

**Chemico-physiological observations on plants / By M. von Uslar.  
Translated from the German, with additions, by G. Schmeisser.**

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CHEMICO-PHYSIOLOGICAL  
OBSERVATIONS  
ON  
PLANTS.



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CHEMICO-PHYSIOLOGICAL  
OBSERVATIONS  
ON  
PLANTS.

BY  
*M. VON USLAR.*

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TRANSLATED FROM THE GERMAN, WITH ADDITIONS,  
By G. SCHMEISSER, F. R. S. &c.

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EDINBURGH:  
PRINTED FOR WILLIAM CREECH.

1795.





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TO  
THE PATRONS AND PROMOTERS  
OF  
PHILOSOPHICAL INVESTIGATIONS  
IN  
*G R E A T B R I T A I N.*

**P**ERMIT me, Gentlemen, to lay before you this small Publication, containing some ingenious observations lately communicated to the public in the German language by Mr V. Uslar. I embrace this opportunity to make known to you a Gentleman, whose laudable endeavours are directed to the improvement of that part of the knowledge of plants and of vegetation, which has hitherto appeared the most obscure, and which has yielded least to the investigations of philosophy.



I have no doubt, but that some of you, to whom the various sciences are already so much indebted, will deem it not unworthy of them to examine the contents, and to improve upon what is here delivered. I have purposely avoided making any essential alteration in Mr V. Ussler's observations, and I have omitted no part which appeared interesting respecting the object of his publication, or which I knew to be not generally known in this country. But I have prefixed a general view of those principles, and of such of their properties, as I thought most worthy of attention, in the proper investigation of that interesting subject. As I considered part of the observations related in the original work, as not yet sufficiently and accurately ascertained, and that much must still be done towards the complete establishment of

of



of the theory, I have taken the liberty of inserting a short sketch of my ideas respecting Light and its properties ; in expectation, that this may be honoured with examination, by those who wish to contribute towards the improvement or correction of the subject of this publication ; a subject, surely well deserving the attention of experimental philosophers. Whatever I have to say upon, or to add to Mr Uslar's communications, I have purposely postponed ; as I have many experiments in view, which I shall perform with all possible accuracy, and of which, I shall communicate the results at another opportunity.

I hope to give then also an account of some subsequent observations, which Mr V. Uslar has promised on this subject ; and to be able to present some new observations, made by the ingenious Mr Hedwig,

Hedwig, whose merits are already well known to many in this country; and probably also, to make known some new discoveries, which I anxiously expect from Mr V. Humbold, a Gentleman already celebrated among the learned in Germany, by some ingenious publications on this subject.

I have the honour to be,

Gentlemen,

Your most obedient servant,

G. SCHMEISSER.



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## INTRODUCTION.

**H**APPILY the time is arrived, when Chemists and Physiologists unite their endeavours to investigate the nature, construction, composition, and functions of the vegetable tribe ; in order to perfectionate our knowledge of the Economy of Plants, and to display the many interesting and entertaining particulars, which the study of this branch of science is calculated to afford.

Many arts and sciences have already derived great advantages from the aid of chemistry, by the many improvements which that important study has suggested. But though Botany has met with great admirers, and has been cultivated by many original geniuses, little has it been advanced in proportion, by  
chemical



chemical and physiological inquiries into the nature of vegetables.

Chemists by their usual ardour of investigating every body which presents itself to them, have indeed discovered and pointed out, the immediate component parts of vegetables, and their various products or combinations. By ascertaining many of their chemical properties, they have shown how they may be further prepared to serve for alimentary, medicinal, and other useful purposes in the arts and manufactures.

What variety of successive phenomena do we perceive in visiting our gardens, fields, forests, and meadows, from early spring, till the close of the autumn; when, during this period, plants make first their appearance, proceed in their growth, and attain to perfection. But we should not be satisfied with admiring their external beauties, with knowing how to distinguish them by their external characters, and with collecting them or their products  
whenever



whenever they are fit to serve for our various purposes. Nor are we entitled to enjoy the contemplation of all the phenomena, and receive the manifold donations of those products of nature, nor surely to murmur at their accidental failure, or untimely decay, without enquiring more particularly into the causes of their diseases, to remove them if possible; and endeavouring to investigate the origin and progress of all these phenomena, and the causes whence they result: *e. g.* To ascertain the food of Plants, and the situation best suited to their respective constitutions, and the means by which they may most certainly obtain their proper nourishment; to discover their natural associates, as well as those which are inimical to them. Laudable, must therefore be every attempt or endeavour, which tends towards discoveries or improvements on so interesting a subject.

It is the express design of the present treatise,



tise, to enquire into several of these interesting particulars. How far the Author has succeeded in his endeavours, the candid reader must judge.

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## OBSERVATIONS

ON

## VEGETATION.

IN attempting to investigate the economy of vegetables, it is necessary to have a general knowledge of those substances and principles, that are found to furnish and produce the requisite supplies for the purposes of vegetation, as well as of such as may tend to destroy these supplies. Later discoveries in chemistry have shown that these principles are chiefly the following:—Matter of HEAT:—Matter of LIGHT:—OXYGEN:—HYDROGEN:—AZOTE or NITROGEN:—CARBO:—and their combinations.

A

HEAT.



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## H E A T.

THIS elementary principle, existing in all bodies, manifests itself by numerous phenomena resulting from its effects. It exists in different states according to circumstances afterwards to be mentioned.

In one, (probably its original state,) it is not perceptible by our organs of sensation, and is apparently inactive upon other bodies existing within its atmosphere. This state of heat, properly defined Latent Heat, is the source of all its other states, in which it becomes so powerful an agent for innumerable purposes necessary for organized bodies. Immortal, therefore, be the name of that great philosopher, DR. BLACK, to whom we are indebted for its complete discovery, which has led to so many subsequent useful discoveries in chemistry.

Latent



Latent heat, we find, exists in different proportions in different bodies ; and bodies have a different capacity of imbibing, accumulating, and combining with it.

The other state of heat, is that in which it manifests itself to our organs of sensation ; and in which it becomes active upon bodies presented to it. This state is occasioned by different causes. For instance, latent heat is set at liberty, so as to become active, by certain exchanges of the condition, or component parts of bodies, resulting from superior elective attraction among heterogeneous bodies, when brought into near contact ; as we observe, by the separation and exchange of the basis of oxygen gas, in the process of combustion and respiration ;--by the conversion of vapours into liquids, and of liquids into solids ;--by the crystallisation and sudden concretion of saline, vegetable, and animal fluids ;--by the sudden absorption and condensation of fixed air and water by earths, &c.

Whenever heat, in any of the above-mention-



ed cases, is set at liberty from a body, it always discovers a tendency to enter and pervade another presented to it, owing to its general attraction for all bodies ; on which account it cannot be confined, nor exist, in a perfectly free, or uncombined state.

The different degrees in which heat becomes more or less perceptible and active when set at liberty, will be in proportion ; first, to the quantity of latent heat in bodies ; secondly, to the quantity which is separated in a given time from bodies acting upon one another. Its effect on the substances to which it is applied, will be according to the velocity with which it can enter that body, and also in proportion to the capacity of the ambient, or intervening medium, for accumulating or retaining it. If, for instance, a homogeneous body, or also a chemical compound, be exposed to such a degree of heat as is incapable to destroy the chemical attraction of the parts of the compound, it then will gradually produce an equal effect upon such aggregate ; namely, it will merely



enter, occupy, and be accumulated in the most minute interstices of that body, and thus exert its expansive force, or self-repelling power, and thereby increase the bulk of the body, diminish its specific gravity, and occasion an alteration in it, which will continue only as long as heat is supplied; and the expansion will be in proportion as the quantity of heat supplied can overcome more or less the power of attraction of cohesion of particles, under the pressure of the atmosphere. In this case, on removing the body from the supply of sensible heat, its parts will resume their former state without having undergone an alteration in their nature; consequently, the heat applied to such had only produced a temporary effect. Examples of this we observe in the conversion of ice into water,—of water or spirits of wine, or essential oils, into vapour,—in the melting of wax, fat, gelatinous matter, metals, &c.

There are other cases, in which sensible heat when induced in a moderate degree, upon bodies of a heterogeneous mixture, will first occa-

sion



sion a similar effect; yet such bodies will be more or less decomposed or destroyed by an intense heat.

Instances of the effect of a moderate degree of heat occasioning a mere separation of the constituent parts of a mixture, without the production of a new compound, we can observe, on applying a moderate heat to a mixture, of fixed salt and water, of spirits of wine and water, of water and earthy matter,--to animal and vegetable fluids,--oils, and other vegetable matter, &c. In this case, the applied heat first pervades and expands the mixture, and then accumulating, gradually exerts a different effect upon each of the bodies, which effect will be in proportion as their capacity of retaining heat is to the power of attraction and cohesion between the particles of each of the bodies in the mixture. If, therefore, the capacity of one of the bodies (as water), for accumulating heat, exceeds the power of attraction of cohesion among its particles, and if the power of attraction of cohesion among



mong the particles in the other body (as salt), exceeds its own power of accumulating heat, then the expansive force of heat upon the particles of water, will be greater than that upon the particles of the salt, and as thus the specific gravity of water is diminished, the latter will consequently separate first, and will remain suspended in the atmosphere until it part again with that heat. When this happens, the water recovers its former state, and the salt remains undecomposed, parting likewise gradually with its share of accumulated heat and then the applied heat will be set at liberty again.

Another effect of sensible heat applied in a great degree to bodies of a heterogeneous nature, is a more permanent alteration or a total exchange of the component parts. Here a certain portion of sensible heat combines chemically or more intimately with some of these parts, and becomes thus latent, producing a new permanent and elastic compound (or gas), in which the heat remains in combination in the temperature



rature of the atmosphere in which it then exists, and can from that state be separated only by exposing it to such a body, as has a superior elective attraction for the substance to which it is combined. For instance, if we expose animal or vegetable juices, inclosed in a vessel, to a moderate heat, we observe, that the aqueous or more volatile parts first separate, and the less volatile remain; but when more heat is applied, then an exchange, or new combination of the component parts of the residuum will take place, and part of the applied heat will enter into a chemical or more permanent union with some of the principles of the compound, and produce thereby hydrogen gas; or it will combine with a new compound, as carbonic acid, and form the fixed air. Thus we perceive, that no specific effect can be appropriated to sensible heat, since much depends on its quantity and on the disposition of bodies, either to accumulate merely or to combine it.

Sensible heat in a moderate degree applied, promotes vegetation in a variety of ways; it excites the activity of plants; it promotes the disposition



position of some of their constituent parts for new attraction and combination, to obtain such substances as may be requisite for their growth; it likewise causes them to reject such matters as would be hurtful to them in retarding their growth, &c.; it promotes the dissolution or digestion, the formation, and secretion of their different products.

It supports the irritability of some of their parts, in disposing them to acquire and to retain a due proportion of the principle (the oxygen hereafter to be explained) which causes their irritability; and in preventing also the accumulation of this principle in plants, which may become hurtful to them.

It renders their food and juices, &c. more fit for penetrating and passing their different conducting canals; and enables them to dispose of their superabundant portion of fluids, by promoting perspiration and evaporation.

It is also active in the production of electricity, which likewise assists vegetation.



Sensible heat becomes also useful to vegetation in another way : after plants or animals have finished their period of life, or when purposely deprived of it, heat then occasions a dissolution, and new combination of their component parts, by fermentation, &c. according to the nature of the vegetable or animal matter; and thereby promotes the preparation of new food for living plants.

Thus we observe the numerous beneficial effects which heat has upon the process of vegetation.

But heat may prove fatal to the constitution of plants when applied in too great a degree, and for too long a time; as this may occasion a too rapid digestion and perspiration of their nourishment, and consequently an exhaustion. In such cases, plants will only recover by diminishing gradually the application of sensible heat, either by occasioning a slow evaporation of water upon their parts, or by other means.

LIGHT.



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L I G H T.

**L**IGHT I consider as a matter existing in bodies, and which, like matter of heat, may exist in different proportions in different bodies. It can manifest itself in various states, according to the capacity of bodies, for attracting, detaining, or combining with it, whenever it is set at liberty from one body, and induced upon another.

Light, in many of its properties, appears to differ from matter of heat; but heat seems to be a necessary agent for its perceptible and active state. I am also of opinion, that the production of the sensible states of both light and heat, results from their mutual action upon each other when excited.

Light does not enter into the composition of all bodies. Such as do not contain it, are not fit for inflammation, as earths, &c. but such bodies

may



may imbibe a small portion of light ; but they can retain it only under certain circumstances connected with the nature of their composition and structure, and according to the degree of external pressure acting upon them.

Bodies which contain light in their composition, and which are necessary for inflammation, or for the production of perceptible and active light and heat, and which in the combination with oxygen produce no permanent gas, I shall call *perfect inflammable* bodies, such as sulphur, phosphorus, hydrogen. And such bodies as contain it only in some of their component parts, and which produce gas during their inflammation, I shall call *femi-inflammable* bodies ; as oils, camphor, spirit of wine, wood, &c. And we may thence suppose, that bodies contain more or less light in their composition, in proportion as they exhibit the phenomena of inflammation, when properly disposed for it.

Light and heat may, at the same instant, be  
separated



separated from certain bodies (though not strictly inflammable).

*1st*, By external causes, as by collision, friction, or condensation. The production of sparks, when two bodies, as flint and steel, &c. are suddenly and violently struck together, affords a familiar example of this separation.

*2dly*, Light may be disengaged from its combined state, by the mutual action and new combination of certain heterogeneous bodies. To occasion this, it is not only necessary that at least one of the bodies be an inflammable one, and that those bodies which are to act upon one another have a chemical attraction for combination, and be assisted by sensible heat necessary to promote their attraction; but also, that the one body have an attraction for the basis of the inflammable body, superior to that which the basis has for light.—Farther, two heterogeneous bodies, whatever they may be, which have no chemical attraction for one another, cannot combine, and consequently cannot



not emit sensible light and heat. Hence we observe no such interchange takes place on mixing sulphur or phosphorus, with gold, platina, &c.; or hydrogen with sulphur, or phosphorus, exposed to sensible heat. An intimate combination of such a nature, therefore, of two bodies, as mentioned before, is necessary for the production of inflammation.

Sensible light thrown upon bodies which do not transmit nor reflect it, but which imbibe it, but do not retain it, seems to disengage their latent heat; and combining with the latter, gives to it elasticity, and thus produces by such combination sensible heat.

We likewise observe, that inflammable bodies cannot produce the phenomena of inflammation, or emit sensible light without the assistance of sensible heat; and many inflammable bodies will not part with their latent heat, unless their latent heat is excited by sensible light. In the inflammation of an inflamed body, a mutual action



tion and re-action of both principles appears to take place: and accordingly it seems that camphor, resin, spirit of wine, oils, &c. will not inflame by the mere application of heat: but they will do so if sensible light, accompanied at the same time with sensible heat, is applied; as, for instance, in the case when the inflammable body is excited by flame.

It likewise appears, that heat alone cannot dispose all inflammable bodies to combine with the oxygen from the atmosphere; the matter of light latent in these bodies having perhaps a greater attraction for either of their combined parts; and that they will therefore not give out their light until their latent heat be at the same time excited by the action of sensible light applied.

When light is set at liberty during this combination, it will then be visible or not, according as it is, or is not, disposed to combine with another matter, in the moment of its being set at liberty. For instance, when light set

at



at liberty, is immediately, either partly or wholly, disposed to unite with another matter, as that of heat, to produce elastic sensible heat; or when that again is employed for the production of gasses or vapours, then little or no light will become perceptible, and more sensible heat will result accordingly from it. But when light is set at liberty in a greater proportion from the inflammable body, than what the matter of heat in those excited bodies can consume, or combine with, for the production of sensible heat, and where no elastic fluids are produced which can take it into their composition; then more light will become perceptible, and in proportion active.

The perceptibility, or active power of the light extricated, will be greater in proportion as the excited bodies yield that principle in a greater quantity, and as the velocity with which it can enter the bodies is greater, and as bodies can combine more readily with it. The more slowly the combination of such bodies takes place, the less



less will be the quantity of light separated at the time, and consequently, the less its effects.

As the disposition of bodies for chemical combination is promoted by heat, it therefore seems that heat is a necessary medium for inflammation; and that, therefore, much depends upon the degree in which that agent is applied to bodies disposed for combination. We observe but a small quantity of visible light by exposing phosphorus or sulphur in the atmosphere of a low temperature, and a great portion, when more heat is applied.

