D2/60-61

OBSERVATIONS
ON THE
STRUCTURE AND ECONOMY
OF
PLANTS.

THE HISTORY OF THE

REIGN OF KING CHARLES THE FIRST

BY JOHN BURNET

St. Thome
2
OBSERVATIONS

ON THE

STRUCTURE AND ECONOMY

OF

PLANTS:

TO WHICH IS ADDED

THE ANALOGY

BETWEEN THE

ANIMAL AND THE VEGETABLE KINGDOM.

BY ROBERT HOOPER,

OF PEMBROKE COLLEGE, OXFORD, M. D. F. L. M. S.
AND FELLOW OF THE LINNEAN SOCIETY.

Veniet tempus quo ista, quæ nunc latent, in lucem dies extrahat.
LINNÆUS in Introit. ad Syst. Nat.

OXFORD.

Sold by Messrs. FLETCHER and Co.

Messrs. RIVINGTON, St. Paul's Church-Yard; and Messrs.
MURRAY and HIGLEY, Fleet Street. LONDON.

1797

1800

1800

1800

1800

1800

1800

1800

1800

1800

TO THE

REV. JOHN SMYTH, D. D.

MASTER OF PEMBROKE COLLEGE

OXFORD,

AND

PREBENDARY OF GLOUCESTER ;

THIS ATTEMPT TO EXPLAIN

THE STRUCTURE AND ECONOMY

OF

P L A N T S,

IS RESPECTFULLY DEDICATED

BY

THE AUTHOR.

INTRODUCTION.

THE following observations are of an elementary nature, and principally intended for those who have not made the subject their particular study. I have therefore selected such useful information, and elementary intelligence, as may enable the reader to view this department of animated nature with pleasure and advantage; and rather than satisfactorily gratify curiosity, have endeavoured to excite it.

The writers who have described with the greatest accuracy the Anatomy and Physiology of Plants, are GREW, MALPIGHI, LINNEUS, PLENCK, DU HAMMEL, HALES, JACQUIN, HEDWIG, INGENHOUZE,

GENHOUZE, WINDENOW, USLER, and others. To the labours of these writers I am greatly indebted, and ingenuously declare, that from them I have extracted many interesting passages.

At the end is subjoined a general Analogy between the Animal and Vegetable kingdoms. In doing this I have consulted and benefited by the remarks of the most celebrated writers on the subject; particularly BUFFON and BONNET, to whose extensive and learned observations the reader is recommended for further information.

Pembroke College, Oxford,

May 15, 1797.

CON-

CONSPECTUS.

THE STRUCTURE AND ECONOMY OF PLANTS.

CHAPTER I.

	Page
<i>The Structure of Plants in general.</i>	I
The trunk of plants	2
composed of epidermis	2
cortex	2
liber	3
alburnum	3
wood	4
medulla	4
The branches	4
The root	5
radicles of	5
The leaves	5
composed of epidermis	6
parenchyma	6
vessels of	6
use of	6
The flower	7
A 4	The

CONSPECTUS.

	Page
The flower composed of calyx	7
corolla	7
stamina	7
filament	8
anthera	8
pollen	8
pistillum	9
germen	9
style	9
stigma	9
pericarpium	9
seeds	10
corcle	10
plumule	12
roset	10
cotyledon	13
aryllus	10
hylum	10
receptacle	10
observations on	11
The vessels of vegetables	12
divided into succous	12
utriculous	12
medullary	13
proper	13
spiral	13
observations on	13
The juices or humours of plants	14
divided into common	14
proper	15
observations on	15

CHAPTER

CONSPECTUS.

CHAPTER II.

	Page
<i>The Elements of Plants</i>	16
heat	16
light	17
electric matter	18
carbon or charcoal	} 16
hydrogen or inflammable air	
oxygen or vital air	
azot or mephitic air	
phosphorus	
fulphur	
metal	
earth	
vital principle	18
The principles of plants	19
the solid parts, gluten	19
calcareous earth	19
fluid parts, water	20
an unguinous oil	20
an ethereal oil	20
a farinaceous	21
gummy	22
ceraceous	22
melleous	23
resinous	23
balsamic	23
camphorated	24
saccharine	24
bitter	25
saponaceous	25
narcotic	26
acrid	27
astringent	27
colouring	28
acid	28
The	

CONSPECTUS.

	Page
The principles of the fluid parts, an alkaline	29
a neutral	30
mediate saline	30
an extractive	31
The external qualities of plants	31
colour	31
taste	31
smell	31
consistence	31
observations on	32
The native place, or situation of plants	33
The use of plants	33
for diet	33
economy	34
medicine	34

CHAPTER III.

<i>The natural Functions of Plants</i>	35
The absorption of nutriment	36
performed by the oscula of the leaves	36
radicles	36
observations on	37
of vital air	38
mephitic air	39
carbonic air	39
light	40
The nutrition of plants	40
similar to that of animals	41
experiments to illustrate	42, 43
the continued power of the <i>Formative</i>	
<i>Nifus</i>	44
The growth or increase of plants	44
of the seed	45
experiments relative to	46, 47
root	48
stem in length	49
The	

CONSPECTUS.

	Page
The growth of the stem in breadth	50
generation of branches	51
leaves	52
flowers	53
The secretion of the fluids	53
from the sap	53
observations	53, 54
The transpiration of plants	54
by the leaves	55
experiments	55, 56, 57
observations	58
use	59

CHAPTER IV.

<i>The Vital Functions of Plants</i>	80
The vitality of plants	60
physical	60
physiological	61
chemical	61
The respiration of plants	52
performed by the leaves	62
divided into expiration and	62
inspiration	62
plants inhale carbonic air and azot	62
exhale vital air	63
fixed air	63
inflammable air	63
observations on	64
The motion of the fluids in the vessels	65
two theories of, considered	65
experiments to prove that the sap is moved	66
up and down	66
vessel con-	66
tract and dilate	67
depends upon the irritability of the fibres	67
excited by various stimuli	68
	The

CONSPECTUS.

	Page
The generation of heat	69
observations on	69, 72
some plants resist heat	71
attract and retain it	72
it does not arise from vital air	72
use of heat in plants	72

CHAPTER V.

<i>The Animal Functions of Plants in general</i>	73
Plants have no sensation	73
The automatic motion of plants	73
depends on irritability	74
observation on irritability	75, 76
of the <i>Hedysarum gyrans</i>	77
<i>Mimosa</i>	78
<i>Oxalis sensitiva</i>	79
<i>Dionæa muscipula</i>	79
other plants	80
excited by mechanical stimuli	81
light	82
heat	82
water	83
vital air	83
electric fluid	83
diminished by severe cold	84
fixed air	84
mephitic air	84
electricity	85
opium	86
The sleep and watching of plants	87
observations on	87

CHAPTER

CONSPECTUS.

CHAPTER VI.

	Page
<i>The Sexual Functions of Plants in general</i>	88
The mellification of the pistil -	89
observations on	89
The connubium or marriage of plants	90
Experiments -	91
Mode of fecundation -	92
Observations on that of different flowers	93.
aquatic plants	94
The fecundation of the seed -	95
observations on	96
The generation of an hybride plant -	97
observations on	97
hybridation	98
The parturition of plants -	99
diffemination of the seeds	100, 101

CHAPTER VI.

The age of plants	-	-	103
The natural death of plants	-	-	104
Vegetable putrefaction	-	-	105

*THE ANALOGY BETWEEN ANIMALS
AND VEGETABLES.*

Introduction	-	-	-	Page 109
--------------	---	---	---	-------------

CHAPTER I.

<i>The Analogy between Plants and Ve-</i>				
<i>getables in general</i>	-			110, 111
Principles deduced	-	-		112

CHAPTER II.

The Analogy between the feed of the vegetable, and the egg of the animal	-	-		113
---	---	---	--	-----

CHAPTER III.

The Analogy between the bud of the vegetable, and the foetus of the animal	-			114
Principles inferred	-	-		116

CHAPTER IV.

The Analogy between the nutrition of the animal and vegetable	-	-		117
Principles inferred	-	-		118, 119

CHAPTER

CONSPECTUS.

CHAPTER V.

	Page
The Analogy between the growth of the animal and vegetable - -	120
Principles inferred -	121

CHAPTER VI.

The Analogy between the fecundation of the ani- mal and vegetable - -	121
Principles inferred -	123

CHAPTER VII.

The Analogy between the death of animals and vegetables -	124
Principles inferred -	125

CONCLUSION.

Observations on the Analogy -	128
-------------------------------	-----

Shortly will be published by the AUTHOR,

THE
ANATOMY AND PHYSIOLOGY
OF THE
HUMAN INTESTINAL WORMS,
WITH PLATES,
IN WHICH WILL BE GIVEN
AN ACCOUNT AND DRAWING
OF THE
TRICURIS OR LONG THREAD WORM
LATELY DISCOVERED.

C H A P. I.

The Structure of Plants in general—Of the Trunk—Of the Root—Of the Leaves—Of the Flower—Of the Vessels and their Fluids.

THE STRUCTURE OF PLANTS IN GENERAL.

A PLANT is a living, irritable, organic, hydraulic body, destitute of sensibility and voluntary locomotion; composed of three parts, namely, solids, fluids, and a vital principle.

The SOLID PARTS of plants, like those of animals, are formed of *simple* fibres, so arranged, as to give a proper support to their various parts, and that degree of solidity, that each may require.

The SIMPLE FIBRES, intermixed in various ways, form the membranes, cellular substance, receptacles, and vessels.

E

Out

Out of the simple solid parts, are formed the *organic* parts of vegetables, as the trunk, root, leaves, parts of fructification, &c.

THE TRUNK.

The trunk of a tree, is composed of six organic parts, namely, epidermis, cortex, liber, alburnum, wood, and medulla.

The Epidermis, or *cuticle*, is the external or outermost bark, formed of fibres, which cross each other in every direction. Its texture is sometimes so thin, that the direction of the fibres becomes visible, by holding it against the light. The use of the epidermis is to defend the cortex, which lies next to it, from the injuries of the air; to keep open, by its callous nature, the pores of the exhaling and inhaling vessels; to modify the impressions of external objects upon the vegetable; to protect the extreme ramifications of the aerial or aqueous vessels; and to cover the cellular substance, in which the several fluids are elaborated.

When the epidermis is destroyed in the living plant, it is regenerated; adheres more firmly to the cortex; and forms a kind of cicatrix or scar.

The Cortex, or *outer bark*, is situated next to the epidermis, is of a hard texture, and loosely adheres

adheres in *trees* to the next covering or liber ; but in tender plants it is soft, and called the *cutis* or *skin*.

The Liber, or *inner bark*, is the third integument of the trunk of trees ; it is membranous, flexible, and sometimes wholly separable from the cortex and alburnum, hereafter to be described. These two coats of a tree, namely, the cortex and liber, are formed of laminæ, as will appear by macerating them in water ; by which the cellular substance is destroyed, and the laminated appearance becomes conspicuous. They appear to be parts very essential to the life of the vegetable, for in them, the principal functions of life, as nutrition, digestion, secretion, &c. are performed ; as is evinced in those trees which are hollow within, and plants which are kept in vigour by the good state of their barks, although rotten internally.

The Alburnum, is the next integument to the liber, situated between it and the wood, composed of a soft white substance, not easily discernible in some trees : but in the *oak* and *elm* it is harder and more apparent. It is, as it were, an imperfect wood, not having acquired the degree of consistence proper to perfect wood ; on which account, it may be compared to the cartilages of animals, which at length

become bone. It is that state between bark and wood, that the former must necessarily arrive at, before it can become the latter. The hardness of the alburnum is in proportion to the vigour of the plant.

The Wood, or Lignum, is the compact fibrous substance, disposed into concentric layers, surrounding the medulla or pith. It appears to be composed of a congeries of dried vessels, and in annual and biennial plants is called the *Flesh*.

The Medulla, or pith, or innermost substance of trees, is soft and vesicular, and differs from cellular texture by its snow white colour. In young trees it is most copious; but, as the plant grows, it diminishes and at length disappears. Thus it is evident that the medulla is necessary in the beginning of the life of plants, but not for its continuation. Perhaps nature reserves a superfluous nutritious humour in the medulla, if from any cause the young plant should become dry; that it then may be absorbed and converted into aliment.

What has been said of the trunk, is applicable, in every respect, to its branches and ramifications; they having the same parts, continued from the trunk, of which they form a part.

THE

THE ROOT.

The root of trees is only a continuation of the trunk descending into the earth, and it appears to consist of the same parts, although less conspicuous: thus, if the trunk of the *Salix* or Willow, or any other tree, be torn up, and inverted, so that the trunk and branches be put into the ground; then the part, which was originally trunk and branches, becomes root, and the root is converted into trunk and branches.

The root and its ramifications are fixed in the earth, lest the plant be torn up by the wind.

The radicles, which are every where given off from the root and its ramifications, absorb a nutritious juice from the earth, for the increase, &c. of the vegetable; thus, the radicles, with the leaves of the plant, constitute the *absorbent organ*.

THE LEAVES.

The leaves are produced from the barks of the trunk of the plant, and consist of an epidermis, a vascular net-work, and a parenchyma full of a greenish juice. They are every where supplied with fibres, which are commonly

termed the *nerves* of the leaf, but which are merely its vessels running in every direction, and branching out into innumerable small threads, interwoven with the parenchyma, like fine gauze or lace.

The *surface* of the *epidermis* of a leaf, like that of an animal, is full of pores, which serve both for respiration and the absorption of dew, air, &c. These pores or orifices differ both in shape and magnitude in different plants, which appears to be the cause of the variety of texture, peculiar to every plant.

The *parenchyma* consists of very minute fibres, disposed in extremely small cells, which are of various sizes in the same leaf.

All leaves, of whatever figure, have a marginal fibre, by which the rest are bounded. The particular shape of this fibre determines the figure of the leaf.

The *vessels* of the leaf have the appearance of inosculating; but when examined by a microscope, they are found only to be interwoven or laid along each other.

The use of the leaves is to nourish the plant with the nutritious juice they reserve in their parenchymatous substance; and to expire and inspire air and water.

THE

THE FLOWER.

All the parts of a plant appear to contribute to the fructification, by which is understood the flower and fruit of plants; for although the fruit does not swell and ripen until after the flower has fallen, its rudiment or first beginning is in the flower, of which it properly makes a part.

The FLOWER is a temporary part of vegetables allotted to generation, terminating the old vegetable, and beginning the new. It consists of seven principal parts, namely, the calyx, corolla, stamina, pistillum, pericarpium, semina, and receptacle; the four first belong properly to the flower, and the three last to the fruit.

1. The *Calyx*, empalement, or flower-cup, is the termination of the cortex or outer-bark of the plant, which, after accompanying the trunk through all its branches, breaks out in the flower, and is present in the fructification in this new form. Its chief use is to enclose and protect the other parts of the flower. It receives different appellations according to the circumstances with which it is attended.
2. The *Corolla*, foliation, or leaves of the flower,

is the termination of the liber or inner-bark, continued to and accompanying the fructification in this new form of painted leaves. Its use is the same as that of the calyx, serving as an inner work of defence, for the parts it encloses; as the calyx, which is usually of a stronger texture, does for an outer one. The leaves, of which the corolla consists, are called *petals*. The corolla receives different names according to the number, form, &c. of the petals.

