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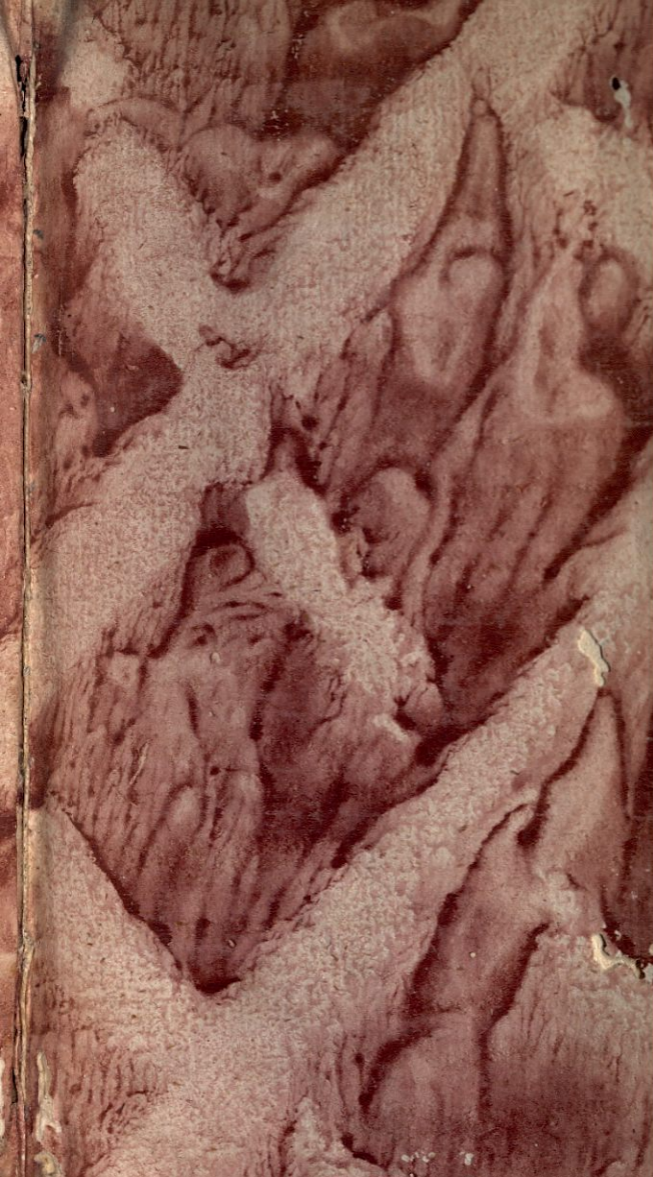
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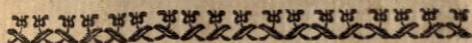
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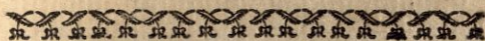




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THE
S L E E P
O F
P L A N T S
E X P L A I N ' D.



(Price One Shilling.)

THE UNIVERSITY OF

THE

SCHOOL OF

OF

PLANTS

EXPLAINED

BY

(Price One Shilling.)

THE
S L E E P
O F
P L A N T S,
A N D
CAUSE of MOTION
I N T H E
Sensitive PLANT,
E X P L A I N ' D.

By J. HILL.

In a LETTER to
C. LINNÆUS,
Professour of BOTANY at UPSAL.

L O N D O N:
Printed for R. BALDWIN in Pater-noster-
Row. M.DCC.LVII.

STUBB
PLANT
Cause of Motion
Sensitive Plant
EXPLANATION

By J. Hill
LONDON
Printed by W. Clowes & Sons, 7, St. Dunstons Hill, London, E.C. 4.



TO THE

K I N G,

S I R,

THE countenance Your
MAJESTY was pleas'd
to give a late work which I
presumed to address to Your

DEDICATION.

facred protection, and the marks of royal favour with which I was honoured on that occasion, claim my devoted acknowledgments; and command me to reverence Your MAJESTY in the double light of Sovereign, and of Patron.

In the highest sense of that distinguish'd favour; and with a heart warm with gratitude and duty, I lay at Your MAJESTY'S feet this second testimony of my most perfect homage.

The discovery, which, may it please Your MAJESTY, is the subject of this work, tho' to the
in-

DEDICATION.

incurious it may appear slight and unimportant, will, by those who are acquainted with the powers of nature, I assure myself, be regarded with more notice; as the solution of a problem held thro' many ages inexplicable: and when names and titles are forgot, it will perhaps be remembered that it was made in BRITAIN; under the protection of Your sacred MAJESTY: who, while the rest of EUROPE is involved in the worst horrors of a destructive war, give to Your subjects a repose, in which they can pursue the calm researches of philosophy.

That God, in mercy to Your
a 4 faith-

DEDICATION.

faithful people may long continue to them the blessing of **YOUR MAJESTY'S** reign, is the first, most earnest, and continued prayer of,

S I R,

YOUR MAJESTY'S

Faithful Subject,

And most devoted Servant,

JOHN HILL.

Advertisment.

