometimes employed by Nature, as you will see.

Reproduction by division tends to diminish the quantity of seed. The vine, which in a state of nature bears five seeds in each grape, when thus propagated has only two ; and some vines lose them entirely, so as to leave no possibility of reproducing the plant but by this artificial process.

EMILY.

The fruit no doubt profits by the deficiency of seed, as the sustenance which would go to ripen the seed will now enrich the juices of the grape. I have observed that apples and oranges, which have the fewest pips, are the highest flavoured.

MRS. B.

The remark is applicable to fruits in general. The sugar-cane, propagated by division, wholly loses its seed ; and so do also the succulent plants of the Cape of Good Hope, after having been, for a number of years, transplanted into Europe.

CAROLINE.

I cannot comprehend how a slip can strike root. That root, branch, and every part of a plant should be developed by the germination of a seed, in which it existed in a latent state, is easy to conceive ; but that a root should grow from the extremity of a young shoot seems to be quite unnatural : as if it were the work of chance.

MRS. B.

We can only account for it by supposing that germs, in some respect analogous to those which are contained in the seed, exist in almost every part of a plant, but are not developed unless placed under favourable circumstances ; that these germs are of two distinct species, the one producing stems, the other roots. The former originate chiefly in that part of the leaf which unites it to the stem ; and which, from the resemblance it bears to the union of the arm to the body in the human frame, is called the *axilla :* the latter shoot out roots on each side of the axilla.

EMILY.

I recollect having seen the leaf of a plant, which, when simply laid upon moist ground, struck out roots from its edges into the soil.

MRS. B.

This is the *Bryophyllum:* the flower is the only part of a plant which is incapable of developing either a root or a stem, except through the medium of the seed, the production of which is its sole and exclusive function.

Let us now examine the several modes of multiplying plants by subdivision. They are of three descriptions: —

The first by layers;

The second by scions, or slips;

The third by grafts.

When you intend to multiply by subdivision, you place that portion of the plant which you intend to separate from the remainder under such circumstances as are requisite to enable it to form the organs in which it is deficient, and which are necessary to its independent existence. If it be a branch, the organ wanting is a root, if it be a root, the organ necessary to be developed is a stem. How is this to be accomplished?

EMILY.

You must, I suppose, in the first case bury the extremity of the branch in moist ground, to favour the developement of roots; and, in the other, train the roots above ground to encourage that of branches.

MRS. B.

Exactly so. It is the cambium, you must recollect, which, in its retrograde course through the liber, and partly through the alburnum, nourishes these germs; if, therefore, you propose to develope them in any particular part of the plant, you must accumulate the cambium in that spot. This may be done in several different ways. In the first place, you may make an annular incision in the bark or rind, and, by thus impeding the descent of the cambium, accumulate it in the upper section, where it will produce a swelling or protuberance of the bark. The germs situated in the neighbourhood of this rich deposit of food, if in other respects favourably circumstanced, are brought out; that is to say, if the annular incision be exposed to light and air, the germs of branches will shoot; if below ground, those of roots will strike into the soil. Indeed any casual interference with the descent of the cambium is almost immediately followed by the sprouting of a bud.

In order to make a layer, you bend down a pliant branch without separating it from the plant, and fasten it in the ground; sometimes a slight incision is made at the spot in which it is confined. — Now, what follows? The cambium, descending through the branch, finds some difficulty in returning to the stem: this obstacle is sufficient to occasion a small accumulation, and the shooting out of several germs of roots.

There are some creeping plants which propagate themselves in this manner without our assistance. Their lower branches, trailing upon the ground, are often partially covered with earth washed over them by the rain. If, in this operation, they are slightly wounded by friction, or the contact of any hard substance, such as gravel or pebbles, the free passage of the cambium is interrupted, roots strike out, and the branch which connected them with the parent-stock, being in a great measure deprived of its nourishment by the young roots, rots and perishes; the separation is thus made, and the requisite organs being developed, the layer becomes a new individual plant.

CAROLINE.

I have seen carnations and ranunculuses thus propagated; and I am delighted to hear the explanation of an operation I have often witnessed without understanding it.

MRS. B.

Laurels and most evergreens are also propagated by layers; and it is the regular mode used in vineyards. A branch of vine is laid under ground, and the extremity of it raised up above the soil in that spot where you wish to produce a new plant. If the branch be long and pliable, several plants may be made to spring from it. This is called a serpentine layer, because the branch takes a serpentine direction, being made alternately to sink below and rise above ground, as often as it is intended that new roots and stems should shoot from it.

Layers are sometimes made in arches by burying the extremity of the branch only; the separation is afterwards made when the branch has struck root: this mode is particularly suited to the raspberry and every species of bramble.

CAROLINE.

I have heard that there is a tree in Senegal called the Mangrove, or Rhizophora, whose branches, descending to the ground, bury their extremities in the soil, and strike root, thus forming beautiful natural arcades around the parent stem.

MRS. B.

At Knowle there is a very large lime tree, the lower branches of which, trailing upon the ground, have struck root into it, and given rise to a circle of young plants surrounding the parent tree. In the course of years these have again spread out their branches so as to reach the ground; have grown into it, and produced a second circle of trees, from thirty to forty feet high; and these, in time, will no doubt form a third circle.

EMILY.

How very curious! Then a whole forest might be produced from this single tree?

MRS. B.

Very possibly; it already covers nearly a quarter of an acre of ground. Several fig-trees in the East Indies grow and are propagated in this manner. The ancients sometimes twisted the branch at the spot where they wished a root to strike: to this process we have substituted the more gentle mode of strangulation by ligatures, which injures the branch less, and yet arrests the cambium sufficiently to produce an accumulation.

Another mode of making layers consists in slitting the branch from the bottom upwards, and drawing the portion slit on one side, so as to form the figure of a Y reversed, the branches being of unequal length. The portion of the cambium which descends into the slit, finding no vent, accumulates and strikes root.

EMILY.

I have seen the gardener propagate the Magnolia, and other rare and delicate plants, by gently bending some of their most pliant branches to the ground, and covering every part of them with earth, excepting their extremities; by this means a considerable number of layers may be obtained at a time.

MRS. B.

Layers are also sometimes made completely above ground, though, it is true, this cannot be done without the aid of the soil; for it is necessary that the branch should be surrounded with moist earth, which may be contained either in a flower-pot or a small basket, having an opening sufficiently large to admit of the branch passing through it.

CAROLINE.

The germs then strike root in this soil. I have seen the Oleander propagated in this manner.

MRS. B.

Baron Humboldt, the celebrated naturalist, when travelling in America, provided himself with strips of coarse pitched cloth, which he substituted in the place of a basket, to confine the earth round branches from which he wished to make layers. He adjusted them round the branches of trees, in forests through which he intended to return some months afterwards, when the roots would have shot out; and by this means he brought over to Europe a number of very curious and valuable new plants, which have not only enriched our botanical gardens, but have been generally disseminated both for use and ornament.

EMILY.

And pray what is the most favourable season for propagating by layers ?

MRS. B.

In temperate latitudes, it is the latter end of February or the beginning of March. This season is called by gardeners the first spring: it precedes the ascent of the sap, and enables the layers to collect the first drops of cambium which are produced. In England and other northern climates, where vegetation is less forward, the end of March, which is called the second spring, is sufficiently early for this purpose. The month of April, in which the budding of the leaf takes place, is denominated the third spring.

The safest way to ensure the success of layers is to leave them a year without separating them from the parent stock, in order to give them the chance of striking root during the ascent of ths autumnal sap, if they have failed to do so in the spring.

Both succulent and aqueous plants are very difficult to propagate by layers; because the cambium, instead of forming a protuberance to nourish the germs, runs out and is lost. The operation is more likely to succeed on plants of this description by strangulation than by incision.

The propagation of plants by slips is very analogous to that of layers; indeed the only difference is, that the branch intended to become a new plant is separated from the parent stem before the roots are produced.

CAROLINE.

I am much better acquainted with this species of propagation than with any other, I have raised so many geraniums by slips. Nothing is more easy: you merely cut off a young branch, and plant it in a pot of earth. But I am completely ignorant how it lives: whether it absorbs water before it strikes root, or whether it nourishes the embryo roots by its own substance.

MRS. B.

I believe no one can boast of having a perfect knowledge of the process; but I am inclined to think, that the cambium which descends in the slip, and which was destined to nourish the lower part of the branch whence it was cut, finding a sudden termination to its course, exudes. The first drops fall into the soil; but, from its viscous nature, those which follow soon coagulate and heal the wound. The protuberance then forms, and roots strike out.

CAROLINE.

This process must, however, be attended with much greater uncertainty than by layers, as the slip is divided from the parent plant before it is able to provide for its own wants, whilst the layer is separated only after it has acquired the power and the means of finding its nourishment.

MRS. B.

It is for this reason that the propagation of rare plants is preferable by layers. There are some trees which have such a remarkable facility for sprouting, that whatever part of them is planted in the ground, will strike root, be it a branch, the remnant of a stem, or even a simple stake. The willow, the ash, and most trees of white wood, sprout with this facility. The weeping willow is so easily propagated by slips, that it is never raised by seed; and all the willows now existing in Europe, and, in all probability, that ever will exist there, are subdivisions of one tree brought originally from Asia.

EMILY.

Greenhouse plants are usually propagated by slips from shoots of the preceding spring; and sometimes the slip is cut a little below the spring-shoot, so as to include a piece of the shoot of the preceding year.

MRS. B.

This is for the purpose of preventing the loss of the cambium by its oozing out, the wood of two years' growth being of a more solid texture.

Branches of three or four years' growth are sometimes planted: they should be placed deep in the soil, to favour the developement of a number of germs. Slips of forked branches are planted with advantage for hedges, as their shoots intermingle, and form an impenetrable fence.

In raising succulent plants by means of slips, it is necessary either to dry up or cover with mastic the cut end, for the purpose of retaining the cambium: in the Isles of France and of Bourbon it is usual to char or burn the ends of slips, in order to prevent the escape of the cambium.

When plants are propagated by slips of roots, they must be planted near the surface, in order to facilitate the sprouting of stems. Jessamine, strawberries, and, probably, mushrooms, are propagated in this manner.

EMILY.

I thought that mushrooms were propagated by a species of seed called the spawn.

MRS. B.

The white filaments, commonly called the spawn of mushrooms, are in fact the fibres of its roots: these are cut in pieces and sown; or rather, I should say, planted in a hot-bed.

CAROLINE.

In planting potatoes, is it not requisite to leave a spot, called an eye, in each piece? It is from these, I understand, that both stems and branches sprout.

MRS. B.

These eyes are the germs of embryo stems and roots. The potato is nothing more than a tubercle formed by an accumulation of cambium in the subterraneous branches of the plant, and destined to nourish the buds which are to be developed the following season. This storehouse of food offers such facility to germination, that when potatoes are heaped in a cellar, of a moderate degree of temperature and moisture, the germs absorb nourishment from the farina of the potato and sprout, either roots or stems, according as their situation favours the developement of the one or the other of these germs.

CAROLINE.

How providential this appears, that the potato, which is so valuable as an article of food, should be so easily propagated!

MRS. B.

We may consider the works of the creation as a natural revelation, in which we read the history of the stupendous operations of the Deity; and which, the more we study, the more just ideas we acquire of their Divine Author, and the more our hearts are elevated by the contemplation of the blessings he has so bountifully lavished upon us. Not only are we provided with every thing necessary to our existence, but care has been taken that even this, our transitory state, should be rendered agreeable: our food, instead of being insipid or loathsome, is delightful to the palate; the landscape, spread before our eyes, instead of being dark or monotonous, is illumined by a splendid sun, and variegated by a thousand hues; delicious odours arise from flowers of enchanting form and colour; in a word, Nature contains innumerable sources of enjoyment, which develope and strengthen a spirit of grateful devotion towards their beneficent Author.

CONVERSATION XVI.

ON GRAFTING.

MRS. B.

We may now proceed to the art of grafting, an operation from which we derive our finest fruits. It consists in placing a portion of one plant in juxta-position with another, in such a manner that they shall unite and grow together. The branch which is cut from one tree to be transferred to another is called the *graft* or *scion*, and the tree to which it is transferred the *stock*.

CAROLINE.

This, then, is not a mode of multiplying plants, but of changing their nature; for if a branch of one plant be added to another plant, the number is not increased.

MRS. B.

Certainly not. The advantage of grafting consists in improving the quality, not augmenting the number, of plants. The ancients entertained very exaggerated ideas of this art: they conceived that every species of plant might be grafted on each other: but it is now well ascertained that this operation can be performed only on plants of the same family. To ensure the success of a graft, it is necessary that the vessels of the liber of the two plants should meet and correspond, in order that the cambium should descend from the graft into the stock; for it is by the union of the vessels of the bark of both plants that they are soldered, as it were, together.

CAROLINE.

Then endogenous plants, since they have no bark, cannot be grafted?

MRS. B.

Several attempts have been made to perform that operation upon them, but hitherto, I believe, they have failed. Indeed it is seldom that grafting succeeds excepting when performed on plants of the same family; for some anatomical analogy is requisite in the form, the structure, and dimensions of the vessels, which is only to be met with in plants of the same family. A certain degree of physiological similarity is besides necessary; such, for instance, as that the sap in both plants should rise at the same period. There must also be a correspondence in the size and strength of the plants; for instance, the lilac may be grafted on the ash; but, as the latter has a much greater power of suction, the graft is gorged by the quantity of sap which is thrown up into it, and dies of plethora. If, on the contrary, the ash be grafted on the lilac, the graft perishes for want of nourishment.

A plant which loses its leaves in winter cannot be grafted (at least not without great difficulty) on an evergreen: the latter, absorbing a small quantity of sap during the winter, would send it up into the graft, which would sprout, in a season in which the young shoots would be destroyed by the frost.

CAROLINE.

And if, on the other hand, you were to graft the evergreen on a plant which loses its leaves, and consequently absorbs no sap during winter, the graft would perish of famine.

MRS. B.

Very true; the last analogy required in grafting is, that the two plants should thrive in the same temperature.

When a tree is grafted, the graft will always bear its own fruit, and the tree its own also.

EMILY.

I am surprised at that. Suppose that a branch of cherry were to be grafted on a plum-tree: the sap absorbed by the latter rises through it into the graft, and, being elaborated in the leaves of the branch of the cherry-tree, I should have supposed that it would change the nature of the fruit of the plum-tree when in its descent it returns into it.

MRS. B.

No; for though the rising sap is the same for both stock and graft, it is different in its return. The sap of the stock and that of the graft are each elaborated by their respective leaves, and, when converted into cambium, each supplies nourishment to its own variety.

Mr. Knight has made many ingenious experiments, which tend to show that each variety of fruit requires its own peculiar leaves to bring it to perfection. He grafted several varieties of apples and pears on trees of the same species, and adjusted the grafts close above the flower-buds on the stock: these buds blossomed and bore fruit so long as leaves were suffered to remain on the tree; but in some experiments he stripped them off, so that the sap could be elaborated only in the leaves of the graft, and in those instances the fruit always withered and fell off.

The principal advantage of grafting consists in its affording an easy means of propagating individual plants, which have, either by cultivation or some casual circumstance, attained a high degree of perfection.

EMILY.

This is similar to the advantages obtained by the propagation of plants by layers or slips.

CAROLINE.

I have heard that it is necessary to graft fruit-trees raised from seed, in order to make them bear fruit: yet, if it were so, no fruit would grow wild; and in a state of nature plants could not produce seed to continue their species.

MRS. B.

It is quite erroneous to suppose that seedling fruit-trees will not bear fruit in due time; but this period is considerably accelerated by grafting. A young tree is not sufficiently strong during the first years of its existence to bear fruit: an apple-tree, for instance, produces none until it has attained the age of ten or twelve years; but, if grafted from a tree that has already borne fruit, it will blossom and produce fruit sometimes as early as the second or third year.

CAROLINE.

Yet grafting cannot increase the age or strength of the seedling-tree?

MRS. B.

No: but the buds on the graft have attained a state of vigour and perfection which enables them to produce seed; and the seedling-tree may be considered merely as the channel by means of which nourishment is conveyed to them, until age has given it sufficient vigour to produce fruit-buds of its own. Grafting increases the size of fruits at the expense of the seeds: the rose acacia, when not grafted, bears seeds; when grafted, it bears none, but its blossom is much finer.

Grafting sometimes produces a change of flavour, and generally retards vegetation: it is often employed as a means to retard that of trees, which bud so early in the spring as to be in danger of suffering from the frost. The walnut, for instance, buds a full fortnight later when grafted on walnut.

In regard to the mechanical part of the process, care must be taken to fasten the graft to the tree with soft ligatures, and in such a manner that the vessels of the respective barks may come into contact; then, in order to prevent the loss of cambium, the wound must be well covered over with a ball, which is generally made of cow-dung and stiff clay. The composition which M. de Candolle recommends for this purpose consists of one pound of cow-dung, half a pound of pitch, and half a pound of yellow wax.

The season for grafting is either in the spring, during the ascent of the sap, or in the autumn, that the graft may receive the sap of the following spring.

CAROLINE.

But does not the sap rise constantly throughout the summer?

MRS. B.

For the purposes of general vegetation it does; but you must recollect that germs and buds are fed by sap, elaborated by vessels appropriated exclusively for that purpose; advantage must therefore be taken of the period when this sap is in full flow, to effect the junction of the two plants.

M. Chondi has distinguished himself by the numerous experiments he has made in the art of grafting: he divides the plants susceptible of undergoing this operation into three classes: —

1. The *Unitiges*, or plants having one central and vertical stem, such as firs, larches, and most evergreens. In these it is the stem which must be grafted, and not the lateral branches.

2. The *Omnitiges*, every branch of which is equally a stem, and therefore each is capable of being grafted.

3. The *Multitiges*, plants in which some branches are stems and susceptible of being grafted, and others are not so.

M. de Candolle once saw every branch of a large pear-tree grafted: this was done in order to preserve a great number of grafts, which had just been received from a foreign country. The following year they were each transferred to separate trees, and succeeded extremely well.

EMILY.

And how are grafts, when brought from distant countries, preserved alive?

MRS. B.

Frequently by dipping them into honey, which, by preventing evaporation, preserves the internal moisture. Another mode is to bury the cut end of the graft in a moist root, such as a carrot or a turnip.

It would be very difficult for me to explain all the various manners of grafting, there being above a hundred: they may be divided into three classes.

1st, Grafting by approach. You bring together two branches of two neighbouring trees, and, cutting off the extremities of each, you graft them together. If three trees be united together in this manner, the stem of the central one may be cut down, and the head will be kept alive and nourished by its two neighbours.

CAROLINE.

This must be a safe mode of grafting rare and delicate plants, as it is attended with no risk; for suppose the junction does not take place, each branch remains uninjured and grows separately, so that nothing is lost.

MRS. B.

It is a good mode, also, for common plants, being both easy and rapid in its results.

CAROLINE.

And might not, in a similar manner, several stems be united to a single head?

MRS. B.

Yes; if a circle of stems of young poplars be bent and united in a centre, they will form but one head, which, nourished by the surrounding stems, will grow to an enormous size.

Some trees graft themselves spontaneously. If two branches of *hornbeam* happen to grow so close together as to rub against each other when moved by the wind, the outer bark will be worn away by the friction, and the vessels of the two libers will come in contact, which is sufficient to produce a graft. The mere act of two branches growing contiguous, when confined for space, will wound the bark; and, indeed, by whatever chance the vessels of two branches are brought together, in such a manner that the sap can flow from the one into the other, a graft takes place.

EMILY.

You sometimes see a young tree growing from the trunk of an old one of a different kind: is this the result of a natural graft?

MRS. B.

No; it is that of a seed which has sown itself, or of a slip which has planted itself in the hollow of a decayed tree, the rotten wood producing a soil which consists wholly of the richest nourishment. I have seen a fine young cherry-tree grow out of the hollow trunk of an oak, and a vine spring from the old stump of a willow.

EMILY.

You sometimes see two leaves and two flowers growing together: is not this owing to a natural graft?

MRS. B.

Yes; this species of grafting extends also to fruits: the double cherry is thus grafted.

The second mode of grafting, and which is in most common use, is by scions: a young branch is cut off from one plant, and grafted on another. In whatever manner the section be made in the graft, one of a corresponding form must be made into the subject, in order that they may fit into each other, and the vessels of the liber come into contact; the union then takes place in the course of a few days.

EMILY.

The mode of grafting by approach bears a considerable analogy to the propagation by layers; and that by scions, to the propagation by slips or cuttings.

MRS. B.

True; and the third class, which is grafting *bourgeons* or buds, may in some respects be compared to propagation by seed: it consists in transplanting a bud from one plant to another. For this purpose the bud must be separated from the parent-plant, in such a manner as to be surrounded by a small disk or shield of bark; for since the union is effected by the vessels of the bark, it is through its intervention alone that the bud can be grafted. A small piece of the alburnum is sometimes cut off in the addition to the bark, but I believe this to be an unnecessary precaution. The bud may be adjusted on any part of the bark of the tree, but it is more sure to succeed, if it be grafted on a spot where another bud had previously existed, in order that the vessels which conducted nourishment into the original bud, may pour it into that which is substituted in its place. In this manner Mr. Tschudy has succeeded in grafting herbaceous plants, — the melon, for instance, on the gourd; and potatoes on tomatas; but one herb cannot be grafted upon another. This species of grafting is rather novel, it being formerly supposed that herbaceous plants were not susceptible of being grafted.

The embryos of buds, before they begin to be developed, you may recollect, are called eyes; and the graft may be made either when the eye is said to be sleeping or waking: that is to say, either in autumn, when the eye is closed for its long winter-night of repose; or in spring, when it is open for its summer-day of activity.

Another mode of grafting buds is by transplanting a broad ring or flute of bark, containing several eyes, and substituting it in the place of a similar ring cut away from the stock: this is less sure of success, on account of the number of buds to be nourished.

These several modes of propagation by layers, by slips, and by grafts, are all calculated to improve the fruit; the grand source of the multiplication of plants is the seed, which we shall enter upon at our next interview.

CONVERSATION XVII.

ON THE MULTIPLICATION OF PLANTS BY SEED. — THE FLOWER.

MRS. B.

We have now reached that part of our subject with which you thought it would have been proper to have commenced — the history of the seed. It will be necessary to introduce it by a description of the organs whose office it is to prepare this important part of the plant.

CAROLINE.

That is to say, the flower, which forms the principal part of the study of botanists in general, and which we have hitherto totally neglected.

MRS. B.

If I have allowed the most beautiful part of the vegetable creation to remain so long unnoticed, it was in order that, when I described it, your interest might be excited, not merely by the brilliancy of its colours, the elegance of its form, or the sweetness of its perfume, but that, having acquired some previous knowledge of the economy of vegetation, and become acquainted with the essential part it performs among the works of Nature, you would take a deeper and more rational interest both in the blossom and the seed. It is the most beautiful part of the vegetable kingdom, which prepares and ushers into life that which is most useful.

EMILY.

No child has so richly ornamented a cradle as the seed when reposing within the recesses of the flower.

MRS. B.

The flower consists of several parts.

The *calyx*, or flower-cup, forms the external covering which shelters and protects the bud before it expands: it consists of several parts, called *sepales*, resembling small leaves, both in form and colour; and probably performs similar functions, being furnished with stomas. These sepales are, in general, more or less soldered together, sometimes so completely as to form a cup apparently of one piece: hence the calyx has acquired the name of flower-cup.

CAROLINE.

I see that you persevere in deriving every organ of a plant from the budding of leaves.

MRS. B.

When you are a little more acquainted with plants, I think that you will concur with me in this opinion.

Above the calyx rises the *corolla*, which is the coloured part of the flower. It is composed of several petals, either distinct and separate, or cohering so as to form a corolla of one single piece; in the latter case the flower is called monopetalous, though the petals are never originally simple, as this name would seem to imply, but, like the calyx, derive their origin from a circle or *whorl* of leaves. When the petals burst from the calyx, and expand in all their beauty, they still serve to protect the central parts of the flower: they are at first curved inwards, forming a concavity around the delicate organs which occupy the centre, which not only shelters them from external injury, but reflects the sun's rays upon them like a concave mirror, thus rearing them as it were in a hothouse. When they are full grown, the artificial heat being no longer necessary, and the admission of light and air not only safe but advantageous, the petals expand, leaving the internal organs exposed to the free agency of these elements.

At the base of the petals is generally situated the *nectary*, so called from its secreting a sweet fluid, which has been dignified by the name of *nectar*. This is the store whence the bee derives honey: it affords also abundant provision for the less provident insect tribe, who, rioting in these sweets during a summer, scarcely outlive the fall of the blossom. These ephemeral beings, however, act a useful part in the economy of Nature, which I shall presently explain to you. Nectar exists in almost all flowers, but is not always contained in a distinct organ.

CAROLINE.

I have often sucked it from the petals of the honey-suckle.

MRS. B.

That flower produces a great quantity of honey, and part of it lodges in the elongated tube whence you suck it.

The most important parts of the flower are those delicate organs which occupy the centre as the place of greatest security. It is here that the seed, which is to propagate the plant, is lodged. It is wrapped in a small leaf, which, instead of expanding its beauties to the sun and air, like its neighbouring petals, folds itself closely around the little treasure it is to protect: the edges of the two opposite halves of the leaf being thus brought in contact, they unite and grow together, and the leaf assumes the form of a pod, or vessel, the shape of which varies according to the form of the leaf and the manner in which it was folded when it first budded.

CAROLINE.

And will you not admit that plants have sensibility, Mrs. B., when you see them showing such signs of maternal care for their offspring?

MRS. B.

No, my dear. Were I sufficiently versed in the physiology of plants, I should no doubt be able to show you, that this tender care of the protecting leaf is the natural result of physical laws.

CAROLINE.

Then I am almost tempted to rejoice that you are not learned enough to do so. I cannot help being vexed when I hear facts, so interesting to the feelings, explained away by the dry results of mechanical or chemical laws.

MRS. B.

You are falling into an error very common among half-learned and superficial observers.

When you feel inclined to murmur at the dry results of physical laws, let not your imagination rest there, but raise your mind from these impassive agents to their Omnipotent Author: you will then consider them as the unerring instruments which his paternal care has provided, to promote and secure the welfare of his creatures.

CAROLINE.

I now understand and perfectly acquiesce in your sentiments. It is very true that the mind, amazed at the wisdom that is displayed in the laws of Nature, is apt to consider them as a sort of mechanical cause, rather than as the mere agents of an all-wise and benevolent Power.

MRS. B.

To return, then, to the flower and the envelope of the seed, in which, I trust, you will continue to take some interest, although we have deprived it of sensibility; — unless in a poetic sense. When this leaf is closed over the seed, and its edges soldered together, it is called an *ovary* or seed-vessel. From its summit rises a little thread-like stalk, called a *style*, which, at its extremity supports a small spongy substance, denominated *stigma*. These three parts form a whole, which bears the name of *carpel*.

EMILY.

Is carpel, then, synonymous with pistil? For I know that an ovary, with its style and stigma, constitutes a pistil.

MRS. B.

Pistils are composed, in general, of several carpels, which, in most flowers, are so neatly fitted to each other, and so closely adhere together, that they are considered as a single organ, containing different cavities for seed; but the most accurate anatomical researches prove that these several cavities have each its style and stigma, and form distinct carpels: thus the blossom of the apple and the pear have several carpels soldered together.

CAROLINE.

Oh, yes; for when they become fruits, they contain several seeds.

MRS. B.

That would afford no proof of the pistil consisting of more than one carpel, which often contains many seeds; but in the apple and pear the seeds or pips are lodged in separate carpels. It is true, however, that a single carpel forms the pistil of some flowers; such, for instance, is the blossom of the cherry, which, you know, has but one seed, the kernel contained within the stone.

In some flowers, the styles and stigmas remain separate, and the ovaries are soldered together: the flower is then said to have two styles with one ovary, containing several cells or cavities for seed; in others, it is the styles which adhere together while the ovaries are detached, and in some few the adhesion takes place only between the stigmas.

Immediately surrounding the pistil are situated the *stamens*; each of which consists of a slender filament supporting a little bag or case called *anther*, filled with pollen, a species of dust or powder. The anthers, when ripe, burst, and being above the stigma, shed their pollen upon it, and the seeds are thus perfected.

EMILY.

Yet I have heard that there are some plants whose flowers have no stamens, and others which have no pistils: in this case, how can the pollen of the stamens fall upon the stigma of the pistils? Nature has, no doubt, provided some resource to obviate this difficulty.

MRS. B.

Or, rather, it is a provision she has specially made in favour of another part of the creation. The pollen is often conveyed by insects, which, in penetrating, by means of their long and pliant probosces, within the recesses of the corolla, in order to obtain the nectar, cover their downy wings with the pollen. This unheeded burden they convey to the next flower on which they alight; and, in working their way to the nectary, it is rubbed off and falls on the stigma: thus they make compensation for the honey of which they rob the flower: and unconsciously labour for those plants which afford them food. Every insect, however ephemeral, every weed, however insignificant, has its part assigned, in the great system of the universe.

In Persia, the palm and date trees under cultivation seldom contain stamens, those having pistils being preferred as alone yielding fruit. In the season of flowering, the peasants gather branches of the wild palm-trees whose blossoms contain stamens, and spread them over those which are cultivated, in order that the pollen may come in contact with the pistils and fructify the seeds.

There are two remarkable palm-trees in Italy, which have been celebrated by the Neapolitan poet, Pontanus:

the one, situated at Otranto, has no stamens; the other at Brindisi, which is about forty miles distant, has no pistils, consequently neither of these trees bore seed; but when, after the growth of many years, they rose superior, not only to all the trees of the neighbouring forests, but above the buildings which intervened, the pollen of the palm-tree at Brindisium was wafted by the wind to the pistils of that at Otranto, and, to the astonishment of every one, the latter bore fruit.

CAROLINE.

How extremely curious!

MRS. B.

Having now completed our examination of the flower, it will be necessary to bestow some attention on the stalk which supports it. This is called a *peduncle* or *pedunculus*. It generally expands a little at the summit, and forms a common base by which the several parts of the flower are connected together. This little expansion is called the *torus*, which signifies a bed.

EMILY.

It is the bed on which the flower reposes; but it belongs to the stem, and, I believe, forms no part of the flower?

MRS. B.

You are quite right: the flower consists of the calyx, the corolla, the nectary, the pistil, and the stamens. If you pluck off these several parts, the torus will remain on the peduncle; but we shall see hereafter, that, though it forms no part of the flower, it sometimes enters into the composition of the fruit.

The peduncle is not always crowned by a flower; it often branches out into a number of smaller flower-stalks called *pedicels*, each of which supports a flower.

When pedicels diverge regularly from the summit of the peduncle, as rays from a centre, it is called an *umbel*, from the resemblance which the pedicels bear to the branches of an umbrella. A second umbel frequently shoots from each pedicel of the first; the umbel is then said to be compound.

EMILY.

I observe that the peduncle expands, so as to form a base for the pedicels which grow from it, and this expansion is surrounded by a little circlet of leaves — probably bracteæ?

MRS. B.

Yes they are, and are usually called the *involucrum* of the umbel. The base whence the pedicels radiate bears the name of *receptacle*; and it not only serves to support them, but the sap being accumulated in this expansion, it becomes a reservoir of nourishment, and supplies them with food which they each convey to their respective flowers.

EMILY.

Does not the Laurustinus blossom in this manner? I have often observed that its peduncle spreads out into a number of different ramifications.

MRS. B.

But they do not spring from a common centre, and, consequently, can have no common receptacle; they are irregular, like the branches of a tree, and the bunch of flowers they support may be compared to its head. It is hence called a *cyme* or *cyma*.

The peduncle often throws out small pedicels at regular distances, as you may have observed in a bunch of currants: this sort of cluster is called *raceme* or *racemus*, and its flowers open in succession from the bottom to the top.

In some plants the flowers are placed around the peduncle on such very short pedicles that they assume the form of a spike or *spica*. When thus disposed they blow in succession, so that those at the bottom of the spike have withered before those at the top are unfolded.

Plaintain blossoms in this manner. In other plants the flowers are crowded still more closely around the peduncle, and form an ear: such is the mode of flowering of corn and grasses; in others they grow in clusters or irregular bunches like the vine. In many trees the peduncle assumes the form of a spike, *articulated* with the branch, and covered with the remains of degenerated bracteæ, resembling scales, under each of which a flower lies concealed: the hazel, the willow, the alder, and the hornbeam, blossom in this manner.

EMILY.

