Thesis

on

Embryology

or

The Act of Impregnation in Plants.

by

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The subject of Embryology in Plants which has of late years received so much elucidation, has for long engaged the attention of Botanists.

The existence of separate sexes in plants was first pointed out by Millington in the seventeenth century, in course of time this opinion was corroborated by other Botanists, and various experiments were performed by them in order to prove that the action of the Stamens in the Pistils was necessary for the production of perfect seeds. Much valuable knowledge was thus gained, and among others who by their exertions contributed to throw light on this subject, we may mention the names of Grew, Malpighi, Hoelreuter, Hedwig, Geditsch, &c.

The earliest experiments made to prove the action of the male on the female organs were by artificial impregnation and hybridization, we shall here mention one or two of these.

1 A female plant of the Chamaepops Humilis, in a
Botanic Garden at Leyden, which had never before produced seeds, was artificially impregnated by Heditsch, by means of pollen from the male plant, sent him from a distance by Koehreuter, and perfect seeds were for the first time produced, from which young plants were raised.

Koehreuter deprived a plant of Nicotiana Rustica of all its stamens, and impregnated its pistil with pollen from Nicotiana Paniculata, the seeds thus produced gave origin to a hybrid which had an appearance intermediate between that of its two parents; by successive impregnations of the hybrid and its offspring with the pollen of N. Paniculata, he completely changed the N. Rustica into N. Paniculata.

Similar experiments have often been performed since with similar results, on the Pitcher plant, Cucumber, and various others; care however is necessary in order to prevent pollen from other plants arriving at the pistil.

But these were and still are those who deny the existence of sexes in plants and that there is a necessity for the action of the pollen on the pistil, they found their opinions chiefly from observations on Hemp, hyacinth Dioecia, Scinellie,斯塔兰札里尼, and Bernhardi are among the older authors who held this doctrine.
More lately Mr. Smith of Kew has stated that a female plant of Camelina produced perfect seeds without the contact of pollen.

But cases of this sort are exposed to numerous sources of fallacy; for instance, the difficulty of telling the female plant from the male before its flower has appeared; or if its flower were developed before it was seceded from other plants, could pollen not already have been wafted to it?; or how easily could small insects having pollen adherent to them escape the eye and cause impregnation; or could the plant not be hermaphroditic? A single stamen might easily escape notice.

An European Fan-palm in the Botanic Garden at Edinburgh, which had for long bore pistilliferous flowers only, shewed in 1841, and 1848 both pistilliferous and staminiferous flowers from which perfect fruit was produced without the artificial application of pollen; it is probable that many of the examples quoted in favour of the doctrine which denies the action of the pollen on the pistil were examples of this sort.

But even allowing that seeds may be produced without the contact of the pollen & pistil, still the general law of sexes is not to be altered, no more than is the opinion held on impregnation in Animals
to be changed by the fact that the Aphid is a female insect propagates itself without the aid of the male.

Phanerogamic plants are either Monocious, Dicicous, or Polygamous; the Stamen and Pistils may be, 1st. On the same flower; 2nd. In different flowers in the same plant; 3rd. On different plants; 4th. In the same or in different flowers, on the same or on different plants; accordingly therefore as the arrangement of the organs of generation differs, the way in which impregnation takes place is different in each.

Modes of Impregnation. 1. By Insects. The fact that in some cases impregnation was effected by means of insects was first clearly proved by Haelreuter, and many interesting observations were made after him by Ewer and in regard to this point.

These insects in their search for honey become covered with pollen and as they creep about in all directions deposit it on the stigma; they only visit flowers which secrete sweet juices, and many of these plants have "Maculae Indicantes" which seem to serve as guides to the insect.

Some flowers have one peculiar insect which alone frequents them; in others the same insect will remain all day on the same species provided there be a sufficient number of flowers of that species.
Many flowers of the Claf Dicotydmia are impregnated in this manner.

In Aristolochia Clematits the process is very interesting; this flower has a radiating stigma with epigynous stamens enclosed in a perianth which is swollen at the base, tubular in the rest of its extent and ending in a tongue-like extremity.

The inner surface of the perianth is covered by numerous deflexed hairs, by which the entrance of any insect is permitted but its exit effectually prevented.

As the Anthers are below the stigma the pollen cannot reach the latter as the flower stands erect, but falls to the bottom of the tube of the perianth, and if allowed to remain there impregnation could not take place.

The insect chosen by nature to fulfil her desire in this plant is the Lipula pennicovus, it easily descends to the bottom of the tubular perianth which is smooth, there it becomes covered with the pollen fallen from the anthers, and as the hairs successfully prevent its egress along the tube, it moves about in its prison trying to escape, in its progress it passes over the stigma, which being covered by a viscid matter detains the pollen and impregnation follows.
As soon as this is effected the flower withers and the insect is once more free.
In other cases of impregnation by insects they are not confined within the perianth, but visit various flowers and thus impregnate several.

