On the Red Clover.
(Triofium pratense)

Thesis for the Master's Degree

By

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1881...1886.
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There is probably no natural order of plants more easily distinguishable than the Lamiinae of the O艭 or Polem tribe; yet, for the most part, people and even students, are satisfied with an acquaintance of the external features of the different plants of this order, leaving unstudied, as it were, the symmetry of form, the delicate mechanism displayed in their structure, and the beautiful contrasts in color only slightly hidden even in the most common representatives of the family.

With the purpose of thoroughly examining into the peculiarities in structure of a leading genus of the order, the latter acquainting myself with the chemical elements entering into its composition, the commercial value and many other attributes, is the purpose of this paper; and, upon this as my particular, I have chosen as my subject one of the most easily attainable, most valuable and most common members of the family, *the Red Clover, Trifolium pratense.*
It is this plant that greatly
the eye of the traveler, calls the
interest of the botanist and raises the
spirits of the farmer and stockman
throughout the greater portion of South
America and Europe. And just here
before I proceed further I deem it not
out of place to note briefly a few
of the external features of the order
to which this notable plant belongs.

The leading characteristics
of the order, Leguminoseae are that
it consists of plants—vines, pods
or leguminous, and as the order is named
from this circumstance it should
be clearly understood. It is a super-
one-celled or many seeded fruit oped
ning along or as to form two valves.
The seeds are arranged alternately
along one side, supported by short
pedicels as in the bean, or detached
as in the clover. As a type of a
legume the pea and beans are ex-
cellent examples, though varying in
form and varieties. It is Aristotelian
perennis-like in the Lucerne, small-like
in the Medicagos, worm-like in the \textit{Arceina}, still it is a legume preserving its identity to the pea pod.

It raises itself in size, being very small in the same, while in the 

Cassia it attains a length of several inches.

This comes from the singular arrangement

of the petals resembling a butterfly with

wings extended. In the subdivision, 

Papilionacea, today, our selected example, the 

claws of the claws, like those of all leguminous 

plants, is apparently composed of one

entire piece, evidently five petals united

into a tube, ending in five distinct

points two of which, I observed, are larger

than the others. It is light green with

two little markings or ribs on its surface, the whole crowd with hairs. 

This contains the corolla with its curiously shaped parts. These parts by 

their natural expanse extend the anomaly of the monopetalous corolla. The 

corolla consists of five petals, one of which is longer and broader than 

the rest, and stands up and back
of time forming, as it were, out of a
draught to wind before the flower expands.
Because of this effect it is sometimes
referred to as the standard, banner, or
millarum. Closey united with and
adherent to the standard are two
wings folded over a projecting append-
cility long shaped petal or petals which
winds forward and is called the keel.
Exaining the organ more closely I find
it is composed of two petals united along
their inner edges. In this sea or cradle,
as it were, lies hidden the provision
which nature has made for the growth
of future generations of this and all similar
plants.

It is a thought worthy of remark, and I find
upon inquiry that it is a failing common among
curious observers, that few find plants
which are not at the alien flowers only:
they are clustered in the head have found
the resemblance. Intense there and the forms
of the pea or bean; but a close inspection
will show that the general configuration
of the flowers is the same; and though
the pod in most instances of the Clerk
family is concealed in a deep calyx, yet a careful examination of this pill finds a perfect pea pod containing from two to six seeds when perfect. The pea-pod-shaped pistil is particularly noticeable in the Trilium repens Endl. et. Nutt. But with me still I must note the difference in the shape of the petal of the pea and ran as compared with the clones.

The flower of the pea differs from that of the clones in that its stamens do not spread, and the ring petals much longer in proportion to the size of the keeled petals. On the ran the close are exceedingly irregular, the ringed ones present. Quite a petal with these considerably developed. The keeled petals differ much from the corresponding one in the clones.

On the ran, the petal terminates in a curl encircling the hairy-like stamens, while in the clone the petal consists of a more hooded simple in structure enveloping the essential organs.