Though I am very fond of flowers, I have paid so little attention to their manner of flowering, that I was not at all aware they afforded so great a variety.

MRS. B.

I am far from having enumerated them all, for every different mode in which the pedicels diverge from the main stem, and which produces a different arrangement of flowers, bears its own peculiar name: but the whole is included in the term *inflorescence*, which expresses the various modes in which the stem of a flower is divided, and, consequently, the arrangement of the flowers upon it.

Plants blossom at regular periods; varying, however, according to the temperature of the country in which they grow, and the vicissitudes of the season. Linnæus formed a register of the season of flowering of different plants, which he called the Calendar of Flora, but no allowance being made for these modifications, it is very imperfect.

EMILY.

I have observed that there are some trees which regularly blossom earlier than others, of the same species and in the same situation: whence does this arise?

MRS. B.

It is not ascertained; but as every peculiarity of an individual plant is preserved when it is propagated by layers, slips, or grafts, advantage has been taken of this anomaly to produce early vegetation. Mr. Knight, by carefully selecting those potatoes which first sprouted for replanting, obtained in the course of a few years plantations of potatoes very considerably earlier than the usual season.

In hot climates the fig-tree produces two crops of fruit; and it is in some countries necessary to accelerate the ripening of the first, in order to leave time for the second to come to maturity in due season. With this view, the peasants in the islands of the Archipelago, where this fruit abounds, bring branches of wild fig-trees in the spring, which they spread over those that are cultivated.

EMILY.

This is, no doubt, the same process as that of the fructification of the palm-trees in Persia.

MRS. B.

It was long supposed to be so; but it is now ascertained that the cases are quite different, the only use of these wild branches being to serve as a vehicle to a prodigious number of small insects, called *cynips*, which perforate the figs in order to make a nest for their eggs, and the wound they inflict accelerates the ripening of the fruit nearly three weeks.

EMILY.

Does the insect produce this effect by the injection of some stimulating fluid into the wound it makes, or is it owing to the growth of the eggs it deposits?

MRS. B.

The precocity does not appear to result from either of these causes: it is, indeed, not well accounted for; but I should think it may probably result from the punctures of the insects, impeding the free course of the sap, and producing, like the annular section, an accumulation of sap in those parts, which, by affording additional nourishment to the neighbouring buds, accelerates their developement.

Have you not observed that fruits which are worm-eaten ripen earliest?

EMILY.

Yes; but I thought that the worms attacked those which were first ripe.

MRS. B.

I do not allude to the external attacks of worms and insects, but to the maggots produced within the fruit; and the nest of eggs, whence they drew their existence, was in all probability the cause of the precocity of the fruit.

Means may also be taken to retard the period of blossoming: too much nourishment is injurious at that season, and sometimes wholly prevents it. Much water is also prejudicial: the water is drained from rice plantations when the rice is in flower; and the watering of gardens in blossom should also be diminished, Snow late in the spring has, in mountainous countries, been known to retard the flowering of corn till the following year.

It is remarkable that the conveyance of plants from one country to another appears to accelerate the period of flowering; for plants brought from foreign climes blossom earlier than usual, the first year of their emigration.

CAROLINE.

That is very singular. Can it be owing to the excitement produced by the motion of the carriage?

EMILY.

Or may it not rather be attributed to the total cessation of vegetation during the journey, when the plant is confined by packing, and the consequent re-action which takes place on its being replanted?

MRS. B.

It is a point very difficult to explain.

It frequently happens that, after blossoming, the fruit perishes from debility. An annular incision of the bark (which you may recollect arrests the cambium in its descent) increases the vigour of the blossoms by affording them more nourishment; but the ring, when made for this purpose, should be very narrow, in order that the upper and under edges of the severed bark may re-unite when this superabundance of sap is no longer required in the upper part of the plant. M. Lancris makes the ring of such narrow dimensions, that the separation of the bark lasts only during the flowering of the plant; at the end of which period, the protuberance at the upper edge of the bark having swelled out, till it reached the lower edge, and being still soft, the contact and gentle friction produced by the continuance of its swelling, occasions it to burst: it then amalgamates with the lower edge, when the wound is healed, and the general circulation restored.

CAROLINE.

That is to say, that the upper edge of the bark grafts itself upon the lower edge?

MRS. B.

Precisely so. This operation has been performed on the vine with some success; but these experiments have not been sufficiently extensive for their general results to be relied on. Its effects on fruit-trees, we have already observed, is very precarious: the branches of fruit trees not being completely lopped every year, like those of the vine in vineyards, they are liable ultimately to suffer from the derangement of the circulation. It answers better with fruit-trees whose seeds are pips, such as the apple and the pear, than with such as have stones and kernels, like the peach and the apricot, because, when the incision is made, the latter exude a gummy juice, so that they are liable to lose more than they gain by the operation.

There is another cause which frequently prevents the fruit from being formed. It is when water falls upon the stamens: this makes them burst before the due season, and the pollen, instead of being shed upon the pistil, is lost. Rain, and even a heavy mist, the latter of which, still more than the former, insinuates itself into the flower, very frequently produces this effect.

CAROLINE.

But all blossoms are exposed to mists and showers: how then can any fruit be set?

MRS. B.

It is evident that Nature has decorated plants with a much greater number of blossoms than she designed to convert into fruit, for the plant would have no means of bringing so great a quantity to maturity. Look at an apple or a cherry tree in blossom, and you will observe, that were every flower to produce a fruit, not only would it be impossible for the tree to nourish so great a crop, but even its branches would be unable to sustain them. Therefore, though every shower may destroy, or rather prevent, the formation of a quantity of fruit, it would require heavy and continued rains to prove fatal to the whole. This, however, sometimes happens, particularly to the vine, which, in wine countries, is a very serious calamity.

I have still some further observations to make on flowers, but I think you have learnt as much to-day as you can well remember; we will, therefore, reserve what remains to be said on them till we meet again. In the mean time, you may refresh your memory on what I have taught you by examining this drawing [Plate I.], in which the various organs of a plant are delineated in the representation of a pea.

This second drawing [Plate II.] represents a plant of the class of Monocotyledons of the liliaceous family, in which it is a disputed point whether the coloured part of the flower is a corolla or a calyx.

EMILY.

It has, surely, much more the appearance of a corolla composed of six petals, than of a calyx consisting of six folioles. One of these two organs, then, is wanting in this family?

MRS. B.

In order to avoid error by deciding which of them it is, botanists call the coloured part of a flower of this description a *perigone*, or *perianth*, composed of one or more pieces; that of the tulip has six.

CONVERSATION XVIII.

ON COMPOUND FLOWERS.

CAROLINE.

I HAVE been studying your drawings, Mrs. B., and imagined that I understood them perfectly; but when I attempted to make out the several parts on a real flower, I am sorry to say that I found myself quite at a loss.

MRS. B.

What flower did you choose for this purpose, my dear?

CAROLINE.

I was, perhaps, too confident of my powers of discernment, for I selected one that had a totally different appearance from the pea or the tulip: it was a China Aster. I made out a calyx and a corolla, but the rest was all perplexity.

MRS. B.

You have fallen into an error which many botanists have done before you: you took the China Aster for a single flower, whilst it is an assemblage of flowers, called in botany a *head*.

This class is so extensive as to constitute no less than one-twelfth part of the vegetable kingdom.

All flowers which shoot in numbers from a common receptacle are called *heads*. The flowers analogous to leaves without petioles are said to be *sessile;* such are the scabious, the daisy, the camomile, &c. The China Aster belongs to a particular family of this class, called *Syngenesia*, which is distinguished from all the others by the peculiarity of its anthers cohering together, so as to form a tube around the style, and it is this peculiarity which constitutes the *compound flower*.

CAROLINE.

Then all heads of flowers are not compound flowers? and yet, from their being composed of a great number of flowers united in one receptacle, they seem to deserve that name.

MRS. B.

No; this appellation is reserved for the family of *Syngenesia*, in which every little flower which forms the head is of a compound nature from the cohesion of their anthers in the tubular form.

Here is a China Aster I have just gathered: let us examine it. [See Plate III.] The stem or peduncle is terminated by what *you* call a flower, and what *I* call a head of flowers. The extremity of the peduncle, you see, expands into a white disk, called a receptacle, analogous to the receptacle of the umbel, and in this all the florets are inserted. This disk is not only the basis on which they rest, but it also contains their food. In the China Aster it is flat, but in many other plants of the same family it is more or less convex: it is sometimes as thin as a sheet of paper, as in the *Scorzonera;* at others, it is very fleshy, as in the artichoke.

EMILY.

Is it not the bottom of the artichoke on which the choke rests, and which is so good to eat?

MRS. B.

Yes. Around the receptacle of the China Aster you see there are a considerable number of small green leaves, or bracteæ.

CAROLINE.

That is what I supposed to be the calyx.

MRS. B.

It is, indeed, a sort of calyx common to the whole head; but as each floret has its separate calyx, this common calyx is distinguished by the name of involucrum, analogous to the involucrum which surrounds the *receptacle* of the umbel.

EMILY.

There seems to be a considerable resemblance between the umbel and the head of flowers?

MRS. B.

That is very true. Were the branches of an umbel to be so extremely short that they could not be distinguished, the umbel would be similar to a head; and this is exactly the case of the *Eryngiums*.

EMILY.

The involucrum of the China Aster differs, however, in one respect from that of an umbel, the bracteæ of which it is composed being much more numerous, and disposed in several rings or whorls around the stem.

MRS. B.

That is the case with the greater number of heads of flowers, but it is not universal: for in the Salsafy (*Tragopogon*), the *Orthonna*, and several others, the bracteæ, or, as they are more commonly called, the *folioles* of the involucrum, are placed in a single ring. When disposed in several rings, they are sometimes equal; at others, vary in size: they are sometimes curled up; at others, spread out. Some are soft, others scaly; and there are some which terminate in a species of thorn or prickle, as in the thistle. These varieties in the nature of the folioles serve to distinguish the numerous classes of *heads of flowers*.

But to return to our China Asters. You see all these little yellow parts in the centre of the head ; and the violet leaves which spread out around it ; they are each of them distinct flowers.

EMILY.

Is it possible ! Such a concourse of tiny flowers, so closely crowded together in the centre ; and these appear totally different from the violet-leaves, which you also call flowers.

MRS. B.

They are far from being so different in their structure as you would imagine from their appearance. In the China Aster, and in several other of the Syngenesia, the florets are not separated from each other by any intervening body ; but there are some plants of this family, such as the endive, the artichoke, and the camomile, whose florets are separated by a species of small bracteæ, which have been called *palix* or chaff, and which shoot up from beneath each floret. These bracteæ are sometimes of a scaly nature, and sometimes they assume the appearance of bristles or hairs. The choke of the artichoke, before the blossom is developed, is of this description.

EMILY.

I do not remember to have seen the artichoke in flower ; but I will certainly examine it when it is in blossom.

MRS. B.

Let us now examine one of these little yellow florets, in the centre of the head of the China Aster [Plate III.]: with the assistance of this magnifying-glass you will be able to follow me as I describe the different parts. Observe, first, this white spot, which forms the basis of the floret : it consists of the tube of the calyx, and contains the ovary or seed-vessel to which it adheres.

CAROLINE.

The external part of this tiny tube, then, is the calyx, and the internal part the ovary; but what are those little hairs which crown the tube, and grow from either the calyx or the ovary, I know not which?

MRS. B.

They proceed from the margin of the calyx, and had there been room for their developement would have become the sepales or leaves of the calyx; but being checked in their natural growth by the pressure of the adjacent florets they assume this singular appearance.

EMILY.

The calyx may perhaps be stinted in its growth for want of food, as well as for want of room.

MRS. B.

That, no doubt, also concurs to check its growth; but the elongated form which the edges of the calyx assume, is chiefly owing to pressure. In some heads, in which the florets are not so crowded as in the China Aster, the calyx wears a more natural appearance, being shaped like a cup, and of a membranaceous texture; in others it resembles small scales. In the present instance, and in most compound flowers, the calyx consists of a species of hairs, either separate or glued together. This was formerly considered by botanists rather as an appendage to the calyx than forming that organ, and was distinguished by the name of tuft or *pappus;* and though this name applies literally only to hairs, it has been extended by analogy to all the various forms which the calyx is capable of assuming.

CAROLINE.

But this little feathery tuft appears much more ornamental than useful: sepales, under such a form, cannot, I think, afford any protection to the flower?

MRS. B.

The florets, being so close together, require no protection from the calyx: this organ is, therefore, converted to another use: under the form of a tuft it first assists the fruit to disengage itself from the involucrum, and then transports it to a distance; for the pappus or tuft remains upon the fruit after the blossom has fallen.

There are some few compound flowers the calyx of which is not at all elongated, and which, consequently, have no pappus; in order to disengage itself from the involucrum, the seed is furnished with other means of separating itself from the parent-plant. Sometimes the receptacle rises up after the blossom is over, to force out the fruit; at others, the weight of the head, when it is mature, bends the pedunculus, and the seeds fall to the ground.

CAROLINE.

You speak sometimes of the fruit, and sometimes of the seed, which the tuft wafts away: do you mean to use these terms indifferently, or have they each of them a distinct meaning?

MRS. B.

I said that the small body, to which the tuft was attached, was composed of the ovary and the calyx. The ovary contains a single seed, which has its own particular covering, called Spermoderm.

EMILY.

Then the single seed of each little flower is wrapped up in three coverings, adhering to each other — the spermoderm, the ovary, and the calyx?

MRS. B.

In some compound flowers, these three coverings are distinctly seen; in others they are only supposed to exist by analogy, without being actually visible. These three integuments, soldered together, form a peculiar species of fruit, which was formerly called a naked seed, but is now distinguished by the name of *Achenium*.

In some families (such, for instance as the *Epilobiums* and the *Apocinums*,) small feathery tufts are attached to the seed, instead of forming the calyx; they then bear the name of *Coma*, to distinguish them from the pappus: though different in their origin, their purpose is the same. But we are digressing from our China Aster.

EMILY.

Pray let us return to it; for it has become very interesting, since I have learnt how much there is in those little things which you call florets.

MRS. B.

Above the ovary, and within the pappus, you may perceive a yellow tube, terminated by five small teeth, this is the corolla. If you slit it up with the point of a penknife, and look very close, you will see five little stamina: they have each their filaments, which appear to grow out of the tube of the corolla, and each of them is terminated by an anther.

CAROLINE.

I can only see one anther.

MRS. B.

Because the five anthers adhere together, so as to form a cylindrical tube, through which passes the style, the extremity of which spreads out into two small branches. It is this tube which constitutes a characteristic distinction of the compound flower. It opens internally by two small slits. The style is also furnished with a peculiar species of stiff hairs, called *sweeping hairs;* being designed to sweep the pollen from off the anthers, so as to make it fall upon the stigma.

EMILY.

How wonderful that a little yellow atom, which I scarcely thought worth observing, should contain so great a variety of curious organs! But we have not done yet with the China Aster, Mrs. B. We now understand the structure of the yellow central florets, but the purple ones which form the circumference are totally different. They have no resemblance to the central florets, either in shape or colour, and look exactly like long narrow leaves cut at the end into fine small teeth.

MRS. B.

Though apparently so dissimilar, you will find, upon examination, that they have the same origin. Pull out one of these violet leaves, and you will see that the extremity by which it is attached to the receptacle is not flat, but round and hollow, in the form of a tube. Now suppose it to have been originally one of the little yellow tubular florets which, having grown to a considerable length, splits open laterally, and spreads out, it would assume the form of a narrow strap, which you see it now wears. It has hence acquired the name of *ligulate* florets, *ligula* being the Latin name for a strap.

EMILY.

Do you mean to say that these purple leaves which surround the head were once yellow florets like those in the centre?

MRS. B.

That is the fact; and if you examine the yellow florets which are contiguous to the purple ones, you may detect some of them undergoing this transformation: they are larger and more developed than those nearer the centre, and the teeth of some of them are beginning to assume the violet tint.

EMILY.

It is, indeed, a most singular metamorphosis; but how do you account for their change of colour?

MRS. B.

I am not competent to answer that question; but it is in all probability owing to the greater exposure to light and air, and probably to a consequently greater degree of evaporation and deposit of carbon. Here is a double China Aster, which is composed wholly of ligulate florets; all the yellow florets having, by the force of cultivation, undergone that change which naturally takes place only with those situated at the circumference of the head. A double flower is, you know, by botanists considered as a monster, unable to bear fruit; and if you examine these florets attentively, you will see that they have no stamens; and even the style often appears imperfect, the corolla having absorbed the sap which would have enabled them to develope these organs. Florets of this description, therefore, yield no seed, and when a head is entirely composed of them, it is incapable of propagation.

CAROLINE.

Here is a scorzonera which has only flowers of this kind, and yet it produces seed.

MRS. B.

This is no monster, but a head in its natural state, its florets having both stamens and styles. Compound flowers exist in three different states:—the head is sometimes composed entirely of tubular florets; the artichoke and the thistle are of this description: they are called *flosculous*, and, with some few peculiar exceptions, all the florets yield seed.

A second state is when the head is composed entirely of ligulate florets, having stamens and styles ; these form the class called *Ligulate*, or, as they are sometimes, though less properly, called, *Semi flosculous*. The scorzonera and the endive belong to this class, and all the florets yield seed. In the third state, the florets in the centre of the head are tubular, and those at the circumference flat or ligulate : these are denominated *Radiate*. The dahlia, the aster (including the China aster), the camomile, the daisy, and many other plants, are comprehended in this division. The central florets generally yield seed, while the lateral ones are barren.

EMILY.

But under what head do you class this China Aster, which consists wholly of ligulate florets ?

MRS. B.

Monsters are discarded by botanists from all classes. These varieties of structure, combined with those which exist in the receptacle, the involucrum, and the pappus, have enabled botanists to separate and divide into classes the numerous compound plants which are spread over the face of the globe. There is also a fourth state of compound flowers, in which the corolla is divided into two lips : they are called *Labiate florets*. But I shall not enter into any details on this class, as it is found only in America, and is very rare in the botanical gardens of Europe.

EMILY.

I am glad that you spare my memory ; for I fear I shall have some trouble to recollect all you have taught me concerning those which grow in Europe.

MRS. B.

I assure you that I have endeavoured to make the subject as easy as I could, and have omitted many difficult parts; but in this case, as in every branch of botany, you will understand clearly only by seeing with your own eyes. Analyse the compound flowers you meet with ; and when you have examined a few, you will comprehend them better than all my explanations will enable you to do. I do not pretend to make you adepts in botany ; I merely wish to direct your attention to the observation of the works of Nature : they will speak for themselves, and in a language far more eloquent than I possess.

CONVERSATION XIX.

ON FRUIT.

MRS. B.

It is now time for us to take leave of flowers, and turn our attention to the fruits which they produce; in which state the seed may be considered as entering into a second stage of existence.

After the flower has performed its office of fructifying the seed, the petals, and every organ which is not destined to become a part of the fruit, wither, and fall off. In the mean time, the ovary grows, and gradually assumes the appearance of a fruit.

EMILY.

Is the fruit, then, formed from the original little leaf which so carefully guarded the seed when the flower was in blossom, and which you called a carpel?

MRS. B.

Yes; when it assumes the form of fruit, it is frequently called by botanists a *pericarp*.

CAROLINE.

But I suppose it retains the name of seed-vessel, since it contains the seed in the fruit as well as in the flower?

MRS. B.

Certainly. Now let us take, for example, one in which the form of the original leaf is not wholly obliterated — this pod of a pea, for instance : you may plainly see that it consists of a leaf doubled over the seeds, with its edges united.

EMILY.

This pod, which is very young, is almost flat ; but here is a larger one, which is become convex, in order to make room for the growth of the peas ; the older it grows, the more it loses the form and appearance of a leaf.

CAROLINE.

In shelling peas, I have observed that the pod readily opens where the edges of the leaf have been soldered together ; but if you attempt to sever the pod at the opposite seam, which I suppose forms the midrib of the leaf, it is much more difficult.

MRS. B.

You are mistaken there, my dear ; for, in shelling peas, the pod is opened by splitting asunder the midrib of the leaf. When the pod is ripe, this rib opens of itself, and the opposite suture or seam, formed by the soldering of the edges of the leaf, also gives way ; so that the pod is separated into two halves or valves, and the seeds detach themselves and fall to the ground. This is a natural mode of opening, for the purpose of shedding their seed, which is common to a great number of pericarps : it is called *dehiscence.*

CAROLINE.

Then the peas, which I thought had been attached to the midrib of the leaf, must grow from its margin : that seems very singular. Is there any instance of leaves, in their common state, bearing seeds thus ?

MRS. B

There are some few leaves which possess this extraordinary property : but what they bear are not seeds, but germs, susceptible of becoming young plants, and these are situated on its margin, like the seeds in a carpel. This structure is found in the *Bryophyllum* and in the *Malaxis paludosa,* a little plant, growing occasionally in bogs in this country.

CAROLINE.

Well, it is not very difficult to comprehend that a leaf may be converted into a pod, which you botanists dignify with the name of fruit; but I cannot conceive how you can metamorphose a leaf into what we ignorant people call fruits; such as an apple, a cherry, or a plum.

MRS. B.

With a little farther explanation, I hope I shall be able to accomplish this. Do you recollect the structure of a leaf?

EMILY.

It has a smooth upper surface, and an under surface more porous, of a rougher texture, and generally downy or hairy. Between these surfaces lies the *pabulum,* a softer body, consisting of an expansion of the cellular system, and this is traversed and intersected by the fibrous vessels which form the ribs of the leaf.

MRS. B.

Extremely well, In the pea-pod these several parts are distinguishable. The leaf is doubled upon its upper urface, so as to render the under surface external.

EMILY.

The most porous surface must, of course, form the outside of the pod, otherwise the stomas could be of no use.

MRS. B.

This is the case not only with the pea but with all carpels. The external surface of the pod takes the name of *epicarp;* and the thin delicate skin, which lines the interior of the pod, and is formed from the upper surface of the leaf, is called *endocarp;* while this soft intermediate layer, consisting of the pabulum of the leaf, is denominated *mesocarp.*

CAROLINE.

Oh, what hard words to remember, Mrs. B.!

MRS. B.

You will, perhaps, be able to retain them more easily if I explain their derivation: *carpos* is the Greek word for fruit, and *epi* for upon or over.

CAROLINE.

That clears up the whole difficulty: for it is easy to understand that *epicarp* signifies the outside skin which is *upon* the fruit; *endocarp* the inside skin; and *mesocarp,* no doubt, means the middle substance between the two. Now, if you will be so good as to tell me the derivation of the word *peri,* I shall not forget the meaning of pericarp.

MRS. B.

Peri signifies about or around; so pericarp means about or around the fruit. According to this definition, the seed alone is considered as the fruit; but, in the usual acceptation of botanists, the pericarp itself constitutes the principal part of the fruit.

A leaf, forming a carpel or pericarp, may be folded in a variety of ways, either cylindrical, or in the form of a cornucopia, or doubled a little convex like a pod; but, however diversified the shape of the fruit, it results always from the manner in which the leaf was originally folded, when it first budded.

Now, into what sort of fruit do you wish that I should convert one of these pericarps?

CAROLINE.

You speak with the same confidence, Mrs. B., as if you were going to perform the metamorphosis with a fairy's wand; and make me expect to see it accomplished with the same facility that the pumpkin was converted into a coach for Cinderella. However I shall endeavour to increase the difficulty of your task, by making choice of a fruit which bears no kind of resemblance to a leaf — a peach, for instance. Will it not require the utmost effort of your art to effect this transformation?

MRS. B.

Far from it; for the peach is one of the most simple of fruits: it resembles the pea-pod, in being composed of a single carpel, but it is still less complicated, for the carpel contains but one seed — the kernel within the stone. The skin is the epicarp. Do you not recognise the hairy cuticle of the under surface of the leaf in the downy skin of the peach? Then the cellular texture of the pabulum, absorbing a great quantity of sap, and swelling out as it grows, forms the fleshy substance of the fruit: — this is the *mesocarp*. Finally, the upper surface of the leaf being, in a great measure, deprived of moisture, and starved, as it were, by the voracious appetite of the mesocarp, its fibres contract, become tough, then indurated, and are at length converted into a shell or hollow stone, which affords most secure shelter for the seed: — this is the *endocarp*.

CAROLINE.

What a very curious transformation! Every vestige of the ribs of the leaf is obliterated in the fruit; but traces of contraction of the endocarp are discernible in the seams and wrinkles with which the stone is covered.

EMILY.

There are also indications of its being composed of two valves, for a sharp instrument will split it open, and divide it into two parts, and, when it is diseased, it separates of itself. Then the curved indenture, which runs along the peach on one side, I think, points out the seam of the carpel. And pray, Mrs. B., are not apricots, plums, and cherries, formed in the same manner?

MRS. B.

Yes, and all other stone fruits. This class is distinguished by the name of *Drupe* or *Drupa*: among these you will, perhaps, be surprised to hear that the almond and the cocoa-nut are classed.

EMILY.

They certainly bear very little apparent resemblance to stone fruits, being wholly destitute of a fleshy mesocarp.

MRS. B.

In these dry drupes, the mesocarp assumes the form and texture of coarse thready fibres, which form the external covering of the nut: the endocarp is the hard woody nut, and the smooth skin with which it is covered is the epicarp.

CAROLINE.

Who would ever have imagined that the flesh of the peach, so delicate and luscious, and the coarse fibres which enclose the almond, had both a similar origin! I suppose, then, that it is the almond which absorbs the chief part of the nourishment, since the whole of the pericarp is so dry and meagre?

MRS. B.

Yes; and in dry drupes it is the almond or seed which we eat instead of the mesocarp.

EMILY.

I suppose that the apple and the pear derive their fleshy substance, like the peach, from the swelling out of the mesocarp.

MRS. B.

No, this is not the case; for the apple and pear are quite of a different description from the drupe. But do not let us proceed too fast, and by degrees I hope I shall be able to make you comprehend them all. I began by selecting the most simple cases, in order to be well understood: we must go on upon the same plan: for in natural science we cannot, as in chemistry, make experiments which gradually lead us from the simplest to the most compound combinations; but Nature makes these experiments for us, and our business is only to arrange the combinations she exhibits in methodical order. We have hitherto confined our observations to fruits formed of a single carpel; but it is not difficult to conceive that a fruit may be composed of several carpels. Take, for example, this Pœony: it consists of a number of carpels, each of which exactly resembles a pod. You recollect my telling you that the pistil of a flower was commonly formed of several carpels: such flowers will produce fruits with a similar number of carpels.

CAROLINE.

Oh yes: and I recollect your saying that this was the case with the apple and the pear.

MRS. B.

A little more patience: we are not yet arrived at the apple and the pear.

EMILY.

But cannot you show us some other fruits similar to that of the pœony? for I see it is only by natural specimens that we can understand the curious transformation of flowers into fruits.

MRS. B.

It is very true, that it is necessary to observe the flower in order to understand the conformation of the fruit. Here is an *apocynum*: its flower bears two carpels, which differ but little from a pod: these carpels are distinguished by the name of *follicles*. Here is another example: it is a variety of the cherry, which, instead of bearing a single drupe like the common cherry, bears several.

We will now proceed another step, and examine the raspberry: this fruit consists of a considerable number of small fleshy carpels, all of which result from a single flower. It resembles an aggregation of small drupes.

EMILY.

The number of carpels, then, I see, offers no difficulty: a flower may bear one carpel, like the pea; or two, like the apocynum; or five, like the pœony; or a still greater number, like the raspberry.

MRS. B.

Certainly. Now, examine this long narrow pericarp of the wall-flower: of what number of carpels do you suppose it consists?

CAROLINE.

Of only one, for it is a pod similar to that of the pea or the bean; — but no, on opening it, I perceive that a thin partition runs down the middle, which divides it into two cavities, and that there is a row of seeds in each. This pod must therefore consist of two carpels growing together, so as to form but one fruit.

MRS. B.

Pericarps of this description are not called pods but *siliques*. The pod belongs to *leguminous*, the silique to the *cruciform* family.

EMILY.

We have seen many instances of the organs of flowers being soldered together: the petals, for instance, are frequently united so as to form a corolla of a single piece; the stamens often cohere together by their filaments; the anthers are united so as to form a tube in compound flowers; and it is not more difficult to conceive that several carpels should be soldered together, and form fruits, having different cavities or cells for seed.

MRS. B.

You may consider it as a law of Nature, that the number of cells for seed contained in a fruit implies the number of carpels soldered together in its formation. This law, however, admits of exceptions, which require some further explanation. The carpels, you know, consist of folded leaves: if these reach to the centre of the fruit, the cells will be complete; if they reach but half way, the centre will be hollow and empty; for the partitions formed by the folding of the leaves will only reach half way; of this the poppy is an instance. If the leaves be still less folded, they will spread out in growing, and the fruit, though composed of several carpels, will only have one cell: the melon is an example of this kind.

EMILY.

How, then, can you distinguish a fruit that has but one cell for seed, because it is formed but of one carpel, from a fruit that has but one cell, though originally composed of several carpels?

CAROLINE.

I think I can explain that. When the fruit consists of one carpel only, the seed will be placed in a row on one side of the carpel; but when it consists of several carpels, there will be as many rows of seeds as there are carpels, since each bears its row of seeds.

MRS. B.

You are right; but recollect that each row, though apparently single, is in fact a double row, the seeds being attached alternately to each valve of the carpel.

Well, now that you have seen and understood the result of the soldering of carpels together, and the effect of the leaves, of which they are composed, being more or less folded or curved inwards, you may readily conceive that such differences are sufficient to account for the various forms of fruits.

When the carpels are *verticillate,* that is to say, situated around a common axis, or a little column (called *columella*), the division of the carpels often completely disappears externally, and the fruit assumes a spherical appearance; but if the convexity of the carpels be greater than that of the whole fruit, each carpel protrudes externally, forming a rib, such as those of the house-leek.

EMILY.

The shrub, which is dignified with the name of Pæony-tree, has the carpels of its fruit enclosed in a sort of membrane, which covers them completely.

MRS. B.

This membrane, according to the celebrated Mr. Brown, appears to be a prolongation of the Torus, or base of the stamens, which grows over the carpels, and, in some instances, adheres to them; but this species of conformation is very rare. One that is much more common, but also more complicated, is when the carpels not only cohere together, but are also soldered with the calyx; so that when the blossom falls, the fruit which grows is composed of the carpels and the calyx, forming a single body.

EMILY.

This must produce a fruit of a very singular appearance.

MRS. B.

Not so much so as you imagine: for the apple and the pear are of this description. This mode of growing can be easily understood when the fruit is traced from its primitive existence in the flower; but I can give you an infallible test to know whether the fruit, when already grown, is of this description. You see the eye at the top of this pear: it is formed by the remnants of the sepals, or leaves of the calyx; and whenever you see such an eye at the summit of a fruit, you may be assured that it consists of the carpel and the calyx soldered together. All fruits whose seeds are pips, are of this nature, and are distinguished by the name of *Pome*.

EMILY.

The quince, I am sure, then, consists of the calyx soldered to the carpels, for it has a very large eye: but is the medlar also of this description? — it has a considerable opening at the top, somewhat resembling an eye.

MRS. B.

Yes; and the aperture results from the calyx not completely covering the carpels: these, therefore, are visible between the teeth, or indentures, which terminate the calyx.

EMILY.

I see that the metamorphosis of a flower into a fruit is in many cases a very complicated affair, and not so easy to understand as I had imagined from your first explanation. Is it the calyx which forms the skin, and the pericarp the flesh of the pome?

MRS. B.

It is difficult to distinguish these organs, when cohering together. The calyx, however, being external, must naturally form the skin of the pome; part of it may also enter into the composition of the flesh, together with a portion of the pericarp. The heart, or core of the pome, consists of the endocarps of five carpels, each containing two seeds or pips.

EMILY.

The orange has no eye; otherwise I should have thought it had been a fruit of a similar construction.

MRS. B.

Far from it: the orange is a pulpy, not a fleshy fruit, like the pome or the drupe. Now pulp does not, like flesh, result from the growth of the mesocarp, but is a peculiar succulent substance, situated inside of the carpels: those of the orange consist of the quarters into which the fruit may be easily divided when the rind is peeled off, and the seeds are imbedded in the pulp contained within them.

CAROLINE.

True: they are not lodged in a core, like the apple or the pear; not in a shell or nut, like the peach or the plum. But might not a fruit have both flesh and pulp?

MRS. B.

Yes; the quince is an instance of this combination: the flesh is, like that of the pear, situated outside the core or cells containing the seeds, and within those cells the quince contains pulp; but this species of complication is not common.

