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VEGETABLE ORGANOGRAPHY;

OR,

AN ANALYTICAL DESCRIPTION

OF

THE ORGANS OF PLANTS.

BY

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TRANSLATED BY BOUGHTON KINGDON.

WITH PLATES.

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Sir,

Enclosed I send you the
first part of an English Edi-
tion of DeCandolle's Vegeta-
ble Organography, and you
will confer a great obligation
on me by taking an early
notice of it in your valuable
Publication.

It is generally
admitted that a transla-
tion of his works will prove
highly useful to all who

pursue the study of Botan[y]
indeed an acquaintance wi[th]
them is indispensable, as m[any]
of our Botanical Lecturers
and Writers follow his sys-
tem.

I am,

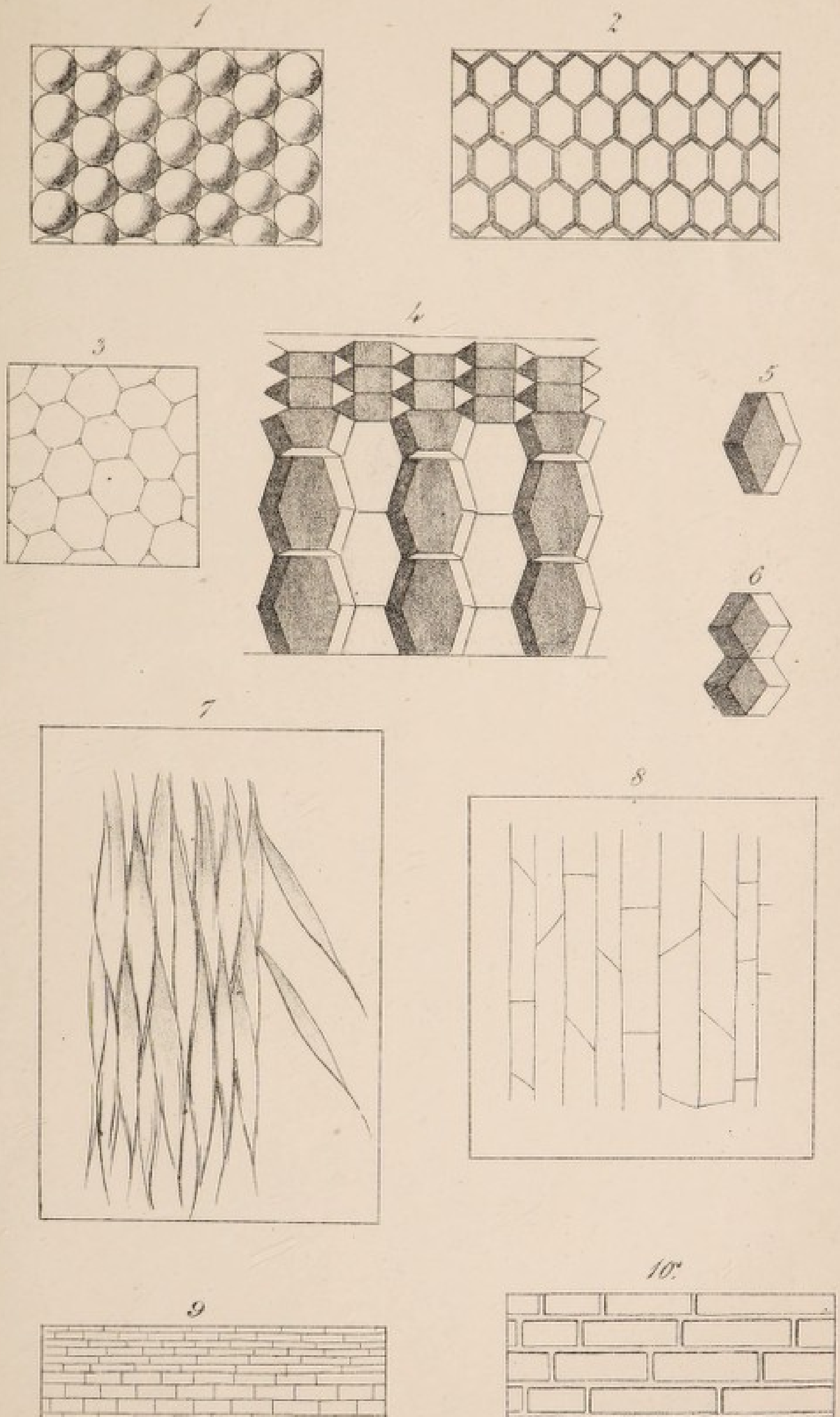
Sir,

Your's most obedien[t]

Boughton Kinga[...]

Gothic House
Stockwell.

Jan[y] 17th 1839.



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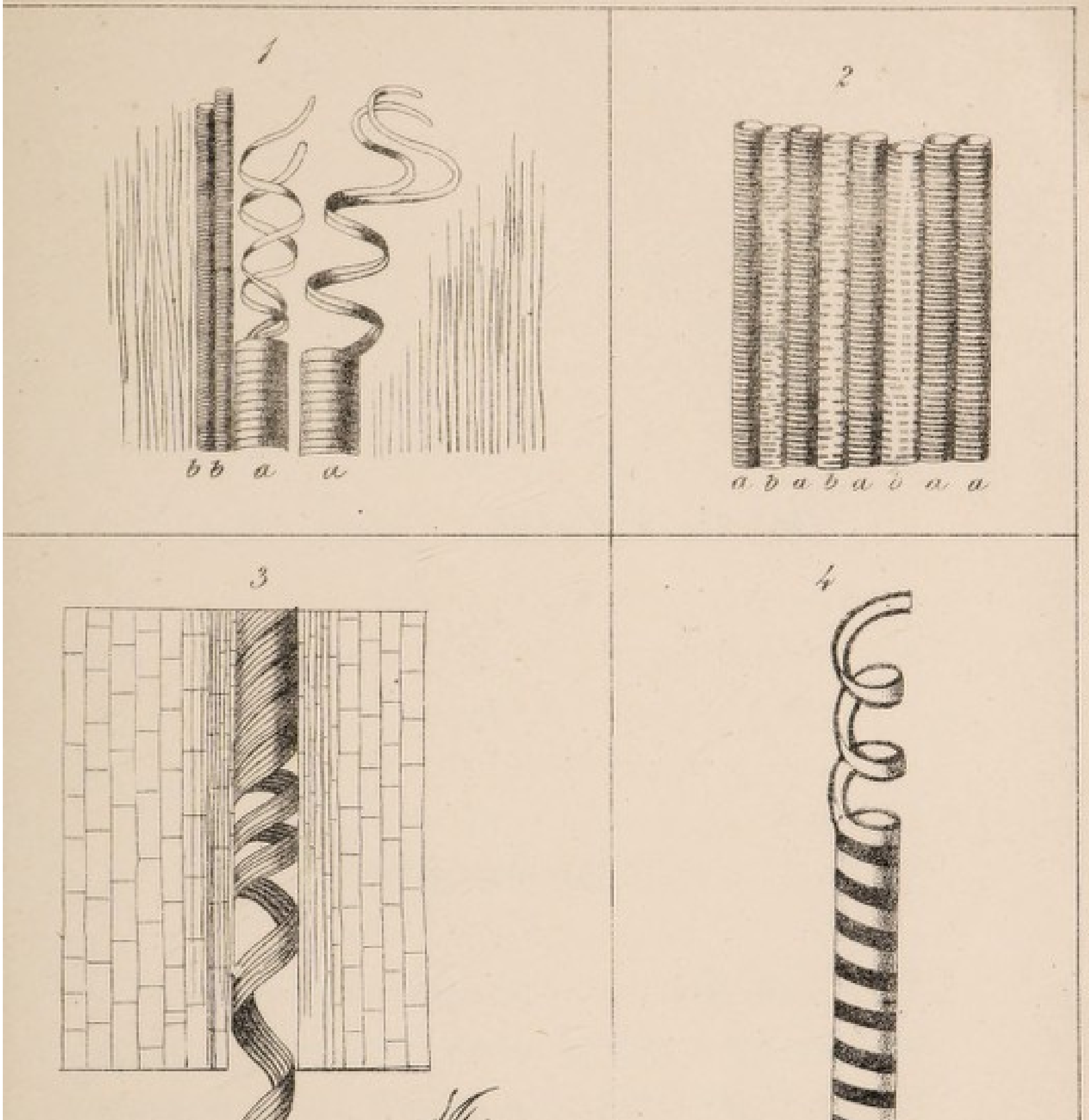

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VEGETABLE ORGANOGRAPHY.

INTRODUCTION.

