The sun flower as a type of flowering plants

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THE

SUN FLOWER

→ AS →

A Type of Flowering Plants.

→ A Thesis, →

→ BY →

Anne B. Jewett,

CLASS 1890.

S.U.I.
Sun Flower

A Type of Flower in China
"And as the Sunflower in some barren field
lights up the waste with cheerful golden glow."
I have selected the Sunflower, "Helianthus Annuus" as the subject of my thesis, first, on account of its accessibility, being cultivated almost everywhere; second, because it illustrates so many different things. In the first place, it at once may be taken as a type of all flowering plants, i.e., of the sub-kingdom Phanerogamia or Spermatophyta. It illustrates also the principal division of that sub-kingdom, viz.
the Angiospermae, i.e. the Sun-Flower is an Angiospermous Phanerogam. Again, the Sun-Flower is a member of the largest order of the flowering plants, an order which though not of great economic importance is yet wonderful in specialization and in the variety of its forms, and thirdly the accurate observation of all the phases of the Sunflower is possible by virtue of the size of the organ concerned, and
the rapidity of their usual development.

I, however, favored under a great disadvantage this year in taking the sunflower for the subject of my study owing to the unusual condition of the weather, and consequently the unusual slowness in the growth of my plants, the reason having been later than any for years. Exceedingly dry, and several frosts having fallen the young plants which
retarded their growth considerably.
The work began April 7, 1890.—The seeds were planted on the same day and I commenced with a study of the seed. A single seed was taken and examined. It is a dry inferior Acheneum, with narrower basal, and broader apical end. At the latter end is a scar where were inserted the style and other floral organs.
structurally a Sunflower consists of 1, a brittle Pericarp, 2, a delicate Testa, (the seed coat), and 3, the embryo.

1st I dissected off the brittle Pericarp from the seed and cut a thin transverse section and examined it under the microscope.

No. 2 - Plate I shows the arrangement of the cells as seen under the 3/4 objective. First is a single layer of epidermal cells which are irregular
and are somewhat pointed or elevated toward the outside. Next to these are five layers of thin-walled parenchymatous cells, which are more or less compressed. Next come thick-walled sclerenchyma tissue, which are a mass of cells which are connected with one another by bundles, as shown in the detail drawing. Fig 4. They are separated from one another by thin-walled cells, which seem to be fitted beneath.
there are smaller thin-walled cells of irregular form. When the reed has been soaked in water for several hours the little hairs which cover it are plainly visible, they are long and slender with divided tips as shown in fig. 4. - Plate I. Under the little Pericarp there is a delicate covering, or envelope, called the Testa, whose cells are very small and filled with
cells around the margin a + b. Within the margin the cells become elongated blade-like cells, which are filled with aleurone grains each grain containing a crystallloid, even the smallest.

Fig. 9. Plate II is a single cell from Fig. 8, but much enlarged. After the seed has commenced to grow, and the root has been sent out, the crystalloids all disappear, and the aleurone grains are scattered around in the forms of
little granular bodies, as shown in Fig. 10.
When the plant first
commences to germinate
the following points may
be noticed in the process.
First, the internal part
of the fruit swell and
cause the brittle pericarp
to split longitudinally.
Second, the radical protrudes
and curves downward.
Third, the hypocotylar
stem elongates so that the
pericarp and testa are
carried upwards by the
Cotyledons, which remain enclosed by them for a considerable time.

Fourth. - The coats of the fruit fall from the cotyledons which soon turn green, on account of the Chlorophyll bodies which are formed as soon as they are exposed to the light, and expand as assimilating leaves with the plumule seated between them, as shown in fig. 11. Plate III.

Fifth. - The plumule develops
leaves (opposite for the first three whorls), and alternate after that, which expand in succession figs. 12 & 13.

Plate III

Sixth - the radicle has meanwhile elongated and produced lateral roots.