2. The wind is sometimes useful in causing impregnation; in flowers in which the Stamens and Pistils are of the same length, impregnation can easily take place in others where these organs are on different flowers the wind wafts the pollen to the stigma.

3. In some plants the sexual organs being on the same flower, the stamens bend over the pistil and scatter their pollen on its stigma; this occurs in Parnassia palustris where the stamens five in number bend over the stigma in succession, deposit their pollen, and resume their former position, the last two do this together.

In some plants the stamens are possessed of a peculiar irritability at a certain point, no body coming in contact with their irritable part the stamens bend over the stigma and rebounding back scatter their pollen on it; this occurs in Berberis Vulgaris and in the Asclepiadaceae.
In Urtica, Pericarpia, Halmia, Medicago, &c the pollen is scattered by the elasticity of the stamens.
The style too in some cases bends itself in order to come in contact with the pollen.

In some plants where the bracteae are shorter than the pistil, the flower is pendulous and the pollen easily falls on the stigma.

In those plants which are not possessed of nectaries and in which the sexual organs are on different stems in the same plant, or on different plants, the pistiliferous stems or plants are lower than the staminiferous, and as they are situated near each other they impregnate themselves or are assisted by the wind, such is the case in Pinus, Carum, &c.

By the exertions of Hoehreuter and others the knowledge of the functions of the sexual organs of plants was fully ascertained in the eighteenth century, and so far as the contact of the pollen with the stigma was necessary for fecundation, the act of impregnation was understood, but the succeeding steps in the process were from the imperfect state of the microscopes then used unknown, and until about the year 1830 all was conjecture, some supposing the impregnating principle to be a "subtile oily vapour" or "volatile aura," others thought that it was electricity or some other force, as yet unknown.
Such is a brief outline of the state of the knowledge concerning the subject of Embryology. Prior to the discovery of the Pollentubes, we shall now see what has been elucidated since the period of that most important discovery.

The discovery of the Pollentubes, that great discovery which at once overthrew the doctrines and hypotheses of the older Botanists, and gave a fresh impulse to those of modern times, and opened up a wide field of inquiry, which was soon occupied by many eminent men both at home and abroad.

Soon the results of their labours furnished us with many most interesting phenomena, but as in the case with every new subject of study, and especially where minute microscopic investigation is necessary, the opinions advanced on the subject although agreeing in some points, yet presented great discrepancies; later researches however coincide more closely and opinions are now no longer conflicting.

In account of the differences of opinion held by Embryologists within the last twenty years, we will give a short sketch of some of the more important of these, and from them draw our conclusions.
1st. Meyen's Theory.

Meyen divides the subject under two heads, according as a special embryosac does or does not exist.

1st. The formation of the Embryo in those cases where an actual embryosac exists.

The embryosac most commonly takes its origin in the apex of the nucleus, and grows downwards from thence to its chalaza end; in other cases as in irisum album it is the reverse, it begins at the base and grows upwards to the apex of the nucleus.

Frequently, however the embryosac grows out of the apex of the nucleus, and ascends to meet the pollen tube, this phenomenon Meyen regards as specially worthy of attention. He first observed it in Phaceolus, the sac having its origin in the apex of the nucleus but being developed outside of it in the cavity of the second tunic, with its apex sometimes at the tectum, at other times protruding a couple of lines beyond the micropyle, owing to the formation of the pollen tubes being prevented by cold weather.

He observed, that Althine Media which flowers early in spring, seldom exhibited embryos till the end of April, the cold preventing the formation of pollen tubes; at this time the apex of the nucleus protruded a
good way beyond the Micropyyle in the form of a cup; this increases in size and afterwards falls off as far as the Endostome; but in the warmer month of May there was no protrusion of the apex of the nucleus. In such cases the apex of the Embryosac serves as a direct micropyyle for the entrance of the pollen-tube, and this union of the sac and tube constitutes the act of Impregnation.

At the place of union of the Pollentube and Embryosac a small protuberance in some cases originates, probably by the reciprocal dynamical action of the one on the other, this protuberance enlarges and becomes filled with a turbid substance, it then separates itself from the Pollentube, and becomes a vesicle which grows deeply into the Embryosac. This is the Terminal Vesicle.

The term vesicle generally originates inside the Embryosac, and in these cases the Pollentube either achieves directly by its apex with the apex of the Embryosac, or more rarely becomes supplied laterally to the apex of the sac.

In Altrine Media the Term Vesicle is formed at the apex and grows into the Embryosac.

In some species of Mesembryanthemum the lateral union of the tube with the sac
is constant.

In either case of the union of the tube and sac complete adhesion first takes place, and afterwards the germvesicle appears in the interior of the apere of the Embryosae, just at the point of cohesion. The germvesicle is formed of the adhering parts of the Pollentube and Embryosae, and receives its nourishment from the contents of both, and by the mixture of these two fluids the future embryo originates.

At the period of impregnation the Pollentube swells at its point of contact with the Embryosae, but after the germvesicle is formed and has received sufficient nourishment from the respective contents of each, the communication between the germvesicle and Pollentube is broken off by the formation of a diagonal septum.