To proceed with regularity in the description of the organs of plants, two absolutely different courses are presented to us. We can, in fact, after the example of Grew and Malpighi, examine successively each of the parts which offer themselves to us at first sight, and look for the elementary organs of which they are composed; or, following the route traced by Duhamel, Sénebier, and most modern botanists, we can first study the elementary organs which are common to all plants and all parts of plants, and afterwards consider how their combinations form the different parts of vegetables.

The first course, which is analytical, is necessarily that of the observer; it was that of the first phytotomists; it was, in fact, the only one which could be followed at the commencement of the science; and it is still that which one must embrace in the course of examination. But since long and laborious analyses have proved that the parts apparent in all plants are formed of a small number of organs resembling each other in different plants, it seems evident that conciseness and also clearness are gained by following the synthetical course; that is to say, by commencing first with the study of the elementary parts, in order to describe afterwards the compound organs which they form. This course, bolder and more concise, obliges us, it is true, to commence with the most obscure, uncertain, and difficult portion of Organography; it requires more trouble and attention on the part of observers; but it avoids frequent and fastidious repetitions, and furnishes some more precise data for the mass of the science: the little preliminary knowledge which it supposes, is limited to notions so simple, that every one possesses it without any study, and by the simple acquaintance with the most usual terms of language.

When we wish to describe first the compound organs, we are compelled, in order to impart the knowledge of their structure, to use terms, the meaning of which is little known without previous study—such as *cellular tissue*, *tracheæ*, &c. When, on the contrary, we commence with describing the elementary organs, we are constrained, in order to express their situation, to make mention of compound parts which have not as yet been explained; but these, such as the leaves, the bark, or the petals, are most commonly known, and consequently there is less inconvenience in speaking of them before having described them.

I will commence, then, by describing the elementary parts which compose the intimate tissue of all the organs of plants; after which I will describe the organic parts or the compound organs which serve either for nutrition or reproduction; I will reduce the exposition of the elementary parts to that which is common to the greater number of the organs of plants; and I will reserve for the history of the compound organs, the anatomical details which are peculiar to each of them.

Following this course throughout, I would here advise beginners, or those who do not wish to dive deeply into the study of plants, to commence the reading of this work with the Second Book, and to reserve the first for the end.

VEGETABLE ORGANOGRAPHY.

BOOK I.

OF THE ELEMENTARY ORGANS, AND OF THOSE PRIMARY COMBINATIONS OF THEM WHICH MAY BE CONSIDERED AS ELEMENTARY ORGANS.

CHAPTER I.

OF VEGETABLE STRUCTURE IN GENERAL.

The intimate structure of vegetables, viewed under very powerful microscopes, offers little diversity. Plants the most dissimilar in their external appearance resemble each other internally in a truly extraordinary degree; all their organs present in the interior but one tissue, of a very homogenous nature, and which seems composed of parts, the structure of which in one plant scarcely differs from that in another, and the absolute dimensions of which are by no means in conformity with the whole size of the vegetable. Grew, who had first made this observation, has given to these parts the name of Similary Parts, because of this great resemblance which they present throughout the whole vegetable world. Sénebier has named them ELEMENTARY PARTS; and I have adopted this last designation on two accounts; first, because it describes better the part which these organs perform in the vegetable economy; and, secondly, because the term used by Grew is not strictly in accordance with truth in the present state of the science; and without doubt it will always become less so, as we dive more deeply into the mysteries of Vegetable Organography.

Every one knows that organized beings are composed of solid and fluid parts; or, to speak in a more general manner, of tissues which form the body of beings, and of substances received into these tissues, or secreted by them. The first are those which constitute the peculiar nature, the life of the being: these are the elements, the modifications of which determine the afflux and the nature of the fluids; they are those alone which form the object of Anatomy, and with which we shall here occupy ourselves. As for the substances deposited, or the fluids, their particular study belongs to Physiology, and we shall only speak of them here incidentally.

The study of the elementary organs of plants was commenced about the end of the seventeenth century, a little while after the invention of the microscope.

Grew in England, and Malpighi in Italy, nearly about the same time commenced the examination of Vegetable Tissue, availing themselves of the assistance of this invaluable instrument; and observed all its parts with more or less precision: thenceforth this study was continued by Leeuwenhoeck; afterwards, about the middle of the eighteenth century, Gleichen, Needham, and some others, began anew to apply themselves to it: Hedwig, again, enlarged its boundaries, either by his genuine discoveries, or by his ingenious hypotheses.

In our own time, Mirbel, Link, Treviranus, Sprengel, Rudolphi, Kieser,* Dutrochet, and Amici, have published very minute examinations of the Vegetable Tissue, and accompanied them with drawings, both numerous and accurate; but the necessity of continually employing in these researches an instrument so difficult to manage well as the compound microscope, rendered abortive the dexterity of these observers: the minute anatomy of vegetable structure is still, in the more fundamental points, in a state of uncertainty discouraging to the friends of the truth. "If any thing," says Dutrochet, (Mem. Mus. 7, p. 385,) "can prove the uncertainty of our information upon vegetable organization, it is the difference of opinion existing amongst naturalists upon this subject." There is, in fact, hardly any point in vegetable anatomy, upon which we do not find that those who have devoted themselves to it with the most care, are divided, not only upon the theory, but even upon the facts, which one would think observation should immediately decide. The contradictions of observers of these points are so great, that it is not an unfrequent occurrence for several persons viewing together the same fragment, with the same microscope, to see, or to think they see, different appearances. For a much stronger reason, are separate observers unable to understand each other upon the most simple

* Those who wish to study the elementary organs of plants more in detail than the limits of this work have permitted me to assign to them, will find an excellent review of this branch of the science in the Mémoire sur l'Organization des Plants, published by M. Kieser, (Haarlem, 1812, 1 vol. 4to.) This work contains a great number of well-observed facts; and it is important to readers of French, inasmuch as it is the only work written in this language which gives an idea of the labours of the Germans in phytotomy. I regret much, myself, that my ignorance of the German language has prevented me from studying these works in the original to the extent which I should wish. I beg these learned men may be indulgent, if I have, contrary to my intention, either omitted to quote their observations, or represented their opinions inaccurately.—A. P. De C.

facts. For fear of seeing these discrepancies multiplied, we conclude by distrusting our own eyes, and by fearing to affirm any thing concerning what we believe we have seen. I shall endeavour to develope on this occasion, with all the caution which the obscurity of this part of the science demands, what appears to me most worthy of attention. I shall report with care the opinions of various observers, in order to endeavour to understand well those points upon which a difference exists, and those upon which they are agreed. But before entering into this exposition of the doubts and the uncertainties of microscopic anatomy, I would first inform beginners, that these doubts have much less influence than might be believed upon the whole of the science. I will also say, in concluding these preliminary observations, that the precautions which have always proved the most sure for avoiding microscopic illusions, are—

First, Never to observe an object of considerable size, without having commenced the observation with glasses of weaker power,—so as to follow it in a gradual manner from the lowest to the highest degree of enlargement.

Secondly, To view the same object with microscopes of different constructions, so that one may destroy any illusion which another may have produced; by these precautions the number of facts which are affirmed is perhaps slightly diminished, but more certainty is given to them.

When a transverse section of a plant, or a part of one, reduced to a thin and transparent slice, is examined first with a lens, and afterwards with a microscope, we perceive unequal cavities, sometimes round or angular, and most frequently hexagonal. If a longitudinal section be made, we always find the cavities closed by diaphragms; frequently there are other tubular cavities without transverse divisions, and sometimes widely scattered filaments more or less opaque. The entirely closed cavities have been called CELLULES or UTRICLES; the tubes, VESSELS; and the filaments, FIBRES.

If we now survey the various opinions which have been formed upon the structure or general organization of vegetables, we see that all the systems of phytotomists may be reduced to three principal ones. Some, after the example of Theophrastus, and perhaps of Grew, have thought that all the vegetable tissue is formed of very minute fibres differently interwoven. Others—and Mirbel appears to be the first who ventured the opinion in a general manner—believe that it is a perfectly continuous membrane, the various doublings of which produce the closed or tubular spaces which we observe. Lastly, most modern observers, following that which appears to have been the opinion of Malpighi, admit that vegetables are essentially composed of Cellules or Utricles differently joined together, and of Vessels, which, by different modes of development and cohesion, form all the organs.

The comparison of these three theories will naturally lead to the exposition of the facts upon which we are about to enter; passing in review—

1st, The CELLULAR TISSUE.

2d, The VESSELS.

3d, That which is called the FIBRE of plants.

4th, The EPIDERMIS, or CUTICLE, which covers all this apparatus.

CHAPTER II.

OF CELLULAR TISSUE.