CAROLINE.

And pray, under what head do you class those fruits in which the seeds are promiscuously situated, such as the gooseberry, the currant, and the grape?

MRS. B.

They are distinguished by the name of *Bacca*, or berry: in these the mesocarp is soft and succulent. Although the seeds are attached to the endocarp, yet the latter is obliterated when the fruit is ripe. A strawberry is not properly so called, because it does not belong to the class of berries. It consists of a fleshy substance, formed by the expansion of the summit of the pedunculus, in which the several parts of the flower are inserted, and which we have called the *torus*. The small grains which you see upon its surface are so many little carpels, each of which contains a seed.

CAROLINE.

They are so small and dry that they look like naked seeds.

MRS. B.

The pericarp fits closely to the seed, so that they seem to form but one body: but they may, thus united, be considered as so many distinct little fruits, imbedded in the soft substance of the torus.

CAROLINE.

They would be very little appreciated as such, were it not for the delicate flavour of this soft substance.

MRS. B.

These little grains, though dry, are analogous to the small fleshy spherical bodies which form the raspberry; and the white conical substance which remains upon the calyx of the raspberry, after the fruit is pulled off, is analogous to the fleshy substance of the strawberry; for they both result from the growth of the torus.

CAROLINE.

With this difference; that in the one it is the torus, in the other, the berry, or true fruit, which is good to eat.

EMILY.

And is not the torus, on which the raspberry grows, analogous to the stalk which traverses the mulberry? For these two fruits bear a great resemblance to each other.

MRS. B.

You are falling into an error to which every one is liable who judges from the appearance of the fruit without having previously studied the flower. If you examine the blossom of the mulberry, you will see that it consists of several small sessile florets disposed around the axis; that each of these, after the blossom has fallen, forms a distinct fruit, consisting of the carpel and the calyx: these fruits being fleshy, and situated so near to each other as to come in contact in growing, cohere together: so that a mulberry, which is in fact an aggregation of several different fruits, proceeding from as many different flowers, wears the same appearance as a raspberry, which is the result of different carpels belonging to the same flower.

There are four degrees of complication in the composition of a fruit.

First. Fruits formed by a single carpel, such as the pea or the peach.

Secondly. Those formed by several carpels, the produce of a single flower, like the pæony and the raspberry.

Thirdly. Those formed of several carpels, surrounded by and soldered with the calyx, such as the apple and the pear.

Fourthly. Those formed by the aggregation of several fruits produced by different flowers, like the mulberry.

I will give you some further examples of fruits of the latter description. The cone of a pine or fir tree consists of an aggregation of fruits, produced by as many different flowers, having each a single seed: these flowers are separated by bracteæ, which remain after flowering: they grow tough and hard, and enclose each of the fruits as it were in a case, the aggregation of which forms the fir-cone.

EMILY.

This is a kind of fruit quite new to us; and the cone of the magnolia is, I suppose, of the same description.

MRS. B.

No; the cone of the magnolia proceeds from several carpels belonging to the same flower. The difference is very difficult to distinguish after the blossom is over and the fruit formed; but is easily observed if the history of the fruit be traced from the period of blossoming.

CAROLINE.

It seems to me to be very difficult to avoid error on so complicated a subject.

MRS. B.

I cannot deny it; and I will give you another instance of deceitful resemblance. Few things bear a greater likeness to each other than the Spanish chesnut (*castanea vesca*) and the horse-chesnut (*æsculus hippocastanum*); yet the horse-chesnut is simply a seed, while the Spanish chesnut is a fruit, consisting of two or more seeds, each of which has its separate envelope, under the form of a reddish-brown skin. The shell of the horse-chesnut is a capsule produced by a single flower. The prickly covering of the Spanish chesnut is an involucrum, which surrounded the several flowers. You see, therefore, that it is very difficult to decide upon the nature of the fruit without having studied the flowers whence it derives its origin.

Another curious example of the cohesion of fruits produced by different flowers is afforded in the pine-apple. This, which you have doubtless hitherto considered as a single fruit, is the result of the soldering of a number of small fruits produced by sessile flowers aggregated on an axis, which is the stalk. These being soft and fleshy, unite together; but traces of the different fruits are seen on the surface, each forming a small protuberance: the axis of the fruit terminates in a crown of leaves, which surmounts the whole.

CAROLINE.

But where are the seeds?

MRS. B.

Cultivation, I have told you, tends to diminish the quantity of seed: in the pine-apple it makes them fail completely, so that the plant can be propagated only by the crown or by suckers. You may see towards the centre of the pine-apple the vacant cells in which the seeds have perished, and in which they are lodged in the wild pine-apple, whose fruit is less succulent and less highly flavoured.

From the pine-apple and the mulberry you may conceive a very good idea of the fruit of the bread-tree, which supplies the inhabitants of the South Sea Islands with food. It may be compared to a very large mulberry, composed of aggregated fruits. When the seeds fail, which is the case in the Friendly Isles, the fruit grows to a prodigious size: when the seeds are perfected, it is in a great measure at the expense of the of the fleshy part, whose place they occupy, and the fruit is consequently inferior both in size and flavour. This is the case with the wild bread tree (*Artocarpus incisa.*)

EMILY.

You said that some carpels do not open to shed their seeds: how, then, can these sow themselves and germinate?

MRS. B.

Fruits, in this respect, may be divided into three classes.

First. Those which do not open, and which contain but one, or at most a very few seeds; such are the fruits of the gramineous family, and of compound flowers. They are distinguished by the name of *Pseudosperma,* which signifies false seeds: because, though they assume the appearance of seeds, yet, being surrounded by their pericarp, they are in reality fruits, and in this state they are sown and germinate.

Secondly. Those fleshy fruits which do not open naturally; these in the course of time become rotten, and thus disengage their seeds.

Thirdly. Fruits which are not fleshy, and which contain a number of seeds are collectively distinguished by the name of *capsular* or *dehiscent* fruits. These open naturally and shed their seeds, which are dispersed in falling, and thus have a greater chance of germinating.

CAROLINE.

This classification of fruits is more easy to comprehend than the others.

MRS. B.

True, but it is much less important; for, instead of explaining the essence of things, it shows only the consequences. It is, however, far from being devoid of interest; but I shall enter into no further details: it is better to rest satisfied with the knowledge of a few principles, which I trust you will find no difficulty in applying to the different plants which may come under your notice. I can never sufficiently repeat, what my professor of botany has so often observed, that natural history can be learned but in a very imperfect manner in books; and that, in order to obtain a competent knowledge of objects they must be studied in nature.

CONVERSATION XX.

ON THE SEED.

MRS. B.

Before we proceed to treat of the germination of the seed, we must examine its internal structure. A seed may be considered as a germ situated at the axilla of a leaf.

CAROLINE.

Of that wonderful little leaf which performs so great a part in the flower and in the fruit, and undergoes as many transformations as harlequin in a pantomime?

MRS. B.

No; the one I allude to is another little leaf, which adheres so closely to the germ as to form the coating of the seed itself: it is called the *Spermoderm,* from two Greek words, *sperma,* signifying seed, and *derma,* skin. The spermoderm, like the pericarp, is composed of three coats.

EMILY.

Derived, no doubt, from the two surfaces, and the pabulum of the leaf, of which it is formed.

MRS. B.

Precisely. The external skin, called *Testa,* or *cuticle,* corresponds with the epicarp; the cellular coating, denominated *Mesosperm,* with the mesocarp; and the internal skin, called *Endopleura,* represents the endocarp.

When this leaf first shoots, it is hollow, and contains a nutritive juice, called *Amnios:* the germ attached to its axilla, when fructified, begins to absorb this fluid: it takes the name of embryo; and is, in fact, a plant in miniature. In proportion as the amnios diminishes, the embryo fills out and occupies the vacant space: in the course of time it grows so large as to distend the spermoderm itself. Here is a very young bean: I slit open the spermoderm, and you see the embryo plant surrounded by the amnios.

EMILY.

But it is the miniature of a bean, not that of a plant.

MRS. B.

It is the cotyledons of the embryo plant which form the greatest part of this little bean: the radicle and plumula are enclosed within them, and are not sufficiently developed to be distinguished without the aid of a microscope. But here is a full-grown bean, in which the embryo occupies the whole interior of the spermoderm, the amnios having been all absorbed. Now, if you separate the cotyledons, you will perceive the skeleton of the plant lodged between them, and making a slight indenture in either cotyledon.

CAROLINE.

I see it perfectly; but it is not in the centre of the bean.

MRS. B.

No; it is situated at that end by which the bean was connected with the pod by a short pedicel. This spot is commonly called the eye or *hilum* of the seed. The pedicel conveys nourishment to the embryo plant. When the seed is ripe, this communication ceases, the pedicel withers and dries, and the seed detaches itself. This scar which you see on the testa, and which interrupts its uniform smoothness, is made by the rupture of the pedicel, and is always considered as the base of the seed; and you may still perceive the small aperture through which the nutritive juices passed into the seed.

EMILY.

But is not the embryo plant nourished by absorbing the amnios?

MRS. B.

Not wholly; for you must consider that it not only requires food for its immediate sustenance, but lays up a store of provision in its cotyledons, which is reserved for its future growth at the period of germination.

CAROLINE.

I always thought that those little threads which fastened peas and beans to the pods were merely to prevent their rolling about in the shell; but now I see that it is necessary they should have a communication with the pod, for the conveyance of nourishment.

EMILY.

What miniature vessels must these be! I know nothing more curious than the extreme, I may almost say the invisible, minuteness of some of the organs of plants.

MRS. B.

In some seeds, the whole of the amnios is consumed by the embryo plant; in others, the absorption of this liquid is only partial: the most fluid parts pass into the embryo, while the more solid particles, being probably too bulky to traverse such minute vessels, are deposited in the interior of the seed. This substance is, at first, of the colour and consistence of the white of egg, and has thence acquired the name of albumen; but, as the seed approaches maturity, it coagulates, and adheres to the endopleur, lining it throughout with a white concrete substance, and, indeed, filling the whole of the space which is not occupied by the embryo plant. This is a resource afforded by Nature for the germination of seeds which do not contain a sufficient store of food in their fleshy cotyledons.

CAROLINE.

But peas and beans are so well supplied by these cotyledons, that they can be in no want of such resource.

MRS. B.

Very true: the whole of the leguminous and the cruciform family, as well as several others, have no albumen. But the gramineous family, which includes all the various species of corn and grasses, are in great need of this auxiliary; for not only do they belong to the class of monecotyledons, but their single cotyledon is so small, that, although slightly fleshy, it affords but very little nourishment. But let us seek for an example on a larger scale: — you have, I dare say, eaten the white substance which lines the shell of the cocoa-nut?

CAROLINE.

Frequently: it has the consistence, and somewhat the taste, of an almond. This, then, is albumen; but what is the water that fills the cavity of the nut? — It cannot be the more fluid part of the amnios, as this, you say, is absorbed when the albumen is deposited.

MRS. B.

The seed of the cocoa-nut is very large, and the embryo plant very small; so that the latter cannot absorb the whole of the amnios, and it is the residue which constitutes the water of the cocoa-nut. Albumen, you will observe, does not, like the cotyledons, constitute a part of the embryo plant; it is merely a deposit of food for its use. The embryo is, in general, much larger in seeds which have no albumen.

CAROLINE.

Of course, such embryos carry their store of food about them, as a snail carries its house upon its back: they must therefore occupy more space; and the whole cavity within the spermoderm being vacant, they have more space to occupy.

MRS. B.

All that is contained within the spermoderm, whether it consist of the embryo plant and albumen, or whether of the embryo plant alone, is called the nucleus, kernel, or almond of the seed.

EMILY.

The amnios, then, either in its entire substance, or a fluid secretion from it, is destined to feed the embryo plant, while the young seed is embosomed in the flower. The albumen and cotyledons afford a coarser sort of food, reserved for the future nourishment of the seed when it germinates.

MRS. B.

So Nature designed it; but art converts the greater part of this coarser sort of food into nourishment for a superior order of beings. In peas and beans it is the fleshy cotyledons that we eat; in corn it is the albumen of the seed which supplies us with bread.

CAROLINE.

But in peas and beans it is the seed itself we eat, not the cotyledons?

MRS. B.

The cotyledons form the principal part of the seed; of those, at least, which have no albumen. If, instead of eating them when young, we allowed them to ripen and germinate, the pea and the bean would separate into two parts, and assume the form of cotyledons.

EMILY.

We then rob the young plant of its destined food?

MRS. B.

Or rather we devour the young plant, together with its store of provision. If corn were not reaped, the grain would fall into the ground, and, there germinating, the albumen of the seed would be expended in nourishing the young plants; but when these struck root, the soil would be unable to maintain a crop so thickly sown: many seeds would perish for want of food, and the rest being but imperfectly supplied, few or none would come to perfection.

EMILY.

It appears to me surprising, that the embryo plant, after having been in an active state of vegetation while the seed remained within the flower and the fruit, should become, as it were, dormant when the seed is mature, and separated from the plant; nay, should often remain so for a long period of time.

MRS. B.

The principle of life, it is true, can be preserved in some seeds a great number of years; but what that living state is, which so nearly resembles death, we cannot explain. It is time, however, for us to rouse the inactive seed from its torpor, and examine it, when it enters into a new existence, as a separate and independent being.

EMILY.

True; we have hitherto considered only the formation of the seed, and its growth in the flower and the fruit.

MRS. B.

Let us now, then, suppose it to have attained a state of maturity, and to be ready, when placed under favourable circumstances, to germinate. For this purpose the seed must first be detached from the parent plant.

CAROLINE.

That is what we every day witness. The fruit, when ripe, drops from the tree; or the pericarps, when dry, burst open, and shed their seeds.

MRS. B.

Not always; some pericarps, we have observed, have no natural mode of opening; such are the nut, the amaranth, the pericarps of compound flowers, and those of gramineous plants. In the latter, the pericarp adheres so strongly to the seed, that they are confounded together, and cannot be distinguished. The seed is, in this case, inaccurately said to be naked; when ripe, it falls from the stem, enclosed in the pericarp, and, thus covered, sows itself in the ground.

CAROLINE.

Then I think that seeds of this description should be called clothed, rather than naked.

MRS. B.

They are so, in fact; but as the pericarp is of a hard dry nature, adhering closely to the seed, it is commonly considered as forming a part of it. Thus the seeds of corn and grasses are sown enclosed in their pericarps.

EMILY.

Then the pericarp, I suppose, rots in the ground, and the seed is left at liberty to germinate?

MRS. B.

The pericarp ultimately rots, but not until the germ has made its escape through a small aperture, which nature has provided for that purpose. That of a grain of corn is too minute to be seen with the naked eye; but you may probably have observed three openings of this description in the cocoa-nut, a seed of sufficient size for them to have attracted your attention. Through one of these the embryo escapes from its prison.

EMILY.

But the stem and the root cannot shoot from the same opening, or they would both grow in the same direction?

MRS. B.

The radicle first sprouts from the aperture with the neck situated at its base; from this vital spot the plumula shoots upwards; but the young plant remains attached to the pericarp by the neck, until it has consumed the albumen of the seed, and is able to supply itself with food from the soil.

It is thus that monocotyledons are ushered into life. The germination of dicotyledons is somewhat different. The seed is not enveloped in its pericarp, and when it begins to germinate, the spermoderm cracks and falls off; the cotyledons, commonly called the lobes of the seed, are split asunder by the stem which rises between them; but, like a careful parent, they follow their nursling at its entrance into life, and continue to supply it with food until its roots are sufficiently strong to perform that office.

In dicotyledons, therefore, the embryo plant consists of three parts: the *radicle*, or root: the *plumula*, or little stem; and the *cotyledons*, or seminal leaves, which make their appearance at the base of this stem.

The first and most essential circumstance requisite for germination is moisture; for a seed, in germinating, absorbs about once and a half its weight of water.

EMILY.

This is, no doubt, for the purpose of softening and dissolving the hardened contents of the cotyledons, and rendering them sufficiently limpid to pass through the minute vessels which convey them into the embryo plant.

MRS. B.

Yes; moisture is equally necessary, whether the germinating plant be fed by the farinaceous matter of the cotyledons or by albumen; for seeds, when ripe, you know, are perfectly dry, or if they contain any water, it is not in a state of liquidity, but solid, like the water of crystallisation in mineral salts. If seeds are deficient in moisture, they are, on the other hand, overladen with carbon, so that you must supply them with water, and free them from a portion of their carbon, to enable them to germinate. It is the great quantity of carbon which seeds acquire in ripening that exhausts the soil in which they grow.

CAROLINE.

But for what purpose do they require this accumulation of carbon, since they must part with it in order to germinate?

MRS. B.

Carbon is a great antiputrescent, and is necessary to prevent the seed from rotting previous to being sown. Some seeds are, through its influence, capable of being preserved several centuries; while others, which are but scantily supplied with it, must be sown as soon as ripe. And in seeds which have not acquired a due supply of this preservative, the principle of life is extinguished before they separate from the parent plant.

EMILY.

With a view of ascertaining whether seeds are capable of germinating, I have seen gardeners throw them into water; discard those which floated on the surface as worthless, and sow only those which sunk. They judged by the weight of the seed, I suppose, whether it contained a sufficient quantity of carbon to have preserved the vital principle.

MRS. B.

Or, rather, they know by experience that heavy seeds are the most likely to germinate. Immersing seeds in water has also the advantage of preparing them for germination, by supplying them with the moisture of which they stand so much in need.

EMILY.

And it is, I suppose, the oxygen of the atmosphere which performs the office of relieving them from the excess of carbon with which they are incumbered?

MRS. B.

Yes; it is therefore necessary that the soil should lie loosely and lightly over the seed, in order that the air should have access to it. The oxygen of the atmosphere then combines with the carbon of the seed, and carries it off in the form of carbonic acid gas. Seeds will germinate in contact with air which contains from one eighth to one third of oxygen: if the proportion be less, it will be insufficient to perform the function required; if more, the excitement will be too great, and the seed will perish from exhaustion.

EMILY.

The proportion of one fifth of oxygen, which the atmosphere contains, is, then, just the desirable medium. And heat, I conclude, is also essential to germination?

MRS. B.

To a certain degree: seeds cannot germinate during a frost, for the water must be in a liquid state: about ten degrees of Reaumur, or fifty-five of Fahrenheit, is the temperature most favourable to the germination of plants in these climates. It is, moreover, requisite that the soil should be sufficiently permeable for the slender plumula, and the tender roots, when first shooting from the seed, to penetrate it; and, on the other hand, it must be sufficiently compact to support the roots and stem when full grown. The looser the soil is, the deeper the seed should be sown, in order to afford more support.

EMILY.

And in very loose soils the air has freer access, so that there is no danger of depriving the seed of oxygen by sowing it deep. Large seeds, I suppose, require to be sown deeper than small ones?

MRS. B.

Yes; but the largest should not be buried more than six inches in the ground, in order that the air may have access to them. Small seeds require to be merely covered with earth, in order to prevent the wind from scattering them, and to shelter them, in some measure, from the light.

CAROLINE.

Is light, then, injurious to germination?

MRS. B.

Light, you may recollect, subtracts oxyger from the plant, and occasions a deposit of carbon. Now, in germination, it is just the reverse which is to be effected.

When the seed, by absorption, has accumulated a sufficient quantity of moisture, it swells, bursts, the radicle shoots downwards, and the plumula rises in the opposite direction: the one becomes a root, the other a stem; and the almond of the seed is transformed into cotyledons. If any of these parts are destroyed, the plant is no doubt injured, but Nature will restore them by fresh shoots. The neck, or vital spot which forms the junction between the stem and the root, being the only part the destruction of which proves fatal to the plant.

EMILY.

Is it known why the stem always rises, and the root descends?

MRS. B.

The roots, you must recollect, grow only at their extremities; and these, being at first of so soft a texture as to be almost liquid, naturally follow the direction of gravity and descend, unless they encounter some obstacle, such as a stone or clod of earth, so compact that they cannot penetrate it; in which case they grow out laterally, in order to avoid what they cannot overcome.

Mr. Knight performed a very curious experiment, with the view of ascertaining whether it was gravity which made the roots of a plant grow downwards. He sowed seeds in moss disposed in cavities, arranged on the circumference of a water-wheel. The cavities were open on both sides, so that the root and the stem were free to germinate at either. The wheel was then made to revolve one hundred and sixty times in a minute. The roots invariably struck in the direction diverging from the centre, like the spokes of a wheel: whence Mr. Knight was led to conclude, that, in this artificial process, the centrifugal force had replaced that of gravity.

EMILY.

That was a very ingenious contrivance. But the stem, on the contrary, grows upwards, and throughout its length.

MRS. B.

Let us suppose that it were free to grow in any direction. Since it shoots from the upper surface of the neck, it cannot grow downwards: it must, therefore, either rise vertically, or shoot out sideways. In the latter case, it will be gradually brought to a vertical direction by the same cause which makes branches tend to grow upright; that is to say, the fluids which circulate in the stem having naturally a tendency downwards, some portion, however small, will exude from the upper to the under side of the lateral stem; so that the lower, being more amply supplied with juices, will vegetate with more vigour, and grow larger. The diminutive upper side will act like the cord of a bow, and make the stem approximate towards a vertical direction; and this cause, continuing to act on the stem so long as it is not upright, will ultimately render it erect.

Let us now consider more particularly how seed should be sown, both in the fields and in gardens. In the former, the husbandman must prepare the land by ploughing, in order to render it as light as possible: the more it is pulverised, the more favourable it will be to germination. Choice must then be made of the finest grain.

CAROLINE.

Is it not considered advantageous to change the grain, and not sow that which grew in the same soil the preceding year?

MRS. B.

It is proper, we have observed, to vary the nature of the crop; but when, in the course of cropping, grain is to be re-sown, I believe that it is perfectly immaterial whether the seed sown was grown on the same land or elsewhere.

The seasons for sowing are in spring and in autumn. It is advisable to be done early in either season, especially in the latter, in order that germination should take place before the frost sets in. In the spring the period must be regulated by the nature of the season and the climate. The seed may either be sown by the hand or by a drill. The latter is preferable, being more exact and regular in its operation. Care must be taken not to sow too thickly. When more seed is thrown into the earth than it can nourish, part of it will perish. But this is not the only loss; for, before it perishes, it will have consumed a portion of the nourishment which otherwise would have gone to the support of the surviving crop.

In order to avoid this, large seeds, such as beans, are frequently dibbled, that is to say, put into the ground separately in holes made by a dibble; and this mode has lately been adopted by some farmers for wheat with great success: the expense of the operation being more than repaid by the richness of the crop — having yielded above an hundred fold.

Lucerne has been transplanted to the distance of six inches from each other: and the plants growing larger, in consequence of their roots having a wider range for food, others were transplanted to the distance of a foot; and others, again, as far as two feet asunder; and it was constantly found that the plants grew and flourished in proportion as the distance between them increased.

EMILY.

There must, however, be a limit to this economy of seed.

MRS. B.

No doubt; land is not to be had at pleasure; but so long as the same extent of soil may be made to yield a better harvest, by sowing a less quantity of seed, it is no doubt highly advantageous.

The only exception to this rule is when you aim at producing long and slender stems. This is the case with hemp and flax. Comparatively little value is set upon the seed; the stems for making linen forming the essential produce. Those seeds must therefore be sown very thick, in order that the stems may grow long and upright, and no space be allowed them to branch out.

CAROLINE.

And I have heard that the Italian corn, with the straw of which hats are made, is sown very thick, with the same intention, and cultivated on a barren rocky soil, in order that a deficiency of nourishment may give the straw that morbid delicacy and slender form which render the Leghorn hats so fine.

MRS. B.

Let us now turn our attention to garden culture When seeds are sown from foreign parts, you may form some judgment of the degree of temperature and nature of the soil which they require, by the latitude and elevation of the spot whence they came. Seeds from tropical climates should generally be sown in hotbeds, having stone or wooden frames: wood, being a worse conductor of heat, preserves plants better from the cold than stone. Experience teaches us that hotbeds are preferable to hothouses, both for the germination of the seed, and the growth of very young plants; and small hothouses are preferable to large ones (though of an equal temperature), so long as the plants have sufficient room to grow. Of course, they must not be cramped and stinted for space; for large plants require extensive accommodation: but the reason why a confined space is advantageous to small plants has not hitherto been ascertained. The heat generated by the fermentation of manure, is also more favourable to germination than the heat of a stove.

CAROLINE.

That, I think, is easily accounted for. The heat of a stove is of a drying nature, whilst that of the fermentation of manure is always accompanied by moisture, which will accelerate the swelling of the seed and bursting of its coats. And why should not this be the reason, that a hotbed is preferable to a hothouse, for the purpose of raising plants from seed? For the one is heated by fermentation, the other by a stove.

MRS. B.

The pots in which they are sown are frequently placed in beds of manure in a hothouse. Besides, the same argument holds good with regard to greenhouses: the smaller the house, the better it is calculated for the culture of small plants. It has been suggested, that small plants being always placed in the front and lowest rows of the greenhouse, and hot air having a tendency to rise, they occupy the coldest strata of air.

CAROLINE.

The seeds, however, are, I believe, never sown in manure itself, but in pots of earth which are sunk in it; the plant, therefore, benefits only by the heat and the evaporable particles.

MRS. B.

That is true. Little or no manure should be mixed with the earth contained in the pots, in which germination takes place; for the seed, at that period, far from being in want of food, requires to get rid of a surplus of carbon.

EMILY.

But when the germination is completed, and the roots shoot out in search of food, some provision should be made for them.

MRS. B.

If the earth contained in the pots consists of rich garden-mould, it will afford a sufficiency. When land is manured for grain, the seed derives no advantage from it: the embryo plant is nourished by the albumen; and it is not till the roots have acquired some consistence and vigour that they begin to supply the plant with food from the soil.

You must observe that it is necessary to cover the hole, which is made at the bottom of all garden-pots, with a small piece of tile; and it is proper, also, to place a second piece, of larger dimensions, over the first, in order effectually to prevent the too rapid filtration of water. Care must be taken to keep the earth light and loose over seeds which are germinating; for if the soil be calcareous, in drying, after being watered, a crust frequently forms on the surface through which the slender stems cannot penetrate, and the young plant is thus literally buried alive. The surface of the mould must, therefore, be kept scratched or raked, to prevent this crust from forming; or to pulverise it, if the evil has already taken place.

Shallow wooden boxes are frequently used, instead of pots, for the purpose of sowing seeds: they have the advantage of affording them more space.

When plants have so far increased in size as to require transplantation, they should not be pulled up by the roots, but the whole clod of earth be carefully shaken out of the pot at once, and then gently divided into parts, so as to run no risk of wounding the fibrous extremities of the roots in separating them from the earth which surrounds them.

EMILY.

I have observed that, in transplanting them, the gardener uses a pointed instrument to make a hole in the ground, and afford room for the roots of the young plant.

MRS. B.

This is exactly the reverse of ploughing: it makes an opening to receive the young plant, no doubt, but it is at the expense of the contiguous soil, which is rendered proportionally more compact. It is true that the young vegetable, at the period of transplantation, has acquired some vigour; and a light soil is not so essential to it as during germination. It is preferable, however, to transplant in furrows, when the earth is turned up with a spade or a hoe, and the roots afterwards covered by raking the earth over them.

But we are deviating from our subject. Now that we have fairly traced the seed through the process of germination, we should conclude our conversation, and reserve what remarks I have to make on planting to some future day.

CONVERSATION XXI.

ON THE CLASSIFICATION OF PLANTS.

EMILY.

You promised when we entered on the subject of classification, Mrs. B., to explain the exact meaning of the word family in the vegetable kingdom; and I hope you will also teach us how to find out to which family a plant belongs.

MRS. B.

In order to satisfy you, it will be necessary to explain the whole theory of classification, which will be long, and sometimes, perhaps, you may find it tedious.

EMILY.

I have no fear of undertaking it; for I am conscious it is necessary, and that, without such information, it would be difficult to remember many things that you have taught us.

MRS. B.

You are quite right: the number of natural beings is so immense, that without some mode of classification it would be impossible to form a correct idea of them. Would you believe that there are no less than sixty thousand species of plants already known, and that this number is increasing every day?

CAROLINE.

Oh, Mrs. B., what a host!

MRS. B.

It is indeed! Well, then, to carry on your comparison of a host, do you conceive that any general, in reviewing sixty thousand soldiers, would be capable of recollecting every individual?

CAROLINE.

Certainly not; but as each regiment has its uniform, and each company its number, he could easily discover to which of them any soldier belonged.

MRS. B.

This is exactly the object a botanist has in view in classification. He endeavours to find out to which regiment and to which company each individual plant belongs; but this is much more difficult than with an army, where the general has himself chosen the uniforms, and arranged the companies so as to make the distinctions most conspicuous. Nature has also, it is true, her distinguishing characters, but they are often placed in organs which are least exposed to view; and botanists do not always agree on the characteristic features of plants.

CAROLINE.

Well; but tell us at least on what points all botanists do agree?

MRS. B.

Willingly. You see yonder in the garden a bed of carrots: every individual plant of which belongs to the same species.

CAROLINE.

Of course; for I know that the gardener obtained the seed sown in that bed from one individual plant last year, so that the carrots must all be descended from the same parent.

MRS. B.

If, then, you extend your idea to all the carrots in the world, which do not differ from the carrots in this bed, more than these differ from each other, you will understand that they may originally have been derived from the same plant.

EMILY.

Certainly; and that is what we have said constituted a species.

MRS. B.

Well, then, if this idea is clear to you, let us proceed a step further, and, considering each species as a unity, compare them with one another. Can you recollect any instance of different species bearing a striking resemblance to each other.

CAROLINE.

Oh yes; there is the white rose, the yellow rose, the China rose, and many others, which are very much alike; and yet the gardener assures me that the seed of the one will never produce the other.

EMILY.

Red clover, white clover, and yellow clover, bear also a similar resemblance to each other, though they are all of different species.

MRS. B.

Your examples are well chosen; for the most ignorant persons could understand them. Species bearing this analogy are classed together under the name of *Genera*. The resemblance of the different species composing some of the genera is so striking, that their affinity cannot be mistaken; while in others it is less marked, and requires some study to be recognised.

CAROLINE.

Like different children of the same family, some of whom are so much alike, that you see at once they are brothers and sisters; while, in others, the relationship cannot be traced in their features.

MRS. B.

The word *genus* is a Latin word, signifying family; your comparison, therefore, cannot but be accurate; and, by following it up, I think you may acquire an idea of the whole system of nomenclature. You may easily conceive, that if there were a separate name for each of the sixty thousand species of plants, no memory could retain them; nor could these names point out the resemblance or difference which exists between the several species.

EMILY.

Of course; just as if every individual of a country had a different surname: it would be impossible to know among which of them any relationship existed.

MRS. B.

I see that you have nearly made out the simple art of nomenclature. Each genus has a substantive name; as rose, carrot, clover: to which is added the epithet of white, black, large, small, to designate each species; so that, instead of sixty thousand names, five thousand only are sufficient: to which are added a certain number of epithets in common use, and understood by every one.

EMILY.

There is, then, really a great analogy between the nomenclature of plants and that of mankind, for the names of the genera correspond with our family names, and those of the species with our Christian names.

MRS. B.

Very true. It is to the celebrated Linnæus that we are indebted for this simple and clear mode of nomenclature; and it is one of the circumstances which has contributed most to facilitate the study of botany. Since, then, the basis of nomenclature rests on the idea of genera, you may judge how important it is that this idea should be clearly understood, and that plants not possessing the requisite analogy should not be placed in the same genus.

EMILY.

It would be easy to ascertain this analogy with regard to the species, by sowing their seeds; but I know not what test there is to verify the genus of a plant?

MRS. B.

No wonder you should be at a loss, for it is a question which has embarrassed the most celebrated botanists. There is but one means of forming a clear idea of genera: it is by placing its distinguishing characters in those organs of the plant, which, in the common course of Nature, are least liable to variation. Now, it has been observed, that stems and leaves more frequently vary in their structure than flowers and fruit; botanists have, therefore agreed to place the characters of the genera in the organs of fructification.

EMILY.

But are not flowers of the same species sometimes blue, and sometimes white; sometimes large, and at others, small? How, then, can you establish the character of the genera, on circumstances which cannot even serve to distinguish the species?

MRS. B.

The difference or resemblance of organs must not all be considered as of equal importance, in deciding the genus of the plant. Those which relate to colour, flavour, smell, consistence, and the absolute size of the organs, must, in classification, be set aside; and those only which are connected with the symmetry of the flower or fruit, the number of parts, their shape, and relative size, are to be attended to.