THE public will please to excuse any particularity of style, in the succeeding pamphlet; since its appearance is accidental in this form. I promise myself so much indulgence from their candour, when they shall know it was originally intended to be no more than its title expresses; a private Letter to a foreign Naturalist.

There is a freedom of style, and assured manner peculiar to this kind of correspondence, which would be too assuming in works addressed immediately to the public; and might not unnaturally draw upon the author a censure of self-sufficiency and vanity. This explanation, I hope, will defend

ADVERTISEMENT.

from so unfair a charge: for indeed no one knows more the narrow limits of human knowledge; or entertains an humbler opinion of the returns for years of application.

That the experiments which were the occasion of writing it, have added their mite to the stores of science, will be allow'd; for it has not before been known, that those changes which are brought on by night, in what are called the sleeping plants, and in the sensitive by a touch, could be at our pleasure occasioned at any hour; and without the touch, or any other motion.

As this depends solely on removing the cause which kept them awake, (so it is the fashion to speak) and expanded, it will be allowed also that cause, tho' hitherto undiscovered, is known.

This is the utmost of the discovery;
and

ADVERTISEMENT.

and from this I persuade myself nothing can be taken.

The word Sleep, used on this occasion, will, I am afraid, appear to the judicious *British* eye, an affected, as well as improper term: but the application of it lies at another's charge; and perhaps the manner of the country where he is native, will excuse it. Having thus disclaimed the word, I shall be pardoned for using it in the following discourse, when the reader considers it as a private letter, written to the person who first adopted the expression.

The preserving that term, and publishing the whole with the particularities which gave occasion to this apology, has been owing to a strict regard to truth; which prompted me to lay the letter before the publick unaltered, rather than amended: nor has the publication of
it

ADVERTISEMENT.

it in England, where the taste of science is not general, any other motive, than to save the tediousness of transcribing, for the use of a few, who have been pleased to flatter me by their desire of preserving the discovery in its original form.



T O

The CELEBRATED

L I N N Æ U S.



T is not strange to you to be addressed from remote countries ; nor in the cause of science can it be unwelcome.

Probably you have less expected this from me than any other ; but I will not suppose you have less desired it : The same pursuits have a long time

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engaged our attention ; and it could not be that I should pass over your great name in silence. If our opinions have differed, 'tis upon a single Point ; your arrangement of plants. In regard to that much greater article, the establishing their distinctions, and ascertaining their characters, I have always admired and revered you : to dispute your determinations there, were to deny the characters of nature.

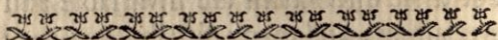
Free in the tribute of applause on this head, I have on the other been as open in my censures ; equally uninfluenced by envy, and by fear. It is thus science may be advanced ; and you will permit me to say, thus men of candour should treat one another. In this light I persuade myself you have always seen my conduct toward you : that you have read with the same equal temper the censures of the *British Herbal*, wherein it came before me to examine systems ; and the just applause
of

of *Eden*, where the characters of genera, and distinctions of species were most to be considered ; and that you will receive these impartial thoughts with more satisfaction, than all the little flattery of your pupils, or ignorant applause of those who have not understood your writings.

Systems are vague and unsubstantial ; but those distinctions are invariable and everlasting : and many distributions may be formed upon the discoveries you have made of them. In this essential part of botany you have alone done more than all who wrote before you : and I am convinced you will entertain no enmity against me, who with equal freedom point out these excellencies and what have appeared to me your imperfections ; that you will read those censures with no more resentment than I wrote with malice ; and will see on what foundation to build your fame : for I have said often, and the world will say it, your system is re-

pugnant to nature, altho' your characters are her own.

This is the opinion I entertain of you ; and in this confidence address to you the present treatise : an attempt to explain the cause of a quality in vegetables, whose effects none has observed with so much diligence or accuracy as yourself.



S E C T I O N I.

That the leaves of certain plants assume at night a disposition different from that of the day, has been long known : *Acosta* records it of the Tamarind ; *Alpinus* of that tree, and of the *Abrus* * ; and from these, all who followed : *Alpinus* extends the observation to several other of the *Egyptian*

* *Glycine foliis pinnatis conjugatis, pinnis ovatis oblongis, obtusis.*

kinds ;

kinds ; and you have carried it much farther among the *European*.

That Author conceiv'd it a provision of nature for the defence of the nobler parts, the flowers and fruit : and he particularly observes of the *Tamarind*, that its leaves embrace the tender pods.

This opinion *Ray* disclaim'd, tho' he allowed the fact : but you have adopted it. I think it will appear upon a strict examination, that the change itself is a natural effect, resulting from the common properties of bodies, and their operations upon one another ; and that the author of nature has in many instances made it effectual to that great purpose ; tho' in others it happens equally, without answering such end.

We see how far the observations of earlier writers carried the discovery ; how much farther your own : and I

persuade myself you will accompany me with satisfaction in a more deep research.

You have deserved greatly of the world in this and other instances, by tracing nature's steps, and recording those observations. To relate these facts is to give the history of nature: but there is something more within our reach. The human mind, daring, tho' weak, and inquisitive under all its limitations, seeks, (and sometimes not unhappily,) their causes.