In most cases the Pollentube now shrivels and loses its connection with the sac; sometimes however it remains adherent, and in Wesenbryanthemum, Inquipelosemum, it swells into a vesicle which remains within the coverings of the nucleus, and in Beveratophylhum this vesicle protrudes beyond the fornacem of the ovule.

The further development of the Embryo varies
in different genera, but most generally the sperm- produce elongates itself into the sac, assuming a tubular form, and in a short time the apex becomes a globular cell which is the embryo, while the remaining part of the tubular vesicle becomes the funiculus, which is either a simple row of cells, or swells at certain points in a vesicular form, or becomes a thick cellular cord.

He regards the globular cell above mentioned as the 1st stage in the development of the embryo; the 2nd stage consists in the development of this cell from within outwards into a cellular mass which is usually of a globular form; and the 3rd stage is the lengthening of this globe and the formation of cotyledons.

After the formation of the embryo, the funiculus seems to be of little more use, for it generally dies and disappears not leaving any trace.

According then to Meyer, in all cases in which the embryo is formed within the embryosee, it originates as a globular cell at the end of the cylindrical germ vesicle which serves for its funiculus.
Meyer next goes on to consider the second division of his subject; viz.,

1st. Impræparation in those cases where no special embryosæc exists.

This is most common in Monocotyledonous plants but is also found in Dicotyledons.

In the Orchideae there is no embryosæc, but about the period of impræparation the nucleus becomes thin and membranous and for a time takes the place of the embryosæc, but it is soon reabsorbed, and the embryo is then within the secundine.

When the pollentube reaches the nucleus sac and comes in contact with the contained fluid, its summit swells to a globular form, and separates by constriction from the cavity of the pollentube, and out of it the germ vesicle originates, which expanding in length descends into the cavity of the nucleus, and out of the end of this cellular body the embryo is formed, and not as is held by Schleiden "out of the pollentube".

The same takes place in Capsella Virca Pustarvis, and in Araba Verca, in which the funiculus is very long.

In Capsella Virca Pustarvis he was unable from the firmness of the tunic to lay open the germvesicle.
until it had been converted into a cylindrical bag four or five times as broad as the pollentube still adhering to but separated by a septum from it. This cylindrical bag increases in size, and at the end in connection with the pollentube swells into a globular form; below this it divides into a series of cells and at the end which lies free in the cavity of the nucleus, a globular cell the first substratum of the Embryo is formed.

In Draba berna the Embryo originates deep in the cavity of the nucleus, the funiculus is long, almost perfectly cylindrical and provided with diagonal walls; as in this plant there is no Embryosac, and as the pollentube frequently remains for a considerable time after impregnation has taken place, the funiculus seems to be a direct continuation of the pollentube, but the former is more than twice as broad as the latter, and is formed subsequently to it.

In Liliaceae and similar plants, where there is no Embryosac, the pollentube penetrates the foramen of the ovule and passes through the cellular tissue at the summit of the nucleus into its cavity which serves in place of the Embryosac, its apex then swells in a clavate or globular form.
and then divides by septa into several large cells, becomes constricted from the still adhering Pollen-
tube, and new cells being formed within it, the
embryo is produced; the funiculus is present but
is not so distinct as in some other cases; the
embryo being formed not out of the apex of the
Pollen-tube, but is the result of the action between
the contents of the Pollen-tube and Nucelus, the
apex of the Pollen-tube serving only as a substratum
for its formation.

Meyen regards the cases of extra-nuclear
impregnation said by some to occur in Archico
as founded on error.

These then are Meyen's opinions, which seem
to have been formed with great care and on
a great number of different plants. We will
next give a sketch of the opinions of Amici
on this "Quercus Vexata".
by the embryonic vesicle
Amici's Theory.

Amici's latest communication on Foundation was in 1846, it was from observations made on Cucurbita Pepo and Orchideae.

In Cucurbita Pepo he says the boyauce on pollen tubes penetrate the nucleus but never enter the embryonic vesicle which is apparent in the nucleus before the application of the pollen tubes to the ovule; he thinks that the human proligique passes by absorption through the walls of the embryonic vesicle, is mixed with the fluid contained in it and that true foundation takes place.

It is only after the penetration of the pollen tubes through the coats of the ovule that the development proceeds, and if the proligique humour does not come in contact with it it dies without any evidence of growth. The development of the embryonic vesicle commences at the base of the nucleus, the point opposite to that where the boyauce exert their influence.

The boyauce disappears when the cells in the embryonic vesicle multiply, these increase chiefly towards the base of the nucleus, finally reaching
its walls and filling all its cavity eventually cause its rupture; the embryonic vesicle ultimately resembles a strangulated sac at the top of which some days after fecundation a greenish body appears which is the embryo of the future plant.