We shall now endeavour to explain, how oxygen gas is not always necessary for the production of light and heat. The combination of other bodies may occasion the same phenomena, provided that one of the bodies be an inflammable one, and consequently containing light, and that all the other circumstances formerly described be present. For instance, if we dispose sulphur and certain metals, as iron or copper, for combination effected by heat, we perceive the



same phenomena, namely, the production of light and heat, without their being exposed in oxygen gas, or any other gas containing that principle; which experiment was lately performed by some well known Dutch chemists, and which any one may easily repeat: indeed the above-mentioned substances will exhibit the phenomena in azotic or hydrogen gas, or in a vacuum; but inflammable bodies, exposed in either of those gasses *per se*, cannot do this, because they do not under these circumstances enter into combination with the basis of either of the gasses, which would be necessary, as observed before.

Oxygen can only produce these phenomena, when it is exposed to inflammable bodies for which it has an attraction of combination, such as sulphur, phosphorus. And it produces the phenomena in a greater degree than other substances, from its superior and more rapid attraction for, and combination with those bodies; and likewise, from the circumstance, that the combinations of these bodies

dies



dies are not attended with the production of gasses and vapours. It may now be perceived, how oxygen is a necessary medium for the production of light from such inflammable bodies as are chiefly composed of hydrogen, as spirits of wine and oils.

Oxygen is likewise requisite for the production of sensible heat in the combustion of charcoal, as it has a strong attraction for that substance. From these and other observations we conclude, that more sensible light and heat are produced by inflammation, in proportion as that process is less attended with the production of elastic fluids.

If, therefore, the proportion of hydrogen exceeds that of carbon in semi-inflammable bodies, then there will be more light set at liberty; and on the other hand, if the carbon predominates, there will be less light and more heat.

Now, in the inflammation of spirits of wine, oils, &c. in oxygen gas, there are both light  
and



and sensible heat set at liberty, which continue perceptible, as long as the supply of both continues. But, we perceive, that this process is attended with a continual loss of light and heat; which is to be accounted for, as a certain quantity of light is immediately employed in the production of sensible heat, from the inflaming body; that a great quantity of heat is likewise employed in the production of fixable air, arising from the combination of carbon in the semi-inflammable body, and the oxygen from the atmosphere; and also, that another portion of sensible heat is employed for the formation of vapours from the water which is formed by the combination of oxygen from the atmosphere, and the hydrogen in the spirit of wine: Whereas, by the combination of phosphorus or sulphur, there is no heat combined, and there is no gas and no vapour produced, as explained before; and that portion only of light disappears,



pears, which was necessary to excite the latent heat in those bodies.

Light, when thrown upon bodies, which do not transmit nor reflect it, but which have a capacity of imbibing it, may become active upon such bodies, as is the case in plants, either by combining strongly with their latent heat, and converting that into sensible heat; or by occasioning, at the same time, a separation of the oxygen or other matter of such bodies, with which it can combine; and thus, in conjunction with matter of heat, produce elastic fluids: or it may partly be detained in bodies; and such bodies will emit it gradually again in the state of visible light; as we observe of certain substances. This property of accumulation and emission of light by certain bodies, is more perceptibly occasioned in them, when previously prepared for it by the effect of heat; first in producing by heat an expansion of such bodies; then exposing them to a strong light, as that of the sun; such bodies will, in proportion as they



they possess those mentioned qualities, imbibe more or less of that light, and will give it out again in a visible state, in proportion as they contract, and when placed in a dark room. This we observe in a certain species of heavy spar, called Bononian stone, and other substances. There are salts which, when exposed to much light during their crystallisation, will afterwards emit light; other salts will emit light when rubbed in a mortar in a dark place; as, for instance, the corrosive sublimate, &c.

Light thrown upon bodies, which do not transmit nor combine, but which reflect it, produces no sensible heat upon them, and it suffers no change. This we observe when sensible light is thrown upon certain metals with a polished surface.

Sensible light, falling upon bodies which are transparent, as glass, gasses, &c. when perfectly homogeneous, is transmitted, and has no apparent effect upon them. Thus the more homogeneous that such bodies are, the less is the diminution



nution of the intensity of the light which pervades them, and the less is the sensible heat which is produced in them. This coincides with M. De Luc's opinion, that there is in proportion more light induced upon bodies, existing on or near the summits of high mountains, and consequently less heat produced in that atmosphere ; and that there is less light reaching the surface of lower ground, as the light descending through the lower region of the atmosphere to the earth, is partly absorbed, and variously interrupted by the heterogeneous bodies in the lower atmosphere, by which the intensity is greatly diminished.

From what has been observed respecting the properties of light, we may perceive in what respect light may be beneficial to plants in general.—Light induced upon plants, may excite heat, occasion the separation of oxygen, and convert other matters into elastic fluids. It may greatly contribute to the formation of the inflammable matter produced in plants, such as  
oils



oils and refinous matters. The formation of such substances is very remarkable in hot climates, and perhaps chiefly depends on the faculty possessed by light of separating the accumulating oxygen, as oxygen destroys the inflammability of bodies.

Light, therefore, seems thus to promote the increase of inflammable matter, only in those plants whose component parts have not a greater attraction for oxygen, than the oxygen has for light and heat, as we may expect in plants which assume an acid nature.

Light induced upon plants occasions a change in their colour, either by entering into their constitution, or by separating the oxygen which causes, in proportion to its quantity, a modification of their natural colours; and by which separation of oxygen, it supports the irritability of plants, as that appears to depend upon this principle, as has been before observed.

Living plants discover a disposition to attract light, and when in want of it, search for it, and direct



direct the extension of their tender or flexible parts towards a place where they can reach it. Certain parts of plants, as flowers, manifest a disposition to present themselves, so as to receive fully the rays of the sun, or they direct their faces towards the sun: This disposition, Mr Girtanner ascribes to the effect of light upon certain fibres peculiarly constructed, as will be seen in the sequel of this book.

I shall finish the subject of light with the observations, that plants may receive light from gasses which contain it, as before mentioned, by imbibing and decomposing them; and that plants may thus receive light, when growing in a situation excluded from the sun, as in thick forests.

D

OXYGEN.



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O X Y G E N.

OF all the principles necessary for the support of organized bodies, oxygen may be considered as one of the most active. It received that name, which signifies the *generator of acids*, from its investigator MR. LAVOISIER; who found it to be a necessary principle in the formation of acids. The existence, and some of the properties of this principle, were already known to, and related by, Dr. John Mayow\*; and also by Dr. Rutherford, the discoverer of phlogisticated air. But Lavoisier has certainly investigated its properties, and active powers, more than any other chemist; and has consequently the greatest merit,

\* In a Treatise published in 1674.—Oxford.



merit. It exists in different bodies, variously combined, and manifests itself, by the various effects which it produces when separated from any of its combinations, and when acting upon other bodies, and entering into a new combination with them.

It is set at liberty from its combined state in consequence of other bodies acting upon it, or upon the substances with which it was combined, by a superior power of chemical elective attraction. *1<sup>st</sup>*, It exists in water, combined with hydrogen. *2<sup>dly</sup>*, In the atmosphere, combined with matter of heat, (and as I believe, likewise with light) and constitutes, in that state a part of the atmosphere, to which it gives the quality of supporting life, combustion, and inflammation. *3<sup>dly</sup>*, It exists in fixed air, combined with carbonaceous matter, to which it has a strong attraction. *4<sup>thly</sup>*, It is the principal component part of acids, combined with the acidifiable substance of animal or vegetable matter. *5<sup>thly</sup>*, It exists



ists combined with metals, which it deprives of their lustre, inflammability, cohesion, &c; and, which are thereby rendered capable of entering into different combinations with other bodies. It has, when applied to vegetables, a great effect upon their growth; and, when plants are too much deprived of it, or when they are overloaded with it, it then proves hurtful to their constitution. It contributes to the motion of plants, as it causes the irritability of some of their parts; and the various degrees of this irritability depend on the different proportions in which it enters, or is accumulated in them. The due proportion, which plants thus require for their irritability, &c. depends, likewise, upon the substances which surround and act upon them. The supply of this principle is produced by such substances as contain oxygen; and this, the more readily, according to the weaker combination of the oxygen with the other substances with which it is united: Hence, combinations in  
which



which the oxygen is retained with very little force, as for instance, super-oxygenated muriatic acid, are most fit for that purpose; for plants can only obtain the oxygen from its other combinations, in so far as they have a power of occasioning a decomposition of these combinations. But this power depends much on the temperature in which the plants grow.

Whenever plants imbibe oxygen, in a greater proportion than what they naturally require; (which may be occasioned by the absence or diminution of the principle which causes the separation of oxygen), then an accumulation of oxygen takes place, which occasions a proportionally greater degree of irritability; and which, consequently, may become hurtful to the constitution of plants.

The principles which cause the separation of the oxygen, are light,--hydrogen, assisted by heat. Hence, the due proportion of oxygen in plants, depends on the different degrees in which any of these principles are applied, or  
can



can act upon them. Thus, a moderate portion of these exciting principles will occasion a preservation of the due quantity ; a less degree, an accumulation ; and a greater degree, a diminution : The two last will occasion a gradual exhaustion of such plants.

Oxygen has also a great effect upon the colours, and upon various parts of plants ; and greatly contributes to the formation of their products. It is an ascertained fact, that the super-oxygenated muriatic acid, which has been found to consist of 1,856 parts of muriatic acid ; 98,105 of water ; and 0,093 of oxygen, deprives green plants of their colour ; or changes them into white, yellow or reddish. What takes place by that acid immediately, can but slowly proceed by the oxygen in the atmosphere, owing to the almost equal attraction which oxygen has for the colouring matter of the plants, and for the matter of heat and light.

It appears, that the colours of plants become  
paler



paler the more oxygen they imbibe, and that the modifications of the green colour depend on the different proportions of oxygen. Thus, we may explain many phenomena that occur during the vegetation of plants. The *hilum* of young seeds is generally colourless, so are the *petals* of the flowers, when perfectly included in the *calyx*.—Leaves, when they first appear, are of a pale colour; owing probably to the oxygen, which, at that period only, begins to be extricated by the effect of light and sensible heat; and thus permits the colouring matter to make its appearance. In the same manner, may the change of the green colour of leaves into yellow, which we observe in the autumn, be explained. Vegetation generally stops in that season, and plants then approach to their winter's rest; the secretion of oxygen diminishes, and the quantity gradually accumulates during that time, and consequently deprives them of the green colour.

The extraction of oxygen from plants by the  
effect



effect of radiant light, arises perhaps, from the superior attraction of oxygen for light. Some plants, as tremella,—noctoc,—filices,—musci,—and algæ, retain the oxygen weakly, and part with it easily.

This explains how plants change their colours, by the free access of air; why plants growing in the shade have generally a pale colour; and why plants, entirely excluded from light, lose their colour; as in that case they are deprived of, or excluded from, those agents which occasion a secretion of the accumulating oxygen, on which the change of colours chiefly depends\*.

The separation of oxygen from plants, may be ascertained, by applying a little diluted acid, such as oxalic, nitric, &c. Plants, or their parts, which contain much oxygen, and  
part

\* That hydrogen gas, applied to plants excluded from light, occasions a separation of their accumulating oxygen; was first ascertained by Mr. Humboldt.



part easily with it, are generally green; and those which contain a great portion, but lose it with more difficulty, are, in proportion, either white, or spotted: As for example, Lichen *miniatus*,—*L. parietinus*,—*L. verrucosus*,—different petals,—ripe apples,—barks,—and bractæ, when growing in the shade.

The different effects which oxygen produces upon plants, when growing in different places, and exposed to a different atmosphere, have led several botanists to mistake trees of the same species: For example, the *betula* and *tinus*, growing upon the *Brokken*, (a high mountain in Germany on the Harz) on account of their smaller size, and deeper colour of the leaves than usual, when growing in a different atmosphere, have been mistaken for new species. Such variations had been ascribed to the effect of different climates and soils; but botanists did not suspect, that any such effect arose from that great agent oxygen.



The cause of the deeper colour of those plants, or of their leaves, is probably,

*a.* The more intense light, transmitted through the atmosphere surrounding the summit of such a mountain, and acting freely, on all sides, upon those solitary trees.

*b.* The different state of the purity of that atmosphere, and the superior capacity of that fluid for receiving oxygen.

*c.* The stronger, and more lasting cold, which causes a great alteration in the irritability of plants by the increase of oxygen; which is, in proportion, separated again by each increasing degree of light.

The effect of light, oxygen, and carbo, upon colour, is equally observable in animals and plants. Besides the well known observations, that the products of hot climates are of a deeper colour than those of the northern; Mr. Ussler observed, that he found repeatedly, the *rana arborea* change its colour, by living in different



ferent situations; the more it was exposed to the sun, the deeper its green colour became; and the green colour changed into a whitish grey, as he observed also of some plants, when it had lived a considerable time mostly excluded from light, or when confined within walls. Perhaps, aliment, climate, and confinement, contribute to the change of colours in organized bodies.

The existence of oxygen in plants, is shown by their becoming acidified, or oxydated; and by their undergoing an acid fermentation. Besides, it is found, that certain plants contain perfect acid in their composition. Such are generally of a pale green colour, as the *oxalis acetofella*. The *boletus suberosus* yields saccharine acid during its growth. The oxygen gas which, we observe, is extricated from plants when exposed to the effect of light, &c. affords another proof that they contain oxygen, or take it into their constitution.

The colouring matter of plants appears to reside in, or to be produced in, the resinous parts,  
in



in combination with oxygen : For instance, if we extract the green parts of plants by spirits of wine in a vessel excluded from light, filter the infusion, and fill with it a phial half full, and expose it slightly corked to the rays of the sun, or to the light of a large burning lamp ; we then observe, that the green colour soon inclines to yellowish. This change, however, does not take place if the bottle is totally filled, or excluded from the access of pure air ; nor when the infusion is kept in a phial, in contact with nitrogen or hydrogen gas. So we find, that the tincture of turnsol, when excluded from light, retains its colour, but loses it on exposure to much light.

Oxygen renders many volatile substances more fixed in the fire ; as we observe of sulphur, phosphorus, and vegetable substances, when combined with it. It also destroys the inflammability of bodies by its combination. Though it appears, that oxygen, when in great proportion, covers the colours of plants ; yet it likewise  
seems,



seems, that in a small proportion, it contributes to the formation of certain colours. Thus, Dr. Bancroft, in his learned treatise on permanent colours, attributes the black colour of charcoal to the combination of oxygen with the carbonaceous matter; and he considers the charcoal as an oxyd of carbon. He observes, that the tincture of violets, when it has lost its colour in close vessels, recovers it by oxygen gas.

Oxygen seems also to be the principal cause of the different colours of the oxyds of metals.

We shall conclude this article, with an extract, containing the result of the ingenious observations made by Fourcroy; who proved the existence of oxygen in plants, by analytical and synthetical experiments. He observes,

1. That oxygen combined with vegetables alters their colour:

*a.* Their colour becomes paler by an increase of oxygen,

*b.* Deeper by a diminution of it.



2. The various modification of colours, exhibited by plants, depends on the different proportion of oxygen, which they take into their constitution.

3. Plants saturated with oxygen lose their green colour entirely ; and a yellow colour is the result of the change.

4. Plants not saturated with oxygen, may appear violet, blue, brown, or purple.

5. Oxygen entering into the constitution of plants, occasions a change in their nature, in proportion as they imbibe it. Oxygen likewise appears to be favourable to the formation of resinous matter.

## HYDROGEN.



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HYDROGEN.

THIS principle we cannot, as yet, exhibit in a separate state, its properties are only discoverable by its combinations. In its combined state it manifests remarkable phenomena, which differ according to the nature of the substance with which it is combined.

It exists principally in the composition of water, which has been verified by synthetical experiments, made by the ingenious philosopher MR. CAVENDISH, and Lavoisier; and it thence received its name, which signifies the *generator of water*.

In the composition of water, it is combined with oxygen, and in this state it is not immediately inflammable; but, when that combination is destroyed, by the effect of a superior elective



lective attraction, of certain bodies, for the oxygen with which it has united ; as for instance, by metallic substances or charcoal ; it then is set at liberty, so as to enter into another combination ; in which case it assumes a different state, and exhibits different phenomena, according to the nature of the matter with which it combines.