3. The *Stamina*, threads or chives, are the male part of the flower, designed for the preparation of the pollen. Each single *stamen* consists of three parts,
 1. The *Filament*, or thread, which serves to elevate the anthera or summit, and at the same time connects it with the flower.
 2. The *Anthera*, or summit, situated on the top of the filament, which contains within it the pollen, and when come to maturity discharges the same.
 3. The *Pollen*, farina fecundans, or meal, contained within the anthera, is a fine dust secreted therein, and destined for the impregnation of the germen, hereafter to be described. Each portion of this meal is by a microscope seen to be concealed in
a very

a very fine pellicle (which at the time of impregnation bursts) containing the prolific liquor.

4. The *Pistillum*, pistil or pointal, is the female part of the flower, designed for the reception of the pollen. It consists of three parts,
 1. The *Germen*, which is the rudiment of the fruit, accompanying the flower, but not yet arrived at maturity. It is situated at the bottom of the style, and is generally called germen until the antheræ have discharged their pollen; after which period, it becomes the pericarpium.
 2. The *Style*, which is the part that serves to elevate the stigma from the germen.
 3. The *Stigma*, or summit of the pistillum. It is mostly covered with a moisture, for the purpose of retaining and dissolving the pollen.
5. The *Pericarpium*, or seed-vessel, is the germen just described when grown to maturity, and which, when ripe, discharges the seeds it contained. The pericarpium of several vegetables has a considerable quantity of a proper juice, contained in a parenchymatous substance or in vesicles, every where supplied with very minute air and sap vessels. These are called *fruits*.

6. The

6. The *Semina*, or seeds, are a deciduous part of the vegetable, each seed including the rudiment of a new one; endowed with a vital principle by the sprinkling of the pollen, which they are capable of retaining for an immense time. The following parts are observed in a seed.

1. The *Corcule*, or embryo of the new plant, within the seed. It is divided into the plumule and rosetel.

The *plumule*, is the scaly ascending part, conspicuous when a seed begins to vegetate.

The *rosetel*, is the plain part of the corcule, and always descends into the earth.

2. The *Cotyledon*, or side of the seed, of a porous and perishable substance.
3. The *Aryllus*, or exterior covering of the seed, which comes off spontaneously.
4. The *Hilum*, or external mark or scar on the seed, where it was fastened to the pericarpium.
7. The *Receptacle*, is the base which connects the other parts of the flower together.

Upon these parts of the flower, but more immediately upon the number, position, &c. of the stamina and pistils, the beautiful SEX-

UAL

UAL SYSTEM of vegetables is founded ; a system, the discovery of which was reserved for the immortal LINNÆUS.

From what has been said respecting the uses of the different parts of the flower, the following principles may be deduced.

1. That *every* vegetable is furnished with flower and fruit, there being no species where they are wanting.

2. That there is *no fructification* without anthera, stigma, and seed.

3. That the anthera and stigma constitute a *flower*, whether the coverings (calyx and corolla) be present or wanting.

4. That the seed constitutes a *fruit*, whether there be a pericarpium or not.

It would be needless to describe the texture and nature of the vessels of flowers, as they are very similar to those of the trunk to be described ; and it would be foreign to the subject, to take any notice of the characters and distinctions of the different parts of the flower, which belongs to the science of botany.

Every part of the flower is perfectly formed before it appears outwardly, and the flowers, which appear this year, are, properly speaking, those of the last ; mezercon, for example,
flowers

flowers in January, but the flowers were completely formed in the month of August preceding. This fact will also be demonstrated, if the coats of a tulip root about the beginning of *September* be separated; for in the center a kind of cell will be found, in which the young flower is situated, which is not to make its appearance until the following *April* or *May*.

THE VESSELS OF VEGETABLES.

Vegetables, like animals, have their fluids contained in certain appropriated vessels, strengthened by a thin fibrous texture. By these vessels, which are disposed in a regular order, the different functions necessary to the growth of the vegetable and its various secretions and excretions are performed.

The vessels of vegetables are divided into,

1. The *Succous*, which ascend perpendicularly, and carry the nourishment or chyme of the plant from the root, to every part. At their extremities they are generally called *absorbents*.
2. The *Utriculous*, which run horizontally in the cellular texture, and are evident upon cutting the trunk in a freight direction.

3. The

3. The *Medullary*, which belong to the medulla; they are few in number, and never fasciculated, and run very irregularly in an horizontal direction.
4. The *Proper*. These are very thin, and found lying close to the larger vessels. May not these be vessels of nutrition?
5. The *Spiral*. These are contorted in a spiral form, and are larger than the succous vessels, by which they are surrounded in clusters. They are situated under the external skin, and carry air and their proper juice at the same time. They are also called spiral tubes or *tracheæ*, but may with greater propriety be termed pneumato-chymiferous vessels. When a leaf is slowly broke, they appear like small woolly fibres, connected at both ends of the broken leaf.

The internal surface of the succous vessels is villous; as the plant encreases, they gradually thicken; and in the stems of annual and biennial plants, they at length form a ligneous ring. In the trunks of trees two of these annuli are found every year, which are separated from the preceding by a dense cellular texture.

THE

THE JUICES OR HUMOURS OF PLANTS.

The fluids contained in the vessels and receptacles of plants, are of two kinds ; namely, proper and common.

The common juice is inodorous and aqueous, and is, as it were, the very *blood* of the plant. It is found in all the vessels of the plant, and is that from which nutrition is performed, and the other fluids separated.

That plants contain *water*, is evident from wounding their trunks, in the beginning of spring. Thus a copious liquor, little different from common water, flows from the Acer or Maple tree, from the Betula or Common Alder tree, and from the Vitis Vinifera or Vine.

If an incision be made in the cortex only, little or no water flows out ; but the deeper the incision into the wood, the more copious the efflux.

If an incision be made before the trees are furnished with leaves, no juice flows out ; but after their developement, it begins to bleed, and that from both the lips of the wound.

Wounds made in autumn, remain fresh in the winter, and drop as often as warm weather follows

follows after frost ; but only in that part of the trunk opposed to the solar rays.

From these experiments it is evident, that the aqueous vessels are principally situated in the wood of trees ; that the water of a tree furnished with leaves, is carried through the vessels to support those leaves ; and that the fluid is conveyed upwards and downwards.

The proper juice is secreted from the common juice, and occupies peculiar vessels and receptacles, and differs in its nature, smell, taste, colour, &c.

In some liliaceous plants it is *green* ; in the Fig, *lacteal* ; in the Celandine *yellow* ; in the Plum tree, *gummy* ; in the Pine tree, *resinous* ; in the Maple, *sweet* ; in the Poppy, *narcotic* ; in the Spurge, *caustic* ; and in many plants, *bitter*.

Although this juice may appear to reside in every part of the plant, yet its proper place seems to be between the cortex and alburnum ; for if an incision be made in that part, it drops in greater abundance : hence it follows, that the vessels destined to convey the juice, are principally situated between those barks.

Such is the mechanism, by which vegetables are nourished, grow, and unfold their parts.

CHAP.

C H A P. II.

Of the Elements—Principles—External Qualities—Native Place and Use of Plants.

THE ELEMENTS OF PLANTS.

THE most simple bodies of a vegetable substance which can no longer be divided by chemical analysis, are called its *Elements*.

The elements of vegetables as yet known are heat, light, electric matter, carbon, hydrogen or inflammable air, oxygen or vital air, azot or mephitic air, phosphorus, sulphur, metals, and an earth, as are explained in chemistry.

A thermometer was plunged into a hole made in a sound tree, and it constantly indicated a *temperature* several degrees *above* that of the atmosphere, when it was below the 56th degree of Fahrenheit : but in very hot weather the heat of the vegetable was several degrees *below* that of the atmosphere. It is also proved, that the sap of a tree will freeze at 32°
when

when taken from the vegetable; but in the tree it will not freeze, unless the cold be augmented 15° more. Thus it appears, that heat resides in every part of a plant, and constitutes its temperature, which, it would seem to have the power of increasing or diminishing. In this manner the atmosphere is continually tempered by the greater or less degree of heat, produced in plants; and the scorching heat of the sun, moderated by the evaporation that takes place throughout the whole body of a tree, but particularly its leaves: hence the atmosphere surrounding trees, is considerably cooler than in other places.

Vegetables deprived of *light* become pale. Plants which grow in dark places, incline to the light, if it be suffered to enter through a hole or crevice. Without light plants present one lifeless colour, and are deprived of those beautiful shades which so much enliven the vegetable creation. By the abstraction of this element, celery, endive, and other plants are blanched, lose their green colour, and are rendered white and sickly; and by this means some poisonous plants are deprived of their noxious qualities, and become agreeable to the taste. These experiments prove, that light enters into the composition of plants; yet there

c

are

are some philosophers, who contend, that it is not an element, but consider it as a stimulus or agent, which decomposes their nutritive principles.

That the *electric matter* (concerning the nature of which, the reader is referred to the many valuable treatises already published) is an element of plants, is evident from several vegetable substances affording this fluid, and which, therefore, exhibit the phenomena of vegetable electricity.

The other elements are sufficiently explained in chemistry, and in the transpiration of plants, hereafter to be mentioned.

The nature, form, arrangement, and union of these elements, determine the species of vegetable. The cause of this union appears to depend upon the *vital principle*, which exists in every part of the plant, and which constitutes its life; for, by its means, a mode of union is induced, widely different from that which arises from the common laws of chemical affinity: in consequence of which, nature produces the sap and proper juices, as the resins, gums, sugar, &c. &c.

The laws of vital affinity having once ceased to operate, constitutes the death of the part in which they thus cease; then, the elements,
recovering

recovering their former properties, become obedient to the laws of chemical affinity, and enter into new combinations, from which new principles, or the products of putrefaction, are produced. In this manner the putrefaction of vegetables and animals is explained, to which inorganic substances, as minerals, are in no respect liable, as they are not compounded according to the laws of vital, but only according to those of chemical affinity.

THE PRINCIPLES OF PLANTS.

The SOLID PARTS of plants are composed of vegetable gluten and a small portion of calcareous earth.

Chemistry demonstrates that the *gluten* is composed of carbon or charcoal, and azot or mephitic air.

Calcareous earth does not appear, according to chemical experiments, to constitute the essential element of this gluten; for all the *Byssi*, and many of the *Octosporæ* and *Pezizæ*, or cup mushrooms, do not afford it in the smallest quantity.

The FLUID PARTS of plants are constituted by the following principles; namely, water, an unguinous oil, an ethereal oil, a farinaceous, c 2 gummous,

gummous, viscous, ceraceous, melleous, resinous, balsamic, camphorated, saccharine, bitter, saponaceous, narcotic, acrid, astringent, colouring, acid, alkaline, neutral saline, mediate saline, and lastly an extractive principle; as will appear by the following observations.

If in the spring an incision be made in the *Betula alba*, it will often yield, in one day, eight or ten pounds of sweet *Water*. By drying, vegetables are reduced from a pound, to two or one ounce, or even half an ounce in weight, as the *Cucurbita pepo*, or Gourd.

If the nuclei of almonds, walnuts, olives, linseed, hempseed, the seeds of the poppy, cocoa, and those of the ricinus or castor-oil tree, be expressed, an *Unguinous oil* is extracted. The manner in which the oil is generally obtained, is by first crushing the seed between large stones, into a kind of paste; which is put into bags and squeezed in a press: the oil is thus forced out of the seed, and received in a proper vessel.

By distillation, plants give over with the water, a quantity of *Ethereal oil*, which floats on the top in small globules. It is collected by pouring a quantity of the distilled water with the oil, as it comes over, into a vessel, so constructed, as to suffer the watery part to escape from

from a stop-cock, near the bottom; the vessel is again filled, and when settled, the water is again let out: in this manner the oil is collected in great quantities, floating upon the surface of the water. The ethereal oil resides in a particular appropriated part of the plant; thus it is only found in the corollaceous petals of the rose, chamomile, jasmine and hyacinth; in the stigmata of the *Crocus sativus*, called saffron; in the calyx of the clove tree; in the leaves of mint, balm, sage, and savine; in the root of valerian, sweet smelling rush, and angelica; in the cortex of the cascarilla tree; in the liber of the cinnamon tree; in the epidermis of the cassia tree; in the wood of sassafras and yellow Saunders; in the whole fruit or berries of the juniper tree and laurel; in the bark of the fruit of the lemon and orange trees; in the pellicle of the bitter almond; in the seeds of aniseed, fennel, and caraways, &c. &c.

The farina, flour or *Farinaceous principle*, is obtained by grinding or bruising the seeds of cereals, and separating the fine part from the husks. It may also be procured from the root of the potatoe plant, from yams, &c. from the fruit of chestnut trees; and by a particular process, from the roots of acrid plants, as bryony,

cuckow pint, and pæony. This principle consists of vegetable gluten, starch, and sweet mucilage. See chemistry.

In warm climates (and even from some trees in this country) the *Gummy principle* exudes spontaneously, in the form of tears, from the bark of trees; as the gum Arabic from the Egyptian spiny mimosa, (*Mimosa Nilotica Linnaei*) the Senegal gum from various species of trees, near the river Senegal; the cherry gum, from the cherry-trees; and the gum tragacantha, from the *Astragalus Tragacantha*. It is also abundant in the leaves of the *Malva rotundifolia*, or round leaved mallow; and in the seeds of quinces, &c. When the resinous principle, hereafter to be described, is mixed with the gummy, it is called the *Gunmi-resinous principle*, of which nature is the gum assa-fœtida which exudes from the *Ferula assa-fœtida*; gum galbanum, from the *Bubon galbanum*; also ammoniacum, scammony, gomboge, euphorbium, myrrh, bdellium, opoponax, sarcocolla, and storax, which exude from their respective trees. The antheræ of almost every plant abound with the *Ceraceous* or *waxy principle*, and a great quantity is obtained from the fruit of the *Myrica cerifera*, *Croton cecifera*, and from laurel berries.

The

The stigmata of most flowers continually secrete the *Melleous principle* upon their surfaces; and in some plants, as the *Fritellaria regia*, &c. it even collects into drops. Chemistry demonstrates, that this principle consists of sugar, dissolved in mucilage; and balsams are found in the nectaria of some plants containing grains of crystallized sugar.

If the roots, leaves, barks, &c. of several plants be put into spirit of wine, suffered to stand a few days, and the spirit then evaporated; the *Resinous principle* is obtained. Sometimes it exudes spontaneously in the form of drops, from the bark of trees; as the gum mastich, anime, olibanum, benzoe, elemi, sandrach, guaiacum, ladanum, tacamahacca, and sanguis draconis, which are found adhering to the trunks of their respective trees.

If incisions be made in the trunk of balsamiferous vegetables, as the *Copaifera officinalis*, *Amyris gileadensis*, *Toluisera balsamum*, *Pinus balsamea*, &c. their several juices flow out; and not unfrequently spontaneously. By chemical analysis these balsams are found to consist of a peculiar resin, dissolved in ethereal oil.

By splitting the trunk of the camphor trees, *Laurus camphora* and *sumatrensis*, which grow in China, Japan, the isles of Borneo, Sumatra,

Ceylon, &c. very large and pure tears of *Camphor* are found between the barks, which are the most pure; but that in the shops is obtained from every part of the tree, by putting the branches; &c. into an iron alembic with water, covered over with a capital containing ropes of rice straw, and thus exposed to heat. The camphor in this manner is sublimated in greyish grains, and these again unite into larger pieces. This *Principle* (which, in some of its properties, is nearly allied to volatile oils, but widely different from them in others, as is explained in chemistry) is also obtained in a small quantity from the roots of the cinnamon tree, zedoary, thyme, rosemary, sage, and many other labiated plants, either by decoction, or by distillation; from the fruit of the *Amomum repens*, called cardamoms; from the leaves of the rosemary plant, *Mala-leuca leucadendra*, peppermint, marjoram, thyme, anemone, and fennel.