A peculiarity of the clone family
is that the flowers do not shed their
bloom. It is a matter of general obser-
vation that the calyx or outer cup re-
tains its green and fresh appearance
till the seed has fully matured, and though
the corolla turns either red or die, remaining firm,
but they are not shed at any time.

Having now traced the few parts
of the corolla which differ so much from
each other and the calyx as scarcely to be
recognized, I will now proceed to de-
scribe the essential organs—the stamens
and pistils.

The fruit, in its first stage,
protected by the leaf, is enclosed in a
membrane formed by the filaments of
the stamens which adhere one to another
below and to the line of the corolla above,
but distinct above, surround the green
of the ovary. There ten filaments are
united only at their base, then separated
thereafter into two sets of five each.
It is evident the solitary stamen has
gradually separated itself from the other
and in doing has made it possible
for the eminents to develop itself. The
entire fusion and made apart separation here manifest in a form such a tendency to cohesion is singularly interesting; and possibly this is necessary in order to fill a sufficient aperture to gain access to the nectar.

On the top of each of these slender threads is the anther, bearing the dust-like pollen which falls upon the stigma that terminates the style. The style is a thread-like organ furnished with hair below the stigma for the adhesion of an excess of pollen which falls upon the stigma; and whose only office is to convey the pollen to the unfertilized stigmas and so ensuring the complete conjugation with its perfect seed. The two stamens, faithful to each other, having fulfilled their function, wither and die together leaving the tenth isolated and alone as their only representation. It was because of this peculiar division of the stamens that Linnaeus made the order to constitute this genus Dandelion, or two brotherwise. Plates XVIII & XIX.

The will now direct our thoughts to the consideration of the seed.
The Seed

Not the least interesting feature of this family of plants is their seeds, the singularity of construction and methods of germination of which are worthy of study. If we take a seed in our fingers and scrutinize it closely or shall find that it contains a testa or covering enveloping the cotyledons, or a mass of pulp or meat, as it were, on which the young plant is a while parasitic. This soft substance encloses the little entity to plant, and is composed largely of starch. When the seed is kept dry the process of development does not go on; but when moisture and heat are applied chemical changes immediately take place by which the starch is decomposed and gradually converted into sugar and dextrine. If the seed be planted in the sand or placed between dampened folds of paper, it absorbs water from which causes the seed to swell and burst its external case. The cotyledons spread apart and force
able to distinctly trace the imperfect spiral fibres and wood tissue, and the little empty plait become evident, including first downward with its true radicle or root, and then upwards with its little greenish white plumule or stem the testa in which the young plant was nourished, having performed its function, remains in the ground and soon withers and dies away.

The seed consists entirely of two cotyledons or seed-leaves which cover the empty and which at the time of germination separate allowing the radicle and plumule to come forth. The cotyledons now assume the form of leaves, and, as the time elapses they upward, the cotyledons rise out of the ground with it, presenting that curious phenomenon as noticeable in sprouting peas and beans. What a grand sight is this! All nature seems to be taken preparation for a higher existence. If we follow the progress of the plant further, and
shall see their seed leaves withering away and giving place to the stem leaves and take hence perspective in the budding flower which in all its beauty is but the temporary abode of these leaves which hang for their object the perpetuation of the species. What a grand truth here unfolds itself to us! Nature has skillfully packed away within the tissue of the cotyledon the precious germ of life and when bared in sun-light and moisture God's breath this germ awakens from its slumber and comes forth to develop into the mature plant shedding its fragrance and scattering its seed spread wide for man's welfare a testimony of God's goodness to mankind.

Plate IV. & VII

The Root.