There have not been wanting from the time when this property in vegetables was first regarded, some who have sought its origin; but all yet unsuccessfully. Those who supposed it the effect of heat and cold, might for a long time seem to have judg'd rightly; but when we find the same thing happen with equal regularity in stoves, where there is no change in the temperature

rature of the air, we are convinc'd that opinion cannot be just.

They were as far from truth, who supposed the health or sickness of the plant of any consequence in this respect; nor can I affirm, that I have found nature in all instances confirm your observation, that it is more obvious in young plants than old.

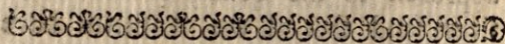
It will appear from the following trials, that the sleeping and the sensitive plants are naturally allied; that their motions, tho' differently brought on, are dependent on the same principle; that many of the sleepers approach to the quality of the sensitives; and that all the sensitives have theirs.

This will shew the subjects are connected, and the principal experiments will prove, that, with this connection, the principle of their motion is also found.

If I can close the Abrus leaves at noon day, and open them again at pleasure, you will own, I know the principle of their change of position.

If I can throw down, as well as close the leaves of the sensitive plant, without a touch, by removing the power which keeps them erect, and expanded, you will acknowledge the latent principle of their motion is also understood.

We always know the cause of those effects we can ourselves produce; and experiments are the true test of reasoning.



S E C T. II.

We see a great number of plants close their leaves at evening. The fact is as obvious as it is strange: but we know every effect has its cause; and we are
to

to seek this, not by vague conjecture, but in the established properties of bodies, and their known influence in different cases, upon one another.

The structure of plants we may easily know; and of no part more perfectly than of the leaves: for a good microscope shews their smallest veins.

Between the two skins of the leaf, which are continuations of the outer rind of the stalk, there run innumerable fibres of a larger kind; with clusters of more minute ones, in various forms among them.

The larger vessels are of a woody substance; hollow; and smaller all the way from the base of the leaf: they are collected together in a compact manner in the footstalk; with delicate clusters at its base: and they are originally sent from the pith within the stem.

They serve to support the leaf in its proper position; and therefore whatever external or internal cause affects them, will change that position.

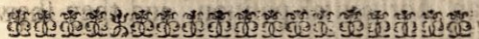
This is the construction of the part to be influenced; the question remains, what it is that affects it; and to know that we are to examine whatever may have such power.

Leaves thus constructed are always surrounded by the air; and they are occasionally and variously influenced by heat, light, and moisture: The air also itself being in a continual state of variation, its alterations are to be considered as possible subordinate causes of change.

These things, and these only, come within contact of plants, or within the sphere of influence. Bodies do not affect bodies, but on contact, or within that sphere: therefore the cause of the change

change of position in leaves, is to be sought among these agents, and no other.

They are naturally complicated, and they act on most occasions together. We are therefore to observe, first, what effects result from their mutual combinations in a state of nature: and having assigned in these cases the effect to the proper and particular cause, from this power of that agent, whichsoever it is, that acts thus in concert with the rest, we may deduce its operations singly.



S E C T. III.

Pinnated leaves, such as are composed of numerous lobes, or smaller leaves plac'd on a common foot-stalk, are most remarkable for their change of position: it will be therefore best to waive all other consideration here; and ob-

serve solely the condition of these.

The four agents we have named are universal ; but we shall find their operation differs in various climates. In these temperate kingdoms, our native plants which have pinnated leaves, naturally hold the lobes nearly horizontal, and shew but a moderate sensibility in this respect : in the hotter regions of the East, the usual position of the lobes in these plants is turning upwards, and they are extremely susceptible of change of posture ; in *Ægypt* most of all : in the more northern nations, on the contrary, they scarce ever reach an horizontal position, and they shew very little change on any occasion.

As we see different appearances in these parts of plants in hot, temperate, and cold climates ; observations of a like kind shew, they are not less variously affected in the same kingdom in rainy and fair seasons. In those places where there are regular periods

periods of rainy weather, the change in the face of the pinnated plants is very great, and certain: Those which in the fair months carry their lobes in an obtuse angle upwards, constantly hang them obtusely downward in the time of the rains.

These are the observations of curious voyagers; and they have been confirmed by the immediate notice of botanists in those places. The first would seem at once to give the effect to heat; and the other to moisture: but farther observation shews it is otherwise. You have justly observed, that the same thing happens to plants in the stove, where there is no alteration in point of heat; and I have found by careful tryal, that moisture has in the same respect no effect: I have for this purpose watered some plants almost to destruction, and left others of the same kind dry; and no alteration has been made by this: They all expand, or raise their leaves in the morning,

ing, and drop them in the evening; at the same hour and in the same degree.

Two of the four natural agents, heat and moisture, are therefore excluded from any share in this effect: the air is too universal and its changes too much depend on these to be admitted in the research. The attention therefore falls on light alone: and I have found by many experiments, that the change of position in the leaves of plants at different periods of the day and night, is owing to this agent and no other. This is the discovery I persuade myself I have made; and I shall endeavour to shew, that it is founded on reason, and supported by experiments.

