OBSERVATIONS

ON THE STRUCTURE OF

FRUITS AND SEEDS;

TRANSLATED FROM THE

ANALYSE DU FRUIT

OF

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Comprising the Author's latest corrections; and illustrated with Plates and Original Notes by

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TO

WILLIAM JACKSON HOOKER, ESQ.

FELLOW OF THE ROYAL, LINNEAN, AND

ANTIQUARIAN SOCIETIES,

AND MEMBER OF THE WERNERIAN SOCIETY OF

EDINBURGH;

THE FOLLOWING SHEETS

ARE MOST RESPECTFULLY INSCRIBED BY

HIS VERY GRATEFUL AND

AFFECTIONATE FRIEND

J. LINDLEY.

PREFACE.

AMONG the number of elementary works which have issued from the English press within a few years, it is to be lamented that not one should have appeared, which is at all equal to explain one of the most important parts of Botany, the structure of Fruits and Seeds. This is a circumstance which is the more to be regretted, since an intimate acquaintance with that division of the science, is of the utmost consequence, not less in a practical than a philosophical point of view.

The *Philosophia Botanica* of Linnæus is more perfect than could have been expected, from the progress science had at that time been able to make; but the mighty mind of its immortal author had to struggle with difficulties which would have overwhelmed a genius less powerful than his own. The Augean stable was again to clear; in the short space of half a century, the rubbish and the building were removed together, and a noble superstructure raised in their room. With such veneration on this account have the followers of Linnæus been inspired, that his productions have been considered sacred, and it has been held almost profane, either to suggest amendments of his system, or to expose defects in his works. His *Philosophia* has afforded most of the materials of every publication of a similar nature which has since appeared among his followers, who have suffered themselves by this predilection in his favour, to overlook the rapid strides of the science in another quarter. To such lengths indeed have some proceeded from their desire to uphold the sexual system, as even to attempt to conceal the important improvements of the method of his great opponent. The NATURAL ORDERS of the great Jussieu have this important advantage over the system of Linnæus, or any other system whatever, as far as regards natural arrangement, that their characters are not confined to any one part of the fructification. They require that the most scrupulous attention should be given to every modification of the organs of reproduction. This it is which has occasioned the discovery of the most beautiful truths, which has opened the way to the most interesting fields of observation. By it the mind is kept perpetually in action, the ideas are extended, the sphere of comprehension is enlarged, and admirable opportunities are afforded for contemplating nature in her most bewitching form.

Although, as has been already observed, the characters of Natural Orders are confined to no particular part of the fructification, yet experience has shown that the organ which contains the rudiment of a plant is usually one of the most important for combining natural groups in their perfect state. To this therefore the most unwearied attention has been paid; and it is hoped that the little *Analyse du Fruit* of M. Richard will afford young botanists the opportunity of studying the principles of Carpology, without having to experience such difficulties as have hitherto presented themselves.

The necessity of the additions which have been made, will be best explained by an account of the circumstances under which the original was published.

M. Duval, an intimate friend of M. Richard, and to whom the scientific world must be for ever indebted, had for several years attended the lectures delivered by the learned Professor at the Ecole de Médicine at Paris, and had carefully preserved memoranda of them, any defects in which his personal intimacy with M. Richard enabled him to supply. "Every botanist" observes M. Duval in his preface "who is acquainted with our laborious Professor, knows that he has amassed a great quantity of observations from which he one day intends to deduce the fundamental laws of botany. They all know that these are to be accompanied by figures drawn by his own hand with the greatest care. Every one interested in the progress of our science, must anxiously look for the publication of so useful a work. But the unfortunate situation of M. Richard: the ill success of his repeated applications to Government for assistance: the resolution he has taken to publish nothing unless he possesses the pecuniary means of engraving his drawings: such are the motives for a delay which is the more distressing as the length of it is uncertain. Perhaps it may be accelerated by a successful execution of his plan of selling all he possesses except what relates to botany! It is the last effort he can possibly make for defraying the expence of engravings and consequently of publishing his observations." For the use of botanists till this great work could appear, M. Duval undertook the publication of that part of his lectures, which immediately related to the structure of fruit and seeds. Eleven years have now elapsed and this little Prodromus is all that has appeared, except a few memoirs in the *Annales du Muséum.*

Every one will immediately perceive that although the observations of the Professor would be perfectly clear when delivered by himself, and explained to his hearers by examples before them ; yet to those beginners who are deprived of such advantages, many things would become difficult to comprehend, and from want of previous acquaintance with the subject, even unintelligible. To remedy as far as possible this defect, illustrative notes and figures have been added. The latter have been drawn by the editor with the utmost care, but no more details have been introduced than were absolutely necessary, as they would have encreased materially the expence of the publication. When the subjects themselves could not conveniently be procured, recourse has been had to the figures of others, but never without acknowledging it.

The translation, as far as the different idioms of the two languages would possibly admit, has been scrupulously formed on the model of the original. It is hoped that the evident necessity of this, from the peculiar nature of the subject, and the editor's inexperience in the literary field, will serve as an excuse for the numerous defects of the work as a piece of composition; if he has at any time failed in explaining the meaning of his author, he must endeavour to shelter himself under the protection of the adage, *in magnis vel voluisse sat est.* He, however, thinks it necessary to observe that he is by no means answerable for all the opinions which the following sheets may contain: their learned author is fully prepared to support them, and on him must that duty fall. It is to be regretted that so many new terms should have been substituted for old ones, which, if not quite so expressive, were at least better understood, and from their right of priority should have been retained. To remedy this in some degree, the synonymous terms of Gærtner have been added in the notes.

From the hasty manner in which the original was published, (in seven days,) it unavoidably contained many particulars which later observation has made it necessary to alter. This has been effected partially, by the distribution of corrected copies, to a few select friends. Some passages, however, still remained, the interpretation of which did not appear to be entirely satisfactory; the interest which Mr. Hooker has taken in the publication, induced him to propose them to M. Richard for more precise explanation; with his usual liberality, he not only immediately complied with the request, but communicated all the corrections which ten years' additional experience has induced him to make; these have been incorporated with the work, and give the present edition some additional and important claims on the attention of the public, as containing the Professor's latest views of the subject. The *Primaria plantarum divisio* has been inserted at the end by M. Richard's particular request.

The following letter to M. Duval will throw some additional light on the principles which M. Richard has exposed in the body of the work:

SIR,

I have carefully perused the abridgment of my lectures on the structure of fruit, which you think of publishing. As I find nothing in it which disagrees with what I have said and observed myself, I adopt it entirely and authorize you to give it to the public. The errors it contains, for I cannot flatter myself that I have avoided them in so difficult a department of the science, must be attributed to me.

Some readers will exclaim against the introduction of so many new terms, but others will perhaps be found to adopt them; especially when it is remembered that if the work of Gærtner has not been so much applied to the improvement of generic and ordinal characters as it might have been, the cause may be found in the want of terms to express with brevity the observations of that learned carpologist. This partial sketch which you are about to publish of a greater work, will shew that I have laboured to diminish this inconvenience. Indeed I cannot refrain from demonstrating, by only a few examples, that the new terms I propose, may be employed to advantage in compressing the characters of the fructification of natural orders into a small compass.

ENDORHIZÆ.

I.—*Embryone epispermico.*

Potamophilæ *seu* Fluviales.

Achenium subdrupaceum: *Sem.* appensum sive inversum: *Emb.* antitropus.

Joncagineæ.

Sem. unicum aut pauca, erecta: *Emb.* orthotropus.

Alismaceæ.

Sem. erectum, aut duo ascendentia: *Emb.* homotropus, hippocrepicus.

Butomeæ.

Sem. plura, parietalia, ascendentia: *Emb.* homotropus, rectus aut hippocrepicus.

II.—*Embryone endospermico.*

Gramineæ.

Caryopsis rarò *Achenium*: *Sem.* subascendens: *Emb.* extrarius, obliquè sublaterali-basilaris, heterotropus, macropodus.

Cyperaceæ.

Achenium sæpius subdrupaceum: *Sem.* erectum: *Emb.* intrario-basilaris, orthotropus, brachypodus.

Typhineæ.

Achenium drupaceum: *Sem.* inversum: *Emb.* axilis, orthotropus.

Nevertheless I am far from supposing that my carpological labours have made great advances towards perfection. The progress of the Philosophical part of a science of observation is necessarily slow and successive. Its end is concealed in an unbounded futurity; to arrive at it is impossible; to diminish its distance a little is all that the most ingenious and most enthusiastic mind can desire. I shall be happy if I succeed, before my death, in adding fresh light to that with which my predecessors have illumined the dark and difficult road of fundamental Botany.

But in an age when the size of a work, its typographical elegance and the seductive beauty of its figures are the best guarantees of the talents of the Botanical writer, what kind of fate may this little book expect, which has nothing of that sort to recommend it to the notice of those who may determine on its reputation! I confess, Sir, that these reflections have hitherto had no little effect in deterring me from venturing on the publication of extracts, which, from their want of attractions and support, would always tend to sink in the obscurity from which they sprang.

Yet the present may be useful to students who attend my course. Why not add to this first motive of publication, the hope of seeing it noticed by Botanists of celebrity! In such a matter the approbation of a chosen few is to be preferred to the commendations of the multitude. The praise of a few truly learned men will encourage me; their just criticisms will assist me. Some one of them may perhaps be induced, by the perusal of this tract, to allow that I have used some exertion by my public lectures to contribute to the progress of science, and may pencil my name on the margin of the report which the Institute has presented to HIS MAJESTY.

RICHARD.

CONTENTS.

ERRATA.

Page 23, line 12 for COMPOSITEÆ, read COMPOSITÆ.

56, —— 24 — *Nymphea*, read *Nymphæa*.

56, —— 27 — *Nuphar*, read *Nymphæa*.

56, —— 29 — *And*, read *Nuphar*.

57, —— 27 — NYMPHEACEÆ, read NYMPHÆACEÆ.

A

BOTANICAL ANALYSIS

OF

FRUITS.

EVERY Fruit is essentially composed of two principal parts, which are the *Pericarp* and the *Seed.*

OF THE PERICARP.—The *Pericarp* is that part which determines the exterior form of a perfect fruit, and in which the seed is immediately and entirely enclosed.

Since it is only the ovarium in an advanced state, it ought to indicate on some point of the surface, most frequently at the summit, traces of the style or stigma; and this is the chief character which enables us to distinguish the *Pericarp* from certain coverings which have sometimes usurped that name.

Every *Pericarp* is formed by a parenchymatous substance, traversed by vessels: but as it is impossible that the vascular system of an organized body can be naked, this parenchymatous substance is covered on the outside by the *Epidermis* and on the inside by the *internal parietal membrane.*

I propose naming the epidermis of fruit *Epicarp,* the parenchyma *Sarcocarp*—and the internal lining which forms the seminiferous cavity, I would call *Endocarp.*[a]

The epicarp is frequently formed either entirely or in a great measure by the tube of the calyx, whose parenchyma is then incorporated with the sarcocarp.[b] The union of the calyx with the pericarp is recognized in this, that the latter is surrounded at a distance greater or less from the origin of the style or stigma by the salient edge of the calyx, or by a scar occasioned by its fall.

The endocarp is always membranous; but it

a For example in a Peach, the wooly outer integument is the epicarp, the fleshy part which is eaten is the sarcocarp; and the bony covering in which the seed is enclosed is the endocarp united with an indurated portion of the sarcocarp;—this is better known by the name of *Putamen.*

b An example of this is found in the common Apple.—see *tab.* 1. *fig.* 1. where *a* is the fleshy tube of the calyx—*b,* the point where the sarcocarp unites with it—*c,* the sarcocarp itself—*d,* the endocarp.—see also *tab.* 2. *fig.* 4. where the same letters represent the same parts in *Thesium alpinum.* It is hardly necessary to observe, that such a formation can only take place in fruits which for convenience are called inferior, though this explanation of their structure shews them to be superior.

may be enlarged externally, by some portion of the sarcocarp differing in size and in hardness. When this portion of the sarcocarp acquires a bony[a] or woody texture, it forms what is termed a nut, and *nuculæ,* when there are more than one. These nuculæ which characterize the kind of fruit I call *Nuculanium,* are much more frequent than is supposed by botanists, who usually mistake them for seeds. Perhaps they may be considered as the wood of the fruit; but this ligneous part arrives at considerable hardness much more rapidly than the wood of the stem, and it sometimes is the only woody part about the plant which bears it.

The cavity of the pericarp that contains the seed, is defined by the endocarp. If the endocarp be every where continuous, or be only interrupted by one or more distinct seminiferous processes, then the cavity of the pericarp is simple and it is unilocular.[b] If the endocarp itself form processes which unite by their inner edge in such a way as completely to divide the inside of the pericarp into several partial cavities, the pericarp then becomes multilocular.[c] These cavities take the name of cells and the plates which divide them, that of dissepiments.[d]

[a] As in *Prunus* and all drupaceous fruit.

[b] See *tab.* 1. *fig.* 4. [c] See *tab.* 1. *fig.* 3.

[d] Thus in *tab.* 1. *fig.* 2. *a* is one of the dissepiments—*e* is a cell. In *fig.* 3. *a,* dissepiment—*b,* cell.

Every true dissepiment[a] is made up of two lamelliform processes of the endocarp, placed back to back, and united to each other by a very delicate elongation of the sarcocarp. Since the origin of the dissepiments of every sort of pericarp is the same, we must consider as erroneous the simple marginal application, either external or internal, that some botanists have attributed to that part in certain capsules.[b] It is the same of dissepiments formed by the introflexed margin of the valves.[c]

Some pericarps (those of certain CRUCIFERÆ, CUCURBITACEÆ, HYDROCHARIDEÆ, &c.) are divided internally by false dissepiments which

a The endocarp of each cell turns inwards at the place where it meets that of the other cell; the two endocarps become united, and extending as far as the axis, form the dissepiment. Whatever be the number of cells, such is always the origin of the dissepiments.—*Note communicated by M. Richard.*

b It sometimes happens that a pericarp opens into two valves opposite the dissepiment, so as to separate from the latter, which retains its position. This is caused by the two endocarpic plates of the cells being ruptured with the rest of the pericarp; the two portions of the plates which form the dissepiment still preserving their cohesion. It is therefore evident that the expression "*dissepimentum marginibus valvarum circumappositum*" employed by Jussieu and his followers (vid. Juss. *Scrophulariæ,*) is not strictly correct. This sort of dehiscence is what I call *septifragal. Rich. Mss.* See *tab.* 3. *fig.* 4.

c Some pericarps open by the middle of the dissepiment, so as to divide it into two plates, each of which comes away with the valve to which it belongs. Since these plates are only extensions of the endocarp, and not of the same thickness as the valves themselves, botanists are wrong in saying "*dissepimentum a valvarum marginibus introflexis*". I call this sort of dehiscence *septicidal. Rich. Mss.* See *tab.* 2. *fig.* 8.

existed even in the ovaria.[a] They are known, first, because they are not formed by the endocarp, properly so called;—secondly, because they most generally answer to each stigma, or to each division of the stigma; whilst the true dissepiments usually alternate with them. It results from what I have said, that the fruit of HYDROCHARIDEÆ, NYMPHEACEÆ, CUCURBITACEÆ, &c. has as many cells as seeds.

The internal structure of a pericarp, is essentially indicated by that of the ovarium of the plant which produced it.[b] What a host of errors have been committed by botanists from neglecting this important law! What seeming discordance between the fruits of certain neighbouring genera, and even of some natural orders, (JASMINEÆ for instance) in which the ovarium have all an internal uniform structure! It is by the comparison of the perfect fruit with the ovarium, that we are able more easily to recognize the true loculation of fruit, either incomplete or pulpy; and above all of those that are *Pseudo-multilocular* or cellular—among others the chief part of ANNONACEÆ.

a See *tab.* 1. *fig.* 5. *A.* This sort of false dissepiment M. Richard considers to be only an extension of the trophosperm.

b On account of the frequency of abortion of some of the parts. The ovarium of the Oak for example has three cells and six ovula—the acorn has never more than one seed. Here then two cells become entirely abortive and one ovulum in the other cell.