We have seen that the first outward appearance of the presence of life the seed remain lies in the seedling
forth from its cotyledons a tiny shoot. The radicle - which turns downward and becomes the root to the growing plant. Continuing onward in its course it develops into a root not sending up roots
lets from all sides clothed with hair innumerable which absorb plant food from the soil. The first green growth is small, the plant dies, little more than establishing itself for the life that is soon to follow. The second year as the warmer days of Spring come and go, a tiny stem starts from the central axis and is soon provided with leaves. Other lateral stems follow and these furnish the forage which later is cut and cured as hay or utilized for fertilizing purposes. The great root has, in the meantime, penetrated the soil to considerable depth, the tiny nodules ever in possession ensure loosening the soil, making it more active and adding both to its size and value by pumping up as it are, as good valuable plant constituents from the subsoil. The clear root is a remarkably deep finder, curves tiny in record of roots.
measuring from four to seven feet in length. Of the benefits which an abundance of growth is to the poplar, I will discuss under another head.

Clove roots are effected by the frosts of winter and the drenching rains of spring. Often times the roots are bladed from the soil several inches only, the tip of the root remaining in the ground. This injury of course interferes with the growth of the growth of the crop; the lateral stems do not set forth their leaves, apparently all except the central from die and the resulting crop is worse. To remedy the injury I was advised as to as possible apply a roller as soon as the ground will admit.

Stripping down the lateral stem one finds a central axis comprised entirely of woody fibres which extends to the small root and slowly spreads add to the stem after.

Plate 18 illustrates different sections of the root.

An experiment was made to ascertain whether or not the branches could be made to produce roots. Sand to the depth of eight inches was heaped about a strip of down. At the expiration of three weeks into...
One-quarter to one-half inch long have started from several stems two or three inches aotn, the surface. They also attained the same results by turning the stems flat down upon the ground and placing a light weight upon them.

The Stems.

The stem of Red Oak is small, quite smooth, round, more or less hairy, with its diameter nearly equal throughout its whole height, and broken by nodes at regular intervals. The color is light brown. It may be distinguished from the large medium red by its stem being much smaller and less sturdy, having fewer, short, broad leaves from oval to heart-shaped and turning into them from two to four times earlier.

In size the diameter of the stem varies much. The largest specimen I have measured 7.0 cm., the smallest 1.5 cm.; average of several 6.025 cm. and 1.75 cm. respectively. A cross section of the stem studied under the microscope revealed
much that is interesting in structure.

The epidemic is composed of cell tissue destitute of coloring matter. These cells were quite regular in form and apparently forming one tier. Next within are irregular, constructed cells with thickened walls forming parenchyma. Both classes of cells are shown in Plate XVIII, figs. 1, 2, and 5 respectively. Next in order is a set of cells in crescent-shaped bundles forming one division of the fiber vascular system—the Bast cells. These may be described as elongated, spindle-like shaped cells with sharp ends and either simple or branched. They seem to have intercommunicating lateral connections existing into bundles they also possess little central discs. In Plate XVI, fig 1.

Plate XVIII shows dotted cells of single fibers after having been treated to KOH 8% HNO3. The next tissue is made up of thin tubes which form the medullary rays in timber. These are shown in Plate XVIII, fig. 2. These tubes are greatly elongated and very much in size and outline, walls composed of delicate, colorless, celllose membrane.
The woody bundles, the other division of the vascular system, are next met with. The walls are heavy and tinner than the pit cells follow in order and are illustrated in Plate XII. Figs. 20, 21. The canals connecting the cells are figured.

The Leaves.

A corn leaf consists of a petiole furnished with stipules and true leaflets nearly sessile on the apex. The uniform appearance of the true leaflets on each food stem gives to the genus its Latin name, *Dipsacus*. *Tri* - *le* - the true and *folium* a leaf.

This has been converted into the English *triple* which was originally the generic name.

The stipules are broad, linear appendages with distinct, marked margins, ending in two acute points. These accessories seem to protect the young shoot as it pushes forth from the axis.