The *Saccharine principle* is detected by the taste in many vegetables, especially in dates, figs, filiquæ dulces, cassia in the pod, raisins, apples, quinces, plums, cherries, mulberries, currants, &c. but the plant in which it exists in the greatest quantity, and from which it is obtained for economical purposes,

poses, is the *Arundo saccharifera*, or sugar cane, which is bruised between iron cylinders in the West and East Indies, where it is cultivated; the juice, called Melasses, is then expressed, and by several operations made into sugar. The trunks of the *Acer saccharifera* and *Fraxinus ornus* also afford this principle very largely; as is evident from the quantity of manna, which spontaneously flows every season from their barks. It may likewise be obtained from carrots, parsnips, the roots of dandelion, ferns, liquorice, &c.

If deep incisions be made in the leaves of the *Aloe socotorina*, or aloe plant, the *Bitter principle* flows profusely from the incision, which inspissated by the sun, forms the aloes of the shops. It predominates in wormwood, quassia, gentian, colombo, sumarouba bark, and the bitter apple.

If the leaves of the *Saponaria officinalis*, or soap-wort, be dried and powdered, it washes greasy spots out of linen with water, and froths like soap. This *Saponaceous principle* is also found in the nuclei of the *Sapindus*, the roots of the *Cichorium*, *Scorzonera*, *Tragopogon*, *Barbana*, *China nodosa*, *Sarsaparilla*, *Scabiosa succisa*, *Carex arenaria*, *Ononis arvensis*, and *Astragalus exscapus*.

If

If the pericarpium of the *Papaver somniferum* be wounded, a juice flows from the incision, is inspissated by the heat of the sun (which in Turkey, where the plant is cultivated, is very powerful), and, when the poppy ceases to afford any more, is collected by the Turks for sale. This *Narcotic principle* is called Opium in the poppy, and only resides in the seed vessel. That obtained in this country would appear to be as powerful as the opium imported from abroad, and may, by cultivation, be collected in considerable quantities. I wounded several poppies, last year, with the point of a needle, and each afforded a grain and a half, many three grains. If these punctures or incisions were made in twenty different places of the same poppy, half a drachm would be collected; and as an acre of ground will produce many thousand poppies, the quantity would be very considerable. The leaves of the Tobacco plant, Hemlock, *Lauro-cerasus*, &c. afford a similar principle; and those of the *Stramonium*, *Hyoscyamus*, *Belladonna*, and *Lactuca*; the seeds of Coryander; and the stigmata of the *Crocus* also contain it in a less degree.

If the least portion of the *Arum seguinum*, or dumb cane, be put on the tongue, the person will

will experience the most dreadful sensations on the part for several days after, so powerful is its *Acrid principle*. The *Arum maculatum*, or Cuckow pint, *Cochlearia armoracia*, or horse radish, impart the same sensation, but far less powerfully. It resides also in the root of the *Scilla maritima*, or squill, *Helleborus niger*, and *Veratrum album*; in the fruit of the *Momordica elaterium*; in the seed of the *Sinapis* and *Piper*; in the pericarpium and seeds of the *Capficum annuum*; and, lastly, in every part of the *Cicuta virofa*, *Aconitum napellus* and *camarum*, all the *Euphorbia* or sparges, *Ranunculi* or butter cups, *Anemones* and *Clematides*.

The *Astringent principle* (which chemistry demonstrates to consist of the gallic acid, and the gummous principle) is found in a vast variety of vegetables, but more particularly in the *galls* of the Oak, the *inspissated juice* of the *Mimosa catechu*, called terra japonica, the *bark* of the fruit of the Pomegranate and Walnut, the cortex of the *Cinchona officinalis*, called Peruvian bark, that also of the *Quercus cerrix* and *robur*, *Betula alba*, *Æsculus hippocastanus*, *Ulmus campestris*, *Salix caprea*, *fragilis* and *pentandria*, *Fraxinus excelsior*, &c. &c. It resides likewise in the wood of the *Casalpina brasiliensis* and *Hematoxylon campechiana*; the root of the *Tormentilla*

mentilla erecta; the leaves of the *Thea bohea*, *Betula alnus*, and *Arbutus uva ursi*; and in the petals of the *Rosa centiflora*, *gallica*, *canina*, and *Punica granatum*.

All vegetables afford the *Colouring principle*; it therefore must be very various. The art of dying depends upon the knowledge of this principle. If the stalk of the *Indigofera tinctoria*, or indigo plant, be macerated in water, it affords, by precipitating the *fæculum*, a beautiful blue colour, called Indigo. It may also be obtained from the *Isatis tinctoria*, or common woad, *Lichen roccella* and *parellus*, and the *Croton tinctorius*. In the root of the *Rubia tinctorum*, or madder, *Anchusa tinctoria*, or alkanet; and in the wood of the *Fernambucus* or *Cæsalpina vesicaria*, this principle is red. Lastly, the *Carthamus tinctorius*, *Crocus sativus*, *Serratula tinctoria*, *Anomum curcuma*, *Reseda luteola*, *Trigonella fænum græcum*, *Genista tinctoria*, and *Bixa arenella*, afford in the same manner, a yellow *fæculum*.

Chemistry, to which we are indebted for all our knowledge of the principles of plants, has of late made many curious and valuable acquisitions in regard to the nature of the *Acid principle*, which, it has taught us, is various. From the vegetable kingdom are obtained the citric, malic,

malic, oxalic, tartaric, gallic, and benzoic acids. The citric acid is obtained from the fruit of the *Citrus medica* and *aurantium*, *Limonia acidissima*, *Berberis vulgaris*, *Punica granatum*, *Rubus idæus*, *Ribes rubra* and *grossularia*, *Pinus cerasus*, and *Vaccinium myrtillus*. The malic resides in the fruit of the *Pyrus malus* and *cydonia*, *Fragaria vesca*, *Rubus chamæmorus*, *Vaccinium myrtillus*, and *Sambucus nigra*. The oxalic, in the leaves of the *Oxalis acetocella* and *corniculata*, *Geranium robertianum* and *acetosum*; in the root of the *Rhæum rhabarbarum*, *Bryonia alba*, and *Helleborus niger*; the *Boletus suberosus* also exudes an acidulous humour, which, inspissated by the rays of the sun, goes into very pure crystallized oxalic acid. The tartaric is found in the fruit of the *Tamarindus gallica*, and in the root of the *Rumex acetosa*, and others. The gallic acid is detected in all astringent plants, combined with the gummous principle. Lastly, the benzoic acid is obtained from gum benzoe and balsam of Peru, and lies concealed in the balsam of Tolu and in Storax.

The *Alcaline principle* of vegetables is of three kinds, namely, ammoniac, soda, and potash. The former resides in ethereal oils, and most nasticine plants; for it is obtained during

ing distillation by the addition of the carbonate of potash or fixed alkali. Soda is present in the ashes of all maritime plants; and Potash is obtained from the ashes of plants not maritime.

The *Neutral* salts from the vegetable kingdom, are various. The *Hyosciamus*, *Borago*, *Nicotiana*, *Helianthus annuus*, *Mesembryanthemum crystallinum*, *Millefolium*, and *Fumaria*, afford nitrate of potash ^a. The *Tamarindus gallica*, the fulphat of soda ^b. The muriate of soda ^c is obtained from the *Salicornia herbacea*, from the leaves of the American tree called *Cerciba*, which abounds so much with it, that one leaf is sufficient to salt a salad. There are also plants of this nature growing in the Province of Jago, which is far distant from the sea; and what is wonderful, not a particle of salt can be obtained from the soil, in which they grow. The cinders of many vegetables afford the fulphat of potash ^d.

The *Rhæum rhabarbarum* conceals the *Mediate saline principle*, for fulphat ^e and oxylat of lime are obtained from it; and the *Zea-mays*,

^a Nitre. ^b Glaubers salt, or Sal Mirabile.

^c Culinary or Sea salt. ^d Vitriolated Tartar.

^e Gypsum.

or Indian corn, affords muriate, and nitrite of magnesia.

Lastly, the *Extractive principle* is given out by all plants, which, with the ligneous principle, is as yet not sufficiently known in chemistry.

THE EXTERNAL QUALITIES OF PLANTS.

To this head principally are referred the colour, taste, smell, consistence, and magnitude.

The COLOUR of plants seems to depend upon the colouring principle, the quantity of vital air, and light; and is proper to various parts of the same plant: thus if the exhalation of plants be prevented, and the light intercepted, the green colour of the plant is changed into a white.

The TASTE depends upon the different principles which constitute the humours of the plant, and is different not only in different plants, but in different parts of the same plant.

The SMELL also is of different natures, according to the part; and depends upon the volatile principle exhaling from the plant.

The CONSISTENCE of plants is various, as downy, membranous, carneous, arid, &c. which

are perceptible to the touch. Young plants are mostly mucilaginous, but as they grow, become hard ; yet many flourish in continual softness, as the *Tremella*, and some are so hard as to sink in water, as the Iron wood, which grows in the island of Ceylon.

When the simple fibres of a plant are aggrandized, as far as the nature and arrangement of its elements will admit, the fibre ceases to receive the nourishment destined for its increase ; and the alimentary principles only replace what is dissipated by the transpiration and secretions of the plant : every plant, therefore, has a prescribed INCREASE or *measurement*. The *Ficus indica*, by reason of the ramifications sent off, and concreted with the primitive trunk, insensibly acquires a considerable thickness, whose diametric section is twenty, or even thirty cubic feet. Lastly, there are accounts given of some plants, scarcely visible to the naked eye ; and of trees, so large as to afford by their branches covering for two hundred men.

THE NATIVE PLACE OR SITUATION OF PLANTS.

Plants from their situation have been divided into terrene, subterranean, aquatic, parasitic, indigenous, and exotic.

The whole surface of the earth, the bottom of the sea, and even subterranean passages, are furnished with plants.

THE USE OF PLANTS.

It is not intended to enter fully into the uses of the vegetable kingdom, as it would far exceed the limits of the present publication, being alone sufficient to form a volume ; it shall therefore be considered under three general heads, namely, Diet, Economy, and Medicine.

The vegetables which afford *diet* to man and beasts are numerous ; indeed it would appear that every plant was intended to afford a nourishment, either to man, beast, or insect ; for where is the plant by which the one or the other is not nourished ? Thus, cereal, oleraceous, leguminous plants and fruits are collected for man, and by his industry converted into wholesome food and pleasant drinks. Thus,

D

cattle

cattle feed upon grafs ; birds eat with impunity, feeds, &c. which are deleterious to man ; and thus alfo insects devour that which is refused by the former.

The substances afforded by the vegetable kingdom, for *Economical purposes*, are various. To hemp, flax, cotton, &c. we are indebted for clothing ; and the Americans, and other lately discovered nations, make cloth as fine as filk, by merely beating out and preparing the bark of the *Phormix tenax* and *Morus papyriferus*. To the oak-tree we are indebted for our ships, by which we are enabled to cross the ocean, and collect riches from every quarter of the globe : and in many places, even in the present day, perfect houses are built of wood alone. Many nations have no fire but that which is made of wood, or soft plants, as turfs, &c. And lastly, the wooden utensils in use in this, and every other country, are numerous.

Mankind have by experiments become acquainted with the *medicinal properties* of the far greater part of the vegetable kingdom, and have selected a considerable number of the most efficacious, which, by experience, are found to cure particular diseases.

CHAP.

C H A P. III.

Of the natural Functions of Plants ; namely, Absorption of Nutriment—Nutrition—Growth or Increase—Secretion of the humours, and transpiration of Plants.

THE NATURAL FUNCTIONS OF
PLANTS.

VEGETABLES have a very great analogy to animals, in regard to the functions by which they are nourished and increased, and which, on that account, are called NATURAL. Under the head of natural functions, therefore, are considered the absorption of nutriment, the nutrition, growth or increase, secretion of the humours, and the transpiration of plants.

THE ABSORPTION OF NUTRIMENT.

The oscula of the absorbent vessels, on the surface of the plant, take up a nutritious juice, and convey it to the different parts.

The surface of a plant has two sets of absorbents, which constitute the ABSORBENT ORGAN of vegetables; the oscula of the radicles of the roots, and those on the surface of the leaves.

The *root* imbibes the nutritious juices from the earth, by means of its absorbent oscula, as long as it remains tender; but as soon as it becomes ligneous, it emits radicles on every side, which continue the absorption, and convey it, first to the root, and then to the whole plant. Thus, if a plant, or tree, be transplanted, it succeeds with greater certainty, the more absorbent radicles are preserved with the root.

The *Leaves* absorb humours from the air, in the same manner, as the radicles do from the earth, and convey them to the other parts of the plant, as will be sufficiently obvious from the following observations.

Plants which grow tabid by the heat of the day, revive in the night-time by the dew, which

which cannot be attracted by any other organ than the leaves.

Leaves lying in the water, or on its surface, preserve their greenness ; but immediately become yellow, if spread over with oil or varnish, by which the absorbent vessels on the leaf are obstructed.

The whole plant is enervated, if deprived of its leaves.

Lastly, the *Cacti* and *Seda*, although they have very small roots in proportion to their size, and grow on the driest hills, are very succulent.

The Leaves of plants, especially their inferior surfaces, are furnished with innumerable villi ; these villi are their absorbing vessels.

By means of the absorbent system, the water is distributed to every part of the plant, and constitutes its principal aliment ; deprived of this universal fluid, the plant droops and dies, but by its influence is not only nourished, and the vessels of the whole fabric dilated, but it contributes greatly to irritate the languishing fibres, and thus to augment the vital power of the vessels. By means of this system of vessels, the atmospheric air, which is essential to vegetation, is also absorbed ; for plants *in vacuo* cannot be evolved from the seed, nor

can they afterwards vegetate. This most probably is the reason why seeds buried very deep in the earth, do not vegetate, but die.

It appears from the following observations that the two airs, of which our atmosphere is compounded, are absolutely necessary to the nourishment of vegetables; I mean the vital air or oxygen, and the mephitic air or azot.

Plants placed in *vital air* grow larger, become more powerful, and are greener than in atmospheric. If the seeds of the *Phaseolus*, *Pisum*, or *Lepidium* be put into filicious earth, and sprinkled with water mixed with a small portion of the oxygenated muriatic acid (for in no acid does oxygen so abound and so laxly adhere), they germinate much sooner than if sprinkled with pure water: but if seeds be immersed in diluted muriatic acid, they become black and rugous, and never germinate.

In no kind of air, deprived of oxygen, do plants vegetate; for if they be placed in azotic or mephitic air, carbonic or fixed air, hydrogen or inflammable air, they become flaccid by the heat of the sun, and gradually die away. In nitrous air plants become inactive in a few hours. From this it would appear, that the portion of vital air imparts a natural stimulus, which is highly necessary to excite the fibres,
and

and sustain the vital strength of the vessels of plants. Lastly, vital air, with the peculiar acidifiable bases, generates the various acids which are found in plants.

The vegetable gluten of the fibres consists of carbon, chemically combined with azot, as is explained in Chemistry: hence it follows that the azotic air is absorbed by the plant; and thus it is that plants increase so rapidly in cemeteries, and other places where animals and vegetables putrefy in large quantities on the ground.

Carbonic air dissolved in water, is also absolutely necessary to the vegetation of the plant, in order to obtain their carbonic principle, which is a constituent part of the fibres, oil, mucilage, and other vegetable principles.

Plants appear to obtain their *caloric*, or matter of heat, from the surrounding atmospheric air; thus the shades of trees are so cool; and hence nothing is more healthy for almost all plants than tepid showers, by which they obtain water together with this principle. Lastly, seeds do not vegetate in the cold, and many plants die in it.