SECTION I.—*Of Cellular Tissue in general.*

THE CELLULAR TISSUE *(contextus cellulosus)*, considered collectively, is a membranous tissue, composed of a great number of cellules or cavities, closed on all sides. The froth of beer, or a piece of honeycomb, gives a rude but pretty accurate idea of it; each wall of water or wax represents the membrane, and the place of the air or the honey gives the idea of the cavity or cellules. This tissue has also received the name of the UTRICULAR TISSUE *(complexus utricularis)*, which makes a more particular allusion to the theory, in which we admit that each cellule is a perfectly distinct vesicle. Link has named it *Tela Cellulosa*, and others *Complexus Cellulosus.* When considered collectively, and in contradistinction to parts which are furnished with many vessels, the name of PARENCHYMA has been given to it.

The cavities of cellular tissue bear the name of CELLULES *(cellulæ)*. Malpighi, who considered them as so many distinct vesicles, calls them UTRICLES *(utriculi)*. Grew has indifferently described them under the names of CELLULES, PORES, and VESICLES.

The cellular tissue is found in all plants: there are even some which are entirely formed of it; such as the Algæ, Fungi, Hypoxylons, Lichens, and most probably Hepaticæ and Mosses, or in other words, all the true Acotyledones. As for other plants, although not entirely composed of cellular tissue, it is found in them very abundantly; it everywhere encircles the vessels; so that in the vegetable, as well as in the animal kingdom, the vessels are never found destitute of covering: fruits, fleshy leaves, pith, the bark of roots, &c. present a great mass of cellular tissue. Regard being had to proportion, it is more abundant in herbaceous plants than in trees; in young plants than in those which are aged; in fleshy parts than in these which are dry and fibrous; and it seems entirely to compose plants at the period of their first development. The walls which form the cells are of transparent membrane: these easily swell up by maceration in water, and rapidly shrivel and become obliterated by exposure to the air; so that their examination requires some care. These membranes are generally without colour when they are properly deprived of the sap stored up in the cellules.

The diameter of the cellules varies much; in general, the larger it is, the more the part to which it belongs has a loose texture, or the more rapidly it grows. Kieser calculates, that the largest cellules—those of the Gourd, for instance, or of the Balsam, under a magnifying power of 130 times their diameter, are from five to six millimetres;* and that the diameter of the smallest, as, for example, those of the leaves of the Wallflower,

* A millimetre is about equal to $\frac{1}{26}$th of an inch. It is the thousandth part of a metre, a French measure, which is equal to about thirty-nine inches English.—B. K.

is not, under the same magnifying power, more than one millimetre; so that there are 5,100 cellules under a millimetre square of the natural size.

Section II.

Of the different Forms of the Cellules.

The Cellules of cellular tissue, considered only as to their general form, present themselves under four principal forms: viz. 1st, round; 2d, spindle-shaped, or tapering towards the two extremities; 3d, tubular, or prism-shaped, that is to say, not narrowed at the extremities; 4th, elongated transversely.

The ROUND (Pl. 1, fig. 1) seems to be the original form of the cellules; and it may be said in this sense, that all the other appearances which they present, result from the unequal pressure which they exercise on one another during their growth; that they thus become hexahedral, or nearly so (Pl. 1, fig. 2, 4, 5, and 6), when they are equally pressed on all sides; that they take an elongated form, either in a horizontal direction or in a transverse one, when the pressure is exercised on one or the other side: but in all these cases it is necessary to be careful to remember, that the forms of the cellules will not be as regular as the figures which have been published would lead us to think. It is evident that, in representing them with the exaggerated regularity which the majority of plates exhibit, one would wish either to point out that state which one would suppose normal, rather than to represent exactly the appearance of these organs from simple observation; or to disentangle the examples of numberless anomalies, which the impulse of vegetation occasions in the form of cellules. Pollini has particularly insisted on the variety of the form of the cellules in one and the same organ.

The cellules which are termed *round* or *hexahedral*, compose the cellular tissue called regular, that is to say, which is not perceptibly lengthened in one direction more than another. These cellules compose the pith of trees, the cellular envelope of the bark, the flesh of pulpy fruits, the parenchyma of leaves, and, in general, all the parts of plants which are susceptible of little or no elongation.

The Tissues which Link describes under the names of *Globular*, *Vesicular*, or *Irregular*, appear to me to be modifications of that which we here name *Round Cellular Tissue*.

This round cellular tissue is destined, according to Link, to preserve and to elaborate the sap. Dutrochet assures us, on the contrary, that sap is not usually found here. The difference between these two assertions, resides probably in the meaning which is attached to the terms: if it is understood by the *sap*, the juice not yet elaborated, and which is proceeding to the foliaceous organs, there to receive the action of the air and light, it is consistent with truth to say that the round cellules do not contain any of it: if the word *sap* is used to express a juice which has already undergone some elaboration, or which is placed in a situation to receive it, in that case we can say that the cellules contain this juice; and what happens in the parenchyma of fruit during their maturation, seems to me to prove it.

Cellules elongated in a longitudinal direction, (Pl. 1, fig. 7) are sufficiently different from the preceding, and even sometimes come nearer in *their* form to true vessels. Mirbel described them first under the name of LITTLE

TUBES (*petits tubes*), and has considered them as modifications of vessels; but it is evident to any one who may have observed them, that they are not vessels, because they are closed at the two extremities;—this is the reason why, in the elementary principles placed at the head of the third edition of the *Flore Française*, I have described them under the name of TUBULAR CELLULES (*cellules tubulées*), which indicates their form well enough; and I have given the name of ELONGATED CELLULAR TISSUE to that which is formed of them. Rudolphi actually viewed them in the same light, and described them under the name of ELONGATED CELLULES (*cellules alongées*). Mirbel has finished by adopting the same opinion, and has described this organ, when in a mass, at first under the name of WOODY CELLULAR TISSUE (*tissu cellulaire ligneux*), because he found it in abundance in wood; and afterwards under this of ELONGATED CELLULAR TISSUE (*tissu cellulaire alongée*). Treviranus has likewise coincided in this opinion, and has given to these cellules the name of FIBROUS UTRICULES (*utricules fibreuses*). Cassini has called them LITTLE TUBES (*tubilles*).

After the observations of Kieser and Dutrochet, it appears to me, that two very different states of cellules elongated in a longitudinal direction must be distinguished, viz:—

1st. *The Cellules which enter into the composition of wood and of the cortical layers.* They have the appearance of spindles, tapering to the two extremities (Pl. 1, fig. 7); and Dutrochet has given them, from this circumstance, the name of *Clostres*, which signifies a spindle.

These *Clostres* are commonly parallel to one another, touching by their swollen parts; and the intervals which they leave at their extremities are filled up by the points of the neighbouring *Clostres.* They are filled with a particular matter, more watery in young wood than in old; and the nature of which determines the hardness, the weight, the varying colour of different woods compared together, and of the same wood at different periods and from different parts of the same plant. The tissue, described by Link, under the name of the Tissue of the Alburnum *(tissu d'aubier),* comes under this class.

2d. There are other cellules to which the name of Little Tubes *(tubilles),* (Pl. 1, fig. 8; Pl. 2, fig. 1, 3) proposed by Cassini, will be tolerably well adapted: these are *cylindrical,* or *prismatic,* and are not swelled out in the middle of their length. They are always found around the vessels of vascular plants; and they alone compose the nerves, peduncles, and stems of plants destitute of vessels, as the Mosses and Algæ. It must be remarked, that in several of these cellular plants, as the Mosses and Hepaticæ, there is suddenly a remarkable change of figure among the elongated cellules which form their nerves, and the round cellules which compose their parenchyma; whilst in vascular plants there often is an insensible transition of form, of elongated cellules which surround the vessels, to the round cellules which form the parenchyma. Rudolphi concludes from this, that the elongated cellules of Mosses might well be considered as a particular class of vessels; but this opinion does not appear to us to be sufficiently proved by this sole consideration.

Lastly. There is a final order of cellules, which, instead of being lengthened in a longitudinal direction, are elongated *transversely* (Pl. 1, fig. 9, 10): these are the cellules which compose the medullary rays, and which are necessarily peculiar to the class of Dicotyledons. Kieser, who first proposed to distinguish them as a particular class of cellules, observes that they are remarkably smaller than all the others.

All these cellules, elongated either in length or breadth, seem less adapted than the round for the elaboration of the sap, but appear to assist perhaps in its progress; this is, at least, what may be concluded from their habitual presence in the organs where the fluids are in motion, and, at least as regards the Little Tubes *(tubilles)*, from the fact that they compose the largest part of the organs where the motion of the juices appears to be performed.

Section III.

Of the Substances contained within the Cellules, and of the Appearance of their Walls.

The Cellules, examined in different plants, or at different periods of their growth, are sometimes full of a watery juice, and sometimes of air: in neither of these cases is their transparency affected; and the history of these substances contained in the cellules, most important in Physiology, has not been confounded by anatomical errors. But it is necessary to remark, that besides these fluids, we meet with in these cellules different opaque or coloured bodies, which deserve some attention.