The petiole is irregular, green, linear and not covered with fine, white hairs.
The three leaflets are oval or obovate, often
notched at the end; one-half to two inches
long and marked with a white spot or ter-
mate veins finely toothed. Minute distinct
punct, under surface of leaves clothed with
hair; heads terminal, serice, globose
at length ovoid, sometimes by opposite
leaves with much dilated stipules. The
microscopic appearance of the upper
epidermis is interesting. There are two
five striata on the upper surface and
about twice as many lower. The minute,
striata, a greatly magnified hair and
surrounding tissue are shown in Plate
1. L 5, 2, 3.

Chap. II. Myotropic movements
of leaves.

This is one of the most interest-
ing phenomena connected with the study
of these plants. Several branches of crow
representing the red, medium, white,
and a variety of the latter having red
disk color; leaves and branches, are
marked for study. The plants were examined at 8 A.M., 2 P.M., and 9 P.M. for several successive days, and it was observed that the leaves of all species assumed widely different positions at night from that they held during the presence of sunlight. The leaves seemed to close up, go to sleep, as it were, one after another towards sundown and did not expose their upper surface directly to the sun's rays till long past daybreak, and, in some cases, till 9 A.M. In nearly every one at 9 A.M., the upper surface of the lower leaves was turned away from the sun's rays at angles ranging in the different species by similarly complicated movements. The lowest leaflets would gradually face each other while the terminal leaflet which first assumed a vertical position would a little later bend over and finally expose its entire under surface to the leaves forming a curb or roof, as it were, to the sunlight. This position was especially noticeable in the White Clover, why the clover and thousands of others
Plants assume their positions is not clearly understood. Mr. Darwin thinks it is to prevent the chilling of the leaves by radiation. Thick and flowering, obtaining or gardner known is detrimental to the growth of the plant. At any rate it seems to be the way nature has provided for the plant to husband its powers.

I observed that when the sun shine intensely upon the leaflets at 12 PM, they would upward. This peculiar phenomenon of the movement of the leaflets, Mr. Darwin says is affected in two ways first by means of pulvini which become turgid cent on opposite sides, and second, by increased growth along one side of the petiole or midrib, and then on the opposite side.

To test the protective effect of radiation on a clover leaf three leaflets were pinned to light pieces of cardboard about 7 PM, so that their upper surfaces were exposed to the sun during the night. At six o'clock the next morning the result was noted: the leaf was turned to the Cornell wit
dew, leaves from leaves growing from the same root which had not been disturbed are comparatively free from moisture, which would seem to indicate that the temperature of the leaves experimented with was lower than those undisturbed.

During the time and in connection with the experiments with the home, only at spring time has time directed to other plants assuming mysticific movements. The dandelions lift its flower and leaves like sunflowers on the first approach of night and open them at sunrise... The dandelion opens before six when exposed and closes about sundown. The little daisy that greets us by the wayside, returns to rest each evening and rises to meet the early hours in the morning. The marsh marigold goes to bed at sun down and rises at sunrise.

Tulips trying to prepare for repose about ten times and are late risers.

Plate X IV.
Fertilization.

Fertilization is effected by the presence of the essential organs of the flower, the stamens and pistils. In many families these organs are present in one and the same flower, as in the Rose and Grass families; it is then called a perfect flower. Sometimes these organs are borne in different parts of the plant, the pistils and stamens being produced upon different branchlets, as in the Com and Oke families; the flower is then said to be monoecious.

In the fertilization of monoecious flowers, some means of transportation of the pollen to the pistil must be effected to accomplish fertilization; and I have observed that even in perfect flowers, as the cham, it is found to be not the rule for the pollen, wholly unaided, to fall on the stigma of the same flower. Hence it is evident that some assistance must be given such plants to effect complete fertilization, such help may be found in the wind.
was another insect.