Light also contributes to the life of plants; for those which vegetate in atmospheric air deprived of its light, as in the night and dark

places, become pale and weak ; but in the daylight, strong and coloured. Thus the *Lactuca endivia*, tied up by the gardener, grows white internally and green externally; the *Asparagus officinalis* covered with argillaceous earth becomes tender and white, and increases slowly; but if not covered, soon branches out, becomes firm and saturated with a green colour. The rays of light appear, likewise, to contribute to stimulate plants to exhale their superfluous vital air, and the matter of light itself enters into the composition of plants with the various *gasses* or vapours they absorb from the air.

From these observations, it will appear, that water and air form the principal nourishment of plants, and that their different modifications and respective actions on the irritable fibre, are advantageous or destructive to vegetable life.

THE NUTRITION OF PLANTS.

The nutrition of plants is one of the principal actions of the vegetable economy, and is defined, that operation, by means of which the absorbed substance is converted or assimilated into alimentary matter.

The nourishment of animals is found to be composed of principles analogous to those
which

which enter into the nourishment of vegetables. It is true, the alimentary matter is less attenuated and less divided, when it enters into the interior of the former, than when into that of the latter. The animal by peculiar powers decomposes all the nutritive substances in the *primæ viæ*, or stomach and intestines, into their elementary parts, which chemically unite and form proper alibile substances to be absorbed by the patent oscula. Nature performs the same operations in the earth, to supply vegetables; for by the putrefaction of the various inorganic substances, their elementary principles are disengaged and attracted by the mouths of the absorbent radicles. Thus, vegetables, like animals, are nourished by a similar set of vessels, which in the former are situated externally, but in the latter are placed internally in the intestines.

The organs of nutrition of vegetables (like those of the circulation in animals) are the most active powers that nature has bestowed upon them; for by their actions the aliment is converted into a peculiar fluid (totally different in its nature from what it was before its absorption) called the sap, which, in consequence of this action, becomes endowed with the vital principle. This animated alimentary matter, universally distributed, serves for the nutrition, develop-

developement, and reproduction of vegetable substances, in which respect it is perfectly similar to the blood of animals. It serves for nutrition, by its intimate penetration into every part of the plant, and for its developement by its softening the parts, and rendering them ductile enough to admit of extension and increase.

The manner in which the different parts of plants receive the nutritious juice, has never as yet been satisfactorily demonstrated. The following experiments, it is presumed, may tend to throw some light upon the subject.

If a very succulent plant, as the *Sempervivum tectorum*, or common house-leek, the *Sedum telephium* or *acre*, when they begin to emit floriferous peduncles, be placed in a warm and perfectly dry place, after cutting the root; then not only the peduncles are observed increasing, but the flowers also gradually unfold, and very often bear fruit. In the mean time, the inferior leaves gradually die away, and then the superior, until they are all deprived of their nutritious juice, and nothing remains but the epidermis and a few parenchymatous vessels.

The same phenomena are observed in the drying of plants (when uninjured) to be put into an herbarium.

Secondly, the inferior leaves of plants left in
their

their native soil become arid when the flowers blow, and all the leaves gradually dry and fall, as soon as the fruit is quite ripe.

Thirdly, succulent plants in very dry places, and in very warm countries upon a defect of rain, appear to live in the summer months upon the nutritious juice of the leaves alone. The bulbs also of bulbous plants seem to prepare a nutritious juice for the stem, leaves, and flowers; for as soon as these parts are evolved, the bulbs waste away.

Fourthly, plants without leaves, as the *Cacti* and *Cuscuta*, consist of a carneous substance, similar to the parenchyma of leaves, which would appear to be their nourishment; for the juice in this, as it were, fleshy substance is elaborated to supply the parts of fructification of the plant.

From these observations, it is evident, that chyme is carried through the absorbent oscula into the succous vessels, of which they are a continuation; and by the pneumato-chymiferous vessels into the parenchyma of the leaves; there to be changed into a nutritious juice by the vital principle: and thus prepared, to be carried to all the other parts of the fructification, through their proper vessels, and inserted by the same power into all the fibres, or to serve for the various secretions.

In this mode then, all the parts of a plant
are

are nourished, the vessels elongated, and the whole plant increased; and thus nutrition appears to be, the continued power of the *Formative nifus**, by which the plant was generated from the seed, and by which it is increased and preserved by nutrition until it perish.

The leaves of plants being thus supplied with parenchyma, which is the receptacle for the nutritious juice, may with propriety be considered as analogous to the *adipose paniculus* of animal bodies.

When the fruit of plants is ripe, nutrition and increase cease, and the vessels gradually become ligneous and impervious.

THE GROWTH OR INCREASE OF PLANTS.

Many ingenious theories have been invented with a view to explain the mystery of the growth of organic bodies. When it is once well understood how a simple fibre increases and extends itself, it will be comprehended how a grain becomes a tree, and an egg produces an animal.

Experiments may be made to discover the laws, which organic bodies observe in their

* See Professor Blumenbach's Treatise on Generation, translated from the German by Dr. Crichton.

growth or increase; an exact scale may be formed of their respective extensions: observations may be made on the interior structure of such bodies, and on the manner in which the organs separate and distribute their respective juices: and the action of the vessels and the motion of the humours may be reduced to calculation. All this knowledge, though precious, does not suffice to dissipate the darkness which involves the mechanism of increase, by which is understood, when applied to vegetables, the evolution of parts which constitute the plant; for if the seed be observed in the microscope, it will appear that it has in miniature all the parts essential to form the future tree.

In order, therefore, to render this part of the physiology of vegetables as clear as its nature will admit, it is necessary to examine the formation of the seed; to demonstrate the uses of its different parts; and to accompany it from the time it begins to vegetate, until it arrive at a state of maturity.

The seed is composed of two *essential* parts, namely, the cotyledon and corcule.

The *Cotyledon* is that farinaceous mass, for the most part separable into two lobes.

The *Corcule* is a fusiform body immersed in the vertex of the cotyledon. It may with propriety

priety (as will hereafter be explained) be considered as the true embryo of the plant, and consists of two parts, the plumule, bud or gem, and the rosetel; the first immersed in the cotyledon, the other projecting from it, as is explained in the anatomy of the seed, page 10.

If the seed of the *Phaseolus* be put into water, after a short time it begins to swell, and becomes turgid, on account of the water absorbed through the pores of the cuticle of the seed, which by the assistance of the vital power dissolves the farinaceous matter in the cotyledon. The cuticle of the seed, incapable of further distension, is then ruptured, and the corcule unfolds itself into the rosetel and plumule. The rosetel, which contains the rudiments of the root and its ramifications, soon pierces the earth, and is gradually prolonged into the root; and the plumule (which contains the rudiment of the future stem, branches, leaves, flowers, &c.) advances slowly, and at length ascends through the earth.

As this little plant, as soon as it is evolved from the seed, wants organs and strength, by which it may attract its nourishment, nature has placed a farinaceous matter in the cotyledon of the very seed, which is dissolved by the absorbed fluid into a nutritious mucilage, and
carried

carried by the vessels of the cotyledon to the corcule of the plant for its first nourishment. Thus, if a seed have no *farina*, or if what it has be corrupted, it never becomes a plant.

When the farinaceous mucilage is consumed, the cotyledons are changed into seminal leaves; conveying the nutritious juice to the new plant, until it has, at length, acquired sufficient strength to gather aliment from the earth by its own proper radicles; then, and not before, the seminal leaves, like the placenta in animals, are no longer necessary, and having exhausted their nutritious juice, they become dry and fall off.

The analogy between the animal and vegetable, in this respect, is better illustrated in the tender almond, which encloses a rosy substance, very similar to the yellow of the egg, covered over with a vesicle: which vesicle is lubricated with a transparent liquor, similar to the white. Those who are acquainted with the formation of the ovula of animals, will immediately perceive this wonderful similitude.

When, by a certain stimulus to the latent vital principle, vegetation commences, the vessels may be seen ramifying on the interior of the lobes *.

* I have in contemplation the publication of some very beautiful

It is a very singular phenomenon, and as yet has never been explained, that the seed, placed in whatever direction in the earth, always turns itself so, that the rosette, which forms the root, branches and radicles, grows downwards, and the plumule, which is to form the trunk, &c. proceeds upwards*.

Thus it appears that the same evolution which conducts an animal to that state of perfection which is proper to it, accompanies a vegetable; which, like the animal, may also be detected in miniature in the seed or bud†.

Having thus demonstrated the evolution of the seed, the growth of the root shall next be considered, and then that of the stem.

beautiful drawings from plants, illustrative of the various changes the seed undergoes before it arrives at a state of maturity, and exhibiting the different coverings, vessels, &c. &c. of vegetables.

* It is from this, and other very surprising phenomena hereafter to be mentioned, that several authors have offered many ingenious speculations on the perceptivity of vegetables.

† The flowers of the Pear tree in bloom in the spring are visible the preceding year. The sagacity of some observers has pierced this cloud, and surprised nature occupied in preparing her future productions. Some have gone still further in their researches, and have found in the bulbous roots of plants the rudiments of the future vegetable.

The

The root at first advances more rapidly than the stem; for an oak plant a foot and a half high has a root four feet in length. If the principal root be mutilated, the plant emits radicles in every direction; which always grow faster than if the root had remained perfect. The radicles at first do not receive any considerable increase; but soon after augment into a body almost equal to the principal root, and then protrude new lateral radicles.

The roots are prolonged at the extreme apex, as will appear, if any root be coloured with varnish in different places; and it is well known, that the radicles always shoot out in that part where the earth is most humid, so that walls are frequently overturned by the power of the roots penetrating towards moist places.

The trunk of vegetables is expanded throughout its whole length, and not, like the root, at the apex only; for if the tender stem of a plant, at the beginning of spring, be coloured over with varnish, and marked in different places, the marks will, after a few months, be observed to have receded.

In *annual* plants the expansion of the stem in length continues until the explication of the

E

flower:

flowers ; then the fibres of the stalk begin to be indurated, and at length gradually become dry.

In *perennial* plants the increase of the stem continues until the leaves fall in Autumn, whilst a gem or bud arises in the apex, in which the rudiment of the new stem during winter increases slowly until the following spring ; when, casting off its winter involucra, it continues the increase of the stem in the same way as the inferior part increased during the former years : for in that place where a bud is seated, a tumour extends, which is so continued with the new stem as scarcely to leave any vestige.

The increase of the stem in breadth does not arise from the dilatation of the ligneous strata, but from the generation of new strata, which are annually deposited by the vessels of the bark. This is fully illustrated by the following experiments.

If the ring of the bark be torn from the trunk of a tree, and the ligneous cylinder of the naked part be perfectly surrounded with a leaf of tin, and the whole (after having replaced the cut-out ring of the bark) be covered with the tree plaster ; then, upon cutting the tree
some

some years after, it will appear that the ligneous cylinder covered with tin has received no increase, and that the tin inserted between the ligneous cylinder and the new ligneous strata is complete. These ligneous strata appear to be generated from the cortex; for if metallic threads be inserted obliquely into the cortex, they are after some years found in the wood itself, and not in the cortex.

Observation teaches, that the trunk of trees receives two ligneous strata annually; but the thickness of these strata is not every year the same; for it is greatest when the tree is of a middle age, and the warmer the summer, the more slender the bark.

The bark would appear to be protruded by the vital power of the vessels placed in the wood.

The generation of *branches* appears to be from the *corona*, or plexus of vessels situated between the wood and medulla, from whence they proceed. A germ or bud produces a new branch, so that it may be said to give birth to a new plant, which was shut up and laid concealed in that bud; for the branch contains every part essentially necessary to form a new plant, as is evident from cutting off a branch,

and planting it, by which a perfect tree is produced.

The vessels principally protrude where there is the least resistance in the bark, as in the axilla of the leaves, nodes, and joints; the same is observed of the branches of the root, and explains:

Why the propagation of plants does not succeed by the slip or branch, unless a node, joint, or germ, remain in them.

Why, if a branch of a tree (as yet adhering to it) be plastered round with earth or humid dung, there proceeds from it a root into the earth or dung.

Why the antients falsely attributed the generation of boughs to the medulla of the tree; for in trees destitute of pith, we see that no branches are produced.

The generation of *leaves* originates from the vessels of the bark only; for, the bark being separated from the wood, no connection of the leaves with the wood can be observed; and the bark alone, if put into water, produces leaves.

In the generation of *flowers*, the exterior bark, or epidermis, appears to proceed into the calyx, the alburnum into the corolla, and the series of vessels into the nectarium, stamina, and pistil.

THE

THE SECRETION OF THE FLUIDS.

The similitude between the animal and the vegetable kingdom is marked by many striking characters, of which the separation of the different humours is one; they being all secreted from the common mass called the sap, as the animal secretions are from the blood.

During the motion of the fluids in the plant, the nutritious part is, by the formative power of the *vis vitalis*, applied to all the solid parts of the plant; another part is deposited, by peculiar secretory vessels, in particular receptacles, or on particular parts; and the useless or superfluous part is transpired through the leaves, or perhaps eliminated through the roots*. Thus the ethereal oil of the *Citrus aurantium* is secreted only into the vesicles of the bark of the fruit. In the *Laurus cinnamomum* it is secreted in the liber of the trunk, it being the only aromatic part of the whole plant. Thus,

* Humboldt assures us, that vegetables secrete impurities or faeces through the extremities of their roots during the night, and thus derives the effect of fallowing, and the harmony which exists among plants. " Sic lœditur," says he, " avena a ferratula arvensi, triticum ab erigero acris, linum " ab euphorbia peplo et scabiosa arvensi, &c."

the unguinous oil of the almond is secreted in no other part of the tree ; the same should be observed of all the resins, mucilages, saccharine, and other humours of plants, they being all secreted from the sap by peculiar vessels.

As these different fluids cannot be detected in the ground, nor in the atmosphere, nor in the sap of the plant, it is evident they are generated by a peculiar power in the secretory vessels. By the specific oscillation of these vessels, the vegetable chyme seems to be decomposed into their elements, and these, at length, forming new unions, composed into new principles.

THE TRANSPIRATION OF PLANTS.

Plants emit from the surface of their leaves an exhalation, in the form of vapour, which is called the transpiration of plants. The truth of this fact is proved by their diminished weight in the day ; and by placing a glass bell over some mowed grass in a field ; in two minutes, although the season be very warm and dry, the internal surface of the glass will be covered with a great number of aqueous drops.

That transpiration is chiefly carried on by the leaves, would appear from several experiments

ments hereafter to be mentioned ; indeed it is evident from their structure being so very porous, and from trees destitute of leaves suffering no diminution of weight : whereas those trees which are furnished with leaves, are very considerably diminished in weight through the day.

It has been very satisfactorily proved by several writers, that the leaves are the principal organs of perspiration : by some they have been considered also as the powers which elevate the sap ; but the prodigious force of the secretion of the weeping vine would seem to demonstrate that the leaves are not the sole powers which nature has here set to work ; and injections confirm this idea ; for the coloured fluid elevates itself very high in branches deprived of leaves, and in a very cold season.

The perspiration of a plant by day exceeds that by night ; and when a dew falls, it almost wholly ceases.

In the night time the leaves rather inhale than transpire.

The quantity of perspired water in the day, is, in some plants, very considerable, as will appear from the following experiment.