It may be noticed that when the young root is removed from the soil, many particles adhere to it, especially at some distance from the apex; these are held by the root hairs, which attach
themselves closely to the particles of the soil.
I next cut transverse sections of a young stem
(about an eighth of an inch in diameter) — a diagram
of the stem is given
fig. 14. Plate IV showing the position of the fifteen
open fibro-vascular bundles,
which seem to be in
five groups of three
each. fig. 15 shows a
single bundle and the
arrangement of its cells.
The bundle consists of two
well marked masses of thick-walled tissue, the portion between them being thin-walled and transparent. In examining the latter carefully, however, you can see that the external part of it has thicker walls and is less regularly arranged than the central portion, and therefore cannot be distinguished from it. One has, then, four portions of the bundle which, taken in succession...
from the periphery to the centre are as follows:

I. A mass of Schlerenchyma.
II. Soft Part. [These two together constitute the Phloem, or bark portion of the Bundle]
III. the Cambium.
IV. the Xylem, or woody part of the structure.

Examining 1st the Schlerenchyma, which is a half moon-shaped mass of tissue, the cells are thick-walled, rounded cavities, some of them containing the remnants of protothaenic...
Contents. There cells show differentiation into layers, of which the most prominent is the middle lamella.

II. The soft bast consists of three different kinds of cells: the sieve tissue, which are the larger cavities of the soft bast; as found in the Angiospermae is made up of sieve ducts, and the so-called latticed cells; the former, the sieve ducts, consist of soft, not lignified, colorless tubes, of rather wide diameter, having
at long intervals horizontal or obliquely placed perforated septa. The lateral walls are also perforated, in restricted areas, called piece discs, and through these perforations and those in the horizontal walls the protoplasmic contents of the contiguous cells freely unite. Plate I. fig. 2. shows the piece tissue which occurs in the phloem portion of the bundle, associated with the companion, and bast-fibrous chymo cells which make up the soft bast.
2nd. Closely adjoining the sieve-tubes are numerous smaller cells called the companion cells, which are smaller sister cells of the segments of the sieve-tubes, cut off during development.

III. The remaining cells of the consipicous or phloem-parenchyma resemble the sieve-tubes except that they are smaller and they have no sieve plates. The next layer of cells is the cambium, or active
Formative layer of the whole stem, the cells in this are arranged in radial rows with thin cellulose walls, and contain protoplasmic contents. The form of the individual cell varies from oblong to square. In passing from the Cambium to the Phloem or Xylem, the form of the cell is modified in the direction of the cells already differentiated. From this we can plainly see that the development
of the mature xylem or phloem proceeds from originally uniform cells, alike in all particulars. Each cell capable of constant development and differentiation make up, whenever found in connection with a fiber-vacuolar bundle. The cells of the cambium divide with the xylem consists of the vessels, easily recognized by their large cavity; the walls are thick, and they have no protoplasmic cell
contente. The vessels are imbedded in a mass of tissue of two kinds, (a) **xylem** or wood-fibres, which are irregular and have thick walls, and (b) **xylem-parenchyma**, cells which retain protoplasmic contents, and the form of ordinary isodiametric parenchyma cells. The cell walls are cellulose, or are sometimes lignified.

Taking into next a longitudinal section of the young stem of the Sum-
Flower. Fig. 16. Plate V we find as in the case of the transverse section, starting at the periphery.

I. the Epidermis, which consists of rounded or elongated cells (a single layer) not very well defined from the underlying tissue, and containing a few chloroplasts. Bodies scattered around close to the cell walls.

II. Next to the Epidermis lies the Collenchyma, which consists of elongated cells with thick cellulose walls.
Each cell contains protoplasm, a nucleus, and chlorophyll grains.

III. Next is the thin-walled cortical parenchyma, the cells of which are shorter and wider than those of the collenchyma; there are a very few chlorophyll bodies in these cells.

IV. The next series of cells are the Bast Fibres; these appear as long, narrow chyma-tous cells, occasionally divided by more oblique septa; the walls are thick and
fitted, remnants of the protoplasmic contents may be found in these cells when stained by erythrosin. Then there are several more layers of parenchyma cells and next to these the cambium cells, which in the longitudinal section are oblong cells with very thin walls, and dense protoplasmic contents. Passing the cambium, the next group of cells is that of the fitted vessels, which are quite large, having large
cavities, walls with pits which appear oval in form and mark the entire surface. The spiral vessels are next to these, those nearest to the oval-pitted vessels having the spiral most closely coiled. There is only one spiral in a vessel.

The wood-faenenchyma cells come next to these, again and are oblong cells with square ends; they have cellulose walls and retain their protoplasmic contents.