1st. There are frequently found little moveable granules, opaque and colourless, which are of an amylaceous nature, and bear the name of Fecula; these granules are formed in considerable quantity in certain parts of the tissue—as, for example, in the fleshy Cotyledons, and farinaceous albumen of seeds, the parenchyma of tubercles, &c.

2d. There are also found in the cellules of the foliaceous parenchyma other little globules, more frequently applied to the walls, which are generally coloured green by the action of the light: they are capable of assuming different colours; but remain colourless, and scarcely, if at all, visible in the parts not exposed to the light. These globules are of a resinous nature, and constitute the green matter of leaves, or that which some chemists call *Chlorophylle*. The coloured globules of the cellules of flowers may be compared with this class of bodies, for several reasons. It results from several very curious experiments, performed by Macaire, that this same matter is coloured red or yellow in the autumn, and that this is the same matter which, differently coloured, is again found in the calyx, and even in the corolla and the other parts of fructification; consequently the name of *Chlorophylle* is very improper: we may, by analogy with the word *fecula*, term it CHROMULE.

3d. Finally, the cellules of wood, of alburnum, and of the layers of the bark, contain, according to the observations of Dutrochet, granules of woody matter, which are applied to their walls, encrusting them, and rendering them opaque, constituting the differences so remarkable among the different woods.

If we remove these three classes of matter, the tissue of the cellules, viewed under very powerful microscopes, appears perfectly transparent, and represents neither regular folds, nor dots adhering to it, nor visible pores. Mirbel has vigorously supported the contrary opinion, and has even represented the round cellules marked with pores, encircled by a raised border, or with transverse slits; but no other phytotomist has ever seen the like. It appears that this error arose in different cases, from one of the two following causes:—

1st. One might take the amylaceous granules whilst they adhere a little to the walls, or those of the colouring matter and of the woody matter, for integrant parts of the tissue.

2d. In the opinion of those who consider the Strangulated Vessels *(vaisseaux en chapelet)* as kinds of cellules, we might be justified in saying that their tissue was dotted; but still, even in this case, it was very hazardous to call them porous. We will examine the nature of these markings of the tissue, when we direct our attention to the different classes of vessels. We digress for a moment, to prove, after the almost unanimous testimony of anatomists, and even our own observations, that cellules properly so called, whether round or elongated, are formed of a transparent tissue, which is neither dotted, nor pierced with visible pores, nor still less marked with transverse slits.

Section IV.

Of the Relation of the Cellules mutually, or of the Continuity of the Tissue, and of the Intercellular Passages.

The most important question which can present itself upon the nature of the cellular tissue, is to know if all the parts which compose it are distinct bodies, more or less united to each other, or if they are the doublings of a single continuous membrane. This question affects almost all those which we shall have to examine hereafter upon the organic nature of vegetables; and it is the basis of all discussion upon the use of these same organs. We shall endeavour to explain it with as much clearness as the difficulty of the subject will permit. It is not easy to affirm, in a very positive manner, what was the opinion of Malpighi; and probably he had not formed any decided one upon the subject: nevertheless, the name of *Utricle* or *Vesicle*, which he has given to the closed cavities, and most of the figures which he has published, afford us grounds for presuming that he regarded each of them as a separate little body, furnished with its own partitions, and simply adhering to or in juxtaposition with the neighbouring bodies; whilst, on the contrary, Grew, in giving to these same cavities the names of *Pores* or *Cellules*, has more clearly indicated that he considered them as cavities combined together into a tissue or a texture, continuous in all directions, of such a kind that each of them is separated from its neighbour by a single and simple partition. In accordance with the opinion which Malpighi appears to have entertained, Leeuwenhoeck seems to admit the existence of distinct utricles bound together by intermediate fibres. Hedwig and Mayer have considered the cavities as the receptacles destined to receive the liquids, and have admitted that many little vessels wind spirally upon their walls.

Treviranus and Kieser have maintained that vegetables are composed of vesicles more or less joined together, separated by visible interstices, which they have described under the name of INTERCELLULAR or INTERVASCULAR PASSAGES *(méats intercellulaires ou intervasculaires)*, Pl. 1, fig. 1, 3. Link has adopted the same opinion, and says, that he has frequently seen the cellules isolated, especially when he has subjected the tissue to boiling in water. Du Petit-Thouars admits likewise, that these cellules or utricles are bodies distinct from one another. Pollini favours the same opinion, from peculiar observations of his own. Amici avers, that not only, by means of his microscope, he can see the intervals of the cellules, which often appear as angular spaces full of air, but that he can, having boiled the tissue, detach the cellules from one another, and observe them isolated; so that, according to him, one cannot deny the existence of these spaces or intercellular passages, which are filled with air. Dutrochet says, that the cellules, having been boiled in nitric acid, separate, and appear as so many distinct vesicles; but moreover, where two cellules touch, the wall which separates them presents a double membrane; that there is never a wall common either to the cellules or to the vessels; and that the hollow organs have no other mutual relation than that of contiguity. Finally, Turpin admits likewise, that vegetables are entirely composed of distinct vesicles, variously combined, or sometimes perfectly free; and he proposes to give the name of *globulin* to this vegetable element.

The contrary opinion, maintained, it is said, first by Wolf, has been vigorously adopted by Mirbel, who admits as the fundamental base of anatomy, that vegetables are entirely composed of a tissue continuous throughout all its parts; that the neighbouring cellules have always a common wall; that there are also tubes resembling the neighbouring cavities; that when one thinks he has seen a double partition, it is because he has seen by its transparency the sides of some other cellule. This opinion has been adopted by Rudolphi, and I myself formerly supported the elementary theory. The partisans of the two opinions rest for support upon the same comparison. Grew had said that the cellular tissue resembles the froth of a liquor in fermentation; Mirbel approves of this comparison thus far, that in froth each bubble of air is separated from its neighbour by a single film of water, and that the films are continuous one with another. Link approves of it also, for this reason, that each bubble of air must be considered as surrounded by a watery membrane which is peculiar to itself; and that, when they unite to form the froth, each film of water is formed of two films adhering together. Thus the partisans of the two theories are divided even as to the meaning of simple metaphors.

Shall we venture to affirm any thing decisive between these diametrically opposite opinions? Is there any intermediate theory which may reconcile them? 1st. Microscopic observation directed to this point has frequently left me in doubt: the membrane which separates the cellules appears simple with a microscope of small power; but as soon as we employ a powerful instrument we very often can no more venture to affirm whether we see a single or a double membrane; and when it appears double, whether this effect is due to some projecting shadow. One thing I can affirm, and that is, that I have seen triangular spaces between the cellules, as are represented in the figures of Treviranus, Kieser, and Amici; and that with them I am inclined to consider them as spaces filled with air: but one cannot conclude from this that the tissue is not continuous for it might easily happen that there might be among the cellules full of juice some empty cellules, which would present this appearance. Grew himself, always admitting the simple nature of the membrane, has very frequently represented intervals between the cellules, very much the same as the authors whom I have previously quoted. 2d. In tearing irregularly the tissue of a leaf, I have frequently seen, especially in the leaves of Monocotyledons, some cellules which appear perfectly untouched, separated entirely or in part from their neighbours; but these facts are so rare, that one cannot but think that they are either out of the ordinary course of things, or that the tissue of neighbouring cellules has perhaps been broken.

3d. The separation of cellules by boiling in water or in nitric acid, seems likewise to confirm the idea of the double nature of the membranes, and tends to make us consider the cellules as distinct bodies. But it must also be confessed that, in subjects so difficult, it is dangerous to decide after observations where the natural tissue has been altered by such powerful agents. The boiling in water itself has all the inconveniences of the maceration formerly made use of—that is to say, it destroys the delicate intermediate organs, and tends to isolate artificially organs which may in reality be continuous in their natural state.

4th. There are some cases where one sees the cellular tissue resolve itself into isolated bodies, which at first sight appear like dust, and which, viewed through the microscope, evidently appear as cellules: of this kind are the mass of globules which are found in Lenticels upon the development of adventitious roots, &c. From the general result of these observations, I do not now retain any doubt that the cellules which compose the cellular tissue in general are vesicles distinct from one another and differently joined together.

If I wished to search in nature for an example of this kind of structure, which, though rude, should be visible to the naked eye, I would cite the membranous vesicles, full of juice, which are found in the interior parenchyma of the orange: each of these little sacs, which I do not pretend to compare completely to the cellules, is found nearly free, and they collectively form a species of parenchyma.

Where the cellules are lightly or partially united, they may be found disunited entirely or in part; as is seen, for example, in the loose tissue of the leaves of several Monocotyledons.

If any cause, altering the ordinary state of vegetables, should chance to break the adherence of the cellules, some may then be found disunited, and having the appearances of little vesicles; as, for example, at the instant of the development of the adventitious roots, and perhaps in the efflorescence of lichens.