CAROLINE.

But why should the relative size of organs be considered of more importance than their absolute size?

EMILY.

That appears to me quite clear. If a plant grows in a rich soil, all its parts will be larger than a similar plant growing in a meagre soil; yet the plants will be of the same nature. But if the stamens of a plant be twice as long as its petals, it will certainly be of a different nature from a plant of which the stamens are shorter than the petals; and, were the two plants well or ill fed, their proportion or relative size would not be altered.

CAROLINE.

You say, Mrs. B., that the number of organs of a plant is admitted as one of the characters of genera; but I think I remember having seen, on the same syringa shrub, flowers, some of which had four, and others five petals.

MRS. B.

Your observation is correct; and, in order to obviate this difficulty, you must be guided by the same rule, in regard to number, which Emily has just pointed out with regard to size. Thus, for example, the pink has twice as many stamens as petals: this character never varies, unless in some peculiar cases of monstrosity, which derange the whole economy of the plant.

With regard to the absolute number of organs, that is to say, whether a plant has four or five petals, eight or ten stamens, is a circumstance attended with much more uncertainty; it may, however, be used as a character in classification, provided it be done with caution, and in cases only, in which experience has shown, that the variations are inconsiderable. Botanists know, for instance, that the greater the number of organs, the more liable that number is to vary. This is a law which prevails throughout all Nature.

EMILY.

For instance, the number of our fingers varies less than that of our teeth, and the latter less than that of our hair.

MRS. B.

These general rules will, I hope, make you understand how botanists have been enabled, gradually, to draw a more accurate line of demarcation in circumscribing the genera of plants, and determining their characters. This constitutes one of the most essential branches of botany; for it is certain, that the better the structure of plants is known, the more easily new plants are discovered, because we are enabled to ascertain their characters, and, consequently, to class them with greater precision; and thus the art is gradually brought to some degree of perfection.

EMILY.

But since the nomenclature is founded upon genera, if you change the genera you must change also the names of plants, which is very perplexing for beginners.

MRS. B.

That is true; but it would be a source of still greater perplexity to allow a plant to remain in a genus, in which, through ignorance, it had been erroneously placed, and of which it had not the characters, for you would never be able to recognise it. Let us suppose, for instance, that the pear-tree had been placed in a genus, the distinguishing character of which is to have six petals: as it has only five, you would never think of searching for it in a genus of six petals. Would you, then, disapprove of its being transferred to the genus whose character is to have five petals?

EMILY.

No, certainly; but such errors seem to me to be impossible.

MRS. B.

Not so much so as you imagine, owing to the number of the organs frequently differing in the same plants, like the petals of your syringa. Besides, foreign plants are often described in a hurried manner by incompetent botanists, and are sometimes brought to Europe in such an imperfect state of preservation as to afford very bad specimens. You see, therefore, that in this case, as well as in many others, truth must be preferred to simple convenience.

CAROLINE.

But, Mrs. B., you have not yet said one word of the families of plants, which you had promised to explain to us.

MRS. B.

A little patience, my dear. In classification it is absolutely necessary to proceed methodically. I have explained to you how all individual plants, resembling each other, form a species; and how, by following up the same idea, and uniting in your mind all the species whose flowers and fruits are nearly similar, you form a genus. When you have accomplished this, proceed a step further: consider the genus as a unity; and we will then endeavour to make out how the five thousand genera of the vegetable kingdom can be so arranged as to be most easily recognised. But first tell me what is your particular aim in studying the classification of plants?

CAROLINE.

I wish to be able to find out the name of any plant I may chance to meet with.

EMILY.

I confess, for my part, that I am not very anxious about the name; but I should like to understand the structure of any plant I see, and how far it coincides with or differs from other plants.

MRS. B.

You have each answered as I expected. Caroline, who is the youngest, and the most volatile, is satisfied with inquiring after names. Emily, who is older, and more considerate, seeks after things. Well, my dears, the learned world have done like you. In the infancy of botany, they sought after names: when further advanced, they aimed at learning the essence of things. I shall follow their steps, and first explain how to find out the name of a plant, by mere nomenclature, and afterwards teach you what has been called the natural method. But I think you must be tired to-day: we will, therefore, defer it till our next interview. In the mean time, reflect upon the subject; and let me know, when we meet, which you think may be the best means of attaining the object you each have in view.

CONVERSATION XXII.

ON ARTIFICIAL SYSTEMS OF CLASSIFICATION OF PLANTS.

MRS. B.

I HAVE promised to explain to you to-day, Caroline, how to discover the name of a plant. But why should you not inquire of some botanist the names of the plants you may wish to know, and then fix them by rote in your memory?

CAROLINE.

Oh, Mrs. B., you think me still more childish than I really am. In the first place, is it probable that I should always meet with a person capable of telling me the name of a plant? And, then, I should be liable to be imposed upon and misinformed. No; what I desire is to be enabled to find out the names of plants myself — with the assistance of books, I mean.

MRS. B.

It would be necessary for this purpose to have a dictionary arranged the very reverse of those commonly used. Instead of giving the word, and then the definition, as dictionaries usually do, you must begin by learning the characters of plants, and then come to the name.

CAROLINE.

But a dictionary of this description would be but of little use to me; for as I am completely ignorant of the characters of most plants, I should not know where to seek for them in the dictionary. Indeed, my principal reason for wishing to know their names is to be able afterwards to learn their history, and become acquainted with their uses and properties.

MRS. B.

I see that Caroline is coming round to your opinion, Emily: she proceeds from names to things. This shows me that you have reflected upon the subject, since our last interview. Various modes have been resorted to, with a view of composing the peculiar species of dictionary to which I have alluded; and in order to give you some idea of them, tell me, have you ever played at a game called *Four-and-twenty Questions?*

CAROLINE.

Oh yes, frequently. One of the party thinks of a word or a thing, and the others try to discover it, in a series of twenty-four questions.

MRS. B.

In this game, the art consists in so skilfully pointing the questions, that each reply shall contract the field of inquiry, till it is at length brought within so small a compass, that the object thought of is attained.

EMILY.

It is like the Indian mode of entrapping elephants. They are surrounded by horsemen, who at first enclose a large space of ground, but, gradually narrowing the circle, drive them gently towards the centre; where they have no resource but to run into the trap, which is there open to receive them.

MRS. B.

Well, botanical nomenclature is very much the same thing. Indeed, the analytical method — the simplest hitherto used — is exactly similar to the game of Four-and-twenty Questions. It was first introduced by M. de Lamarck, and forms the basis of a work he published, with M. de Candolle, called the *Flore Françoise.*

Here is a plant in blossom in this flower-pot: I know that it grows wild in the south of France. I shall ask you a few questions relative to it, according to the method followed in the *Flore Françoise,* and you will see that you will soon discover the name of the plant yourself.

CAROLINE.

Oh, that will be very amusing.

MRS. B.

First, then, tell me whether the flowers are visible to the naked eye, or whether they require to be seen through a microscope?

CAROLINE.

The plant is quite covered with them, and they are perfectly visible; for you may see them from some distance.

MRS. B.

Are the flowers united by an involucrum or not?

CAROLINE.

No; they have no involucrum.

MRS. B.

Have the flowers both pistils and stamens, or only one of these organs?

CAROLINE.

They have both.

MRS. B.

Have the flowers both a corolla and a calyx?

CAROLINE.

Yes; they have both.

MRS. B.

Is the corolla of one entire piece, or composed of several parts?

CAROLINE.

It consists of several parts.

MRS. B.

In this case, I must refer to No. 211. of the *Flore Françoise;* and pray tell me, does the ovary adhere to the calyx or not?

CAROLINE.

It adheres to the calyx, and is consequently situated below the petals.

MRS. B.

Are there several ovaries?

CAROLINE.

No; only one.

MRS. B.

Is the flower regular or irregular?

CAROLINE.

Regular.

MRS. B.

Are there more or less than twenty stamens?

CAROLINE.

There are, certainly, more than ten; and I should think about twenty.

MRS. B.

Is the calyx divided into more than two lobes?

CAROLINE.

Yes; into five.

MRS. B.

Are the leaves opposite or alternate?

CAROLINE.

They are opposite, and placed very regularly on the stem.

MRS. B.

Is your plant herbaceous, or is it a shrub?

CAROLINE.

A shrub.

MRS. B.

Is the fruit dry or fleshy?

CAROLINE.

Let me see if I can find any: there is very little fruit; but it appears to me fleshy.

MRS. B.

Is that part of the calyx which crowns the fruit membranaceous or coriaceous?

CAROLINE.

It is membranaceous.

MRS. B.

Well, then, your plant must be a myrtle. Were there several species of myrtle growing in France, by continuing a similar series of questions, I should soon discover the species; but as there is only one (which is the common myrtle), I am already fully answered.

CAROLINE.

What a simple and ingenious method! You would easily have won the game of Four-and-twenty Questions; for you have asked only thirteen. This mode of analysis must, I suppose, be in very general use?

MRS. B.

It has been much used in France, but little in England.

CAROLINE.

I am surprised at that. Is there any thing to be objected to it?

MRS. B.

It has been thought tedious; and, to one no longer a novice in botany, it is tiresome to have always to recommence and follow up the same routine of questions; besides, the slightest inattention, or the least mistake in the printed numbers, is sufficient to put you quite out. Then, after all, when you have succeeded in discovering the name of the plant, it is not very easy to remember the characters which enabled you to find it out. Notwithstanding these objections, which certainly have their weight, I cannot but think this method the best for beginners.

CAROLINE.

Still, if it is not adopted in England, it would not be of much use to us. Then, what mode of nomenclature is employed by English botanists?

MRS. B.

In general that of Linnæus, which I have here, and will show you.

EMILY.

Pray do; for the name of Linnæus is so celebrated, that any method invented by him cannot but be interesting.

MRS. B.

Certainly. A method derived from a man so eminent in science, though it may have been surpassed by subsequent botanists, well deserves our attention. Here is a table of the different classes into which Linnæus divided the vegetable kingdom.

- Plants with stamens and pistils.
  - Visible to the naked eye.
    - United in the same flower.
      - Not adherent together.
        - Stamens equal to each other.
          - Less than 20 stamens.
            - 1 - - - - - 1 Monandria.
            - 2 - - - - 2 Diandria.
            - 3 - - - - - 3 Triandria.
            - 4 - - - - 4 Tetrandria.
            - 5 - - - - - 5 Pentandria.
            - 6 - - - 6 Hexandria.
            - 7 - - - - - 7 Heptandria.
            - 8 - - - 8 Octandria.
            - 9 - - - - - 9 Enneandria.
            - 10 - - - 10 Decandria.
            - from 11 to 19 - - - 11 Dodecandria.
          - 20 stamens at most -
            - growing on the calyx 12 Icosandria.
            - not growing on the calyx - - 13 Polyandria.
        - 4 stamens, 2 of which are long - - 14 Didynamia.
        - 6 stamens, 4 of which are short - - 15 Tetradynamia.
      - Adherent to each other.
        - Stamens not adherent to the pistil, but soldered together.
          - By the filaments.
            - All bound in a single bundle - - 16 Monadelphia.
            - In two ditto - - 17 Diadelphia.
            - In more than two ditto 18 Polydelphia.
          - By the anthers - - 19 Syngenesia.
        - Stamens glued to the pistil - 20 Gynandria.
    - In two different flowers -
      - Flowers with stamens, and flowers with pistils, on the same plant — 21 Monœcia.
      - Flowers with stamens, and flowers with pistils, on two different plants - — 22 Diœcia.
      - Flowers with stamens and pistils, or having the one or the other organ on one, two, or three individuals - — 23 Polygamia.
  - Invisible to the nak' d eye - - - - - 24 Cryptogamia.

CAROLINE.

It appears very complicated!

MRS. B.

You will find it less so than you imagine. This system of Linnæus forms precisely an analytical table. Return to your myrtle, and let us follow it. — Stamens visible to the naked eye, in the same flower as the pistils, but not united to them; all of the same size; about twenty in number; growing from the calyx: the myrtle belongs to the class Icosandria of Linnæus.

CAROLINE.

And then what follows?

MRS. B.

These classes are divided into orders, which depend principally on the number of styles.

CAROLINE.

The myrtle has only one style.

MRS. B.

Therefore it belongs to the order Icosandria Monogynia. Here is an edition of Linnæus, published by Willdenow. You see that the above order contains twenty-two genera: you must therefore examine the characters of each genus, and you will soon find out those which correspond with the myrtle.

EMILY.

This method is, certainly, much less simple than the other.

MRS. B.

You would soon become used to it: and I assure you that it is a very convenient mode of discovering the names of plants; at least, of those which do not belong to a class containing a very great number of genera; such, for instance, as those of *Pentandria* and *Syngenesia*, which contain from four to five hundred each. But, even in these cases, practice and habit soon render a system familiar which at first sight appears perplexing and difficult.

EMILY.

But, Mrs. B., the system of Linnæus rests almost entirely on the number of the different organs of plants; and we have observed more than once, that number is a character which cannot be relied on in botany. Yesterday we mentioned the irregular number of petals of the syringa; and this morning I observed a plant of rue which bore in the same cluster flowers, some of which had eight, and others ten stamens. Now does it belong to the eighth or the tenth class? I am sure I deserve to know, were it only to make up for its disagreeable smell.

MRS. B.

In cases of this sort, botanists have agreed to class the plant according to the first flower which blows in the cluster; and, following this rule, rue belongs to the tenth class. But what is still more embarrassing is, that the number of stamens often varies in an irregular manner. Thus, you may meet with tulips, and several other plants, bearing indifferently five, six, seven, or eight stamens. In this case you must class them according to the number most usually found.

Several other sources of error occur in the system of Linnæus. For instance, there are many plants in which the inequality of the stamens and their adherence is so difficult to distinguish, that it is not easy to know to what class they should be referred. There are also *Diœcious* or *Monœcious* plants, which are become so by mere accident; and which you would seek for in vain under the head *Diœcia* or *Monœcia*.

The class *Polygamia* is also one of those which can scarcely be made out by a beginner. Notwithstanding the imperfections of the Linnæan system, it is one of the most convenient; and, even were it less so, it would be necessary, in order to make any proficiency in botany, to be well acquainted with it, as it is that which is most generally used in botanical works.

EMILY.

But, in small flowers, does not the extreme minuteness of the organ which it is necessary to investigate render the system of Linnæus liable to error?

MRS. B.

It is very true; and this is one of the sources of error which even the genius of Linnæus could not overcome.

EMILY.

When two plants have each an organ perfectly similar, is it a necessary consequence that they should resemble each other in other respects?

MRS. B.

No; they sometimes do so, but not always. Thus, in the system of Linnæus, the class Tetradynamia contains plants all having a certain natural resemblance; the same may be said of the class Syngenesia; but in the other classes they frequently differ considerably.

EMILY.

This is not very logical, I think!

MRS. B.

It would not be so, had Linnæus meant that his system should point out the real differences of plants. But his intention was merely that it should answer the purpose of a dictionary, by means of which it would be easy to discover their names; and in this point of view it may fairly be affirmed, that the greater the number of points of difference existing between plants, belonging to the same class, the easier it is to discover the name of each.

The followers of Linnæus have unfortunately not always well understood his intention of thus supplying botanists with a mere nomenclature, or, as it has been called, an *Artificial System;* and the habit of studying the pistils and stamens has made them attach too great importance to these organs of fructification, while they have neglected the fruit and the seed. They have also, in general, paid too much attention to the number of the organs, and not sufficiently considered their relation to each other; so that, if they have rendered it an easy thing to discover the name of a plant, they have not advanced the science of botany so much as they would have done had they directed their researches more to the general properties of plants.

EMILY.

The system of Linnæus might, I think, be compared to a dictionary, which, though you learnt all the words it contained by heart, you would still be ignorant of the language, unless you added to it a knowledge of the grammar which teaches the value of the relative terms.

MRS. B.

Well; the grammar is taught by another system of classification, which is called the *Natural System.* But, in reply to your observation, I might retort that a grammar alone is not sufficient to make you acquainted with a language — a dictionary is also necessary, in order to look out for the words; you must not therefore undervalue botanical dictionaries, which facilitate the study of nomenclature: yet always bear in mind that they teach only the names of plants; and that if you wish at the same time to acquire a knowledge of their structure, you must study the *natural system.*

EMILY.

This is what I am most anxious to do; pray, give us some general idea of it.

MRS. B.

With pleasure; but not to-day: we shall examine it when next we meet. In the mean time reflect upon the subject, and endeavour of your own accord, to discover some mode of classing plants which would most easily show their true analogy.

CAROLINE.

I will think of it; but it appears to me a very difficult task.

CONVERSATION XXIII.

ON THE NATURAL SYSTEM OF CLASSIFICATION.

MRS. B.

WELL, my dear, have you been able to discover any mode of classing plants, according to the analogy they bear to one another?

CAROLINE.

I have endeavoured to class the plants in our garden according to this method. I began by comparing them all together, and then divided them into groups, according as they more or less resembled each other.

MRS. B.

I should have no fault to find with your mode of proceeding, if the whole vegetable kingdom contained, like your garden, only a small number of plants. This mode was, in fact, the first employed, and was called the *Méthode de Tâtonnement.* It is still occasionally used by botanists as a guide in their researches. But you will easily understand, that independently of the impossibility of being put in practice, since the number of plants known has so much increased, it has also the great defect of depending merely upon opinion, and affording no certainty of the reality of the resemblance assigned to different plants. It is much the same as with likenesses of different persons: how often people vary in opinion in regard to such resemblances!

The same diversity of opinion would take place in natural history, had not botanists laid down certain precise rules for judging of the external characters of plants; — and, Emily, have you no new mode of classification to suggest?

EMILY.

If I tell you the one that has occurred to me, I fear you will think me very presumptuous.

MRS. B.

By no means, my dear: on the contrary, nothing is more gratifying to me, than to see that you are capable of reflection, whatever may be the object.

EMILY.

We examined yesterday the system of classification founded upon a single organ: well, if I had to class the vegetable kingdom, and was well acquainted with the structure of plants, I should make as many different arrangements as there are different organs. The first, for instance, would be made after the roots, the next after the stems, one after the leaves, another relating to their position, another according to the number of the organs, and so on. I should thus form, perhaps, a hundred different systems. Now, I suppose that the plants which were placed together in ninety-nine of these systems would bear the strongest possible resemblance to each other; in ninety-eight a little less so: in a word, that the resemblance between plants could be ascertained by the number of systems common to each.

MRS. B.

Your idea is very ingenious, my dear Emily; and though I do not agree with you in opinion, you may boast of having suggested the same theory as a very distinguished French botanist, M. Adanson. He called it, "Method of General Comparison," and bestowed much labour upon it; but, as he lived so long ago as the year 1760, he was far from being acquainted with all the different characters of plants, which necessarily rendered his system very incomplete. Even in our time, though great progress has been made in botany, new characters and properties are frequently discovered in plants ; consequently, a classification of this description would still be incomplete.

EMILY.

I own that objection did not occur to me, because, I thought that the degree of precision in any mode of classification depended upon the state of the science at the time it was made.

MRS. B.

There is another objection to your system, of still greater weight. You count the number of organs that resemble each other in different plants, but you make no estimate of the relative importance of each ; yet you must consider that all the organs are far from being of equal importance. Plants which resemble each other in a few of their principal organs, have more real analogy than those which are similar in a great many minor points. You may easily conceive that plants whose seeds are alike, resemble each other infinitely more than those which shoot out thorns of the same nature. For the seed may be considered as the miniature of the plant, from the developement of which all the growth of it must arise ; while the thorn is a mere accidental degeneration which may or may not take place.

EMILY.

This objection is certainly of great weight, and I am afraid that I must abandon my system ; but is it possible to appreciate the relative importance of the different organs ?

MRS. B.

To a certain extent, at least. The method of classification, grounded on this principle, is called "Method of Subordination of Characters." It was first suggested by Bernard Jussieu.

EMILY.

How much I should like to read his work on this subject!

MRS. B.

He never published any; like Socrates, he taught in conversation. His nephew, M. Antoine Laurent de Jussieu, who is still living, published, in 1789, the results of his uncle's theory. In 1823, M. de Candolle published a work, in which the principles of this mode of classification are fully developed: they are probably the same as those of M. de Jussieu, since his deductions from them are similar to those of his predecessor.

CAROLINE.

Then M. de Candolle must be the Plato of this modern Socrates?

MRS. B.

Or even something more; for Plato, I believe, wrote only what Socrates had taught; but M. de Candolle brought to light those principles from which M. Bernard Jussieu had drawn his deductions.

EMILY.

It is a curious thing in science for the founder of a new school not to publish his opinions. But, pray, what are these principles? They must, I think, be very difficult.

MRS. B.

We have agreed that all the organs of plants are not of equal importance: now, there are three modes of ascertaining the degree of consequence of each. The first is its utility: this is the most general, and would be sufficient of itself, were we so perfectly acquainted with vegetable physiology, as to judge of the importance of an organ by its degree of utility in the economy of a plant. Thus, we may safely conclude, that an organ essential to the life of a plant is of a higher order than one of which it can be deprived without sustaining any material injury.

EMILY.

But are the functions of different organs not sufficiently known, to enable us to judge whether they are more or less essential to a plant?

MRS. B.

Not always; but in a doubtful case there are two other rules by which you may be guided. Generally speaking, the greater the number of plants in which the same organ can be found, the greater is the degree of importance that ought to be attached to them. For instance, the calyx may be pronounced to be an organ of much greater consequence than the involucrum, because a much greater number of plants have a calyx than an involucrum.

EMILY.

I understand that perfectly.

MRS. B.

There is, besides, a third criterion. In all plants of the same family there are certain organs which exist, and others which are wanting; and some that are occasionally found in plants, otherwise very similar to each other. The first of these organs are naturally of much greater importance than the latter, as they appear to be indispensable to the system of organisation of these plants. Were you to ask me, for example, whether a stipula or a thorn were of greatest importance, I should not hesitate to say the stipula, for the reason I have just assigned.

EMILY.

When you judge of the importance of an organ by its degree of utility in the economy of a plant, how can you compare organs adapted to functions of a completely different nature? In the animal frame, it would not be easy to determine whether the lungs were a more useful organ than the stomach, the eye than the hand; — does not the same difficulty occur in the vegetable structure?

MRS. B.

Your observation is perfectly just; and, in fact, botanists can only, with any degree of certainty, compare such organs as are adapted to the same class of functions. For instance, you will readily admit that the brain is of higher rank than any single nerve, and the heart superior to any other blood-vessel: but if you enquired whether the heart or the brain were of greater importance, it would be quite out of my power to answer you. To return to your comparison of an army.

You know that a captain is of higher rank in the army than a lieutenant, and a colonel than a captain; and the governor of a province is of more elevated dignity than the mayor of a small town: but, pray, how would you answer, if I asked you whether a captain or a mayor ranked highest? You might say, in some particular cases, the one takes precedence of the other; but that would depend entirely upon arbitrary decision, and not on the nature of their functions, which will not admit of comparison. Now, if you apply this simile to vegetable physiology, in which there are two great classes of functions; one of which belongs to the reproduction, and the other to the nutrition of plants; you will understand that those organs alone admit of comparison which belong to the same class.

EMILY.

Pray, give us some example of this?

MRS. B.

In re-production, for instance, the organ of most importance is the embryo; next to that the stamens and the pistils, which, taken collectively, are no less indispensable than the embryo, for without them it cannot receive life. Then follow the integuments which protect the embryo; and next those which guard the pistils and the stamens; after these come the accessary organs, such as the nectary. You see that I have already given five different degrees of importance to the organs of re-production.

EMILY.

But must you not also arrange, in a similar order of gradation, the different points of view under which a plant may be considered?

MRS. B.

No doubt; and, for this purpose, you must be guided by the rules we used in forming the different genera; the most important of which consists in carefully observing the symmetrical position of the organs in different plants. The natural method of classification consists in studying the details of the symmetry of the organs, in the same manner as mineralogy is founded on the regular symmetrical laws of crystallisation.

EMILY.

All this appears to me very ingenious in theory, but difficult in practice. Supposing that I were capable of classing the vegetable kingdom according to this order of different organs; what proof should I have that I was following the right method?

MRS. B.

You might afterwards class the vegetable kingdom according to the organs of nutrition, and you could then compare the two arrangements. Now, if, in following two methods, each founded upon a set of different organs, the same plants are to be met with in the same class, is it not infinitely probable that the mode of classification you have adopted is the true one — the image of what really takes place in Nature? Thus, the natural order of botany is that in which you obtain the same result, whether the vegetable kingdom be classed according to the organs of re-production, or to those of nutrition. More importance is usually attached to the organs of re-production, as being the most numerous and the most varied; the classification is, therefore, first made with reference to them, and afterwards with reference to the organs of nutrition: the latter of which serves to verify the former.

CAROLINE.

It is like making a proof in arithmetic: but is not this very difficult to reduce to practice?

MRS. B.

I do not deny that it is sometimes attended with difficulty. In botany, as in every other science, no progress can be made without labour and perseverance: much yet remains to be done, but it is gratifying to have a great end in view: it elevates the mind, and renders the details of a science interesting. The difficulties that occur in classification arise, either from our not yet knowing all the plants that exist, or from our limited faculties often preventing our acquiring a competent knowledge of the nature and internal structure of their organs. Time may overcome the former of these difficulties; but the latter will probably never be completely conquered. Sometimes, for instance, the organs of plants which ought to be symmetrical, are not all developed; at others, they are joined together so that their number cannot be distinguished: — this we have called soldering. Sometimes they assume unusual form and dimension: this is called degeneration of the organs. These three causes, considered either collectively or separately, often deceive botanists in regard to the real nature of the vegetable organs, but, by dint of observation, the truth is gradually brought to light.

EMILY.

We should, no doubt, be incapable of understanding in detail the results of the principles you have explained to us; but cannot you give us some slight idea of them?

MRS. B.

I will make the attempt, at least. You may recollect learning, the other day, that genera were composed of those species most nearly resembling each other. Now, by means of the principles I have just laid down, it was soon discovered, that in a certain number of genera the organs of re-production were very analogous: it was then ascertained, that the organs of nutrition of these same genera also bore a striking resemblance to each other. These genera were then united, as it were, in a group, and denominated a *family*. Thus the five thousand genera form about two hundred and fifty families.

CAROLINE.

Families of plants, then, are nothing more than a numerous collection of genera resembling each other. But, then, *genera*, in the sense in which it is here taken, means not *families*, as it ought to do, from its Greek origin, but merely branches of families: is not this liable to create confusion?

MRS. B.

I think your remark very just: using the word in some measure in a different sense from which it is derived appears to me an imperfection in this mode of classification.

EMILY.

Families are to genera, what genera are to species; or, to follow up the comparison you made between plants and the human species, we might say, that families of plants were like nations of human beings; and that all these families collectively form the vegetable kingdom, in the same way as all the nations of the earth form the population of the world.

MRS. B.

Exactly so; and the families of plants, like the different nations of the world, have each their peculiar characters and habits. Thus, independently of the analogy between their organs, plants of the same family often resemble each other in their mode of life, and in their peculiar properties. For instance, all the *Ficoideæ* have succulent leaves, suffer from moisture, and inhabit climates where the sun's rays are powerful; then, the *Malvaceous* family bear leaves of an emollient nature: the embryo of all the *Euphorbiaceæ* is of an acrid nature: the roots of the *Valerianeæ* have all a particular smell, and act in a peculiar manner on the nervous system; the Cruciform family is, in all its branches, antiscorbutic. In a recent voyage, undertaken with a view of discovering the spot where the celebrated La Peyrouse was shipwrecked, the whole of the crew was afflicted with a scorbutic complaint, which was greatly relieved by feeding on an unknown plant of the cruciform family growing on the coast of New Holland — a remedy which was pointed out to them by the botanist attached to the expedition. There is another point of resemblance between plants of the same family, I have before mentioned; which is, that these alone are susceptible of being grafted on each other.

EMILY.

And we must not forget, Mrs. B., that the exudations of plants of one family afford nourishment to those of another.

CAROLINE.

These analogies are extremely curious; and I understand now, perfectly, how much superior your method is to those which merely indicate the name: for when I know that a plant has four stamina, it teaches me nothing further; whilst the knowledge that a plant belongs to such or such a family makes me acquainted, in a great measure, at least, with its structure and its properties.

EMILY.

I am glad, Caroline, that you are come round to my opinion; for I felt a sort of instinctive conviction that it was in analogies of this description that the interest of the study of Nature consisted. But pray, Mrs. B. is it not possible to group families together in the same manner as you have done genera?

MRS. B.

Yes; there is still another step in classification, which brings us to the three great distinctions with which you are already acquainted.

First. That class of vegetables called *Dicotyledons*, relative to their organs of re-production; and *Exogenous*, relative to their organs of nutrition. This is by far the most numerous of the three classes, comprehending about two thirds of the vegetable kingdom.

Secondly. The vegetables called *Monocotyledons*, or *Endogenous*, according as you allude to their re-productive or nutritive organs.

Thirdly. The class called *Acotyledons*, from being destitute of cotyledons, are also called *Cellular*, because their nutritive organs have no vascular system. To complete the comparison we have followed up, these three great classes may be considered as the three great continents of the world; the different families of plants as the various nations into which these continents are divided; the genera represent the families of each nation; and the species must be considered as the unity of the scale. This comprehends the whole system of classification, which every day becomes more extended and more perfect.

EMILY.

Let me see whether I can make out this genealogical table of plants.

The three grand divisions give birth to 250 families.

These 250 families produce 5000 genera.

And the 5000 genera, 60,000 species.

MRS. B.

The species, in their turn, give rise to races, varieties, and variations; but we shall not enter upon these subdivisions at present, as they are the result of an artificial, rather than of a natural, mode of propagation; and, indeed, their numbers are both too great and too variable to be reckoned in a table of classification. There are, for instance, no less than fifteen hundred varieties of the vine, and five hundred of the pear-tree: it is true that other plants do not afford so great a number.

CAROLINE.

If they did, you might almost as well undertake to count the individual plants as to number them. But do not the number of species also increase by the discovery of new plants?

MRS. B.

No doubt they do. Since the death of Linnæus, about fifty thousand new species have been discovered, making, on an average, one thousand species every year.

The numbers, therefore, which I have given you, are intended only to enable you to form a general idea of the present state of the vegetable kingdom; but they cannot be considered as permanent.

This explanation will, I hope, enable you to understand the basis of the *natural classification*, the details of which can be acquired only by study and practice.

CAROLINE.

But how can we study this system, since the English botanists follow that of Linnæus?

MRS. B.

Generally they do, but not exclusively. We already possess two excellent English works: the one called the *Flora Scotica*, by Mr. Hooker, in which the plants are classed both according to the system of Linnæus and that of Jussieu; the other, the *British Flora*, published by Dr. Lindley, Professor of Botany in the University of London, in which the plants are arranged according to the natural method. You may afterwards consult works of a more general description, which will carry you still further; and, when once you are accustomed to investigate the affinities of plants, your eye will enable you to guess, as it were, a great portion of what remains to be learnt.

EMILY.

If these affinities are so evident to the eyes of a botanist, whence comes it that they have only been so recently studied?

MRS. B.

Botanists have long been acquainted with the affinities of plants growing in great numbers in Europe. Thus, ever since botany has become a science, the Cruciferous, Gramineous, Umbelliferous families, and several others, have been distinguished. But those families which are dispersed over every quarter of the globe could not be classed until the analogy of the different plants had been discovered and studied; and travellers, ignorant of botany, are incapable of recognising the affinities of plants they have never studied.

EMILY.

What an interesting study the comparison of plants of different countries must be!

MRS. B.

Undoubtedly it is. This study is called botanical geography; and, if you wish to acquire some idea of it, we will make it the subject of our next conversation.

EMILY.

With the greatest pleasure.

CONVERSATION XXIV.

ON BOTANICAL GEOGRAPHY.

MRS. B.

At our last interview I promised to give you some idea of the laws which regulate the distribution of plants on the surface of the globe.

This constitutes the science of Botanical Geography. It is of very recent date; indeed, it is only within the last few years, that it has been cultivated with any degree of success. It is founded entirely on the distinction made between the *habitation* and the *station* of plants.

CAROLINE.

I do not understand the meaning of this distinction. Are there two modes of indicating the country of a plant and the spot in which it grows?

MRS. B.