It is evident there are two processes of fertilization, cross or self fertilization, at least the pollens of one flower acts directly upon the stigma of the same flower, and second cross fertilization, when the pollen of one flower is applied to and acts upon the stigma of another flower. We would naturally suppose that in perfect plants self fertilization would be the rule, and as it used to be taught, but now we know it is the exception. This is true of the corn. Some plants protected from the approach of insects, particularly small wasps, have none seed, but put a small quantity as compared with those protected to which the bees had free access.

In connection with a classmate while I was an undergraduate, an experiment was undertaken to determine the necessary presence of bees for the fertilization of corn, and how it was effected.
A small box containing 50 heads was protected by a cover netting, through which small insects could pass freely but not fly. When the clover matured, the 50 heads were examined, 31 of which were not fertilized; in the others there were some times 2, 3, and in a few instances 6 flowers fertilized. In turn examined 50 heads from plants growing near the first lot, on which no hand had been used daily, but failed to notice the presence of any insects. Of the 50 heads examined 38 were dead, the remainder were unfertilized; hence 38 heads contained from 0 to 12 seeds each, proving quite conclusively that the presence of flies in this time season was a necessity, also that self-pollination was again shown to be the exception.

Some have been noted when other insects, particularly butterflies, have seemed to be the prevailing means of fertilization of the clover. However, it is my object to show that clover is not self-pollinated, but that insects, this particular butterfly and some species for the matured of a full crop of seed.
Now that a single tree or other insect is essential for the fertilization of Red Elm, the question follows: What is the position of the tree in the flower, and how is fertilization effected? See Plate XIX, Fig. 3.

The bee, Sham stowt or long searching for nectar, lights upon the wings and sits in the floor of the sea, and soon do the same in the flower. He is a simple flower that is large enough to sustain him. He raises his head against the former petal and pushes his tongue downward in search of nectar. In the act, the wings and cell are pushed forward, and the pistil which is furnished with little horns below the stigma, to which the pollen adheres, protrudes in consequence. The stigma strikes the stamen of the petal and the pollen, also brushes against it. The visit to the next flower is similar. The stigma strikes the stamen as before but leaves from dusted with pollen from the previous flower a portion of it is retained by the stigma, thereby effecting cross fertilization. The bee usually visits all the flowers in the head before leaving for new fields, and it is customary to take the flowers in the order in which they
occur, that is beginning with the lower circle and going around and round the heat till the top of it is reached. Post XI.

**Vector Plants.**

The vector plants lie in the class, and may be seen in Post XI, as drawn up above the filament of the stamens which extend to the base of the tube. These plants produce vector in abundance while the flower is fresh, and they may be seen under the microscope by preparing a portion of the corolla of a young flower in the usual way.

**General Points.**

Red Clover is a perennial plant, though with proper treatment it may be made a perennial, and seems to be especially adapted to nearly all kinds of soil. It is a forage crop that becomes an important factor in the crops of all well-regulated farms. I think I may safely assert...
The red clover has been found to contain 35% of lime in its inorganic constituents. Therefore, that a lime-clay soil or a loamy soil will grow it luxuriantly. Mr. Gould says: "The best soils for clover are the red wheats.
“soil, other than the soil good luxuriously dry, will be other good luxuriously dry.”

Professor They have determined the chemical elements entering into its composition as follows:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>16.40</td>
</tr>
<tr>
<td>Fatty Matter</td>
<td>3.18</td>
</tr>
<tr>
<td>Ashmen and other flesh forming matter</td>
<td>10.81</td>
</tr>
<tr>
<td>Bone, sugar, mucilage and Earth hydrate</td>
<td>34.42</td>
</tr>
<tr>
<td>Ammon. into sugar</td>
<td>7.52</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
</tr>
</tbody>
</table>

This is one analysis of Clove Hay.

Dr. Collier of the Department of Agriculture gives the analysis of Clove in full bloom and in seed.