He believes both from his own observations and from those of Bramanti and Brown on Orchidaceae and Asclepiadaceae that the phenomena of fecundation are the same or present little difference in these families as well as in all the M. uniovulac plants he has examined. He has shown that the more recent opinions of Brown, viz., "that the mucous tubes seen in the tissue of the style were not pollen tubes but produced by their influence is incorrect, and has proved that the bundles of tubes are pollen tubes by pressing the stigma between two pieces of glass and observing the continuity of the Pollen and Mucous tubes.

The coagulations which take place at certain points in these tubes he attributes to the gradual withering of the stigma and style preventing the communication of the parts above and below the points of coagulation, the upper part not having any granular matter in it as that has descended to the lower end of the tube. Brown thought the Pollen tubes were too numerous
To be produced by the pollen granules, but Amici has shown that in the two principal pollenspecies of Orchis Morio there are 200 secondary masses which may be divided into 200 smaller masses, the granules being united in fours, making 120,000 orifices from which tubes may be emitted; in Orchis Abortiva the tubes are very numerous also.

In Orchidaceae the pollen grains are arranged in fours; after the pollen has lain for some time on the stigma, the tubes are prolonged downwards in Fischeraeus, their granular contents coagulate at some points and chiefly at the lower end.

At the time of opening of the flower the primine secundine and nucleus are apparent, afterwards the integuments open leaving bare the nucleus, at the summit of which a quantity of granular fluid is collected; when the flower has begun to fade the tegmen has grown beyond the testa, and the granular fluid at the tip of the nucleus has become converted into a cellule filled with granular fluid, this is the Embryonic Bercule.

At the period of fading of the flowers the pollen tubes have passed through the conducting tissue of the style, the stigma has withered, and the ovary has increased in size.
The pollen tube enters by the micropyle, its extremity becomes applied and then adherent to the superior part of the embryonic vesicle, and after a time shrivels up. The tube does not enter the vesicle for its lower end is filled with a granular fluid of a greenish colour, while the vesicle at its point of contact with the tube is full of a limpid fluid which contrasts strongly with the contents of the pollen tube, while the inferior extremity where the pollen tube has not arrived contains a white granular fluid. The fluid from the pollen tube passes by Endosperm into the vesicle, and then changes begin to take place in it; the fluid in the vesicle condenses, the lower becomes shrivelled up in a new cell which divides into others and these multiply themselves extremely, thus the embryo is formed.

That portion of the embryonic vesicle in contact with the pollen tube elongates itself and is resolved in like manner into a vast number of cells placed end to end forming a thick converyoid filament which pursues a course the reverse of that of the pollen tube, passing out of the micropyle and prolonging itself into the interior of the placenta. The pollen tube generally becomes destroyed, but
sometimes remains even until the nucleus is filled with cells.

Amici has never observed more than one protentube in the nucleus, although he has seen two vesicles, and two embryos; from these facts pays he which are constant it results that the protentube is not transformed into the embryonal vesicle because the latter exists already in the unfertilized ovule, still less is the protentube developed into the embryo for the latter is not produced till long after, when the vesicle very much enlarged has become the embryophore; moreover the embryo is visible long before its diameter is equal to that of the protentube, so that this latter cannot have become converted into it.

According then to Amici the embryo is formed within the embryophore by the mixture of the fluids contained in the protentube &c. &c.

The next opinion we shall give is that of Motel.
Mohl's Theory.

Mohl holds similar views with those of Asmics; he says that the pollen tubes are easily distinguished from the cells of the conducting tissue of the style, by their greater length and smaller diameter, that of the former being 1/50 while that of the latter is 1/5 of a millimetre. He also states that the mucous tubes described by Brown as being formed out of the coagulable fluid of the stigma through the agency of the pollen tubes are themselves pollen tubes.

From the 4th to the 6th day after the expansion of the flower, the ovary is two or three times enlarged as it was at that time; the integuments of the ovule have grown, the tegmen further lift on the nucleus than the testa; the nucleus is enlarged in a clavate form; the embryo-sac much increased in size has caused by its pressure the outer layer of cells of the nucleus to become flattened.

In two or three days after, the ovule has become amniosperms, the integuments are about equal length, both projecting some distance beyond the nucleus; the embryo-sac is composed of ovate cells, and contains in its cavity protoplasm with a watery fluid, the protoplasm being collected
at the two ends and chiefly at the upper, while the watery fluid occupies the centre; the inner coat now projects considerably beyond the apex of the nucleus, its official margin is swollen causing narrowing of the canal leading to the nucleus, the outer coat begins to elongate downwards in an obtuse form.

In a fortnight after the opening of the flower, the Embryosac has displaced the outer layer of the upper and larger half of the nucleus; it remains to be determined whether this displacement of the nucleus results from a gradual compression of its cells and the obliteration of their cavities, or whether its membrane has become blended with that of the Embryosac, or is absorbed.