I substitute the name of *Trophosperm* for that of *Placenta,* which botanists have given to the internal part of the pericarp, on which the seeds are immediately attached.[a] Every visible process of the trophosperm which bears a single seed is known by the name of *umbilical chord,* (a name just as improper as the preceding,) for which I shall adopt that of *Podosperm.*[b] When the summit of the podosperm forms a protuberance or an expansion manifestly extended on the seed beyond the margin of the hilum; this protuberance or expansion, usually fleshy, constitutes the true arillus which is seldom developed before fecundation.[c] Since the trophosperm has an immediate communication with the sarcocarp, the endocarp is always pierced or interrupted at that point where the trophospermic substance penetrates or projects iuto the seminiferous cavity.[d] Thus the scar or hollow

a See *tab.* 1. *fig.* 6. *a.* b See *tab.* 1. *fig.* 5. *B. b.*

c See *tab.* 2. *fig.* 10 and 11. where *a* is the podosperm—*b* the arillus wrapping up the seed in the shape of a fleshy, loose, red bag—at c the seed is seen appearing beyond the arillus--in *Euonymus Europæus.* The mace of the nutmeg affords another instance of an arillus.

d When a central trophosperm falls or is detached, the dissepiment exhibits a hole or scar at the place which it occupied, because the endocarpic plate is always interrupted or perforated by the matter of the trophosperm, that is, the substance which bears the seeds. *Rich. Mss.*

The importance of this is explained by the following observation of M. Richard;

"Carefully examine the interior of the capsule of *Papaver;* the sudden interruption of the endocarp towards the origin of each projecting plate decides that these are so many trophosperms, and not dissepiments."

made on some part of the endocarp, by the spontaneous separation of the seed, or of the trophosperm, assists us in discovering their true position, when the former are loose in the pericarp, or even when they have been taken from it.[a]

The trophosperm of a multilocular pericarp results from the meeting and union of the parenchyma of the dissepiments; when this leaves that edge of the latter which is next the axis, it expands to the right and left, so that the particular trophosperm of each cell is made up of the parenchyma of two dissepiments.

The sutural or parietal trophosperm of an unilocular pericarp is also produced by the confluence of the parenchyma of the two sides; and to this almost universal mode of formation of each trophosperm, is to be attributed the frequent disposition of seeds in two ranks, and the common mode of dehiscence by the middle of trophosperms which are immediately parietal.

The base of a pericarp is indicated by the

[a] The seeds of a pericarp in a dry state are frequently loose or detached. If the surface of the endocarp be examined, a scar will be observed, or a hole or some sort of interruption which indicates the point where the seeds were attached. *Rich. Mss.*

centre of its point of attachment, or by that extremity which is nearest its pedicel.[a]

Its summit is equally determined by the point of origin of the style or sessile stigma.[b]

The want of a real axis named *Columella*[c] is supplied by an imaginary axis, by which is to be understood a line supposed to traverse longitudinally the middle of the whole mass of the pericarp, from the centre of the base to that of its summit.

Many pericarps are indehiscent; that is to say never open after maturity.[d]

Ruptures which burst irregularly,[e] *Orifices*, which gape by an opening either at the summit or the side, without denticulations,[f] and those which are perforated at the top, or laterally,[g] are very rare. Care must be taken not to confound the true rupture of the whole substance of the pericarp, with spontaneous excoriation, which does not open the endocarp,[h] nor with the

a In *tab.* 1. *fig.* 6, the base of the pericarp is pointed out by the letter *b*.

b See *tab.* 1. *fig.* 5. *A. a.*

c See *tab.* 2. *fig.* 8, where the summit of the Columella is seen above the valves at *a*.

d See *tab.* 1. *fig.* 7.

e As in *Momordica, Kiggelaria, Ryana*, &c.

f See *tab.* 1. *fig.* 10, *Reseda alba*, also *Colutea*, &c.

g See *tab.* 1 *fig.* 9, 11, *Antirrhinum, Campanula.*

h See *tab.* 3. *fig.* 2. *Euphorbia.*

cracking of the latter, which does not answer to the valvation of the sarcocarp.

Divisibility, by which a pericarp separates into one seeded, and several closed divisions, is sufficiently common.[a] *Solubility*, by articulation, borders upon this, but is much more uncommon.[b] A very few pericarps are *circumscissile* ; that is to say open by a transverse circular separation.[c] *Semi-circumscission* is known at present only in the genus *Jeffersonia*. *Sutural*, or *leguminous* dehiscence,[d] which takes place by a marginal suture, is common ; but the most frequent of all is the *valvular*. It is by this latter that a perfect pericarp divides or splits regularly in the direction of its axis, into several pieces usually of equal size. These valves are called teeth, if they are sharp and short with respect to the part remaining entire.[e]

The valvular mode of dehiscence, offers two important characters by its relation with the dissepiments. If it takes place in the middle of the cells, or in the intermediate space between the dissepiments, it is termed *loculicidal*, and the latter then answer to the middle of the

[a] Umbelliferæ. See *tab.* 3. *fig.* 3.
[b] See *tab.* 2. *fig.* 9. *Ornithopus.*
[c] *Anagallis arvensis.* *tab.* 1. *fig.* 8.
[d] See *tab.* 3. *fig.* 1. [e] See *tab.* 1. *fig.* 12. *Silene.*

valves.[a] If it occurs immediately opposite the dissepiments, these are usually separated into two plates, and it then receives the name of *septicidal*;[b] but it is called *septifragal* when it bursts the external edge of the dissepiments, which are then divided from the valves.[c]

An analogy exists between loculicidal and septicidal dehiscence, in unilocular capsules whose trophosperms are parietal.[d]

Not to be deceived respecting the true number and only characteristic of valves, it is useful to know that these parts, in certain capsules, are spontaneously bipartible by exsiccation, and subject on that account to a false mode of dehiscence. An unilocular pericarp can have no more true valves than its ovarium has stigmata or divisions of the stigma. These two principles will sometimes be productive of embarrassment, unless a third is admitted, that *septicidal dehiscence* is always true.

a As in IRIDEÆ. *tab.* 1. *fig.* 6.

b As in *Rhododendron Ponticum. tab.* 2. *fig.* 8.

c As in *Ipomœa purpurea. tab.* 3. *fig.* 4.

d If an unilocular pericarp opens by the middle of its parietal trophosperms, so as to divide them longitudinally, this mode of dehiscence answers to the septicidal dehiscence of a plurilocular pericarp. If on the other hand, it divides into two valves, each furnished with a trophosperm in its middle, the dehiscence is similar to loculicidal. *Rich. Mss.*

Much difficulty is frequently experienced in deciding whether a fruit be simple or compound.

It may be useful to notice some of the means for determining the unity or plurality of fruits, and consequently of pericarps produced by a single flower.[a]

Every simple fruit must be the production of a single flower.

Unilocularity (provided there be no abortion) always establishes the unity of fruit.

Every fruit which proceeds from an ovarium with one style, must be considered simple. If some plants such as APOCINEÆ and the new order SIMARUBACEÆ, appear to deviate from this law, it serves at least to mark their affinity with others.

Every fruit whose seminiferous cavities are distinguished completely, and as far as its semiferous summit, by true dissepiments, is simple.

A complete separation of the pistils of a flower, that is, their division throughout the whole of the face, or edge, which is opposite the imaginary axis of their assemblage, requires the

[a] It has been suggested with great probability by Mr. Brown, that all multilocular pericarps are really formed by the coalescence of many simple fruits, differing only in the various modifications of cohesion and solubility of their parts, See *Prod. Fl. N. Holl.* and also the same profound Botanist's paper on *Compositæ* in *Linn. Trans.*

admission of a natural plurality of fruits; natural I say, because it is possible that only one of the pistils may have been fecundated.

Every fruit whose seminiferous cavities do not communicate with each other, and are only distinguished by a common axis, to which all the parts forming these cavities are fastened by their axile borders, immediately, and without elongation or change of the curvature of their endocarp at the place of junction, is an assemblage of fruits always unilocular, and consequently equal in number to the cavities.[a]

This plurality of fruit essentially distinguishes the COLCHICHACEÆ from the EPHEMEREÆ and JUNCINEÆ; it brings near the first the JONCAGINEÆ and ALISMACEÆ by *Alisma Damasonium*, and it removes many RANUNCULACEÆ nearer their affinities.

Every fruit which forms a single mass,[b] and presents on its surface protuberances, or scattered and distant scars, each of which has borne a stigma, is an assemblage of the same number of fruits united to each other.

Since no law is yet established which will decidedly determine the limits of the pericarp, and

a See *tab.* 3. *fig.* 2. b As in *Magnolia, Annona, Rubus, &c.*

the seed, it is necessary before I come to treat of the latter, to give a sketch of this important point of Carpology.

Botanists have sometimes not only falsely attributed to the pericarp, or taken for it, some exterior covering; but also have frequently given to the seed, parts essentially belonging to the pericarp.[a]

Sometimes it is an arbitrary arillus with which

[a] Thus that part in *Carex* which Linnæus called a nectarium and which has since been considered an arillus by Sir J. E. Smith, is perhaps, as Mr. Brown has observed, a true *perigonium*. An analogy has been thought to exist between the two valves that *Kobresia* should have, according to the view of its structure that authors have taken, and the *perigonium* of *Carex;* but from careful and repeated examinations of *K. spicata* I am persuaded that these two genera are as entirely dissimilar in their structure as any others of the same natural order. The very different texture of the glumes in this genus from the perigonium of *Carex* first led me to doubt their identity, and from subsequent observations I am persuaded that what has been taken in *Kobresia* for a single flower with a bivalve perigonium, ought rather to be understood as a three flowered spike of which the outer glume is abortive, (as in *Schœnus,*) the second female, and the third male—this hypothesis is materially supported by the consideration that if *Kobresia* had really a two valved bisexual perigonium, the stamens would be inserted round the base of the ovarium, which is not the case, since they are lateral with respect to the pericarp, arising from the bottom of the uppermost valve which wraps round the base of their filaments. Another circumstance is not less in favour of this idea; what I consider the uppermost spike has always four glumes, that which is exterior being sterile, the second female, the third male with perfect stamens, and the fourth male with the stamens abortive.

The perigonium of *Carex* itself seems to be formed by the confluence of two bracteæ resembling the glumes of GRAMINEÆ. This is rendered probable by the almost constant division of its apex, and by the nature of its nerves, which, when they are present, have precisely the same situation and direction as in GRAMINEÆ; to this I may add, what is perhaps the most important circumstance of all, that the perigonium of *Carex arenaria* when half grown is easily and perfectly divisible into two equal carinate valves. See *tab.* **2.** *fig.* **1.** *and* **2.**

the seed is clothed; often has the endocarp been taken for one of its integuments, and sometimes even for its immediate covering. Very frequently the whole pericarp has been regarded as a single integument.

I was the first who fixed the application of the word arillus by the definition I gave of it in my *Dictionnaire de Botanique.* (Observe the word *stylum* is printed there by a typographical error instead of *hilum.*) Exact definitions of the parts of plants, so difficult and therefore so generally neglected, are one of the most solid bases on which the fundamental laws of the science must be supported. Already has the arillus, now that it is better defined, become the foundation of a law, which was published in the same dictionary, and has pointed out to botanists some errors into which they have fallen; and it may prevent the recurrence of similar mistakes in future. Hereafter the name arillus will not be given to parts entirely different, such as the endocarp in some RUBIACEÆ, RUTACEÆ, &c. or the real integument of the seed in *Jasminum, Kiggelaria,* ORCHIDEÆ, &c. Since the arillus proceeds from the pericarp, which produces it in the form of an expansion of the trophosperm, it is not surprising to find it sometimes developed about an abortive seed.[a]

a This frequently happens in *Euonymus Europæus.* See *tab.* 2. *fig.* 10. *d.*

In the greater part of seeds to which have been attributed two and sometimes three integuments, it is the endocarp which forms the outer one, as in most RUBIACEÆ, CAPRIFOLIACEÆ, RHAMNOIDEÆ, *Malpighia* (which ought to be divided into three very distinct genera) CUCURBITACEÆ, &c. In a word, this error is almost universal in the fruits I have named *Nuculania*. LAURINEÆ, some MYRTOIDEÆ, &c. offer examples of the endocarp having been regarded as the real integument of the seed.

The presence of a membrane which is totally, or at least in part, distinct from the internal lining of the ovarium, and which contains the pulpy substance of the entire ovulum, requires also the existence of a peculiar integument to the seed, which is only the ovulum in a more advanced state. There is then no such thing as a naked seed;[a] that is to say, proceeding from an ovulum with a covering that is simple, and consequently immediately sexiferous. The ovarium not only bears the sexual organ, but is even an integral part of it; how then is it possible that it can be the immediate covering of the produce of fecundation?

[a] Not entirely naked, certainly; but in some few plants the ovarium ceases its functions immediately after the ovula have been fecundated; so that the latter, continuing to increase in size, quickly rupture the former, and when ripe, assume the appearance of naked seeds. Such has been observed by Mr. Brown to obtain in *Leontice thalictroides*. See *tab.* 3 *fig.* 5. where *a* is the ruptured ovarium—*b* the seed—*c* an abortive seed.

And notwithstanding this, many fruits have been regarded as naked seeds, and sometimes, which is yet more astonishing, fruits have been described without a pericarp.

Among these imaginary naked seeds, some have a pericarp clearly distinct from the seminal integument; in others these two parts are so coherent that they appear to constitute a single covering. The former will range without difficulty in the series of fruits; but the error with regard to the second, will be the more difficult to remove, as it is enveloped in an obscurity of connexion almost impenetrable to simple botanical analysis. But in uniting with the latter the advantages of physiological examination, and especially by the aid of natural affinity,[a] it becomes less difficult to attack this error, which the senses may excuse, but which reason must condemn.

I shall conclude this article, by stating the general law which establishes the respective limits of the pericarp and the seed, previously remarking, that this like other laws has its subordinations and dependencies, the knowledge of which is necessary to its just and more easy application.

Every thing which in a ripe fruit is on the outside of the real integuments of the seed, belongs to the pericarp.

a Thus in most GRAMINEÆ it is scarcely possible to detect the presence of a pericarp, but its existence is demonstrated by the diaphanous *utriculus* of *Eleusine*.

Of the Seed.—The seed is that internal part of every perfect fruit, which, under a single organized covering, completely encloses a body, the whole mass of which, or a part only, is the rudiment, already formed, of a new plant.[a]

Of the Episperm.—The covering or integument peculiar to the seed being the most exterior of its constituent parts, I give it the name of Episperm.[b]

The scar or the place by which the seed was attached to the pericarp is called the *Hilum.*[c]

The hilum is the place by which the parenchyma of the trophosperm communicates with that of the episperm; this point of communication then is the common origin of the vessels which are distributed in the substance itself of this integument. The hilum is the natural limit between the pericarp and the seed. When it is small, its centre indicates that of the base of the seed: but if it is large, or remarkably long, the centre of this same base must be confined to the point by which the series of vessels of the hilum passes into the episperm. This principle, which best establishes the relative situation and structure of the different parts of the seed, seems

[a] See *tab.* 2. *fig.* 4. *e.* [b] See *tab.* 3. *fig.* 7. *a.* Testa *Gært.*
[c] See *tab.* 3 *fig.* 6. *a.*

pointed out by nature. Indeed in some genera, *(Lacistema, Brunellia,* which thus approaches *Zanthoxylum, Magnolia, &c.)* the series of vessels of the hilum separates spontaneously from its parenchyma, under the form of a filament, and ceases to fix the seed, except by the point of the hilum where it penetrates the episperm.

Easy as it is to find the base of a seed, it is not a little difficult to fix on its summit. Nevertheless, as it is very useful to know the relative position and direction of the different parts of the seed, it becomes necessary to determine on some plan which shall be at the same time general and certain in its operation; this appears most likely to be effected, by first establishing an imaginary longitudinal axis. Let this be represented by a line supposed to be drawn from the centre of the base, to that of the summit, passing through the centre of the whole mass. Experience will quickly show that this axis may be either curved or straight, perpendicular or more or less oblique, according to the regularity, or irregularity of the seed. The summit remains to be ascertained either by the indications of nature, or by geometrical determination. Its natural indications may be drawn, first, from the general direction of certain furrowed or projecting lines of the episperm towards a point, more or less exactly opposite the hilum; secondly, from this same direction of its principal vessels; thirdly, from a particular areola of the integument, of which I shall presently have occasion to speak. If a right line supposed to be drawn from the centre of the hilum to the point vertically opposite, pass nearly through the central point of the whole mass, the summit must be almost vertically opposite the hilum, and the imaginary axis is nearly straight and perpendicular. But if a line directed from the same place towards the central point of the mass, is very evidently oblique, then this axis can only be expressed by a curved line, which first follows the bend or the angle of that extremity which is nearest the hilum, and then extends itself towards the other end, preserving nearly the same parallelism with all the corresponding points of the outline, and making as much allowance as possible for deformities. But in all cases a geometrical determination of the imaginary axis should only be recurred to when no indication of the summit is presented by nature.[a]

[a] The hilum is almost always the most evident point of the integuments, and serves to unite the seed to its parent plant. It has been proposed by some botanists as the most natural indication of the base, and not without reason: the base once known, to find the summit, it seems only necessary to determine on the point exactly opposite the hilum: and in reality, when the seed has a regular form and is perceptibly elongated in some determinate direction, an imaginary axis with the hilum for the base would indicate the summit by its superior extremity. But it often happens that the form of the seed is so irregular, that it becomes very difficult to say where the summit ought to

The position and direction of the parts of a seed may be referred to the *face,* the *back,* the *sides,* and the *edges.* We have only to assign a just application to these words.