In the month of July, commonly the warmest season of the year, a large sun-flower, three

feet and a half high, was purposely planted in a flower-pot when young. The pot was covered with thin millen lead, leaving only a small hole to preserve a communication with the external air, and another by which the plant might be occasionally supplied with water. Into the first hole was inserted a glass tube nine inches long, and one shorter, into the hole by which the water was introduced; and the latter was kept close stopped with a cock, except when there was occasion to use it. The holes in the bottom of the pot were also stopped up with corks, and all the crevices shut with cement. Things being thus prepared, the pot and plant were weighed for fifteen several days; after which the plant was cut off close to the leaden plate, and the stump well covered with cement. By weighing, it was found that there perspired through the unglazed porous pot two ounces every twelve hours; which being allowed for in the daily weighing of the plant and pot, the greatest perspiration, in a warm day, was found to be one pound fourteen ounces; the middle rate of perspiration, one pound four ounces. The perspiration of a dry warm night, without any sensible dew, was about three ounces; but when there was any sensible, though small, dew,

dew, the perspiration was nothing ; and when there was a great dew, or some little rain in the night, the plant and pot was increased in weight, two or three ounces.

Thus the quantity of water which plants in a flowering state perspire is very great. It is known by experiment, that one leaf of a tree within twenty-four hours perspires ten grains, so that a tree which has 20,000 leaves perspires within a day one pound. The single stem of the Indian corn, *Zea mays*, perspired in the same time seven ounces. A single plant of the sea cabbage, *Brassica oleracea*, twenty-three ounces, and that of the *Heliotropium*, twenty-four ounces. Hence an acre of a field (which contains 30,240 square feet) in which plants are so disposed, that each be a foot distant from one another, would soon become a lake of water (provided there were no provisions for its absorption), allowing that every plant perspires eighteen ounces.

Plants cannot draw in this great quantity of water from the summer rain only, for in many places it can be proved, that the rain is not in sufficient quantity ; so that it is evident, that the rain which falls in the winter moistens the earth, and is retained until the summer, when, by means of the heat of the atmosphere,
it

it is absorbed by myriads of radicles, and transpired by the plant.

Having thus established that the leaves of vegetables are the principal organs of perspiration, it is proposed making some observations on the laws relative thereto.

The immediate action of the solar rays, greatly promotes transpiration; hence plants in ripening should be exposed to the solar rays, that they may the sooner ripen by transpiration.

In winter there is scarcely any transpiration, nor in rainy weather, nor in humid air: but the greatest degree of transpiration takes place in warm dry weather, and especially when there is a dry wind.

An healthy plant perspires more than a weak one, so that *they* labour under an error, who think that by watering plants in some diseases, they assist them; for it makes them putrefy sooner.

Excess or defect of transpiration, is hurtful to a plant; it should in general be in proportion to the aliment.

As, in transplanting of trees, some branches of the root are unavoidably mutilated, and consequently the absorption of nutriment diminished; it is necessary that the boughs answering

swering to the destroyed roots, should be re-scinded, in order to diminish the transpiration in proportion to the aliment.

The use of vegetable transpiration is to free the plant of its noxious and superfluous humours.

C H A P. IV.

Of the Vital Functions ; namely, the vitality, respiration, motion of the humours in the Vessels, and the generation of heat of Plants.

THE VITALITY OF PLANTS.

LIFE may be said to be that power in a living plant, by which it exists, and defends itself from putrefaction ; hence the vitality of plants is of three kinds, namely, physical, physiological, and chemical.

The irritability of the vessels, and other parts, constitutes the PHYSICAL VITALITY of vegetables. This irritability is dependent upon the vital principle, and produces in the vegetable the same essential effects, as the heart in the animal ; presiding over, and governing, the movement of the sap. In consequence of this vitality the cuttings of plants remain, for a long time after the motion of the humours has ceased, in a state to commence it again.

The

The **PHYSIOLOGICAL VITALITY**, is that power, by which the fibres of the vessels by an innate principle move themselves, and propel the contained fluids.

The **CHEMICAL VITALITY** consists in the power of defending the plant from putridity. This power appears to be in consequence of the specific attraction of the elements into certain constituent principles, according to the laws of vital affinity. It depends, however, upon the adhering vital principle, and is common to all the solid and fluid parts of the plant. During the presence of this principle, a piece of wood lives for ages; but in its absence, the elements again become obedient to the laws of vulgar chemical affinity, and enter into new combinations, by which they go into the products of putrefaction, or generate putrid vapour.

The *chemical* vitality remains much longer in plants than the *physical*, or *physiological*; for, even when the two last are destroyed, the chemical will remain perfect for ages; as is evident in the oak, and other hard woods.

To the *physiological* vitality is referred, the respiration of plants, the motion of the humours, and the generation of heat.

THE RESPIRATION OF PLANTS.

That action by which plants inspire and expire air, is termed the respiration of plants.

As the *leaves* perform the greater part of this function, they are not improperly called the *lungs* of plants.

The leaves continually inspire from the atmosphere, mephitic and carbonic air dissolved in the dew, especially in the night time ; by which the transpiration of the aqueous vapour is diminished. Chemical analysis demonstrates, that not only the dew, but also the water in the clouds, contains carbonic acid.

In the same way as the leaves suck in aerated water from the atmosphere, so also do the roots from the ground.

Vegetables, in regard to expiration, differ very much ; for the air which is expired varies not only in different plants, but also in different parts of the same plant, and depends upon the time of the day, the place, and a variety of other circumstances. Thus the leaves, and all the green parts of plants, exposed to the light of the day, expire pure vital air ; in order to ascertain which, a plant need only be put into a glass vessel, filled with water, and exposed to the
the

the rays of the sun. A number of air bladders will soon be seen occupying the surface of the leaves, which at length arise to the top of the vessel; this air being collected, affords a free and commodious respirable element to animals, and candles burn in it very brilliantly. If this experiment be tried with the same leaves, in a dark place, or in a dark shade, or by night; the air which is obtained, extinguishes flame and suffocates animals, and, consequently, is not vital air, but fixed air mixed with a little mephitic or azotic air, as chemistry explains.

The coloured parts of plants, as well as the root, bark, wood, flowers, fruits, and seeds, under certain circumstances, (if even exposed to the rays of the sun) expire only fixed air.

The *Dictamnus albus*, or *Praxinella*; most of the *Fungi*, but particularly the *Agaricus campestris* and *androsaceus*, and many of the *Byssi*, expire inflammable air; for if they be shut up in a vessel containing vital air, it becomes so vitiated as to be lighted with a candle.

If plants be put into inflammable air, and exposed to the rays of the sun, they emit pure vital air as long as they vegetate.

From what has been said, it is evident, that the matter of light of the rays of the sun, and inflammable air, act as *stimuli* on plants; and
draw

draw from them, as it were, by chemical affinity, pure *vital air*. Heat does not appear to contribute any thing, for the evolution of vital air is more powerful in the cold, than in heat.

All the parts of plants, from which no vital air can escape, and which abound with it, exhibit a white and variegated colour : as *Fungi*, the corollæ of plants, immature apples, barks, the bractææ of the *Melanopyrus nemorosus*, the *Verrucariæ*, *Lichen miniatus* and *parietinus*, and all green plants in an obscure situation, as *Asparagus* covered with earth, &c.

A dead or diseased plant exhales nothing, or only impure air ; and it is wonderful that some healthy plants do the same, although exposed to the solar rays ; as the *Ilex aquifolium*, *Prunus lauro-cerasus*, *Mimosa sensitiva*, and *Acer foliis variegatis*.

By inspiration plants inhale their nutritious vapours ; and by expiration, they appear to free themselves from those which are superfluous, lest they be too much irritated by them. These two operations constitute the *primary use* of the respiration of vegetables.

THE MOTION OF THE FLUIDS IN
THE VESSELS.

Two theories have been applied to the motion of the fluids in vegetables; the advocates of the one maintaining, that the vegetable sap had a circulation analogous to the blood of animals; while others affirmed, that it only ascends in the day, and descends again at night. In order, however, to prove the former, it would be necessary to demonstrate in plants, as in animals, a centre from which the circulation begins, and to which it again returns; but no such centre has ever been discovered by any naturalist.

As it has been proved that the roots and leaves attract a nutritious juice, and communicate it to the other parts of the plant; it is evident, that it must be carried upward and downward; and from several experiments, it appears, as satisfactorily proved as its nature will admit: that the humours, attracted by the leaves, descend at night, and those by the root, ascend by day; for the leaves by night inhale dew, and seldom perspire vapour, and vice versa.

It does not appear improbable, although it
F is

is not proved by ocular demonstration (which is the only way to ascertain the fact), that a plant is constructed with special vessels for the ascending and descending juices *. This idea is to be considered as purely conjectural, but may at some future time be ascertained.

The experiments which prove that the nutritious juice, taken in by the absorbent vessels of the radicles, ascends through the vessels into the leaves and flowers, are,

The *erection* of flaccid plants, if water be poured on the ground, or if the root only be put into water.

The *colouring* of flowers by putting plants into water impregnated with a colouring principle.

* If a vegetable be not supplied with these special vessels for the ascent and descent of the sap, it must be performed in the same vessels, which at one time must therefore raise, and at another depress it. What would, however, seem to strengthen the opinion of its being thus moved, is, that nature has made no apparent provision whereby the sap might be prevented from descending, in the very same vessels through which it ascends. In the vessels of animals, whose office it is to return a fluid, there is an apparatus called VALVES, which effectually prevent the contained fluid from going back. These valves are entirely wanting in the vessels of vegetables.

Although

Although the ascending succous vessels have been seen conveying the coloured fluid, it has never been carried so far as to enable one to detect whether the fluid was returned by the same or by special vessels; yet I am very much inclined to favour the latter hypothesis.

That the vessels of plants are endowed with vital power and irritability, and after the manner of animal vessels alternately diminished and augmented in diameter, would appear,

1. From the ascent of the contained fluid.

For this could not be returned again by the capillary attraction of the radicles, or the heat rarefying the fluids, or the internal villosity of the vessels.

2. From the increased and diminished motion of the vessels, from various stimuli; for some increase the motion of the fluids, and others diminish it.

Without this contraction and dilatation *,
the

* Von Marum was the first who decided this point, in a dissertation he published at Groningen, on the motion of the fluids in plants, in which he says, "*Videtur verisimillimum, ipsis plantarum vasis actionem quandam esse attributam, quæ absorptos humores profundat versus illam partem, quæ minorem offert resistentiam; quænam autem sit illa actio, inquirendum restat.*"

the very rapid circulation of the common juice or sap of plants, could not take place. It is observed that the motion of the sap varies in every plant: this depends upon the irritability of the vessels; thus it is quickest in those plants which are the most irritable, and vice versa.

The contraction of the vessels is evident in most of the Euphorbia; thus, if a branch be cut when fresh, a milky juice will flow out, and continue for some time.

The cause of the contraction depends upon the irritability of the fibres composing the vessels; hence it follows, that the efflux of the milky juice will not take place when the vessels of the plant are deprived of that property: but this will be considered in its proper place.

The *stimuli* by which the irritable fibres are excited into motion, and diminished and augmented in diameter, are; water, a requisite degree of heat, vital air, light, electric matter,

“ Diametro alternatim diminui aut augeri plantarum
“ vasa, et hac ratione contentos humores urgori, ex una va-
“ sorum parte versus alteram, requiri videtur.

“ Utrum vero hæc vasorum contractio oriatur a vi quâ-
“ dam contractili ipsius insitâ, quæ a contractilitate vasorum
“ animalium non diversa est, an vero ab aliâ quâdam vaso-
“ rum facultate derivanda, haud facile determinare licebit.”

and

and artificial stimuli, as nitre, sal ammoniac, sulphur, &c. *

THE GENERATION OF HEAT.

Every plant, by its vital power, is possessed of a proper degree of heat, by which it vegetates, increases, and is enabled to resist the cold and heat of the atmospheric air.

The power of resisting cold is very conspicuous in the roots of some plants; thus those of the *Betula alnus* are often incrusted the whole winter with ice, yet the tree blooms with vigour the following spring.

* A small portion of nitre in water stimulates the Hyacinth, Narcissus, and other bulbous plants, to germinate much sooner than they otherwise would. Two portions of the Peppermint (*Mentha Piperitida*) were put, the one into a solution of nitre, the other into water: the first increased in weight three hundred and seventy-eight grains; the other only one hundred and forty-eight, in the same space of time. A branch of the *Betula alnus* sucked in $\frac{1}{4}$ of the liquor in which a small quantity of sal ammoniac was dissolved; but in the same quantity of pure water, only $\frac{1}{12}$. The seeds of the *Phaseolus vulgaris*, when put into sulphur powdered and watered, after a short time are observed to germinate; and their roots are firmer, and their increase greater, than those planted in the ground, and watered with the same quantity of water.

If the *Avena* or oat, and the *Phaseolus* or kidney-bean, be torn up with their leaves, and exposed to a certain degree of cold (22°), the leaves die, but the roots, after a while, begin to vegetate abundantly.

If the green leaf of the Pine, or *Phaseolus*, be put into the frozen juice of spinach or cabbage, it in a few minutes becomes thawed.

In the northern regions plants and fruits are discovered, upon which the frost has no effect; and the woods with acerose trees are the most beautiful in those countries.

In general it is observed that acerose trees, grasses, and all plants filled with a tenacious juice, more easily escape the frost than folious trees and those plants which have an aqueous humour; thus tender plants, young sprigs of trees, and flowers, are easily destroyed by sudden cold in the autumn, or by cold late in the spring.

Some plants have the power of resisting the atmospheric heat. If in very warm weather the earth be touched with one hand, and the grass with the other, the former will be found warm, and the latter cold. Thus, also, if water be exposed in a glass placed in a bed of cucumbers, the water soon grows warm, but the cucumbers remain cold to the touch; and if one
be

be eaten, it cools the stomach like ice. The same thing is observed in fruits, while hanging on trees.

There is an account given of a Lake in the Island of Luson, which is so warm as to kill swallows when flying over its surface; and yet historians of undoubted veracity tell us, that the *Vitex agnus castus*, and two species of *Apalatus*, grow on its shores. The soil of the island of Tanna, about the Volcano, is 217 degrees of heat; and yet plants are found there bearing fruit in great perfection.

The temperature of plants arises from the matter of heat absorbed from the atmosphere; and hence it is, that the shades of all trees are so cooling.

Some plants have a great, and others but little power of *attracting* and of *retaining* the matter of heat.

In trees and plants which flourish in the winter, there seems to be a great quantity of *latent* or retained heat.

The heat of plants does not appear to *arise* from absorbed and decomposed water or vapour; for although the matter of heat may be in combination with the portion of vital air contained in either, it is to be observed, that

vital air is again exhaled in much larger quantities from the plant.

The beneficial effects of heat in plants are many. It supports the irritability of their fibres, by means of which all the functions are regularly performed, as the respiration, secretions, &c. renders their sap and other fluids more fit to penetrate and pass through the various vessels, and after the death of the plant occasions a dissolution and new combination of their component parts ; as is evident when putrefaction commences.

C H A P. V.

Of the animal Actions in general—Of the Automatic Motion—Of the Sleep and Watching of Plants.

*THE ANIMAL FUNCTIONS IN
GENERAL.*

THE motions of the leaves, and parts of the fructification, which are very similar to those of animal muscles, constitute in vegetables the *animal functions*: to which are referred the automatic motion, sleep, and watching of plants.

Plants are supposed to have no sensation, because in the vegetable system no nerves are detected: but is not sensation perceived in all the intestinal worms *, in which also nothing like nerves can be found?

THE

* This the author has proved in a work on the ANATOMY and PHYSIOLOGY of HUMAN INTESTINAL WORMS, ready for

THE AUTOMATIC MOTION OF PLANTS.

The contraction and relaxation of the leaves, or parts of the flower of a plant, from the application of a stimulus.

This contraction and relaxation cannot be considered as voluntary ; for plants are destitute of volition : nor can it arise from the influence of nerves ; for, as it has been before observed, no such instruments have as yet been detected in them.