Precisely so. For instance, when you say that the tulip-tree grows in America, you point out what, in botany, is called its *habitation;* when you say that it grows in marshy districts, you intimate its *station.* Thus, the term habitation relates to the geographical distribution of plants on the face of the globe, while station denotes the peculiar localities in which they are generally found.

EMILY.

I cannot conceive that any degree of importance can be attached to this distinction.

MRS. B.

I beg your pardon. You will readily admit that the nature of the soil, the aspect, the degree of moisture, &c. is sufficient to account for particular plants growing in certain spots rather than in others. Their *station* is thus explained by physical laws, with which we are more or less acquainted. The causes of their *habitation* are, on the contrary, perfectly unknown to us. Were you, for instance, to find in America a marshy district, perfectly similar both in regard to temperature, moisture, and the nature of its soil, to another marshy district in Europe, the two marshes would be peopled with plants of a very different description. It is impossible to ex-explain the cause of this singular phenomenon, as it appears to have existed prior to the actual state of the globe.

EMILY.

It is singular that Nature should have clothed different parts of the earth with plants of a different description where the temperature and properties of the soil are the same ; especially as these plants will bear transplantation. The tulip-tree, of which you were just speaking, grows very well when transplanted to Europe ; and I have heard that our walnut-trees thrive equally well in America : but neither of these trees grow spontaneously out of their natural country, or, as you call it, their habitation.

MRS. B.

Well, then ; botanists, after having studied the surface of the earth under this point of view (as far as their imperfect knowledge of barbarous countries would admit), have divided the globe into twenty districts, which they named *botanical regions*. Each of these regions possesses a vegetation peculiar to itself, plants of the same species being seldom found growing in different regions.

CAROLINE.

How are these regions to be distinguished from each other?

MRS. B.

Those whose limits are the most correctly determined are separated from each other by a vast expanse of sea. A narrow sea like the Mediterranean would not be sufficient to define the limits, because seeds would be wafted by the wind across it from one continent to the other. There is scarcely any difference between plants which grow on the two opposite shores of the Mediterranean, or between those growing in the north of France and those growing in England. Nor do islands in the vicinity of continents constitute a boundary, as they have generally the same species of vegetation as the neighbouring continent; while islands situated at a considerable distance from continents have often quite a different vegetation. For instance, the plants of St. Helena and the Sandwich Isles are almost all different from those of any of the continents.

EMILY.

And do large tracts of continent, also, differ in the nature of their vegetation?

MRS. B.

As the Old and the New World approach very near to each other, if they are not actually united towards the north pole, the plants of the northern regions are nearly the same in the three continents; and the further you recede from the pole, the more distinct the different regions become in regard to vegetation.

EMILY.

But of what nature are the limits which separate different regions in the same continent?

MRS. B.

They are less defined than those separated by seas; so that there is a greater mixture of plants in these regions. Their natural limits in continents are, for instance, either extensive sandy deserts, such as those of Sahara, which divide northern Africa from Senegal, or chains of high mountains, which oppose an insuperable barrier to the conveyance of the seed by natural means; or, again, vast salt-plains, which prevent the germination of seeds.

EMILY.

But are there not a variety of means by which plants may be conveyed from one region to another?

MRS. B.

No doubt; and that accounts for plants appertaining to different regions often being found growing in the same. Rivers, for instance, and high winds, convey seed from one country to another; birds of passage transport the seed on which they feed; animals carry them in their woolly or hairy coats; and, finally, man conveys seeds wherever he goes: sometimes voluntarily, as corn and potatoes, which he has disseminated all over the known world; at other times, unintentionally. And it is owing to this casual transport, that the plants, and even weeds, of most of our villages, have found their way to America.

CAROLINE.

Like Robinson Crusoe, when, by shaking the dust out of a bag, he produced a crop of corn.

MRS. B.

Very true; but men have even gone further, and conveyed seeds from one part of the world to another, much against their intention or inclination; such as the seeds of the wild poppy and corn-flower, which can never be completely separated from the grains of corn.

But, independently of these emigrations, it must be confessed that there is a small number of similar plants existing in different regions, without the possibility of explaining how they could have been conveyed from the one to the other.

CAROLINE.

This geographical distribution of plants is quite a new idea to me: I always thought that a great number of the same plants were to be found in countries very distant from each other. I have heard of the American elm, the apricot of St. Domingo, and many other trees and shrubs bearing the same names, both in Europe and in America.

MRS. B.

This is owing, in a great degree, to the first colonists who settled in America being ignorant of botany, and giving European names to plants, which, in fact, were very different from those whose names they assumed.

EMILY.

I suppose they considered it as a sort of tribute paid to their native country; just as they gave the names of New York and New Holland to countries very different from those of Europe.

MRS. B.

Another reason may also be alleged. It often happens that different species of the same genus inhabit different regions; for instance, the *Vaccinium Macrocarpum*, which we call Canadian cranberry, is of a different species from the *Vaccinium Oxycoccus*, or English cranberry, which we eat dressed exactly in the same way. Thus, also, the oak, the pine, and the maple, of the United States, are of a different species from those which bear the same name in Europe.

EMILY.

It appears, then, that there is no sort of connection between the classification of plants and their geographical distribution.

MRS. B.

There is some slight connection, but it is so variable that it is little to be depended on. Thus, while certain families and genera are dispersed all over the world, others are confined to a single region; all the *Cacti*, for instance, come from America; the *Aurantiaceæ* from India or the neighbouring countries; the *Epacrideæ* from New Holland; and, amongst the genera, there are many, every species of which inhabit the same region. Thus, all the *Cinchonas* are derived from South America; the *Gorterias* from the Cape of Good Hope, &c.

It often happens that different genera bear so near a resemblance to each other, that the various species of the same genera or families are divided, as it were, between them. For instance, a portion of the *Pelargoniums* is situated at the Cape of Good Hope, while another portion of the same family grows in Van Diemen's Land. Botanists have of late paid great attention to this subject; but the result of their researches can be considered only as temporary, as it will ever be liable to change so long as unknown plants remain to be investigated.

EMILY.

Cannot you give us some idea of the result of their researches?

MRS. B.

It has been calculated, for instance, that in almost all the botanical regions of the world one sixth of the plants are monocotyledons; and that, in regard to the other two classes, the number of dicotyledons increases as you approach the equator, and that of the acotyledons, on the contrary, as you draw nearer towards the pole.

This rule does not prevail in islands situated at a great distance from any continent: in these the proportion of monocotyledons is greater, and that of the dicotyledons less, than is usually found in continental regions of the same latitude.

CAROLINE.

You do not mean to say that the same proportion of monocotyledons exist in Europe as in Asia — in cold northern countries as in tropical climates? To judge from the views I have seen of India, the greater part of the trees are of the family of Palms.

MRS. B.

A few of those magnificent trees make a great show in a landscape; but recollect that all our corn and grasses are monocotyledons. The difference between this class in England and in India consists, not in the number, but in the size, of the plant. The vigorous vegetation of tropical climates produces monocotyledons of stupendous dimension, while the chilling temperature of northern regions checks their growth; and if we go beyond the gramineous family, it is but to produce lilies, tulips, hyacinths, and other imperfectly developed bulbous roots. It is only in the most southern parts of Europe that a few straggling palms denote the approach to a more vigorous region of vegetation.

CAROLINE.

But tropical climates produce corn and grasses as well as palm trees.

MRS. B.

True, but in much less quantity; herbaceous plants require less heat and more moisture than is to be met with in such climates. The number of ligneous, compared to that of herbaceous plants, universally increases as you approach the equator.

I do not however mean to say that this increase and decrease proceeds in a regular progression from the equator to the poles.

The number of annual plants, for instance, is very considerably greater in temperate than in either the tropic or frigid zones. The delicate structure of those plants renders them incapable of resisting either the dry heat of the tropics or the severe cold of the polar regions.

EMILY.

We have also the advantage of the most beautiful and delicate colours in the vegetation of spring; while I have heard that, both in the polar and tropical regions, the spring-leaves are of a much darker and more sombre colour.

MRS. B.

That is true. Now that you have acquired some idea of what is meant by a botanical region, let us observe how the plants are distributed in one of these regions, and why different plants prefer different localities.

You will easily understand, that every plant, according to its particular structure, requires the concurrence of many circumstances in order to be brought to perfection.

EMILY.

No doubt. It is evident that the same soil, or the same degree of heat, light, or moisture, cannot be equally good for all plants.

MRS. B.

When plants shed their seed it is more or less dispersed by wind, rain, or other natural agents, and is finally deposited on a soil which may or may not be favourable to its germination. Thus, in particular spots, a sort of struggle takes place among the different species of vegetables which it produces. The most vigorous plants, and those best suited to the nature of the soil, make the greatest progress, and ultimately exclude the others.

CAROLINE.

So that in the vegetable, as well as in the animal kingdom, the strong oppress the weak, and a contest takes place even among flowers, to all appearance the symbols of peace and harmony.

MRS. B.

I am sorry to spoil your poetical ideas of vegetation; but such is the law of Nature. You will now understand, that the richer the soil the greater is the number and variety of plants that can grow in it. Thus, in tropical climates, the forests are composed of a much greater variety of trees than in the temperate zone; and, as you approach towards the polar regions, the number of different plants gradually diminishes.

EMILY.

It is, perhaps, on this account that in the highlands of Scotland we meet with immense tracts where no plant is to be seen growing but heath or furze.

MRS. B.

Precisely. These species of plants being of a hardy nature, and able to live in a soil from which most other plants are excluded, meet with no competition, and establish a colony apart from other plants. Such plants are called by botanists *Social*, from their habit of living together in societies.

CAROLINE.

I think they should rather have been called unsocial, from their excluding plants of a different species.

MRS. B.

They at least deserve the name of inhospitable: the *Potamogetons* which grow in stagnant waters, Kelpwort (*Salsola*), and Saltwort (*Salicornia*), which grow in salt districts, are of this description. There are some plants which become social from their mode of propagation; those, for instance, which have spreading roots, such as the *Hieracium Pilosella*, or Mouse Ear Chickweed. Plants, on the contrary, whose seeds are crowned with a tuft, which enables the wind to have more power over them, are dispersed to a great distance: between these two extremes there exists a great variety of intermediate degrees.

There are some plants which, so far from excluding those of a different species from their society, seem to take delight in the neighbourhood of trees to which they themselves bear no resemblance: thus, the *Salicaria* loves to grow at the foot of the willow; the *Monotropa*, at the foot of the pine; the *Saxota*, to grow amongst oats.

CAROLINE.

And the reason of this singular kind of attachment of one species of plants for another arises, no doubt, from the exudations of plants of one family being favourable to the growth of those of another; thus, the salicaria absorbs the exudations of the willow, and the saxota those of the oats.

MRS. B.

Since this hypothesis has been verified by experiment, we may conclude that to be the case; but other reasons have also been assigned for this partiality of plants,—such as, that those of different families frequently require the same soil; and that certain plants often serve to protect others of a different nature, as hedges and bushes protect the creeping plants which grow amongst their branches.

EMILY.

It appears, then, that we can in some degree explain that prodigious mixture in the vegetable kingdom, in which at first I thought there was no sort of order.

MRS. B.

There is always order in the works of Nature; and what appears to us disorder is the result of different laws acting at the same time. By following the mode of reasoning I have pointed out to you, and by constantly comparing the structure and the habits of plants with the nature of the soil in which they grow, a great number of curious facts may be explained. I am glad to have drawn your attention to this subject; it will be a source of amusement in your walks: and the greater the number of plants you become acquainted with, so as to be enabled clearly to distinguish their different species, the more interesting will your observations prove.

CONVERSATION XXV.

ON THE INFLUENCE OF CULTURE ON VEGETATION.

MRS. B.

Let us now examine to what extent the natural state of plants can be modified by the art of man. For this purpose it will be necessary for me to make you acquainted with certain differences which exist in plants of the same species.

A species, you recollect, comprehends all those plants which bear so great a resemblance to each other, that we may reasonably suppose them to be descended from the same parent stock. But, independently of this general similitude, each species admits of various shades of difference, some of which are strongly marked, and of a permanent nature; others more slight and evanescent: hence spring the three modifications of *Races*, *Varieties*, and *Variations*. Several races derive their origin from the same species; and the points in which they differ are of so decided a character, that they are continued, when it is propagated by seed.

Varieties are a subdivision of races; in which the points of difference are of so slight a character, that they are obliterated when it is raised from seed and continued from one individual to another only when the plant is propagated by subdivision; that is to say, by grafting, budding, or layers.

Variations are the feeblest of all deviations from the parent stock: they originate in the peculiar circumstances or situation of the plant, such as peculiarity of soil, temperature, &c., and are susceptible of being continued to successive individuals only if placed under similar circumstances.

Now, the art of man has great influence in varying and multiplying these several modifications of species. If, for instance, the pollen of the flower of one species be made to fall on the pistils of another species, one of two things may happen: either the flower will produce no seed; or, if it produce seed, the plant which results from it (which is called a Hybrid) will partake of the form and nature of the two plants from which it springs; and hybrids very rarely produce any seed.

CAROLINE.

It is then, I suppose, only performed as a curious experiment, since the seed is lost, and nothing is gained in exchange.

MRS. B.

True; but the result is very different, if, in two plants of the same race but of different varieties, the pollen of one be made to fall on the pistils of the other, the blossom will in general bear fruit, and thus a new variety will be produced, differing from those from which it drew its origin. Let us suppose, for instance, that there were but two varieties of cabbages in nature, the one spherical, the other spreading: by the intermixture of the pollen of these two, a third variety would be produced; and by continuing the process between these three varieties, ten, twenty, or thirty new ones would result. But as these varieties bear seed capable of reproduction, it is, in fact, new races which are formed.

In Belgium, the horticulturists, with the most patient perseverance, produce, by this process, a great number of new varieties of fruit trees, which they propagate by seed, and thus give birth to new races; but this is extremely tedious, for it is many years before the fruit tree raised from seed is capable of bearing fruit.

EMILY.

This period might be accelerated by grafting; but then I suppose that process would alter the nature of the new variety of fruit.

MRS. B.

Certainly. The Dutch are celebrated for the beauty, or rather the variety of colour, of the tulips they have thus introduced. These flowers change their colour during the first seven years, they afterwards never vary: this renders a course of experiments, with a view to produce certain colours permanently, much more tedious, and, consequently, more expensive than with most other plants; and the Dutch horticulturists prosecuted their labours with such enterprising zeal, and the passion for these flowers was carried to such excess, that the Government thought it requisite to enact a law, forbidding the sale of a tulip for above the sum of four hundred pounds.

EMILY.

Is it possible that any one would go to so great an expense for a simple flower! It is by these means, I suppose, that many fruits and flowers have of late years been so much improved. The great variety of magnificent geraniums and gigantic strawberries and gooseberries are, doubtless, the result of similar experiments; but the flavour of the fruit does not, I think, correspond with its size; I even doubt whether the bulk is not increased at the expense of the flavour.

MRS. B.

If the same quantity of flavour be diffused over a greater bulk of fruit, it will seem to be diminished to the palate; but I believe that the horticulturists consider that they have improved the flavour, as well as the size of the fruit.

The influence of culture on Variations, results from its influence on the soil, and the quantity and quality of the nourishment afforded to plants. Hence some parts of a plant may be made to prosper more than another; the stem more than the foliage and fruit, if timber be required; the leaves more than the seed, if grasses; or the fruit more than the leaves, with most fruit trees. A change of colour may also be produced. Thus the Hydrangea, when first brought from the Isle of Bourbon, was blue; in this country it is commonly of a pale pink, and it is the soil principally which has effected this change; for if cultivated in a ferruginous soil, similar to that of its native land, the blue colour is reproduced. Pink flowers may be also changed to blue or white; but cannot be made to assume a yellow colour; and the Hydrangea or the Campanula may be varied from pink to blue or white, but you never see them of a yellow colour.

EMILY.

That is true; Hyacinths are also pink, blue, or white, but they are seldom of a yellow colour.

MRS. B.

They are the only flowers which occasionally form an exception to the rule, being sometimes yellow.

The neighbourhood of the sea produces a variation in plants, rendering them more succulent or fleshy.

Grafting also modifies the variations of plants, and the art of pruning has a very considerable influence, by altering the direction of the sap; but its effect, however great on the individual plant, produces no change on its successors.

Trees are pruned with a view to improve either their beauty, their health, or their produce. They were formerly cut and trimmed into all kinds of grotesque figures, according to the tasteful ideas of beauty of our ancestors.

CAROLINE.

And I assure you that I know an old lady's garden in which there are still some cocks and hens cut out in box, which used to delight me when I was a child.

MRS. B.

This grotesque taste is of great antiquity. Pliny describes his Tusculum villa as being ornamented with figures of animals cut out in this manner.

EMILY.

Is it not strange that the Romans, so celebrated as they were in the fine arts, should have such bad taste in the ornaments of their gardens?

MRS. B.

So it appears to us, but in all ancient descriptions of gardens, we find their formal regularity pointed out as one of their greatest beauties. The gardens of Alcinous, Homer tells us, were planted with trees in rows, and watered by two corresponding fountains; and those of Academus at Athens were planted with rows of plane-trees, watered by a stream and inclosed by walls. It is indeed somewhat difficult to account for such a taste in people so refined as the Greeks and Romans, but we must consider that in those early ages, when the space left to wide uncultivated Nature was far greater than that improved by art, those scenes were most admired where art was the most prominent feature.

It is only within these last fifty years that we have begun to lead the way back to Nature, and have aimed at improving whilst we imitated her graceful and picturesque varieties, and this English style of gardening has been followed in almost every civilised country in the world. When this barbarous system was exploded, that of heading young trees, in order to thicken the branches and foliage, was introduced; but this, we have agreed, injures the natural appearance and character of a tree; and all the pruning that is allowed in the present times, with a view to improve the appearance of a tree, is to strip off the lower branches while young, to prevent its assuming the form of a bush. This operation should not be performed too soon: the stem, while young, requires the aid of these lower branches to carry on the process of vegetation, and supply it with nourishment: they pour the cambium into the stem at its base, and thus assist in increasing its vigour.

EMILY.

Yet, would not this operation become dangerous, if long delayed? for the larger the lower branches are suffered to grow, the more serious would be the effect of their amputation.

MRS. B.

The proper time for lopping them is, when the tree has attained sufficient vigour to enable it to recover from the wounds, in the course of the year.

Resinous trees suffer from pruning, by losing too much of their resinous juices: fir trees should never be pruned; but if planted in groups, as they grow naturally, the lower branches, being deprived of light and air, dry up and perish: it is thus that Nature prunes them without the infliction of a wound, from which the resinous juices would flow, to the great detriment of the plant.

In regard to the pruning, which relates to the health of plants, not only should all the dead branches be carefully removed, but the pruning knife must penetrate into the quick of the wood. It is advisable, also, to cut away all the parts which are diseased, as these seldom recover, and would continue, during a few years of sickly existence, not only to absorb a portion of the sap, but very probably to communicate their malady to the contiguous branches.

All branches seriously injured by hail should be immediately removed; they will then rapidly shoot afresh, and, in the course of a few weeks, their loss will not be perceived.

EMILY.

Greenhouse plants must require a great deal of pruning, for as their roots cannot grow freely in search of food, the branches, I suppose, should be diminished, in order to correspond with their limited quantity of nourishment.

MRS. B.

True; both root and branch require pruning annually, when the plants are fresh potted. But observe that the gardener takes care to atone, as far as lies in his power, for the contracted sphere in which they vegetate, by affording them as much food as can be contained in so limited an extent of soil.

Pruning fruit trees is done with the view of either increasing the quantity, or improving the quality of the produce. It consists in retarding the descent of the cambium, in order that by remaining longer in the branches it may nourish them more abundantly. For this purpose, the branches which grow vertically should be pruned, because the sap, descending through them straight downwards, moves with greater velocity than when it descends obliquely, as it does in lateral branches.

It has sometimes been found advantageous to bend down the vertical branches, in order that the cambium should be compelled to rise, in its return from the extremity of the branch: the time required to overcome this difficulty retards the march of the cambium, and enables the branches to absorb more nourishment from it during its passage.

Espaliers are usually trained in the form of a fan, by cutting away the central stem: or the stem may be preserved, provided that the branches be trained laterally; for it is in these, which produce the fruit, rather than in the stem, that it is essential to diminish the velocity of the cambium.

You recollect my having already made you acquainted with three species of buds: those which yield fruit;

those which develope leaves only; and those of a mixed nature, containing both fruit and leaves.

CAROLINE.

Yes; and we observed that the more fruit buds escape the pruning knife, the greater will be the crop of fruit.

MRS. B.

Care should be taken, however, not to leave more fruit buds on the tree, than the sap will be able to bring to perfection, else the quality of the fruit will be deteriorated. Good gardening consists in preserving as many fruit-buds as the tree can nourish without exhaustion; for if you force a plant to labour beyond its strength, either the fruit will not ripen, or its size and flavour will suffer.

CAROLINE.

But this pruning, with a view to improve the quality of the fruit at the expense of the quantity, is an unnatural state of vegetation, which, I should suppose, would eventually be prejudicial to a tree.

MRS. B.

I cannot consider it so: the finest trees and the choicest fruit are those in which art has judiciously assisted and modified the efforts of Nature. We contribute to the health and general prosperity of the tree by preventing it from bearing an excess of fruit; and we make amends for the diminution of quantity by the increase of its size and flavour.

CONVERSATION XXVI.

ON THE DEGENERATION AND THE DISEASES OF PLANTS.

MRS. B.

We shall preface the history of the diseases of plants by that of the degeneration of their organs, which often undergo a species of metamorphosis, and, instead of being developed in the usual manner, become monstrosities.

There are several causes which produce this effect on plants: 1st. The natural soldering, or cohesion, of the parts. You frequently see the leaves of branches, the petals of flowers, and even fruits which unite, forming double leaves, double flowers, and double fruits.

Such cohesion sometimes regularly occurs. The single petal which forms the corolla of many flowers, such as the convolvulus, is composed of the union of several others; but as it is not unfolded until after the junction is completed, we are led to consider it as a single petal; and such flowers are called in botany monopetalous.

EMILY.

But where this union regularly occurs, it should, I think, be considered as the natural state of the plant, and not as a monstrosity. Pray, how does it take place? Is it a species of grafting one petal upon another?

MRS. B.

No; it is rather a simple adhesion than a continuity of vessels through which the sap passes. The petals in which this adhesion so frequently occurs have no liber; and this, you know, is essential to the process of grafting, as it is through the vessels of the liber that the cambium descends.

Another species of degeneration arises from a want of vigour in the plant to bring all its parts to maturity. That which most commonly fails is the seed, which is produced in such abundance, and requires so much nourishment to ripen, that the greater part perishes in the bosom of the flower. The blossom of the horse-chestnut, for instance, contains six seeds, enclosed in three cells; but one only, or at most two, come to maturity. It is the same with the oak: each blossom has six acorns, but only one is brought to perfection.

CAROLINE.

And to what cause is the want of developement owing? If the plant be incapable of ripening so many seeds, why has Nature furnished it with so useless an abundance?

MRS. B.

The causes of these abortions are probably numerous; but the principal one is, no doubt, a deficiency of nourishment. Yet so far from inferring that such failures imply a want of regularity in the laws of Nature, it is to them that we are indebted for one of the most efficient means of ascertaining the order which reigns in the natural world.

A third species of monstrosity results from a degeneration of the organs, which disables them from fulfilling the purpose for which Nature originally designed them. Thus, in some plants, the leaves do not sprout, and the stem, receiving the nourishment which the leaves should have absorbed, swells out to a considerable size, and expands like leaves. The *Xylophylla* and the *Cactus opuntia* are constantly in this state. It is said, that the leaves of these plants bear flowers: but the fact is, they have no leaves; the flowers grow on the flattened and expanded stems.

Flowers having double blossoms are also classed among the tribe of monsters. This arises from the stamens being too abundantly nourished. They swell out, flatten, and are converted into petals; hence the flower becomes double. Thus we have double roses, double stocks, double blossom cherry, &c. The process of this metamorphosis is very plainly discernible in the double hyacinth and the double tulip, where many of the stamens are completely transformed into petals: others, while expanding for that purpose, still partially retain their original form. As this metamorphosis never occurs but when the anthers have perished, it is probable that they are starved by the stamens absorbing the whole of the nourishment.

EMILY.

It is, I suppose, owing to the destruction of the anthers, that double flowers bear no seed. But why should such beautiful productions of Nature be stigmatised by the name of monster? It is considering beauty as a deformity.

MRS. B.

However disagreeable are the ideas commonly annexed to the term monster, the word simply implies a deviation from the common course of Nature. In the animal kingdom, such a deviation almost always excites disgust, and is associated with the idea of ugliness. Were there consciousness in plants, they might very possibly consider the unusual quantity of petals and the deficiency of anthers as a deformity; but we, who look upon a flower merely to delight our sight with its form and colour, associate the idea of beauty to this unnatural state.

Another instance of degeneration is, when the petioles or foot-stalks are transformed into leaves. The Acacia, for instance, has six or eight pair of leaves, a number which diminishes every year, till at length the foot-stalk is wholly deprived of leaves; but receiving all the nourishment which was previously distributed to them, it expands, flattens, and is itself finally converted into a blade resembling a leaf.

EMILY.

Though the acacia is not a very common tree in England, I have seen a great number on the Continent, but never observed the species of metamorphosis you describe.

MRS. B.

The acacia to which I allude is that of Arabia, which produces gum arabic, and is known in Europe only as a hothouse plant. It is the original and only true acacia. The tree we cultivate under that name is derived from North America: it obtained the name of acacia from some resemblance between its fruit and that of the Arabian plant, and was distinguished from it by the title of *false* acacia: but as the American tree multiplied in Europe whilst that of Arabia was known only to horticulturists, the epithet false was dropped, and it now usurps the name which really appertains to the Arabian plant. Its botanical name is *Robinia*.

Instead of wholly disappearing, folioles often degenerate into tendrils, for want of sufficient nourishment. The flower-stalk, or peduncle, is also sometimes converted into tendrils. This occurs constantly in the vine. The plant at first shoots out abundance of branches bearing large leaves and clusters of grapes, when, after a time, the food proving insufficient to support such profuse vegetation; the new leaves, gradully unfolded, become of smaller dimensions, and the clusters of grapes contract in size. Still nourishment is wanting, and the later shoots, incapable of developing either flower or leaf, are converted into tendrils. Is this an imperfection in the system of vegetation, or is it not rather a beautiful contrivance, to enable the plant, when it has sprouted all the branches it can feed, to sustain these branches by means of the tendrils in which they terminate, and which cling to the first object capable of affording them support?

EMILY.

These organs, which you call degenerated, appear to me to serve a purpose no less useful than the functions they would have performed had they come to a state of perfection. But do all the various sorts of tendrils of climbing plants result from the degeneration of other organs?

MRS. B.

There is great reason to suppose so. The most common of these degenerations is the transformation of the young shoots of branches into thorns. When a plant shoots more branches than it can nourish, the most weakly almost wholly cease to grow. The scanty sustenance they receive serves, however, to harden and strengthen them: hence the tender extremity is converted into an indurated sharp point.

CAROLINE.

Is it not singular that these two last degenerations, resulting from a similar cause, should be so different in their effects? In the thorn the food hardens without extending the shoot, whilst in the tendril it is extended to a considerable length, and is extremely flexible and slender.

MRS. B.

Nature has so contrived it (though by means which are unknown to us), no doubt, with a view to provide support for climbing plants, which are too weak to bear the weight of their produce; and where no such assistance is required, she has converted the abortive shoot into an arm of defence.

EMILY.

Would, then, these plants have fewer tendrils and thorns if transplanted into a richer soil?

MRS. B.

No doubt; because a greater number of young shoots would be brought to perfection. M. de Candolle transplanted a wild medlar-tree, covered with thorns, into his botanical garden, and in the course of three years not a single thorn was to be seen upon it.

EMILY.

Yet I have never observed that the rose or the gooseberry bush lost any of their thorns by cultivation.

MRS. B.

They are not thorns, but prickles, which grow upon the rose, the bramble, the gooseberry, and many other plants; and these are quite of a different nature. The prickle is a natural appendage, which has no connection with the wood; it springs from the bark, and is peeled off with it; and since it does not result from the degeneration of any organ, it is not susceptible of being diminished by cultivation.

The peduncle of the grape terminates in a tendril, when the vine is loaded with as many clusters of fruit, as it can bring to maturity. But in a very favourable soil, more grapes would be produced, and this transformation of the fruit-stalk takes place later, and probably less frequently.

CAROLINE.

And may not monstrosity of organs also be produced by plants having too much nourishment?

MRS. B.

Certainly: this happens if the nourishment, instead of being equally diffused throughout the plant, partially increases the growth of any particular part. All disproportion of size among the relative parts is a deviation from the regularity of Nature, and must be considered as deformity; but as it is much more common for plants to be under than over fed, the monstrosities which arise from the latter cause are of rare occurrence.

Though these various irregularities and metamorphoses are classed under the head of monstrosities, I am far from considering them as evils: I view these changes as advantageous to plants, and if naturalists rank them as imperfections in the system of vegetation, they are, by the beneficence of Providence, turned to such good account, that we cannot but estimate them as blessings.

We shall now proceed to consider the influence of culture on the diseases of plants. The botanical physician must not rest satisfied with studying the symptoms of a disease, for the same symptoms may be produced by very opposite causes: thus, plants turn yellow if they receive either too much or too little water; in order, therefore, to afford a remedy, the cause of the malady must first be carefully investigated.

CAROLINE.

And that must be very difficult: since, in examining the patient, you cannot ask him any questions.

MRS. B.

Fortunately, the diseases of the vegetable kingdom are of a less complicated nature than those of animals.

The diseases of plants may be ranged under six different heads: —

1. Constitutional diseases.

2. Diseases arising from light, heat, water, air, and soil, improperly applied.

3. Diseases arising from contusions and external injury.

4. Diseases occasioned by the action of animals on plants.

5. Diseases proceeding from the action of vegetables on each other.

6. Diseases arising from age.

Variegated or party-coloured leaves, such as those of the box and the holly, are classed as constitutional diseases. They arise from certain juices of plants, which, from some unknown cause, change their nature, and thus affect the colour of the leaf. These changes are preserved if the plants are multiplied by subdivision, and even sometimes continued when propagated by seed.

The second class of diseases results from circumstances connected with the undue supply of elements, which are in themselves necessary to vegetation; such as temperature, light, water, air, soil, &c. If a plant has too much or too little light, heat, or water, it has no means of avoiding the excess, or of compensating for the deficiency.

CAROLINE.

The poor plant, it is true, rooted to the ground, cannot, like an animal, fly the evil, or seek a remedy; it must patiently submit to it, and endure the diseases it entails: if the soil afford too much nourishment, it must continue feeding, and cannot stop when its appetite is palled.

EMILY.

Or, what is worse, and more frequently the case, when the soil does not yield a sufficiency of nourishment, it cannot seek it elsewhere, and famine must weaken the roots, and diminish that vigour which would enable them to stretch out their fibres over a greater extent of soil.

MRS. B.

We have already entered so much into detail on the influence of light, heat, water, and soil, on plants, that I shall confine myself to recalling a few of the most essential points to your memory. Excess of light produces too much excitement; the oxygen escapes, and the carbon is deposited too rapidly; the plant vegetates in a fever, and the sap, incapable of supplying its wants, is exhausted; it withers, and the leaves fall off. There are two modes of remedying this disease; either to increase the aliment, or diminish the vegetation; the first may be done by plentiful watering, the other by diminishing the intensity of the light.

Excess of heat dries up the juices: if you attempt to remedy this by plentiful watering, the plant sprouts leaves, but very little fruit.

CAROLINE.

This sort of vegetation must be well adapted to meadows, where a produce of leaves is principally aimed at.

MRS. B.

True; but plentiful irrigation is not always attainable: where it can be had, no evil effects need be apprehended from the sun.

A deficiency of heat produces dropsy, and often decay: the most delicate parts of the plant are first affected, such as the articulations of the branches and of the leaf-stalks; hence the leaves and young branches fall off. A plant evaporates much more water than it retains; it may be compared to a tube into which you introduce water: now, it is evident, that the more you pour in at one end, the more must be poured out at the other: the evaporation by the leaves must correspond with the absorption by the roots, else the plant will suffer.

Plants are also often injured by exposure to external moisture. Rain is more hurtful to the wood than to the bark; the latter is a sort of great coat, provided by Nature to shelter the wood from the inclemencies of the weather: she has stored it with carbon, to enable it to resist putrefaction; and with siliceous earth, to render it firm and durable: but if, as it sometimes happens, the great coat be rent and ragged, the rain penetrates into the wood (which is very differently organised), and having no means of escaping, the stem becomes rotten.