The Pollentubes forming a dense mass of filaments with swellings on them being, reaching the placenta, changes soon follow in the contents of the Embryosac; in the protoplasm at the upper end of it, three contiguous cells are formed from nuclei, they are of an ovate form and grow rapidly downwards reaching the middle of the sac (as a general rule) in 24 hours the protoplasm in their interior collecting at their lower end.
The tunicae fyllertubes passing over the placenta enter the fornix of the ovule, they can easily be seen in the canal of the outer coat, but not so easily in that of the inner, owing to their becoming of a less diameter and to the refraction of the light; however, the tube may be seen in contact with the embovixosac lying a little to the side of its apex, this turning aside of the fyllertube is a strong proof that it is on the outside of the sac, while if it lie either before or behind the sac it appears as if it were in its interior.

The end of the fyllertube now swells in a elevate form, and owing probably to the pressure of the coats of the ovule upon it, it slightly indents the sac; the contents at the end of the tube are coagulated and have a greenish yellow colour, sometimes this appearance is seen in the contents of the tube outside the coats of the ovule.

At this period, one, rarely two, of the three cells in the upper end of the embovixosac begins to grow, and is divided by the formation of septa into three or four cells lying above one another, the cells at the two ends being larger than those in the middle; the primary cell is the terminal beside.
The prothallus in the lower end of the Embryosae becomes at the same time organized into cells, but the terminal vesicle gradually displaces these, and comes to occupy the whole of the cavity of the sac, and is now 100th of a Millinile in diameter.

The lowest cell of the Germbesicle first and then the one above it becomes divided by longitudinal septa and increases more rapidly than those above; the swollen blind extremity of the Pollentube is of a Millinile in diameter still remains without any change; the cells at the upper end of the Germbesicle now grow and form transverse septa, and then pass out of the mouth of the ovule in the shape of a conicoid filament lying beside the Pollentube and easily distinguished from it by its cylindrical shape and its transparent cells which contain watery fluid with a little granular matter.

The lower end of the Germbesicle is now a dense opaque cellular mass, the Embryo; the Pollentube disappears apparently by absorption, and spiral fibres appear in the outer coat of the ovule.

According to Mohl, the Germbesicle exists in the Embryo-sac before the arrival of the Pollentubes at the sac; after fertilization, the Embryo is formed at the end of the Germbesicle.
Brown's Theory.

Brown in an elaborate paper on the mode of fecundation in Orchidaceae and Asclepiadaceae read before the Linnean Society and published in their Transactions, after giving a history of the different opinions held on the subject, and making some interesting remarks concerning the structure, position and relations of the stamens and pistils, goes on to observe that in Orchidaceae the agency of insects is often employed in order to cause impregnation, although in many cases from the relative position of the sexual organs this is not necessary.

The ovulum is ready for impregnation generally when the flower expands, but in Cypripedium and Cypripetis it is not ready until after the expansion of the flower, when the pollen tubes have penetrated the stigma.

Brown's investigations were chiefly on Satyrinae or Sphrynda and Orithyseae; in these he perceived that after the application of the pollen to the stigma, boyaux or pollen tubes penetrated into the conducting tissue of the style; from one simple grain of pollen one tube only was observed to arise, each tube being generally less than \( \frac{1}{2000} \) of an inch in diameter.
The tubes become long but were never seen to be connected with the pollengranum after they had passed the stigma; they are numerous and form a cord which passes through the conducting tissue (the style); occasionally apparent interruptions are observed in them, probably caused by partial coagulations of their fluid contents.

On reaching the ovary, the cord of tubes divides into three, and at the point where the placenta commences each of these is subdivided into two; these six cords generally extend as far as the placenta and are nearly in contact with them; the pollen tubes probably receive nourishment from their contents as well as from the conducting tissue with which they are in contact.

Brown observed the tubes passing into the ovulum, he also remarked the presence of mucous cords; his investigations in regard to the origin of these mucous tubes were principally made on Monataea; they first become visible when but not immediately after the production of the pollen tubes; they are first seen in the tissue of the stigma in the immediate vicinity of the pollen tubes from which they are with difficulty to be distinguished, only they are not so in a small degree granular, and have coagulations in their interior.
The thinks it possible that they may be derived from the pollentubes, not by mere elongation of these but by an increase in their number in a manner which he does not attempt to explain, or they may be generated by the pollentubes in the coagulated fluid of the stigma, and are only present at the period of fecundation.

They are next found in the style, at first few in number, but soon increasing from a cool which appears through (perhaps not for some days in the cavity of the corolla which it divides.

In Orchis macro he observed tubes going off from these cords, scattered on the surface of the placenta, and in some cases passing into the aperture of the ovule becoming pretty firmly adherent to it. On impregnation taking place the ovule enlarges the nucleus being covered by the testa soon disappear probably by acquiring greater transparency, and becoming confluent with the substance of the testa; soon after a minute opaque prot appears generally about the middle of the testa, this is the commencement of the embryo.

From the apex of the embryo a thread may be traced nearly to the open end of the testa, it consists of a series of short cells, the lowest most
cell being probably the original state of the embryos, which becomes opaque by enlargement and deposition of granular matter; in the ripe state the embryos have an ovate or spherical form and consist of cellular tissue covered by a thin membrane.