In numberless cases where the cellules are intimately united, there are often found between them empty spaces, which are the intercellular passages; to which we shall return presently.

Finally, there are cases where the union is so intimate that it cannot be perceived: this is what happens particularly in the cellules of cryptogamic plants, among which the intercellular passages are not visible, and the partitions which separate the cavities appear to be simple.

The Intercellular Passages or Canals, then, are the spaces which exist between the cellules, and which have no other walls than those of the cellules. Their form is most frequently that of a triangular prism: they are found, according to Kieser, hexagonal or even dodecahedral, according to the number of the walls of the cellules which concur in their formation. These canals follow the general direction of the cellules, either lengthways, which is the case most frequently, or transversely, as in the medullary rays. They are often full of water, sometimes of air, and appear also to receive the proper juices. Their size varies much in different plants; they are generally larger in those with a loose and succulent tissue; but their situation and history are still very obscure, and deserve to occupy most particularly the attention of anatomists. We will return to this subject in speaking of the Air cavities, and Receptacles of proper juices.

It must be seen from the foregoing, that the principal property of the cellules or vesicles forming the cellular tissue, is the faculty of uniting together. This property plays an important part in the whole history of vegetation: not only to its different degrees are all the internal appearances of the tissue to be referred, but also it is these combinations of the cellular tissue that cause all the combinations of the different organs, which, at first being distinct, finally form a single texture, in appearance simple, in reality compound.

A second peculiarity of the tissue of the cellules is, that they are eminently hygroscopic; that is to say, that they absorb water with which they may be in contact, and in particular that which is conveyed by the Intercellular passages. Probably this water, deposited in the cellules, undergoes a particular elaboration, from which results the formation of the substances which are observed in them. This hygroscopic property has appeared to me for a long time, as it did to Sénebier, to be one of the principal bases of the phenomena of vegetable life. Kieser has also insisted, on a later occasion, upon its importance.

Finally, the third property of this tissue appears to be organic contractility; a phenomenon purely physiological, which I ought only to mention incidentally in this place, but without which it is difficult and perhaps impossible to comprehend the course of the sap.

SECTION V.

Of the Origin of the Cellules.

The origin of the cellules, like all which relates to the origin of organized beings, is a problem absolutely impossible to be solved in the present state of our knowledge. Two opinions on this subject have been put forth by naturalists. Treviranus appears disposed to think that the amylaceous granules which are found in the cellules are the rudiments of new cellules, which, being developed, tend to increase the mass of the tissue. It seems that Raspail has adopted this opinion, from the manner in which he considers the fecula of the Gramineæ.

Kieser thinks, on the contrary, that the globules which are found swimming in the juices of the intercellular canals are the rudiments of young cellules, which, deposited here and there in their route, tend to increase the mass of the tissue.

Without affirming any thing on a subject so obscure, I am, for the present, more disposed to admit this last opinion; because the first supposes, either that the amylaceous granules come out of the cellules, which seems inconsistent with the absence of any visible pore; or that they break, in their development, the cellules whence they have taken their origin, which point has never been seen to take place. Finally: I only advert to these opinions as curious points of meditation; and I am cautious in taking up any decided opinion upon subjects so difficult.

Section VI.

On the Physiological Function of the Cellules and Intercellular Passages.

The physiological function of the cellules is a subject entirely belonging to Physiology, and one which we can only here examine in a very brief way, and solely in an incidental manner.

The cellules, being closed on all sides, can only receive the sap by means of the hygroscopicity of their walls. Those which are round suck up the juices which surround them, and elaborate them in their interior: and it is thus that, by a vital process, they form the feculent and mucilaginous substances, and the resinous matter which gives them their colour. We also see these different substances abound in all parts of plants which are essentially composed of round cellules; as the parenchyma of the external covering of leaves and fruits, the pith and the receptacles of flowers, &c.

As to the elongated cellules which surround the vessels, the part they perform is very difficult to comprehend: one never finds there the substances which we have noticed; and, for the most part, they appear empty, or else filled with air, and in consequence participate in the function of the vessels.

The intercellular passages are generally full of sap, and it is very probable that they are the parts which serve essentially to its progress. We can, in this point of view, divide them into three classes:—

1st. The intercellular passages, situated between the elongated cellules which surround the vessels, appear to serve for the ascent of the unelaborated sap, which, from the roots, spreads throughout all the foliaceous parts of the plant.

2d. The intercellular passages situated between the cellules of the medullary rays establish the transverse communication of the sap, from the centre to the circumference.

3d. The passages situated between the round cellules of the parenchymatous parts receive the sap in larger quantity, considering that their movement is slower. The cellules are thus surrounded by sap, which they can imbibe for the purpose of elaborating.

We shall see hereafter, that intercellular passages, when dilated, produce the greater part of the Air cavities, and Receptacles of proper juices; and present thus new support for the life of the vegetable.

We must not lose sight of the fact, that the cellular tissue is the only elementary organ which exists in the whole vegetable kingdom; and consequently it is to it, and its modifications, that we must refer all the more general phenomena, the ascent of the sap, and their principal elaboration.

CHAPTER III.

OF THE VESSELS.

Section I.—*Of the Vessels in general.*

Of all the parts of vegetable anatomy, the structure and history of the Vessels is that about which there has been most dispute, and upon which there is still but little accordance.

We describe under this name (adopted from analogy with animal anatomy) those cylindrical, or nearly cylindrical tubes, which are observed in the greater number of vegetables; and which differ from even the most elongated cellules, both because there is not found in them any diaphragm which closes them in a transverse direction, and because their walls are marked with dots, stripes, rings, slits, or spires, which are not to be found on the walls of cellules.

For a long time, vessels have been distinguished into Proper Vessels, and Lymphatic Vessels. Under the former name were described the tubular cavities which contained the peculiar juices of certain plants; such as the milky, resinous, &c. Under the second were comprehended all the tubes full of air, or of water, which is but little if at all elaborated. But it has been since found, that the Proper Vessels are not true vessels, but peculiar modifications of the cellular tissue, which we shall afterwards describe under the name of Receptacles of proper juices. We shall only comprehend, then, under the collective name of Vessels, those which have been long described under the name of Lymphatic Vessels; but as this appellation, founded on the function which is attributed to them, is itself only hypothetical, we shall not adopt it, since it becomes useless the moment that the Receptacles of proper juices are no longer confounded with the vessels.

These vessels, termed Lymphatics, have been described in English, by Grew, under the names of Sap Vessels or Lymph-ducts: others have named them Sap Vessels *(vaisseaux séveux)*; and Mirbel describes them under the name of Great Tubes *(grands tubes)*. Kieser comprehends them collectively under the name of Spiral Vessels *(vaisseaux spiraux)*, which is only applicable to one of the forms under which they are presented to us. These vessels present five very distinct varieties of form, viz.—

1st. TRACHEÆ *(trachées)*.

2d. ANNULAR OR STRIPED VESSELS *(vaisseaux annulaires ou rayés)*.

3d. DOTTED VESSELS *(vaisseaux ponctués)*.

4th. STRANGULATED, MONILIFORM, or NECKLACE-LIKE VESSELS *(vaisseaux en chapelet)*.

5th. RETICULATED VESSELS *(vaisseaux réticulaires)*.

We shall commence by describing them separately; then we shall occupy ourselves with discussions which divide anatomists upon their reciprocal relation, their history, and their use.

Section II.

Of Tracheæ, or Spiral and Elastic Vessels.

The Spiral Vessels (*vasa spiralia*), or the Tracheæ (*tracheæ*), or, as Cassini calls them, the Helicules, (Pl. 2, Fig. 1, *a a*, 3, 4,) are organs of an entirely peculiar kind, and about the structure of which there has been much dispute. Henshaw discovered them in the Hazel in 1661, that is to say, a year after the completion of the microscope by Hook. Malpighi, who first examined them with care, compared them to the tracheæ of insects, which name he has retained: he regarded them as the respiratory organs of plants, and described them as tubes formed of a band rolled spirally upon itself, capable of unrolling with elasticity. The unrolled tracheæ can be easily seen in breaking a young shoot of the Rose or Scabious. A trachea, seen by the naked eye or through a lens, presents the appearance of a brilliant silver band rolled spirally, as a spring in a funnel. Duhamel compares it to a riband which has been rolled round a cylinder, and which by its spiral circumvolutions would form a continuous tube; Mirbel confirms this opinion of the structure of the trachea, and only adds that the edge of the band is a little thicker than the middle. Hedwig, on the contrary, has described these same organs in a manner entirely different; he names them *Vasa pneumatochymifera*, and believes them to be formed of two distinct organs: he thinks that that which was considered to be a band previous to his observations, is a real tube, which is rolled spirally upon another straight and central tube:

he imagines that these spiral tubes are destined for carrying the sap, and he calls them for this reason *Vasa adducentia spiralia*, *Vasa chymifera hydrogera;* on the contrary the central tubes may always be full of air, whence he has given them the name of *Vasa pneumatophora.* Schrader and Link differ from the opinion of Hedwig in this,—that instead of admitting that the spiral is formed by a tube, they think that it is composed of a band hollowed out into a gutter in its internal part. Bernhardi, on the contrary, admits that there is an upright membranous tube, continuous and transparent, in the interior of which is rolled a spiral band which serves to keep it open; and which, proceeding to unroll itself with elasticity when the exterior tube is broken, only appears to our eyes under the name of trachea. He supposes that this same band exists in the tubes of all vessels; that when it is continuous and spiral, it forms the trachea; when it is divided into interrupted lines, the striped vessel, (Pl. 2, Fig. 2, *a;*) and more interrupted still, the dotted vessel, (Pl. 2, Fig. 2, *b.*) Kieser calls what we name trachea, a simple spiral vessel; and he believes that membrane exists neither on the inside, nor on the outside, nor among the spires. Lastly, Dutrochet admits that the spires of the tracheæ are united by an intermediate transparent membrane, which is torn when the spiral thread is unrolled; he believes that in their natural state they have not any openings, but that they form a continuous tube.