If it unites merely with sensible heat, it then produces a compound which is inflammable, or which, when light and heat is applied to it in contact with atmospheric air, is capable of exhibiting the phenomenon of inflammation ; in that state it is called hydrogen gas or inflammable air.

This compound elastic fluid is lighter than atmospheric air, or any other gas ; it does not support life nor combustion like oxygen gas ; but it is in that state, capable of disengaging the accumulated oxygen from plants as observed before. When it is set at liberty from the composition of water, without the presence of a  
sufficient



sufficient quantity of sensible heat, it then has a disposition to unite with other matters; as, for instance, with carbonaceous matter, and may thus produce an oily compound, or enter into other compositions, and thus become an aliment to plants.

Sometimes we observe, that plants emit hydrogen in the state of inflammable air; such as, *Dictamnus albus*, or *Fraxinella*, when it is in flower; and likewise most of the fungi and byssi, by reason of the greater attraction of their component parts for oxygen.

Sometimes the hydrogen gas thus emitted by plants is observed to have united with a little of carbonaceous matter; and in that case, the heavy inflammable air is produced; such is the air emitted by *agaricus campestris*.

Occasionally we find plants containing sulphurous or phosphoric matter; and such plants may emit the hydrogen in the state combined with either of these, and it will therefore appear in the state of either hepatic air or phosphoric gas.



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## AZOTIC PRINCIPLE.

THIS matter we cannot exhibit in a separate state, its properties are only distinguishable in its various states of combination.

In the state combined with heat, it was first discovered by the eminent Chemist, DR. RUTHERFORD, Professor of Botany at Edinburgh; it was then called Phlogisticated Air, but now Azotic Gas, on account of its having the opposite quality to that principle which supports life. It exists in the state combined with heat in the atmosphere; and mixed with a certain portion of oxygen gas, it forms the essential composition of atmospheric air.

It exists in the atmosphere, apparently for the purpose of modifying the effect of that powerful agent, the oxygen, in the process of respiration



tion of animals and plants; as oxygen gas alone may become hurtful in many respects. It serves also for modifying the rapid effect of oxygen during combustion and other operations, and thus also enables us to modify the heat extricated from bodies during their decomposition and combination.

It is most likely, that in that state in which it exists in the atmosphere, it enters into combination with another body, and produces new compounds.

It constitutes, according to the discovery of Cavendish, Lavoisier, and Priestly, the basis of nitre and nitrous acid, and also of nitrous air; these three substances differ from one another, only in the proportion of the oxygen to the azotic principle, of which the latter, the nitrous air, contains the smallest; but this has a strong tendency for saturating itself with oxygen whenever it can receive it from a surrounding body, as, *e.g.* the atmosphere; and hence it has been found useful for ascertaining the quantity of oxygen



gen gas contained in certain mixtures of gases, as in the atmospheric air, &c.; as may be seen from the publications of different authors, as Dr. Priestly, Ingenhouz, &c.

The azotic principle combined with a due portion of oxygen, forms nitric acid; this has a strong disposition to combine with many other bodies, as *e. g.* with alkaline salts, in combination with which it is found in certain plants and earths.

The azotic principle has also, when set at liberty, an attraction for hydrogen; with which, when combined in a due proportion, it forms ammonia or the volatile alkali, a substance likewise found in some plants, united with acids.

Azotic gas, or azote combined with heat, may be obtained free from oxygen, with which it is mixed in the atmosphere, by exposing to atmospheric air a body which has a superior elective attraction for the oxygen, and which will therefore absorb the oxygen; as for instance, phosphorus or heated sulphur. It is set at liberty when mixed with fixable air, by the process of combustion



combustion of charcoal, or more difficultly by respiration.

When combined with heat, it cannot support life nor combustion; and therefore, its presence, when not accompanied by oxygen, must be more or less hurtful to animals and vegetables in the process of respiration, &c; yet its other qualities soon prevent the bad effect which might arise from its presence: As for example, its being lighter than atmospheric air, causes it to rise in it, or to leave that part of the atmosphere where it has been deprived of the oxygen either by the process of respiration or combustion, and consequently, it is carried off from the place where it might have been hurtful to organized bodies, and have interrupted the process of combustion.

Most plants soon die when exposed in it, but there are some which continue to grow in it, such as *Lichen verticillatus*,—*L. aidelus*,—*L. radiciformis*.—*L. pinnatus*, and most of the  
byssi;



byffi;—*Agaricus acephalus*,—*A. aberuntius*,—*Boletus botryoides*, &c; according to the observations of Mr. Humboldt, and Scopoli.

## CARBON.



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## C A R B O N.

THIS matter we consider as one of the principal constituent parts of vegetables. And it appears, that it enters and accumulates in the constitution of plants in proportion to their successive growth.

Some plants however, take more into their composition than others, *e. g.* *Agaricus quercus*,—*A. antiquus*,—*Boletus versicolor*,—*B. igniarius*,—*B. striatus*,—*B. perrennis*,—*Clavaria hypoxylon*,—*C. pistillaris*, &c. ; all these contain, from the results of analysis, a quantity almost equal to all their other component parts; but others; as *Lichen crispus*, *pinaster*, *granulatus*,—*Agaricus piperatus*—*Clavaria aurea*,—*Peziza agaricus*, *Lycoperdon tessellatum*, contain a very small portion of carbon.

Carbon



Carbon is obtained from plants in its most simple state by heat; namely, in exposing vegetable substances, excluded from the access of pure air, to such a degree of heat as to separate all the volatile substances with which carbon is combined; in which case, all that adheres then to the remaining carbon may be a few earthy or fixed saline particles, which may be separated from the carbon by water and acids.

From some experiments it appears, that carbon in that state retains a certain portion of water, and according to Dr. Bancroft, also a portion of oxygen which causes its black colour. When, therefore, carbon in that state, is exposed in a close vessel, and a great degree of heat applied, that portion of water may then be decomposed, and thus yield hydrogen gas, and likewise fixed air according to the new theory.

Carbon obtained from vegetables in the above-mentioned process, is a black, light, opaque, matter, which is insoluble in water, and as far

as



as we know in any other fluid which does not enter into a new combination with it ; it is further indestructible by the mere effect of heat, and is not inflammable when excited by heat and light alone.

But, it has an attraction for combination with other matters ; as for instance, for oxygen assisted by heat ; in combination with which, it produces the carbonic acid ; and that, by the additional combination of sensible heat, produces that elastic fluid called fixable air or carbonic acid gas, which is the general result of the combustion of inflammable substances which contain carbon in their composition. In this state of combination it is absorbable by water, and thereby rendered fit to enter the constitution of plants. For the knowledge of the properties of that combination, we are indebted likewise to the great Dr. Black.

It appears, from the results of some experiments, that carbon is a compound ; and some are of opinion, that it consists of hydrogen and the



azotic principle ; this supposition certainly deserves the attention of chemists, as in that case, we might be able to explain the formation of carbonaceous matter in plants growing in a situation merely surrounded by sand, water, and atmospheric air, in which no carbon has been discovered ; for even then, plants in the course of their growth obtain a great portion of that matter, in which case the water may be supposed to afford the hydrogen, and the atmosphere the azotic principle.

The editor of this essay, intends to enquire by experiment into the truth of this opinion, by exposing a plant to mere water and a sufficient quantity of atmospheric air free from carbonic acid, in order to find, whether, in the course of the growth of the plant, the quantity of azote is greatly diminished ; and also to examine what quantity of carbonaceous matter the plant may then contain in its composition ; in this experiment, it can easily be contrived to give an additional supply of oxygen gas if necessary.

However,



However, as it is, carbon may be useful in many respects in promoting the growth of plants. In the state of carbonic acid, it may serve as a stimulus, or as a supply to plants: In its other state, it may serve for separating the oxygen from such combinations as surround plants, and which may have a noxious effect upon them; or it may promote the dissolution of old, and the formation of new, combinations.

In the mixture of carbonic acid and heat, as fixable air, on entering the respiratory organs of living bodies, it soon extinguishes life; but, when introduced into the other parts of living bodies destined for digestion, &c. it discovers beneficial qualities.

The noxious quality of fixed air upon respiration and combustion, is however happily modified or prevented by one of its other qualities, and by the properties of other substances; in the first place, it is heavier than atmospheric air, and consequently, it occupies (when formed and set at liberty,) the lower region of the atmosphere,



mosphere, and cannot thus exert its hurtful quality in that part of the atmosphere from which our respiratory organs receive their food, and from whence combustion is supplied; secondly, it is absorbable by water and different earths, by which it is therefore taken up and afterwards conveyed to those parts of plants, upon which it induces a beneficial quality.

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THE earthy and saline particles, which are occasionally found in the analysis of plants, seem not to be peculiar to their composition; as there are plants, in which we scarcely discover any, and others again which contain a great quantity of them: So for instance, earth is found in a great proportion, in *hypnum cristacastrensis*, and *neckera dentroides*; and Mr. Humboldt found by an analysis, that the *chara vulgaris*



*vulgaris*, contained about  $\frac{1}{3}$  of calcareous matter.

Earths probably enter plants, in a state prepared by carbonic acid and dissolved in water; in this state, earth may part again with the carbonic acid, by a new combination with the acid formed in vegetables, and may thus produce the vegetable selenite which is found in plants. Earths in which plants grow, may become very useful to them in many respects: As for instance, by attracting and absorbing moisture or other nourishing effluvia from the surrounding atmosphere, and communicating such to the proper parts or organs of plants in a due proportion, according as they may require it in the different periods of their growth: Farther, by imbibing the matter secreted by the roots of plants, which might become hurtful either to themselves, or to those growing near them; by absorbing and retaining the hurtful part of some of their applied food, or other destructive matter which their decomposition may produce.

Earth



Earth is likewise useful to plants, in preventing by its cohesive power a too rapid extension of their roots, so that these may acquire a proper firmness, both to sustain the different effects induced upon them by their surrounding medium, and to prevent, by its interposition, a too sudden effect upon them.

Earths have also the quality of imbibing such matter from the ambient atmosphere, as fixed air, which may become noxious to the different parts in the atmosphere.

Earths or soils become beneficial to vegetation, by their property of imbibing light falling upon them, by which sensible heat is produced, which heat occasions a moderate evaporation of humidity, and disposes such to enter the plants. This evaporation is attended with the production of a moderate degree of electricity, likewise useful to vegetation; and lastly, the heat thereby produced, becomes active in promoting a gradual dissolution and preparation  
tion



tion of their applied food, &c. Vide Article  
HEAT.

Other substances, as saline bodies, may be useful in promoting the growth of plants, by acting as a stimulus upon them when they are exhausted, or when they are too much excluded from the other general agents which excite and support their irritability, or may become a substitute of the absorbent earth, or modify a too strong cohesion of certain soils: As for instance, the muriates and nitrates of alkaline substances, selenites, &c.

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AMONGST all the above-mentioned substances which are necessary for vegetation, we find water, in its fluid state and of a moderate temperature, is certainly the most essential substance; and not only, that its component parts enter into the composition of plants and their products, but that it likewise enters the vessels of  
plants



plants in an undecomposed state, extends them, modifies the heat, conveys their various foods to their different parts, and gives fluidity to the component parts of their juices, and thereby renders them more fit for circulation. It refreshes exhausted plants, acting as a stimulus; and lastly, it disposes the substances intended for their food to dissolution, as it is necessary, for fermentation, or putrefaction.

## PLANTS.



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P L A N T S.

PLANTS, placed immediately after animals, constitute the second class of organized bodies.

The more we inquire into the economy of plants, the more we discover a similarity between them and animals. Plants live; they originate from bodies of their own kind in an uninterrupted succession; they assume various forms successively, from the first moment of their existence and life, till their final decay; they contribute to their own growth and preservation, by receiving foreign substances into their bodies through their vessels or organs. These received substances are changed by the peculiar internal operations of the plants, and are therein prepared, partly, to enter into their proper constitution, and partly, for the purpose of the for-



mation of their products, which become thereby different from the component parts of the plants themselves, and different also from the nature of the substances which they had received from without. Plants die, that is, their organs are deprived of the power of receiving food, and of preparing it for their further existence.

Plants like animals, experience three different periods in the course of their existence ;—*viz.*—origin or beginning,—formation,—and death.

Death is attended with a decay of bodies, and this again with a separation, dissolution, and decomposition of their constituent parts ; which thus follow the laws of chemical attraction and combination.

The living body is indued with a peculiar internal power, which occasions a dissolution of the attraction of chemical combination, and which prevents the principles of bodies from acting upon, and from combining with each other,



ther, according to the law of chemical attraction.

The substances of which organized bodies are composed and constructed, when these bodies are living, follow the laws of their natural impulse of figuration, (*nifus formativus* of Blumenbach), which impulse exists in all organized bodies, and causes each of them to assume and preserve their peculiar shapes.

The distinguishing marks for the two general classes of organized bodies, are derived,

1<sup>st</sup>, From their organs or parts for receiving food.

2<sup>d</sup>, From motion.

(*Blumenbach, Handbuch der Naturgesch.*

§. 3. 4. & 170.)

All bodies which receive their food through more than one channel or mouth, and which are destitute of the power of a voluntary extension and contraction of parts, are arranged under the division of plants.

Life



Life signifies the uninterrupted motion of organized bodies.

In plants we observe,

1<sup>st</sup>, An uninterrupted motion which is caused,

a. By the vital power.

b. By external stimulus.

2<sup>d</sup>, Uninterrupted motion, occasioned by an internal stimulus; as for instance, the motion of the *stamina* towards the *stigma*, and the recession from the *stigma* before and after impregnation in the *parnassia palustris*, &c.—Vide Mr. Humboldt's observations on the stamina of the *parnassia palustris* in *Usters Annales* of botany, No. 3.

Another example of the same nature, and which will be referred to when treating on the irritability of plants, is, that most of the water plants rise or move to the surface of the water when about to bloom, and so sink, or are immersed again, as soon as they are impregnated; such we observe in *valisneria*;  
the



the female flower of this plant is fixed upon a long spiral stalk, when the time of the blossoming approaches, the stalk unwinds, and raises the flower above the surface of the water; the male plant produces a number of flower buds under the water, these grow upon short and straight stalks, but when about to blow, they separate or detach themselves from the stalks, and rise to the surface of the water, where they swim and burst or unfold, and then impregnate the female flower; which, after the impregnation, returns again under the water.

3d, Interrupted motion occasioned by external stimulus; as for instance, in the *mimosa pudica*, *dionæa muscipula*, *oxalis sensitiva*, &c.

In the strictest sense, vital power is the cause of all motion, it only manifests itself variously, according as it is excited, or brought into activity, by external or internal stimulus, or by mechanical powers.

Though plants generally seem not to be capable of moving from their situation, or to be stationary,



tionary, yet there are exceptions ; as, for instance, the *lemna*, which changes its station.

Like plants, there are also animals, as the *lepus balanus*, *astrea edulis*, and *lernæa*, which are incapable of changing their situation ; hence, the capacity of organized bodies, of changing the station, is not peculiar to animals alone.

If we take it in the strictest sense, we may appropriate a moving power to several plants ; as *ajuga reptans*, *glecomahederacea*, and *cuscuta europæa*.

There are many instances in which animals resemble plants ; as, for instance, we observe that many insects begin and finish their course of life with the close of one summer, like the annual plants. As to the propagation of separated parts of plants, we observe similar instances in parts separated from animals, as polyps, and other aquatic animals.

Uninterrupted motion, we consider as a doubtless characteristic mark of living bodies. This we observe in animals and plants ; both  
discover



discover more activity in the spring than in winter.

The total interruption or suspension of life causes death. Though the motion of many plants is scarcely, or often not at all perceptible in the winter season; yet it would be contrary to all experience, to suppose that plants should then cease to live, if nothing else has occasioned their destruction.

We know that plants, like animals, receive and excite matter of heat, and that both manifest sensible heat. Later discoveries have also proved, that plants emit or yield matter of heat even in the winter season.

The moist atmosphere which we perceive in the shade under trees, probably originates, not merely from their being excluded from the light of the sun, but because the trees attract and imbibe a great portion of matter of heat, by which the water thereby held in the atmosphere is deprived of its elasticity, and is thus made to separate in the state of moisture.