EMILY.

Among the injuries plants sustain from rain, we must not forget that of its making the pollen of flowers burst before it is mature, and hence preventing the seed from being brought to perfection.

MRS. B.

True; but we have already entered sufficiently into detail on that subject.

In regard to the influence of the air, I have formerly observed, that the agitation which the wind gives to plants is advantageous if not carried to excess: the cambium, being a thick viscous juice, requires motion to promote its descent.

CAROLINE.

Yet you have said that the great aim of the gardener is to retard the descent of the cambium, in order that, by remaining longer stationary in the branches, it may afford more nourishment to the fruit.

MRS. B.

That is true, if the production of fruit be the object aimed at; but if, on the contrary, it be timber, we must promote the descent of the cambium into the trunk, instead of endeavouring to detain it in the branches.

Gentle exercise is, however, generally advantageous in the vegetable economy, and promotes the circulation of the juices. Hence the objection to props and espaliers, which confine the stem and branches; yet these are often required to prevent the mechanical injury trees receive from boisterous winds, which rend their branches, and sometimes tear up their roots from the soil.

Plants are affected by the nature of the atmosphere in which they grow. There is nothing more prejudicial to them than smoke.

EMILY.

I am surprised at that; for smoke, you have told us, consists of small particles of carbon which have escaped combustion; and carbon, you know, is the favourite food of plants.

MRS. B.

The particles of smoke, though apparently so small to our senses as scarcely to be distinguished when separate, are mountains compared to the very minute subdivision which matter must undergo in order to enter into the vegetable system. Smoke may clog the pores of plants, but is too bulky ever to obtain admittance through them.

EMILY.

But smoke is always accompanied by a current of hot air, which must be strongly impregnated with carbonic acid; and in this state the carbon is so minutely subdivided as to be quite invisible, and, I suppose, sufficiently so to enter the pores of plants.

MRS. B.

You must remember that the pores of the leaves are destined much more for exhalation than for absorption. Carbonic acid is advantageous to plants only when it enters into their system by their roots; and is as prejudicial to them externally as it is to animals; for plants, under a receiver containing carbonic acid, die in the course of a few hours. Azote and hydrogen do not appear to be injurious to plants, unless in such quantity as to diminish the proportion of oxygen in the atmosphere, which their vegetation requires.

The third class of diseases arises from contusions or other external injury.

The accidental loss of their leaves, from whatever cause it may proceed, must be considered as a disease of plants: if it is not the effect, it is the cause of one; for when the sap rises to the branches, and finds no organs to elaborate its juices, it descends almost in the same state as that in which it rose, a thin crude fluid, little adapted to the nourishment of the stem and branches. Under these circumstances, its only resource is to feed and develope young shoots, which Nature intended should not sprout till the following year. The sap is then elaborated in the leaves of the new shoot, is converted into cambium, and the regular circulation is restored.

EMILY.

How wonderfully prolific Nature is in resources to remedy any accidental interruption to her regular progress! One would almost imagine the sap to be endowed with a sort of instinct, when we find that it is no sooner disappointed in meeting with those organs requisite to its perfection, than, abandoning its natural course, it busies itself in feeding and prematurely forcing into vegetation the organs which are deficient.

MRS. B.

This admirable fund of resources springs from an origin far superior to instinct. Its immediate cause is, it is true, probably either mechanical or chemical. The sap, for instance, cannot deposit the various juices required by the different organs, when a deficiency of leaves prevents these juices from being secreted. In its immature state it is, in all probability, better able to supply the elements required for the vegetation of buds; and thus the young shoots are prematurely forced into life. The mere mechanical philosopher will rest satisfied with this explanation: but if to the reflecting mind be added a feeling heart, he will discover that the beneficent Author of nature has so wisely regulated the laws by which it is governed, that they frequently contain in themselves means of supplying remedies and resources against accidental contingencies.

CAROLINE.

This is, indeed, admirable. In a work of human mechanism, however ingeniously contrived or skilfully executed, constant attention must be paid to watch and remedy any accidental defect; whilst the laws of Nature are of so perfect a description that they are stored with those resources which the mechanist is obliged to supply.

MRS. B.

The loss of bark is so serious an injury as often to prove fatal to plants. If the evil prevail entirely around the stem, so as to effect a complete solution of continuity, the cambium can no longer descend, and the plant must inevitably perish.

CAROLINE.

But do you forget, Mrs. B., that in cutting a ring in the bark, to improve the fruit, you perform the very operation you say is so dangerous?

MRS. B.

True; but this ring, you must recollect, is so narrow, that the swelling of the upper edge, from the accumulation of sap, soon produces a re-union of the severed parts; whilst I was alluding to the destruction of the bark to so great an extent as to preclude all chance of such a remedy. If the bark be only rent on one side of the stem or branch, it may be considered as a partial infirmity, of which the plant may recover. For this purpose, the diseased part should be carefully cut away, and the wound be covered with an ointment. Let us suppose the rent to be of a long oval form, as is generally the case; the cambium, when it reaches this spot, meeting with obstruction, will accumulate, and produce a swelling on the upper extremity of the wounded part: this will gradually descend on each edge of the severed bark, till it meets at the bottom, and the swelling will increase, till the two sides unite, when the wound will be healed.

EMILY.

I have often observed the swelling of the bark where a branch has been lopped; it forms a protuberant ring around the wound, but does not close, so that the central part of the wood remains exposed.

MRS. B.

In this instance, not only no ointment has been used to shelter the part affected, but the wound being of a circular form, it is more difficult for the edges of the bark to meet. The young wood, however, which it is the most essential to shelter, is covered by the swollen ring of bark.

Plants often suffer from improper pruning. When a tree is lopped of its branches, they should be cut off obliquely; the sap, when it rises to the wounded part, will then flow down its slanting surface, while, if the amputation be made horizontally, not only will the sap be less able to run off, but the wound will be more exposed to the rain and wind, and putrefaction will probably ensue.

EMILY.

I have seen the trunks of old willows, whose branches are lopped every year, become perfectly hollow; which arises, no doubt, from the wood having been injured.

MRS. B.

This operation, which is called pollarding a tree, is done with a view of turning the branches to the greatest account: in willows, generally, for basket-work; in other trees, for fuel. When a tree is in the full vigour of life, it will be able to resist such merciless amputation; but when it becomes aged the wood will not support it without decaying.

Slight contusions, instead of being prejudicial to plants, produce an excitement which accelerates vegetation. The prick or perforation of insects, which we have noticed in the fig-tree, simply occasions a small swelling like that produced by a blow given to an animal: in this swelling a minute quantity of sap is deposited, which nourishes more abundantly, and, consequently, developes more rapidly, the surrounding parts.

Beating trees in order to bring down the fruit is, we have observed, advantageous to them, if performed with moderation and judgment; by slightly wounding the young branches, it arrests the sap, and furnishes a store for the nourishment of germs; but when much violence is used it is hurtful, by injuring the young branches; it is so also to the fruit, unless these be of the nut kind: for apples, pears, and olives, when thus brought down, are bruised, and very liable to rot.

This leads us to the class of diseases arising from the action of animals on plants. But it is too late to enter upon it to-day: we shall reserve it for our next interview.

CONVERSATION XXVII.

THE DISEASES OF PLANTS CONTINUED.

MRS. B.

PLANTS suffer much from their leaves being devoured, either by quadrupeds or insects. The former not only wound the branches in biting off the leaves, but, if the soil be of a loose nature, their feet disturb the young roots; hence pasturage is esteemed injurious in loose and wet soils. But the insect tribe is a far more insidious and fatal enemy. Insects not only perforate the plant, in order to deposit their eggs, but, when these eggs are hatched, the larvæ or grubs prey upon the trees which have afforded them shelter, devouring their leaves, and often rotting the wood by their acrid juices. Most of these insects bear the name of *Cynips:* that which produces the excrescence called gall-nuts, from which ink is made, is one of the most remarkable. The smoke of tobacco, and washes made of infusions of that plant, are the best preservatives against these minute but inveterate enemies. The insect called Cochineal fastens itself to the bark of trees, and sucks the juice through it. The black spots on orange-trees are insects of this class; they are generally pernicious in green-houses, and should be brushed off.

CAROLINE.

I thought that cochineal was of a bright red colour, and that it was peculiar to hot climates.

MRS. B.

The species you refer to comes from Mexico, and feeds on the *Cactus Opuntia*, from which it derives the name of cochineal; but there are many other species of this insect, which are not confined to tropical climates.

The fifth class of diseases results from the action of plants on each other. Being destined by Nature to produce a much greater quantity of seed than they can possibly bring to maturity, we may consider plants as constantly struggling with their neighbours to obtain nourishment for their numerous offspring: they thus impoverish each other, and check that vigour of vegetation, which would take place, had every plant sufficient space and food not to interfere with the wants of its neighbours.

EMILY.

That is very evident in the fine growth of a single tree, which has ample space for its branches, and food for its roots, compared to that of a tree in a crowded forest, where every inch of ground is disputed by surrounding plants.

MRS. B.

But, independently of this general competition for food, there are various other modes by which some classes of plants are noxious to others. Among these the parasitical plants stand pre-eminent. There are two classes of this description, distinguished by the epithets of *false* and *true*. The false parasite fixes itself to the plant, for support, without feeding on its juices; while the true parasite derives its nourishment from the plant to which it adheres. These two classes are each subdivided into external and internal parasites, denoting the parts of the plant which they attack.

The false parasites consist of mosses, lichens, and fungi, which grow on living plants just as they would grow on a rock or a dead tree.

EMILY.

Such as the various mosses which grow on the stems of fruit-trees. But, if they do not feed on the tree, whence do they derive their nourishment?

MRS. B.

From the moisture of the atmosphere, and, possibly, from the relics of some preceding mosses, which supply a few particles of vegetable mould.

CAROLINE.

Then, if they do not feed on the juices of the tree, in what manner do they injure it?

MRS. B.

Chiefly by attracting moisture to the stem, and thereby endangering the wood; and also by affording a harbour for insects. In these temperate climates, however, the harm they do is not of a very serious nature; but, in tropical regions, parasitical plants grow with such luxuriance (the vanilla, for instance,) that the tree suffers mechanically from the weight of the mass it has to bear.

EMILY.

I recollect, in the Caschines of Florence, seeing many of the elm-trees so completely covered with ivy, that at first sight I concluded the tree itself was of that description.

MRS. B.

Ivy is a creeping plant, not a parasite. Its roots are planted in the ground, and feed on the soil: all it requires of the tree on which it hangs is support. Yet these plants, as you observe, are frequently prejudicial. I have seen trees so covered, and strangled, as it were, with creepers, that scarcely any room was left for its natural foliage; and the growth of the tree was thus considerably impeded.

But to return to our parasites. The Rhizomorpha is a false internal parasite, which attacks wood; and, though it does not feed upon its juices, the mere growth of the plant proves fatal to it, disorganising its parts, and reducing the wood to a sort of vegetable mould. This malady seldom occurs but in very old trees.

EMILY.

We, who wish to have plenty of sound timber for building, consider this as a dreadful malady; but, in the course of nature, it may, perhaps, simply be a means employed to reduce old or dead trees, to the state in which they are fitted to return again into the vegetable system, for this mould must afford rich food for other vegetables.

MRS. B.

In natural forests, where the hand of man does not interfere to turn the timber to his own account, the Rhizomorpha may be useful in hastening the decomposition of wood, a substance so hard and compact that it would require a great length of time to effect it by the usual process of decay. In this operation, it is aided by a tribe of insects, which take up their abode in the cracks and crevices it has made in the wood.

CAROLINE.

The Mistletoe is, I suppose, a true parasite; for it derives its nourishment from the tree to which it is attached.

MRS. B.

Yes. The seed of the mistletoe fastens itself to the tree by means of a glutinous substance with which it is covered. The radicle of this seed sprouts in a manner different from that of any other plant: being too feeble, on its first entrance into life, to penetrate so hard a soil as wood, it shoots out in some other direction.

CAROLINE.

It grows then like a stem in the open air, which must be a very uncongenial soil! as much too light as the other is too compact.

MRS. B.

True; and it no sooner makes this discovery, than it changes its course, and curving round, retraces its steps towards the branch whence it sprouted.

CAROLINE.

Just as if it were conscious that the soil it had abandoned was that in which it was destined to grow.

MRS. B.

It is said that it is in order to avoid the light, that it alters its course; for roots, you know, dread the light as much as leaves and branches delight in it.

The extremity of the root having now grown stronger, as soon as it comes in contact with the branch, pierces the bark, and plants itself in the alburnum, whence it sucks up its food, just as other plants do from the soil.

CAROLINE.

With the advantage that its food being already prepared, it can scarcely require leaves to convert the sap into cambium.

MRS. B.

On the contrary, the soil from which it feeds is the wood, not the bark: it is therefore the rising not the descending sap which it receives; so that the mistletoe and the tree to which it adheres, may be considered as the same individual plant, the parasite receiving the sap after the same manner as the branches of the tree, and like them requiring leaves for its elaboration.

EMILY.

This junction must be very analogous to a natural graft.

MRS. B.

I beg your pardon, it is quite the reverse. In a graft, it is the vessels of the liber which unite; whilst the mistletoe strikes its little root through the bark into the wood, and the junction of the vessels takes place in the alburnum.

EMILY.

Is it not wonderful that so young and tender a root should be able not only to pierce the bark, but even to penetrate into the wood?

MRS. B.

It is, indeed; but observe that it does not go deeper into the wood than the external layer, which, being the last formed, is the most tender.

EMILY.

If the root of the mistletoe is so superficial, it cannot be so difficult to root it out, as I have heard.

MRS. B.

Though the root of the mistletoe does not penetrate beyond the outer layer of wood, you must recollect, that every year a new layer grows over it, so that it is annually buried deeper; and after some years' growth in so hard and compact a soil, there is but little chance of being able to extract it, without wounding the branch beyond recovery. The only mode of effectually extirpating the mistletoe, is to cut off the branch to which it is suspended; it is better to lose a part than to suffer the tree to be molested by so disagreeable a companion.

The mistletoe is more partial to some species of trees than to others; but the oak is the only one almost wholly exempt from its depredations.

CAROLINE.

I thought that it attached itself to the oak in preference to all other trees, and that the Druids considered their union as sacred.

MRS. B.

It was probably owirg to its so seldom attacking this tree, that the Druids held the mistletoe in such high veneration when they found it there. The oak has, however, another enemy, of a very similar description, called the *Laurientius*, whose ravages are exclusively confined to this sovereign of the forest.

The *Cuscuta*, commonly called *Dodder*, is a parasite, which attacks lucerne, trefoil, and several of the artificial grasses: it has neither cotyledons nor leaves, consisting simply of a sort of filament or stalk, which, after it has sprouted, falls and perishes, when it finds no plant to which it can adhere; but if it meets with any of the artificial grasses, it fastens upon them, and feeds upon their juices. The seeds sometimes germinate in the soil, and sometimes on the artificial grass itself. The mode of destroying this noxious parasite, is either to burn or to mow the artificial grass very frequently, in order to prevent the seed of the Dodder from germinating; or else to change the course of cropping, and sow corn, for this parasite will not attack grain, or any other endogenous plant. There are three species of Cuscuta, one of which attaches itself exclusively to the vine: its filaments are as large as a small packthread; fortunately, this last is very rare.

The *Orobanche* is a genus, one species of which adheres to the roots of hemp, and destroys them by devouring their juices.

Fungi form a very considerable class of false parasitical plants; to this class belongs the *Erisiphe*, which attacks the leaves of plants: it first makes its appearance under the form of yellow spots, which afterwards turn black. There are no less than forty different species of this parasite.

The *Rhizoctonia* is a species of fungus, which confines itself almost wholly to the roots of lucerne and saffron: this disease shows itself by the fading of the head of the plant; and the contagion soon spreads around it, in rays as from a centre. If one of the affected plants be pulled up, the roots will be found covered with the noxious filaments of this fungus: their effects on saffron is so baneful, that the malady it produces bears the name of *death;* and the only way to prevent its spreading, is to bury the affected plants in a sort of cemetery, for it is necessary to surround them by a ditch; and in digging it, care must be taken to throw the earth inwards, to prevent the contagion from spreading. There are three species of this destructive fungus; the brown, the carmine, and the white: the latter attacks fruit-trees; its filaments are free from tubercles, while those of the former are covered with them.

The class of internal fungi is very numerous, there being not less than three hundred species, each attaching itself to the plant which suits it. Some of them attack all the plants of the same family; others confine themselves to those of the same species. Two of those species of fungi belong to the rose-tree: they appear at first under the form of small yellow spots; these increase till they run into each other; their colour then changes to various tints of brown and red,—tints which you must have observed the leaves of the rose-tree often assume, long before their natural decay.

CAROLINE.

This malady, far from disfiguring the plant, adds to its beauty; but who would ever have imagined these colours to have proceeded from a separate vegetation growing on the leaf?

MRS. B.

Smut is a fungus, under the form of a black powder, which lodges itself on the surface of the ears of corn, particularly of oats. But the most insidious enemy of grain, of the mushroom tribe, is called the *Rot.* It devours the seed, without making its appearance externally. When the corn is thrashed, the rotten seeds burst, and the disease is thus communicated to the rest of the corn; so that if sown, the rot will be propagated as well as the corn; to prevent which, corn that is at all affected with this disease should be soaked in a lime wash, which destroys the seed of the rot, without injuring that of the corn.

Mr. Benedict Provost has found that washes of vitriol or verdigris are still more efficacious.

EMILY.

But are they not pernicious to the grain, and even dangerous to those who employ them?

MRS. B.

It was at first apprehended to be so, but it is now well ascertained, that neither the labourer nor the grain suffer from this process: it is much used in France; and even arsenic has been used with success for this purpose.

The *Ergot* is a disease peculiar to rye, which attacks the ovary of that plant; and bread made of rye thus affected is extremely unwholesome, frequently producing gangrene.

It would be endless to detail the various fungi which molest the vegetable kingdom; we will conclude, therefore, with the *Rust*, which confines its depredations to the grasses.

It is time now to turn our attention to the last class of diseases, those resulting from age; and here you must observe that a very essential difference exists between the animal and the vegetable creation. In the former, all the organs are developed at once: these after long use become indurated, obstructions take place, decay follows, and life thus often terminates from old age. But the economy of the vegetable kingdom is totally different: the organs of the plant, that is to say, the vessels which convey the juices, the leaves which elaborate them, the buds which produce flowers and fruit, are renewed every year; they are always fresh, always young: how then can a plant decay from age?

CAROLINE.

I should rather ask why all plants do not, like annuals, die every year? for these organs, which are renewed in the spring, perish in the autumn.

MRS. B.

Of all the organs which are annually renewed in perennial plants, the layer of wood and of bark alone survive in an active state of vegetation: the others may, in fact, be considered as annuals, living but one season.

CAROLINE.

Then, when a tree dies of age, it is from the stem being worn out; every year the wood hardens by the pressure of the new layers which grow around it: its vessels must, in consequence, become obstructed, and less adapted to convey the fluids which are to pass through them: this bears a strong analogy to the decay and death of animals.

MRS. B.

True; but observe that if these vessels are no longer calculated to transmit the juices, the plant no longer requires them to execute this function: it is performed by the fresh layers of wood and of bark, which are renewed every year: the old repose after their labours, but do not perish; age, therefore, does not necessarily entail death, as in the animal kingdom.

EMILY.

From what cause, then, do plants perish? for, though, it is true, some trees live to a great age, they all ultimately die, as well as animals.

MRS. B.

They are certainly not destined to immortality; but their ceasing to exist seems to depend upon some accidental disease proving fatal, rather than upon any prescribed term of years assigned to them by Nature.

The malady which most commonly destroys plants is exhaustion, arising from their bearing, and ripening, too great a number of seeds: it is this which regularly, though not necessarily, occasions the death of annuals; for, if from any accidental circumstance the seeds are not matured, the plant retains sufficient vigour to live through another season. Perennials. which live several years, perish ultimately of the same disease.

CAROLINE.

And are there no means of diminishing the number of seeds of annuals, and, by thus preventing exhaustion, of transforming them into perennials?

MRS. B.

This may be done by making the flower grow double: the additional number of petals are produced at the expense of the seed; but requiring much less nourishment, the plant is not exhausted.

EMILY.

But, if trees only perish by accidental death, some, at least, should escape; for accidents do not always occur.

MRS. B.

Not, perhaps, to a certainty in any given period; but in the long course of time they never fail to happen; and the extreme inequality in the length of life, in trees of the same species, afford ground for believing that its duration depends upon accident.

EMILY.

But some kind of trees are regularly much longer-lived than others: the oak, for instance, than the poplar; forest, than fruit trees.

MRS. B.

Some plants are naturally much more hardy than others, and therefore resist during a longer period accidental attacks. The oak, so vigorous and magnificent a tree, out of six seeds which it produces in every blossom, brings only one to maturity; and yet with how much less effort could the oak ripen clusters of acorns than an orchard tree the heavy load of fruit, under the weight of which its branches bend? and if any of them break, how great is the probability that decay will ensue: the enfeebled vessels of the wood, exhausted by the labour of carrying sap to so much fruit, are unable to resist the consequences of exposure to the weather; and, after a series of accidents of a similar nature during a course of years, the tree at last perishes. When, therefore, it is said that such a species of tree usually lives such a number of years, the duration refers to the average of time in which it falls a sacrifice to accident, and this average, is very difficult to ascertain.

But it is not only ripening seed, which eventually exhausts plants; all the various diseases we have enumerated tend to shorten their existence.

EMILY.

Yet those only which injure the wood or bark can prove dangerous to the life of the tree: injury to the other organs can be of little consequence, since they naturally perish in the autumn.

MRS. B.

True; but observe that most of the diseases we have mentioned attack the body of the plant; the parasites suck up the juices of the stem; the fungi which adhere to the stem and branches, those which coil round and strangle the roots, all eventually injure the wood.

There is in the island of Teneriffe a tree, the *Dracæna Draco*, of so remarkable a size, that it served to point out the limits of possession of different tribes when the island was first discovered: it has since been repeatedly visited by different travellers, and during several centuries past appears to have remained unchanged: it may possibly be of so vigorous a nature as to have existed some thousand years.

CAROLINE.

And the extraordinarily large tree in the Cape Verde islands, in which Mr. Adamson discovered an inscription buried under three hundred layers of wood, must have been of a very great age.

MRS. B.

From its dimensions and appearance, he calculated that it was probably about five thousand years old.

CAROLINE.

Even allowing for an error of a thousand years or two in his calculation, the tree would still be of a highly venerable age.

And without going so far for an example, in Blenheim Park there are now in existence old trunks of trees, which are said to have shaded the retreat of the fair Rosamond; and are supposed to be not less than a thousand years of age.

CONVERSATION XXVIII.

ON THE CULTIVATION OF TREES.

MRS. B.

NATURE has divided the surface of the earth into meadows and forests: in some parts of the globe, these are so happily blended as to form the most beautiful variety of prospect; but in general, where the hand of man has not interfered, they are divided into immense masses of wood and pasture, which render the appearance of the country monotonous and melancholy.

EMILY.

I should have thought that, in the course of a series of years, these different species of vegetation would have intermixed, so that the seeds of the forest-trees would have sown themselves and grown up amongst the grass, while the latter, on the other hand, would have spread amongst the trees and gained ground upon the forest.

MRS. B.

On the contrary, these two species of vegetation reciprocally interfere with each other, so as to prevent either from encroaching on their established limits; for grass will not grow under the impenetrable shade of a forest, nor will the seeds of trees germinate in those thick and rich wild pastures called Steppes, where the grass rises to six or eight feet in height.

In tropical climates, forests are composed of a much greater diversity of trees than they are in our less genial latitudes; and the more you travel northward, or the greater the elevation of the land, the more homogeneous the woods become.

CAROLINE.

I have observed this, both in travelling in Scotland, and in ascending the mountains of Switzerland. The walnut, the oak, and the birch successively disappear, and the summits are almost always crowned with firs.

MRS. B.

It is remarkable, that under the same latitude, America can boast of a much greater variety of trees than Europe: we possess but thirty-four species, while she has no less than one hundred and twenty. It is to be hoped, at least, that we shall be able to increase our stock from so well furnished a market.

EMILY.

America being a more recently settled country, and less populous, can afford to raise wood in a better soil, whilst we, in Europe, are so restricted for space, that all our good soil is set apart for grain, and we plant wood only where nothing more valuable will grow.

MRS. B.

That is necessarily the case in all highly civilised and thickly peopled countries; corn, being a more valuable produce than timber, will obtain the preference where the soil is adapted to it.

Our natural forests, in such poor land as we allow them to occupy, consist of little more than the oak, the ash, the beech, the birch, and, in elevated situations, the fir.

Forests are divided by botanists into tolerant and intolerant: the former admits of trees of another species growing amongst them; the latter exclude all but their own.

A forest of oaks is of the former description; underwood of various descriptions growing beneath it; whilst beeches and firs do not allow this privilege to the inferior plants, and are hence denominated intolerant.

The thirty-four species of European forest-trees are divided into four classes.

1st. Class. Trees with hard wood: this class comprises three species of oak.

Long-stalked oak.	Chestnut.	Hornbeam.
Stalkless oak.	Elm.	Pear.
Tauzin oak.	Ash.	Apple.
	Sycamore.	

2d Class. Trees with soft wood.

Lime.	Poplar.	Willow.

3d Class. Trees with resinous wood.

Pine.	Fir.	Larch.

4th Class. Evergreens, not resinous.
The Evergreen Oak of the south of Europe.

There are two modes of felling forests; which the French call *en Jardinier*, or *Taille réglée*, and for which we, who devote much less time to this species of cultivation, have no equivalent terms in English. In the former, you successively cut down the large trees as they grow up to the size of timber; in the latter, the whole of the forest is felled at once.

CAROLINE.

The former must surely be the best mode; for it seems mere waste to cut down the young trees before they are large enough to be of use.

MRS. B.

It is difficult to fell the large trees without injuring the small ones. They are deprived of the shade and shelter of the large trees, and their roots are often disturbed and their branches broken by the fall of their protectors. When forests are felled completely, it is done at regular periods, which are determined either by the nature of the wood or the purpose for which it is intended. For the ordinary consumption of fuel, it is usually cut down every twenty years. When the trees have attained a sufficient size for fire-wood, and in countries where wood is the only fuel, this is the principal object in view. This is generally the case in most parts of the world. England, where coal is so commonly burnt, forms an exception. We devote much less time to planting, because we derive our fuel from the interior, rather than from the surface, of the earth; and our woods are raised chiefly to produce timber for building: but the *taille réglée* is generally adopted on the Continent. It admits, however, of some modification: instead of cutting down the large trees, and leaving the young ones to grow up, the young trees are cut down generally about the age of twenty years; with the exception of the finest plants, which are reserved for the next periodical felling. These trees are called standards or standers. The young trees are cut up into faggots for burning, and into props to support vines: their stumps quickly send forth new shoots, which at the end of another twenty years are fit to be cut down for the same purpose. The greater number of the standards are then felled, having acquired dimensions which enable them to be cut into logs for fire-wood. The standards which escape the second felling, in France, assume the name of *sur taillis:* if reserved a third time, they are called *sur écorce;* and should they be so fortunate as to survive the fourth felling, they become timber.

EMILY.

I really quite tremble for the reserved trees every time the wood-cutter enters the forest; it is well they are not endowed with a consciousness of the risk they run. And at what age are timber trees felled?

MRS. B.

Their length of life will be more likely to excite your envy than your compassion. Oaks and beeches are not considered as ripe for timber, until they have attained the age of 120 or 130 years. After that period, there is a greater chance of their deteriorating, than of their improving.

CAROLINE.

Wood for burning, then, cut down in the successive fellings is from twenty to nearly fifty years of age?

MRS. B.

Beech, when not reserved for timber, is not suffered to live beyond thirty years; because after that age, young shoots will no longer sprout from the old stumps.

Resinous trees do not shoot out afresh after felling; woods of firs must therefore be cut down altogether, and resown; or the forest may be felled in alternate stripes, which is attended with this advantage, that the stripes left growing, shelter the young plants which shoot in those that have been felled. When the firs are situated on the declivity of a mountain, as it very frequently happens, the wood-cutters must begin their operations from below, in order to be able to carry away the trees with greater facility.

The proper season for felling forests is from the middle of November to the middle of April; and the instrument best adapted for that purpose is a sharp axe, which should be used as near the ground as possible; the buds of the old stumps shooting much more readily when an axe is used than when a saw is the tool employed.

EMILY.

And pray what species of trees are reckoned to make the best fuel?

MRS. B.

Those which are heaviest: the weight indicates the quantity of carbon it contains; and you may recollect that, in the combustion of wood, it is the carbon which gives out most heat.

CAROLINE.

Yet I should prefer the wood which produces most flame. Flame is so cheerful, that it appears, perhaps, to give out more heat than it really does.

MRS. B.

The light which accompanies it, in a great measure, atones for its deficiency of intensity; but flame must be considered as a species of luxury, in which those only can indulge who do not aim at economy in fuel. The greatest quantity of heat is given out when the wood burns red, without flame; consequently, the wood which has the fewest volatile parts producing flame, and the greatest quantity of carbon, producing red heat, is the most valuable for fuel. Here is a list of the various proportions of carbon contained in equal quantities of wood of different species:—

	Oz. of Carbon, the Cubic Foot.		Oz. of Carbon, the Cubic Foot.
Black fir	86	Oak	60
Red fir	84	Beech	64
Evergreen oak	69	Pear	54
Box	68	Willow	27

I have already mentioned the danger incurred by stripping trees of their bark, in order to harden the wood, by forcing the cambium to descend through it. This mode is, however, sometimes attended with success, provided that it be performed only the spring previous to the trees being felled; and that the naked tree be charred or slightly burnt, as a substitute for the covering of which it has been deprived, and a preservative against the inclemency of the weather.

CAROLINE.

That is to say, that the wood is burnt to save it from suffering from wet! I should really think the remedy worse than the disease. In travelling in Italy, I recollect seeing such miserable flayed and blackened trees, looking as if they had been put to various species of torture before the executioner came with his axe to strike the final blow.

MRS. B.

Why should you not compare them to sheep shorn of their fleeces in the spring ? — the bark of the tree is no less useful in the arts than the fleece of wool : you recollect that it contains the astringent principle called tannin, so essential in the preparation of leather : it is oak bark which is principally used for this purpose, as it contains the greatest quantity of tannin.

Let us now consider the cultivation of single trees.

EMILY.

Such as form the ornament of parks and pleasure grounds ; and those which, dispersed throughout the country, produce such beautiful scenery in England.

MRS. B.

There is certainly no country which can boast such a natural and picturesque arrangement of trees. On the Continent, single trees are generally planted in rows : in some districts they may be considered as a supplement to forests. Almost all the trees in Belgium, for instance, grow in hedge-rows, or in avenues on the side of high roads. What species of trees should you think best calculated for the latter purpose ?

CAROLINE.

Evergreens would not be suitable ; at least in our northern climates, because the road requires exposure to the sun and wind during winter, and the passenger requires no shade in that season.

EMILY.

They should be trees which afford sufficient shade in the summer, but whose foliage is not so thick as to prevent the road from drying, after heavy showers.

MRS. B.

For this reason the horse-chestnut is not adapted to such a situation; for, though it would afford excellent shelter to passengers during a shower, it would render the road damp. Trees with very wide-spreading roots are also objectionable, as they encroach on the adjacent culture: on this account the acacia is excluded.

EMILY.

But in England the road is almost always separated from the contiguous fields by a ditch, so that the roots could not well interfere with their produce.

MRS. B.

The roads in England are seldom bordered with trees, except occasionally in hedge-rows: our climate being too damp to admit of such an ornament; while in the southern parts of the Continent trees are almost a necessary accompaniment to roads, on account of the shade they afford.

CAROLINE.

I think fruit-trees, and such as have sweet-smelling blossoms, should he planted for the gratification of the passengers.

MRS. B.

I am afraid that the kindness of your intention would be frustrated; for as these trees are not the property of the public, it would be only leading the passenger into temptation, and exposing the tree to danger; the fruit would be unlawfully gathered, and eaten, in all probability, before it was ripe; and the tree would suffer from the pulling and breaking of its branches. When fruit-trees grow on the high road, the proprietors are often obliged to fence the stems with briars and brambles, to prevent their being climbed, and to lop the lower branches, in order that the fruit may be above the reach of the passengers.