Nor is there any thing strange in the effect, when duly examined. By excluding the supposed causes, we have discovered the real, for there remained no other: and in examining

ing the subject, on the principles here laid down, we shall find not only that no other power could produce the effect ; but that light inevitably must.

These are the discoveries on which the everlasting seal of truth is stamped : which reason dictates ; and which experiments confirm.



S E C T. IV.

We have proposed to search the latent principle of this change in the qualities of bodies, and their natural operations upon one another.

We have shewn what is the structure of leaves in general ; and it will now be proper to fix on some one in particular : Let us chuse for this purpose an *Ægyptian* plant, since those shew the effect most of all ; and among these

none

none can be more proper than the *Abrus*, celebrated for it by the earlier writers.

The leaf of this plant consists of thirteen pairs of lobes, fixed by very short and extremely slender footstalks to the middle rib; and this to the main stem of the plant.

Examining its internal structure by the microscope, we find a number of delicate fibres, rising from the central part of the main stem, and continued in a course obliquely upwards, through the intermediate parts, and to the outside of the rind. Here they swell; and run into several regular clusters, spreading downward and on each side; and these form (under the continued covering of the stem) the base of the common footstalk, or middle rib of the leaf.

From this part they are carried in a small compacted bundle, strait forward

ward to the extremity of the rib ; and there, as there is no odd lobe to close the leaf, they terminate in a point, covered by the common integuments.

From each side of this middle rib rise the footstalks of the separate lobes. These are formed of a multitude of delicate vessels, ranged close together, and confined by the covering, which is the common rind of the plant continued to that part.

At the base of each lobe, there is another complex cluster of fibres. From this part they are protended forward, strait to the end of the lobe ; and they send out only slight branches into the several parts of the leaf.

This is the particular fabrick of the Abrus leaf, as seen upon a careful dissection, and with a good microscope : it agrees with the general construction, we have given before, as the common course of nature in these parts ;

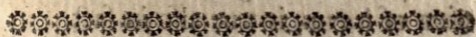
parts; and it will regularly explain the change of posture in the lobes, under the different influence of light.

Light is subtle, active, and penetrating: by the smallness of its constituent parts, it is capable of entering bodies; and by the violence of its motion, of producing great effects and changes in them. These are not permanent, because those rays which occasion them, are, in that very action, extinguished, and lost.

Bodies may act on light without contact; for the rays will be reflected when they come extremely near: but light can act on bodies only by contact; and in that contact the rays are lost.

The change produced in the position of the leaves of plants by light, is the result of a motion occasioned by its rays among their fibres: to excite this
mo-

motion, the light must touch those fibres; and where light touches, it adheres, and becomes immediately extinguished.



S E C T. V.

These are the everlasting and invariable properties of light: and, according to these, the change we attribute to it, being once effected, must be continued as naturally and as necessarily as it began, so long as the light continues, and no longer.

The raising of the lobes in these leaves will be owing to the power of those rays which at any one instant fall upon them: these become extinguished; but others immediately succeed to them, so long as the air in which the plant stands, is enlightened. It ought therefore to be seen, that in full light, the lobes continue in their most raised position;

fition; and that they droop from that in proportion as the light becomes less.

This which appears necessary from the powers of light, and the construction of leaves, is true also in fact.

We have seen that the footstalks of these lobes, are clusters of fibres protended from the center of the stem; that they are continued thro' the lobes; and that they support them in their position, whatsoever it is.

The effect of light upon these fibres is, the putting them into an incessant vibration: This happens necessarily from the continual impulsion and extinction of the corpuscles, of which light is composed, and the fresh impulsion of others, upon the extinction of the first.

It cannot be, but that a cluster of delicate fibres, affected incessantly by these concussions, must be put into a

vibrating motion; and this will be greater, as the light is more, and weaker as it is less.

This vibration is simple in the expanded fibres; but it operates as variously as distinguishably on those clusters of them, which are placed at the bases of the main rib, and of the several footstalks of the lobes.

It is on the operation of light upon these interwoven clusters of fibres, that the motion of the leaves in gaining their different position depends; and consequently, the motion itself is various, according to the construction of those clusters.

In the Abrus they are large, and of a lax composition; consequently the lobes are capable of a drooping, an horizontal, and an oblique upward position: in the Tamarind, and the broad leaved Robinia, they are more compact, and hence all the motion of which
those

those leaves are capable, is an expanding open, and a closing sideways; which the direction and course of the fibres also favours: in the *Parkinsonia* they are smaller, and yet more compact; and the consequence of this is, that its lobes have no farther possible motion, than the expanding and closing upwards.

Hence the effects of a full light are different on various of the pinnated leaves; raising the lobes of some, as the *Abrus*, and opening or expanding those of others, as the *Parkinsonia*.

The impulse of light, and the vibration it produces, are the same in all these instances: but the direction of that motion into which the lobes are thrown, is according to the course of the fibres; and the quantity of it, in equal degrees of light, to the construction of those reticulated clusters.