A solitary seed in an unilocular pericarp, if it be globular, ovoid, or cylindrical, can of course offer no indications either of face or back,

When, in a multilocular pericarp, the greatest diameter of each seed is nearly parallel with the axis of the former, or tends manifestly to approach such a position, the face of the seed then regards the axis, and the opposite part is the back.[a] If this same diameter be in nearly a straight direction from the axis to the circumference of the pericarp, then the face of each seed regards the top of the latter.[b] The sides are where the face and the back unite.

Seeds fixed to the bottom or the summit of an unilocular pericarp are considered as the preceding; but the parietal or sutural trophosperm performs the functions of an axis with regard to them.

If a flat seed have the hilum in its margin, it is compressed;[c] if it be entirely on one of its faces, it becomes depressed.[d]

be placed. This however is of little importance practically, for experience proves that when the base of a seed is once found, the situation of the embryo may be determined with precision; and this character is what requires most particularly to be known. *Mirb. elem. de phys. veg. et de bot. p.* 66 and 67.

a See *tab.* 1. *fig.* 1. b See *tab.* 3. *fig.* 13.

c See *tab.* 3. *fig.* 5. *B.* d See *tab.* 3. *fig.* 9.

From these preliminary observations, which could scarcely be shortened, I proceed to consider the annexion and direction of the seed with regard to the pericarp.

The manner and place of annexion of seeds, especially if definite in number, furnish a most important character in the natural arrangement of plants. They also serve to express with more precision the direction of the seed with respect to the pericarp. Nevertheless the best authors have paid but little attention to it, and the invaluable work of the laborious Gærtner is not free from negligence, nor even errors, in this important point.

Every seed fixed to the bottom of a pericarp, of which it follows more or less the direction, is, or ought to be considered, *erect*.[a] By opposition, that which is attached by its end to the top of its cell is called *inverted*.[b]

A seed attached to an axile, parietal, or sutural trophosperm, is *ascending*, when it directs its summit towards the top of the pericarp[c]; it is *suspended*, when, being annexed by the upper part of its edge or internal face, it directs its summit towards the base of the cell which contains it.[d] If it be attached to the axis, or to an

[a] See *tab.* 2. *fig.* 6. [b] See *tab.* 3. *fig.* 10.
[c] See *tab.* 1. *fig.* 1. [d] See *tab.* 3. *fig.* 13.

axile trophosperm, by an hilum equi-distant from the two ends or occupying the whole length of the inner edge, it is called *peritropal*.[a] Few characters are to be drawn from other directions which the seed assumes; being, besides, sufficiently indicated by the point or manner of their annexion.

When the free extremity of a very curved seed is nearer that point of the cell which answers to the summit of the pedicel or other support than to its fixed extremity or podosperm, it must be regarded as inverted, or at least suspended; such for instance is that of *Potamogeton*, &c.[b]

When a seed bends back suddenly in a direction contrary to its podosperm which is sensibly elongated, it is *reclined* by its proper direction; but its direction with relation to the pericarp is indicated by that of the podosperm. Thus the seed of PLUMBAGINEÆ, *Rhus*, *Pistacia*, &c. is reclined; but it ought to be considered erect, as to the pericarp, because its podosperm is fixed to the bottom of the latter.

If the episperm adhere to the endocarp, the direction of the seed cannot be determined without first discovering the point of attachment. To ascertain this, we may proceed either to

[a] See *tab.* 3. *fig.* 9. [b] See *tab.* 3. *fig.* 11.

examine the two extremities of the seed, (of which the base will be indicated by a more marked vascular adherence, and by the origin of the perispermic vessels, whose summit is denoted by the chalaza,) or to determine the position of the ovulum, which is much better.

The point of annexion of the seed, and its direction with respect to the pericarp, characterize essentially neighbouring species, indicate the affinity of certain genera, and are often common to the whole of a natural order.

Erection of the seed is general in COMPOSITEÆ, or SYNANTHEREÆ, &c; it places OPERCULARIÆ between RUBIACEÆ and DIPSACEÆ; it separates *Hippophae* and *Elæagnus* from THESIACEÆ; it limits the number of ALISMACEÆ, distinguishes JONCAGINEÆ from POTAMOPHILÆ, &c.

Its ascending direction separates POMACEÆ from other ROSACEÆ.

Its suspension allies JASMINEÆ to APOCINEÆ, distinguishes GUAIACANÆ from SAPOTÆ, brings *Callitriche* near EUPHORBIACEÆ, groups some ROSACEÆ, and contributes to separate the CUPULIFERÆ from the true AMENTACEÆ.

Its inversion brings together *Zannichellia* and *Potamogeton*, *Ruppia* and *Zostera*, and separates these four genera from ALISMACEÆ; it would bring *Globularia* near DIPSACEÆ, if the structure of the ovarium did not prevent it. VISCOIDEÆ, (containing *Chloranthus, Viscum, Loranthus, Codonium* and *Aucuba*), are by it formed into a section of CAPRIFOLIACEÆ, and it seems to indicate some analogy between *Adoxa* and these last. It fixes HYGROBIÆ, (*Hippuris, Proserpinaca, Haloragis, Myriophyllum*) near the yet imperfect order of ONAGRÆ; and it powerfully contributes to the distinction of SANGUISORBEÆ.[a]

Every perfect seed is composed of two principal parts, which are the *episperm*,[b] and the *kernel*.

The perfect state of a seed is essentially indicated by that of the embryo.

The episperm is the only proper integument of the seed, the kernel of which it immediately and completely envelopes. It is always simple and formed by a vascular parenchyma contained between two membranes; that is to say, the

[a] To the peritropal direction of the seed, M. Richard has not here adverted. It exists in *Plantago*, and a near approach to it serves to distinguish *Cratægus* from *Pyrus* and *Mespilus*. Indeed attention to the insertion of the seed in these three genera will separate them into very natural groups. *Pyrus* will contain all the species whose fruit is a pome, including most, if not all, the American *Mespili*. *Mespilus* will, I believe, be confined to the eatable species, if it be distinguished by the ascending position of its seeds and the bony putamen of its fruit. *Cratægus* will be limited to the species with angular leaves, and essentially characterized by its nearly peritropal seeds.

[b] Testa *Gærtner*.

epidermis, which is hollowed or interrupted towards the hilum, and the *inner parietal membrane,* which is perfectly continuous. This last is often separable, either artificially or spontaneously; and then some botanists have regarded the episperm as double. But this separation of a single integument into two, is ascertained by the rupture of their vessels, or by the nakedness of the parenchyma which united them.

Most frequently the main vessels of the episperm take a direction towards one point, where they unite and form with the parenchyma an areola or tubercle usually opaque and differently coloured from the surface near it. It rarely happens that one or the other chiefly originates from the expansion of the superior extremity of a single trunk or series of vessels. This areola or tubercle the learned Gærtner named *Chalaza,* and it indicates the true or natural summit of the seed.[a]

The episperm is for the most part simply applied on the kernel, from which it is easily separable. But it also becomes adherent, and often with so much tenacity that it can only be removed by grating. This adherence may take place whether there be any endosperm or not; whether the embryo be monocotyledonous or

[a] See *tab.* 3, *fig.* 14. *a*

di-polycotyledonous; sometimes it only takes place at the areola.

The episperm is always unilocular; it is a mistake to admit the existence of many celled seeds.

Of the Kernel.—The kernel (*Nucleus*) is the whole of that usually white substance, which fills the episperm, and consequently determines the size and form of its cavity. It has no vascular connexion with it by any point of its surface.

If the kernel of a perfect seed be so entirely continuous, that no part can be detached from it without fracture or rupture of the parenchyma, it is formed by a single body which is the embryo.[a] If it be composed of two dissimilar bodies but contiguous, or enveloped the one by the other, without parenchymal continuity, one of these bodies is the *Endosperm*,[b] and the other the *embryo*. A third substance has been admitted in the body of certain seeds, under the name of *Vitellus*, but it seems to me to be only a part of one or other of the two preceding.

Before treating particularly of these three parts, I must premise, that the kernel of a ripe

[a] See *tab.* 2. *fig.* 6. *a.* and 7.

[b] Albumen of Gærtner. See *tab.* 2. 13 *a*, Albumen, *b*, Embryo.

seed may be either incomplete by the absence of its embryo, or monstrous by a plurality of embryos. But a little practice in the dissection of seeds, and an exact knowledge of the distinguishing characters of the endosperm and the embryo, will soon place the observor beyond any danger on this head. The seeds of some plants seem to be always imperfect; such for instance is the case with *Monotropa Hypopithys.* I have frequently analysed with the utmost care, seeds of it collected in various places and at different seasons, and have never been able to discover a true kernel. Is it possible that this plant can be a Peloria of *Lathræa Squamaria?*

The *Endosperm* (Albumen, *Gært.* Perisperm, *Juss.*) is that part of the kernel which forms at the side or around the embryo, a body of a similar texture throughout, uniformly continuous, without sap-vessels, and having no parenchymal continuity with it.

It is almost always white or nearly so; sometimes yellowish, very rarely green, as in *Viscum.* Its white colour, its texture, size, or tendency to separate easily from the episperm, form the most common distinction between the two; but frequently its extreme tenuity and firm adhesion, make this difference less evident, because then the endosperm forms a scale so delicate and closely glued to the episperm, that it may be mistaken for the internal lining of the latter. If its colour and texture, which are usually sufficient for the practised botanist, do not establish with precision its presence where it is expected to exist, we must recur to other means in order to decide.

Natural or characteristic affinity, the beacon to the philosophical botanist, ought immediately to solve the difficulty. Thus, if we know from description, or, which is better, from actual observation, that a plant of the same natural order, or of the same genus as that of which we are examining a seed, has an embryo provided with endosperm, we may rationally expect it should exist in the plant under consideration also. This probability tends to excite our sagacity, while it removes our difficulties, and it may be the means of discovering this organ in some cases, where it would otherwise have escaped observation. Thus if we analyze by itself the seed of *Daphne Mezereum*, we shall not distinguish the endosperm: the excessive tenuity of which, and especially its unusual lateral interruption, render it at first imperceptible; but but if it be compared with its allies, we shall soon perceive that the endosperm evidently exists, and that it varies in thickness. This double discovery excites us not only to pursue our examination, but also to search for some species of the same genus, where it may be more evident. Accordingly by submitting to analysis the seed of *Daphne Laureola* an endosperm will be easily discovered, in the form of two very thick fleshy scales, applied to the back of the cotyledons, attenuated and confluent at their two extremities. Transferring our examination to the seed of *Daphne Mezereum*, we readily now perceive the same envelope existing about its embryo; but so delicate that without such a comparison, it might have been confounded with the episperm.

But when this advantageous method of comparative analysis cannot be applied to a seed in which the presence or absence of the endosperm is doubtful, we are reduced to an abstract examination, the result of which is so important, that a frank expression of doubt, is preferable to a decision without evidence. It will readily be perceived that all the difficulty of this examination consists in fixing the internal limits of the episperm. Now this limit may be known, first, by the sudden termination of the parenchyma, and of the vessels which are peculiar to it; secondly, by the interior structure of the areola, or chalaza; thirdly, by an examination of the embryoniferous cavity.

1. If the membrane immediately applied all over the embryo appear veined, or if it be so

delicate that it suddenly defines the parenchyma of the episperm, without a possibility of cutting or tearing off a portion, without altering the parenchyma or its vessels—if the parenchymatous tissue without any remarkable difference be applied on the embryo, at the same time firmly adhering to it—the limit sought for is in these cases at the very surface of the embryo, and consequently there is no endosperm.

2. This organ is equally absent when the particular skin of the chalaza, or even its parenchyma touches the embryo, and above all, when the latter immediately receives from it a modification either in its form or colour.

3. The most difficult part of the question, (the solution of which is more easily obtained by long practice, than certainly given by precept) is to fix the true limits of the episperm, when the embryoniferous cavity is lined or formed by a white or whitish scale, more or less fleshy, and not adherent to the embryo. If this scale be so united to the parenchyma of the episperm, that the vessels of the latter penetrate at least a portion of its exterior face in such a way, that the colours and the substance are not then suddenly cut off—if by a clean section the gradual change from the same parenchyma can be distinctly recognised—if the internal face shew

vessels passing especially towards the hilum or the chalaza, the scale may be considered to belong to the episperm. If on the contrary, this scale be totally distinct, by its colour and entirely homogeneous substance, and seem to be formed as it were by incrustation—if its superficies do not appear to be wrinkled—in one word, if it have not the above mentioned characters of the internal lining of the episperm, we must in spite of its adherence to the latter, and notwithstanding its tenuity, consider it a true endosperm.

The presence and absence of endosperm furnishes two generic, and frequently ordinal characters, which are mutually repulsive. Its absence is remarkable in *Nelumbium*, *Crescentia*, *Thevetia*, &c.

Endosperm may exist in the seed, although its embryo be abortive, or even if the latter be absent altogether. It is always simple even when there is more than one embryo.[a] If it is pierced or interrupted, the hole or interruption never answers to the extremity of the cotyledon of the embryo which it envelopes.

Its substance immediately about the embryo not unfrequently assumes a different colour and density, especially in *Monocotyledones*; sometimes this part even separates from the rest.

a See *tab*. 3. *fig*. 16.

The embryoniferous cavity is always single; if there be more than one embryo, it either remains simple, as in *Allium fragrans*, or else it divides itself into as many ears, always confluent, as there are embryos, as in *Viscum album.*[a]

This cavity is usually formed on the mass of the embryo; very rarely it follows the plaits of it, as in CONVOLVULACEÆ.[b]

The *Embryo* is that body which forms entirely, or in part, the kernel of a perfect seed, and constitutes the already formed rudiments of a new plant.[c]

If the embryo forms by itself the entire kernel, and is immediately covered over by the episperm, it is called *epispermic*;[d] it is termed *endospermic*[e] when endosperm is present.[f]

An endospermic embryo is internal when it is

a See *tab.* 3. *fig.* 16. b See *tab.* 2. *fig.* 18.

c See *tab.* 3. *fig.* 15. *a.* 16. *b.* &c.

d Exalbuminous. Gært.

e Albuminous. Gært.—but these terms are applied to the seed by Gærtner, not to the embryo. Thus an exalbuminous seed is the same as perispermic embryo—Albuminous seed as endospermic embryo.

f It is a very curious remark that in all exorhizal exalbuminous seeds, the gemmula is pretty evident; whilst most of those which are albuminous appear to be without it. See *Richard in Ann. du Mus* 17. 447.

enveloped by the endosperm ;[a] external, when it is applied to the latter outwardly ;[b] the first is much more common than the second.

Its situation with regard to the endosperm is modified by its form, and furnishes, by its constancy and diversity, very good characters for genera, and even for orders.

Its form is independent of that of the endosperm.

It is always smooth.

Plurality of embryos indicates monstrosity.

Externally we distinguish two extremities ; the *radicular,* and the *cotyledonar.*

The radicular extremity of the internal embryo sometimes immediately touches the episperm ;[c] but the cotyledonar never appears to offer such a contact.

Sometimes the radicular end adheres firmly to the endosperm, as may be observed in many Monocotyledonous plants ; very rarely it seems to contract a sort of parenchymatous adherence with it, as in CYCADEÆ, and CONIFERÆ; *Casuarina* which does not possess this last character, belongs to the family of MYRICEÆ.

[a] See *tab.* 3. *fig.* 16, &c. [b] See *tab.* 5. *fig.* 2, and 3.
[c] See *tab.* 3. *fig.* 15, and 16, &c.

Sometimes the radicular extremity penetrates immediately into the substance itself of the episperm, as in *Hippocastanum vulgare,*[a] and *Sapindus ;* but this is very rare.

The epispermic embryo may be either *homoidous,* i. e. having the same form as the seed ; or *heteroidous,* when the shape is dissimilar.

It is by means of the two extremities of the embryo, that we are able to determine its *particular* and *relative* direction.

The *particular* direction of the embryo, is that of its mass considered abstractly. This, combined with its form, generally presents a beautiful character for genera, and often even for natural orders ; but then we must overlook such trifling modifications as may result from those of the seed itself. The *relative* direction of the embryo is its particular direction compared with that of the pericarp or the seed.

The first comparison establishes the relation of direction between the extremity of the radicle and one of the points of the seminiferous cavity. The second indicates the direction, or the position of this extremity with respect to the centre of the base of the seed.