To attempt to choose our opinion in the midst of so many contradictions, it is necessary to discuss separately each of the assertions of these authors, and to divest them as much as possible of all systematic idea.

1st. *Does there exist in the interior of the spire a peculiar tube, as Hedwig was the first to assert?*—Let us remember that this tube has only been seen by a small number of observers, and that Hedwig himself seems less to have seen it, than to have conceived it in theory; for notwithstanding his skill as a draughtsman, he has not ventured to give a drawing of it. Link says that the observation of Hedwig has not been confirmed by any anatomist; and, for my part, I do not deny this assertion. Mirbel assures us that, in some cases, the old tracheæ present in the interior a kind of incrustation more or less dense, which resembles a true internal tube; but as this appearance of the interior tube is very rare, one would be authorized in not considering it as an integral part of true tracheæ.

2d. *Is the part which forms the spire* flat, *as former observers asserted; or is it a* little hollowed into a channel *and* bordered by a thickened rim, *as the figures of Mirbel indicate; or is it* tubular, *as Hedwig and Mustel affirm?*

The greater number of observers are opposed to this last opinion, although several among them have observed the tracheæ with more powerful glasses than those of Hedwig. Still later, Amici, who makes use of the strongest microscopes known, remains in doubt concerning the tubularity of the tracheæ; and believes that the question cannot be solved by the optical means which we possess. One of the arguments which appears to have persuaded Hedwig to admit the tubular nature of the spiral part, is, that when a coloured liquid rises in these organs, one distinctly sees that it follows the spire; but this appearance is as easily explained by admitting that it is a band a little concave, along which the coloured liquid glides, as in supposing it to be a perfect tube. Nevertheless, the hollow form of the band, or the existence of the rims, is still contested by several of the most able observers. Kieser, in particular, without affirming that the spire is tubular, believes that it approaches the cylindrical form; and as for myself, it appears to me flat, with the two borders more or less opaque and probably a little prominent (Pl. 2, fig. 4).

3d. *Is the spire of the trachea contained in a particular tube, as Bernhardi would have us think?* — I believe that we cannot deny the existence of this tube, but it is necessary to know whether it is one which might be formed by the edges of neighbouring organs, or whether it is a part of the trachea. Dutrochet admits the existence of a tubular membrane, which is not on the outside of the spires, but between them. The existence of a membrane which would unite the spires together, appears confirmed by the existence of tracheæ which are incapable of being unrolled, mentioned by some authors; but they have never been seen in a clear manner, and probably they are nothing more than annular vessels, of which we shall speak hereafter.

According to Mirbel, the tracheæ are continuous with the cellular tissue by their extremities; according to Dutrochet, they terminate, by their two extremities, in a very acute conical spire.

The spires of the tracheæ, according to Hales, are always rolled from right to left; this disposition appears, in fact, the most common, but Link has remarked some which were rolled from left to right.

Mirbel, Rudolphi, and Kieser, have discovered some tracheæ with a double and triple parallel spire; I have counted some even with seven in the tracheæ of the Plantain (*Musa paradisiaca*,) Pl. 2. fig. 3; and M. De la Chesnaye says that he has counted up to twenty-two. Rudolphi says that the tracheæ also have a doubled, or a multiplied spire, in *Canna*, *Amomum*, *Kæmpferia*, *Maranta*—genera all allied to *Musa;* and even, he says, in *Heracleum speciosum*, which belongs to a very distant family. Kieser has remarked, that in the greater part of vegetables the tracheæ which are furnished with a simple spire are disposed in bundles: on the contrary, we find them solitary in the Banana, which has the spires multiplied; whence one might infer, that this multiplied spire is formed by the union into one single tube, of filaments usually distinct.

Malpighi and Reichel say that they have observed contractions in the tracheæ, but no subsequent observers have seen them. Mirbel asserts positively that these are optical illusions. The diameter of the tracheæ is about the twenty-fourth of a line, according to Mirbel; but according to Kieser, their diameter is very variable in different plants.

Malpighi says that, "during the winter, the tracheæ are endowed with a vermicular movement, which delights the observer." It appears that this anatomist has here attributed to irritability, that which arises simply from hygroscopicity combined with elasticity. A motion in the tracheæ, when laid open, may be occasioned either by approaching and removing the ends of a young shoot broken across, or by exposing them alternately to moisture and aridity. Mirbel asserts that the tracheæ of the *Butomus umbellatus*, once unrolled, never contract again. The tracheæ are very visible in most of the young shoots of the year, especially in those which can be broken clean off without tearing them, as those of Roses: they are to be found, according to the observations of Mirbel, only around the pith in the old stems of Dicotyledons; for it appears that all that former observers have said of tracheæ observable in the wood, must be attributed to the striped vessels: the tracheæ appear to be organs essential to the medullary sheath, and they are to be found there, in the form of those which are incapable of being unrolled, even in aged trunks of trees, and in wood which has long been cut down. In the fibrous bundles of the herbaceous stems of Dicotyledons, the tracheæ are found, according to Kieser, in the part nearest the centre of the stem; among Monocotyledons, they are found in the woody bundles: according to Mirbel, they occupy the centre of them; Amici appropriates this place to the dotted vessels. The stem of the Plantain appears to be almost entirely composed of tracheæ, when it is cut across; they are so abundant, that in the Antilles they gather them by handsful, and a kind of tinder is made of them, which has long been publicly sold there. M. De la Chesnaye says that each Plantain tree yields five or six *grammes* (a drachm and a half) of these vessels, and that they may be used either in making a species of fine down, or may even be spun. Tracheæ are also found in the veins of leaves, in the corolla and sexual organs, but never in the bark. Mirbel says that they are very rare in the roots. Dutrochet asserts, and my own observations agree with his, that the tracheæ are absolutely wanting in the roots; and that those who have fancied they have seen them, must have taken for true roots subterraneous stems which have tracheæ just as aërial stems. Perotti must, therefore, be quite wrong when he says that the roots differ from the trunks in having the tracheæ more visible and more numerous. Tracheæ are entirely wanting in all cellular plants, such as the Mosses, Hepaticæ, Lichens, Fungi, Algæ, and *Chara*.

Some naturalists, upon whom we may rely, assure us that tracheæ exist in some Mosses, as in *Splachnum;* but this is doubted by several—as, for instance, by Rudolphi and others. Without denying that a negative observation has not so much weight as a positive assertion, I am of this last opinion, as I have never been able to discover them. Others consider the elaters of the Hepaticæ as organs similar to tracheæ; but I cannot admit that there is any real analogy between tracheæ and these organs, resembling each other, it is true, in their spiral turnings, but very different in their size, texture, and position. I persist, then, in believing that tracheæ are entirely absent from cellular plants.

Amongst those which we are obliged to refer to the class of vascular plants, tracheæ are wanting, according to Link, in *Lemna, Zostera, Ceratophyllum,* and *Najas,* all of them aquatic. Amici confirms their absence in *Najas minor,* but he is contradicted on this point by Pollini; and the absence of tracheæ in vascular plants is a fact which requires to be confirmed, especially since tracheæ not capable of being unrolled have been mentioned, and since there have been found true tracheæ in *Hippuris* and *Myriophyllum,* where it was at first believed that none existed.

Several anatomists, and in particular Wahlenberg, Rudolphi, &c., assure us that they have not found tracheæ in the Coniferæ, neither around the pith, in the leaves, in the younger branches, nor at the first development of the plant: this was found to be the case, according to them, in the anatomy of several species of Pines, Deals, Larch, Cedars, Thuja, and Cypress; but it was already known that true tracheæ exist in the young branches of the Juniper, &c. An anomaly so remarkable in the same family was difficult to be admitted: since then, Kieser, in a special treatise on the Coniferæ, has shown the existence of them, though they are more rare and more difficult to be seen than in other plants.