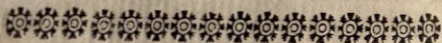
This universally appears on exami-

mination of the clusters of fibres by a microscope, and observation of the motion of the lobes: that motion being universally of greater extent, where the clusters of fibres are longer, and more loosely interwoven; and of less, where they are shorter, and more compact.

The effect of light upon bodies we see is to put their parts into a vibrating motion; the construction of pinnated leaves is such as naturally admits, and propagates that influence; and the clusters of fibres are as a kind of joints on which their lobes are capable, under the influence of light, of a certain limited motion.

As the state of water uninfluenced by heat is ice, the natural position of the lobes in these pinnated leaves is drooping. This is their posture of repose: but in this they were not intended by the author of nature to remain; for vegetation is very imperfectly performed, while they are in it. The effect of light is this vibration, and the alteration
of

of position in those lobes. This is the doctrine here advanced, and this is supported by the following experiments.



S E C T. VI.

I removed a plant of the Abrus from a stove, in the evening of the seventh of August, and placed it in my study, where it could have the effect of moderate day-light, without being expos'd to the immediate action of the sun.

This might be conceived the most natural and equable degree of light; and therefore fittest for the first experiments.

The lobes of the leaves were at evening, when the plant was brought in, fallen perpendicularly from the middle rib, and closed together by their under sides.

Thus

Thus they continued during the night; in a state of perfect repose. Half an hour after day-break they began to separate; and in a quarter of an hour after sun-rise stood horizontally; flat, and perfectly expanded. Long before sun-set they began to droop again; and toward evening they were closed underneath, as at first.

Next day the plant was set in a room, where there was less light. The lobes were raised in the morning; but not to a horizontal situation; and they drooped earlier at evening.

The third day it was set in a south window, open to the full sun. Early in the morning the leaves had attained their horizontal situation; by nine o'clock they were raised considerably; and they continued in this state till toward evening, when they by de-
C grees

grees fell to the horizontal situation ;
and from that droop'd gradually to
the usual state of rest.

The fourth day the plant stood in
the same place, but the sun did not
appear. The lobes obtained early
their horizontal situation, but did not
rise beyond it : and in the evening
clos'd as usually, below.



S E C T. VII.

These experiments shew the effects
of various degrees of light : at the
same time, that they prove the whole
change to be occasioned by light only.

The effect of moderate light, that
is, the light of a bright day out of the
sun-shine, is to raise the lobes to an
horizontal position : Less than this
places

places them at an obtuse angle downward : more at an obtuse angle upwards.

The fifth day the plant was set in a less enlightened room : and the leaves had obtained by nine o'clock their position at an obtuse angle downward : it was then brought into the lighter room, and they rose to the horizontal situation in a quarter of an hour. It was then removed to the window, where the sun shone, and the lobes were elevated as before : and being thence carried into the less light room, they drooped again. All these changes were produced between the hours of nine and two, the weather the same, and only the place of the plant changed.

On the sixth day it remained in moderate light ; and kept its leaves horizontal.

On the seventh I made the final experiment.

It appeared to me that if light were the sole cause of the motion, and change of position in the leaves, then denying the plant the benefit of light at any time, must bring on that change: that it would not be difficult to darken the place where the plant stood, at any time: and that the consequence of this must be, if the principles already laid down were true, a bringing on of the change at any time of the day. This experiment appeared as a just proof of the foregoing reasonings: if darkness would at any time throw down the lobes, the system of that motion before delivered must be true; if not, that all the reasonings must be false.

The assent of the world must also depend on this. Deductions of reason
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son may be disputed, but it will be allowed certainly, that we understand the cause of a change we can produce.

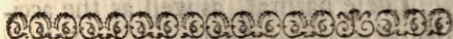
In the evening of the sixth day I set the plant in a book-case, on which the morning sun shines; and throwing open the doors, left the whole to nature. The succeeding day was bright. The lobes which had met in their drooping position at evening, and continued so during the night, began to open early in the morning, and by nine o'clock they had pass'd their horizontal situation, and were elevated in the usual manner.

I then shut the doors of the book-case: the plant was by this left in darkness; and on opening them an hour afterwards, the full change had happened: the lobes were all drop'd, and it was in the same state that it would have shewn at midnight.

On the opening of the doors the change began very soon: and in twenty minutes the lobes had obtained their elevated situation. This experiment I have since many times repeated, and always with the same success.

It is in our power therefore to bring on this state of repose at pleasure; and by the admission or exclusion of light, to make the plant at our own time put on all its changes, from the drooping to the most elevated position of the lobes.

We know that in these experiments, light alone is the cause: we are therefore certain, that what is called the sleep of plants, is the effect of the absence of light alone, and that their various intermediate states are owing to its different degrees.



S E C T. VIII.

This being explained, a second discovery follows naturally. The motion of the sensitive plant, at the cause of which no philosopher has hitherto ventured a conjecture, is in a great measure owing to the same principles: and the explanation of it, which before the effect of light upon the leaves of plants was thus shewn, must have been enveloped in impenetrable obscurity, may now be regularly pursued.