Plants



Plants may receive heat from the surrounding atmosphere, by imbibing the air, and partly decomposing it, and also from their food during the digestion. Buffon and Hunter have proved the fact, that plants have a power of producing sensible heat.

THOUGH plants receive their food through various canals or mouths, and do not collect them in one reservoir like animals; yet, the mode and effect of their digestion resembles much that of animals. They part like animals, with the superfluous and useless matter; and this separation they effectuate, not only by their respiratory organs, the leaves and stems, but also by other secretions similar to what we observe in animals.

Mr. Humbold, a gentleman of great reputation among the learned in Germany, has observed, that plants really secrete impurities through the extremities of their roots during the night, which excrements may, like those  
of



those of animals, prove sometimes useful, sometimes hurtful, to other neighbouring plants. "Sic  
 " læditur," says he, "*avena a ferratula arvensi*,  
 " *triticum ab erigero acris*, *linum ab euphorbia*  
 " *peplo et scabiosa arvensi*, *polygonum fagopy-*  
 " *rum*, *a spergula arvensi*, &c." From this he  
 derives the effect of fallowing, and the harmony  
 among plants.

It is a well known fact, that some trees will  
 not grow well near others, or that the one is  
 hurt or suppressed by another of a different  
 kind. The cause of this was thus explained,  
 that the one deprived the other of its necessary  
 portion of food; but Mr. Ussar supposes, with  
 much plausibility, that the secreted matter of  
 one kind of plants or trees, may likewise add to  
 the cause of the destruction or injury of others.  
 There are plants which do not allow others to  
 grow near them, and which seem to prefer a  
 solitary life. This circumstance has given rise  
 to a division of plants, into SOCIATÆ and SOLI-  
 TARIÆ. Similar antipathy we observe likewise



among animals; as certain different genera of animals will not live together in harmony.

Mr. Uflar is opinion, that this partly arises from physical causes; as he observed, that certain animals cannot bear the effluvia of others.

Though certain plants show a great antipathy to one another, yet there are some which assist the growth of others. So, for instance, we find the birch often nourishing the oak and the beech.

PLANTS and animals perspire liquid and permanent elastic fluids. The exhalation from certain parts of animals varies respecting the quantity and composition of the matter perspired; the same we observe respecting plants.

The cause why certain parts of plants produce constantly the same juices and exhalations, lies probably in the peculiarity of structure of the organs, disposed in the various parts of living plants.



With respect to propagation, we observe again a similarity in both classes of organized bodies, in the more natural mode of propagation, and in the production of mules or hybrids.

With respect to the production of hybrids, the following laws are common to both :

1<sup>st</sup>, Only such plants and animals are miscible, as have natural affinity to each other; hence, neither hens and rabbits, nor oaks and pines are miscible.

The affinity of plants is not always to be determined by their external form; not unfrequently we must ascertain it by the similarity of their pollen.

2<sup>d</sup>, The hybrid approaches always to the male, in the subsequent generation. In regard to the parts of generation, we observe great differences between animals and plants; those of the former are permanent, and those of the latter are reproduced for every successive generation.

How nearly plants approach to animals respecting



specting their copulation, &c; we may see from the observations contained in the valuable dissertations of the great HEDWIG, *viz.* his History of Mosses, and Account of the Fructification of the Cryptogamic Plants.

Winter sleep or rest, is common to animals and plants; during this time the action of their organs does not cease, it is only modified.

To the analogy between plants and animals, we may add the power of reproduction.

*a.* Reproduction of parts lost by the natural disposition which is common to both; *viz.* in animals, the fall and reproduction of hairs, feathers, and horns, in the autumn and spring; in plants, the separation and reproduction of the cuticle and leaves.

*b.* The reproduction of parts accidentally destroyed, to which we refer the consolidation of wounds.

The cause of reproduction was generally attributed to the presence of a number of original embryos, existing or previously dispersed through the



the body, and which are occasionally evolved, if there be a sufficient supply of food, &c.

The excellent Physiologist, Professor Blumenbach of the University of Gottingen, however, has favoured us with a different and very ingenious theory; according to him, there exist no preformed embryos in organized bodies; but he alleges, that in the prior unformed generative matter of organized bodies, after it arrives at maturity, and has reached its fixed and destined situation, a peculiar and continually acting impulsive force is set at liberty, and causes this matter to acquire or assume a certain form at first, and to preserve the same afterwards; so, that if such form be injured or lost, it may be repaired or reproduced. This impulse or impulsive force is connected with the vital powers, but equally and evidently differs from contractability, irritability, and sensibility, as well as from the common physical powers of bodies; and it appears to be the first, and most essential instinctive power  
necessary.



necessary for generation, conservation, and reproduction.

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OF THE

NISUS FORMATIVUS OF BLUMENBACH \*.

THERE are two theories known of generation and reproduction. The one is distinguished by the name of Epigenesis: by this it is maintained, that when the mature, but crude and unformed generative matter of the parents, reaches the place destined for its reception, at the proper time, and under the necessary circumstances, it is then gradually formed into a creature.

The other theory is distinguished by that of Evolution. This theory denies all generation of the organized world; it contends, that nature had at once produced the embryos for all animals

\* Vide his treatise on that subject.



animals and vegetables, which ever have lived, and which ever shall live, at the first creation ; so that now nothing is necessary for the production of these, but a successive evolution of the embryo. To this theory Mr. Blumenbach makes very strong objections, as may be seen in his treatise on generation, lately translated into English by Dr. Crichton of London.

Blumenbach remarks, that many unorganized bodies assume a regular form when properly disposed for it, as we observe in the crystallisation of salts, and various other substances. Though this power or cause is different from the impulse of figuration of organized bodies ; yet it is evident, that there must be something which has the power, or which causes the same bodies to assume the same regular form under the same circumstances.

In order to perceive the effect of the impulse of figuration most distinctly, Dr. Blumenbach chose such organized bodies for the subjects of his observations, as have a considerable size,  
yet



yet are almost transparent and grow very fast. In these he was enabled to observe even the interior change and operation of their formation; *e. g.* *conferva fontinalis*. This vegetable being is well known to botanists; it consists of a single, almost straight, short, and slender thread; the fine hair-like matter which we observe in the spring in wells, &c. consists of a great number of these plants, which have shot forth and fixed their roots in the mud.

The propagation of this plant thus proceeds; the extremities of the threads swell, and form small tubera or heads, which gradually separate from the mother threads, and attaching themselves to some particular spot, they grow in a short time to a perfect thread. The whole progress of their formation can be observed in the course of 48 hours.

Dr. Blumenbach could not discover, by the aid of the best magnifying glasses, any trace of an involved embryo, &c.; he made also similar



milar observations on a certain kind of polyp.

The result of his observation was, that ;

1<sup>st</sup>, The impulse of figuration proceeds rapidly in early life, slowly and more perfectly in advanced age.

*a.* By the generation of the foetus ;

*b.* By the reproduction of parts on the formed bodies of plants and animals.

2<sup>d</sup>, The power of figurative impulse varies ;

*a.* In various parts of the body ;

*b.* In different bodies.

In like manner, we observe diversity respecting irritability in certain parts of plants hereafter to be treated of.

3<sup>d</sup>, The impulse of figuration, or *Nisus Formativus*, takes sometimes a preternatural direction ; in which case there are produced,

*a.* Heterogeneous forms, as horns and hairs ;

or, in plants, we observe leaves resembling those of a different species.

*b.* Preternatural forms, as monsters.



The cause of such deviation we cannot investigate. Instances of it more rarely occur, however, in wild and unconfined animals, and more frequently in such as are confined or domesticated; for climate and food, both seem to have great influence in causing such deviations.

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### ORGANIZED BODIES CONSIST;

1<sup>st</sup>, **O**F solids;

2<sup>d</sup>, Of fluids.

The latter are,

a. Liquid; or,

b. Permanently elastic fluids.

Carbon, hydrogen, azotic principle, and oxygen, are the chief principles of plants.

The solid mass of such bodies is partly organized, partly destitute of organization.

Every living creature is provided with various  
vessels



vessels and instruments, necessary for its propagation, preservation, and for promoting its periodical growth; these constitute its organized part.

The organs of animals and vegetables have, or assume, a determined structure, which does not depend on accidental causes.

The solid parts of plants Mr. Ussler divides into,

1<sup>st</sup>, Primitive solid fibres, which he calls *faser*;

2<sup>d</sup>, Simple fibres.

By primitive fibre (*faser*), he means the unorganized matter; it is the whole corpuscular mass, which possesses the vital power only when in connection with the organized parts; the use of it is, to connect the smallest fibres, and those vessels which are more or less composed of them, to cover them, and to fill up their interstices.

The whole unorganized mass Mr. Ussler calls  
cellular



cellular web ; what BORDEU calls *tissu mu-queux*.

All solid parts of plants are formed of one and the same matter, Cellular Matter. This probably originates from gelatinous juices, in combination with other principles ; by the acquirement of it, all forms are generated ; hence the appearance of organization, in unorganized parts.

The simple parts of the organized mass consist of fibres. “ Solidarum partium in animalibus et vegetabilibus communis est ea fabrica, ut earum elementa, quæ subtilissima microscopium attingit, fibræ sint.—HALLER.”

Fibres, as far as we have been able to discover their most simple state, are thin cylindrical lines ; their matter is cellular web.

The solidity of the fibres, as well as that of the whole organization, depends on the density of the cellular web, that being the matter of which they were formed ; and the density of the cellular web, depends upon the close, or loose condition



condition of the imaginary simple fibres of which that is again composed, as well as from the intimate connection of those parts among themselves.

By the combination of fibres vessels are formed ; this is the second step of organization. The third step consists in the connection of certain vessels, of which compound organs or instruments are formed. It appears, that a very intimate combination among the organs of organized bodies takes place ; else considerable injuries of parts of plants would immediately cause their destruction or death ; which, however, is seldom the case. According to Mr. Ussler's opinion, the combination of fibres, vessels, and instruments, is produced,

- a.* Directly by the unorganized mass.
- b.* By the interweaving of very minute branches, whose extremities terminate in open mouths.

Simple as the structure of plants and their organization



ganization appears, yet we observe a great complication in the connection or composition of the fibres of the cellular web. This has been sufficiently observed and shown by physiologists; and any body may easily convince himself, by the aid of a magnifying glass, that each genus and species of plants has something peculiar in the connection of the fibres of the cellular web; and that the proportion of the vessels varies as to size and number; it hence naturally follows, that the preparation of the received alimentary juice must thereby be variously altered or modified; and thence the great variety among vegetables may originate.

In the animal body we discover two different kind of fibres,

1<sup>st</sup>, The sensible or nervous fibres; of which the nerves of animals are composed. We shall hereafter observe, that sensation depends on nerves, a property of which plants are destitute, according to the general opinion. In so far as we understand by sensation, the perception

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tion of external things, and the susceptibility of pleasant and disagreeable impressions, we may consider plants to be destitute of that sensation.

Animals possess the property of sensation in very different degrees. In many of them we discover it in a very inferior degree; so that the motion by which it becomes manifest, appears to result merely from a stimulus acting directly upon the irritable fibre, like what we observe in plants.

Mr. Ussar does not choose to compare this to the motion which is caused by the irritability of plants, though something might be deduced from it, which may show the close analogy between the inferior tribes of animals and plants. The nervous fibre has not yet been discovered in plants; and the want of sensation, taken in the strictest sense, affords already the analogical conclusion of the absence of this fibre.

2d, Another kind of a fibre, totally different  
from



from the foregoing, is the muscular fibre, (*fibra irritabilis*.) This is common in all organized bodies. It exists in plants as well as in animals. It not only causes the motion; but it is also the material cause of life, in so far as we consider irritability as a vital principle of organized bodies.

The power of contraction, in organized bodies, depends on the irritability of the muscular fibre; that wherever, therefore, we observe a contraction of the parts to which a stimulus is applied, we may safely conclude the presence of muscular fibre in these parts. Haller says, that, in many cases, we discover the existence of muscular fibre in certain parts, more by its effect, than by our organs of vision.

If the cause of contraction, observed after applied stimulus, lies in the irritability; and if it is true, as it really appears to be, that only the muscular fibre possesses irritability; it is then not difficult to prove the existence of irritable fibres in plants; by visible perceptions.



It is well known, that the leaves, stalks, and stamina, of many plants manifest irritability, or contract when touched ; *e. g.* the leaves of *drosera longifolia*, *drosera rotundifolia*, *dionæa muscipula*, *averrhoa carambola*, *mimosa*, &c. the stamina of the cactus *opuntia*, and several other species of that genus, the stamina of *berberis vulgaris*, *heliotropium*, *parietaria officinalis*, *lilium superbum*, *calendula*, *martynia annua*, and several of the *urtica* genus, as, for instance, *urtica dioica*. On this subject we have a valuable dissertation by MR. MEDICUS, Prime Counsellor, &c. Of the Instinct of Plants for copulation, in *Hist. et Comment. Acad. Theod. Palat. Tom. III. pag. 116, et seq.* and also by Des Fontaines, on the irritability of plants in general, Bonnet, Broussonet, Hope in *Dissert. quædam de Plantarum Motibus et Vita complectens*, Edin. 1787 ; and Gmelin de *Irritabilitate Plantarum*.

This may suffice, for the present, to prove the existence of irritable fibre in plants, or in all

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organized



organized bodies ; more will be said upon this subject in treating of irritability, in particular examples.

Mr. Gritanner, by his experiments, endeavours to prove the existence of three different kinds of irritable fibres.

1<sup>st</sup>, The Straight Fibre (*recta*), which contracts longitudinally, or in such a manner, that the extremities approach each other.

2<sup>d</sup>, The Spiral Fibre (*spiralis*), by the contraction of which the diameter of the vessels which are formed by it is diminished.

3<sup>d</sup>, The Circular Fibre (*circularis*), generally discovered at the extremities of vessels ; the apertures of which it closes by its contraction.

The contractility of the irritable fibre manifests itself after an applied stimulus. But there is a difference in the effect of the contraction, according to the different external form of the fibre ; and also, with respect to the velocity  
with



with which the stimulus is received. The contraction of the straight fibre takes place quickly, or even instantly throughout the whole fibre, as soon as one of its parts receives the stimulus; from which it may be concluded, that these straight fibres exist particularly in those parts of plants, the contraction of which takes place immediately and perfectly; as, for instance, the leaves of *dionæa muscipula*, and *mimosa pudica*. The contraction of the circular fibre takes place more slowly and gradually; that of the spiral fibre is slowest of any. The stimulus which is quickly communicated from every part of the straight fibre to the others, proceeds but slowly in the circular and spiral fibres; it is communicated successively to their different parts; and manifests corresponding effects. This contraction of the spiral fibre has been called Peristaltic Motion; and Malpighi was perhaps the first who discovered it in the spiral vessels separated from the stem; it is likewise found in the intestines of animals.

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THE VESSELS AND INSTRUMENTS, OR  
ORGANS OF PLANTS, MAY BE  
DIVIDED INTO ;

1<sup>st</sup>, ORGANS for secretion ;

2<sup>d</sup>, Organs of motion.

Farther, according to HEDWIG, with regard to the direction in which they move their contained juices.

a. Either from the stem towards the branches, (*adducentia.*)

b. Or from the branches towards the stem and roots, (*revehentia.*)

Moreover, the organs of plants may be divided into those which ;

1<sup>st</sup>, Serve for the continuation and preservation of life ;

2<sup>d</sup>,



2d, Effectuate the propagation and generation of the germs of new bodies of the same kind.

For this purpose it appears, that all the organs and single fibres harmoniously unite their powers. Harmony manifestly exists in the whole creation; by it all nature is concatenated; the more therefore may we presuppose it in the structure of any single body.

In the more particular discrimination of the various vessels, Mr. Ussler follows the famous Mr. Batfch; he considers them as,

1st, Filamentous.

- a. Utricles, (*utriculi*), which are produced or adhere horizontally;
- b. Succiferous, or sap-vessels (*vasa succosa*), which proceed longitudinally in plants; these may be divided into,
  - a. Pith-vessels, (*vasa medullaria*), which are chiefly found in the medulla;
  - b. Nutricious-vessels, (*vasa propria, nutritiva* ;)



c. Lymphatic-veffels, (*lymphatica.*)

2d, Spiral veffels; they confift of flatted fibres or threads, of an equal breadth, which are wound or coiled up in a fpiral manner, fo as to form a tube; (*tracheæ, vafa aërea* or *fpiralia*).