Oken thinks that tracheæ are analogous to the nerves of animals. This paradoxical opinion has not, that I am aware of, been admitted by any naturalist: it is thought to be founded on a simple hypothesis, viz. the sensibility of plants; but, even in admitting a nervous system in plants, it would be impossible to believe that it was represented by an organ which is found wanting precisely in those plants which bear the greatest resemblance to animals.

Section III.

Of Annular or Striped Vessels.

The vessels which I here designate (Pl. 2, fig. 1 *b*, *b*, 2 *a*, *a*, 5 *a*, *a*.) are those which Mirbel has described under the name of False Tracheæ *(fausses trachées)*, Kieser under that of Spiral Annular Vessels *(vaisseaux spiraux annulaires)*, and which I have often mentioned under that of Striped Vessels *(vaisseaux rayés)*. Seen with the microscope, they commonly present the appearance of simple cylindrical tubes, marked with regular transverse parallel lines; when they are observed embedded in the tissue, they resemble true tracheæ which will not unroll; and they have often been described by the old anatomists under the name of *Tracheæ;* they differ from them, however—

1st, Because they do not unroll, and do not afford any trace of elasticity.

2d, Because their lines *(raies)* appear parallel, and not spiral.

3d, Because in the same plant they differ in diameter from the tracheæ.

Striped Vessels are found, in general, in the woody part of vascular plants; among Dicotyledons they are found in all the layers, except in the immediate envelope of the pith; in Monocotyledons they occur in each of the woody bundles; they are very abundant in the centre of the stem of the Lycopodiaceæ.

The largest annular vessels known are those in the stem of the Balsam.

Kieser considers these vessels to be composed of parallel rings, which, according to him, are of an analogous nature to the tissue of the tracheæ, and are capable, in certain cases, of gradually changing into spires (*Pl. 2, fig. 7 *b*,): these rings are sometimes, according to him, very slightly adherent to the membranous tubes formed by the walls of the neighbouring cellules.

Mirbel considers them to be tubes marked with parallel slits; others, as tubes provided with opaque parallel lines, which are of an analogous nature to the dots of dotted vessels.

Perhaps under the name of Annular Vessels *(vaisseaux rayés ou annulaires)* we really confound two different structures.

Section IV.

Of Dotted Vessels.

I include, with Treviranus, under the name of Dotted Vessels, *(vaisseaux ponctués, vasa punctata)* those which Mirbel calls Porous Tubes or Vessels, *(vaisseaux ou tubes poreux,)* and Kieser, Spiral Dotted Vessels, *(vaisseaux spiraux ponctues,)* Pl. 2, fig. 2 *b*, *b*, 5 *b*. Their ordinary state, under the microscope, is the form of a cylindrical tube, the walls of which present transverse series of opaque dots: they differ,

* From an excellent plate in Dr. Lindley's valuable "Introduction to Botany." 8vo. London, 1836.

then, from Striped Vessels, in having these dots separated from one another, and not joined in continuous lines; and from Strangulated Vessels, (of which we shall speak presently,) in their tube being cylindrical and not contracted at intervals.

These vessels are found abundantly among Dicotyledons, in the woody layers both of the root and of the stem and branches; among Monocotyledons, in the woody bundles: when they make part of a bundle of vessels, they are commonly situated in the side nearest the circumference of the stem. We are assured that they have also been found in the bark of Dicotyledons, but this fact is contested by more recent anatomists. The diameter of dotted vessels generally exceeds that of tracheæ and striped vessels; but this rule is liable to frequent exceptions.

Kieser considers dotted vessels to be formed of a trachea or annular vessel, of which the spires or rings are joined by a dotted membrane.

Mirbel, who first discovered these organs, does not admit the evidence of spires or rings in the formation of these vessels; but regards them as simple membranous tubes, marked with pores which are surrounded by a rim, giving them a dotted appearance.

Dutrochet also considers them as simple membranous tubes, marked, not with pores, but with dots caused by projecting vesicles.

As for my own observations, I have neither seen the spires nor the rings which Kieser admits in the structure of these vessels; but as I am of opinion that a negative observation cannot invalidate a positive one, when it is confirmed by all observers, I hesitate before I confirm their absence. At present I am disposed to consider these vessels as membranous tubes, marked with glandular dots.

Section V.

Of Strangulated Vessels.

The Strangulated Vessels (Pl. 2, fig. 6,) have been seen by Malpighi without his giving them much attention. Mirbel was the first who really called the attention of anatomists to the subject; and he has given them the name under which they are here designated. Treviranus described them under that of *Corps Vermiformes.* They are tubes marked with dots in transverse lines, as in Dotted Vessels, but contracted at intervals by transverse strangulations, more or less perceptible. Mirbel considers them as cellules, placed end to end, which supposes that there exist diaphragms which separate them: in following this opinion, it will be necessary to class them among the modifications of cellular tissue, and not among those of vascular tissue; but the existence of these diaphragms is very doubtful; the majority of anatomists deny it most positively. It appears that from considering these bodies as a series of cellules, Mirbel has been led to admit the existence of a dotted cellular tissue; but their analogy with dotted vessels is so strong, that it is impossible not to consider them either as modifications of these organs, or as very analogous organs. Kieser regards them as formed, like the preceding, by spires or rings very distant from each other, and connected by a dotted membrane.

Strangulated vessels are abundant in roots, articulations, joints, in branches and leaves at their first development, and, it is said, in natural or accidental warts.

Section VI.

Of Reticulated Vessels.

This form of vessel (Pl. 2, fig. 7 *a*,) is extremely rare in nature, and has been studied the least of all. Kieser has only discovered them in the Balsam and the Nasturtium (*Tropæolum*): he suspects their existence in other plants of a loose texture. According to this observer, these vessels are owing to the spiral or annular fibres which compose the tracheæ, or striped vessels, anastomosing unequally together, and leaving between them open spaces or oblong holes. They never attain, according to him, the size of dotted vessels, and are often ramified; they are more frequent in the root than in the stem.

Section VII.

General Considerations on the Structure of Vessels.

I have described, in the preceding sections, the usual forms which the vessels of plants present under the microscope; and I have intentionally avoided confusing these descriptions with any hypothetical or even theoretical ideas. It remains for us now to examine what are the modifications of which these forms are susceptible; and thence to deduce, if possible, the relation of these different vessels with one another, and their true nature.

Hedwig was the first to treat of these delicate questions in his Programme upon Vegetable Fibre: he thought that the turns of the spire of the tracheæ anastomosed together as they advanced in age, whence resulted the appearance of the annular vessel; then, if the junction continued to increase, the tube would take the appearance of a dotted vessel.

Rudolphi differs from Hedwig, for he regarded the tracheæ as simple spiral bands, which form a tube by their circumvolutions; but he considered that they gradually anastomosed, and thus changed into annular vessels. He affirms, in favour of his opinion, that he has found only spiral vessels in the young growing plants of *Alsine media, Caragana arborescens*, &c.

Mirbel, on the contrary, sets out with the principle, that vessels are a modification of the cellular tissue, and that they are formed of porous cellules: he believes that these cellules, placed end to end, form the strangulated vessels; and he seems to indicate, without expressly saying so, that these may change into porous vessels; that, by the near approximation of the pores, they become the vessels which he calls Slit Vessels (*vaisseaux fendus*), or False Tracheæ (*fausses trachées*), which only differ from true tracheæ in being incapable of unrolling. He admits that all the intermediate states are found in nature; and that the same tube may, in different parts of its length, offer all these different forms: he calls this the Mixed Tube (*tube mixte*). But he thinks that each of these states of the vessels is primitive, and not produced by the act of vegetation.

Treviranus (probably in consequence of the idea originally thrown out by Sprengel) states as the effect of vegetation upon the vessels, that a course of things diametrically opposite ensues. He supposes that the granules which are observed in the cellular tissue, are so many organized vesicles, which, swelling up, form as many new cellules; that these cellules, according to their respective arrangement, form either the round cellular tissue, or the elongated cellules, or the cellules disposed necklace-like (*en chapelet*); that in this last state, the dilatation of the vesicles always continuing, the diaphragms break, and change the series of necklace-like cellules into dotted vessels, into false tracheæ (*fausses trachées*), and into true tracheæ, according to the degree of development. By this system, Treviranus explains how all the parts of a plant seem to derive their origin from the cellular tissue.

Kieser gives an entirely different opinion: he refers all this organization to an elastic fibre. When it is rolled spirally, it forms the trachea; when it is disposed in circular or parallel rings, it forms the striped or annular vessels; when the spires or rings are joined by a porous membrane, the result is the formation of dotted vessels; when these dotted vessels have their origin in the articulations, they are contracted at intervals, thus forming strangulated or necklace-like vessels (*vaisseaux en chapelet*); lastly, when the spires or rings are remote from one another, detached, or united in different degrees, the formation of reticulated vessels results.