[a] See *tab.* 3. *fig.* 17.

The direction of the embryo with respect to the pericarp, is called *pericarpic* ; that with respect to the seed we shall term *spermic*.[a]

There are some other epithets which are applied to the embryo with respect to its direction.

It is *homotropous*, when it has the same direction as the seed—*orthotropous*, when like the last, but straight: it is *antitropous*, when its direction is contrary to that of the seed—*heterotropous*, when it does not follow the direction of the seed—*amphitropous*, when its two ends are turned towards the hilum.

The homotropous embryo, or that which has the end of its radicle answering to the hilum, is common; some *Monocotyledones*, certain SOLANEÆ, RUBIACEÆ, &c. offer examples of it.

The orthotropous embryo, which is straight, and has exactly the same direction as the seed, is very usual, whether it be upright, as in most *Monocotyledones*, some RUBIACEÆ, COMPOSITÆ, &c. or with the seed inverted, as in TYPHINEÆ, DIPSACEÆ, UMBELLIFERÆ, &c.

Examples of an antitropous embryo are

[a] Thus in Rosa, the embryo, as regards its spermic direction, is *homotropous*; but is *antitropous*, if its pericarpic direction be considered. See *tab.* 3. *fig.* 12.

somewhat rare; but it furnishes excellent generic, and sometimes ordinal characters.

I shall cite a few examples of it.

1. In the ascending seed—SAURUREÆ, HYDROCHARIDEÆ; true MELAMPYRACEÆ; *Acanthus*; *Nepenthes*, whose embryo is interior, and cleft a little beyond its middle into two cotyledons; &c.

2. In the erect seed—some THYMELEÆ, MYRICEÆ, &c.

3. In the inverted or suspended seed—POTAMOPHILÆ or FLUVIALES; *Ceratophyllum*, *Platanus*, ERIOCAULEÆ, &c.

4. In the peritropal seed—EPHEMEREÆ or COMMELINEÆ.

The heterotropous embryo, neither of whose extremities answers exactly either to the base or the summit of the seed, is not common. It allies *Samolus* to the ANAGALLIDEÆ, among which it is nearly general; it isolates *Anguillaria*; serves as a good distinction between GRAMINEÆ and CYPERACEÆ, whose embryo is always orthotropous, &c.

The amphitropous embryo which is so recurved that its two ends almost equally approach the hilum, forms a clear character for ALISMACEÆ; is general in ATRIPLICES, and other neighbouring orders; CARYOPHYLLACEÆ; CRUCIFERÆ; some species of *Allium; Cneorum; Ternströmia; Cannabis; Hippocastanum,* &c. It assembles some genera around *Cissampelos,* of which *Wal-tiedde* of Gærtner is a species.

The pericarpic direction of the embryo, frequently offers remarkable differences and oppositions in the same natural order, and even in the same genus, but this last is very rare. It is sometimes impossible, and frequently difficult, to establish it justly; especially when the seeds are vaguely directed. In many genera it is not easy to indicate it without knowing the precise point and manner of annexion of the seed.

As the direction of the seed ought always to be considered with respect to the pericarp, so that of the embryo must always be compared with the seed.

Two examples will suffice to demonstrate the utility of this principle.

If we compare the genera *Bucida,* (singular on account of its ovarium with three ovula) *Nyssa,* *Thesium*, &c. with some THYMELEÆ, we shall find that the pericarpic direction of the embryo is the same in each; that is to say, that the embryo is equally reversed. Nevertheless, the embryo of the first is orthotropous, of the second, antitropous.

Each of the three cells in the ovarium of the genus *Hippocastanum* contains two ovula; the one erect, the other inverted. Each of the four cells in *Halesia* and other STYRACEÆ, contains ovula, differing by pairs in a similar way. When the two ovula of the first, and one of each pair of the second, have been fecundated, there remain in the same cell two seeds, the pericarpic direction of whose embryo is opposite; but the spermic direction remains the same. This also obtains in *Arum Dracunculus*, whose ovula and seeds are both upright and inverted in the same fruit.

Now let us proceed to consider the structure of the embryo.

The parts which characterize the embryo, are 1st. the *Radicle*; 2nd. the *Cotyledon*, which is either simple or divided; 3rd. the *Cauliculus*; 4th. the *Gemmula*.

1. *Radicle*. This forms one of the extremities

of the embryo; it is always simple and perfectly undivided through the centre of its base.[a]

2. *Cotyledon.*—When it is simple, it is completely closed; that is to say, it has neither incision nor cleft on any point of its surface.[b] When there are many cotyledons, they spring immediately from the same point, and are exactly opposite or verticillate.[c]

3. The *Cauliculus* runs on the one hand, into the radicle, of which it is only an extension, and on the other, terminates at the base of the cotyledonary cavity, or at the division which distinguishes the bases of the cotyledons.[d]

5. The *Gemmula*[e] is the little simple or compound body which either springs from the bottom of the cotyledonary cavity which completely encloses it, or between the bases of the cotyledons by which it is concealed or surrounded. The first observers called it *Plumula*, because in the seeds submitted to their examination, it seemed to resemble a little feather.[f]

The exterior surface of the radicle and cotyledon, united by the cauliculus, constitutes that of the embryo.

a See *tab.* 3. *fig.* 15. *b*, &c. b See tab. 3. *fig.* 8.
c See *tab.* 2. *fig.* 7. *a.* d See *tab.* 2. *fig.* 6. 7. *b.*
e *Plumula* Gærtner. f See *tab.* 5. *fig.* 2. *a*, *tab.* 3. *fig.* 17. *a.*

The embryo should always be considered in its state of inaction.

Germination ought never to be considered with respect to the embryo, except as the means of better understanding some particular part.

The absence and the presence of the embryo, form the base of my two first great divisions of plants—EXEMBRYONATÆ and EMBRYONATÆ.

OF EXEMBRYONATÆ.—Plants of this division are characterized by the absence of an embryo in the corpuscles with which they are furnished, instead of seeds. These corpuscles have no hilum, and are not covered with a parenchymatous integument.

They have been called ACOTYLEDONES; but this word seems improper, because it does not always exactly indicate the distinguishing character which has been attributed to them. Besides, it ceases to form an important feature in my new division.

They are also known under the Linnæan name of CRYPTOGAMOUS plants. But I am persuaded that Nature has not furnished them at all with sexual organs, which would be quite useless to them. A prejudice of the necessity of sexes in all vegetables, has hitherto contributed to conceal this truth from the most acute observers, who, however, are the more excusable, because, unlike their parasites, they have paid to science a tribute of facts collected by actual observation.

That you may be the more able to recognise these errors, I shall, before I treat particularly of EXEMBRYONATÆ, submit to your consideration, certain remarks which will be of material assistance in your search after the truth.

Since we know that the propagation of some animals can take place without the existence of sexes, what reason can there be why vegetables should not also be capable of reproduction by corpuscles, which may have the property of vegetating without fecundation?

The reproductive corpuscles, which that excellent observer Hedwig, has called *Sporulæ*, sometimes differ so materially from each other in neighbouring species, and even in individuals of the same species, either in form and thickness, or in their receptacle, that they point out by that very circumstance, how distinct their nature is from that of seeds.

The uniformity of the plan which nature pursues in their formation, from the arborescent ferns to the microscopic fungi, is not only admirable, but yet more strongly proves their identity throughout the whole series, and the impossibility of their sexual fecundation.

Since the formation of an embryo makes it necessary that fecundation should actually take place, the organs destined for that purpose should be found in those plants only, which are reproduced by seeds.

Sporules differ from seeds, not only in the manner in which they are formed,[a] but above

a The rudiment of a sporule is one of the cellules, or a cellular portion of the substance of its receptacle. This cellule dilates and is filled by degrees with a peculiar matter, whose adherence to it is constantly increasing. When this matter has acquired the nature and the volume necessary to the perfection of the sporule, the cellule detaches itself from its neighbours, or from its receptacle. The internal substance of the receptacle may be made up of cellules, immediately, and in every sense, united with each other; if they be all equally filled, the whole substance becomes converted into sporules, at maturity. If some part only have received the sporular matter, the others remain coherent either together, or with the receptacle, with interruptions or spaces occasioned by the emission of those cellules which are become sporules. If the superficial matter of the receptacle be very delicate, it may either fall away piecemeal, or drop with the outer sporules. But when the cellular internal structure of the receptacle is traversed by vessels distinct from the cellules themselves, these vessels which have been considered as a placenta, fall with the sporules, or else remain in the form of filaments, or of a kind of tissue. *Richard in Ann. du Mus.* 17. 444.

The opinion of the absence of sexes in Cryptogamous plants, has received material support from some acute and valuable observations on the germination of Mosses, communicated to the Linnæan Society by Mr. Drummond, of the Cork Botanic Garden. It is to be hoped that this very curious paper will soon appear in the Transactions of that body.

all, in their want of embryo. A perfect sporule excited by germination, *creates* what it first produces. The germination of a perfect seed, first unfolds the pre-existing parts of its embryo. The points of germination of the first are uncertain; the embryo of the second has always two which are determinate and opposed to each other.[a]

But I must dismiss the consideration of these plants, since, as they have no embryo, they are in some measure foreign to the subject.

OF EMBRYONATÆ. *Embryonate* plants are such as are provided with sexual organs, and are reproduced by an embryo. This embryo has received from the reciprocal and momentaneous action of the air, that principle of life which the sporule draws immediately, and during the whole time of its formation, from the vascular texture of its receptacle.

I divide EMBRYONATE plants into two great series; ENDORHIZÆ and EXORHIZÆ.

The essential characters of *Endorhizæ* are,

[a] The embryo of some AROIDEÆ, such as *Calladium*, has been observed by Mr. Brown to offer an apparent exception to this rule. "In these the nucleus of the seed is not properly a monocotyledonous embryo, but has an appearance and œconomy more nearly resembling those of the tuber of a root; for instead of being distinguishable into a cotyledon, a plumula, and radicula, and of germinating in a particular manner, and from a single point, it is composed of a mass whose internal structure is uniform, and on the surface of which frequently more than one germinating point is visible." See Mr. Brown's remarks in *Linn. Trans.* 12. 150.

that the radicle emits from its extremity during germination, a tubercle which before was interior, and which becomes the principal root of the young plant.[a] It rarely happens that an enlarged body occupies the place of the radicle, and forces the internal tubercles to break through the sides of the cauliculus.

In *Exorhizæ* the radicular extremity of the embryo itself becomes the root of the nascent plant.

Hitherto botanists have founded the principal divisions of Vegetables on the number of their cotyledons; separating sexiferous plants into *Monocotyledones* and *Dicotyledones*, to which must be added with the immortal Gærtner, *Polycotyledones*. This numerical principle for main divisions, is seducing by its apparent simplicity; and if it could always be reconciled with the affinity of natural orders, its priority would give it a right to be preferred to any other. But it will be seen by the sequel that it not only does not possess this important quality, but that in its application it presents here and there some striking difficulties and uncertainties.

The character I propose for the two series, appears to be immutably established by nature.

a See *tab.* 5, *fig.* 1. *a*, and 3.

I am warranted in considering it constant, by very numerous observations. It is independent, first, of the remarkable dissimilitude of the parts that are called radicles and cotyledons. Secondly, of the variation of their number. Thirdly, of the anomalies they present. It also admits the aid of affinities derived from the differences in texture, of which botanists make more use than of the embryo,[a] to refer plants to their *primary* divisions. It has moreover a double advantage over these latter; it is the first character that is indicated at the commencement of germination, and may be the last examined, either immediately, or by the assistance of the sheath of the cotyledon, when the latter is itself obliterated by germination.

It is evident by the two characters I have drawn from the radicular extremity of the embryo, that what is called radicle in certain plants is essentially different from what bears that name in others. The difference in the cotyledons is necessarily inherent in that of the radicles.

What I have said of ENDORHIZÆ, is sufficient

a The characters of the vegetation of Dicotyledones and Monocotyledones, as proposed by M. Decandolle, are as follows:

I. *Dicotyledones* or *Exogenæ*. Trunk conical, composed of bark and wood; the exterior part of the wood, younger and softer than the rest.

II. *Monocotyledones* or *Endogenæ*. Trunk cylindrical, homogeneous, younger and softer in the centre.

to show that the admission of more radicles than one in an embryo, is erroneous. Variation in the number of cotyledons, in the same natural order, in neighbouring species, and even in the same individuals, is notorious in Coniferæ. Unity of cotyledon, accidental plurality, and here and there, their adhesion in a single mass, are anomalies which weaken and obscure the character of Dicotyledonous plants.

Of Endòrhizæ. *Endorhizæ* are the true monocotyledonous plants of authors. Many *Botanographists* have written on these plants without giving themselves the trouble to examine the embryo on which they founded their denomination. Nevertheless, its structure might have offered them a differential character, less equivocal than such as may be obtained from the texture of other parts.

I cannot refrain from expressing my surprize, considering the number of years I have here publicly demonstrated the singular structure of the monocotyledonous embryo, that no one should, as far as I know, have robbed me of the priority of my discoveries on this head. Their publication would have been useful to the science, and this it is which has already consoled me for more than one plagiarism and loss of anteriority. The same idea would have again diminished my regret. But I know how much men are naturally attached to the principles which support their writings and their glory. It is chiefly therefore, on the attentive young men, whom I address, that I have founded the hope of one day seeing the fruit of the new observations I annually expose to them, arrive at maturity. This hope induces me again to go over, with some additions, what concerns the embryo of ENDORHIZÆ.

The embryo of ENDORHIZÆ, is not divided by the two extremities of its radicle and cotyledon, and it offers no lateral separation between them. To distinguish these extremities, is often therefore no easy task. Here the excellent work of Gærtner contains some mistakes, as in AROIDEÆ, TYPHINEÆ, *Zannichellia*, *Triglochin*, &c.; that illustrious author must have possessed a vast deal of sagacity not to fall into more errors, since he determined on the radicle and cotyledon without the aid of analysis. Nevertheless, without the latter, this denomination is almost always uncertain; a truth of which the great carpologist seems to have been aware, since he has frequently confined himself to indicating the absolute position of the embryo.

The distinction between the radicle and cotyledon, is the more important, as it serves to determine the spermic direction of the embryo.

Without this distinction, we should be deprived not only of the excellent character which it furnishes, but also of the means of describing these two parts.

Let us then examine generally, the internal structure of the embryo of ENDORHIZÆ, before we attempt to distinguish its extremities with greater certainty.

The radicular extremity encloses or produces a tubercle which is internal, and which, during germination, pierces or bursts through the apex of the radicle and becomes elongated as the rudiment of a root. I call it *primary radicle.* This extremity is rarely terminated by a large radicular body, of which I shall presently have occasion to speak. In GRAMINEÆ, where this body exists, a conical projection of the cauliculus resembles a radicle and sometimes contains several radicular tubercles. As in *Avena, Hordeum,*[a] *Secale, Triticum, Coix,* &c.

Hitherto some celebrated botanists and those who have copied them, have regarded such tubercles as so many radicles, and have attributed to these genera a multiradicular embryo. But it is only necessary to dissect the radicular extremity or the base of the cauliculus to discover these

a See *tab.* 5. *fig.* 1, 2

tubercles which are at first enclosed in it, and then the former no longer forms of itself the radicle. Now if the radicular extremity of the embryo of ENDORHIZÆ be not itself the radicle, the cotyledonar extremity cannot be considered cotyledon; this must also be dissected, and then we shall find that it sometimes encloses the rudiments of several leaves, as the other conceals the rudiments of many roots. I do not think it necessary to proceed further in order to convince you that the analytical mode of naming the parts of the embryo of ENDORHIZÆ cannot be erroneous.

Thus the knowledge of one extremity will determine the other; but it will soon be perceived that the cotyledonar is the better index of the two.

The cotyledonar extremity, or the cotyledon, is usually almost solid, containing only a little cavity at the base, which closely shuts up the gemmule. Sometimes this cavity occupies the middle, or the axis; sometimes it is nearer one side than the other, and then it usually inclines towards that side which is next it.

It is by a longitudinal division of the embryo in a state of repose, or just beginning to germinate, that this gemmuliferous cavity is most easily discovered; the gemmule is then fixed by its base which points towards the radicle; otherwise it is disengaged. This free extremity it is, that it is first necessary to discover, since its direction usually indicates that of the embryo with respect to the seed, and points out the cotyledon, and consequently the radicle.

The embryo of ENDORHIZÆ, is very rarely epispermic, or without endosperm: I have never yet seen it so, except in *Nelumbium*,* HYDROCHARIDEÆ, ALISMACEÆ, POTAMOPHILÆ, JONCAGINEÆ, BUTOMEÆ, &c.