Meffrs. Grew and Reichel confider them, contrary to Malpighi's opinion, as confifting of feveral fibres, whereas the latter confiders them as made up of a fingle fibre.

They are found for the moft part underneath the bark, and frequently under the cuticle of fuch plants as have no proper cortical ftrata; as, for inftance, the graffes; they are very irritable, and contract by an applied ftimulus.

Malpighi represents, that thefe veffels are constantly filled with air, and that they refemble the tracheæ, or air-veffels of infects; Mr. Grew, on the contrary, afferts, that they contain occasionally different juices. Their great ufe is to ferve as refervoirs for air; but modern phyfiologists afcribe fome other qualities to them:

Linné



Linné thought that he had discovered the living power of plants to reside in the medulla or pith, and that the production of the corculum or rudiment of new plants was derived from it; this however, at present is believed to be produced by the *fistulæ spirales* \*.

The before-mentioned supposition seems to be very probable; for how should it be possible, that plants, or hollow trees, which have lost the greatest part of their pith or medulla, as we frequently observe on the old stems of willows, &c. should be able to produce new parts, *e. g.* buds, and seeds, and should continue to grow as vigorously as if they contained all their pith.

The classical writers on this subject are; MALPIGHI, GREW, in the Anatomy of Plants: BONNET,

\* The necessity and efficacy of these spiral vessels, is sufficiently and ingeniously demonstrated by HEDWIG, in a dissertation on the Origin of the Male Parts of Fructification of Plants; and likewise, in another, in which he has answered the question; What is properly the Root of Plants?



NET, *Recherches sur l'Usage des Feuilles dans les Plants* : BAISSE de *Vasis Plantarum*. In which Jampert's opinion, against the probability of the existence of vessels in plants, is refuted.

Indeed, natural appearances, and the results of many microscopical examinations, seem to prove sufficiently, that plants have vessels.

The UTRICLES seem to be intended for containing the juice or sap, and probably likewise for assisting in the preparation of it. The formation of the vegetable juice is too subtle an operation to be demonstrated or imitated by chemistry. For, notwithstanding the many opinions which have been suggested respecting the interior oeconomy of plants, we are still much in the dark with regard to it; we know little of the more minute combinations and structure of organized bodies, but still less do we know of their internal operations.



WE may suppose, that plants like animals have,

1<sup>st</sup>, COMMON JUICES, which are diffused through all parts of their body.

2<sup>d</sup>, PARTICULAR JUICES, which are found only in certain parts, and are probably secreted from the first. They are contained therefore in particular secretory vessels. One part of the juice thickens, from time to time adheres to the solid fibre (*faser*) of the cellular web, increases thereby the mass, and thus promotes growth. In this manner the origin and formation of new ligneous fibres may be explained.

In order to understand how the nutritious liquid received by plants, and the juices secreted by them, can appear in such different forms or states; as a solid body in the woody plants; as a compact inflammable matter; and how the aqueous liquid is changed into vegetable juices; recourse must be had to the first part of this treatise.

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We know, that bodies may assume various states; they may pass from a solid to a liquid, and from a liquid to an elastic fluid state, solely by means of heat.

The nutritious water in plants may change its liquid state to an elastic fluid, in two ways;

*a.* By the accumulation of heat; or,

*b.* By decomposition.

By decomposition, the two constituent parts, the oxygen and hydrogen, are separated from each other. The hydrogen enters into a new combination with the vegetable matter; the oxygen is set at liberty, and escapes in the state of oxygen gas by means of light. Light acts, partly as a stimulus upon the leaves and upon the green coats of the tender stems, partly as a matter having a strong attraction for the oxygen, and thereby effectuates the formation, and subsequent escape of the oxygen gas.

All elastic fluids are condensible; the hydrogen appears to exist combined in plants in a state of condensation. Hydrogen, or hydrogen  
gas,



gas, is, as we know, inflammable; and by its combination with oxygen gas flame and sensible heat are produced; the latent heat of these fluids being disengaged in consequence of the greater attraction of the oxygen for hydrogen.

Newton's supposition, that water is a body, intermediate between an inflammable and non-inflammable substance; that water is necessary for vegetation; and that plants receive their inflammable matter from it, is now verified by experiments and facts. By the discovery of the composition and decomposition of water, much light has been thrown upon the nature of plants. Another portion of their inflammable matter, plants may obtain from the atmosphere, by the absorption of air and effluvia therein contained.

The matter with which the hydrogen, when separated by the decomposition of water, is combined again in plants, seems to be carbon. A great quantity of carbonic acid gas is constantly produced by the respiration of animals.



mals, by fermentation, by various decompositions, and by the combustion of vegetable substances.

There are even plants which emit carbonic acid gas, *viz.* *salix viminalis*, *pinus cedrus*, *quercus robur*, *betula alba*. We know, as observed before, that this gas is specifically heavier than atmospheric air, in consequence of which it sinks towards the surface of the earth, which it gradually enters; it is then conveyed to the roots of plants, and thus becomes beneficial to them. It appears, that plants receive and have the power of decomposing carbonic acid gas in like manner, as they receive and decompose water.

The following simple experiment will suffice to support this opinion.

Plants yield oxygenous gas when exposed in the sun: If two branches of a plant are immersed, the one in common water, and the other in water impregnated with fixable air or carbonic acid; we then find, that the branch immersed  
in



in the latter liquid, yields, under the same circumstances, a greater quantity of oxygenous gas than the other. The difference in some experiments has been found in the proportion of 264 to 1. The proportions vary however, when different plants are subjected to trial, so much, that no general law can be established. The carbonic acid, with which the water is impregnated, is decomposed then by the branch, the carbon enters seemingly into the constitution of the plant, while the oxygen is set at liberty, and flies off, more or less of it, in the state of gas.

Plants do not, however, retain all the carbonaceous matter which they receive; they obtain more in the course of the day when acted upon by light, than they naturally require. By the absence of light, plants lose part of this carbon, as during the night; hence, the cause, that plants yield respirable gas only in the day-time, particularly when the sun beams fall immediately upon them; and that

plants



plants do not yield pure air in the night, but frequently at that time give out bad air.

That water, or its component parts, afford the principal aliment for plants, not only appears from their quick growth after an electrical rain, but also, by the quick formation and growth of many fungi, viz. *clavaria fastigiata*, *agaricus campestris*, &c. The opinion, that these fungi were formed by fermentation and crystalisation from the mucilage of other vegetables, is sufficiently refuted by the ingenious Mr. Wildeno. Later discoveries in chemistry, have enabled us now to understand the various combinations and decompositions which may take place of substances which enter plants; that the more simple substances not only may assume different forms, but that they may change likewise their properties when combined with each other in various proportions, has been explained in the former part of this treatise.



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OF THE SUCCESSIVE INDURATION OF CERTAIN  
ORGANS OF PLANTS, OR THEIR CHANGE INTO  
WOOD, AND OF THE DIFFERENCE AMONG  
PLANTS.

FROM the physiology of animals, we know,  
that ;

1<sup>st</sup>, The living body in its infancy, consists of more succulent parts than in older age, and that the solid parts increase with every year in the course of life, to a certain period, when they attain their perfect state.

2<sup>dly</sup>, That, by the constant exertion, many organs are weakened or become less active ; many parts are condensed by pressure, as well as by attraction of cohesion. Some of the small vessels lose thereby the capacity of transmitting the juices, others are deprived of their extensibility ; this occasions



cavities the cavities to be filled up, the rarer parts are changed into solid web, and by this again many vessels are closed. The irritability is diminished by age, some parts are entirely deprived of it, and they remain uncorrupted or alive, only in as far as they are still connected with other sound and active parts.

These observations applied to plants, make it likewise comprehensible, how their organs or parts may be changed into solid and woody fibres (*faseru*).

The result of all these changes is the death of the parts. The quantity of juice diminishes, as parts become more compact and solid; the absorbent vessels gradually suffer; and becoming unfit for their functions, the nourishment is thereby diminished.



OBSERVATIONS ON THE IMPORTANT QUESTION,  
WHAT CAUSES THE GREAT VARIETY OF THE  
INTERNAL AND EXTERNAL CONSTRUCTION OF  
PLANTS?

1<sup>st</sup>, THE first cause lies in the organization. The main body or general mass, we observe, has a different structure in different plants. Not only the construction of the solid fibre of the unorganized part (*contextus cellulosus*), varies with respect to density, &c. ; but also the form of the organs, of the juice vesicles, &c. the structure of which, and thinness of their coat, enables them to secrete more or less of the elementary constituent parts of their nutritious juice in a variety of ways : So that we may almost consider them as instruments for chemical operations. We find that some are more fit for the susception, rarefaction, and preparation of food, than others. There is no doubt, but that the dissolution, fermentation,



cretion, assimilation, &c. of the principal constituent parts of the nutritious juice, presupposes a variously modified, but determinate structure of the different organs.

2d, Another cause of the variety, lies in the altered state of the received food, and in the different proportion of mixture.

Water and atmospheric air are the substances which afford plants what they principally require for vegetation. Though simple these substances appear to be, yet we know, by the aid of chemistry, that they are not only composed of the most efficacious elementary substances, but also that they contain a variety of heterogeneous matters.

Oxygen, hydrogen, and carbon, seem to constitute the main aliment of plants; a great portion of the two last is taken up by the vessels, and combined in them with the vegetable matter. Earth appears not to be a necessary component part of all plants; for by the analysis of many vegetables, such as the byssus, peziza,  
and



and several other cryptogamic plants, particularly of the genus of fungi, we find no earth in their mixture; and though there are plants which contain more or less earthy parts, particularly calcareous earth, yet this does not prove that earthy parts are necessarily component parts of plants.

A great number of experiments, both of earlier and later periods, have shown that plants do not immediately obtain the requisite earthy particles from the soil in which they grow, but that they receive such from water and the atmosphere.

Hales, Bonnet, and others, have ascertained these facts directly by the increase of weight; and how would it otherwise be possible, that an oak could vegetate ten years in water, and its mass continually increase. Nature presents similar instances, and shows by parasitic and pseudo-parasitic plants, that the earth or soil upon which they grow, does not afford them pabulum, but that they receive their earthy particles by other channels,

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We frequently find plants (which Mr. Uflar calls Pseudo-Parasitic plants), upon sterile and naked rocks, upon walls, &c. viz. *rubus idæus*, *vacinium vitis idæa*, *rubus fruticosus*, which by accident are often found upon the stems of old decayed trees, and continue there their growth.

Mr Uflar found that plants would grow in mere pounded quartz; not only herbaceous plants, as *lepidium sativum*, or *reseda odorata*; but also shrubs, the *heliotropium*, e. g. grew particularly well. The insoluble particles of quartz could serve here as only a fixed place for those plants, and as a reservoir of the water.

The supposition, that plants in such cases were nourished by the heterogeneous, earthy, and saline particles contained in the water, and not by the water itself, is sufficiently refuted by Mr. Hoffman; who by very ingenious experiments found, that plants grew in distilled water and air; (which are described in Green's journal.)

This eminent Botanist accidentally observed,  
that



that a plant, *mentha crispa*, growing in a glass with water, had shot out roots; this immediately engaged his attention, and led him to the following experiment, he put the same branch in distilled water, and found that the plant did not only continue alive throughout the winter; but also, that in spring it began to push forth buds, which produced branches, flowers, and seeds.

In order to examine the justness of Mr. Von Beunie's, and Spallanzani's assertions; that not only water and fixed air, but also several earths, particularly lime, marle, clay, promote the growth of plants; and that indeed water did not so much itself assist vegetation, as the oily and saline parts contained in it; Mr. Hoffman employed, in the following experiments, water which had been previously freed from all heterogeneous parts by distillation.

Having cut off a small branch of mint, weighing one dram and fifty grains, he placed it in a phial containing 8 ounces of distilled



tilled water, and secured the mouth of the phial with a waxy cement, fitted close also round the stalk, so that no water could escape at this place, nor any heterogeneous matter get into the phial. The phial with the plant was placed in a large room, and after 10 days, he perceived already small roots shooting out from the lower joint of the branch which was immersed in the water; these increased in number more and more; after 14 days he cut over the branch above the second joint which was without the phial; the part thus separated weighed 1 dram 15 grains. Three weeks after, new buds began to shoot out from this joint, between the two leaves and the stalk, and these grew out into branches similar in size, form, and odour, to those commonly produced on this plant.

After six weeks, all the eight ounces of water were consumed, and the plant had altogether increased in weight eight scruples, or two drams and forty grains.

The phial was again filled with distilled rain water,



water, and the same experiment repeated. The evaporation of the water in these experiments could only proceed through the plants; the consumption of the water varied, according to the temperature and the intensity of the light to which the plant was exposed, and likewise, according to the different state of vegetation; for, in the first days, before the buds were apparent, the quantity consumed was only 10 grains in the shade; but, as the growth advanced, the quantity of water consumed also increased from 10 grains to several scruples in the sun, often to two drams. At the approach of autumn, the perspiration diminished and gradually became imperceptible; at the same time, the leaves of the plants became relaxed and lost their colour. The water then is consumed only during the growth of the plant; it therefore seems probable, that the water in this process has undergone a decomposition to promote the growth.

The weight of both branches which had been produced in the latter part of the experiment,



ment, amounted to two drams; and nothing but water and air could in this case afford pabulum to the plant, or the matter of which its parts were formed. Hence, therefore, the decomposition of water by vegetation, and the combination of its constituent parts with vegetable substances, may be fairly deduced.

The cause why all plants will not grow upon the same ground, depends probably on the capacity of the soil to receive the food, and to retain it for the proper time.

Succulent plants require generally a moist soil; such, *e. g.* as shall consist chiefly of garden mould, or the earth of decayed vegetables: For this not only imbibes the water easily, but likewise retains it very long. Such soil is, however, often adverse to the growth of other plants.

That plants receive their food from water, has been also lately confirmed by Von Marum; who also repeated the observation, that plants extend their roots towards moisture.

Trees



Trees growing near the banks of rivers, extend their roots, particularly towards the water; and if a moist sponge is laid near a side root, we observe, that the root is attracted, as it were, by the moist sponge, as iron by a magnet.

Leaves appear to be the most necessary instruments for supporting vegetation. They answer not only the purpose of receiving food, but likewise the purpose of lungs, for respiring and perspiring air or other elastic fluids.

Plants which have a considerable foliage, perspire more than those with few leaves.

If we take two branches, and deprive the one of its leaves, we then find,

1<sup>st</sup>, That that branch which is destitute of leaves, does not take up so much water as the other which has its foliage entire.

2<sup>dly</sup>, That the first becomes nevertheless heavier than the latter, by reason that the water which it absorbs is not decomposed by it, but remains for the greatest part within it in an un-

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altered



altered state : while, on the contrary, the other, though it retain most of the hydrogen, retains only a small part of oxygen, emitting the greatest part of the latter in the state of gas, by the effect of light. Trees, therefore, with much foliage, seem to require a more humid soil than those with less foliage. This is generally indeed observed to be the case : but there may be now and then exceptions, for some plants perspire less than others. The difference seems to proceed, partly from their internal structure, according to Mr. Ussar ; because the trees of hot climates, which have much foliage, do not perspire as much as those of more temperate climates.

A lemon tree, for instance, perspires in proportion less than acer pseudo-platanus or sycamore.

The external form of the leaves is also different and may have effect on the perspiration. The leaves of the lemon tree are entire and smooth : whereas, those of the sycamore are angular, and  
their



their under surfaces are covered with fine hairs, which are probably intended for perspiration.

As the external form of parts assists perspiration; in the same manner, it appears that the form has influence upon the reception of food from the air; and Mr. Ufflar believes, that the situation of the leaves, the direction, circumference, margin, surface, promote the one or the other more or less: *Folia serrata, incisa dentata, acute crenata, &c.* all these are not only better conductors, but also more capable of perspiration, than such as have a smooth or even margin.

Bodies armed with, or ending in sharp points, not only attract electricity better, but when impregnated with electric matter, they allow it to stream out of them with greater velocity than smooth or blunt bodies do; and as plants receive, not only elastic fluids from the atmosphere, but also electric matter; it may be concluded from analogy, that their form will have likewise considerable influence on this occasion.

The great difference among leaves, their different



ferent origin, and use, &c. is well demonstrated by Professor Batfch in his book, entitled, Anleitung zur Kenntniss der Pflanzen, §. 87, to 102.