The sensitive plant, beside its singular quality of closing and dropping its leaves upon the touch, is subject to the same changes with the *Abrus*, and those other kinds, we have named from the effect of light.

These natural, as well as the accidental motions on the touch, I have traced regularly in the common sensitive plant: but before we enter on the detail of those observations, it will be proper to remark, how nearly some other plants approach to the quality of this, and the other species of sensitive, which they have been hitherto supposed to possess alone.

This surprizing quality is a power of motion in the lobes and their footstalks. No change of position can be made without motion of the parts, therefore the Abrus, and all these other plants have also motion.

They agree with the sensitive in displaying this motion from the power of light; and all that remains particular in the sensitive is, that it is capable of the same motion from another cause. This is an
 acci-

accidental shock of its parts,



S E C T. IX.

Even that is a quality common to some other kinds, tho' in an inferior degree: for a Tamarind tree has lately been under my observation, closed its leaves on motion.

A flourishing plant of this, a yard high, being brought from Mr. Lee's nursery at Hammer-smith, to me in St. James's Street, in the middle of the day, came in with its leaves closed; as it naturally has them at midnight, and as the sensitive plant on being touched.

An Abrus suffered no change under the like circumstances.

Hence we infer, that the same construction of parts, which gives the

sensitive plant the power of motion, is in the Tamarind tree, tho' less delicate ; so that a ruder shock is required to bring on the change.

It is in a lower degree also in the Abrus, for light has that power, tho' the effect cannot, so far as we have yet seen, be produced by a shock.

Plants which suffer this change from the effect of light, may, tho' they do not universally, shew it also from motion ; and all plants which are capable of this change by motion, suffer it also from the absence of light.

Light gives their leaves that position, from which they are to be thrown by a touch : and the absence of light takes the same effect with that touch ; tho' in a slower manner.

The sensitive plant at noon day, has its leaves raised and expanded.

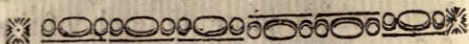
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The footstalks make an acute angle with the main stem, and the two leaves which grow on each of the first or lower ones, stand remote from one another. The lobes which compose these, are about twelve pair to each, and these also stand in an horizontal direction.

Thus the young plant appears in the middle hours of day. At the approach of evening, the lobes begin to draw themselves together upwards, as in the *Parkinsonia*; and the middle rib of each approaches toward the other: at night the lobes are as entirely shut upwards, as those of the *Abrus* downward, the two ribs are placed close to each other; and the footstalk which supports them both, hangs down.

This is the state of repose of the sensitive plant: into this it falls every night naturally; and into this it may, in the same manner as the *Abrus*, be
 C 6. thrown

thrown at noon day in a darken'd place.



S E C T. X.

As we have seen the cause of this change in the Abrus, to be light, and have traced the manner of the operation; it is easy to follow it also in the *sensitive* plant, thro' the same course of enquiry.

At the base of the footstalk, where it joins the main stem, there is a cluster of complex fibres: These have risen from the medullary part, and pierced the woody sides of the stem.

From this complex cluster, the fibres proceed in a strait line up the footstalk, till at the head of that, where the two leaves rise, there is another such cluster: thence the fibres run strait the length of the main rib, and
send

send out on each side other clusters at the base of every lobe. From these the more minute fibres run strait thro' the leaf, and send out lateral shoots.

This the microscope discovers plainly, and this shews that not only the natural motions of the sensitive plant, are the same with those of the Abrus and others; but that the construction also is the same in its kind; tho' more complex.

In the night the sensitive plant is not capable of the common motion on the touch, for the leaves are already in the condition whereto they would be reduced by it. In the day they rise and spread: and 'tis then the strange effect appears on touching them.

Light expands the lobes, separates the ribs, and raises the footstalks. It does this, by putting all the parts of
them

them in a vibrating motion. This we have seen in the Abrus, is principally effected by means of those clusters of fibres which are placed at the bases of the footstalks. In this plant, as there are no less than three sets of those clusters, the effects of the same principle are naturally much greater than in the Abrus, where there is only one.

The vibration of the parts is that which keeps the leaves of the sensitive plant in their expanded and elevated state: This is owing to a delicate motion continued through every fibre of them. When we touch the leaf, we give it another motion more violent than the first: this overcomes the first: the vibration is stopped by the rude shock: and the leaves close, and their footstalks fall, because that vibrating motion is destroyed, which kept them elevated and expanded.

That

That the power of motion in the sensitive plant depends upon the effect of light on the expanded surface of the leaves, is certain; for till they are expanded, they have no such power. The young leaves, even when grown to half an inch in length, have no motion on the touch, tho' rough and sudden.

To propagate the motion when the leaves are in a state to shew it, there requires a perfect and confirm'd state of those clusters of fibres lodged at their base. This is evident: for when the young leaf has first come into the state of vibration, a touch will make its lobes close; but the effect is not continued down the foot-stalk, till it is more confirmed. No shock on the young leaf will affect the foot-stalk before it is expanded: hence the clusters of fibres at the bases of
the

the lobes first acquire their due condition for motion; and afterwards those at the head of the main foot-stalk.