I purposely pass over several other theories, which agree in different points with those which I have rapidly sketched out: an historical narrative of this subject may be found in Kieser's *Mémoire sur l'Organisation des Plantes*. What I have said is sufficient to show the extreme diversity of opinion entertained by anatomists, and the almost impossibility of having, in the present state of things, a satisfactory opinion upon points so refined.

The only idea which appears common to all these theories is, that all the different orders of vessels have the most intimate mutual relations, and can only be considered as modifications of one another; an opinion which is confirmed by this circumstance,—that all, or almost all the orders of vessels exist simultaneously in certain classes of plants, and are as regularly absent from others.

It is also confirmed by the extreme difficulty which most anatomists have encountered in distinguishing these orders of vessels with any certainty. Thus, for example, there are some observers, such as Dutrochet and Rudolphi, who admit the existence of tracheæ incapable of being unrolled; a state which, if it were well demonstrated, would seem to establish a kind of identity between tracheæ and annular vessels. Dutrochet particularly affirms, that when these vessels are subjected to boiling in nitric acid, we can destroy the junctions of their spires, and render them capable of being unrolled. Kieser remarks, that the rings of the vessels are often oblique; and that they are seen to pass by degrees, in the same vessel, into the form of true spires. The transition of annular vessels into dotted vessels has been pointed out and figured, by several of those who have thought that these dots, whatever may be their nature, being continued, form the transverse lines.

The analogy of dotted vessels with strangulated vessels is so great, that several observers have made little or no distinction between them.

It seems then admitted by observers, whether collectively or in detail, that all these different organs are only modifications of a single kind; but nevertheless, in commencing on this theoretical foundation, many doubtful points still remain to be examined. We proceed now to pass them in review, not for the purpose of solving them with certainty, but to show the contradictory tendencies, and the probabilities of the different opinions:—

1st. *Does each of these vessels, the structure of which* *we have described in the preceding chapters, preserve the same form throughout its entire length?*—The uncertainty on this subject has been caused by Mirbel, who admits the existence of mixed tubes *(tubes mixtes)*—that is to say, tubes which in different parts of their length may be dotted, striped, or spiral like a gun-screw. "The same tube," says he, "exhibits successively these different forms: a trachea of the stem may terminate at the root in a strangulated vessel—may become a false trachea at the knot at the base of a branch—may pass over this in the form of a dotted tube, and resume in the leaves or petals the form of a true trachea." Almost all the anatomists who have written since this opinion has been published, have written against it, or at least against its general application: several acknowledge that they find some tubes which bear at the same time short and long stripes, so that it may be perhaps admitted that annular and dotted vessels pass one into another, and in this very restricted sense the existence of mixed vessels may be admitted;—but the majority deny the other combinations. Rudolphi says, that he believes that it is impossible for an annular tube ever to change into a spiral vessel; and he explains the assertion of Mirbel, in thinking that he has, unconsciously, passed from one vessel to another under the field of the microscope. Dutrochet, in particular, affirms that there are no mixed vessels, in the sense which Mirbel assigns to this word; and that the tracheæ preserve their organization throughout their whole extent. Amici says, that he has never met with any vessels compounded of tracheæ and of tubes. The assertion of Mirbel, he adds, may perhaps be only a simple hypothesis: every one who has applied himself to the anatomy of plants, easily comprehends the impossibility of following the course of a vessel for so long a distance.

Kieser does not admit mixed vessels as a particular class; but he agrees much with the opinions of Mirbel in this,—that he admits the passage of one form into another. Thus, according to him, a tube may be partly a trachea, and partly an annular vessel, as he has represented in the Balsam; or partly a trachea, and partly a reticulated vessel, examples of which are found in the same plant. He thinks that, when they grow old, most tracheæ become dotted vessels, by the separation of the spires or the rings, and by the development of an intermediate dotted membrane: consequently, intermediate forms ought to be found from time to time between these two periods. Lastly, he affirms that all kinds of vessels become strangulated vessels at the articulations.

For my own part, I have not any theoretical objection to admitting transitions of form in the vessels; but I confess that I have never seen them but in an obscure manner, and one which has appeared to me doubtful, either for fear of passing from one tube to another under the field of the microscope without suspecting it, or because of the same difficulty which is also found in classing these different forms. I am inclined to think that these changes of form of one and the same tube have rather originated from theoretical ideas than been clearly seen by direct observation; and I venture still to direct observers to the verification of the facts.

2d. *Are vessels always simple, or do they ramify?*

This question is as difficult as the preceding, and equally merits the attention of observers. We find several figures of the old anatomists where the vessels appear ramified; but it is difficult to recognise, either in these figures or in the descriptions, whether they be in reality ramified vessels, or bundles of vessels which are distinct. Mirbel has most positively affirmed that tubes really branched do exist, and he has given a figure of them in his *Elemens*, Pl. 10, fig. 9. Kieser adopts the same opinion, at least with regard to the reticulated vessels; and represents them ramified (*Mémoire Org.*, Pl. 11, fig. 51; and Pl. 12, figs. 56, 57), but respecting the other kinds he does not say it is the case; however, he appears not to doubt the possibility of this ramification. It is certain that it is very rare: if it really does occur, it is perhaps only in the articulations; and as this is the part in plants where the usual interlacement of the fibres renders the observation very difficult, there remains some doubt about those ramifications, which, however, probably do exist. Still, even in admitting the appearances represented by Kieser, must we not well distinguish whether he does not really examine new vessels which are united with the old, or vessels which, being enclosed in one sheath, tend to diverge at their exit?

3d. *Do the different kinds of vessels which we have enumerated preserve the same form during the whole period of their existence?*

If the same tube could be examined at different periods of its existence, this question would be susceptible of solution in a direct manner; but as this observation is impossible, we must have recourse to other means of solving it.

Those who think that the trachea is the original form of all the other vessels, rest their theory upon facts striking enough—viz. that tracheæ exist, both in young plants and young shoots, more abundantly in proportion than other vessels; and consequently it is probable that these other vessels are no more than transformed tracheæ. Kieser, in particular, has given great weight to this opinion by his dissections of the Gourd at different ages. In admitting the truth of the fact, we nevertheless cannot deny that there are others quite as positively affirmed, and from which one must draw an opposite conclusion. Thus it is certain, that the first woody layer of trees contains tracheæ in a state incapable of unrolling, even in aged stems; and that they have not been found in the next layers, even in a young state.

Those who derive the origin of vessels from the cellular tissue, support their opinion, 1st, upon this,—that in the vegetable kingdom the cellular tissue is the most universal texture, and that it alone composes those plants which appear the least perfect; 2d, that in every plant it is more abundant in the individual or its organs at the time of their first development, than at an advanced age. The first of these proofs appears to me to be deduced from an inadmissible description of reasoning—viz. the plan of considering the vegetable kingdom as an individual plant, and of deciding upon one species and one class from another, as if the general forms of beings were endowed with immutability. As for the second, the point is true; but it is as easily explained by supposing that the development of vessels is a little slower than that of the cellules.

Lastly. There is a third class of anatomists who regard all the forms of vessels as constant, and who assert that age does not determine the forms under which the different orders of vessels have been established. But even these give credit to the incrustation of the cellules of the wood and bark, to the formation of an analogous incrustation, or a development of a peculiar cellular tissue in the aged vessels: and it must be confessed that their principal argument is purely negative; that is to say, that it relies upon the fact, that none of the changes admitted in the different theories have ever been demonstrated by direct observation.

4th. *What is the nature of the markings which are observed on the dotted and strangulated vessels?* This

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ADDRESS.

THE fame of DE CANDOLLE, as a learned and philosophic Botanist, has been too long and justly established in this country, and throughout the scientific world, to require any eulogy. His botanical writings are universally admitted to be of the highest order, and it has been a subject of surprise and regret that no edition of his elementary works has appeared in an English dress. This desideratum it will be the Editor's endeavour to supply, by publishing, in a form to suit the more general class of purchasers, this eminent Author's comprehensive Work on VEGETABLE ORGANOGRAPHY, to appear in Monthly Parts, price 2*s.* 6*d.* each. The Work will be printed in a clear bold type, on fine paper; each Part to contain two or more Plates, illustrative of the minute parts of vegetable anatomy, and of the various modifications which the organs of plants present, &c. &c. It will be completed in 16 Parts, forming two handsome octavo volumes, and, it is hoped, will be found to be the most complete and comprehensive, as well as useful work, that has appeared on this branch of Botanical Science in the English language.

N.B. *This Work will be followed by a translation of the same Author's Work on* VEGETABLE PHYSIOLOGY.