The embryo of ENDORHIZÆ then, is usually endospermic, and almost always internal; I am not aware of its being external, except in SAURUREÆ,[a] PIPERACEÆ, ERIOCAULEÆ, GRAMINEÆ, HYDROPELTIDEÆ, and NYMPHÆACEÆ.

In *Musa*, ZINGIBERACEÆ, EPHEMEREÆ or COMMELINEÆ,[b] some CYPERACEÆ, (*Scleria*) &c. the radicle is enclosed in a hollow projection of the episperm, and enveloped by a very delicate membranous elongation of the endosperm. When in a dry state, this extension is difficult to perceive; care must therefore be taken not to fall into a mistake, by considering the hole of the endosperm which contains the radicle to be closed by the episperm alone.

a See *tab.* 4. *fig.* 1. b See *tab.* 4. *fig.* 8.

* CYAMUS, *Smith, Exot. Bot. V.* i. *p.* 59.

When one of the two extremities of the endospermic embryo is manifestly nearer the episperm than the other, it is that extremity which contains the radicle. If this law, to which I as yet know no exception, preserve its general application, it will often supply the necessity of dissection.[a]

The embryo is generally straight; it may be variously curved, but is never plaited.

Its two extremities are usually of the same shape. Therefore names cannot be deduced either from the exterior dissimilarity or from the conformity of different embryos. *Cabomba*,[b] EPHEMEREÆ,[c] &c, have a fungilliform embryo, almost like that of *Musa*,[d] ZINGIBERACEÆ,[e] &c; in the first the radicular extremity is thickest, but the contrary is the case with the second. The cotyledon is often straighter than the radicle; in *Dioscorea* it is much dilated and extremely attenuated.

OF THE VITELLUS. The embryo of some ENDORHIZÆ has so remarkably different a structure from that which I have just explained, that the great carpologist has attributed to them one

[a] This idea is completely confirmed, except in GRAMINEÆ, by the subsequent observations of the learned author. See *Annales du Museum*, 17. 417.

[b] See *tab.* 4. *fig.* 9. [c] See *tab.* 4. *fig.* 8.

[d] See *tab.* 4. *fig.* 10, 12. [e] See *tab.* 4. *fig.* 5.

part more than the others. In the examination I am about to make of the pretended vitellus of Gærtner, I shall proceed for the sake of clearness from the most simple vitelliferous embryo to the most compound.

First, however, I shall remove from this important article ZINGIBERACEÆ, in which the vitellus is nothing more than a central indurated portion of the endosperm.[a] *Zamia* must also be removed, since it belongs to EXORHIZÆ.[b]

The vitelliferous embryo is either epispermic, as in *Ruppia*, *Hydrocharis*, *Zostera*, *Nelumbium*, or endospermic, as in GRAMINEÆ.

1. That of *Ruppia*[c] is formed by a great white, amygdaloid, solid body, the upper extremity of which appears obliquely cut off and rather concave, producing a filiform, cylindrical corpuscle, which inclines suddenly towards the point of attachment of the seed. The substance of these two bodies is so continuous that the lesser is manifestly only an elongation of the larger. Divide the cylinder longitudinally; you will find on the inside a little above its origin, near the curvature and on the side opposite its inclination, a very minute cavity. This contains a conical compressed body

[a] In *tab.* 4. *fig.* 3, and 4. *a* is the Vitellus.
[b] See *tab.* 4. *fig.* 12, and 13. [c] See *tab.* 4. *fig.* 14, and 15.

whose free extremity is directed towards that of the cylinder.

Referring to what I have said above, it will easily be seen that this corpuscle is the gemmule; that the cylinder which encloses it is the cotyledon, and that the great body, named vitellus by Gærtner, is really the radicle enormously distended.

2. If the seed of *Hydrocharis*[a] be stripped of its episperm, and of its outer integument, which is formed of numerous cylindrical vesicles united at their base, it will present an oval kernel which appears entirely solid. But casting the eye over it attentively, we can just perceive on one of its sides near the middle of its length, a very little hole which penetrates across the kernel almost to its centre. From the bottom of this hole springs an oblong body which fills it, and whose extremity so completely stops up the orifice, that the superficies of the surface does not appear to be interrupted.

This body is the cotyledon enclosed in the radicle, of which, as in the former genus, almost all the kernel is composed.

From these two examples of an unusually large

[a] See *tab.* 4. *fig.* 16, 17, & 18.

undivided radicle, I pass on to the plant in which it is, as it were, two valved.

3. The kernel of *Zostera*[a] is an oblong oval, and presents at its upper end a cavity in which is received a swelling of the base of the episperm. Throughout the whole length of the posterior surface, it is cleft almost to the axis. From the middle of the centre of this cleft, and nearly through the centre of the entire mass, springs a filiform body which forms a bend in its descent to the lower end of the kernel, and then again takes an opposite direction towards the contrary extremity, continuing to preserve its proximity to the cleft, through which it may in part be seen. Dissect this body, and you will find at the very bend an internal flattened cavity, nearest the outside, with the curvature of which it preserves its parallelism. This cavity encloses a gemmule much shorter than itself, (which is unusual,) broadly ligulate, rounded, obtuse, with its fixed extremity looking towards that of the corpuscle. The description I have given of the two first, will make it sufficiently clear to you that the almond-like divided body of the present, which has been called vitellus, is the radicle; you will also recognize the cauliculus in the part which descends from that body to the gemmuliferous cavity, and the cotyledon in the rest.

[a] See *tab.* 4 *fig.* 19, 20.

4. The genus *Nelumbium*[a] is not less remarkable for the structure of the embryo, till now imperfectly known, than for the other characters which are peculiar to it. (The identity of its radicle with the vitellus of Gærtner was first discovered by Correa de Serra.*)

The kernel of *Nelumbium* is either a short oval, or a sphere, terminated at the lower end by an areola, which seems mammillary, and is of an hard amygdaline white substance.

It is nearly divided the long way into two equal lobes, slightly united at their upper extremity into a common base, which is also that of the inverted kernel.

Between these two lobes, whose interior face is a little concave in the middle, is contained a body which appears suspended from the centre of their common base, and almost as long as themselves, but much narrower. This body is completely enveloped in a sort of membranous bag, which like it, originates from the common base of the lobes. This covering is extremely delicate, of a whitish colour, becoming pulpy by maceration. It is so brittle when dry, that it never can be found perfectly entire in old seeds. The body it encloses is green, pierced all over by little

a See *tab.* 5. *fig.* 5, and 6.

* *See Smith on this subject, Tr. of Linn. Soc. V.* ix. *p.* 204.

superficial pores; its lower end is a little cylindrical stem; the upper is longer and thicker, and seems to be divided in two, being formed of two very unequal rudiments of leaves; the petiole of the largest, bends down in such a way that the summit of the disk of its leaf is brought up to the point of bifurcation; the other is seldom erect, but usually bends down so as to apply its disk to its base in the inside. The disk of each leaf is fixed to its petiole by nearly the middle of its back; it is spindle-shaped, and its two edges are rolled inwards. The base of the larger petiole on the inside is naked; but the lesser has a small oval bud, formed by the sheath split on one side, and filled with the very minute rudiment of a leaf which in its turn is gemmiferous also.

It now remains to determine on the names of the different parts we have analysed.

This kernel is an inverted embryo; the radicle instead of being simply cleft as in *Zostera,* is deeply divided into two parts. The cotyledon is the sacciform covering of the green body which is the gemmule.

5. The species of *Nymphea* with yellow flowers ought to constitute a genus, which for the present I would name *Nymphozanthus.*[a] It is chiefly

[a] See *tab.* 5. *fig.* 7, and 8. *Nuphar* of Salisbury, who effected this division two years before the publication of the *Analyse.* *See Annals of Botany.—And Smith Prodr. Fl. Græc.* V. i. 361.

distinguished by the persistence of the calyx: by the form of what are called petals: hypogynous insertion of stamina: &c.

The kernel of the seed of *Nymphozanthus vulgaris,* is oblong-oval, and almost entirely formed of a white endosperm, which is at first fleshy, afterwards farinaceous and friable by desiccation. At the narrowest end of this endosperm is situated a little spheroid body which is turbinate in a slight degree, whitish, and partly enclosed by the former, but covered otherwise by the episperm. This spherical substance is the embryo. It is composed, first, of a sort of tunic completely closed and undivided, thin, fleshy and a little coriaceous; secondly, of a corpuscle, which fills the cavity and assumes the form of the latter, attached only by its outer end or that which is opposite to the endosperm.

The tunic is the cotyledon; the end by which it unites with the corpuscle is the radicle; the corpuscle itself is the gemmule. This gemmule is deeply divided into two thick, fleshy pieces, which by their approximation, conceal a third, which is pale green, oval, remarkably compressed, and slightly divided on one of its edges.

This description shews that the embryo of NYMPHEACEÆ, brings them near HYDROPELTIDEÆ, SAURUREÆ, and PIPERACEÆ.

6. The genus *Nymphæa,* in which the insertion of the petals and stamina is *pleurogynous,* does not differ from the preceding as far as regards its kernel; except that the embryoniferous spheroid is so remarkably depressed that it is not so long as broad. At present I know of only one example of this mode of insertion amongst EXORHIZÆ. It exists in *Parnassia.*

7. The botanical analysis of the seed of GRAMINEÆ more particularly requires your attention, both because it is in itself very difficult, and because the descriptions you will find in the best authors are not only incomplete, but in part erroneous. The last assertion surprizes you: what! you will say, the seed of corn, as common as it is interesting by its utility, is that not yet understood by botanists? Remember that the progress of science is necessarily progressive, and instead of criticizing the writings of others, let us add our own observations.

The grain of GRAMINEÆ is covered with two integuments which are very delicate, and almost always united so inseparably that they appear to form but one. A brownish spot at the base, or a longitudinal tawny line, which I call *spilum,* indicates the hilum of the seed or the true point where it is connected with the outer integument which is the pericarp. At the base of the grain on the outside is a sort of areola which indicates the scite of the embryo, and to which I give the name of *areola of the embryo.*

The embryo[a] is applied obliquely and laterally on the base of an endosperm, which is farinaceous, and much larger than the former; so that the whole of its front surface and lower end are immediately covered by the seminal integuments. This embryo is composed, like those which are called vitelliferous, of two distinct bodies; one, posterior and larger; the other anterior, shorter, and narrower. The first I call *hypoblastus*; it is a sort of fleshy disk, flattish in front, more or less convex or gibbous behind; its circumscription, which forms that of the embryo, varies in figure from orbicular to subulate. The second, named *blastus*, is a cylindrical body, lying longinally on the former, to which it is attached as it were by the middle of its length, so that its two extremities appear disengaged. Sometimes this cylinder seems simply applied to the posterior body; most generally it is retained by the two more or less projecting edges of a slight furrow, grooved out of this body; it seldom happens that the two edges of the furrow dilate and converge, so as to touch each other and entirely enclose the cylinder.

[a] See *tab.* 5. *fig.* 1, and 2.

In certain genera, as *Avena, Triticum,* &c. a sort of appendage, termed *epiblastus,* is applied on the front surface of the cylinder, with the lower end of which it becomes united; it seldom happens that it covers the cylinder entirely, its edges coalescing with the posterior body, from which it is then scarcely to be distinguished. This structure may be observed in the embryo of *Oryza,*[a] and of those to which it is allied.

In the admirable and immortal work of Natural Orders, a precious mine of knowledge decried by certain writers more to the profit of themselves

a With the greatest deference to the opinion of the learned and excellent author, it is necessary to observe, that my view of the structure of *Oryza* differs very materially from that which he has exposed both in the present work and in his more recent and extended observations in *Annales du Museum.* M. Richard describes and figures the exterior surface of the embryo as perfectly continuous; an unusual structure in the order, which he explains, by saying, that the epiblastus coalesces with the margin of the little cavity in which the blastus is lodged. The origin of the mistake seems to be this; if old seed-vessels of Rice be macerated for a long time, or fresh ones for a short time, the testa and the pericarp come off together without apparent disunion, and the real surface of the embryo is exposed; but if Rice in a fresh state be submitted to the action of hot water for two or three hours, the pericarp readily detaches from the testa; the latter by this operation becomes unusually fleshy, and *adheres* to the surface of the embryo, from which it is not readily separated, and for which it appears that M. Richard has actually mistaken it. (See *tab.* 6. *fig.* 10, and 11.) I have no doubt that such must have been the cause of an error which is the more necessary to be pointed out, as it has occurred to a botanist in the well known accuracy of whose observations the greatest confidence may be placed.

The surface of the embryo of the genus before us, instead of being continuous, presents about its middle a small squamiform body (part of the epiblastus, *Rich.*) in some degree concealed by the superincumbent attenuated margins of the hollow in which the plumula (blastus *Rich.*) lies. Mirbel has taken the same view of the structure of *Oryza* as M. Richard, and probably from the same cause.

than of science, the posterior body is called the cotyledon. Gærtner named it *vitellus scutelliformis* or simply *scutellum*, and he has taken the cylindrical part for the whole of the embryo.

Now let us examine the singular structure of the embryo. The pretended vitellus is the body of the radicle; the point by which the cylinder is attached to this, is the base of the cauliculus; the lower extremity of this same cylinder is a lateral protuberance of the cauliculus, enclosing one or more radicellar tubercles; its upper extremity is an oblique extension of the cauliculus, and is composed of several conical scales contained one within the other; that which is most interior is thicker than the rest and undivided; and is the cotyledon.

I have thus acquainted you with certain facts relative to embryos which have been considered *vitelliferous*. But facts are only the materials of science. To give them a suitable form and to combine them by analogy is to prepare them for building; by uniting them we raise the edifice. The solid or philosophical elevation of a science is only effected then by arranging facts prepared in a manner suitable to the end proposed. We have already prepared them; it now remains to unite them, since it is the only way to contribute to the real advancement of Botany.

Although the comparative name vitellus is not here justly applied, we must nevertheless admit, that its immortal author is not much to be blamed for having introduced it. By it he has not only given a proof of his sagacity; but he has done a service to the science by pointing out to botanists an extraordinary structure of the embryo of ENDORHIZÆ. I shall proceed to examine the latter with regard to the size of the radicle.

Let us recollect that it is always from nature herself that we should borrow the light which is necessary to guide us in discovering the analogy of her productions under the various masks with which she has disguised them. We shall then find that she has prepared the eye of the observer for this excessive enlargement of the radicle, by the gradations of different endorhizal embryos. These gradations are very evident in certain PALMÆ, SAURUREÆ, EPHEMEREÆ, *Cabomba,* &c. Even the formation of some EXORHIZÆ will throw light on this point; since the genera *Lecythis, Bertholletia, Pekea,*[a] have an embryo whose enormous radicle constitutes, as in *Ruppia,* almost all the kernel of their seed. A tendency to similar enlargement exists in the genera *Zannichellia,*[b] *Potamogeton,* and *Naias.* The thickness of their radicle is not much greater,

a See *tab.* 6. *fig.* 4. b See *tab.* 6. *fig.* 5, and 6.

except at the end, than that of the cotyledon, but the situation of the gemmule towards the middle of its length, or near the upper end of the embryo, gives the radicle a length unusual in ENDORHIZÆ which makes up for the thickness.

Having sketched the chain which assimilates the embryo of *Ruppia*, to other ENDORHIZÆ, let us compare together this genus, *Hydrocharis*, and *Zostera*. Although the cylindrical corpuscle which springs from the body of the radicle be in part formed by the cauliculus, yet for the sake of brevity, I shall call it cotyledon.

The cotyledon of *Ruppia* is seated in a little trough at the top of the radicle; a lateral hole receives that of *Hydrocharis*; a longitudinal cleft contains between its approximated edges that of *Zostera*. The chief difference between the embryos of these two last genera is the existence of a lateral hollow, instead of a longitudinal cleft. The concealment of the cotyledon in the radicle may be considered then to be gradual. It (the cotyledon,) is nearly all visible in *Ruppia*; the end of it only is seen in *Hydrocharis*; a part of it is seen through the inferior hiatus of the cleft in *Zostera*. Now let us pass to the embryos whose cotyledon is perfectly concealed in the radicle.

In considering abstractly the nymphoidal characters of *Nelumbium,* taking its pistilliferous receptacle for a sort of alveolate spadix, and comparing its embryo with that of *Zostera,* are we not tempted to regard it as almost intermediate between this genus and *Nymphæa*? Some genus, hereafter to be discovered, may one day unite this approximation, which though sudden, does not appear to me to be far from the truth. The central point of the face of the radicle of an embryo, is at the lower extremity of the elongated axis of its cauliculus. This point in *Zostera* is that of the exterior face of the body of the radicle which answers to the origin of the cauliculus. Placing the body of the radicle on this point, its cleft becomes apicular, and it then resembles that of *Nelumbium,* which besides its form, differs only in having its separation deeper. Nevertheless this genus offers two remarkable peculiarities in its cotyledon and gemmule. The first, whose extreme tenuity and above all its fragility has caused it to be misunderstood, admits of no exact comparison with any other that I am acquainted with; that of GRAMINEÆ is nearest perhaps. The second, which resembles germination within the cotyledon, still differs from all other ENDORHIZÆ by the inflexion of the rudiments of its leaves.