The elm is one of the trees best adapted for the high road: it may be transplanted without injury, after it has attained such a growth as to enable it to resist the attacks of cattle, an essential point, for trees so much exposed; it is hardy in its nature, of long duration, and affords a light and pleasant shade: its roots are superficial, and yet not spreading, and it bears neither flowers nor fruit which can tempt the passenger.

The plane, a tree very common on the Continent, is also well adapted to roads. It comes into leaf very late, so that the roads have full time to dry in spring. The oak is so hardy and durable a tree, that it would be excellent for this purpose, could it be transplanted sufficiently large to preserve it from accidental injury; but it suffers from transplanting, unless very young. The best mode of rearing oaks for avenues is to plant them in hedges: the bramble, or other shrubs of which the hedge is composed, afford them shelter and defence, until they are of an age to resist accidental injury; the hedge may then be cut down at pleasure. This has also the advantage of forcing the roots of the oak to descend; for the roots of the hedge, being more superficial, consume the nourishment near the surface of the soil, and compel those of the oak to seek it in a lower region.

The birch is well calculated for roads, if the soil be sandy: it thrives in a cold climate and in elevated situations, and the lightness of its foliage is an additional advantage in such temperatures.

The sycamore is a beautiful tree for avenues. The hornbeam is objectionable only on account of the slowness of its growth. The aspen, the ash, and the poplar, are well adapted to a moist soil, as they help to drain it. An avenue of poplars is not picturesque, it is true, but it affords almost as much shelter from the wind as a wall, and in some situations this is very desirable.

EMILY.

A few poplars, interspersed with other trees, form, I think, beautiful groups; but an avenue of poplars is associated with the idea of marshy ground, and from its formality is extremely ugly.

MRS. B.

In planting trees by the road-side, the holes should be made both deep and wide; for the ground, not being cultivated, is hard and compact, and the young roots would be unable to penetrate it, were it not prepared and lightened by the pickaxe or the spade.

The young trees should never be headed or lopped; it thickens their foliage, but destroys the natural character of the tree. Some of their lateral branches may be slightly pruned; for as the branches in general correspond with the roots, the more erect the former grow, the more the roots will descend into the soil.

CAROLINE.

The beauty of the greater part of the trees on the Continent is spoiled by the merciless mode they have of heading them when young, in order to make them grow thick and bushy.

MRS. B.

They do this in transplanting young trees, for safety; for the more they are lopped, the more certainty there is of their living; and nurserymen who usually supply them, and warrant their taking root, make no scruple to amputate both head and branches.

CAROLINE.

The life of the plant may be thus secured, but it no longer deserves the name of a tree; it is a stake, or a pole; which, though it may throw out branches, will never have the free, natural character of its species. Is it not, therefore, far preferable to run some trifling risk of losing the tree, rather than mutilate it in so barbarous a manner?

MRS. B.

I perfectly agree with you: besides, the risk is very trifling. In transplanting trees into the botanical garden at Geneva, the branches are never lopped, and only about five per cent. die; yet the chance of their perishing must greatly exceed that of common transplantations, as the trees come from foreign climates, and are placed in a soil and temperature more or less unsuited to them; besides which, they have undergone the confinement of packing, and the fatigues of a long journey. It must, however, be acknowledged, that the art of packing and conveying plants is highly improved; for M. de Candolle frequently receives plants from foreign countries, not only in leaf, but in full blossom.

If, however, gardeners will persevere in the system of lopping, they should at least do it with moderation and judgment.

EMILY.

There is some apology for nursery gardeners: the trees, in their grounds, are so thickly planted, that they cannot be taken up without injury to their own roots, or to those of their neighbours; and if the roots be cut, is it not necessary also to lop the branches, for mutilated roots can ill supply the whole of the branches with nourishment?

MRS. B.

Your observation is very just; but young trees, raised with a view to transplantation, should never be allowed to grow so thickly as to interfere with each other; it is the duty of a nurseryman to transplant them in his own grounds, in order to give them space to grow in, if he has not a market for them elsewhere.

When a very large tree is to be transplanted, it is advisable to do it in the heart of winter, during a frost; a trench should be dug around, and, as far as attainable, below the stem of the tree, and be filled with water, if the rain does not sufficiently perform that office. When the water is frozen, the tree will be enclosed, as it were, in a vase of ice, and may be taken up with the clod of earth attached to it; and, contained in the icy vase, it may then be conveyed to the place of its destination, almost without being sensible of its change of situation. This is, however, a very expensive operation, as it requires a considerable mechanical force to accomplish it. It can be done, also, only where the frost is severe and of long duration; for if the ice be melted or broken before the tree is placed in its new situation, the operation fails.

Sir Henry Stewart of Allanton has, within a few years, introduced a mode of transplanting large trees, which appears to have been attended with great success. It is precisely the reverse of that I have mentioned, yet founded on the same principle of guarding the roots from injury: with this view, instead of carefully covering up the roots, he lays them bare, but he separates the earth from them with such extreme precaution, that not even the smallest fibres are injured; this is done by labourers, whom he calls pickmen; because their business is to clear the roots from the earth by means of a small instrument adapted to the purpose, or with their fingers; a ball of earth is left close to the stem with the sward upon it. An engine is then brought up to the tree, consisting of a strong pole mounted upon two high wheels; the pole is strongly secured to the tree, while both are in a vertical position; they are then brought down to a horizontal one, by the pole acting as a lever; and by its descent, the few central roots, which the pickmen could not reach, are rent from the ground. The tree is so laid on the machine as to balance the roots against the branches, and one or two men are placed aloft among the branches of the tree, where they shift their places like moveable ballast, as occasion may require. Both roots and branches are carefully tied up. The pit for receiving the tree, which should be prepared a twelvemonth before, is now opened, and the tree set in the earth as shallow as possible. The roots are then loosened from their bandages, and divided into the tiers, or ranks, in which they grow from the stem; the lowest of these tiers is first arranged, as nearly as possible, in the manner in which it lay originally, each root with its rootlets and fibres being imbedded in the soil with the utmost precaution, the earth being carefully worked in by the hand and the aid of a small rammer: additional earth is then gradually sifted in, and gently kneaded down, till it forms a layer, in which the second tier of roots is extended in the same manner as the lower tier, and so on till the whole is covered with earth. This attention to incorporate each fibre of the roots with the soil not only answers the purpose of inducing the roots to recommence their function of absorbing sap, but also serves to fix and secure them firmly in the soil, and renders stakes, ropes, and other means of adventitious support unnecessary.

CAROLINE.

By your account this does not appear to be a very expensive process.

MRS. B.

No; independently of the engine, which is very simple, it is estimated that trees from twenty-six to thirty-five feet high, may be moved half a mile, at the expense of from ten to thirteen shillings. But the experiments have always been made with healthy trees, whose roots and branches have had ample space for growth; not tall emaciated plants torn from the interior of forests, with stinted roots and branches, and so little vigour of vegetation, that their bark would not be either of sufficient thickness or hardness to shelter the stem from the rude blast, nor the roots of sufficient strength or extent to fix it firmly in the soil. Sir Henry Stewart, therefore, particularly recommends transplanting trees which have been freely exposed to the advantages of light and air; and should they, by such exposure, have suffered in their growth on the weather side, he advises, in transplanting them, to reverse the aspect, in order to shelter the weak side of the tree, and expose the luxuriant one to the severity of the wind.

EMILY.

By this means, then, large trees may be transplanted without either cutting the roots or lopping the branches?

MRS. B.

By adopting all the precautions I have mentioned, it appears that scarcely a tree failed. Sir Henry is, no doubt, perfectly correct in not cutting, even the little tassels of rootlets which grow at the extremities of the roots, provided the operation of transplanting be performed with so much caution that these suffer no injury; but if the spongioles be crushed, or the fibres any way mutilated, it is better to amputate the extremities, which will shoot afresh more quickly than they would recover of their wounds.

It is wrong to plant in wet weather; for, though watering is required after planting, the hole in which the tree is placed must not be filled with mud: it would greatly endanger the roots.

In such wet countries as Holland, they are often obliged to bury faggots beneath the soil intended for planting, in order to increase the filtration of the water.

From the cultivation of trees we shall proceed to that of hedges: these are destined either for shelter or defence. In former times there was a third description of hedges, designed for ornament; but these our landscape gardeners have entirely exploded.

That district in the west of France, called the Bocage, derives its name from the high and bushy hedges with which it abounds, and which are designed to afford shelter from the stormy winds of the Atlantic.

There are but few trees in those parts; but the hedges, being from eight to ten feet in height, are sufficient to protect the crops from the boisterous sea-breezes, and they hence bear the name of *brise vent*.

CAROLINE.

In England, our hedges are calculated more for defence; but the trees, with which they are interspersed, serve also the purpose of shelter.

MRS. B.

Our climate is unfortunately so damp, that exposure to the sun and air is rather an advantage than otherwise.

Hedges for defence answer the double purpose, of enclosing cattle in their pastures, and excluding those which might trespass on it.

It is objected to hedges, that they occasion a waste of ground: when necessary, therefore, they should be made to occupy as little space as possible, and be thickened, by crossing and engrafting the branches on each other, rather than by planting a double row. An external ditch is liable to the same objection; but it has the double advantage of serving as a defence to the hedge, and of raising a bank, which gives additional elevation to the hedge when planted on it. When the shoots are two years old, they may be crossed and fastened by a worsted thread, and they will engraft of themselves; for the friction of the ligature will wound the young bark sufficiently to expose the cortical vessels, and enable them to unite with each other.

EMILY.

The plants have, then, a double source of life; and, if one of the stems should perish, its branches would be fed by those on which it is grafted.

MRS. B.

Yes; and the dead stem may be cut away without injuring the hedge. By this system of crossing and grafting the branches, the hedge becomes so thick as to be absolutely impassable. Great attention should be paid, not to plant hedges of shrubs which grow thin at the base, or have spreading roots. The hawthorn or quickset is decidedly the plant best adapted for hedges; its shoots branch out in such a variety of directions, and cross and intersect each other so frequently, as to render all ligatures for that purpose unnecessary.

The Paliurus aculeatus succeeds well in dry soils. It is armed with two species of thorn, one of which is straight, the other curved: so that the animal that would trespass, if it can avoid the straight thorns, on entering the hedge, has very little chance of escaping the crooked ones in passing through it.

The Barbary is well adapted for hedges, having three thorns issuing from the same point. The Ilex is furnished with thorns at the extremity of its leaves. The Lentiscus (Pistachia Lentiscus) and the Cockspur Hawthorn (Cratægus crusgalli) are shrubs which admit of being planted in hedge-rows: but their cultivation does not extend further northward than the southern parts of Europe.

CAROLINE.

I begin to think we have been confined long enough by these hedges; and I am impatient to break through them, to get into the orchard, and examine the fruit-trees, which are of a much more interesting nature.

MRS. B.

I was just going to direct your attention to them.

You will be surprised to hear that, of one hundred and twenty families of fruit-trees, known in Europe, we cultivate only seventeen; and by far the greater part of these have been brought from the other quarters of the world. The apple and the pear, some few cherries, and the raspberry and strawberry, are alone indigenous in Europe.

CAROLINE.

Alas! what a poor figure our quarter of the globe makes in the vegetable kingdom.

EMILY.

We have the greater merit in having enriched it with such a number of foreign plants.

MRS. B.

True. These seventeen families give us thirty-four genera, sixty-eight species, and, finally, about two thousand varieties of fruit-trees: a number which is multiplying every day, from the increased facility of intercourse with foreign countries, and the improved mode of conveying plants, united to the general progress of science.

CAROLINE.

From what countries do we derive our choicest fruit-trees?

MRS. B.

Chiefly from the East. Africa is but very imperfectly cultivated; and America, though so remarkable for its forest-trees, appears to be but scantily supplied with fruit-trees. The Opuntia, the Diospyros, and a few others, are the only fruit-trees that have been brought to Europe from the northern parts of the New World.

The orange and citron we derive from Japan; the pomegranate from Africa.

New Holland, which contains not less than three or four thousand different plants, has but three or four species of fleshy fruit-trees, and the fruit of these is small and insipid.

In some fruits we distinguish those in which the fleshy part is attached to the nut or kernel, as the plum and the peach, from those which are separated from it, as the apricot. Peaches, plums, apples, and pears, are of the family of *Rosaceæ*.

CAROLINE.

This family is, then, equally celebrated for the beauty of its flowers and the excellence of its fruits.

MRS. B.

There are two species of peach, both of which we derive from Persia: one of them having a smooth skin, we distinguish by the name of Nectarine. Each of these species has two varieties, in one of which the pulp adheres to the stone, in the other it is separate from it.

The other members of this family are the almond, the apricot, which comes from Armenia, and the cherry, of which there are five species. There are besides, of this family, the plum, the strawberry, the rose, the service-tree, and the medlar.

The orange forms a family of its own, bearing its name *Aurantiaceæ*, and includes the lemon, the citron, and the pample, or mousse.

The sweet orange and the bitter were formerly supposed to be of the same species, and the sweet was often grafted on the bitter orange; but this is an error: they are of different species—and the sweet orange does not require grafting.

There are no less than twelve known species of walnut trees; one of which we derive from Syria, and the eleven others from America. We cultivate the first for its fruit, but the latter produce the finest timber.

CONVERSATION XXIX.

ON THE CULTIVATION OF PLANTS WHICH PRODUCE FERMENTED LIQUORS.

MRS. B.

There exists in all vegetables, though in very different proportions, a saccharine substance from which sugar is obtained; and this substance is susceptible of being converted into alcohol or spirit of wine. For this purpose it is not necessary to resort to the laboratory of the chemist: when placed under favourable circumstances, the transformation takes place spontaneously by a process called *fermentation*.

EMILY.

It is a process with which we are already tolerably well acquainted, as you explained the different fermentations to us in our Conversations on Chemistry.

MRS. B.

You will, then, recollect that the juice of all fruits, when expressed, will (like that of the grape) ferment; and that during this process a general disorganisation of the parts takes place, and a new arrangement is established, in consequence of which the sugar or saccharine matter contained in the liquor will be converted into spirit. But fermentation is not confined to the juice of fruits: spirit may be obtained from any part of a plant containing the saccharine principle; thus the sap of the palm-tree, when fermented, produces palm wine.

CAROLINE.

It is to be regretted that we have no trees whose sap can be fermented: it would be so much more easily obtained than fruit.

MRS. B.

The sap of the birch is sometimes fermented. But you may recollect that the vinous fermentation is frequently followed by another of a very different nature called the acetous fermentation, which reduces the wine or spirit to vinegar: this occurs in some measure with the fermented sap of the birch; it becomes slightly acid, and may therefore be considered rather as a refreshing than a spirituous beverage. All sap would yield spirit; but, independently of its susceptibility of turning acid, the liquor would, in general, be insipid. The excellence of wine is not confined to the spirit it contains, but to its aromatic flavour; and this is produced by the fermentation of fruit. If spirit of wine alone be required, it may be obtained from potatoes or any other vegetable, however insipid. Brandy and common spirits are, in England, usually distilled from fermented grain: gin has more flavour, as juniper berries are distilled with the spirit.

EMILY.

Yet grain does not appear to contain any sugar?

MRS. B.

Though grain is not sweet to the taste, it contains the elements which produce sugar, and the mode of developing this substance, is to make the grain begin to germinate. For this purpose, barley is moistened and exposed to a certain elevation of temperature which stimulates germination; the saccharine principle is thus produced, and the grain becomes sweet: the germination is then suddenly stopped by drying the barley in a kiln or a heated oven; in this state it is called malt. When mixed with water, the liquor is so sweet as to have obtained the name of sweet-wort, and its fermentation produces beer; but this would be a very insipid beverage, were not hops added previous to the fermentation, to give it the flavour and astringent quality found in fruits.

The fermentation of apples produces cider. There are three species of apples; the sweet, the sharp, and the acid. The two former, fermented together, produce excellent cider: the sweet apple supplies the spirit; the sharp, the astringent principle; but the sour apple is not fit for fermentation. In order to make good cider, it is not only essential to choose the kind of apples, but they must be gathered with care, to avoid being bruised; they should then be collected into heaps, in which state they ripen and exude moisture: they must next be crushed and reduced to a pulp, and $\frac{1}{20}$ of water added; the mass is then pressed to obtain the juice, which ferments spontaneously, and produces cider.

EMILY.

Perry is, I believe, obtained from pears in a similar manner?

MRS. B.

Precisely. But it is to the vine that we are indebted for the most valuable of our fermented liquors. This plant is of the family called *Sarmentaceæ*. It bears alternately clusters of grapes, and of leaves, opposed to each other on the stem. The vine derives its origin from the countries situated between Persia and India: it was brought by the Phœnicians to Greece, and thence conveyed by the Phocians to a colony they had formed in that part of Gaul where Marseilles is now situated.

EMILY.

The vine is a plant of such interest to society that its history can be traced with more accuracy than that of most other plants.

MRS. B.

And hence governments have interfered more with the culture of the vine, than with that of any other plant. Numa Pompilius first introduced it at Rome. The Emperor Domitian ordered all the vineyards to be rooted up. Charlemagne protected the culture of the vine; whilst Charles IX. discouraged it. His successor, Henry IV., re-established it, and ever since it has flourished unmolested in France.

CAROLINE.

It appears, then, that cruel and tyrannical sovereigns forbade the culture of the vine, whilst the humane and enlightened ones encouraged it; and yet the former could have been influenced only by its moral effect on their subjects, for it was evidently prejudicial to the interests of the country to destroy so valuable a branch of commerce.

MRS. B.

Commercial interest was very imperfectly understood in ancient times, especially by unenlightened sovereigns; these, therefore, considered only the prejudicial effects of the vine in producing intoxication; whilst the better informed not only esteemed it as a source of wealth, but of health and comfort to those who enjoyed it without excess, — and this latter class is certainly by far the most numerous.

EMILY.

I have heard it observed, that there is less intoxication in wine countries than in the more northern districts, which do not admit of the growth of the vine.

MRS. B.

In England, for instance, it is cheaper to drink spirits than wine, or even than strong beer; and as alcohol is the intoxicating principle, these distilled liquors have a more intemperate tendency. The culture of the vine, since its introduction into Europe, in extending northwards, has spread itself more to the east than to the west, because the eastern part of this continent is hotter in summer than the western, under the same latitude. Now, the vine derives more advantage from the heat of summer than it suffers from the cold of winter : in the latter season it does not vegetate, so that it requires only the degree of temperature necessary to escape freezing, while heat in summer is absolutely requisite to ripen the grapes ; and you have seen that the vine succeeds much better in Switzerland than in England, because, though the winters in the former are generally colder, the summers are hotter.

CAROLINE.

We read in history, of vineyards growing, and wine being formerly made in England. Do you suppose that the climate was then warmer than it is now ?

MRS. B.

No ; but the palate of our ancestors was probably not so delicate as that of their descendants. The same has been affirmed of Brittany and Normandy, provinces in which vineyards are now unknown, and where the vine is cultivated, as in England, trained against walls in a favourable aspect ; and even then the grapes ripen but imperfectly. If wine was really ever made in those countries, it must have been a beverage somewhat analogous to vinegar ; but it is very possible that such wine was once produced ; for the fact is ascertained, that in proportion as the means of transport has increased, the extent of country in which the vine is cultivated has diminished.

EMILY.

I should have imagined that the increase of high roads, canals, and shipping, would, by diminishing the expense of conveyance, lower the price of wine, and thus render it more attainable to the northern countries, where it is not grown.

MRS. B.

Your argument is perfectly just: the increased facility of conveyance augments the demand for, and, consequently, the production of, wine; but that does not prevent its restricting the extent of latitude in which the vine is cultivated. When wine could be conveyed from the south of France to Brittany and Normandy, of a much higher flavour and better quality than that which was produced in those provinces, and with but little additional expense, the Bretons and Normans gradually converted their vineyards into corn and pasture, and exchanged their grain and cattle for the juice of the grape.

CAROLINE.

Whilst the increased demand for wine must have induced the southern districts to convert their pasture and corn fields into vineyards. The same reasoning will hold good with regard to England; and wine must have been conveyed across the Channel, to the utter destruction of the English vineyards. It is the division of labour which naturally takes place in civilised countries. You see, Mrs. B., that I have not forgotten your lessons of political economy.

MRS. B.

I am glad to hear you remember them so well; the cultivation of vineyards at present extends from 29° to 50° of latitude, as far south as Shiraz, in Persia: as far north as Cologne, on the Rhine.

EMILY.

Pray, does not the vine grow naturally in America?

MRS. B.

It does; but it is of a different species; and grows only wild: the vine which is cultivated, is brought from Europe; but its introduction has not hitherto been attended with complete success.

EMILY.

I am surprised at that, as the islands of the Atlantic, Madeira, and the Canaries, are so celebrated for their wine.

MRS. B.

On the continent of America, all the grapes in the same cluster frequently do not ripen at the same time; so that, when gathered, some are decaying, whilst others are not yet come to maturity: and this circumstance, which is not yet accounted for, prevents the wine from being of a good quality.

It is at the Cape of Good Hope that the vine has made the most remarkable progress, and particularly since England has been in possession of that colony. Whilst it belonged to the Dutch, it produced only a small quantity of rich Cape wine; but now a variety of different vines are cultivated there with great success, and the Cape Madeira will, perhaps, ultimately rival that of the Atlantic island.

The height at which the vine can be cultivated, from the level of the sea, is four hundred fathoms.

EMILY.

But that must vary according to the latitude?

MRS. B.

No doubt; this is the elevation of the most northern limits of the cultivation of the vine in France. There are many circumstances to be attended to, in the culture of a plant of so much importance as the vine. In the first place, the nature of the plant: the varieties are innumerable; there are no less than six hundred in the botanical garden of Geneva, the fruit differing either in colour, form, flavour, consistence, &c. The degree of flavour, of firmness and compactness of the fruit, is, in general, proportioned to the heat of the climate. The flavour of the muscat grape is, however, richer than that of the common grape in any climate.

Every flower of the vine contains five seeds, two or three of which often fail.

No cultivation requires greater care to repair the exhaustion which the soil undergoes, and attention to prevent weeds from engrossing any portion of that food which is so much in request. Yet a great deal of manure should not be used; for it injures the quality of the fruit, though it increases the quantity.

The grapes should be neither very close, nor very distant from each other in the cluster; so far apart only, as to leave sufficient space for each grape to attain its full growth. For this purpose, the grapes at Fontainebleau, when young, are thinned by the scissors. But these grapes are cultivated exclusively for eating, and sold at a price which repays such an expense of culture.

There is also a great diversity in the degree of precocity or tardiness of this plant. When it shoots early, there is danger of its suffering from the frosts in spring; if late, it may not have time to ripen its fruit in autumn. Care, therefore, should be taken to choose the medium, especially in cold climates.

Old plants produce the finest fruit, but in the smallest quantity. It does not, therefore, answer to continue to cultivate the same plants above a certain number of years.

CAROLINE.

So that they are not allowed time to meet in the course of nature with their accidental death?

MRS. B.

Not often. The influence of climate on the vine is very considerable. The greater the degree of heat, the more sweetness is developed in the fruit, the greater is the quantity of alcohol produced by fermentation, and the astringent principle is proportionally diminished: but this may be carried too far; a certain admixture of the astringent principle is both wholesome and palatable. The grapes of Fontainebleau will not produce good wine, from not possessing a sufficiency of this principle; and, accordingly, we find that the wines in highest estimation are not those produced in the hottest climates, but in countries situated between 30° and 45° of latitude. The most favourable aspect must be determined by the situation and the latitude. The vines of Epernay, which produce the finest champagne, have a northern aspect; those situated on the two opposite banks of the Rhône, in the neighbourhood of Avignon, yield equally good wine: but in colder climates, the more vineyards are exposed to the south, the better they thrive.

It is rather singular, that fine grapes may be produced in almost every kind of soil, provided the vine be of a nature to suit it. The vineyards of Bourdeaux are planted in a gravelly soil, and hence bear the name of *Vin de grave;* those of Burgundy, in calcareous clay; Hermitage grows in granite; and Lachryma Christi is raised in the volcanic soil of Mount Vesuvius. The vineyards of Switzerland consist of a stiff, compact, calcareous earth.

In order to determine upon the mode of culture, the question must first be ascertained, whether it be grapes of the finest quality, or in greatest quantity, that are required. In hot countries, the former are most in demand; in cold countries, the latter is principally aimed at: for in districts which form the limits of the cultivation of the vine, it is desirable to produce a large quantity of wine, though it be of inferior quality, for the beverage of the common people, who cannot afford to pay the conveyance of wines from more favourable climates.

An argillaceous soil produces but indifferent grapes, even in a favourable climate. Under such circumstances, therefore, quantity rather than quality is aimed at, in order to obtain spirit for brandy; for in wine countries brandy is distilled from wine rather than from grain. For this purpose, the plants, instead of being kept low, as you have seen in France and Switzerland. are allowed to grow to a great length, and are suspended in garlands from one tree to another.

CAROLINE.

This mode of cultivation is adopted in Italy, and is most beautiful in appearance.

MRS. B.

But the fruit is not of so fine a quality ; and, consequently, the wine is not so good. In the south of France, as well as in Italy, vines are often cultivated without being propped, and the branches are suffered to grow six or eight feet in length.

During the wars of the revolution, the French having destroyed all the props of the vineyards in the valley of the Rake, on the banks of the Rhine, the peasantry were obliged to let the vines grow without support; when, instead of being deteriorated, they found the fruit so much improved, that they have ever since continued the same system.

EMILY.

Then I conclude that they did not allow their vines to shoot out to a great extent.

MRS. B.

Certainly not ; or the fruit would have been impoverished, instead of being improved. The use of props in vineyards is, perhaps, carried to the extreme. M. de Candolle suggests the experiment of fastening four plants to one prop placed in the centre. In doing this, the branches would be curved towards the prop, and the descent of the cambium retarded.

CAROLINE.

We have seen vineyards in some parts of Italy trained on a horizontal trellis-work, the grapes being suspended beneath the verdant roof. In other places, the vines are trained over trees, which are planted merely to afford them support, and they derive some little shelter from the leaves, that grow on the few branches which are not lopped.

MRS. B.

These various modes of training vines, though they may be used in hot climates with less injury to the fruit, never fail, more or less, to be prejudicial to it; and though the climate of Italy is generally hotter than that of France, the latter is celebrated in all parts of the world for the excellence of its wines, while those of the former are scarcely ever exported.

In hot climates, the grapes are sweet, contain less acid and astringent principle, and the fermentation is less complete, the proportions not being so well adjusted as in France, and other countries of a more moderate temperature.

It will be unnecessary for me to enter into any further detail on the nature of the vinous fermentation, as it is a chemical process, an account of which I have formerly given you.

CONVERSATION XXX.

ON THE CULTIVATION OF GRASSES, TUBEROUS ROOTS, AND GRAIN.

MRS. B.

THE subject which we shall next investigate, is the cultivation of the grasses.

The principal use of the grasses is to feed cattle; a class of animals, which, both during their life, and after their death, are useful to us in so many different ways, that it is very important we should make ample provision for their support. Then the advantage we derive from them in agriculture is not confined to the labour they perform in the field; they also supply manure; and the more forage we produce for cattle, the greater is the quantity of manure we shall be able to obtain for the fields.

EMILY.

Poor soils, then, must require more cattle, and, consequently, more grass-land, than rich ones. But may not cattle be fed on other vegetables besides grass?

MRS. B.

Unquestionably; cattle will eat the same vegetables that serve for our subsistence; but we reserve these for our own use, and feed them on those which would afford us little or no nourishment, such as grasses. These are of two kinds, natural and artificial. The natural grasses are of the gramineous family, which belongs to the class of monocotyledons, or endogenous plants.

EMILY.

Yet how very little resemblance they bear to the palm-tree, or other tropical endogenous plants.

MRS. B.

They are not so dissimilar as you imagine, since they grow like them internally.

CAROLINE.

They may, then, be considered as the miniature palm-trees of our ungenial climates, being contracted both in space and time; for the mower comes with his destructive scythe, before they have passed through a single season.

MRS. B.

The natural grasses are either annuals or perennials. The first are very rarely used for meadows. In some countries, however, rye, Indian corn, and millet (all of which are annuals), are sown as grasses; that is to say, for the sake of their leaves, which are mown as soon as they appear above ground; and thus several successive crops are obtained in one season.

But our meadows are all formed of perennial grasses: they are sown with hay-seed, which consists of a mixture of various sorts of grasses, generally more or less adulterated with the seed of weeds. These different grasses ripening at different periods, a medium must be taken in order to mow the crop.

EMILY.

Would it not be better to sow only one species of grass?

MRS. B.

Perhaps so; provided it were first ascertained what species would best suit the soil and climate. There are some agriculturists, however, who dispute this opinion, and think that a variety of grasses makes the best fodder for cattle. Several naturalists are now engaged in endeavouring to raise very pure unmixed grasses, with a view to produce seed for sale : a measure which will greatly tend to the improvement of meadows.

CAROLINE.

Do not meadows occasionally require to be sown afresh ? for as the crops are either pastured or mown before the seeds are ripe, it cannot re-sow itself ; and the grasses, though perennials, do not, I suppose, last a great number of years.

MRS. B.

Grasses are renovated, not so much by seed as by means of their roots and subterraneous branches, which spread out in various directions, interweaving and forming a sort of network of roots and branches ; and from this entangled mass springs abundance of new shoots, which thicken and renovate the meadow. If grass be kept short, it consumes less nourishment, and a greater quantity remains to push out fresh shoots.

EMILY.

This accounts for the fine thick turf of which our lawns are composed, for, being so continually mown or fed off by sheep, the grasses never come to seed, and therefore cannot re-sow themselves.

MRS. B.

This, however true in England, where the climate is temperate and moist, will not hold good in countries where the grass is burnt up in summer, when mowing cannot take place ; and it is for this reason that it is perhaps impossible on the Continent to produce those beautiful lawns, so ornamental to our country seats.

These lawns, when first prepared, are not usually sown, but the grass is laid down in sods. By this means the roots are obtained ready matted, together with a thick fine turf, which it would require many years' growth, and constant mowing, to produce from seed.

Meadows are mown in England but once, or at most twice, in the season; whilst in many parts of the Continent, three or four crops are obtained, according as the soil is dry or moist, elevated or low.

The Phleum, the Dactylis, the Anthoxanthum, and Rye-grass, are the plants best adapted for meadows; but Rye-grass degenerates in the dry warm climates of the Continent, as it requires a great deal of moisture to keep it fine and tender.

EMILY.

The great defect of grass, which I have observed both in France and Switzerland, is the quantity of weeds which are mixed with it, and which render the hay strong and coarse.

MRS. B.

That is owing to the impurity of the hay seed, and is attended with every possible disadvantage. The coarse leaves of the weeds are not only unpalatable and unwholesome for cattle, but in growing they fill the spaces which the grasses would occupy, and, by separating them, prevent their roots from combining and giving rise to new shoots.

There are some meadows which, from peculiar circumstances, are not susceptible of being mown. The grass of mountains, for instance, does not grow sufficiently high to require it. Being frequently covered with mists, it remains green throughout the summer; much resembling our English lawns, and affording delicious pasture for cattle, when the meadows in the valleys and plains are burnt up. The fine turf on the mountains of Switzerland and the Alps, consists principally of phleum, intermixed with other grasses of an inferior quality. The matted roots of these plants are extremely useful in preventing the surface of the soil from being washed down by rains: the meshes of the net-work which they form, confine the earth, and retain it, as it were in a basket, on the surface of the declivity. It is on this account very imprudent to attempt tillage on the sides of mountains. Small flat patches of land, which are occasionally met with in such districts, may be cultivated with advantage; but it is dangerous to displace the fence which Nature has provided; and however inadequate the means may appear to the end, it is certain that the massive mountains are upheld by the roots of some of the smallest of the vegetable tribes.

EMILY.

That is, indeed, wonderful: but it is merely the surface of the soil which the roots of the grass support.

MRS. B.

True; but if one surface were washed down, another would be exposed to the same danger; and thus, in the lapse of time, successive surfaces would be destroyed, and the mountain finally be brought low!

Another description of meadows incapable of being mown are common fields, every parishioner having a right of pasturage; a circumstance which renders this species of tenure extremely disadvantageous: it is, in fact, condemning the land to yield as little produce as possible.

Let us now proceed to the artificial grasses, the most beneficial of all the vegetable tribe. It is to them that we are indebted for repairing the injury which the land sustains from the culture of grain. They were first introduced into France by the celebrated agriculturist, Olivier de Serres, in the sixteenth century.