I next cut a transverse
section of the cotyledon, showing the stoma, and the arrangement of the cells of the cotyledon, viz. the epidermal cells being small and oblong with square ends and the large palisade cells next to them. This is shown in fig. 17. Plate VI. S = stoma. ep = epidermis cells, pp. = parenchyma of the leaf. The stoma considered physiologically are nothing more than the mouths of the intercellular spaces of
the inner tissue, which open in places externally between the epidemis cells. The origin of the stoma is always the result of the formation of a mother-cell, first of all by division of a young epidemis-cell, which is sometimes proceeded by several divisions in it or in the adjoining epidemis-cells; and this mother-cell becomes more and more rounded off, and the guard-cells of the stoma are.
produced from it by division. It may be assumed that in plants provided with a thick cuticle, transpiration takes place principally through the stoma on, and is therefore dependent on their smaller or larger number and size.

Fig. 15, Plate VI - shows a section of the upper side of the cotyledon showing the stoma - a being a single stoma much more enlarged.
Fig. 19. Shows the section of the epidermis from the under side of the cotyledon, the cells in this being much more irregular and the stomata more numerous. The evaporation does not in this case proceed from the surface of the organ (or only slightly), but in its interior, viz. at the places where the cells of the parenchyma bound the intercellular spaces which contain vapor. The production of vapor in
in the intercellular spaces is more abundant the larger they are themselves. This circumstance and the much larger number of stomata on the under side of the leaves are the reasons why evaporation is generally more copious from it than from the upper side of the leaf. The number of stomata on the upper side of the leaf of the sunflower in one square millimeter is estimated to be 173.
And the number of stomata on the under side of the leaf in one millimeter is 325. I next made a cross-section of the embryo of the Sunflower. Fig. 20. Plate VII is a diagram of this. Fig. 21 is a section of this, showing all its parts, (a) being the strongly swollen outer wall, (b) the epidermis, (c) the cortex (or parenchyma), (d) the inner fibro-vascular bundles, (e) the parenchyma and (f) the pith.
the embryo is less differentiated than the stem. Although here, even before the seed has germinated we may discern the inception of all that appears later in the fully developed stem.

Fig. 22. is a single parenchyma cell containing a nucleus and aleurone grains containing crystalloids.

I next took the apical bud of a young plant and cut a longitudinal...
median section, of which a diagram is given fig. 23. Plate VIII, and observed I that the axis ends in a naked broadly-conical apex, which is surrounded and enveloped by II leaves; these may be observed in various stages of development the youngest being nearest to the apex, (i.e. the order of their development is thus acrofetal); the surfaces of the older leaves are covered with III hairs, which are absent from the apical
cone, and the youngest leaves, (i.e., the hairs are developed subsequently to the leaves themselves,) this is as we should expect, the hairs being epidermal structures, see also page 37. — The apical cone itself, fig. 24 consists of thin walled cells, with plentiful protoplasmic, the cells are quite small, and are meristemmatic, that is, all undifferentiated, alike, and capable of subsequent change and growth.
Fig. 25 shows the same portion of the apical cone, only at a more advanced stage of growth. The epidermic cells contain proplasm and nuclei; some contain a nucleus with two or three nucleoli, others contain two nuclei with each a nucleolus. The cells below these are quite large and rather irregular. The origin of the root-cap in the Sun-flower as in all Phanerogams, may
be considered simply as a luxuriant growth of the primordial epidermis (Dermatogen), situated at the apex in such a way that the part of the dermatogen which covers the apex of the root divides periodically by tangential walls. Thus the dermatogen splits at the apex into two layers of cells, the outermost of which develop into a multicellular cap — the Root-cap.
while the inner layer at first again performs the functions of the dermatogenous, until a new splitting of this layer at the apex causes the formation of a new stratum, which again, on its part, becomes separated by tangential divisions into several layers, as shown in Fig. 16, Plate IV. h.h. is the root of d.d. the dermatogenous, f.f. the pericambium, l.l. the fleurons, and r.r. the
perisblum - i.e. are the primary mother cells, the origin of the perisblum and phloem.

Hair or trichome is the term employed in the higher plants to describe those outgrowths which arise only from the epidermis. The hairs may originate from the primary meristems of the functional vegetation or from young leaves and lateral shoots, if an external layer of cells has
already been differentiated as dematiaceous, in Phaeoro-
game, but they may originate also in much wider fount of the tissue,
system of which have already become further differenti ated, because in
such cases the epidemic long remains generative; e.g., produces rhomata,
and allows of cell division. Hairs are always strikingly different in their form
from the leaves and lateral shoots of the same
Plant, although they sometimes bear a certain resemblance to those organs of other plants.