It appears from what has been observed, that the aliment which the roots take up from the surrounding earth, scarcely differs as to quality in different plants; and, that the alteration of it takes place only by peculiar co-operations and modifications within the particular plant: this is obvious in grafted fruit trees, and indeed in others; quercus *ilex*, for instance, grafted or inoculated upon quercus *robur*, retains its leaves through the winter in a sound state like its mother plant.

That there is great variety of organization in plants, and that through various operations thence resulting, the various preparations are effected and produced, is very obvious; but of the manner, in which these are precisely formed and conducted, we have at present but an imperfect idea, yet something more satisfactory, it may be hoped, shall accrue from the indefatigable labour of chemists,



mists, who have already demonstrated, that the minute particles of two heterogeneous bodies, when intimately combined, possess a power to produce a mutual change upon one another; and have also found, that by the combination of different bodies, new bodies are produced, which are in all respects the same with those produced by nature.

Whether the external form of plants likewise originates from their internal condition and composition, like what we observe in unorganized bodies, as salts, &c.; is a subject, in our present state of knowledge, too early for discussion.

Organized bodies possess another power, already mentioned; which causes their determined figure; *Nisus Formativus* of Dr. Blumenbach.

Mr. Uslar is of opinion, that the pollen of the flowers contains a very subtile, elastic, highly active matter, which gives the proper direction



tion to the Nifus Formativus, under altered circumstances; this he concludes from the following observations.

*1st*, Because hybrid plants deviate always in their form from that of the female, and assume more nearly that of the male;

*2dly*, As a proof of the elasticity of this matter, it may be observed, that the pollen, which is deposited, and which adheres to the viscous humour of the stigma, cannot enter that organ, on account of the minuteness of the pores, or mouths of vessels terminating on its surface. The impregnation must therefore proceed indirectly, or mediately, by means of an elastic fluid, which, being disengaged from the pollen, is attracted by the liquid of the stigma; and, in combination with this liquid, penetrates the stigma, and passes to the germen; perhaps, there it acts as a stimulus, excites irritability, and thus produces alterations in the seed.

Irritability appears to be the principal effect; for, immediately after the deposition of the pollen,



len, the embryo in the germen shows vitality or motion; the feed vessels open themselves, swell, and become filled with juices, which are gradually perfectionated in the germen.

There is scarcely any doubt, that the access of air by this means, as well as in general by the combination of the food with the solid parts, has here a considerable effect. HALEs supposes that it is probable, that the air contributes much to the concretion of the particles of bodies; and the supposition seems to be supported by the observations of Mr. Achard, that the formation, crySTALLISATION, or consolidation of saline matters, is accelerated, and really occasioned by the combination of gasses, such as fixed air, &c.

The pollen discovers its elastic and inflammable nature, also when blown into the flame of a candle; in which case, not only the particles which come into immediate contact with the flame, but all the rest are immediately kindled.



One of the most important subjects which can engage the attention of philosophical botanists, is the irritability of organized bodies. This was demonstrated with respect to animals, by the immortal Haller, and it is now more and more discovered to reside in plants.

Haller distinguishes,

1<sup>st</sup>, Nervous power (*sensibilitas*), from

2<sup>dly</sup>, Muscular power (*irritabilitas*).

Besides these, we observe another in living bodies; that is,

3<sup>dly</sup>, Elasticity (*elasticitas*).

Very often are these three powers confounded, though they differ essentially from one another.

Elasticity is common to all parts, but in different degrees. This power was well known to Bellini, De Gorter, Stahl, &c. The latter called it the *tone* of the fibre; and derived from it the irritability; which opinion is, however, now found to be erroneous; as elasticity is a power different from all the rest.

That



That it differs from irritability, is sufficiently demonstrated by Haller, Oeder, De Haen, Whytt, Zimmermann, Fontana, &c. vide Haller on Muscular Fibre, &c. ; of which Mr. Ullar, the principal author of these fragments, has inserted, in the German original, a short extract.

The power of contraction of certain parts, exhibited after applied stimulus, is also evidently observed in plants, and is therefore not merely peculiar to animals.

Whatever destroys the irritability in animals, does the same in plants ; as, for instance, violent electrical strokes. Whatever excites irritability in animals, excites it also in plants. If the contraction observed in *dionæa muscipula*, *mimosa sensitiva*, *averrhoa carambola*, *onoclea sensibilis*, &c. be not considered as effects of irritability, what cause can be assigned for it ?

Other instances have been given before, as, for instance, in the *vallisneria* ; and there is another in *nigella fativa* ; at the time of impregna-



tion of this plant, the antheræ and pistillum incline towards each other, and remain in the same position until the impregnation be completed. Such motion cannot be called voluntary, as plants are considered to be destitute of volition; it must therefore be of another kind, excited by an internal stimulus. It cannot, as far as we know, arise from the influence of nerves, as these have never yet been discovered in plants. The principal modern authors who have written on this subject, are *Ellis, Medicus, Girtanner, Gmelin, Hope, Percival, Cavallo, Sömmering, Wrisberg, &c.*

All fibres do not possess an equal degree of irritability; and hence, all the parts of organized bodies are not equally irritable. The cause lies probably in the greater or lesser access of the principle of irritability, and in the various capacity of bodies for receiving it.

Those parts appear to be most irritable which are most frequently moved.

Mr.



Mr. Uslar has also convinced himself that plants possess different degrees of irritability, without reference to their perceptible motion :

For instance, *reseda odorata* is destroyed by an electrical stroke, which applied in the same degree to another plant, *lepidium sativum*, does not hurt it in any degree.

The first is rendered sickly or gangrenous by water mixed with super-oxygenated muriatic acid, while the latter, when such water is applied to its roots, becomes more vigorous.

In the spring, we often find that some plants, as *phaseolus vulgaris*, &c. become gangrenous by the night's frost; while others, as *pisum sativum*, are never hurt by it; many other examples of this kind are observed in garden and forest trees, which prove the existence of different degrees of irritability in plants.

WE have farther to distinguish :

1<sup>st</sup>, Irritability, as the cause of many phenomena.

2<sup>dly</sup>,



2dly, The principle of irritability.

The first is understood to be the capacity of the irritable fibre to receive the principle, and its power of contraction.

The other signifies the principle itself which animates the fibre, and without which this cannot exert its capacity or power by applied stimulus. From both these differs,

3dly, The stimulating irritating matter.

There is probably a very powerful penetrating principle diffused throughout nature, and which affords the vital principle to all organized bodies.

Its existence was acknowledged at all times, as far as we know; but as to its nature, very different opinions have prevailed. Plato and Hippocrates already suggested their opinion on that subject: The latter called the vital principle *το ἐνστικτον*.

From the different degrees of irritability, which the same body possesses at different times, that is, in the two conditions or states in which  
the



the irritable fibre may exist ; namely, *1st*, When the principle of irritability is accumulated in it ; and, *2dly*, When exhausted of it ; it follows, that irritability depends on some foreign matter or principle. Vide REHFELD, *an Vis Irritabilis Fibrarum Muscul. insita ipsis inhæreat, an aliunde ad eas accedat.*

This principle appears very probably to be an elastic fluid ; and, according to Girtanner, it is the oxygen.

Oxygen is conveyed to all living bodies by the atmosphere and by their food ; and their parts variously possess more or less capacity for receiving it.

If oxygen is the principle of irritability ; it will follow, that its different proportion in the irritable fibre, must occasion different alterations.

If the irritable fibre contains the due proportion of it ; then obtains,

*1st*, The healthy state, which Girtanner calls the tone of the fibre.

*2dly*,



2dly, If the fibre abound too much with this principle, then the first preternatural state is caused, namely, that of ACCUMULATION.

3dly, If the muscular fibre is destitute or deprived of it, then follows the state of EXHAUSTION.

It has been before observed, that living bodies receive the principle of irritability by their food and from the atmosphere. In order to prevent the accumulation of it, therefore, it is required, that some matter be applied to them, which shall deprive the irritable parts of the superabundant portion; such substances or matter, are called STIMULANTIA, or stimulating principles.

Now, if these are applied in a due proportion, corresponding to the increase of the principle, so that the fibres are deprived of the superabundant portion, and retain only that portion which is necessary for their natural state, then health is maintained.

If



If on the contrary, the stimulus applied, is disproportionate, then two cases are possible ;

*a.* If the stimulus is too weak, then the fibres retain more than is necessary, and accumulation follows.—But,

*b.* If the stimulus is too great, then the fibres lose the principle more rapidly than they receive it from without ; and exhaustion is the consequence.

Exhaustion may then be ;

1<sup>st</sup>, Temporary, or

2<sup>dly</sup>, Irreparable.

The first continues until the fibre has recovered the principle of irritability ; and till that period, the fibre is insensible to every stimulus, or no stimulus can produce contraction in it.

But on the contrary, the exhaustion becomes irrecoverable, when the stimulus has been too great, *e. g.* in the case of a violent electric stroke, or application of strong poisons, so that the capacity of the fibre is destroyed, or the body is deprived of all its principle of irritability ; then, gangrene

or



or decay is the consequence ; the parts of the fibre become subject to the laws of chemical decomposition, and putrefaction gradually follows.

Both, therefore, accumulation, and diminution or exhaustion, of that principle are diseases ; the consequence of the latter we have just observed ; that of the first is the same.

By the accumulation, the fibres become too irritable ; hence, the contractions they perform are more violent than they can sustain. It is possible, that the consequence shall be, either that the fibre, by too violent action, shall lose its contractile power as far as this depends on the particular structure ; or, that the access of the principle shall be cut off or interrupted by the lost capacity of the fibre for receiving it. In either case, a relaxation follows which leaves no hopes for recovery, for the weaker stimulus has the same effect upon the fibre with accumulated irritability, as the stronger stimulus, *e. g.* electrical percussion



percussion or poison has upon that with the natural tone.

The effect of a frost in the spring is thus explained; the greater the intensity of cold, the more the principle of irritability is accumulated in the irritable fibre, because the general stimulus heat is absent, and because, both for this and many other reasons, more oxygen combines with bodies that are capable of receiving it, in a lower than in a higher temperature. In such circumstances, the principle accumulates so much in the fibres, that a small portion of sensible heat is capable of inducing an irreparable exhaustion.

Two examples which prove this theory, were experienced almost throughout Germany.

*1<sup>st</sup>*, In winter 1788-9, great destruction was occasioned by the violent cold in forests and fruit gardens, though scarce any bursting of their vessels, from expansion of the water while freezing, was perceived in the trees, as there were no sudden changes of temperature.

Q

In



In the spring, the greatest part of these trees produced flowers and leaves, which very soon thereafter, not only dried up, but the trees themselves actually died. The same was observed in those trees which were already in foliage, and had formed their fruits. This was the consequence of too great irritability; from which the fibres, by the application of the usual stimulus were greatly affected, and irreparably exhausted.

2d, The month of April 1792 had already the appearance of June; in May, most plants were in bloom and in full foliage, and rich crops were expected: But by the frost which happened on the 7th and 8th of May, all these flattering hopes were destroyed.

On the 11th, Mr. Uilar collected the following observations:

a. The trees in the woods, on the east and south side, having been most acted upon by the sun in the rising of the day, had suffered more by the frost, than those situated towards the west



west and north. The leaves of most trees became gangrenous and decayed on the side exposed to the sun.

b. All kinds of trees had not suffered equally. The oak and beech had suffered most. *Acer*, *fraxinus excelsior*, *betula alnus*, had likewise suffered much; but *carpinus betulus*, *betula alba*, *forbus aucuparia*, had suffered much less, though they all stood mixed and interspersed with the former. May not this be considered to arise from their different degrees of irritability?

It is well known to gardeners, that when night frosts prevail in the spring, it is necessary to protect the tender and most irritable plants with matts, and thus defend them, not only against the cold, but also against the sudden effects of the sun, and heat thereby induced.

The covering appears to prevent the accumulation of the principle of irritability in the fibre during the night; and also the too violent effects which would then be caused, by the stimulus of light and heat.

The



The increasing temperature, as the day-light increases, affords already a sufficient stimulus for them ; plants are thus deprived of part of their irritability, which in due proportion, gives tone to the fibres, and by this they become gradually capable of sustaining the stimulus induced upon them in the middle of the day without injury.

The change of the fibre from the accumulated state to the moderate, and from this to the exhausted state, proceeds very quickly. Such changes, we observe in the phenomenon which is called the Sleep of plants. But the irritable fibre when exhausted, recovers its irritability very slowly.

According to Mr. Ufflar's opinion, a plant, particularly an evergreen ; as *Ilex aquifolium*, or *quercus ilex*, whose irritability has increased during the winter ; if in the approaching spring, it were placed and well preserved in an ice-house, would become so very irritable, that when afterwards taken out and suddenly expo-

sed



fed to the warm atmosphere of the summer, it would be so exhausted in a short time, that the capacity of its fibres would be entirely destroyed.

THE irritable fibres of organized bodies have a connection or sympathy with each other (*consensus*), from which follows ;

1<sup>st</sup>, That a stimulus applied to one is communicated to the rest : But the effect of the stimulus thus applied to the fibres, is in general greater upon that which first receives it, and proportionally less upon the others as they are more remote.

If a branch of the mimosa *pudica* be touched, it shrinks and collapses ; the stimulus which is produced by the touching, produces an effect upon the whole plant, but not equally upon all its parts.

2<sup>dly</sup>, If the stimulus applied to one fibre has an influence upon the rest ; it follows, that if the one is injured in any way, it must then likewise affect



affect the other ; that is, if one fibre be deprived of its principle of irritability, then the same change will take place in the other connected fibres, but in a less degree.

*a.* Because the stimulus applied to one single fibre, affects the whole system of fibres, and every stimulus occasions a loss of a part of the principle of irritability.

*b.* Because the rest of the fibres afford supply to the exhausted fibre, by parting with some of their own principle, provided this single exhausted fibre has not lost its capacity for receiving it.

The more frequent the stimulus is applied, the more the fibre is deprived of its principle of irritability, the less irritable it becomes, the less is the effect of the stimulus, and the contraction is diminished in proportion ; if the fibre is quite exhausted, then the effect of the stimulus ceases totally. This is one of the most interesting facts which Girtanner has demonstrated,



monstrated, and which shall be more considered in treating of the sleep of plants.

The degrees of contractibility is in proportion ; to,

1<sup>st</sup>, The degree of irritability which the fibre possesses ;

2<sup>dly</sup>, The intensity of the stimulus.

As there exist different degrees of irritability and stimuli of different power.

Bodies when disposed to come in contact with the irritable fibres, exert different effects upon them, according to the degree of attraction of the oxygen for them.

If the attraction of oxygen is greater for the foreign body than for the fibre ; in this case the body takes the oxygen from the fibre, and the fibre loses thereby its irritability ; all bodies of this nature are called Stimulating Substances.

But, if on the contrary, the oxygen has a greater attraction for the fibre than for the body which is brought into contact with the fibre, then



then the body loses its oxygen, which the irritable fibre takes up, and thence its irritability increases.

If the attraction for oxygen is equal in both, then no alteration takes place, and bodies of this kind do not increase nor diminish the irritability.

To the stimulating matters, belong: heat, light, electric matter, spirit of wine, carbonic acid gas, and all gasses which have a strong attraction for oxygen, *viz.* hydrogen gas, &c.

Leaves immersed in water impregnated with carbonic acid, soon lose their irritability and fade. All bodies which contain oxygen, and which, when brought into contact with the irritable fibre, lose their oxygen by a superior attraction of the irritable fibre for this principle, increase the irritability of the fibre; *viz.* super-oxygenated muriatic acid, metallic oxyds, water, as this latter is decomposed by plants; cold, in so far as by a diminution of sensible heat, one principal stimulus is lessened, so that the fibre  
being



less irritated, retains the oxygen from the decomposed water, whence the irritability of the fibre is increased. A similar effect of the accumulation of oxygen by cold, is observed in the manufacturing of paper; for paper made in the winter by a strong cold, is much whiter than that which is made in the summer.

Heat as a stimulus excites the activity of the vessels, and promotes vegetation in general; the living power is considered as an alternate contraction and extension of the fibres. Cicero already considered heat as the vital principle: "Omne vivum, five animal, five terræ  
"editum, vivit propter inclusum in eo calorem."  
"rem."