When I was in Cayenne, and examined for the first time the kernel of *Pekea butyrosa,* I was astonished at finding no interruption of its surface nor any cavity in its sections, whether longitudinal or transverse. I then submitted to examination that of *Pekea tuberculosa*[a], which Gærtner has well described under the name of *Rhizobolus.* The latter having its cauliculus as well as the two little terminal cotyledons lying in a superficial hollow, I made a slight corresponding incision in the other, and discovered a similar cauliculus, but entirely enclosed in the substance of the radicle. The resemblance between the kernel of *Pekea tuberculosa* and *Ruppia* is striking ; and if we compare that of *Pekea butyrosa* with the embryo of GRAMINEÆ, we shall be less surprised at the complete inclusion of the radicular cavity in that of Rice. These two comparisons also confirm the denomination of radicle, which I have substituted for that of vitellus.

By giving the embryo of GRAMINEÆ the position I have pointed out for *Zostera,* that is to say, by placing it on the dorsal protuberance, or convexity of the body of the radicle which is really its base, we see that the cauliculus, which is extremely short, and the cotyledon suddenly take a transverse direction. This direction being nearly the same as in *Zostera* ought to surprise us less than the caulicular protuberance

[a] See *tab.* 6, *fig.* 4.

directed the contrary way. The latter, which is peculiar to GRAMINEÆ, resembles so much the usual extremity of the radicle of the embryo of ENDORHIZÆ, that botanists have regarded them as the same. But this projection is in reality nothing more than a lateral extension of the base of the cauliculus which contains from one to six radicellar tubercles. Nature, who always assists those who examine her productions with zeal, herself furnishes the proof of this assertion. Indeed in certain GRAMINEÆ, the base of the cauliculus offers on different points of its contour, many other gibbosities which each also enclose a little radicellar tubercle, not differing from the principal protuberance except in size. Often also these gibbosities do not shew themselves till germination has commenced.

The cotyledon of GRAMINEÆ being nearly as in CYPERACEÆ beginning to germinate, a hollow cone, encloses several rudiments of leaves rolled up in each other. But this convolution does not usually exist in the second, which are besides essentially distinguished by their embryo which is orthotropous, axile, seated nearly at the base, and with a simple radicle,

I think I have sufficiently shewn you that the structure of embryos called vitelliferous, does not essentially differ from that of other ENDORHIZÆ, except by the great body I have called radicle. If this denomination be rejected we must also refuse to consider the other extremity of the embryo as a cotyledon, and then the embryo of ENDORHIZÆ can no longer be compared with that of EXORHIZÆ.

To render more easy the description of Embryos with a swollen base (*Embryones macropodi,*) I think it right to indicate by a particular name each of the bodies which compose them. I call *Blastus* the cylinder, whose upper part forms the cotyledon.[a] I give the name of *Hypoblastus* to the great body of the radicle, to which the former is attached. The name of *Epiblastus* is applied to the anterior appendix of the *Blastus* of GRAMINEÆ; and the term *Radiculoda* to the protuberance of the cauliculus which appears to constitute its lower end.

OF THE GERMINATION OF ENDORHIZÆ.

Desiring to render my lecture on ENDORHIZÆ as useful as possible, I cannot terminate it without something on their germination. *Something*, I say, because until I come to treat in another place of germination in general I shall

[a] See *tab.* 6. *fig.* 10, 11, where *a* is the *Blastus*, (Embryo *Gært.*); *b* is the *Hypoblastus* (Scutellum *Gært.*); *c* the *Epiblastus*; and *d* the *Radiculoda.*

confine myself to mentioning the principal marks which characterize the plants with which we have been occupied.

We call germination that first spontaneous action, by which the vegetable body, isolated by nature from the individual which produced it, indicates its first degree of increase, and its tendency to become itself a plant. Perhaps it might also be called *Plantulation*, since the formation and developement of a little plant is the result.

The embryos of ENDORHIZÆ usually undergo fewer changes during germination than those of EXORHIZÆ, which is chiefly to be attributed to their frequent uniformity of structure, and to their almost constantly upright position.

The radicle usually first pushes from the episperm, or pericarp; and its end bursts open to permit the radicellar tubercle to escape. If the emission of the latter take place without remarkable extension of the radicle, the edge of the radicular opening is very narrow, and forms as it were a slight rim round the base of the radicel, or a little ring or disk, more or less developed. If the radicle extends before its end opens, it forms a sheath more or less long, which envelopes the base of the radicel; the latter becoming elongated to form the base of a new vegetable. But it frequently happens that when several lateral radicels are sufficiently developed, the primary one withers and perishes, as does the *Hypoblastus*.

The cotyledon increases more or less before it is perforated by the gemmule which it contains. When its perforation or rupture, which is always lateral, takes place next the summit, it is entirely converted into a cylindrical sheath enveloping the gemmule. When it opens at a distance from the summit, its upper part remains solid, and afterwards becomes enlarged in a greater or less degree; its lower part forming round the gemmule a sheath, proportioned to the elongation or dilatation it has undergone previous to being perforated by the latter.

The extraordinary construction of the radicle of *Embryones macropodi*, called vitelliferous, necessarily occasions some difference in the manner in which the radicels are formed. In fact the great body of the radicle called *Hypoblastus*, does not sensibly increase at all, and, enclosing no radicellar tubercle, remains *in statu quo*, and the radicels spring from the surface of the cauliculus at its base.

We may reduce to three principal heads the different modifications of germination in ENDORHIZÆ; 1. *Immotive*. 2. *Admotive*. 3. *Remotive*.

In the first, which is peculiar to *Embryones macropodi,* or those furnished with an *hypoblastus,* the episperm remains fixed to the base of the young plant, by means of the *hypoblastus.* In the second, the episperm encloses the head of the cotyledon, and is retained laterally near the sheath of the latter. In the third, the episperm is carried up to an indeterminate distance from the primary radicel, by the elongation of the cotyledon, to the summit of which it remains fixed for some time.

I shall conclude what concerns ENDORHIZÆ, by remarking that Gærtner, the most laborious, and the most learned scrutinizer of the vegetable embryo, has himself been wrong in considering as monocotyledonous that of *Zamia, Taxus, Aristolochia, Asarum, Hippuris, Loranthus,* and *Nepenthes;* so true is it, that the author of a work not only long, but full of difficulties can never hope to be exempt from error.

The next lecture will chiefly apply to the embryo of EXORHIZÆ, which constitute my second division of EMBRYONATE plants.

NOTE.—My observations on this structure will be very brief as I shall reduce them to their most remarkable part.

Of Exorhizæ.—The division of EMBRYONATÆ EXORHIZÆ, is composed of mono-di- and polycotyledonous plants; but a gradation founded on the number of cotyledons, cannot be the base of even a secondary division, because it would disturb the affinities of orders, and even of genera. Nevertheless, having here to speak only of the embryo, in some measure isolated, I shall divide my observations according to the above gradations.

1. The embryo of monocotyledonous EXORHIZÆ is very rare. It is epispermic in LENTIBULARIÆ and endospermic in *Cyclamen* and *Cuscuta*.[a] It forms a body whose surface is perfectly continuous, and whose substance appears homogeneous and entirely solid. At the period of germination its radicular extremity enlarges in *Cyclamen*, and elongates in the others, to become a root; the opposite extremity assumes in this genus and its allies the character of a radicular gemmule, and becomes elongated in *Cuscuta* into a simple thread which is the rudiment of the stem.

The kernel of *Lecythis* is a fleshy amygdaline body, so solid and homogeneous that it is extremely difficult to discover the two extremities. One of the ends forms at first a little protuberance which after having burst the episperm, extends itself as root; the other produces a scaly gemmule, which, being developed, forms the

[a] See *tab.* 3. *fig.* 6, 7, 8.

stem. The resemblance between this kernel and that of *Pekea* induces me to regard it as an enlarged radicle, or as an embryo which seems to consist of the radicle only. This body after germination appears like a bulbshaped or tuberous excrescence at the bottom of the young stem. The kernel of the seed of *Bertholletia* resembles that of *Lecythis* ; but I have not seen it germinate.

The embryo of the plants of which I have been speaking, might perhaps be better named acotyledonous, since I never have been able to discover any thing that can be considered analogous to cotyledon. Yet we see by what precedes, that it does not on that account cease to be *Exorhizal.*

It confirms then, through the medium of *Cyclamen* the affinity of LENTIBULARIÆ with ANAGALLIDEÆ; an affinity that the astonishing sagacity of the celebrated Jussieu had before perceived.

2. Of various embryos, the dicotyledonous is the most common. The knowledge of its structure does not require, at least very rarely, the aid of dissection or germination. One of its extremities being always undivided, forms the radicle, which itself becomes the root; the other presents two cotyledons resulting from its more or less profound division.

The cotyledons are usually equal; they nevertheless undergo in some genera different degrees of inequality, and *Trapa*[a] affords an instance of of their greatest disproportion. Almost always their inner surfaces are mutually applied to each other; very rarely they diverge more or less as in *Thesium*, many RANUNCULACEÆ, certain VITIGINEÆ, *Myristica*, *Ruizia*, (fl. Per.) &c. In these plants the embryoniferous cavity is simple; only in the two last genera, a protuberance of the endosperm separates the cotyledons, which in *Ruizia* are remarkably divided.

In two species of *Menispermum* that I have not had occasion to observe, Gærtner saw the cotyledons lodged in two distinct cells,[b] only communicating towards the radicle. This last observation is the more surprizing as in other species considered as allies, such as *Cissampelos*[c] and *Abuta*, the embryo is curved like an horse-shoe in an endosperm of the same form, and has its two cotyledons entirely contiguous and applied face to face.

We might to a certain extent oppose the *Embryones macropodi* of ENDORHIZÆ to certain *Embryones macrocephali* of EXORHIZÆ. Gærtner has distinguished the last by the sesquipedalian, but

[a] See *tab.* 2. *fig.* 14, 15, 16. [b] See *tab.* 6. *fig.* 1, 2.
[c] See *tab.* 6. *fig.* 7, 8, 9.

correct name of *pseudomonocotyledones*. I shall describe a few of them, to enable you to avoid the errors into which their structure might lead you. They have the common character of union of cotyledons in a single body, which I name cotyledonary body.

I shall commence by CYCADEÆ, whose structure is more simple and will serve to explain the nature of theirs. This order is as yet composed only of the two genera, *Zamia* and *Cycas*.

Gærtner having only analysed some incomplete seeds of *Zamia*, is very excusable for having taken the endosperm for a vitellus, and a rudiment of embryo for the embryo itself. But what shall I say of those who, having in their hands complete fruits of this genus, have chosen to find in the imperfect figure of *Zamia villosa* an analogous situation between its embryo and that of PALMÆ; of PALMÆ, which by their flowers and fruit have no characteristic affinity whatever with CYCADEÆ.

In a memoir which should have been printed before now, if I could support the expence of having the figures engraved, I hope to prove that CYCADEÆ are inseparable from CONIFERÆ.

1. The embryo of *Zamia*[a] is reversed with regard to the pericarp, and occupies an axile cavity

[a] *See tab.* 4. *fig.* 12, 13.

in a large endosperm, the orifice of which it seems to fill with the end next the radicle. It is straight, linear oblong; the radicle is very short, rounded, obtuse, and terminated by a peculiar filament; the cotyledonary body is oblong and becomes slightly narrower towards the radicle. A little above the latter, a longitudinal slit is observable, which passes through it from one side to the other, and divides the attenuated base of the cotyledonary body into two pieces between which the gemmule is narrowly confined.

2. The embryo of *Cycas*[a] *circinalis* only differs from the preceding by the cotyledonary body being proportionably larger, a little bent, and obliquely divided on one side near the summit.

3. The cotyledonary body of the embryo of *Hippocastanum*[a] is a spheroid which constitutes almost all the kernel; from one of its faces suddenly springs a conical elongated process, curved in the shape of an horn, and directed towards the areola at the base of the seed, at the edge of which it terminates. Pretty near the middle of this corniform elongation exists a little longitudinal cleft so completely closed that it escaped the piercing eye of Gærtner; this cleft contains the gemmule as in the preceding genera, and indicates

[a] See *tab.* 5. *fig.* 4. [b] See *tab.* 3. *fig.* 17.

that the major part of the elongation belongs to the body of the cotyledons, and that its extremity only forms the radicle.

The embryo of *Hippocastanum* is exactly the reverse of that of *Ruppia*; their exterior conformity renders this inversion striking.

4. The two cotyledons of the embryo of *Castanea*, have at the bottom only a slight point of union, taking place by the intervention of the neck of a little radicle, beneath which they extend so as just to conceal it. Besides this necessary union, they contract another which sometimes commences near the first, and sometimes only takes place by their upper extremity. This last cohesion is now and then destroyed by germination.

5. The kernel of a seed of *Tropæolum*[a] is an inverted embryo, and almost entirely formed by the cotyledonary body. This is shortly ovoid; its base is a little flattened by the pressure of the epispermic areola, and is divided into four thick teeth which by their approximation form a little interior cavity. In this is fixed an oblong corpuscle attached by two opposite lateral points, but otherwise free. The inferior extremity of this corpuscle is a conical radicle terminated by a membranous filament, standing erect between the

[a] See *tab.* 5. *fig.* 12, 13, 14.

summits of the four teeth; the upper is the gemmule, visibly terminated by the rudiments of two primordial leaves which are opposite, bistipulated, &c.

Now let us compare together, for comparisons are a source fruitful in information, these *Embryones macrocephali:* let us even admit into this comparison the commencement of their germination.

Gærtner was well aware that the union of two cotyledons in a single body does not establish the unity of cotyledon. Their gemination is easily demonstrated in the three first genera. In the embryo with two free cotyledons, where are the bases of the latter? Is it not at the top of the radicle and round the point of origin of the gemmule? But the gemmule of that which we are examining springs from the bottom of the cleft that encloses it; two parts springing from the same point form this cleft by their approximation; these two parts then are the two bases of the cotyledons and prove the double nature of the latter.

This gemination is not at first so evident in the two last genera. But, by reflecting on the distinct nature of the two points by which the cotyledonary body is attached to the summit of the radicle, we easily perceive that the interval which separates them, answers to the cleft in the preceding genera.

Germination will make this truth more apparent.[a] By it the divided part, drawn out of the seed as it were by the radicle, becomes elongated. The cleft is sometimes extended into the cotyledonary body; this elongation of the bases of the cotyledons renders them more manifest. By it, the two connective points which attach the radicle to the body of the cotyledons, form two prolongations which push the radicle out of its cavity, and of the seed, and assume the character of the bases of two cotyledons. In all, the gemmule pushes through one of the sides of the cleft, when vegetation takes place.

The cotyledons of the freely dicotyledonous embryo, are usually developed by germination at an indefinite time after the exsertion of the radicle. But when they are retained in their envelope like the cotyledonary body of which I have spoken, they also form two basal elongations which perfectly resemble those of this body. Such elongations, which may regarded as the petioles of the cotyledons, are particularly evident in embryos where these organs have their point of union, and their radicle re-entering or concealed between the bases of the cotyledons. CUPULIFERÆ, or AMENTACEÆ with inferior ovarium, offer examples of this.

[a] See *tab.* 6. *fig.* 12, and 13.

Since the cotyledons or the cotyledonary body may be retained in their envelope, and do not emit during germination more than a narrowed extension of their bases; so also and as it were by inversion, the great body of the radicle of *Lecythis* and *Pekea* remains enclosed in its integument, preserves there for a long time its form and its size, and then suddenly produces from its base an elongation which becomes root.

The embryos of certain EXORHIZÆ which I have named *Blastocarpi*, germinate or commence germination in a pericarp whilst attached to the plant which produced them. Many genera, like *Rhizophora*,[a] *Sechium*, *Avicennia*, *Sphenocarpus* (or *Conocarpus racemosa*,) &c. offer examples of it. We sometimes also see fleshy fruit such as *Citrus*, &c. without apparent alteration, enclose seeds in a state of germination.

3. Gærtner has clearly demonstrated[b] that there certainly are embryos with more than two cotyledons. The possibility of their existence is proved from time to time even by dicotyledonous plants, whose embryo sometimes assumes three cotyledons. That of the singular genus *Ceratophyllum*[a] has constantly four, of which the two opposite are constantly smaller; its gemmule is

[a] See *tab.* 6. *fig.* 3.