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>17.00</td>
</tr>
<tr>
<td>Water</td>
<td>8.50</td>
</tr>
<tr>
<td>Ash</td>
<td>7.60</td>
</tr>
<tr>
<td>Fat</td>
<td>4.35</td>
</tr>
<tr>
<td>Carbo. hydrate</td>
<td>47.42</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>14.85</td>
</tr>
<tr>
<td>Ashmin.</td>
<td>17.50</td>
</tr>
<tr>
<td>Total</td>
<td>117.60</td>
</tr>
</tbody>
</table>
There are so many method of curing clover hay, it is hard to work the while to enter into the discussion here. Each farmer has a way of his own and each thinker his in the text. I pass to the cultivation of the seed.

This has become quite a source of revenue to some farms. A farm near my birthplace, a few years ago, produced 1,000 bushels of seed in a single season, and my father has not infrequently raised 200 bushels of seed per acre for several successive years. The method was to mow the first crop when about one-third of the heads were in bloom. It was observed that more and little seed could be raised per acre (often 10 to 3 bushels) by this process than by pasturing the clover field closely from June 10, and then grazing it to mature its seed.

The objection to pasturing clover was that the stock, particularly sheep, would bite so closely as to nip out the central stem, hence partially checking the stocking of the stand. However, without this objection, besides checking the growth and of the time destroying worthless. The seed should be cut with a self-oake reaper where at least three-fourths of the heads
are both, the material being left in touch with ground until cured, then piled upon the ground with a fork, fork. This method which I always followed when in the farm prevented the waste of seed and the collection of foreign material in the stubble as is likely to be the case when the seed is gathered after the method of making hay.

Just as to land choose seed to ensure a good "catch" varies with different soils and with the season. Most farmers agree that seed should not be sown in the fall as the tender root is almost certain to be winterkilled, and in spring as the soft snow, or litter, after the soil has been settled, when a light harrow may be applied. The seed should not be sown more than one-half inch deep, home a roller is quite enough to press our newly seeded land. Of the spring crops, only I chose to be the first to seed with, the early maturity of the crop ensuring ample room for the growth of the young plants.

The amount of seed to be sown per acre varies with the condition of the surface, coarsely divided to lumpy soils requiring more seed than finely pulverized land.
From four to eight quarts per acre are usually sufficient; when used with timothy or orchard grass a still less quantity is sufficient. The mature seed has a purplish tint, and weighs 64 pounds per barrel.

It must not be understood that potatoes demand only on the farm; it is largely used in the arts and manufactures for dying colors and in many other ways.

As a fertilizing crop, clover has no equal on any soil on which it grows. Mr. Flint says of it: "It's long roots penetrate the soil, breaking it and admitting the air, while it also seems to fix certain important elements which enrich the soil. Being a rapid grower its foliage keeps the check on weeds, thistles, and invades the shade afforded the soil, which improves its fertility a little." Also, clover is one of the best crops that can be grown for green manuring. Being largely an atmospheric grower it is not exhaustion to the soil; in fact, it leaves tons and one-half tons more of nitrogen in the soil than it consumes. The root storing this amount in excess of the foliage; and if the crop is allowed
to mature its ' and the soil is still richer in Nutrition, a fact known to Storing Farmers in the yield of a wheat crop which grew on them and that had manured its 'ed.

And thus we might go on praising and extolling the many virtues of this valuable plant; but enough has been written concerning it by other pens to warrant me in bring this lengthy paper to a close.

And here I desire to thank my preceptor, Dr. W. J. Bell, for his kindness and attention during the prosecution of my studies in his department. I fully appreciate the interest he has shown in me and shall endeavor to merit this kindly assistance, through out all my future efforts.
Description of Plates.

The drawings are made from sections cut from fresh specimens of the Cohns by means of a razor. The section was placed upon a thin plate of glass, a drop of water was applied, and a very thin cover glass put over the whole. The section thus prepared was put under the compound microscope and the result is as shown in the plate. Sometimes they were drawn to no scale, but in most cases the number of dimensions which the object was magnified is marked in figures near the drawing.

Plate I, Fig. 1.