As there requires a due firmness to give the clusters of fibres the susceptibility of motion, and power of propagating it farther; there needs also a concurrence of favouring circumstances, to preserve them in that delicate state wherein they are capable of exerting these powers.

The cold air hardens the fibres and impairs their susceptibility of motion. The sensitive plant becomes more languid in this respect when removed out of the stove.

The correspondence between this motion, and what you have called the sleep of plants, or their natural closing of their leaves at night, appears also in this instance: for as the
sen-

sensitive by being removed out of the stove, loses in some degree the quality of closing its leaves on the touch, the Tamarind by the same change loses in great part its quality of closing the leaves at evening. This is probably owing to the juices stagnating in the clusters of fibres, and to the contraction of the bark by cold.

The communication of motion is less from the lobes to the foot-stalk; and greater from the foot-stalk to them. The greatest shock is given to the plant by a rude touch of the stem: but even this does not affect the unexpanded or young leaves.

The analogy between the effect of a sudden morion, and of the absence of light is confirmed also by this; for as light decays naturally at evening, or artificially by shutting up the plant, the lobes first close, and the foot-stalks afterwards fall.

The

The power of absolute darkness is greater on the sensitive plant, than that of the rudest touch. The rudest touch will only cause the lobes of the separate leaves to close, and the foot-stalks to hang down: the two leaves will remain far asunder. The effect of absolute darkness exceeds this; for the two leaves close also absolutely together, and it appears as if the foot-stalk supported only one. This proves that the expansion of those parts depends solely upon the effect of light; and that altho' it may be disturbed by a superadded and ruder motion, yet it can be taken away absolutely only by darkness; by the defect of that to which alone it was owing.

These experiments every one may easily repeat: the observations will be familiarly made by any who have stoves: They are constant and

and invariable; and the conclusions from them are certain; for no other cause intervenes.

The effect of light is continual while the light continues. The plant therefore whose leaves have been thrown down, and clos'd by this rude shock, is immediately affected by the light, as at its first appearance in the morning; or as on its admission, when the leaves had been clos'd by artificial darkness. The vibration begins; and if the light be at its full strength, the expansion and elevation of the lobes is so quick, that one may almost look upon the plant, and see it. A few minutes often perfects it.

That the touch of the leaves no other way affects them than by a motion greater than their own internal vibration, is plain from this, that if they be touched with a finger in
so

so deliberate and gentle a manner as not to move them, no effect is produced: and on the other hand, if they be any other way moved, the full effect follows.

If the pot be shook, tho' no part of the plant be touched, the leaves close, and their foot-stalks fall: or if the wind blow them, the effect is the same.

Hence it is certain that the expansion of the lobes, and elevation of the foot-stalks in these pinnated plants, is occasioned solely by that vibrating motion, in which their parts are kept by the continual impulses of light: and consequently that in all of them they collapse or sink on the absence of light; and in the more delicate kinds upon the shock of any ruder motion, which for the present stops that vibration.

Hence

Hence also the different appearance of pinnated leaves in various climates is understood ; and may be assigned to its true cause, which is the different degree of light.

In the east the lobes are expanded, not because of the heat, but because the light is strong : In the northern kingdoms they droop, not from cold, but because the air is less enlightened : In the rainy seasons they also droop, but it is not from the moisture, but the darkness of the weather ; and in *Egypt* they are most rais'd of all, not because it never rains ; but because the light is constant.

The *Abrus* plac'd in a south window perfectly shews this ; for the expansion and elevation of its leaves is proportion'd always to the degree of light, and consequently it is affected by the cloudy or clear weather, though
the

the plant remain in the same place.

The lobes begin to rise before the sun is above the horizon, because the air is enlightened in a proportion'd degree ; and they begin to close again long before it sets, because in the south window the shadow of the building darkens the air about them.

In the rainy weather which we have lately had, the leaves wore the same appearance they would have done in a plant native of a country where there are seasons of rain ; they never at any time of the day reached the horizontal position, and they droop'd much earlier in the afternoon, and began to expand much later in the morning.

The sensitive plant which was plac'd near the Abrus, was affected in the same manner : and by repeated and careful examination, I have always

ways found, that in both these and in all others, the degree of elevation or expansion in the lobes, is exactly proportion'd to the quality of light; as it is solely dependent on it.

When the sensitive has been kept out of a stove some days, and has lost some part of its power of motion, if the leaf be touch'd softly, and the force encreas'd gradually, it will bear a great deal without drawing up the lobes; but at the same time a much less pressure given with a sudden stroke will occasion their closing.

In this manner we may also trace the extent and progress of the motion according to the force; a slighter shock raising only the lobes that are touch'd, a harder the opposite ones, and so the whole.

This quality in the leaves of
plants,

plants, as their general structure is the same, and the same agent operates universally, ought to be found in all : tho' in various degrees, according to the construction of their parts. In this, as all the preceding instances, just observation confirms the principles deduced from reason. In some it is greater, in others less : in many obvious to the common eye, in others difficultly perceiv'd by the most accurate ; but on a strict and close examination, I have not found any plant or tree wholly unaffected by it.



S E C T. XI.