It is evident, therefore, that it must arise from the IRRITABILITY of the fibres ; for every plant possesses, in a greater or less degree, this *principle of irritability* *.

The cause of the difference would appear to depend upon the capacity of the fibres to re-

for the press ; in which he has given an account of the TRI-CURIS, very lately discovered by him, which only inhabits the human body, and also plates of all the species of worms. There are likewise many insects which are destitute of nerves, but which nevertheless shew evident marks of sensation.

* This principle has, by some writers, been considered to be OXYGEN ; there are, however, many objections to this opinion.

ceive

ceive the irritable principle : thus every plant has a degree of irritability peculiar to it, and hence one species is deprived of its irritability by external stimuli, when another will bear the same with impunity. Many plants also become gangrenous in the spring time, after a severe cold night, while others are not in the least hurt. The *Phaseolis vulgaris*, for instance, will be found dead under the above circumstances, and the *Pisum sativum* flourishing by its side.

A plant also possesses, at different times, more or less of the irritable principle, which would appear to depend upon various external stimuli, as will be explained hereafter. When it is abundant, it is called ACCUMULATED IRRITABILITY, and when deficient, EXHAUSTED IRRITABILITY*.

The irritable fibres of a plant would seem to have a connection or *sympathy* with each other ; for if a stimulus be applied to one fibre only, it is communicated to the rest : but the

* The diseases of plants are in the present day very little understood ; but the doctrine of irritability, which every day is experiencing very rapid improvements, it is to be hoped, will establish some rational system, by which the pathology of the vegetable creation will be better understood, and the diseases in a great measure remedied.

effect

effect is always the greatest upon the fibres that immediately receive it, and much less upon those which only act by sympathy. Thus when a plant, whose contractions are visible to the naked eye, as the *Mimosa sensitiva* (hereafter to be described), is irritated by a stimulus, the whole plant is affected, but not in that degree as the part to which the stimulus was applied.

The irritable fibres of plants, like those of animals, are deprived of their irritability in proportion to the frequency of the application of the stimulus; and consequently the contraction of the fibre (which is totally dependent upon the principle of irritability) is diminished in the same proportion: thus if the irritability be diminished, the contractions are also; and if exhausted, they totally cease.

From these observations it is evident that the automatic motions of plants arise from the peculiar fasciculæ of irritable and muscular fibres, which do not, like animal muscles, become red, but are white.

In this manner the contraction of the parallel and fasciculated fibres of the stalk of the leaf of the *Hedysarum gyrans*, *Mimosa pudica*, *Oxalis sensitiva*, *Dionæa muscipula*; the nodding of the filaments of the *Parnassia palustris* and *Ruta lepensis*,

lepnis take place, when the different stimuli irritate them to motion.

The *HEDYSARUM GYRANS*, or moving plant, is of the class *Diadelphia*, and order *Decandria*, and a native of the East Indies, where it is called *Burruu Chundalli*. It is a trifolious plant, and the lateral leaves are much smaller than those at the end. The leaves in the daytime are continually moving up and down, and circularly. The circular motion appears to be performed by the twisting of the fibres at the bottom of the stalk; and while the one leaf is rising, its associate is generally descending. The motion downwards is quicker and more irregular than the motion upwards, which is steady and uniform. If a branch of this plant be cut off, and put into water, the same motions continue in its leaves for the space of twenty-four hours after. If from any obstacle the motion of the leaves be retarded, upon the removal of that obstacle it is resumed with a greater degree of velocity. What is most remarkable in this plant, is, that the larger terminal leaves do not move, unless stimulated by the solar rays, on which account they cease when the leaves are clouded; whereas the stipuliform leaves constantly move, and are interrupted by no stimulus. The motion of the
larger

larger terminal leaves is also increased in the night-time by a stimulus, at present unknown.

The MIMOSÆ are of the class *Monœcia*, and order *Polygamia*. Mimosa signifies mimic, and is given to this genus on account of the irritability of the leaves, which, by their motion, mimic or imitate, as it were, the motion of animals. All the species are more or less irritable; but the following are the most so:

1. The MIMOSA SENSITIVA, or *common sensitive plant*, whose leaves and footstalks recede from the touch, though not with the same facility as some of the following.
2. The MIMOSA PUDICA, or *bashful sensitive plant*. By the least touch the leaves instantaneously recede, contract, close, and, together with the footstalk, quickly decline downward, as if ashamed of the approach of the hand.
3. The MIMOSA PERNAMBUCANA, or *slothful mimosa*. The leaves of this species do not recede from the touch; but its *pinnæ* are a little contracted when smartly struck: hence it is called slothful.
4. The MIMOSA ASPERATA, or *panama sensitive plant*. This species would form an
hedge

ledge or fence round a garden. The leaves are numerous, small, and winged, and, next to those of the *M. pudica*, are the most irritable, contracting with the least touch, and remaining so for many minutes after.

5. The *MIMOSA VIVA*, or *lively mimosa*.

This is the smallest of the sensitive plants, is furnished with creeping roots, and spreads itself so as to cover large spots of ground. By running a stick over the plant a person may write his name; and it will remain visible for ten minutes.

6. The *MIMOSA QUADRIVALVIS*, which slightly recedes from the touch.

7. The *M. PUNCTATA*, and *M. PLENA*, are only sensitive in the *foliola*, which are very susceptible of any substance, or even of the air.

The contractions of the *OXALIS SENSITIVA*, are of the same nature with those of the *Mimosa sensitiva*.

The *DIONÆA MUSCIPULA*, or *Venus's fly-trap*, is of the class *Dicandria*, and order *Monogynia*. It grows in America, about 35 degrees of N. Latitude, in wet, shady places, and flowers in July and August. The peculiarities of this plant are in the leaves, which at their
upper

upper joints are furnished with a particular apparatus, so that when an insect alights upon it, the parts are irritated, the two lobes of the leaf rise up, grasp it fast, and by means of two rows of spines, which close together like teeth, squeeze it to death. The lobes never open again while the dead animal continues within. Every part of this apparatus is besmeared with a sweet secretion, which attracts the unfortunate animal, and tempts it to taste it. It is nevertheless certain, that the plant cannot distinguish an animal from a mineral substance; for if a piece of straw, or a pin be introduced, it will be grasped full as firmly; nor will the lobes open while it remains. If the substance enclosed be gradually pushed out, the lobes again expand themselves; but if any force be used to open them, so strong has nature formed the spring of the fibres, that one of the lobes generally snaps off rather than yield.

Automatic motion is also to be noticed in a great number of flowers; which motion is observed to take place at particular times. Some flowers, for instance those of the *Raflesia* *luteola*, or Dyer's Weed, *Helianthus annuus*, and several others, constantly turn towards or against the sun: others are influenced by certain states of the air or sky. Thus the
flowers

flowers of the Syngenesious plants shut in cloudy, cold weather, and open when it is serene and warm. The flowers of the erect campanulæ, in cold rainy weather, either nod or twist round their petals, lest the pollen be washed away by the rain from the anthera, or the smegma, or moisture, from the stigma. Many flowers open in the morning, and close again in the evening: others open and shut themselves at certain and regular hours; as the Common Dandelion (*Leontodon taraxacum*), which opens between five and six in the morning, and contracts between eight and nine in the evening; and the *Mesembryanthemum lingui-forme*, which opens between seven and eight, and shuts about the third hour after noon*.

There is a connubial motion observed in the parts subservient to generation, during the time the pollen is discharging upon the stigma; as will be explained in its place.

The STIMULI, which excite the irritable fibres of plants to motion, are mechanical irritation, light, heat, water, vital air, and electric fluid, when moderately applied.

* From a variety of similar circumstances, the immortal LINNÆUS divided flowers into the *Flores Meteorici*, *Æquinoctiale*, and *Tropici*; and formed the HOROLOGIVM FLORÆ. Vide Linnæi Philosoph. Botan. l. c.

The leaves of the *Mimosa pudica*, &c. contract by *touching* them; and those of the *Dionæa muscipula* are irritated by the fly, and other substances, to so powerful a contraction, as to retain the substance. These and the like stimuli may be considered as acting *mechanically*; for a pin, a straw, or any other substance, will equally affect them.

The terminal leaves of the *Hedysarum gyrans* are irritated to move by the rays of the sun; but when clouds intervene, the motion ceases. The *Mimosa pudica*, if concealed for twenty-four hours in a dark place, is found to be much more irritable when exposed to the sun. These actions, therefore, would appear to be from the stimulus of *light* alone, as no other stimulus produces the same effect.

The motion of the leaves of the *Hedysarum gyrans*, in its native soil, or when in a hot-house, is more vivid and stronger than when surrounded by cold air. The stamina of the *Berberis* are known to be less irritable when exposed to a northern wind, than those which lie concealed, and cannot be affected by the cold air; and all plants are excited to put forth their flowers by the stimulus of *heat*, when applied proportionably to the irritability of the plant; under which circumstances heat
is

is known to effect the activity of the irritable fibres, and to facilitate vegetation in general*, as is obvious in hot-houses, &c.

The flaccid stamina of the *Berberis* also recover their former irritability, if the bough be cut and put into water. The *Mimosa pudica*, although in earth well watered, is in dry weather less irritable than when surrounded by humid air.

The power of *vital air* in stimulating plants, is evident from this; that no kind of air deprived of oxygen, is favourable to vegetation; and that water mixed with the oxygenated muriatic acid, very much accelerates the germination of the seeds.

The leaves of the *Hedysarum gyrans*, when in motion, are said to gyrate more strongly by applying moderately the *electric fluid*; but if it be applied in too great a degree, the motion is destroyed.

Lastly, the irritability of all plants is generally the greatest in the morning and noon, less during excessive heat, and least in the evening.

* Thus Cicero appears to have considered it as the vital principle; for he says, "Omne vivum, sive animal, sive terra: editum, vivit propter inclusum in eo calorem."

The STIMULI, which diminish the irritability of the fibres, are excess of heat, cold, light, mephitic air, electricity, and opium. Thus the stamina of flowers in the morning move with more strength in moderately warm weather, than in *excessive heat*; and the leaves of the *Mimosa sensitiva*, exposed for a long time to the heat of the sun, cannot be agitated nor irritated into a gyrated motion.

During *severe cold weather* the irritable fibres become rigid, dry, and hard; hence in the vegetable, as in the animal fibre, the irritability disappears. Thus the leaves of the *Hedysarum gyrans*, and the stamina of the *Berberis vulgaris*, are much less irritable when the north wind blows. Thus also many plants, as well as animals, become torpid, the organs of circulation and of nutrition perform their functions but languidly, and life itself appears suspended.

Tender plants, too long exposed to the *light* of the sun, languish. For this reason gardeners defend young plants in the earth from the light of the sun; and thus seeds deprived of light, germinate sooner than if exposed to it.

The *Mimosa pudica* flowering in *vital air*, droops if put into *fixed* or *mephitic air*, and becomes less irritable; and if continued, dies (almost in the same manner as animals which
are

are suffocated therein), and exhibits no signs of irritability. Most plants in general die if exposed long in these airs. The leaves of many plants, very tenacious of their irritability, if put into water impregnated with the carbonic acid, become very soon deprived of it, and die *. Inflammable air kills plants; in nitrous air they become turbid in a few hours; and seeds placed in mephitic air, never germinate.

The *Murina*, and other animals severely struck by the *electric shock*, shew no signs of irritability, and cannot be moved by any stimulus: in the same manner the *Mimosa sensitiva* and *pudica*, when severely struck by the electric power, cannot be excited to contract by any known stimulus: nor can the terminal leaves of the *Hedysarum gyrans* be stimulated to motion, nor the wounded branches of the *Euphorbia* or *Carica* pour out any milky juice, if their irritability be destroyed by the same means.

* There are, however, several plants which grow and flourish in mephitic air; as the *Lichen verticillatus*, *aidetus*, *radiciformis*, and *pinnatus*, most of the *Ryffi*, the *Agaricus acephalus* and *aberuntius*, the *Boletus botryoides*, &c. and which, if put into any other air, die; but these are to be considered as exceptions, and do not lead to any general rule.

The irritability of the *Hedysarum gyrans*, and *Mimosa pudica*, is gradually diminished, and at length destroyed, by watering the earth in which they grow with a solution of *opium*.

Lastly, the irritability of plants, like that of animals, when harassed by too frequent application of stimuli, becomes less powerful ; and the moving parts of the plants already mentioned have, by being too frequently stimulated, their irritability totally destroyed. The same parts, when cut off from the plant, although not put into water, do not lose their irritability for a considerable time ; for the stamina of the *Berberis*, and leaves of the *Hedysarum* and *Mimosæ*, are obedient to a new stimulus for some time after.

THE SLEEP AND WATCHING OF PLANTS.

The closing of the petals and leaves of plants constitutes the sleep ; and the unfolding of the different parts, the watching of plants : hence most flowers shut themselves at particular times, and again unfold them.

The reason why plants fold up and close their petals generally in the evening and at
night-

night-time, is, most probably, in consequence of the usual stimuli, heat and light, being at those times absent.

There are, nevertheless, many plants in which sleep does not take place in the evening, &c. but which rest even when exposed to the stimuli just mentioned. Thus the *Solanum nigrum*, *Ranunculus repens*, &c. shut and close their petals some hours in the day-time; the *Spiræa filipendula*, &c. in the middle of the day; the *Cactus grandiflora* opens its flowers at sun-set, and folds them up in the morning: and the *Mesembryanthemum noctiflorum* is awake only during the night.

There are also several plants which discover the state of rest clearly by their external appearance: thus the *Alfina media* joins the upper sides of its leaves; the *Ænothera mollis*, &c. fix them on the stalks; and in some the leaves are erect, and in others drooping.

If this remarkable phenomenon, sleep, depend or be connected with the irritability of the plant, as from many experiments it appears to be, it follows, that, when the state near to exhaustion is present, it is necessary that the plant should sleep (be that time when it may), in order to re-accumulate its lost irritability.

C H A P. VI.

*Of the Sexual Functions of Plants in general—
Of the Mellification of the Pistil—Of the Con-
nubium or Marriage of Plants—Of the Fecun-
dation of the Seed—Of the Generation of an
Hybride—And of the Parturition of Plants.*

*THE SEXUAL FUNCTIONS OF
PLANTS IN GENERAL.*

THE functions by which a plant produces another, and propagates to infinity, are called **SEXUAL**. To this head are referred, the mellification of the pistil, the connubium or marriage of plants, the fecundation of the seed, the generation of an hybride, and the parturition of plants.

THE

THE MELLIFICATION OF THE PISTIL.

By this is understood, the secretion of a melleous juice, which, about the period of puberty, besmears the surface of the stigma.

This secretion transudes from all the parts of the pistil, but especially from the stigma, the pores of which may be observed in the hyacinth, furnishing the melleous fluid. In many plants this sinegma fills the whole surface of the stigma, and the cavity of the style.

Chemical analysis demonstrates, that this secretion is a solution of sugar in mucilage; and in some balsamic flowers grains of pure crystallized sugar are often detected in the nectarium.

It appears from experiment, that this juice is actually necessary to the fecundity of the germen; thus, when, by the application of artificial heat, it is dried, the germen is not fecundated by the pollen of the male: for it is adapted by the nature of its viscosity to receive, detain, dissolve, and carry the pollen through the cavity of the style to the germen, which is the OVARIUM of the plant.

The male flowers in general separate no
melleous

melleous juice, but merely pollen, for the purpose of impregnating the female, and which is also collected by the bees, who convert it into wax for their hives.