Asto the effect of the matter of heat, we know, that if it is applied as a stimulus to plants, proportionably to the irritability of the irritable fibre, it then promotes vegetation: But if the heat is proportionably greater than what the fibre can sustain, in such case, an irreparable exhaustion and death will follow.



Heat always causes a diminution of the irritability of the irritable fibre, and this is necessary to prevent accumulation. MEDICUS has found, that the irritability of plants is greater in the morning, less in the middle of the day, and much less in the evening. Mr. Ufflar was well convinced of these facts by his observations respecting the sleep of plants; he also found, that by long continued rainy weather and cool air, the irritability of those plants, whose irritability is observable by contractions, was considerably increased. The proofs of the effects of a moderate heat promoting vegetation are numerous, and very obvious in hot-houses, &c.

Many animals which hide themselves during the winter, and remain apparently lifeless in their cells, disappear, as Mr. Spallanzani has observed on the lacerta *salamandra*, at a season when the temperature of the atmosphere is much higher than in the spring when they again make their appearance. The cause of this phenomenon lies in the state of irritability; in the autumn, the  
fibre



fibre is much exhausted by the heat and light of the summer; but, in the approaching spring, the irritable fibre is in the accumulated state, by the greater absence of those principles during the winter; in which case, a less degree of heat has a greater effect, than a higher temperature could produce in the autumn.

This explanation may with much propriety be applied to similar phenomena observable in vegetables, and many other phenomena may be explained upon the same principles.

Vigorous is the growth of plants in the spring, quick the motion of their juices, and from month to month both decrease: By the approach of the autumn, vegetation is stopt, and in the finest days of the autumn, at which time it is even warmer than in the spring when plants grow so vigorously, the vegetable tribe is so absorpt in sleep, that the light of the sun is then not capable to awaken them. The warmer the summer had been, and the more the sun had shone, the sooner the leaves of trees and plants change their



their colour; and the longer they retain their green colour, if the summer has been cool and the sky much covered with clouds.

Plants which have stood all the winter through in warm rooms, grow but slowly in the spring when other plants grow very vigorously. In order to preserve the plants growing in rooms, it is very proper to expose them occasionally to a colder atmosphere. Mr. Ufflar recommended this, and the results of experiments were always agreeable to his theory of irritability; it however must be done with caution, and the plants must not be too long exposed to a cold air, nor in a very cold atmosphere, else the principle of irritability accumulates too much, and the warmth of the room becomes then too great a stimulus, and injures the plants. This is not the only remedy for procuring new strength to plants that grow in rooms, but any substance which supplies them with oxygen answers the purpose; as, for instance, moistening the earth in which they grow, with  
water



water containing a little super-oxygenated muriatic acid ; of which more will be mentioned in the following part.

Respecting the different degrees of irritability in different plants, Mr. Ullar had made many observations.

Plants from warm climates, he found generally more active than those from more northern. *Jasminum azoricum* still produced branches and leaves, when plants of a colder climate had long ceased to grow.

It appears to M. Ullar, that the plants of northern climates, are more irritable than those of the warmer climates ; and although organized bodies, by change of climate, change in some respect their constitution in the following generation, yet we find that they retain always some difference respecting their irritability.

Most of the plants which have been transplanted from their warmer climates into our northern, part, for instance, later with their leaves, and likewise change their colour later, and not unlikewise



frequently we find the wood of a paler colour.

So, for instance, the wood of trees which grow nearly under the equator, is of a deeper colour, *viz.* *fwietenia mahagoni*, *cæsalpinia brasiliensis*, *hæmatoxylum campechianum*, *asphalathus ebenus*, &c. This is not merely limited to the wood, it is also observable in the green colour of the leaves. The leaves of trees of hot climates are generally of a deep green colour, *viz.* *caſuarina equisetifolia*, or at least they are of a deeper green than those of the plants of northern climates.

Moreover, it is known, that the colour of animals living within the tropics, is not only deeper and more shining than of those which live nearer to the poles, but that they also change their colour into a paler one when they are transported from thence into our northern countries.

The cause of the paler colour appears to be the presence of oxygen, a supposition which is  
verified



verified by the observation, that all vegetable substances which cannot part with oxygen are colourless.

This is shown by nature, and proved by experiments. If plants are placed in the dark, where they must retain the oxygen which they receive, they become paler and more irritable. Branches, or wood, which cannot absorb it are white; plants which do not emit pure air, or only a very small portion of it, *viz.* Fungi; lichen *parietinus*, *L. pallescens*, *L. lacteus*, *L. ericetorum*, *L. miniatus*; melampyrum *nemorosum*, &c. are almost colourless: but all the parts of plants, as leaves and calyx, and all plants which yield pure air, are coloured.

That oxygen is the principle of irritability, will be more fully proved by experiments. Plants acquire oxygen from their aliments, and from the air: they receive it by decomposing the water. Plants take a certain portion of it combined with hydrogen and carbonaceous matter into their constitution: they part with some of the  
received



received oxygen again by the applied stimulus ; and it appears that the deeper the colour is of plants or their parts, the less oxygen do they take up, and the more carbonaceous matter do they contain.

If oxygen be the principle of irritability, it will follow :

1<sup>st</sup>, That plants of a deep colour are more irritable than those of a lighter colour : and from the deeper colour of plants of hot climates, we may conclude :

2<sup>dly</sup>, That these are less irritable than plants of northern climates.

That such difference of irritability in plants exists, appears very evidently ; for, if the plants of hot climates were not less irritable, the continual uninterrupted growth of plants within the tropics would be impossible : they would be exhausted like those of our countries, and they could not sustain the stronger stimulus of light and heat : we may hence perceive, why barley ripens in Lapland in 60 days, and  
why



why it requires twice that time in France. The explanations now offered of the different above-mentioned phenomena, are derived from the principles of the new theory ; and deserve highly the attention of philosophers.

MR. GIRTANNER draws some general conclusions from the doctrine of irritability, such are the following :

The irritability of living bodies always bears proportion to the quantity of oxygen which they contain ; hence it may be deduced,

*1st*, That whatever increases the quantity of oxygen in organized bodies, increases also their irritability.

*2dly*, Whatever diminishes the quantity of oxygen in living bodies, diminishes at the same time their irritability.

The following experiments which corroborate what has been just mentioned, were made in support of Mr. Girtanner's principles by Mr.

S

Ullar,



Ullar, and they are confirmed by the observations of Mr. Von Humbold in his *Flora Friburgensis Subterranea*; Mr. Ullar took different seeds and plants, and caused an accumulation of oxygen in some, while no such accumulation took place in the rest: he found, that under certain circumstances, the first germinated sooner and grew quicker than the latter. In order to dispose plants for imbibing more oxygen, it is necessary to apply to them bodies, which contain the oxygen but weakly combined, or from which it is easily separable, and whose basis has less attraction to oxygen than the vegetable matter has; such a body is the super-oxygenated muriatic acid.

Mr. Ullar sowed *lepidium sativum* in two different pots, the earth of the one he moistened with pure river water, and that of the other with the same kind of water mixed with super-oxygenated muriatic acid. The seeds in the latter germinated much sooner than in the former, which  
was



was only moistened with pure water, and which consequently could not communicate to the plants so much oxygen as the other, and thence too, the plants in it were much retarded in their growth. In these experiments it is to be observed,

1<sup>st</sup>, That the quantity of super-oxygenated muriatic acid which is added to the water must not be too great; otherwise, it proves rather noxious than beneficial, as the oxygen accumulates, the plant becomes too irritable, and bad consequences soon follow.

2<sup>dly</sup>, That the germinating plants, especially those which are impregnated with oxygen, are not to be immediately exposed to the sun rays; for light proves generally hurtful to the embryos and germinating plants, or while in their earliest stage; the cause of it is the too great irritability at this period, which however diminishes with the increasing age of the plant.

Those seeds which were moistened with an equal quantity of super-oxygenated muriatic acid and water; and of which some were exposed

fed



fed to the sun, others kept in the dark exhibited very different phenomena; the first did germinate, but their colour soon changed; they became gangrenous and faded.

The latter germinated likewise, but they were left covered until the first leaf was evolved, and were not till then placed in the light: these made a rapid growth, and soon reached their state of perfection.

Besides what is above-mentioned, there is another chemical cause, whence the bad effect from exposing plants suddenly to the light, may be derived; namely, it has been observed, that light has a strong attraction for oxygen. It is this which renders the formation of super-oxygenated muriatic acid so difficult, and which causes the separation of oxygen from this acid when exposed to the light of the sun, so that the muriatic acid is then left behind in its common state. Mr Ullar convinced himself by experiments, that the common muriatic acid has a very different effect from the super oxygenated muria-

tic



tic acid, very probably by reason of the weaker attraction of the oxygen in the latter acid.

The results from the experiments made with other seeds; as, for instance, with *brassica campestris*, *brassica napus*, *lactuca sativa*, *pisum sativum*, *reseda odorata*, coincided with the results of the experiments before mentioned.

In order to ascertain in a more satisfactory manner, that the greater proportion of oxygen caused the vigorous and quick growth of plants, Mr. Ufflar varied his experiments.

1<sup>st</sup>, He took pounded quartz instead of earth, and moistened one portion of it with the super-oxygenated acid, another portion with pure water; the result was the same as in the former trials.

2<sup>d</sup>, He took a metallic oxyd, namely, oxyd of lead or litharge, and he found that the plants grew very well in it, and better indeed than in pure earth. This proves besides, that all metallic oxyds do not destroy plants.

Mr.



Mr. Ufflar also made the following experiments, in confirmation of the hypothesis, that oxygen is the principle of irritability.

He moistened, with super-oxygenated muriatic acid, earth in which he had planted *mimosa pudica*, and *drosera rotundifolia*, and he thereby brought them, not only to the highest degree of irritability, but he found that if he continued the accumulation, the light had so great an effect upon them, that they were destroyed by that stimulus. Other plants which showed scarce any marks of irritability, soon became irritable; all lost their irritability, often to irreparable exhaustion, when too often and too long stimulated, and when the supply of irritability was cut off.

The different degrees of capacity of different plants were also observable, as some took up so much oxygen from the same impregnated water, that they lost their proper colour and died; while others of different species, continued to grow vigorously.

It



It appears that the durability of organized bodies, particularly of plants, bears a certain proportion to the time in which they come to their perfection.

Forresters have frequent occasion to observe, that not only trees which grow very fast are of shorter duration, than those which require a longer time to come to their perfection ; *e. g.* *salix*, *betula*, *populus* ; compared with *quercus*, *fagus*, *acer* ; but also, that those whose growth has been accidentally accelerated, seldom arrive at the usual age which nature had determined for the species to which they belong. Not unfrequently we find, that trees sicken when growing in too rich soil. Of this Mr. Ussler was satisfied by experiment : by the increased supply of oxygen, and by plenty of food, the irritability is increased, and consequently the growth hastened : but he also found, that plants thus hurried on to blossoming and perfection, were not of such durability as those which arrive at those states in the natural course of time.

Pure



Pure air (oxygen gas) is in general favourable to vegetation, and even necessary to it ; but azotic gas, and hydrogen gas, when plants are included in them, prove fatal to them. Yet there are exceptions as to both, not only in certain circumstances which shall be mentioned on another occasion ; but also according to the various constitution of different plants.

Some plants grow better in bad air than in an air which contains much oxygen : Plants growing in deep mines are examples of this ; for if some of them are removed and exposed to atmospheric air, they soon die ; many of the *byffi*, lichenes, *agarici*, &c. grow not only in azotic or hydrogen gas, but even better than they do in the common atmospheric air, and they will not grow at all in pure air. The cause of this appears to be the want of a sufficient portion of hydrogen for their proper composition, and also the great irritability of their fibres, while the principle of irritability is not proportionably accumulated to sustain the stimulus.

The



The vital power of plants was formerly supposed to be derived from the ascent and descent of the juices, and this motion again, from the attractive power of the vessels for the nutritious juice; just as fluids rise in capillary tubes, from the attraction of the glass for the fluid: in like manner, a number of capillary tubes were imagined to exist in plants, extending from the roots to the extremities of the branches, and in which the juice rose upon the same principle as in capillary glass tubes.

This explanation Mr. Ussler contends to be repugnant to sound physiology, and he thinks that it is impossible that by this power alone, the juice can be conveyed to the extreme points of high trees.

Hales considered the ascent of the sap as the effect of heat and air, by which the juices were attenuated and more disposed for ascending, but this hypothesis appears very unsatisfactory. The doctrine of irritability leads to another theory, which is supported by many facts.



Without internal activity and contractility of the fibres, the quick circulation of the juice in many plants could not take place: were this effected by heat, it must be expected that the circulation should be quicker in the summer than in the spring; but we find, that the circulation of the sap in plants is quickest and most copious in the spring, when the plants are most irritable.

Mr. Von Marum has now decided this point in a dissertation, *De Motu Fluidorum in Plantis*. Groningen, 1773; towards the end of it he says:

“ Videtur verisimillimum, ipsis plantarum vasis actionem quandam esse attribuendam, quæ ab sorptos humores profundat versus illam partem, quæ minorem offert resistantiam; quænam autem sit illa actio, inquirendum restat.

“ Diametro alternatim diminui aut augeri plantarum vasa, et hac ratione contentos humores



“ mores urgeri, ex una vaforum parte versus al-  
“ teram, requiri videtur.

“ Utrum vero hæc vaforum constrictio oria-  
“ tur a vi quâdam contractili ipsis insitâ, quæ  
“ a contractilitate vaforum animalium non di-  
“ versa est, an vero ab aliâ quâdam vaforum fa-  
“ cultate derivanda, haud facile determinare li-  
“ cebit.”

It appears probable, that the vessels of plants possess a contractile power, such as Haller called irritability in animals. And it has been demonstrated by many experiments, that the diminution and extension of the diameter of the vessels, is produced by means of the spiral and circular fibres,

When Mr. Marum observed that milky juice flowed from the end of a branch of euphorbia when fresh cut, he immediately endeavoured to enquire into the cause of this phenomenon; and he compared it to that cause, to which the bleeding must be ascribed, when small veins of animals are cut asunder, *viz.* the alternate contraction



traction and dilatation of the vessels, during the circulation of the blood in animals.

Irritability is the cause of contraction ; if the contraction in the vessels of plants arises from it, it will follow that their action will cease as soon as the irritability of the fibres is destroyed : and if such shall be found to be the case, it may be deduced ;

1<sup>st</sup>, That contraction causes the flowing of the juice from the vessels.

2<sup>dly</sup>, That the cause of the contraction must be derived from the irritability.

3<sup>dly</sup>, That this, and its effect contractility, must cause the circulation of the juices.

In order to be convinced of the assertion, that strong electric shocks kill animals, by depriving them of, or destroying the irritability of their irritable fibres, Mr. Marum for want of amphibious animals, which retain some of their irritability for a considerable time after they are killed, took eels (*muræna anguilla*), which, as is known, possess the same power. By means of  
the



the Teylerian electric machine, he passed shocks through several of these animals, and the results of his experiments were ;

1<sup>st</sup>, When the stream of electric matter pervaded the whole animal from head to tail, it died immediately, and no mark of irritability could be discovered, even in its smallest parts, by any stimulus whatever.

2<sup>dly</sup>, But if the stream was directed through certain parts of the animal only, then he found that those parts only had lost their irritability, and consequently their contractile power.

These experiments, tried upon animals with warm blood, succeeded of course equally, as the irritability of their muscular fibre does not remain so long after death.

These experiments sufficiently proved, that the irritability of animals was suspended by the electric shocks ; in order to ascertain the same with respect to plants, he took various species of euphorbia, viz. *euphorbia campestris*, (perhaps *esula*) *euphorbia lathyris*, *euphorbia cyparissias*,  
and



and sent a stream of electric matter through them; he then cut off the stem, but no mark of effusion of the juice was now observed; the same was remarked in *ficus carica*.

If the stems of these were afterwards squeezed with the fingers, then some juice was forced out as long as the pressure was continued, which afforded a proof, that a certain power which had caused the effusion in former trials was now destroyed (namely irritability.)

By sending a stream of electricity through single stalks of these plants, the result corresponded with the experiments upon certain portions of animals, as in this case, only the particular part which had sustained the shock had lost its irritability.