In Asclepiadaceae the agency of insects is indispensable for fecundation. After the application of the pollen mass each grain of it sends down a tube transparent, cylindrical and 1/20 of an inch in diameter. The cord formed by the tubes proceeds along the surface of the base of the stigma, and arrives at its articulation with the two styles, then it introduces itself into the style nearest it, but this is not soon for the admission of the whole of the tubes, some become bent and assume a zigzag form, and seldom enter the style. Soon after this the ovary and style enlarge, and the cord of tubes passes down the centre of the latter, but Brown was unable to trace them further than the placenta.
Giraud's Theory.

His observations were made on Tetrapodium Majus, and he divides the process into seven periods or stages of development.

1st Period. The ovule is anatropous, the nucleus has only one segmentary covering the Primine opening in the Microstyle.

2d. Before the dehiscence of the stamens, a small elliptical cavity appears near the apex of the style, the nucleus having a delicate lining membrane, this is the Embryosac, at its apex it contains a quantity of organized mucilage, and a canal may be traced leading from it to the exostome.

3d. At the apex of the style and Primine is inclined, the Embryosac has become much longer and larger, the mucilage in it has disappeared, and in its place an elongated diaphanous utricle appears which is the Primary Utricle; at first it may be clearly seen to be distinct from the Embryosac, afterwards however it comes in contact with and penetrates that membrane, thus proving that it is not an involution of the sac.

After impregnation the Pollen tubes are seen in the conducting tissue of the style, not however...
reaching the micropyle, but in the channel between this and the pollen tube the foilla is found in abundance, and is doubtless brought into contact with the embryosac through the exobone and canal in the opening of the nucleus.

4th. The embryosac increases in size, the Primary utricle becomes cellular and at its extremity next the base of the nucleus it is terminated by a spherical body consisting of numerous globular cells, the Primary utricle now assumes the character of the suspensor, and its extremity that of the embryo, the formation of which results from a process of nutrition determined by the dynamic influence of the foilla conveyed by means of the Primary utricle or suspensor.

5th. The spherical body of embryo now almost fills the cavity of the embryosac, the upper end of the suspensor has protruded through the micropyle, from this extremity a number of cells are formed some of which hang loosely in the conducting tissue of the style, others unite in forming a process which surrounds the ovule, being thus situated in the carpellary cavity; it resembles the sponge-like of a root and may be withdrawn from the ovule with the suspensor and embryos attached.
6th. The cellular processes have reached the base of the ovule and the first traces of cotyledons appear.
7th. The nucleus and ovum are now united in one, distinct, fleshy cotyledons, and radicle, and plumule are in process of development.

His deductions from these facts then are:
1st. The primary utricle and embryo never have any structural connection with the pollentube.
2nd. As the primary utricle appears before impregnation it cannot form the end of the pollentube.
3rd. The primary utricle takes its origin wholly within the embryo sac, at its earliest period of formation, it is not in contact with that membrane and therefore could not be an involution of the sac produced by the indenting of it by the pollentube.
Schleiden's Theory.

According to him the Embryosac exists in the nucleus in all Phanerogamic Plants before fecundation; this sac contains a formative matter for the cellular tissue, which sooner or later often even before fecundation develops itself in its cavity, and when not absorbed during the growth of the Embryo forms the Albumen. The Pollen grain consists essentially of a simple cellule whose membrane is thin and transparent, in the it contains fœcula of mucilage or gum.

The ovary has always a communication with the exterior; at the period of inflorescence the conducting tissue secretes a mucilaginous liquid; the pollen dispersed by the dehiscence of the anthers falls on the stigma, and the essential membrane of the pollen grain elongates itself into a tube, which following the conducting tissue of the style extends even to the placenta and ovule.

During the prolongation of the tube, its membrane grows by inter-susception, becomes thicker and more solid, perhaps the conducting tissue furnishes nourishment for its growth.

Arrived at the ovule the pollen tube penetrates the opening in its integuments, traverses the summit of
the nucleus, and reaches the Embryosac; be observed from 15 or even 1 pollen tubes enter the Micropyyle, but rarely did more than one penetrate the intercellular passages of the nucleus and reach the sac. The tube has often a number of venire enlargements which are more common near the ovule, it pushes before it the membrane of the Embryosac, and becomes enveloped in it as if by a pouch, it then assumes a spherical or oblong form, and its contents become transformed into cellular tissue; it produces laterally one or two cotyledons, and at its primary extremity the plumule is formed; the extremity of the pollen tube thus surrounded by the duplicature of the Embryosac becomes the Embryo, the tube now becomes constricted and obliterated and the embryo is then contained in the Embryosac.

In other cases in which the continuity of the pollen-tube and Embryosac cannot be traced on account of the arrangement of the cells of the nucleus round the summit of the Embryo, he states that the identity of the Embryo with the Pollen-tube improved by these circumstances: 1. The constantly equal diameter of the Pollen-tube exterior to the Embryosac and of the Embryo within it; 2. The invariable chemical similarity of their contents as shown by
different reagents; 3d. That in such plants as have several embryos, there are always precisely the same number of pollen-tubes and embryos developed.