The honey of the female flowers is sucked up by the same animal, and other insects which have a proboscis, and by them carried into their cells.

THE CONNUBIUM OR MARRIAGE OF PLANTS.

The explosion of the pollen from the anthera upon the stigma, constitutes the marriage of plants ; hence at the age of puberty the following phenomena take place.

The antheræ, when mature for marriage, on a sudden break, and explode their pollen into the whole ambit of the flower.

The stigmata, when prepared for marriage, become turgid, with a viscid melleous humour, which receives the exploded pollen. The antheræ, after the explosion of the pollen, contract, become empty, and decay.

The stigmata are now observed covered with the pollen ; soon after, with the style, they gradually become dry : and at length marcid, like the antheræ and stamina.

The

The *experiments* by which plants are known to celebrate marriage, and to fecundate the seeds from the explosion of the pollen, are the following.

First, Flowers that have stamina only, never produce seed.

Secondly, Flowers which have pistils only, never fecundate unless the pollen be brought from the stamina of a neighbouring plant.

Thirdly, If, in a solitary tulip, the antheræ be taken away, or if the stigma be covered during the explosion of the pollen, the seeds in the germen continue increasing as usual: but if those seeds be put into the ground, they do not vegetate, but remain sterile.

Fourthly, Monstrous flowers, the stamina of which form petals, bear sterile seeds: but if some of the stamina remain unchanged, then a few seeds only become fruitful.

Fifthly, The bilabiated stigmata of plants at the age of puberty, are seen unfolding themselves, and remain so for some days in expectation of the pollen; and if the male be not present, they become marcid.

Sixthly, Plants which have female flowers only, are never fruitful, unless its male plant be in the vicinity, or the pollen be sprinkled over it. Thus the great PALM TREE in the garden of
the

the Royal Academy at Berlin flowered, and bore fruit, for thirty years; but the fruit never ripened, nor did the seeds when planted vegetate: the plant being a female. There happened, however, to be at that time a male Palm-tree in the garden of Leipsic, twenty German miles from Berlin: a branch was procured when in full bloom, which was suspended over the female plant. The experiment succeeded; the female-tree produced more than an hundred perfectly ripe fruit, from which many young Palm-trees were generated. The experiment was again repeated the following year, and the female-tree bore above two thousand ripe fruit.

The female KIGGELARIA plant flowered every year for fifty years, but never bore any fruit. At length the male-tree was procured, and planted fifty paces from it. The flowers fecundated the first year, and at present there is a progeny from the seed. The CLUTIA PULCHELLA affords a similar example.

The MODE, however, of fecundation is different in respect to the situation of the stamina and pistils of the plant.

In *hermaphrodite flowers*, the explosion of the pollen to the stigma is very easy, as the parts of generation are in the same flowers.

In

In *erect flowers*, the stamina, for the most part, are very long, and the pistils very short; so that the exploded pollen may easily settle upon the stigma.

In *pendulous flowers*, the pistils are mostly long, and the stamina very short; so that the pollen, when discharged from the antheræ, may fall upon the pistils.

In *erect flowers* with *short* stamina and *longer* pistils, it is observed, that the style at the period of marriage curves itself downwards, and offers its stigma to the antheræ for the reception of the pollen; after fecundation, the style again erects itself: of this the *nigelli* afford a very striking example.

In *erect flowers*, whose stamina are placed *horizontally*, as in umbelliferous flowers, the *Ruta hortensis* and *Parnassia*; the stamina so erect themselves, that daily one or other of the antheræ copulate with the stigma, and the explosion of the pollen having taken place, the stamina again return into their natural horizontal situations. In the *Ruta hortensis* sometimes two antheræ adhere at the same time to the pistil. In the *Parnassia*, the stamina, one after another, so apply themselves to the stigma, that the coition lasts for several days.

In

In flowers of the class Syngenesia, the stigma passes through the tube coalesced with the anthera; and the explosion of the pollen takes place *sub transitu*.

In Monœcious plants, whose stamina and pistils are situated in different flowers of the same plant; and in Diœcious plants, whose stamina and pistils are placed in two separate plants; the translation of the pollen to the female flower is trusted to the wind and insects. The masculine flowers of some Diœcious plants yield so great a quantity of pollen, that it is conveyed by the wind to different places, and is often found (in countries where the trees are abundant) in lakes upon the surface of the water, so thick, that it has excited an idea among the country people of sulphureous rain from heaven.

Diœcious plants flourish before the eruption of the leaves, lest they should drive away the pollen from the stigma of the flowers. The *Fagus Castanea*, however, protrudes the leaves before the flowers, but has a remarkable number of male flowers in comparison of the number of female.

Aquatic hermaphrodite plants, at the time of fecundation, erect their flowers above the surface

face of the water, left the pollen of the anthera, and the melleous sinegma of the stigma, be washed away.

The celebration of the connubium in aquatic plants is most wonderful in the *VALISNERIA DIOECA*. At the period of puberty the female plant erects its flowers, by a very long spiral peduncle, above the surface of the water. At the same time the male flowers, of their own accord, are broken from the masculine plants (by the peduncle, which is short), and swim on the surface of the water; the flowers now open, and are driven by the winds to the female flowers, and then, but not before, explode the pollen upon them. The impregnation of the flowers being finished, the spiral peduncle, with the female impregnated flower, withdraws again to the bottom of the water.

The *Nymphææ*, *Potamogetons*, and other aquatics, be the water in which they grow ever so deep, send up their flower stems until they reach the surface; when the flower is developed for the purpose of generation.

Lastly, in *Cryptogamia* plants the propagation is not to be observed, but takes place in the parts of the fructification lying concealed in the leaves.

THE

THE FECUNDATION OF THE SEED.

The impregnation of the seed concealed in the germen, by means of the pollen of the anthera acting upon them.

The seed while in the germen, and not as yet impregnated, contains a *peculiar* fluid ; and each atom of the pollen is also furnished with a similar prolific vapour. See the structure of the seed and pollen.

The pollen being sprinkled upon the stigma, is there detained by its viscous humour, and, when chemically dissolved, gradually descends through the vessels of the style, and impregnates the contained seeds with the VITAL PRINCIPLE.

The vegetable embryo appears to be formed from the mixture of the pollen with the liquid in the seed, by means of the formative stimulus, unknown to us, but which is the same as in animals ; for the albuminous liquor contained in the ovula of the ovarium, is impregnated by the AURA of the *femen virile*.

Hybride plants and animals show that embryos do not pre-exist in the seeds of vegetables and the ovula of animals ; but in what
manner

manner the paternal parts of such a plant or animal pre-exist in the animal ovum, or in the vegetable seed, before copulation with the male, is a subject to be ascertained.

It is not necessary to the fecundation of the seeds, that all the pistils of a flower should be impregnated: it is sufficient if the pollen be spread over one; for I have destroyed all the pistils, except one, in the same flower, and yet most of the seeds have fecundated.

Nor is it necessary that the pollen of all the antheræ should be spread over the stigmata; for the *Hybiscus Syriacus* has some thousand grains of pollen in one anthera, and yet all its seeds are fertile, if besmeared with only fifty or sixty: but under twenty, its seeds are sterile.

Thus it would appear, from these observations, that nature has provided so prodigious a quantity of flowers, and number of pistils, that the fecundation of the seed should never fail.

THE GENERATION OF AN HYBRIDE PLANT.

A plant from an union of two different species of one genus, is called an Hybride: and

it

retains

retains some peculiarities from both species of its parental plants.

If the *NICOTIANA RUSTICA* be deprived of its stamina, and its pistils sprinkled with the pollen of the *NICOTIANA PANICULATA*, it produces seeds which afford the *NICOTIANA HYBRIDA*; which neither resembles the *rustica* nor the *paniculata*, but has a few of the characters of each. Thus the *rustica* has ovated leaves, and short and greenish yellow corollæ; the *paniculata* is furnished with lanceolated leaves, longer corollæ, of a yellowish green colour, and has a very long stem; but the *HYBRIDA* maintains a medium in all these respects.

Hybridation succeeds equally well with other plants.

Experiments have ascertained, that this phenomenon only takes place between different species of the same genus, but not in different genera of plants.

The seeds of an hybride plant increase like those of another plant, but when put into the ground do not propagate: hence it is that no new species of plants can be produced.

From these facts it is known of how much importance it is, that gardeners should place plants of a different species, which have the
same

same period of floescence, remote from one another ; lest, by the confusion or mixture of the pollen, the seeds be rendered unfit for further propagation.

MONSTERS may be generated in plants as well as in animals ; but these would appear to originate not only from an error in the *formative nifus*, but also from heat, cold, the sun, nature of the climate, insects, and other causes as yet unknown.

THE PARTURITION OF PLANTS.

The spontaneous delapse of the seed from the plant, is called the parturition of plants.

As soon as the seeds are perfected and matured, the pericarpia burst, and let them out.

The peduncles of fruits, when the seeds are matured, become dry ; that the fruit, by its own weight, or the slightest agitation, or by the wind, may fall from the tree.

The very frequent abortions, whether of flowers or immature fruits, seem to be in consequence of a law in the economy of the plant ; for some fructiferous trees produce a stupendous quantity of flowers : on which account it is necessary that many of them should fall, or be destroyed by the wind, cold, dryness, insects,

sects, showers, &c. before they are far advanced towards maturity, lest the boughs of the tree be broken by their weight, or the tree too much exhausted of its nutritious juices.

The number of seeds which some plants naturally yield, is beyond all conception. The *Zea mays* alone produces three thousand; the *Helianthus annuus*, four thousand; the *Papaver somniferum*, thirty thousand; the *Nicotiana tabacum*, forty thousand.

The seeds thus matured are disseminated on the surface of the earth, either by the elasticity of their capsules, or they fly of their own accord, or fasten to other substances by a peculiar apparatus, or are swallowed and not digested, but deposited with the excrement of the animal.

Thus the capsules of the *Impatiens balsamina*, when they rupture, throw their seeds to a very great distance; thus the seeds of the *Arctium lappa* fasten to the wool of sheep and the clothing of animals, and are conveyed to a distance; thus the seeds of *Mosses* and *Fungi* (which are so minute as to be almost invisible to the naked eye) and all seeds furnished with a plumous or pilous appendix, or an inflated calyx or pericarpium, or a kind of tail or wing; fly about from place to place, and are deposited

sited on high towers, and in distant countries. Lastly, thus the seeds of the *Loranthus europeus*, and *Viscum album*, are deposited in the trunks of trees with the excrement of birds, the seeds of the *Ligustrum* by the fox, &c. Hence, by manuring a field with the fresh dung of animals, innumerable weeds spring up, which did not exist there before.

The seed, by one of these methods deposited in the earth, evolves at the proper season, when the stimuli to vegetation are present, into its primordial parts: the nutritious juice is attracted from the earth by the absorbing vessels in the *hilum*, and the pulp of the seed swells, ruptures, and gradually throws off its *arillus*.

The FORMATIVE NISUS, or power of vegetation, thus called into action, expands the pulp of the seed into the cotyledons (when present) and corcule; and the former, like the placenta of animals, prepare a nutritious juice for the nutrition of the corcule.

The corcule, by the same power, shoots upwards into the plumule, which constitutes the stem, and downwards into the rosetel, which is prolonged, partly into the root and partly into the basis of the stem, elevating the cotyledons without the earth.

In this manner the developement of the plant commences. The little plant, having acquired strength enough in its radicles and leaves, absorbs by their means its nutrition from the earth and air; the cotyledons then become dry, and fall off. See *growth and increase* of plants.

C H A P. VII.

*Of the Age, natural Death, and Putrefaction of
Vegetables.*

THE AGE OF PLANTS.

THE continuance of life in plants is various ; they are however divided from their duration, into annual, biennial, and perennial.

Some trees and fruits arrive not only to a great but stupendous age : thus the Cedars of Lebanon have existed for two thousand years. In this country the Oak is the most durable.

The age of some trees may be ascertained by the number of ligneous annuli : it is however very difficult to distinguish these in many ; and in others totally impossible.

The life of vegetables, like that of animals, is divided into the same periods, and is also diversified by continual change : thus infancy is marked by the characters of weakness and

tendernefs ; youth acquires beauty and fize, the veffels attra&ct and convey their juices ; and the full growth is crowned with the robuft fibre, and full exercife of all its functions ; the fruit therefore ripens, but as old age advances the veffels begin gradually to harden and lofe their tone, the plant droops, the juices move no longer with equal celerity as in youth, the vital power ceafes, they ftagnate and corrupt, and the tottering plant is at length decomposed into its priftine principles.

THE NATURAL DEATH OF PLANTS.

By a law of nature all organized fubftances have a conftant tendency to diffolution ; and when the vital principle ceafes of its own accord, a plant is faid to die a natural death.

In perennial plants and fruit trees, and thofe which are not ever-green, the parts of the fructification only, and the leaves die every year, but are renewed the fucceeding one.

VEGETABLE PUTREFACTION.

When plants are deprived of their vitality, they foon become putrid, and exhibit feveral very curious phenomena, many of which are
peculiar

peculiar to them, and many also common to the animal kingdom.

The consideration of these is foreign to the present publication, and belongs particularly to the province of the chemist: we shall therefore conclude with observing, that the earth is continually manured by the putrefaction of dead vegetables, so that the ELEMENTS, disengaged by spontaneous decomposition, become again obedient to the common laws of chemical affinity; enter into new COMBINATIONS; form new principles; and at length, prepare new food for living plants, which constitutes the primary use of vegetable putrefaction.

THE
ANALOGY
BETWEEN
ANIMALS AND VEGETABLES.

—————" behold the chain of love
" Combining all below and all above.
" See plastic nature working to this end,
" The single atoms each to other tend ;
" Attract, attracted to, the next in place
" Form'd and impell'd its neighbour to embrace.
" See matter next, with various life endu'd,
" Press to one center still, the gen'ral good ;
" See dying vegetables life sustain,
" And life dissolving, vegetate again ! !"

POPE.

1800

1800

1800

1800

Of the Analogy between the Animal and the Vegetable.

TO discover the similitude that exists between the animal and vegetable kingdoms, does not require a very minute investigation : for such is the external structure and internal organization of both (as may be observed throughout the present publication) as to afford, in every respect, a very striking analogy, even to a superficial observer.

Nor do the laws by which their lives are regulated, and their various functions performed, appear to differ in many respects. In short, the analogy may be carried to such a degree of perfection, that the philosopher would be unable to distinguish the two, were sensibility and the locomotive faculty laid aside.

CHAP. I.

OF	OF
VEGETABLES	ANIMALS
IN	IN
GENERAL.	GENERAL.

A PLANT is composed of three parts,

Solids,
Fluids, and a
Vital principle.

The SOLIDS are formed of simple fibres.

The *simple fibres* constitute the hard and soft parts, as the wood, bark, leaves, &c.

The FLUIDS are divided into,

1. Those which have not entirely acquired the nature of the vegetable, as the *chyme*, *chyle*, &c.
2. Those which have partaken of the nature of the vegetable,

An ANIMAL is composed of three parts,

Solids,
Fluids, and a
Vital principle.

The SOLIDS are composed of simple fibres.

The *simple fibres* form the hard and soft parts, as the bones, cartilages, muscles, &c.

The FLUIDS are divided into,

1. Those which have not entirely put on an animal nature, as the *chyme*, *chyle*, &c.
2. Those which have partaken of the nature of the animal,

vegetable, as the *sap*, &c.

3. Those which are secreted from the *sap*, as the proper juices, &c.

From the chyme which is absorbed from the earth and the surface of the plant, the chyle is elaborated, which is propelled into the succous vessels, and constitutes the *SAP*.