The development in size of a single hair is usually extremely small compared to that of the member which produces it. Fig. 27. Plate IX shows a trichome taken from the young stem of the Sunflower. The trichomes here are long and narrow with pointed ends, and arise simply or outward.
extensions of the epidermal-cell proper. — The only variation observed is in the number of cells entering into the composition of the individual pair. None seem to have glandular tips. — Accordingly, the surface of the plant is rough but not glandular. Fig. 27.—Plate IX shows a single cell of the trichome with its nucleus, and its protoplasmic contents. These protoplasmic contents are slowly moving, and
ever changing their position.

The amount of protoplasma
is very great as compared
with the amount of water,
(vacuoles). The protoplasm
is limited by the walls
of the cell, but to all
appearances it passes from
one individual cell to
another through the ends
by which they are joined
together.
The fibro-vascular system. The pèine of the higher Cephalogranum and of Phanerogams are traversed by string-like masses of tissue, which in some cases develop by increase in thickness in such a manner that they lose externally the form of strings, and present that of strong masses. They retain however, always, some trace of all their successive differentiations internally, and are
called the fibro-vascular bundles. Very often with care they can be completely isolated from the rest of the tissue of the plant. Each separate fibro-vascular bundle consists, when it is sufficiently developed, of several different forms of tissue, and must therefore itself be considered as a tissue-system; but different bundles, often in very large numbers, unite in most plants to form a system of a higher order.
the fibro-vascular bundles are always formed singly, and in the axis of the root, even in very slender filiform steins, in the case of the Sunflower.-fig. 29. Plate V. -
the fibro-vascular bundle consists at first of similar cells combined without intercellular spaces,- this form of tissue of the young bundle, which has not yet undergone differentiation, may be termed procorpusculum, as it
grows older, single cells of the rows forming the young bundle change into permanent cells of definite form; from these points of origin the transformation of the pro-cambium cells into permanent cells, as seen in the transverse section of the bundle, advances until the cells are all changed into permanent cells, except a single inner layer. This cell-layer remains in a condition
capable of further development, and is then called contivium; and each a bundle is commonly known as an open bundle. Those bundles which contain contivium are termed open bundles, and those which do not contain contivium are termed closed bundles. As soon as a procontivium bundle has become transformed into a closed fibrovascular bundle, all further growth ceases. A given bundle may, and
generally does change much during its course, interlacing here and there with other bundles, and giving off branches at different points. In this case the lateral fusions occur only at or near the nodes. In the internodes the bundles run parallel to one another, and as a rule without lateral fusion. This regularity is disturbed at the nodes by (a) lateral fusions of some of the bundles, but
not all of them, and (V.) by the entry of fresh bundles from the leaves, (usually in the case of the sunflower, three bundles enter) from the petiole of each leaf into the vascular ring. The studies of the bundles, as illustrated, were made after the leaves began to exhibit their alternate arrangement. The cross section of the earlier phloem of the foliage show the bundles, ris in
number, i.e., three from each of a pair of leaves.

Phytotomy - is the study of the distribution of the leaves upon the stem, and of the leaves which govern it. The general conclusion reached is, that leaves are distributed in a manner to economize space, and have a good exposure to light etc. and that this economy, in the whole, results from the formation of leaves in the bud over
The widest intervals between the leaves next below. In the case of crowded leaves we can, by a very simple calculation, ascertain the angle of divergence, and thus determine the primitive spiral. For example, a stem bearing a series of cycles of eight leaves moderately separated on three turns of the spiral, the cycle will be easily recognized, and the expression of the angle of divergence will be \( \frac{3}{4} \).
This is the arrangement in the case of the Sunflower. The leaves in the head becoming so crowded into a rosette that the spiral becomes a very close one, comparable to a watch spring of which the coils contract in approaching the axis. Further, if the inner end of this spring represents the top of the spiral, and its outer extremity the base, it is obvious that on this depressed
Spiral, the leaves nearest the centre would have been the nearest to the top of the more often spiral, and those nearest to the circumference would have been the lowest.