EMILY.

These grasses do not, I suppose, form permanent meadows, but are sown alternately with crops of corn, in order to recruit the soil after the exhaustion it has undergone from the latter.

MRS. B.

Certainly: thus interchanged, they form an excellent course of cropping. Most of the artificial grasses are of the leguminous family; among these the vetches and the scarlet clover are annuals. The common purple clover lasts two or three years. It is difficult to obtain the seed unadulterated by that of other plants. Clover has long been cultivated on the left bank of the Rhine, for the sole purpose of producing seed for sale: this commerce was chiefly carried on with England; for though we cultivate a considerable quantity of clover, we use it, almost wholly, as food for cattle; our summers seldom being hot enough to ripen the seed, so that we are obliged to have recourse to that of foreign growth. A very profitable trade was carried on with us in this article, when Buonaparte issued his decree against exportation, and the poor agriculturists on the left bank of the Rhine, then under the dominion of France, were nearly ruined. The Germans, on the opposite bank, supplanted them in a branch of commerce they were compelled to abandon: England continued to be equally well provided with clover seed; and thus it was Buonaparte's own subjects who alone suffered by his absurd prohibition.

Saintfoin, or Esparcette, is another artificial grass of the leguminous family, of longer duration than clover. The seed appears larger than it really is, because it is sown with the husk or pericarp, and no less than twenty pounds of seed is required per acre; whilst ten or twelve pounds of clover seed, which is sown without the husk, is sufficient.

Lucerne, also of the leguminous family, lasts from twenty to thirty years, according as the soil is more or less favourable to it.

EMILY.

It is, then, too long-lived to enter into a course of cropping?

MRS. B.

In some parts of the valley of the Rhine, these courses are made of thirty years' duration, twenty of which is occupied by lucerne. The roots of this plant strike twelve or eighteen feet into the soil; a depth at which moisture is always found, so that lucerne is enabled to resist drought much better than clover, whose roots are more superficial. Yet, if the season be dry, there is some danger of its failing the first year of its growth, the roots not having reached a depth of soil which is always moist. The seed for sowing should be chosen of a bright yellow colour, and heavy; a caution necessary to be attended to in the choice of all seeds. Lucerne is mowed from three or four to seven or eight times in the year, according to the climate in which it grows. Its herbage is less delicate than that of saintfoin.

CAROLINE.

Have we not seen lucerne growing as a shrub in some parts of Italy?

MRS. B.

This lucerne is of a different species; it is naturally a shrub, and grows wild on the sea-coast in Italy, where it is used as fodder for cattle. Furze may also be cultivated, either as a shrub or as artificial grass. In the latter state, it should be mown very young, while still soft and tender.

There are some artificial grasses which are not leguminous; *Burnet* is of the family of *Rosaceæ:* it has the advantage of thriving in calcareous soils.

The wild endive, and, indeed, the leaves of almost any plant, are susceptible of being cultivated for forage; excepting those which have either milky or astringent juices, such as the leaves of the fig, or the oak: cattle will not eat them; or at least not unless they are mixed with a considerable proportion of good forage. But without cultivating them as grasses, the young leaves of the ash, willow, and the acacia, gathered from the tree, make very wholesome food for cattle.

EMILY.

In Italy, the cattle are very commonly fed on the leaves of trees; and I have often admired the industry of the Tuscan peasants, who collect green weeds, the clippings of hedges, and the leaves of trees, in order to supply their cattle with food.

MRS. B.

The small size of the Tuscan farms, which seldom exceed fourteen acres, does not admit of meadow-land, excepting the grass walks with which they are intersected. The nearer we approach the tropical climates, the more we find meadows, both natural and artificial, diminish; the climate becoming too hot and dry for the cultivation of grasses.

We have observed, that there are some species of plants which afford food both to men and cattle. These are the class of tuberous roots, which constitute one of the most valuable of the gifts of nature. The potato, the turnip, beet, and carrot, all belong to this class. Were these vegetables cultivated only in quantities sufficient to supply the wants of the human species, they would be considered as a most valuable acquisition, by varying, in a salutary and palatable manner, our stock of vegetable food. But when produced in such abundance as to be applied also to the sustenance of cattle, the benefit is not only extended to a lower order of beings, but furnishes, in case of need, a store of food for man.

CAROLINE.

And, should both fail, we should have the resource of feeding on the cattle. This explains what appeared to me very unaccountable,—that meat is sometimes cheap, when bread is dear.

MRS. B.

If forage fail, whether it be owing to a scarcity of grasses, or of roots, a greater number of cattle will be sent to market, and the meat will consequently be low priced, because it is plentiful; though corn may at the same time be scarce, and bread dear. But the meat will be of inferior quality; for, under such circumstances, the cattle cannot be fattened.

The culture of tuberous roots requires very deep and frequent ploughing. Beet is of various colours, most commonly of a rich crimson. It is raised from seed sown in rows, and the young plants afterwards thinned: the soil should be neither very moist nor very dry, but it should be extremely fine: the seed ripens only the second year. This plant contains so great a quantity of saccharine matter, that, during the prohibitory system of Buonaparte, the French had recourse to it for the fabrication of sugar. Indeed, the manufacture is still carried on, and I understand that some recently discovered mode of facilitating the process enables them to compete with the West Indian market.

There are three species of turnips; — *turnips, Swedish turnips,* and *the Kohl Rabi,* or turnip-rooted cabbage. The leaves of the first are rough and hairy, those of the second smooth, and those of the last form a medium between the other two, being hairy when young, and becoming smooth afterwards. There are many varieties of turnips; the white are the most delicate, the yellow more hardy: a light loose soil suits them best, and they require a good deal of manure; for being of the cruciform family, which contains *azote,* they must be furnished with the means of obtaining this element, and it is animal matter which yields it in greatest abundance.

The *Topinambour,* or Jerusalem artichoke, produces a great number of tubers, which are much eaten in

England, but are not relished on the Continent. This plant is cultivated in some parts of America, and is brought to Europe from the mountains of the Brazils.

Carrots require a light but not a loose soil: they are rather of a delicate nature, suffering both from excess of cold or of heat.

The potato, it is universally acknowledged, we derive from America, but from what part is not well ascertained; for it is remarkable that neither M. Humboldt, nor any other traveller in that country, has met with it in its wild state. Clusius, the first botanist who speaks of potatoes, says that they were introduced into Europe by the Spaniards, in 1588. Sir Walter Raleigh brought them from Virginia to England and Ireland, where their cultivation succeeded much better, and they were more liked, than on the continent of Europe; and it is the English, who have subsequently been the means of introducing a taste for them into other countries.

EMILY.

When we were in Italy we found the lower classes still much prejudiced against potatoes, considering them as food fit only for hogs or cattle.

MRS. B.

There are from one hundred to one hundred and fifty varieties of this plant, which differ in colour, form, precocity, &c. Potatoes are usually raised from germs, contained within the tuber, and commonly called eyes: these germs contain the rudiments of the young plant, similar to the buds on the branches of a tree. In order to make them sprout, the potato must be planted either entire or cut in pieces, leaving an eye in each piece, from which the young plant shoots; or in case of scarcity, the eye alone may be planted, reserving the fecula or mealy part for food.

EMILY.

I thought that the mealy part was a magazine of food for the young plants which shoot from these germs, and was, therefore, necessary to their developement.

MRS. B.

That is true; and the plant will shoot with much more vigour if the fecula remain attached to it; it is not, however, absolutely necessary: for the eye, if planted naked, has the power of absorbing moisture, on which it feeds, till it has struck out roots, which supply it more regularly with nourishment. Potatoes may also be raised from slips, and as a last resource the seed may be sown: but this is so slow a process, that it is resorted to only with a view of procuring new varieties. Though the potato bears the name of tuberous root, the bulb does not grow upon the root of the plant, but on the lower branches, which bury themselves under ground: in cultivating the potato, it is necessary to hoe up the earth over these branches, in order to cover them more completely. There is a small tubercle produced by the potato-plant at the axilla of the leaf, which being exposed to the light becomes green, and is of so acrid a nature as not to be eatable. Half the weight of the potato consists in fecula: the saccharine principle may be developed in this tubercle as it is in barley; it will not produce wine, but spirit may be distilled from it when fermented; and the rest affords excellent food to fatten hogs. The other half of the potato consists in fibrin and mucilage.

We may now proceed to the examination of one of the most important of the vegetable productions in civilised countries,—I mean corn. We have hitherto considered gramineous plants as cultivated only for their leaves, under the name of grasses: but there are many of this family whose seeds are large enough to afford food for man, and it is with this view that he cultivates them. These are distinguished by the name of grain or corn, in Latin *Cerealia*, from Ceres the goddess of plenty, who is said to have first introduced corn into Sicily; but whence it originally came is unknown, it having never been found growing in a wild state. Some naturalists are of opinion that we derive grain from the mountains of Persia and Thibet; a species of wheat, the *Triticum Spelta*, commonly called *Spelt*, having been found growing wild in those countries. Others derive its origin from Tartary.

As corn belongs to the class of monocotyledons, the stems have no bark; but these tall and slender stalks derive their stability from a quantity of silex, which, not being of a volatile nature, is deposited on the surface of the straw or *culm*, when the more volatile parts evaporate. Here it accumulates, and in the course of time encloses the straw in a species of coat of mail, which not only enables it to resist injury, but also to support the weight of seed it has to bear.

EMILY.

Were it not for this provident supply of Nature, it is true that a slender hollow straw would be quite unequal to support the burden of a heavy ear of corn.

MRS. B.

In this and all northern countries, the straw is generally hollow, but in warm climates it is full. The stems of gramineous plants are also intersected with knots or articulations, designed, no doubt, to add to its strength; and each of these shoots out a long slender leaf, which encloses the stem like a sheath.

Grain constitutes the fruit of corn, and consists, consequently, of the seed and its pericarp: these are so closely attached together that they are not easily separated or distinguished from each other, when in the state of grain; but when ground into flour, it is the pericarp which forms the coarse bran; and the seed, the flour used for common household bread.

EMILY.

This flour then consists of the contents of the seed together with its spermoderm: and it is, no doubt, the latter which renders it brown?

MRS. B.

You are right; in order to obtain the whitest wheaten flour, such as is used for bread in London, the spermoderm, which forms a finer species of bran, must also be subtracted: all this is very adroitly performed by that skilful naturalist the miller, with his sieve of moulting cloth.

EMILY.

How admirably this seed is protected! it is true that it is one of great importance to mankind, but is it not curious to think that so small a body as a grain of corn should have two coverings, consisting each of three coats?

CAROLINE.

And the husk, besides, for an outer garment. I thought it had been the husk which formed the bran.

MRS. B.

No, my dear; the husk constitutes the chaff which is separated from the grain by the operation of threshing.

It is only in one species of corn, the *Triticum Spelta*, which I have just mentioned, that the husk adheres so firmly to the grain as to require a peculiar process of grinding, in order to separate them. This renders it less liable to the depredations of the feathered tribe, who can easily pick out the naked grains of wheat from the ear; but find it very difficult to dislodge those of spelt from the adherent husk.

The seed contains the embryo plant and the albumen, which is to afford it the first nourishment, and this we have already said consists of fecula and gluten.

CAROLINE.

Since the albumen supplies so ample a provision for the young plant, the cotyledon of corn is not, I suppose, of a succulent nature?

MRS. B.

I beg your pardon; but it is so minute as to afford but very little sustenance.

The beard of corn is formed by the prolongation of the husks; it is not improbable that all species of grain were originally bearded, and that many of them lose this appendage when cultivated in good soil.

CAROLINE.

The beard, then, probably is the result of a degenerated organ, like thorns or tendrils.

MRS. B.

Very likely; or at least that in a state of cultivation it disappears. Of the two species, bearded corn is by far the more robust; but it has the inconvenience of being subject to retain moisture, so that in a wet summer it is much more liable to injury.

Grain may be divided into three series: —

First, That whose flowers have both pistils and stamens, and are aggregated in the form of ears.

Second, That with similar flowers, but in the form of clusters or bunches.

Third, That in which the pistils and stamens are situated in different flowers.

In the first series, which comprehends wheat, barley, and rye, there are slits or cavities along the axis of the ear, whence issue smaller ears or earlets: in the spring these put forth a little flower, and sometimes several, each of which contains a single grain, enclosed in a husk: these form the aggregated ear. The flowers have three stamens, and one pistil with two stigmas, The grain of wheat is of an oval form, that of spelt rather triangular.

EMILY.

Is not the wheat sown in autumn more hardy than that which is sown in spring?

MRS. B.

Yes; and besides it ripens earlier.

The largest grains of corn should always be selected for sowing, because the pericarp does not increase in size in proportion to the seed.

It is the gluten contained in the grain of wheat which produces the fermentation of bread: this process is vulgarly called raising the bread; and it is true that the disengagement of carbonic acid, which takes place during fermentation, actually raises the dough, producing those hollow interstices which render bread light and digestible. Other species of corn do not make such good bread, as they contain less gluten.

EMILY.

I recollect, during a scarcity, potatoes being mixed with wheaten flour to make bread; but it rendered it very heavy and unpalatable.

CAROLINE.

I thought that yest, the produce of the fermentation of beer, was commonly used to excite that of bread.

MRS. B.

It is so in England; but it acts merely as a stimulus to hasten that of the gluten. On the Continent, and in wine countries in general, where beer is little drunk, the fermentation is excited by means of leaven, which consists of a piece of dough that has been kept from a former batch of baking, and has turned sour; or, chemically speaking, undergone the acetous fermentation. Now, there is so much analogy between the acetous fermentation and that of bread, that it is sufficient to place a body which is undergoing, or has recently undergone, the former, in contact with dough, to excite it to ferment; and this may be done either with yest or leaven.

CAROLINE.

It is, then, a sort of contagion which these bodies communicate to the dough: but is it not surprising that it should render the bread light and wholesome, instead of turning it sour?

MRS. B.

Were the fermentation of the dough not interrupted by baking, it would become sour, as that portion does which is reserved for leaven. The fermentation of bread is by some chemists considered as a commencement of the acetous fermentation. There must, however, I conceive, be some difference between these processes, as in the regular succession of fermentations, the acetous is always subsequent to the vinous; and bread is so perfectly insipid that there is no reason to suppose it has undergone the latter.

EMILY.

Yet wheat is, I suppose, like other kinds of grain, susceptible of undergoing the vinous fermentation.

MRS. B.

Certainly: alcohol may be obtained from all kinds of grain. There are four species of wheat.

First, the common wheat, whose ears are erect, and its grain opaque and obtuse.

Second, The *Triticum turgidum* of Limoges, which the French call *Gros bled*, whose ears are thicker and larger: it contains less gluten, and, consequently, is not so well calculated for bread; but is much used on the Continent to thicken soup or porridge. This wheat, if cultivated in a very rich soil, produces a variety called *miraculous* wheat, the ears of which are branching from the abundance of their produce.

Third, *Bled dur*, or hard wheat: the grain is semi-transparent; it has still less gluten than the preceding: it is of this species that macaroni, vermicelli, and all the Italian pastes, are made: it requires a dry soil and a warm climate, and thrives best in the southern parts of Europe.

Fourth, Polish wheat. It grows very plentifully in Poland, and is thence exported to other countries; but, being of inferior quality, it is little cultivated elsewhere.

Spelt contains less gluten than other species of wheat: it affords beautifully white flour for pastry, and is also much used for starch.

EMILY.

I should have thought that it would have required more gluten to make starch than to make bread?

MRS. B.

No; starch consists almost wholly of pure fecula, and may be obtained from potatoes as well as from wheaten flour.

Rye is of so hardy a nature that it accommodates itself to almost all soils and all climates: its straw is longer and firmer than that of wheat, which renders it peculiarly adapted to thatching: it contains so little gluten that it cannot be made into bread without an admixture of wheat.

EMILY.

It is, then, no doubt, on this account that the poor Scotch Highlanders, who cannot afford to mix wheaten flour with it, eat it baked in cakes instead of bread.

MRS. B.

It is chiefly oats, I believe, that are thus eaten in Scotland.

Barley is principally used for fermentation. It contains a great quantity of saccharine matter: mixed with hops we have seen that it produces beer; and it is also distilled for spirits.

In the second series of corn, the grain grows in the form of clusters, each earlet having a separate pedicle or footstalk.

This series contains four genera: —

First, Oats: The husks or glumes have two valves and beards springing from the back part of the husk, instead of growing from the summit, as with barley and rye.

Second: A species of oats derived from Asia, the earlets of which incline all in one direction: it is more hardy than the preceding, yet it is very liable to be attacked by the disease called *smut*.

Third: The Phalaris of the Canary Isles, commonly called Canary seed, used chiefly as food for the birds for which those islands are so celebrated.

Fourth genus: Rice, which we derive both from the East and West Indies. Next to the Banana, or bread tree, this is the plant which affords the greatest quantity of wholesome nourishment, and is, perhaps, susceptible of the greatest variety in the mode of cooking; for, being itself insipid, it admits of all kinds of seasoning.

EMILY.

How much, then, it is to be lamented that its cultivation should be unwholesome!

MRS. B.

It is so only at that period when the water is drawn off to enable the grain to ripen. It is sown in the spring in a muddy soil; and as the plant grows, the water is let on, and gradually raised, so as to keep it almost wholly covered, until the grain begins to ripen. I have been informed that in the rice plantations of Lombardy, the mortality is not greater than in the adjacent districts: it is true that the inhabitants of the latter are in a wretched state of poverty, whilst the cultivators of rice are at least supplied with plentiful nourishment, to compensate for the unwholesomeness of their occupation. I should not wish to extend the culture of rice in Europe, in soils adapted to other produce; but, as this plant will grow only in marshy districts, it is as well to convert such land to so useful a purpose: for it is not more unhealthy as rice fields than as marshes. One great objection to the cultivation of rice is, that it injures the surrounding soil by the filtration of the waters, which, in the course of time, destroys all the trees in the neighbourhood.

CAROLINE.

But such a filtration must be very advantageous to meadow land?

MRS. B.

When confined within due limits: but we must remember the old adage, "Too much of a good thing is good for nothing:" the adjoining meadows would eventually become converted into marshes, so that there would be no other resource than to extend the cultivation of rice; and the evil would thus always go on increasing, if government did not interfere to prevent it.

The third series of corn, having the pistils and stamens in different flowers, consist of maize or Indian corn, Canada rice, Sorghum or millet.

We have run through a great variety of subjects today; the natural and artificial grasses, which form the two great stores of food for cattle, and the latter of which enters so beneficially into the rotation of cropping; the tuberous roots, of which both man and beast equally partake; and, finally, the numerous species of grain, which afford a more solid and wholesome nourishment than any other kind of vegetable food.

To-morrow I shall tell you what remains to be said upon culinary vegetables and oleaginous plants.

CONVERSATION XXXI.

ON OLEAGINOUS PLANTS, AND CULINARY VEGETABLES.

MRS. B.

Among the articles of vegetable food, the oils which are extracted from plants afford one of the most valuable: nor are they of less importance in affording us light by their combustion. They are employed also in a number of manufactures, such as soap, woollens, varnishes, and perfumery.

There are, you know, two kinds of vegetable oil, distinguished by the name of fixed and volatile. The latter may be extracted from almost every plant; but it is used only as a perfume, or to flavour liqueurs, such as the oil called attar of roses, with which you are acquainted.

EMILY.

Yes: and with that of jasmine and orange, so commonly used to perfume pomatum. In a word, the perfumer's shop abounds with these sweet-scented oils.

MRS. B.

They constitute the luxury of the sense of smelling, but are frequently prejudicial from their effect on the nerves; and some few of them are employed medicinally. But the essential or volatile oils are not those most deserving our attention: the fixed oils are of much higher importance, and are extracted from a class of plants, hence called oleaginous. The oil is expressed from the seed of all these plants excepting the olive, in which it is obtained from the pericarp, or fleshy part of the fruit which surrounds the seed.

The greater part of the seeds of oleaginous plants contain albumen, and it is from this that the oil is obtained; but when the seed has no albumen, as is the case with the poppy, it is the embryo which furnishes the oil.

In the family of the *Euphorbiaceæ*, all of which have oleaginous seeds, the embryo is of a venomous nature, and oil extracted from it would be poisonous; while that expressed from the albumen of the same plant, situated contiguous to the embryo is perfectly innocent. Such is Bancul nut (*Aleurites Moluccanum*), which is remarkably mild, and is eaten by the inhabitants of the Molucca isles, as we eat hedge-nuts in Europe, while oil obtained from the embryo is an acrid poison.

EMILY.

Can oil be expressed from plants growing wild, or is it necessary they should be cultivated in order to supply it?

MRS. B.

Some small quantity may be obtained from thistles: the stone pine, and plum-tree of Briançon also yield it; but it is the seed of the beech-tree alone which affords it in sufficient abundance to make it worth the labour of obtaining. The forest of Villers-Coterets, in France, produces a great quantity of this oil. It is less liable to become rancid than any other, and, on this account, is often mixed with olive oil, which is to be exported to America or any other distant part; but it all passes under the name of olive oil.

The fixed oils obtained by cultivation may be ranged under three heads: first, olive oil, the produce of warm climates; secondly, nut oil, that of temperate climates; and, thirdly, oils obtained from the seeds of oleaginous herbs.

The olive-tree originally came from Syria. That plant, as well as the vine, was brought to Marseilles by the Phocians; and, at the present day, it is cultivated on all the shores of the Mediterranean. It is a tree of very slow growth, but of long duration; it can support a temperature as low as eight or ten degrees of Fahrenheit, provided the air be dry; but if accompanied with humidity, one or two degrees below the freezing point proves fatal. The plant, however, may recover, if cut down to the roots, a little below the surface of the soil; it then strikes out fresh shoots, forming five or six young trees.

Manure used for olive plantations should be of a dry nature; and it is necessary to heap up the earth over the roots, to keep them well covered.

CAROLINE.

These roots must be naturally very superficial; for, notwithstanding the care that is taken to cover them with earth, I have observed that they are continually making their appearance above ground.

MRS. B.

It is rather the rugged and twisted base of the stems which you have observed, and which wear the appearance of roots.

There are several varieties of olive-trees. Those of the plantations about Nice afford us oil perfectly white and limpid, and equally free from either smell or taste: it is held in very high estimation in northern countries, where the natural taste of oil is disliked, probably from its being associated with that of rancidity; but in the countries which produce oil, where, being eaten fresh, it is very seldom rancid, the oil which partakes of the flavour of the fruit is preferred.

The fruit should be gathered, not shaken from the tree, in order to prevent its being bruised, and the oil expressed as soon as possible afterwards, otherwise there is danger of rancidity. In Spain, and other countries where feudal tenures still exist, the olive-mills belong to the lords of the land, and the peasantry are obliged to wait their turn for their olives to be pressed, to the great detriment of the produce. This is, perhaps, the only harvest which is gathered in about Christmas, the fruit not being ripe earlier.

Olives begin to be cultivated at 43° of latitude: in tropical climates, they will grow at two hundred fathoms above the level of the sea.

EMILY.

And, in temperate climates, where the olive ceases to grow, the walnut replaces it.

MRS. B.

Yes; but the oil obtained from the walnut is far inferior to that of the olive, having both colour, smell, and flavour, qualities which are not esteemed in oils. The walnut-tree succeeds better in a northern than in a southern aspect; for, as the young shoots are very liable to suffer from a white frost, it is desirable that their vegetation should be retarded till the spring is so far advanced, that there will be little danger of their encountering that evil. This tree grows remarkably well at the foot of a mountain, on account of the depth of soil produced by the quantity of earth washed down.

The cultivation of oleaginous herbs enters into the course of cropping: they exhaust the soil almost as much as grain, on account of the number of seeds to be ripened; they require, therefore, a considerable quantity of manure. These herbs are generally of the cruciform family, containing azote, an element of the animal kingdom, which forms excellent manure: so that, after the oil is expressed, the cake which remains serves to restore the exhausted soil. Rape is a species of cabbage with thin roots, whose seeds yield excellent oil.

The Poppy is an oleaginous plant, with white, scarlet, and violet flowers, while the seeds are white or black. They yield oil perfectly innoxious and wholesome, though drawn from the same plant which supplies us with opium.

CAROLINE.

I confess I should always be apprehensive of its being adulterated with some mixture of its poisonous neighbour. Is not flax, also, an oleaginous herb?

MRS. B.

Yes. It is, however, chiefly cultivated for its stalks, from which linen thread is fabricated; but its seed also yields the oil we call linseed oil. It is much used in painting. Hemp is of the same description. There are some few oleaginous herbs of the leguminous family, such as the subterranean Arachis (*Arachis hypogeæa*), a plant we derive from America, which has the singular property of ripening its seeds under ground. This plant requires a loose sandy soil, in order that the lower branches may be enabled to bury themselves in the ground. In a state of cultivation, the earth should be heaped over them, as is done with potatoes. The upper branches, which blossom in the air, ripen no seed; while the lower lateral branches, which burrow in the earth, develope no regular blossom, that is to say, have no petals; but the stamens and pistils bring the seeds to perfection.

Among the objects of cultivation, the vegetables raised in our gardens for culinary purposes form a class of considerable interest.

CAROLINE.

In our choice of these, we must be regulated by the the palate.

MRS. B.

Principally, no doubt; but modified by other circumstances, such as soil, climate, &c. Plants of a fibrous, woody nature are too tough to be either palatable or digestible. Those which are acrid, or very bitter, must equally be rejected. A powerful flavour is also objectionable; and, on the other hand, great insipidity will not gratify the palate. Here, then, are many causes of exclusion, but some of them admit of remedy.

Plants of an acrid nature may be eaten young, before the acridity is well developed, especially if the most delicate parts be chosen, which are those that have been least exposed to the light. Thus the receptacle, or what is commonly called the bottom, of the artichoke, and the internal part of the bracteæ, are mild and pleasant to the taste when young.

EMILY.

And asparagus we eat as soon as the young shoots appear above ground.

CAROLINE.

And do we not even find the taste of rhubarb in tarts delicate and pleasant, when the plant first shoots, while, when full grown, it is repugnant to us?

MRS. B.

It is true that rhubarb requires to be eaten very young, in order to be palatable: but it is the ribs of the leaves which we make into tarts, while that part of the plant, taken medicinally, and which is so pungent and disagreeable, is the root; and it must grow in a warmer climate to have its medicinal properties developed. That which we import from Turkey is grown either in Tartary or at the foot of Mount Caucasus.

All strong vegetable flavours, even that of the prussic acid, which is one of our most deadly poisons, may be rendered agreeable to the palate, and perfectly innocent, if taken in very minute portions, and mixed up with considerable quantities of insipid food. The prussic acid is found in the kernels of peach-stones and in bitter almonds, but in very small quantities; and yet one or two of these is sufficient to communicate an exquisite flavour to a dish of cream or of pudding.

Celery belongs to the class of Conium, or hemlock, the poison which caused the death of Socrates; but its pernicious qualities are not developed, and it grows white and tender, if the stems be kept covered with earth.

EMILY.

Insipid plants should, then, on the contrary, be fully exposed to the light and air, in order to bring forth what little flavour they contain?

MRS. B.

Yes; and they should be eaten only when full grown. Great insipidity is not wholesome, any more than a very strong flavour: the one produces too much excitement in the digestive organs, the other does not afford them sufficient stimulus.

EMILY.

Both these defects, I should think, might be corrected, by cooking vegetables of such opposite qualities together.

MRS. B.

It is with this view that thyme, sage, mustard, onions, and even garlic, are used as seasoning for food of an insipid nature; and sugar and spices are most useful auxiliaries for such a purpose.

CAROLINE.

Salt seems to be the most universal of all ingredients used to season cookery.

MRS. B.

I omitted mentioning it, because it was not a vegetable substance.

There are no less than fifty-four species of plants which may be considered as belonging to the class of culinary vegetables. These are derived from thirty-nine genera and seventeen families; and produce above five hundred varieties.

Among these families, the Cruciform supplies our table with the greatest number of dishes. It derives its name from the blossom having four petals in the form of a cross. Azote is found in this family alone, and it communicates to the vegetables a strong flavour, and often an offensive smell. The various species of cabbages belong to it, such as the common cabbage, the curled cabbage, broccoli, cauliflowers, turnips, radishes, water-cresses, and sea-kale.

CAROLINE.

Do you include turnips and radishes among the species of cabbages?

MRS. B.

Their leaves and blossoms are of the same description; but the appearance of the vegetables when served at table, I confess, is totally different; and no wonder, for in the one it is the leaves we eat, in the two others the roots.

CAROLINE.

The leaves of the turnip, it is true, would be too strong and pungent for our palate. They are relished by sheep and cattle; and the root, which is more delicate, from not being exposed to the light, is better suited to our taste.

EMILY.

The roots of radishes, though not exposed to the light, are, however, so strongly flavoured as to be disagreeable, unless eaten very young. In the cauliflower it is the blossom, and not the leaves, that we eat.

MRS. B.

The head of a cauliflower has, it is true, much the appearance of a blossom, but it consists only of numerous ramifications of the peduncles or flower-stalks, which, not having sufficient space to grow in, adhere together, and form the white mass which is served at table.

EMILY.

But the cauliflower is rather of an insipid than of a pungent nature, and requires salt to season it.

MRS. B.

Its flavour is not strong if the head only be eaten; but the smell and taste of the water in which it is boiled is extremely offensive, and that of the vegetable itself is often unpleasant, when served at table.

EMILY.

I know scarcely any odour more disagreeable than that proceeding from a bed of decayed cabbages, in which the azote is fully developed.

MRS. B.

When the cauliflower is allowed to attain its natural growth, or, as the gardeners express it, is left to run to seed, the flower-stalks lengthen and spread, and the blossoms are developed at their extremities. Broccoli is of a similar nature: the pedunculi amalgamate and form a head; but it is of a green colour, because not so closely enveloped in leaves and sheltered from the light as the cauliflower. The small tender grain which is deposited upon it consists of the embryo of blossoms which cannot be developed, owing to the quantity of nourishment of which the stalks deprive them.

The Leguminous family affords us four species of culinary vegetable, — peas, beans, lentils, and kidney-beans; of some of these we eat only the seeds; in others, such as the kidney-bean and sugar-pea, the pod or pericarp are also eaten.

The family of Cucurbitaceæ supplies us with cucumbers, pumpkins, and melons: the two first are rather arbitrarily denied the name of fruit, and are ranked as culinary vegetables, merely on account of the saccharine principle not being developed in them.

This family is distinguished by a bitter principle contained in one of its species, the Colocynth: it is so strong as to be taken only medicinally.

From the Umbelliferous family we obtain carrots, parsley, lettuces, and hemlock. The narcotic principle exists throughout this family: in hemlock it is so powerful as to constitute a poison; but in most of the other species it exists in such small quantities as not to be deleterious.

The family of Solanum gives us the Potato, Tomata, and the Belladonna, celebrated for the poison it contains.

CAROLINE.

And yet nearly akin to the potato, which is of so innocent a nature!

MRS. B.

That is true of the tubercle we eat, but the fruit of the plant is of an acrid nature: you may probably have been warned, in your childhood, of the poisonous properties of the small green tubercles which grow on the branches.

The family of Fungi supplies us with the mushroom, a vegetable of a most delicate and exquisite flavour; but as those species which grow wild are generally of a poisonous quality, it is important that we should learn how to produce such as are known to be innoxious. For this purpose, the white filaments, commonly called the spawn of mushrooms, should be cut in pieces and sown in a hot-bed. Whether these filaments consist of shoots, runners, or seeds of mushrooms, has not been well ascertained; but when spread over a hot-bed, and sheltered from the open air, either under a shed or in a cellar, they will germinate. In Paris, mushrooms are raised in the Catacombs; and I know no place where they are produced in such abundance, or sold so cheap. The spawn should be sown in December, covered with a little earth and a litter of straw, then watered; and after a short time, if the litter be raised, the mushrooms will be seen growing beneath it.

These are some of the principal families from which we derive our vegetable food: I will not attempt to go through the whole seventeen, — it would be uselessly trespassing upon your patience.

I have now, I believe, imparted to you the whole of my little stock of botanical knowledge. The source from which I drew it was rich and copious; but I am too well aware of my incapacity to do justice to the subject, not to shrink at the apprehension of having disfigured those lessons which afforded me such a delightful source of instruction; which taught me to investigate, with wonder and admiration, the beautiful organisation of the vegetable creation, and raised my mind, with increased fervour of gratitude, towards its bountiful Author.

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