He states that he has examined a great number of plants of different families, and as the result of his investigations fixes it as a general rule that the pollen-tube becomes enclosed in a duplication of the embryosac and becomes the embryo, and refers to various plants such as Alise, Juniperus, hepatocarpe for corroboration of this fact; it was particularly clear in boehis and foxus, and he was sometimes able to draw that portion of the pollen-tube which represents the first stage of the embryo out of the embryosac at a considerably advanced period of its growth; more lately he has admitted that in some cases the pollen-tube may enter the embryosac.
Wyder's Theory.

Wyder agrees with Schleiden in his more modified opinion; he has observed the pollen tubes entering the micropyle, but he could not see the indentation and turning back of the embrousae on the end of the pollinule which that author describes.

It appears to him that the sac prolongs itself in the form of a straight canal to the summit of the ovule, and there opens into the micropyle; he has often seen the entrance of the pollinules into the sac, he also succeeded in preserving the sac from its ovular coverings, and has seen the pollinules partly organized, but never any development of the sac on the tube.

In many of the Scrophulariaceae the sac has an ovoid form, its wall becomes narrowed at its summit and base in a sort of cellular cord on which seems to suspend it to the two extremities of the ovule; this sort of accumulated sac does not agree well with the idea of a return of the sac.

The end of the pollinule thus situated in the interior of the embrousae contains mucilaginous matter mixed with fascula, out of which the cells which soon fill its cavity are
formed, probably from hytoblasts.

The inferior part of the pollen tube first becomes organized, assumes a globular form, and is the embryo, while the remainder of the tube is thin and gradually disappears.

The cotyledons on their first appearance are two cellular bodies filled with fecula and oil globules. The Embryosac is now large and distended from the fecula and oil contained in it, these contents become cellular tissue and constitute the Allumen or Perisperm.

His deductions are then: 1st. There are not two pieces in Plants. 2nd. The Anther is an ovary, the pollen grain the term of a new plant, and the pollen tube becomes the Embryo. 3rd. The transformation of the pollen tube into the Embryo takes place in the Embryosac, which appears to determine its organization, and prepares for it its first nourishment. 4th. The integuments of the ovule serve to protect the embryo. 5th. The embryo is inversa in regard to the ovule, its base being at the Micropyle and its apex at the Chalaza.
Griffith's Theory.

Griffith's observations were made on Santalum, Carya, Lacinium, and Viscum.

The Embryosae protrude at the apex, and present there several cellular convinent teeth, it contains fluid matter along with molecules the latter being chiefly at the apex; the Pollen-tube paraplyrhal the conducting tissue of the style, insert their apices between the cellular teeth at the apex of the Embryosae, and penetrating it pursues its interior.

The end of the Pollen-tube expands into a vesicle of a rounded form containing molecular matter, sometimes a constriction or neck is obvious in it; occasionally there are more than one vesicle, this is by more than one Pollen-tube having penetrated the sac.

After impregnation the sac becomes filled with cellular tissue, and the vesicle likewise becomes cellular and is converted into the Embryo. In Santalum before be unseelated the posterior part of the Embryosae is deplased in the direction of the axis of the Placenta.

In Lacinium the circle consists of a closed
membranous sac, the upper extremity of which is rounded and generally dilated, the Potentntube adheres to the head of this sac, penetrates into its cavity, becomes dilated within its dilated apex, and constricted in its constricted part; it runs to the end of the tube but Grifflitt is unable to say whether it passed through the lower end of it, but prolongations of it close and from these the Embryo is formed. In Aphyris Maculiferis the Embryos are produced in a saciform manner, the Potentntube adheres firmly with the apex of the Embryosac, their membranes sometimes become blended; occasionally the Potentntube swells in a bulbiform manner; then a cellular mass, with some traces of filaments, is developed around the Embryosac at its exerted part, it enlarges by the addition of cells upwards. The Embryo appears in its earliest stage to consist of from three to five cells growing from the surface of a single cell, within the apex of the cellular mass, which however equals the Placenta in bulk before the Embryo escapes from it.
Dickie's Theory.

In examining the flowers of *Nettedia campanulata*, *Bartsia*, and *Euphrasia* he observed a number of transparent tubes, which he at first thought were pollen tubes, but on further examination he found that they were prolongations from the nucleus terminating in blind terminations, these on account of proceeding from the ovule he calls ovule tubes.

These ovule tubes had been observed before by Brown and others, and were called by them mucous cords, but their course and termination were not fully described until Dickie's observations were made known.

In consequence of the discovery of these ovule tubes, Dickie could not reconcile his opinions with the idea of pollen tubes passing into the foreamen of the ovule and applying themselves to the summit of the embryozoeae; he thinks it probable that the existence of ovule tubes is common, and that possibly they have been mistaken for pollen tubes in many instances.