It is not electricity alone which produces this effect in plants; there are other stimuli which may effectuate the total exhaustion of irritability, on which the contraction of the spiral and circular fibre depends. Mr. Ufflar succeeded at different



different times in experiments with *euphorbia peplus*, and *esula*, whose irritability he had highly accumulated, by increasing the supply of oxygen, and by removing the habitual stimuli of heat and light, so that when he exposed them afterwards suddenly to the light of the sun when in the zenith, they became gangrenous and dry in a short time. Mr. Ussler cut off from time to time, the stalks as they approached to this state; and he found, that although the efflux of the juice did not totally cease before they died, yet it was considerably diminished, in comparison with what was observed in other plants of the same kind which had their proper tone.

From what has been observed on this subject, it follows:

1<sup>st</sup>, That the contraction of the vegetable fibre is owing to irritability, as well as that of the animal fibre, and that both are subject to the same laws.

2<sup>dly</sup>, As the cause of the circulation of blood



in the animal body, is derived from the irritability and contraction of the fibres and vessels, we may suppose with some propriety, that the circulation of the juices in vegetables, may be effected by similar means.

ANOTHER remarkable phenomenon which is probably connected with irritability, is the sleep of plants.

The animal body requires rest, *i. e.* sleep; this is the state, during which the fibres and organs recover new powers for future activity, which they had lost by their frequent exertions.

The state of plants which is called the sleep of leaves, or more generally, of plants, appears to Mr. Ussler to be similar to the sleep of animals; and though we do not perceive it by external marks in all plants, it does not thence follow, that such do not enjoy it, or that their fibres do not become exhausted, nor require any time for rest.

There



There are but few plants, in comparison to the great number of plants produced, that show irritability by visible contractions, and yet all plants are more or less irritable. If we consider the cause of the sleep of plants, it will appear the more probable, that this phenomenon does exist in all plants.

Long before Linné, it was observed that plants enjoyed rest at certain times. Garzias observed this first in tamarindus *indica*; afterwards Dr. R. Camerarius wrote a dissertation, De Herba Mimosa l. sentiente, in which the subject was more fully treated; at last appeared the great Linné; his attention to that subject, was particularly engaged by the lotus *ornithopodioides*; he then demonstrated the sleep of plants, directly by observations and experiments, and shewed that it naturally took place in plants, succeeded regularly, and was independant of any extraordinary accidents.

With respect to the sleep of plants, he also observed many circumstances analogous to that



of animals, *e. g.* that young plants like young animals, sleep longer than those fully grown up. The cause seems to lie in the different degrees of irritability in different ages.

Sleep is rest, the time when fibres and organs recover from their relaxed or exhausted state, which has been induced by the living activity or irritability.

The whole organization is not deprived of activity by sleep, for the uninterrupted motion does not stop; this only takes place after death.

Animals and plants generally choose the night for their rest, because two habitual stimuli, light and heat, are then either altogether or mostly absent.

Plants which are only active in the night, are perhaps too irritable, and animals which are awake in the night, are not unfrequently forced to it by fear, and the particular economy of their life.

The sleep of man, consists principally in rest  
of



of the nerves of the brain; the more perfect this is, the more completely are suspended sensation and consciousness, and with the greater power do men awake again for new activity. If the fibres of their body be too irritable, if the stimulus, for instance, of heat, aliment, spirituous substances, are not sufficiently withdrawn, then the muscular fibre thereby stimulated, acts upon the ambient nervous fibre, the impression is communicated to the brain, and the sleep is less quiet, and less found.

The greater the previous exertions of the animal body have been, and the more irritable it was, the greater is the relaxation.

Motion is a mechanical stimulus upon the irritable fibre: Mr. Saussure observed, that a moderate motion which he made on the summit of Mount Blanc, fatigued him more than a considerable one on flat land; cold, or perhaps pure air on the mountain made the fibre too irritable, and the motion as a stimulus, was out of proportion to the irritability.

The



The same laws are observed in plants. The more they are excluded from heat and light during the night, the more perfect is their sleep; the more irritable they are, the sooner they are exhaustable, and the greater the stimulus is, and the longer it is continued, the more they are exhausted.

By means of a continual stimulus, the perceptible irritability of a mimosa may be abolished or suspended. All this leads to the analogical conclusion, that plants may be relaxed like animals, and that both require a time in which they may collect new powers, (*i. e.* accumulated principle of irritability), in order to become fit again for further exertion.

The congregation of nerves in animals exists particularly in the brain, every stimulus induced upon the irritable fibre, is communicated through this to the others, by acting upon the annexed nervous fibre, whereby animals perceive impressions upon the senses; by removing the stimulus, and by the exhaustion of the irritable



ritable fibre, consciousness and a certain degree of sensation are suspended, the nerves receive no impressions; and if their fibres, like the rest of the animal body, are capable of relaxation, they then have time to recover their powers.

Absence of stimulus, and diminution of irritability, are therefore the cause of sleep; and abolished sensation, or a diminution of sensation, are merely the consequence of those causes.

We cannot therefore say, that all organized bodies, in which we do not perceive evident marks of sensation or consciousness, must be also incapable of sleep, the conclusion would be as inconsequential, as if we were to assert, that all animals which are destitute of brains, are also incapable of sleep; or that those beings were destitute of sensation, because in animals which have a brain, sensation depends particularly upon that organ. Have not insects sensation, though they have only nodes of nerves instead of a brain? Do we not perceive sensation in worms, in which no nerves have yet been discovered?



vered? And do not all these beings sleep? Many observations might be produced in confirmation of this suggestion.

Mr. Ussar after having made many observations respecting the marks of sleep in insects; draws the following conclusions, that all bodies which possess irritability require sleep, *i. e.* that periodical rest is necessary for them, during which they recover from their exhausted state, and collect new irritability.

Many experiments which shew that plants by too frequent, long continued, and violent stimulus, become exhausted and relaxed, led him to this conclusion, that the uncommon position which we perceive at certain times of one or other parts of plants, is really a state of rest, and similar to the sleep of animals.

That during this time the growth is not stopped, cannot be proposed as an objection, because animals grow likewise during sleep; their power of reproduction proceeds, so does their respiration and digestion.

We



We find that different animals fall into particular postures when asleep, and that some do not show any external marks of sleep; and that there is great diversity as to the time and the duration of sleep in different animals: we find similar varieties in plants.

Some plants sleep in the night time only, others sleep also during certain hours in the day, some discover the state of rest clearly by their external appearance, and others again, manifest very slight or scarcely any marks of sleep; *solanum nigrum*, *ranunculus repens*, &c. shut their flowers some hours in the day, *spiræa filipendula*, &c. is shut in the middle of the day, *cactus grandiflorus*, opens the flower only at the sun-set, and shuts it in the morning, *mesembryanthemum noctiflorum*, awakes likewise only in the night.

Some plants when at rest, join the upper sides of their leaves, viz. *alfine media*, others fix them on the stalks, like *cænothera mollis*, &c. In some, the leaves become erect, in others they droop or fall down.

Linné



Linné has mentioned all these various dispositions of the leaves, in his *Philosophia Botanica*, and in the *Amœn. Acad.* IV. §. 340. *et seq.*

It was observed, that the closing and opening of the leaves and flowers of certain plants, varies according to the weather and condition of the air; such were called *FLORES METEORICI*: others which varied according to the length and shortness of the day, and which shut at sun-set, were called *ÆQUINOCTIALES*; and those which did so at certain hours in the day, were denominated *TROPICI*. From observations of the last kinds, Linné formed the *horologium floræ*.

Several authors who have written on this subject, attribute the general cause of it to light and humidity. Mr Ussler agrees with them, and allows both; but he takes the whole in rather a different sense, and adds, that whatever acts as a stimulus to the irritable fibre, may contribute to the effect; therefore, not only light and humidity, but also heat and alteration in the state



state of the atmosphere ; as, for instance, the degree of electricity, the admixture of carbonic acid gas, have influence upon the sleep or rest of plants.

We know the effect of electricity upon the irritable fibre of the organized body, and the influence of it upon vegetation in general will be afterwards demonstrated ; we shall here only observe, that most plants which discover strong marks of sleep by their external form, have pinnated leaves (*folia pinnata*.)

Light, heat, hydrogen gas, are matters which act as stimuli upon the irritable fibre ; if the fibre is too irritable, then exhaustion and the state of rest follows.

Without light, or in absence of it, without hydrogen gas, plants cannot continue nor perfect their growth ; proofs of this we observe in plants placed in atmospheric air excluded from light, and in those which are also excluded from light, but surrounded by hydrogen gas ;



for instance, plants which grow in deep mines, filled with bad air.

Both these act as stimuli, and deprive the plants of the surplus of oxygen, that is, of the accumulated irritability.

If the stimulus is too great, too frequently applied, or too long continued, then exhaustion follows, the fibre is of course relaxed; this is observable in many, partly by the interrupted external motion, partly by the marks of sleep.

Heated air, and the heat of the sun relax animals and plants; *hedisarum gyrans*, we find, ceases to move in the middle of the warmest days, particularly if by previous circumstances, *e. g.* low temperature, or moisture, the irritability of the fibre had become accumulated.

Mr. Ussar found the same results in experiments with the *mimosa*, if the irritability had been increased; he observed that the leaves and stalks collapsed sooner than usual, according as the sun had shone shorter or longer upon them,  
and



and by no other means was he able to awaken them from their sleep, than by applying such a body as could afford a fresh supply of oxygen.

If we only look into gardens, forests, meadows, we perceive that plants which have been relaxed and deprived of most of their irritability by heat, are quickly recovered by rain ; for in this case the water affords the oxygen, and agreeably to our new theory, replaces the lost irritability.

Plants in their natural state all follow those laws, which have been already noticed. Most awake at the rising of the sun, and return again to a state of rest at sun-set.

In short, plants are found to be more irritable and more active in the morning ; exhausted, less irritable, less active in the evening ; and it appears that diminished irritability is the cause of the phenomenon called the sleep of plants ; be it in the middle of the day, or in the evening, early or late in the day, the cause lies always in the  
state



state of the irritable fibre ; all are subject to exhaustion and relaxation, and all require a time wherein they may recover new strength. Thus Linné De Somno Plantarum: “ ut quiete  
“ tranquillâ fruentes novas quasi vires recupe-  
“ rent.”

Suppose the stimulus which causes the relaxation is not removed ; is it notwithstanding possible that plants can fall into a state of rest ? Why not ? the stimulating matter is only active as the fibre possesses irritability. It is therefore, not against the principles of our theory that the *portulaca oleracea*, *spirea filipendula*, &c. should shut in the middle of the day ; and although the latter awakes only in the morning towards nine, yet the cause why its fibres suffer a temporary exhaustion in the day, lies in their greater irritability : this may be said of all those plants which cease to be active in the afternoon about four or five ; and the reason why these require a longer time for recovery, depends



pende on the peculiar capacities of the fibres to regain the oxygen of which they had been deprived.

The more irritable animals and plants are, the more readily and the sooner they become relaxed, and the more frequently they require reparation: If, therefore, *portulaca oleracea*, folds up so early as 11, the cause is to be sought for;

1<sup>st</sup>, In the specifically greater degree of irritability of the fibres:

2<sup>dly</sup>, In the greater irritability which it possesses in the morning.

Its irritability is at this time too great, and therefore not in proportion to the stimulus; the fibre is exhausted: and the stimulus becomes only active again, when the principle of irritability has been again accumulated, and this takes place only as far as these stand in a more equal proportion with each other.

Many other phenomena may be explained upon the same principles. But it may be asked, if exhaustion of the irritable fibre is the cause  
of



of the sleep of plants ; how does it happen that the fibre is not irreparably exhausted when the stimulus is not removed ? To this Mr. Ussler replies, that when an irreparable exhaustion does take place, an uncommonly great accumulation, caused *e. g.* by a great or intense cold, must have previously existed ; and in this case, the stimulus acts not as being too long continued, but as being unproportionable and too violent, hence it destroys the capacity of the fibre. As long as the fibre retains the capacity to receive irritability anew, the exhaustion is only temporary ; but if plants are deprived of that disposition by which they receive the principle of irritability, then the temporary exhaustion is changed into an irreparable one ; this we observe to happen by a too long continued heat and drouth, and by a dry electric atmosphere : if the plants are only relaxed, and not totally exhausted by the greatest degree of stimulus, and if they stand in connexion with bodies from which they can receive a fresh supply of the principle of irritability,



ty, then the effect of the stimulus is only suspended, and only until the fibre is become irritable again.

HILL says in his dissertation on the Sleep of Plants :

“ When he made the light fall upon plants  
“ in different degrees, he found that their sleep  
“ was accordingly more or less perfect. Or that  
“ the more intense the light is which falls up-  
“ on plants, the more is their irritability, their  
“ principle of life set in activity ; and the less  
“ the stimulus is in proportion to their irritabili-  
“ ty, the greater degree of irritability remains  
“ in the fibres, and the more sensible they re-  
“ main.

He says farther :

“ According to the degree of light he had  
“ applied, was likewise the degree of sleep.”  
i. e. the greater or less the degree of stimulus  
to a certain point has been communicated, the  
more



more or less the fibre is exhausted and relaxed, as on this depends the degree of sleep.

In animals we observe the same, their sleep is more sound when they have been more stimulated; but too violent stimulus occasions a revolution in their body which approaches to disease, and from which they slowly recover, sooner, however, or later according to circumstances.

If we will not acknowledge the irritability of plants, if we do not admit, that the sun's light acts as a stimulus, and that by it the irritable fibre can be exhausted; it then must appear a mystery, why plants should show indication of taking rest at the time when the sun is in the zenith, while it is allowed by botanists, that the sun's light animates vegetables. But should not the following facts be deemed a proof of the irritability of plants, its exhaustion and accumulation? *viz.* that all the phenomena already mentioned, can be produced by other stimuli besides light, *e. g.* hydrogen gas, and carbonic acid gas; for the effects of these upon plants are similar to those



those of light; the plants undergoing similar changes in perfect darkness, when exposed to them, as by the application of light.

PLANTS, as we know, have different kinds of irritable fibres, straight, circular, and spiral; a stimulus applied to them occasions contractions, which appear according to the nature of the fibre by decurtation of the fibre, by diminution of diameter, or peristaltic motion.

HEDWIG asserts, that the origin and formation of the leaves and flowers are effected by the spiral vessels: when, therefore, a stimulus acts upon the fibre, a contraction ensues, and plants are forced mechanically to give the leaves and flowers a certain direction, and thus contract particular parts or extend them.

If the vegetable fibre is deprived of its irritability, it flags, the straight fibre is then elongated, the others extend their diameter, and thus naturally follow different positions of the stalks and leaves.



In this manner, Mr. Uflar imagines the opening of the flower is effected; if light, a moderate heat, or other stimulus acts upon the fibres and vessels of the calyx and petals, they contract, and the flower opens, to which certainly the life of the whole plant assists. The periodical closing of many flowers may likewise be explained by the extension of the contractile fibres and vessels.

Mr. Uflar has convinced himself by many experiments, of the justness of Dr Ingenhouz's observations, that many plants would surely die in hot weather in a few days if they had not time during the night for rest. He found cucurbita *pepo*, in the middle of a hot summer's day, lying on the ground exhausted and flaccid, he thought to recover it by moistening it with water, but in vain; probably the capacity of the fibre was not then so great as to receive immediately, without removing the habitual stimuli, light and warmth, so much oxygen from the water as would have been necessary to its complete



complete recovery, and to collect this, rest during the night was requisite, when the altered temperature and modification of the atmospheric air, and absence of light, are favourable for the restoration of the tone.

Here Mr. Ussler reminds us of the observation, that most of plants are hurt by moistening them with cold water in the middle of the day when the temperature is highest; for although they exhibit for a short time a vigorous appearance, yet this is only transient, and not unfrequently they die presently thereafter. The cold of the water, and the oxygen communicated by it, easily induce accumulation, which is succeeded by irreparable exhaustion.

F I N I S.



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 the night was reported, when the altered  
 temperature and modification of the atmospheric  
 air, and absence of light, are favourable for the  
 restoration of the same.

There are three things to be observed  
 that most of these are lost by morning in  
 and cold water in the middle of the day when  
 the temperature is high; for although they are  
 it is not a fact that a person's temperature, for  
 it is only a temperature and not a temperature only they  
 generally the first of the cold of the water  
 and the second is indicated by a small in-  
 crease in temperature, which is a sign of the  
 process of evolution.