[b] The celebrated Malpighi was, I believe, the first who noticed this structure. His words are, *Hæc (caro)—versus medium oblonga promit foliola duodecim gracilia, quæ, germinante plantula, diducuntur.* See *Malp. anat. plant. p.* 78.

the most compound one I know. The order of CONIFERÆ is that in which the greatest number of examples occur of a polycotyledonous embryo. The plurality of cotyledons exists there from three to more than a dozen. But the number is not very constant either in allied species or individuals of the same species.

The more we are versed in the interesting study of the characteristic affinities of plants, the more we are persuaded, with Adanson, that the groups indicated by Nature, sketched by that erudite botanist, and made more perfect by a modern work above all praise, can never perhaps be united by a method entirely natural. Jussieu, in founding his system on the solid bases of the insertion of parts, has exhibited a great proof of genius. But it seems to me that, perhaps seduced by the numerical gradations of apetalous, monopetalous, and polypetalous, he has admitted between the first and the last an interval which the separation of sexes could not itself weaken. Whatever may one day be their arrangement, those who occupy themselves with it will be perhaps surprized to perceive that it is the embryo of CONIFERÆ, that is to say of the order most abounding in *Polycotyledones*, which, among EXORHIZÆ, has the greatest relation with the monocotyledonous embryo of ENDORHIZÆ.

a See *tab.* 2. *fig.* 17.

PRIMARY DIVISION OF PLANTS.

EXEMBRYONATÆ: no sexes: producing sporules: having no embryo.

I. ARHIZÆ; no embryo—no radicle.

EMBRYONATÆ: having sexes, seeds & embryo.

II. ENDORHIZÆ; the whole surface of the embryo undivided. Radicle by germination burst or perforated at the apex by an internal tubercle which increases in size, and becomes the root of the young plant. Cotyledon one, first concealing the extra axile gemmule in a basal, perfectly closed cavity, then emitting it through a rupture in its side.

Rarely the radicular body of the embryo (*macropodus*) is larger than the rest, and unchanged by germination; the cauliculus then putting forth radicellar tubercles above it.

III. SYNORHIZÆ; Embryo divided at one extremity or at the sides; apex of the radicle united to the upper and dissimilar part of the endosperm, which, being burst by germination, pushes forth an internal tubercle, increasing and becoming the root of the young plant. Cotyledons two or more, between the centre of whose bases the gemmule rises or is situated.

Obs. To this belong only *Cycadeæ* and *Coniferæ*.

IV. EXORHIZÆ; Embryo divided at one extremity or (rarely) at the side; the whole radicle itself extending, without rupture of its apex, as the root of the young plant. Cotyledons two, sometimes more, between whose bases, in the centre, is the point from which the present or future gemmule is to spring.

Rarely no distinct cotyledon.

EXPLANATION

OF

NEW TERMS.

ACOTYLEDONOUS (*Embryo*); without any true cotyledon. The *Acotyledones* of Jussieu answer to my *Exembryonatæ*.

ACHENIUM; a fruit which is dry or without any evident flesh, indehiscent, monospermous; its episperm distinct from the endocarp.

AMPHITROPOUS (*Embryo*); curved in such a way that its two ends are directed towards the hilum, and almost equidistant from it.

AMPLEXATILIS (*Embryo*); when the radicle surrounds all the rest.

ANTITROPOUS (*Embryo*); having a direction contrary to that of the seed.

AXIS of the *Seed*; a line supposed to be drawn through its middle longitudinally, from its base to its summit. This word is equally applicable to the *endosperm, pericarp*, &c.

Axile (*Embryo*); internal and situated longitudinally in the axis of the endosperm.

Blastus; a body usually cylindrical, fixed to the *hypoblastus*, and made up of the cauliculus and cotyledon: thus named, because it is the only one of the two bodies forming the *embryo macropodus* which is developed during germination.

Blastocarpic (*Embryo*); germinating in the pericarp.

Brachypodus (*Embryo*); when the radicle is short; this is opposed to the word *radiculosus*.

Cellular (*Pericarp*); having the appearance of being plurilocular, but proceeding from an unilocular ovarium.

Coordinal; of the same natural order.

Cauliculus; part of the embryo which unites the radicle to the cotyledon or cotyledons.

Drupaceous (*Pericarp*); when the endocarp is hard, and covered with a thick integument which is separable or distinct from it and scarcely fleshy.

Embryonatus; provided with, or proceeding from, a true embryo.

Endocarp; interior part of a pericarp, immediately forming the seminiferous cavity.

Endorhizus (*Embryo*); when the radicle does not itself form the simple or multiplied rudiment of a root, but encloses it. This word is also applicable to the plants which produce such an embryo.

Endosperm; a body distinct from the embryo, and with it forming the kernel of a seed. Jussieu called it *Perisperm*; Gærtner *Albumen*.

Endospermic (*Embryo*); accompanied or clothed with an endosperm.

Epiblastus; anterior appendage of the embryo of some Gramineæ.

Epicarp; skin or exterior membrane of the pericarp.

Episperm; peculiar integument of the seed.

Epispermic (*Embryo*); forming by itself the whole kernel of a seed, and immediately covered by the episperm.

Exorhizus (*Embryo*); when the radicle elongates and becomes itself the root. This also applies to the plant which produces such an embryo.

External (*Embryo*); situated on the outside of the endosperm.

FRUCTUARIUS; of or belonging to the fruit.

GEMMULATION; developement of the gemmule.

GEMMULE; bud of the embryo; part of the embryo contained between the bases of the cotyledons, or enclosed in a cotyledon, and growing during germination in a contrary direction to the radicle. *Plumula* of authors.

HETEROIDOUS (*Embryo*); of a form different from that of the containing part.

HETEROTROPOUS (*Embryo*); whose direction crosses obliquely or transversely the axis of the seed, neither of its two ends being exactly opposite the hilum.

HOMOIDOUS (*Embryo*); having the same form as its integument or covering.

HOMOTROPOUS (*Embryo*); not being straight, but having the same direction as the seed.

HYPOBLASTUS; basal or radicular body of the embryo of *Endorhizæ macropodæ*, whose form it determines; undergoing no organic developement during germination.

INTERNAL (*Embryo*); enclosed in the endosperm.

LOCULICIDAL; when dehiscence takes place by the middle of the cells.

Macrocephalus (*Embryo*); when the cotyledons are united into a body much larger than the rest.

Macropodus (*Embryo*); when the cauliculus bears the cotyledon, and springs abruptly from the body of the radicle, which is considerably enlarged.

Nuculanium; fruit whose fleshy pericarp forms several distinct nuts.

Nucule; each nut of a nuculanium.

Orthotropous (*Embryo*); straight, and having the same direction as the seed.

Pericarpic (*direction*); with respect to the pericarp.

Peritropal (*seed*); directed from the axis towards the sides of the pericarp.

Pleurogynous (*insertion*); on the body itself of an *ovarium superum.*

Podosperm; extension or projection of the trophosperm, attaching a seed to the latter. *Umbilical chord* of authors.

Radicel; rudiment of a root formed by the elongation of the interior substance of radicle, or of the bottom of the cauliculus of *Endorhizæ.*

RADICULOSUS (*Embryo*); of *Endorhizæ* with a long radicle, or with a gemmule at a considerable distance from the end of the radicle.

RADICULODA; base of the cauliculus or inferior extension of the *blastus* of GRAMINEÆ; enclosing one or more radicellar tubercles.

SARCOCARP; parenchyma of the pericarp.

SEPTICIDAL; pericarp opening by the middle of the dissepiments which are then divided into two plates.

SPERMIC (*direction*); with respect to the seed.

SPILUS; hilum of the seed of GRAMINEÆ, indicated by a brownish spot or reddish line situated on the interior face of the seed.

SPORULE; body reproducing plants of *Agamæ* or *Exembryonatæ*.

SYNZYGIA; point of union of the two cotyledons of the embryo of *Exorhizæ*.

TROPHOSPERM; interior part of the pericarp to which the seed is attached. *Placenta* of authors.

EXPLANATION

OF

THE PLATES.

PLATE I.

1. Vertical section of an apple. *a,* fleshy tube of the calyx. *b,* junction of the latter and the epicarp. *c,* sarcocarp. *d,* endocarp. *e,* seeds.

2. Tranverse section of the same. *a,* sarcocarp. *b,* cell.

3. Capsule of Polemonium cæruleum (from *Mirb.)* divided transversely. *a,* dissepiment. *b,* cell.

4. Transverse section of the nut of Corylus Avellana.

5. *A,* Siliqua of Arabis turrita.

5. *B,* Seed of the same. *a,* trophosperm. *b,* hilum.

6. Capsule of Crocus stellaris. *a,* trophosperm —dehiscence loculicidal.

7. Achenium of Helianthus annuus.

8. Capsule (Pyxis *Mirb.*) of Anagallis arvensis, shewing the circumscissile mode of dehiscence.

9. Capsule of Antirrhinum majus—dehiscence an orifice.

10. Capsule of Reseda alba.—dehiscence an orifice.

11. Capsule of Campanula obliqua—dehiscence a rupture.

12. Capsule of Silene bupleuroides--dehiscence valvular, taking place at the apex only.

13. Utriculus of Amaranthus hybridus,—dehiscence circumscissile.

PLATE II.

1. *A.* & *B.* 2. Carex arenaria.

3. Achenium of Thesium alpinum.

4. The same divided vertically. *a*, tube of the calyx. *b*, point of union of the latter and the pericarp. *c*, sarcocarp. *d*, endocarp. *e*, seed.

5. Achenium of Salvia horminum.

6. The same divided vertically. *a*, cotyledon. *b*, cauliculus.

7. Embryo of the same. *a*, cotyledon. *b*, radicle.

8. Capsule of Rhododendron ponticum. *a*, top of the axile trophosperm,—dehiscence septifragal.

9. Legumen of Ornithopus intermedius (*Roth*), —dehiscence, solubility by articulation.

10. Capsule of Euonymus europæus. *a*, trophosperm separating from the inner edge of the dissepiment, and giving the seed the appearance

of being suspended. *c*, the seed covered by its arillus *b*. *d*, arillus expanded about an abortive seed.

11. Seed of the same taken out of the pericarp. *a*, the trophosperm. *c*, the top of the seed seen beyond the edge of the arillus. *b*.

12. Seed of the same with the arillus pulled off.

13. The same divided vertically. *a*, endosperm. *b*. embryo.

14. Embryo of Trapa natans. (from *Gært.*) *a*, the large cotyledon. *b*, radicle.

15.—16. Radicle of the same magnified. *c*, *e*, small cotyledon. *d*, radicle. *f*, gemmule.

17. Embryo of Ceratophyllum demersum. (from *Mirb.*)

18. Transverse section of the seed of Ipomœa purpurea.

PLATE III.

1. Legumen of Lathyrus latifolius.—dehiscence sutural.

2. Spontaneous excoriation of Euphorbia paralias.

3. Achenium of Chærophyllum aromaticum. (from *Mirb.*)

4. Capsule of Ipomœa purpurea, transversely divided. (from *Mirb.*)—dehiscence septifragal.

5. A small branch of Leontice thalictroides (from *Bauer*). *a*, remains of the ruptured ovarium. *b*, seed. *c*, abortive seed.

6. Seed of Cuscuta Europæa. *a,* hilum.

7. The same divided. *a,* Episperm. *b,* gelatinous endosperm: the embryo just visible through it.

8. Embryo of the same.

9. Seed of Plantago lanceolata.

10. Vertical section of the achenium of Smyrnium Olusatrum.

11. Section of the achenium of Potamogeton fluitans not quite ripe.

12. Achenium of Rosa caucasea.

13. Vertical section of the berry of Ribes uva crispa. (from *Mirb.)*

14. Seed of Citrus medica. *a,* chalaza.

15.—16. Vertical section of Viscum album. (from *Mirb.*) *a, b,* embryo.

17. Vertical section of the seed of Æsculus Hippocastanum. *a,* gemmule.

PLATE IV.

1. Vertical section of the nut of Saururus cernuus. *a,* section. *b,* embryo. (from *Mirb.*)

2. Seed of Zingiber nigrum.

3. Section of the same. *a,* vitellus.

4. Embryo of the same seated in the vitellus *a.*

5. Embryo of the same without vitellus.

6. The same vertically divided (all from *Mirb.*)

7. Seed of Commelina tuberosa.

8. The same divided vertically.

9. Embryo of Cabomba aquatica. (from *Richard*)

10. Fungilliform embryo of Musa coccinea. (from *Mirb.*)

11. The same divided vertically.

12. Section of the fruit of Lamia spiralis.

13. Embryo extracted. (from *Mirb.*)

14—15. Embryo of Ruppia maritima. (from *Richard*)

16.—17.- 18. Seed of Hydrocharis Morsus Ranæ. (from *Richard*)

19.—20. Embryo of Zostera marina, (from *Richard*)

PLATE V.

1. Section of the anterior face of the embryo of Hordeum vulgare. *a,* radicellar tubercles.

2. Vertical section of the same. *a,* gemmule.

3. Seed of the same in a state of germination. *a,* lateral tubercles just beginning to break through the episperm.

4. Section of the seed of Cycas circinalis. (from *Mirb.*) *a,* endosperm. *b,* embryo.

5.—6. Kernel of Nelumbium asiaticum. (from *Richard*)

7.—8.—Kernel of Nymphozanthus vulgaris (*Nuphar lutea.*) (from *Richard*)

9. Kernel of Castanea vesca.

10.—11. Sections of the same.

12. Section of the pericarp of Tropæolum majus.

13. Seed of the same.

14. Section of the last.

PLATE VI.

1.—2. Seed of Menispermum Cocculus. (from *Gært.*)

3. Commencement of germination of Rhizophora gymnorhiza. (from *Gært.*) *b.* calyx. *c,* pericarp. *d,* cotyledons. *(Gært.)*

4. Section of the kernel of Pekea tuberculosa. (from *Richard*)

5.—6. Kernel of Zannichellia palustris. (from *Richard*)

7. Pericarp of Wal-tiedde; a species of Cissampelos. (from *Gært.*)

8. Section of the seed, } of the same.
9. Embryo———— }

10. Surface of the embryo of Oryza sativa. *b,* hypoblastus. *c,* epiblastus. *d,* radiculoda.

11. Section of the same. *a,* blastus. *b,* hypoblastus. *c,* epiblastus. *d,* radiculoda. *e,* radicellar tubercle. *f.* pericarp. *g,* episperm. (testa.)

12. Germination of Quercus pedunculata. (*communicated by M. Richard.*) *a, b,* cotyledons. *c, d,* elongations of the cotyledons. *e,* radicle. *f,* cauliculus developed into a stem.

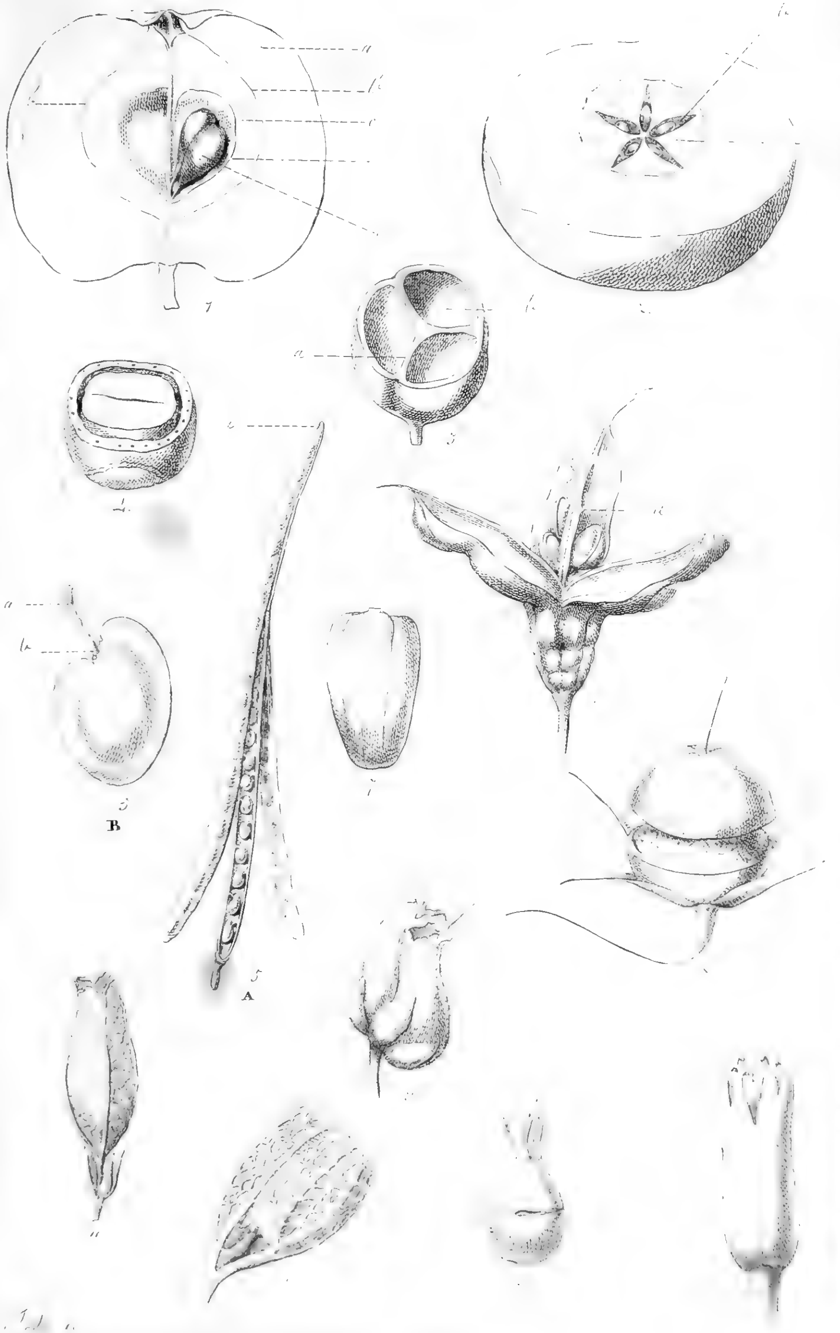
13. Germination of Castanea vesca. (*communicated by M. Richard*) letters same as in fig. 12.