Shows the arrangement of cells comprising the upper epidermis of a leaflet of the Ascid Edson, with connective tissue.

Fig. 2.

Shows the mid. 3. of the upper epidermis.

Fig. 3.

Is a hair greatly magnified found on the upper epidermis.

Fig. 4.

Drawing of the mid rib of leaf of edson.
Shining mid rib, mossy cells, etc. inner face of leaf.

Fig. 5.

Cross section of stem of Cham at base of leaf blade, showing mossy tumuli, hollow topicular peculiar shape of stem and especially the hairs.

Fig. 6.

Transverse section of top of leaf tissue one-half inch below the base of leaf. It indicates the lower or back portion of stem as opposed to the upper surface of leaf. The different kind of cell tissue of middle stem as displayed in a cross section in Plate 1.

Plate 1. Fig. 1.

An edge of leaf stem, outside showing intercellular spaces, etc. red coloring matter as at B, and other smaller cells as C.

Fig. 2.

Another diagram of some tissue differently formed, showing stem as at A.
Fig. 3. Drawing of cross section of petiole of leaflets at the base of the three leaflets, showing the division of the main stem into three, the cellular tissues prominently also woody bundles.

Plate III. Fig. 1.
A drawing of cells and circular vessels of petiole of plant, magnified 110 times.

Fig. 2.
An enlarged view of spiral vessel magnified two thousand diameters.

Lgs. 3, 4, 5, 6.
Exhibit drawings of pollen grains of clear vird at different times.

Fig. 7.
Drawing of portion of petiole of chrysanthemum. Cell (a), faces of hairs (b), heavy mid veins as at c, and hairs as in d, mossy bodies at d, presence of hairs as at e. Magnified 110 diameters.

Plate IV. Fig. 1.
Drawing showing part of cross section of petiole of chrysanthemum, two of the different forms of hairs, the spiral vessels also numerous.
in this specimen and are beautiful in the extreme.

Fig. 2. Draw of \textit{Botryum tuberum} exhibited in right hand drawing as \textit{a sol.} and that of the right hand in \textit{b}. This drawing shows the hairs of different shapes and positions and others in the cylindric hair of \textit{chlor}.

Fig. 3. Section of outer epidermis of root of \textit{chlor}, vertical section.

Plate I. Drawing of section of region of \textit{chlor} near the heart, showing internal tissue and cells, also some chlorophyll.

Fig. 2. Drawing of some root at the surface showing a little different arrangement of cells with outer cuticle.

Fig. 3. Vertical section of root showing protoplasma.
Plate XVIII

This plate is a drawing of the ruled portion of the corolla of red vetch, exhibiting the two divisions of the stamens, two delphores as Linnaeus described them. The ten stamens are divided into two sets, one and nine respectively. The nine are united by their filaments and their anthers alternate in length each way from the central one which is the longest. The one solitary stamen at the right spring from near the base of the corolla and may be seen after the other nine have disappeared. This peculiar division of the stamens is probably due to the fact that the bee and other insects could not reach the nectar glands and gather the pollen near the inner stam.

The words authors which have not yet shed their pollen it being to give a specimen. The ruled portion was taken from a corolla which had not yet tinctured.

A - filaments, and B pollen grains.

The style, B stigma with hairs filmed.
Plate IX.

Fig. 3. Drawing showing the relative position of the petal and sepals.
A. represents the calyx, B. funnel petal, C. a red or petal which encloses the stamens, D, D. winged petals.

Fig. 2.
A side view of stamens, giving their position in the flower.

Fig. 1.
This represents the corolla split open along one side showing all parts.
A. is the funnel petal, B, B. winged petals, C. red petal showing the attachment of the stamens.
D. the pistil, E. ovary or gymn.
F. the odd stamen.

Plate XX.
This represents a portion of a petal. The dark lines are the filaments of the stamens running down.
A, A, A, E. are vestigial glands, then appear as granular bodies heaped up along the base of the filament.