He admits that in some cases, which, however, he considers as being far from numerous, the
Pollentubes reach the ovule, but that physical difficulties are in the way of their reaching this destination, such as, the length of the style, the nature of its tissue, the form of the ovule, the position of the pro/style, the number of ovules, etc.

In Ephoraia about the period of fertilisation, the nucleus is very thin, the embryophore lining it being highly developed, attenuated at the posterior extremity, tapering gradually upwards into a neck which is bent at an obtuse angle, and near its apex which appears to be fissured becomes tubular.

In the interior of the sac is a tube narrow below, somewhat dilated at the part corresponding to the dilatation of the neck of the sac, this tube passes of the fissure in the apex of the sac, is prolonged for some distance upwards, and ends in a closed extremity. It was prevented from the presence of cellular contents in the sac from being the relation between it and the Embryo, but in one instance he thought he observed them connected, on this point however he has not been able to speak decidedly.
Conclusion.

Such then are the most important opinions which have been advanced on the much disputed subject of Embryology, since the discovery of the phæntentes, on certain points all are agreed, on others again we have the most contradictory statements, but the results arrived at by more recent investigations although differing in minor details, with little exception are at one on the main points.

The present theories may be divided into three.

1st. That the end of the phæntentes becomes transformed into the Embryo.

2nd. That the Embryo is developed from the terminal Acicule or Primary Utricle by the dynamic influence of the facilla carried to it by the conducting tissue.

3rd. That the phæntentes applies itself either to the upper or laterally to the Embryo, that a mixture of the contained fluids then takes place and the Embryo is formed in the Embryone.

All the observers here quoted agree in the formation of phæntentes and their descent through the style, and that they grow either by nourishment from their fluids contents, or
from the conducting tissue, or both.

There are different opinions as to the termination of the pollen tubes. Some hold that they stop short in the style, others that they arrive at the inner or penetrate the Embryosac, a third hold that the tube reaches and becomes applied to the Embryosac.

The greater number of Authors are against the idea of the pollen tube in ejection or penetrating the sac; if we hold the first opinion here mentioned viz., that the tubes stop in the conducting tissue of the style, then we cannot for a moment think that there is an indentation or penetration of the sac by it, for it does not reach it.

If again we look to the statements of those who hold that the tube merely applies itself to the Embryosac, we will find the explanation of some fallacies which are apt to occur according to the manner in which the objects are viewed under the microscope; the greater number of opinions and these well worthy of regard hold this theory; none of them as Bruhl and Hofmeister admit that in those cases in which the Embryosac is delicate, a slight in indentation is produced in it from the pressure of the coats of the ovule on the
Extremity of the pollentube, and then of the latter on the sac, but they show that when the membrane of the Embryosae is strong it causes bending of the pollentube; this then is a purely physical cause dependent on the relative strengths of the sac and tube. A strong proof of the tube being outside of the sac is its turning to the side as seen in a lateral view under the Microscope; again when the tube lies either in front or behind of the sac it appears to lie within it, this circumstance might very easily lead to fallacy, and therefore we cannot wonder that some investigators have been misled by it.

We think from these proofs and from the testimony in favour of this opinion, that we must entirely discard the idea of Schleiden and others that the Pollentube incents or penetrates the Embryosae.

Seeing then that we believe that Pollentube neither becomes enclosed in a duplicitus nor penetrates into the cavity of the sac, we must also deny that the Pollentube is transformed into the Embryosae. In the case of extra nuclei, pregnancy said to occur seems to be erroneous.

From our own observations, as well as from the
observations of others, we are inclined to believe that in some cases the pollentubes do not reach the ovule, and that tubes are sent to meet them from some part of the tube, although we think that from the greater number and closer agreement of the proofs, and from what we have ourselves observed, in most cases the pollentube passes down to the ovule and applies itself laterally or directly to the apex of the Embryosac.

The Embryo is formed within the Embryosac, and most authors recognize the previous existence of a terminal vessel at the end of which the embryo is produced.

Müll, Müller, Sturmüster, Anemünst, Michel, Bisch, Meyer, and Girard speaks decidedly upon the previous existence of the Germ Vessel or Primary Vessel; Elminci describes the collection of white groundlar matter at the base of the Embryo-sac, but did not observe it formed into a cell till after the arrival of the pollentube; however we may conclude pretty safely that the Germbericle is present previous to the appearance of the pollentubes in the ovule, and from the lower part of it the Embryo is formed.

So might it not be supposed that the mixture
of the fluids of the tube and one of the first cell of the embryos in the same manner as cells are formed by the mixture of oil and albumen.

The opinions are different as to the formation and origin of the suspensor.

Mühl, Michel & Spach, Hizard, and Meyer describe it as being the upper part of the germnicle and therefore having an intimate connection with the embryos; Ancieux thinks that it is part of the embryo; Bory believed that it is part of the collateral tube; Biérée thinks that the tubular filament has an appendage which protrudes from the apex of the embryos is a prolongation of the terminal part of the suspensor.

It is generally directed to the micropyle, but sometimes it is not, occasionally it is very long, as in

James Kräffer Barlow.
March 29, 1850.