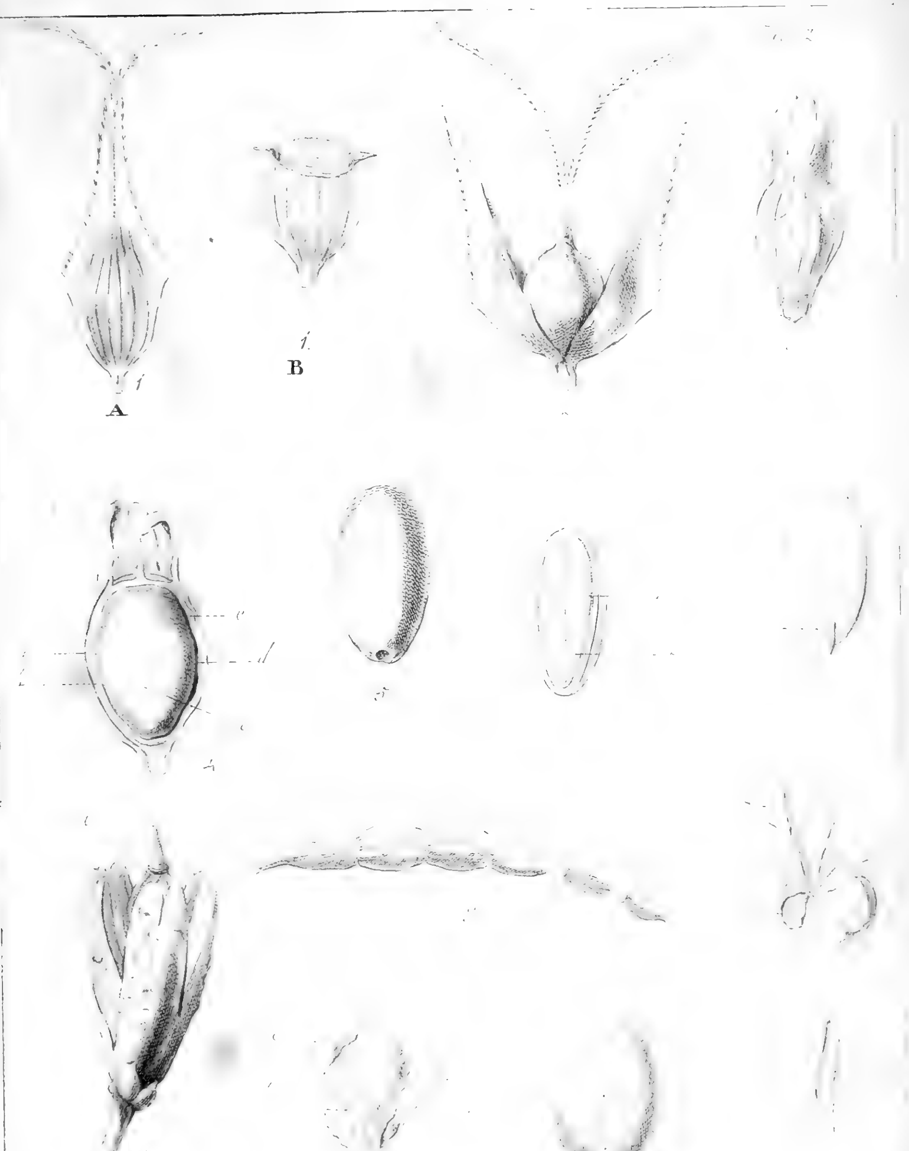
INDEX

OF

NATURAL ORDERS AND GENERA.

Tab. I.

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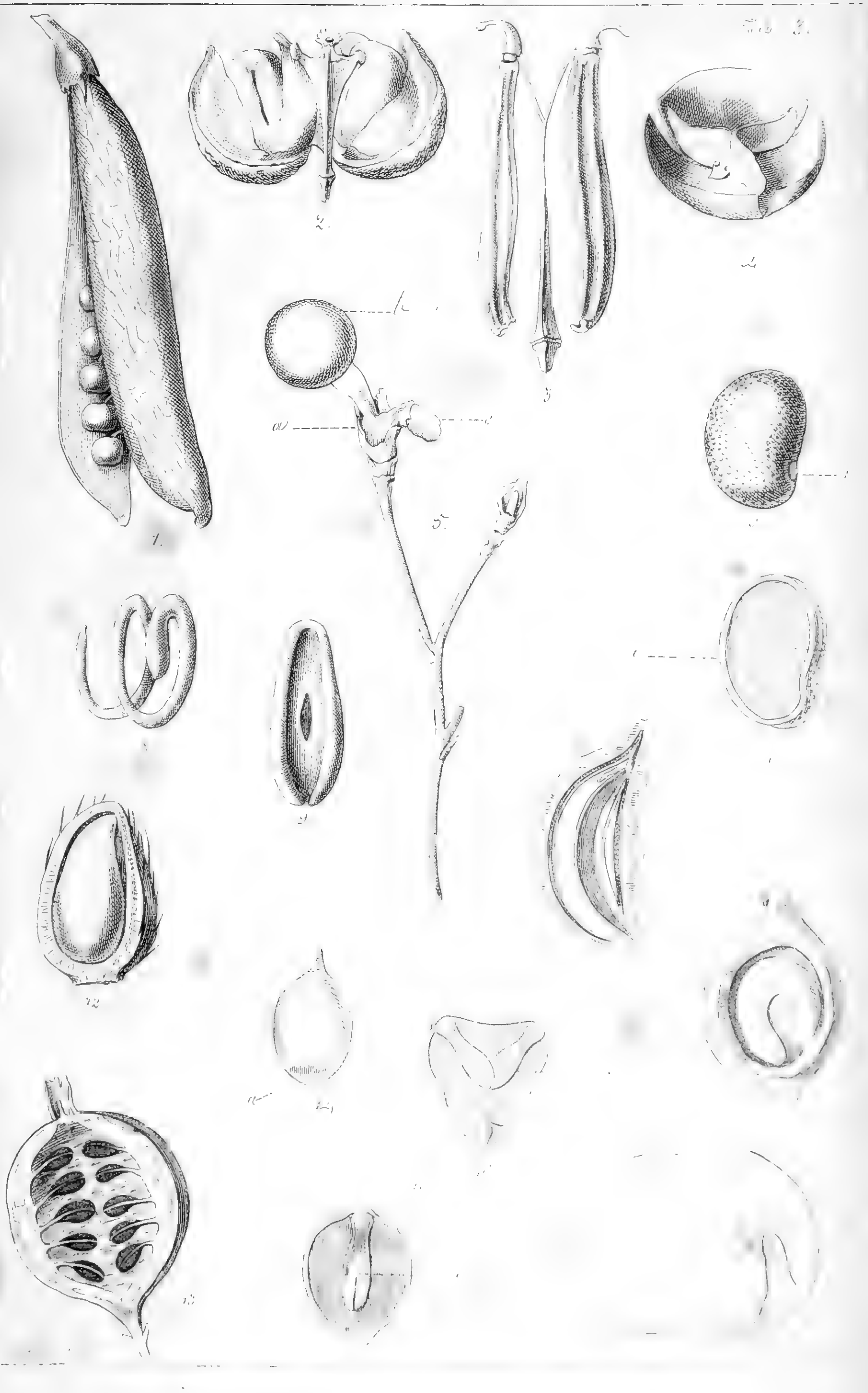
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2.
3
4
5
9
12
13


1 a.
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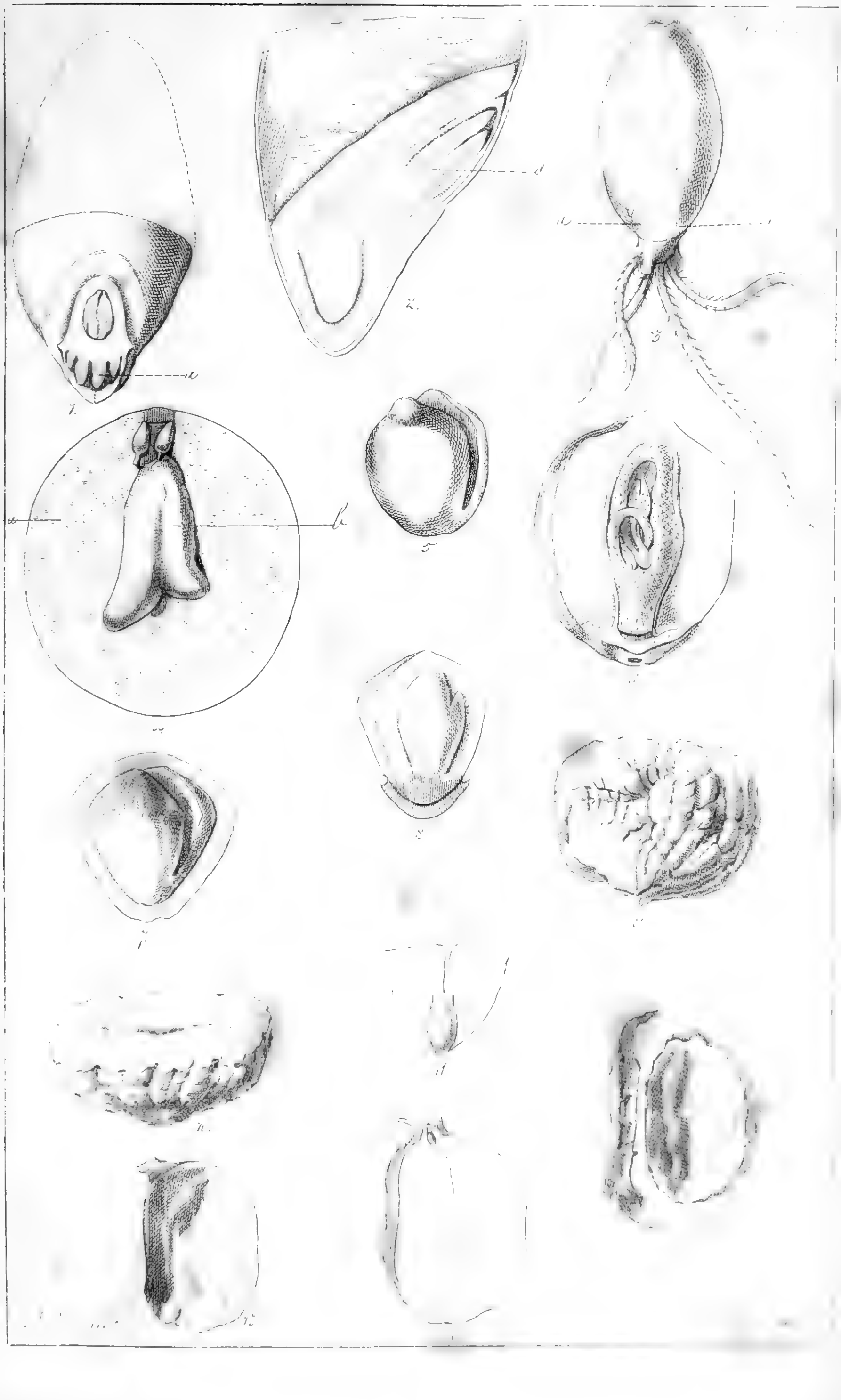
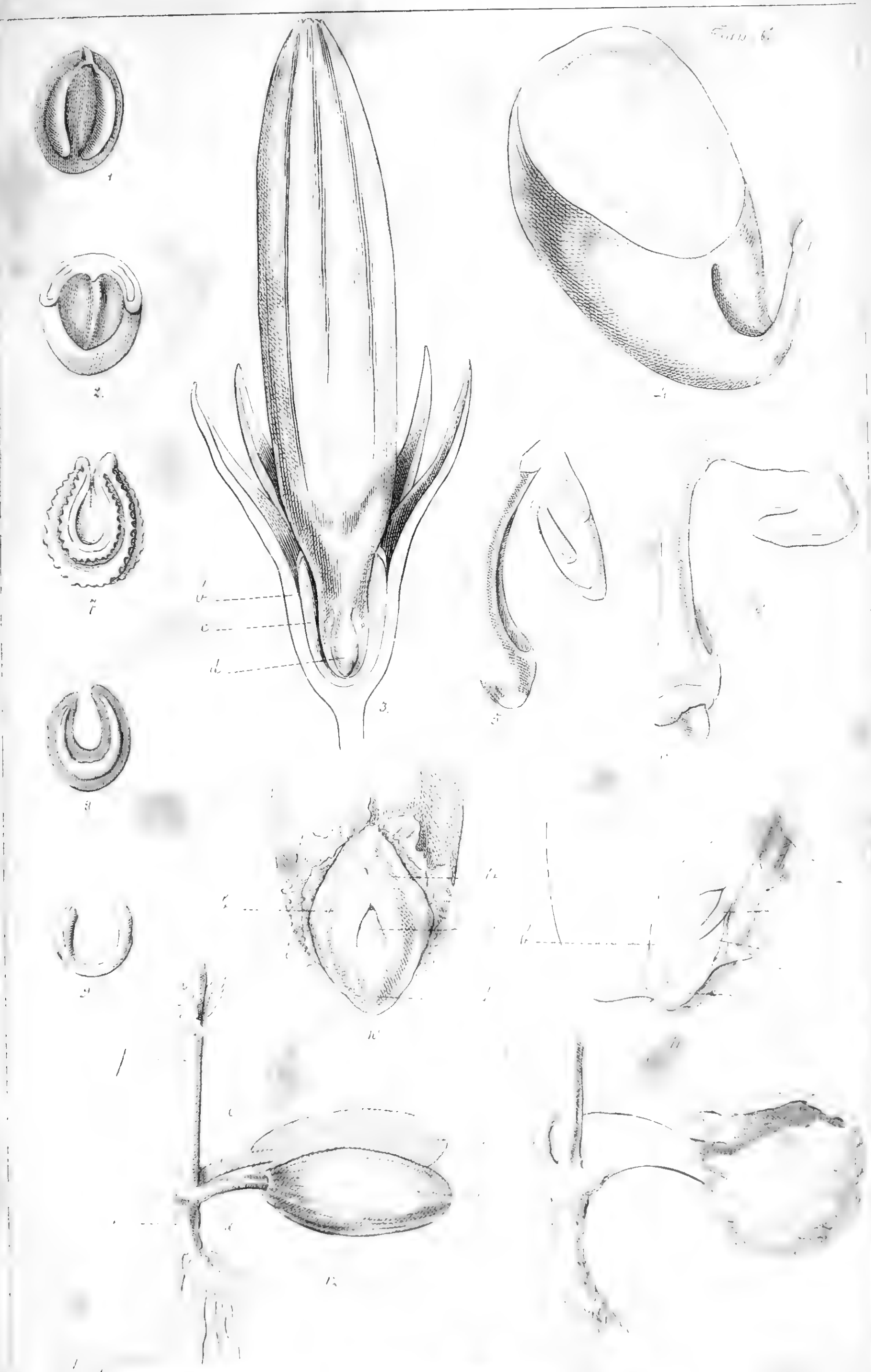
9
10

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b
c
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