That the Curious who shall chuse to repeat the experiments mention'd in the preceding pages, may find no difficulty in that respect, I shall give the particulars of the plants, and
ap-

apparatus with which I made them.

The Abrus, Sensitive, and Tamarind I obtained, in pots, from the nursery of Mr. Lee, near Hammer-smith: a person whose industry and knowledge in his business, will sometime make him known to his advantage.

The microscopes were those of Mr. Cuff.

The Abrus was a flourishing plant, of two foot and a half high: the Tamarind something taller. The Sensitive was a young one; in which state there are only two pinnated leaves upon each footstalk.

A plant of this growth is most manageable out of a stove, and was preferred for that reason; but the same experiments made on those of larger growth, answer in the same manner.

D

The

The place where they were kept, unless when removed for the particular experiments which required it, was a south window.

The Abrus will live very well in such a situation at this season of the year ; and the Sensitive, with due care, may be kept in tolerable perfection in the same manner, a fortnight or three weeks : tho' much more tender than the other.

The apparatus for the experiments, beside the microscope, consists only of a fine penknife, and a flat board, covered with a piece of cork, six inches long, and three broad.

In order to trace the course of the fibres, and see their clusters distinctly, a leaf of the Abrus must be pulled off, by slipping it downward.

ward. This brings away its base entire, and is necessary for obtaining in perfection, the cluster which is situated there.

The leaf must be laid flat upon the cork, and fixed down by a small pin, thrust thro' the middle rib, a little above the place where the first pair of lobes are inserted.

There must be a good light, and a careful steady hand, and the point of the pen-knife must be kept sharp and clean.

It will be easy to let this in at the middle of the rib, a little above the insertion of the first lobes, and to split the rib thence equally to the base.

The object is neither too minute for the hand, nor the eye; nor does it require those powerful magnifiers, which are often needful, in the more delicate researches.

The cluster of the fibres at the base of the main footstalk, will be thus seen: they will appear cut more or less exactly in two, according to the division of the stalk, and their course and interwoven texture afford a pleasing object.

This is the first experiment to be made; and it is very happy that the construction is seen without great difficulty, for it leads the way to the rest, which being minute, require a more strict scrutiny.

The course of the fibres along the middle rib, and their clustering at the bases of the lobes, may be pursued by splitting the footstalk farther up: but as this is not easily done, I have been used to cut off the upper and under part of the leaf, and leaving only a piece, which has one pair of the lobes, to cut it across in the
centre

centre of their bases.

This requires a careful eye, and a very regular pressure of the pen-knife; but with so much caution, it may always be done successfully.

At the base of each lobe there will be seen a cluster, in all respects resembling the first, only more delicate; and from that the fibres will be found continued in a strait course, along the middle rib, as they are in the same way along the footstalk, from the first cluster.

This way the eye perceives that there are such fibres, that they are so clustered, and that their course is regular from thence. The fact is so ascertained, but to admire duly the construction on which this motion depends, the fibres must be separated from all surrounding matter,

ter, and laid before the double microscope in water.

The method is this:

Let a leaf be pulled from the Abrus, as before, and in the same manner cut into two or three short pieces; two lobes remaining with each: let the footstalk be split first at the base, and afterwards crosswise at each joint; thro' the bases of the two lobes, and into the centre of the middle rib of each.

Let the ends of the lobes be cut off; and a number of these pieces be put into a saucer of water, keeping them down by some little weight.

They must lie in this water two or three days, according to the warmth of the weather; and at the end of that time they must be pressed gently against the bottom
of

of the faucer, with a piece of muslin tyed to the end of a pen, or other such implement.

This must be done with a delicate hand; and repeated often. They will thus be cleared from all surrounding matter. The firmness of their own texture will preserve them. They must be afterwards put into fresh water, and left four or five hours to swell and recover their first disposition; and then laid in water before the double microscope. The course of their fibres in their simple and clustered state, will be thus perfectly seen, and the mechanism by which the motion in the lobes is performed easily understood.

The method with the sensitive plant is to be exactly the same. The footstalk supporting the two leaves, must be torn off downwards, and the leaves expanded on the cork with pins,

as directed for the other. The base of the footstalk must first be split with the pen-knife; then the base of each leaf on the head of this stalk, and after that the base of each lobe. The construction in this part is very obvious, for it swells up extremely, and appears as a kind of joint, to serve the motion.

The condition of the clusters of fibres when the footstalk is just split, is more or less distinctly seen according to the age of the plant, the place of the leaf, and the degree of nourishment. It is most distinct in a leaf taken from the lower part of a young plant; but not the lowest, or any placed so low as to be fading: and in the same manner the construction at the base of the lobes is best seen in the second pair from the base of the foot-stalk.

These directions will be useful to
those

those who will not be at the pains
to clear the parts in water : but that
way there is no difficulty in bringing
the whole plainly and perfectly to
view: I am,

With great respect,

S I R,

Your Humble Servant,

London,

Sept. 7.

1757.

JOHN HILL.

(32)

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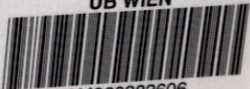
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