The *VITAL PRINCIPLE* exists in every part of the plant, and constitutes its life.

When this *principle* thus universally diffused ceases to operate, the plant dies.

PLANTS that propagate their species by seeds, which, at a proper season, vegetate, and produce young plants, are called *Oviparous*.

PLANTS, that send forth buds or radicles to be separated from the parent plant at a proper period, and which then become perfect vegetables, are termed *Viviparous*.

animal, as the *blood*, &c.

3. Those which are secreted from the blood, as the perspiration, &c.

From the chyme absorbed from the intestines, and the lymph from the surface of the body, the chyle is produced; which is at length carried into the blood-vessels, where it forms the *BLOOD*.

The *VITAL PRINCIPLE* resides in every part of the animal, and constitutes its life.

When this *principle* thus universally diffused ceases to operate, the animal dies.

ANIMALS that lay eggs, which, at a proper season, are hatched, and bring forth young animals, are called *Oviparous*.

Animals which bring forth their young alive, and not enclosed in a shell, are termed *Viviparous*.

From

From what has been advanced in this chapter,
the following PRINCIPLES are deduced

I.

That animals and vegetables, are alike composed of *three essential* parts, namely, solids, fluids, and a vital principle.

II.

That the *barks* and *leaves* of plants are to the vegetable, what the *hard* and *soft* parts, are to the animal.

III.

That the *chyme*, *chyle*, *sap*, and the *secreted* juices of the plant are to it, what the *chyme*, *chyle*, *blood*, and the *fluids separated* from it, are to the animal.

IV.

That the *vital principle* is of the same nature in both, and appears to be governed by *similar* laws.

V.

That plants like animals are *oviparous* and *viviparous*.

C H A P. II.

Of the Seed.

The seed, when vivified by the pollen of the male, is capable of producing a plant.

The seed, thus impregnated, is an organized body, inclosing under various coverings more or less thick, the plant in miniature.

A glutinous, spongy substance, of a whitish colour, and more or less fluid in consistence, forms the internal structure of the seed. In this substance are found very small vessels, arising from every part, and running in every direction.

The seed, when put into the earth, by means of its vital principle, swells; the action of the vessels is induced; heat is generated, and it becomes a living plant. The delicate, spongy substance supplies the vessels with a fluid, which is conveyed

Of the Egg.

The egg, when vivified by the spermatic aura of the male, is capable of producing an animal.

The egg, thus impregnated, is an organized body, containing under various tunics, thicker or thinner, the animal in miniature.

A ropy, gelatinous liquid, more or less fluid in consistence, occupies its inside, and small vessels are seen spreading around it in every direction.

The egg, when warmed by nature or by art, by means of its vital principle, is stimulated to action; the vessels begin to contract and dilate, the animal becomes a living creature, and is supplied with a nutritious fluid from

conveyed to the embryo for its nourishment.

The plant in this manner begins to be developed, and gradually and insensibly increases in size. The coverings, unable to resist the pressure, give way, and the radicle having penetrated the small orifice or hylum, the shell at length splits in two. The root then pierces into the earth, and absorbs from thence a more copious nourishment. The young plant now begins to rise to the surface of the earth; the leaves unfold themselves, and, strengthened by the nourishment the radicles supply, it pierces through the earth, and advances into the air, supplied with every part in miniature.

the gelatinous substance it contains.

The animal thus becomes insensibly and gradually increased in size, the different parts are unfolded, and at length it occupies the whole of the egg, having exhausted its nutritious substance. Nature has by this time furnished it with instruments, by which it breaks the surrounding shell, and in a little time sets itself at liberty. The animal is now produced, enjoys a new life, and has, concealed in miniature, every part it at any future period may expose.

C H A P. III.

Of the Bud.

The bud lies concealed in the body of the tree, between the barks.

In

Of the Fœtus.

The fœtus lies hid in the body of the animal, within the uterus.

At

In the beginning it is extremely small, and covered (in a similar manner to the seed) with the bark of the tree.

It then sends forth very delicate and small vessels, which insculcate with those of the trunk, and absorb from them the sap, which it conveys to every part for its nourishment.

When arrived at a certain size within the trunk, it penetrates and protrudes through the bark into the air.

At its first appearance it pushes the coverings before it, but soon ruptures them.

The bud then unfolds itself, and in a little time exhibits the perfect plant in miniature; and derives its nourishment from the tree until it be torn or cut off, and placed in the ground.

At first it is extremely minute, and is inclosed in membranes in a similar manner to an egg.

In a short time it attaches itself to the mother by means of the small vessels of the placenta, which absorb the blood, and convey it to the child for its nourishment.

When all the necessary parts are developed, and the foetus has acquired a certain bulk, it brings on labour, and an animal is born.

At the beginning of labour the membranes protrude, but are soon broken.

The young animal is, at this time, unable to seek for food itself; the mother, therefore, either gives it herself, or procures some for it.

From what has been said in the two preceding chapters, the PRINCIPLES which follow are deduced.

I.

That the mucilaginous gluten in the cotyledon of the seed, is to the *vegetable* the same as the gelatinous fluid in the egg is to the *animal*.

II.

That the vessels of the cotyledon of the seed, are for the same purpose as those of the cotyledons and placentæ of animals.

III.

That both the seed and egg produce the plant and animal by a developement of pre-existing parts.

IV.

That the root is to the plant what the intestines are to the animal.

V.

That the seed is to the vegetable that which the egg is to the animal.

VI.

That the bud of the vegetable is to it, what the foetus is to the animal.

VII.

VII.

That the bark of a tree is to the bud, what the uterus of the animal is to the foetus.

VIII.

That the vessels of the bud which inosculate with the trunk of the tree, are to the bud what those of the placenta and cotyledons are to animals.

IX.

That the protrusion of the bud through the barks of the tree is the birth of a plant, and is to the vegetable what labour is to animals.

C H A P. IV.

Of the Nutrition of a Plant. *Of the Nutrition of an Animal.*

A plant is nourished by means of the absorbent vessels of the root and those of the leaves, imbibing a prepared chyme, &c. which is conveyed by them into the succous vessels, to be assimilated into sap.

The animal is nourished by means of the absorbent vessels of the intestines and those on the surface of the body, which absorb a prepared chyme, &c. and convey it into the blood vessels, to be converted into blood.

The absorbent oscula of the leaves continually take in air from the atmosphere, which, by a kind of chemical process, imparts to the sap its essential principles, which were destroyed; and the superfluous, noxious, and disengaged parts, are again expired.

The sap is conveyed, by means of the irritability of its proper vessels, to every part of the plant, for its developement and increase, and to serve for the various secretions and depositions; by means of which every part is formed by the continued impulse of the Formative Nifus.

The pores of the vessels on the surface of the air-cells continually transmit from the inspired air, by a kind of chemical attraction, that which the blood is in want of; and the noxious and disengaged parts are again expired.

The blood is conveyed, by means of the irritability of the vessels, to every part of the animal, for its growth and increase, and to serve for the various secretions and depositions; in consequence of which every part is formed by the continued effort of the Formative Nifus.

The PRINCIPLES to be deduced from *this* chapter, are,

I.

That the plant is nourished by a *similar* set of vessels to those which nourish animals.

That

II.

That the *succous* vessels are to the plant, what the *blood* vessels are to the animal.

III.

That the *leaves* of plants are to them what the *lungs* are to animals.

IV.

That plants, like animals, have their *proper* juices or *secretions* separated from a COMMON MASS; called the sap in the former, and the blood in the latter.

V.

That the SAP is to the vegetable, what the BLOOD is to the animal.

VI.

That the *motion* of the sap in the vegetable, is to it what the *circulation* of the blood is to the animal.

C H A P. V.

Of the Growth of the Vegetable. *Of the Growth of the Animal.*

A plant grows, and is increased by the gradual and insensible unfolding and extending of its parts.

This extension is followed by a proper degree of consistence, contracted by the fibres.

The extension diminishes as the hardness increases, and entirely ceases when the proper degree of consistence and the prescribed measurement is affected.

The seed and the bud are at first perfectly soft, and nothing ligneous can be detected; but at length the tender fibres become hard, and acquire the proper degree of firmness peculiar to the species. Thus hard wood, carneous substance, and parenchyma, are produced.

The animal grows, and is increased by the continual developement and extension of its parts.

This extension is always succeeded by a peculiar degree of consistence, proper to the fibres of the part.

Firmness of the part increases as the extension diminishes; and when the degree of consistence and the prescribed size is effected, the extension totally ceases.

The egg and the foetus are originally perfectly soft, and contain nothing like bone or cartilage; but as the tender fibres increase, they become firm, and give to each part its peculiar degree of hardness. Thus bones, cartilages, muscles, &c. are produced.

From

From the preceding chapter the *following*
PRINCIPLES are inferred.

I.

That the plant, like the animal, is produced
from pre-existing parts.

II.

That the growth of both depends upon the
extension of the fibres.

III.

That when the prescribed size is attained,
increase ceases.

IV.

That the essential parts of the plant existed
in the seed or bud, in the like manner as those
of the animal existed in the egg or the fœtus.

C H A P. VI.

Of the Fecundation of the Plant. *Of the Fecundation of the Animal.*

The very subtil, elastic
Vapour, contained in the
farina or pollen of the
anthera,

The very subtil, elastic
Aura, contained in the se-
men of the male, is the
principle

anthera, is the principle which fertilizes the plant.

The parts subservient to the formation of this vapour, are called the male parts of the flower or *Stamina*.

Each Stamen is composed of

The *Filament* and
The *Anthera*.

The vessels of the filament prepare a fluid, and convert it into the farina or pollen; which is then propelled through very minute ducts into the anthera.

The *Anthera* receives and matures the farina, for the purpose of fertilizing, by the act of impregnation, the tender and concealed seed.

The female parts of the flower are termed the pistils.

Each pistil is composed of

The *Germen*, or *pericarpium*,

principle which fertilizes the animal.

The parts immediately engaged in the formation of the Semen, are called the male parts of generation.

They consist of

The *Testis* and
The *Vesiculæ seminales*.

The vessels of the testis prepare the semen, and convey it through the vas deferens into the vesiculæ seminales.

The *Vesiculæ seminales* receive and retain the semen for fertilizing, by the act of impregnation, the tender and concealed ovum.

The female parts of generation are,

The *Ovarium*,
The *Uterus*, and

The

Its

The Style, and
The Stigma.

Its appendages.

The Germen or pericarpium contains the tender seeds.

The Ovarium contains within it the unimpregnated ovum.

The Style conveys the elastic vapour of the pollen through its cavity into the germen, where it fecundates the *seeds*.

The Uterus and Fallopian tubes convey the Spermatic aura of the Semen through their cavities to the ovarium, where it fecundates the *Ovum*.

The Stigma attracts and receives the pollen, exploded upon it by the rupturing of the anthera.

The Vagina and Uterus retain the semen transmitted into it from the vesiculæ seminales.

From this wonderful process of fertilization, the *following* PRINCIPLES are deduced.

I.

That the *Subtile vapour* of the pollen is to the vegetable, what the *Spermatic aura* is to the animal.

II.

That the *male* parts of the flower are to the vegetable, what *those* of the animal are to it.

III.

That the *vessels* of the filament of the plant,
like

like *those* of the testis of the animal, *prepare* the prolific vapour.

IV.

That the *antheræ* of the vegetable are to it, what the *vesiculæ seminales* are to the animal.

V.

That the pistil is to the vegetable, what the uterus and ovarium are to the animal.

VI.

That the germen is to the vegetable, what the ovarium is to the animal.

VII.

That the pericarpium and uterus are for similar purposes in their respective kingdoms, viz. to bring to perfection their young.

C H A P. VII.

Of the Death of Vegetables. *Of the Death of Animals.*

<p>A plant, after having escaped a variety of diseases, to which, from its organi- zation,</p>	<p>An animal, after having escaped a variety of dis- eases, to which, from its organi-</p>
--	--

zation, it is liable, cannot avoid the effects of age. The vital principle ceases to operate: the irritability (upon which the various functions depended) being thus inevitably destroyed, the plant dies; or, in other words, its elements are gradually decomposed and disengaged; in which state they remain but a short time; for the great *chemical laboratory of nature*, ever employed, unites them into fresh principles, to fulfil her immense design.

organization, it is continually exposed, cannot escape the effects of old age. The vital principle ceases to operate: the irritability (upon which all its functions depended) being thereby inevitably destroyed, the animal dies; or, in other words, the elements thus recover their former state, and become again obedient to the laws of chemical affinity; by which new principles are generated, and new beings formed.

The PRINCIPLES to be deduced from *this* chapter, are,

I.

That the *death* of a plant is of a *similar* nature to that of an animal.

II.

That *both* are alike subject to *Death*.

III.

That the functions of the vegetable, like
those

those of the animal, are dependent upon the *irritable principle*.

IV.

That the IRRITABLE PRINCIPLE of both is dependent upon, and governed by, the VITAL PRINCIPLE.

V.

That the death of the vegetable and of the animal is *constituted* by the *cessation* of the action of the vital principle.

VI.

That the vital principle having ceased to operate in the animal and vegetable, they are no longer subject to the laws of vital affinity.

VII.

That vegetable and animal substances then become obedient to the laws of chemical affinity.

VIII.

That the animal and vegetable, when deprived of their vital principle, do not perish, but only lose their organic structure, by the continual *circulation* of their ELEMENTS; the destruction of ONE becoming the generating cause of ANOTHER.

CON-

CONCLUSION.

THUS the analogy between animals and vegetables has been pursued, *in a general way*, from their birth to their death.

The sources of comparison that might have been brought forward are innumerable, and the extent to which it might have been carried is almost incredible; but as the great aim throughout the whole has been perspicuity, brevity was preferred to prolix description.

This imperfect sketch is, therefore, to be considered as an attempt to elucidate, in an elementary manner, a few of those laws which nature has so beautifully displayed, and invariably adhered to, throughout her universe. The contemplation of her secret operations, the admirable simplicity conspicuous amidst her empire (for nature is extraneous to that which is complex), have in every the remotest ages of mankind employed the genius of the philosophic mind. Monarchs themselves, retired from the weight of regal power, have culled the luxuriant plant to explore the periodical polity of the vegetable tribe; and even at the earliest dawn of science, the investigation

tion of this part of creation primarily attracted the enraptured imagination of the muse.

“ Such themes as these the rural MARO sung.”

But how incompetent is human effort to portray the beauties of this sublime subject ! How inadequate the most descriptive talent to approximate to our view the vegetative profusions contained within the recesses of nature ! How limited have been our public researches ! How contracted the knowledge which has been as yet obtained ! What an incomprehensive store remains yet concealed, impenetrable to mortal view ! The rude figures drawn on a wall by the hand of a child, do not so widely differ from the most finished performance of a RUBENS.

Should, however, this concentrated view meet the approbation of the learned, it is proposed to submit the similitude to a more minute inquiry ; to draw the parallel between the different orders, and thereby to pursue the examination from the more perfect and evident species of animals and vegetables, to those which are less perfect and less conspicuous ; and thus to investigate organized nature, and endeavour to establish general rules concerning her operations.

These

These pursuits point out the infinite number of modifications the elements continually undergo; demonstrate the grandeur of their origin, and exalt the mind to the contemplative admiration of that BEING, whose wisdom directs and agitates the whole.

Mysterious round! what skill, what force divine,
Deep felt, in these appear! a simple train,
Yet so delightful mix'd with such kind art,
Such beauty and beneficence combin'd,
Shade, unperceiv'd, so soft'ning into shade,
And all so forming an harmonious whole,
That as they still succeed they ravish still.

THOMSON.

THE END.

Incom 6/82

15
6
77
02/10