Fig. 30. Plate X is a drawing of one of the smaller leaves of the Sunflower. They are simple, pinnatifid, cordate-acuminate, the margin slightly serrate, ciliated. Venation palmate-reticulate. The surface hissulate. The midrib, with
its strongly marked vascular bundle, runs up to the apex of the leaf, where it terminates abruptly in a mass of glandular parenchyma tissue. Lateral branch-bundles pass off from it and form a network by frequent anastomoses, while some branches run up into and terminate in the serrate projections of the margin of the lamina in a manner similar to the midrib. Smaller branch-bundles which some-
Tissues and blindly in the parenchyma and fill the meshes of the network, the arrangement of the leaves at the lower part of the plant, (and including the cotyledons which wither at an early stage) is opposite, higher up the phyllotaxy becomes alternate and has the 3/4 arrangement, as before described. This is illustrated by the diagram from the leaves are at first small, and much longer.
they are wide at length; they are very large, oval, and acuminate, then they diminish again to the shape of the earliest, and blend into the involucral scales.

Fig. 31 is one of the leaf-like chaffy scales, which go to make up the involucres imperceptibly blending into it, it has from 3-5 veins running almost parallel.
In the well known sunflower, we have the structure characteristic of the whole order Compositae. At the flowers are associated in a capitulum or head, or to be more concise, are all borne upon a broadly expanded disk the enlarged top of the stem. The disk or central flowers alone are fertile, the ray or marginal florets being destitute of both pistil and stamens. Each floret is
placed before a bract as flowers in the axils of leaves, but in contracted form. The calyx consists of two or three dry sharply pointed scales, commonly termed the crown or pappus. The whole mass of florets is encircled by a close involucre of leafy bracts, all the flowers are yellow. Fig. 37. Plate XII is a disk flower surrounded by four scales and showing its adjustment on the seed upon which it is borne,
They are perfect and fertile.
Fig. 33 is the same as
Fig. 32, only more enlarged.
Fig. 34 is the corolla, very
much enlarged, and showing
the little trichomes with
which it is covered.
Fig. 35 is one of the thin
chaffy scales which surround
the corolla, it is also
covered with trichomes.
The pistil, fig. 36, Plate XIII,
consists of a lower thicker
portion, the ovary, a, and
a slender curved part, the
style, b, the stigmatic portion.
of which is divided into two parts forming the stigma, etc. This is covered by 
foetillae so as to render it plumose, and to which many pollen grains are 
attached. On the same 
plate, fig. 37, are represented some of the pollen grains 
much enlarged; they are 
spinulose.

Between the corolla and the 
depressed apex of the stam 
ecies a fresh series of or 
whorl of five lobes, there 
are the stamenes, fig. 38.
They are syngnathous, and are inserted on the top of the akene.

As regards fertilization; — Müller says that Delphinium
founds Helianthemum fertilized chiefly by the little insect
Hermes Truncorum, which
topped the flowers in their
first staminate stage, and
dexteriously swept up the
pollen that exuded from
the anther-cylinder with its
abdominal collecting hairs;
hence he concluded that
the insect and the plant
had been especially created for one another. The various relations of insects to flowers prove such a conception to be untenable.
The Sunflower is sometimes said to be Sun-following, but this movement with the sun is more imaginary than real. The better explanation being afforded by the resemblance which the expanded inflorescence bears to "the radiant beam of the sun"; the central disk of tubular hermaphroditic flowers encompassed by the spreading outer florets of the ray, has indeed a marked resemblance to the sun as conventionally depicted.
there are numerous varieties of the common sunflower in cultivation, the so-called double form being one in which the ordinary tubular floretae in the centre become spreading and "ligulate" like those at the circumference. The seeds, or more accurately speaking, the fruitae, contain much oil, for which the plant is cultivated in Russia. The oil is a good driers, oil nearly equal to that of linseed, it is also used in the
The seeds are also valued for their agreeable flavour, and are much used as food for poultry. The leaves are fed to cattle, and the flowers yield good honey. The planting of sunflowers is reputed to be a preventative of miasmatic fever, and the faith is sometimes used instead of the true mora. Few plants so exhaust the soil of potash, the constituent in which most
Soils are deficient; the cultivation of the sunflower sometimes recommended for various uses, would soon render fertile soils unproductive. For this reason it is not likely ever to become a profitable crop.
There are several questions which naturally arise concerning the growth and development of any plant and which can be solved only by experiment; questions concerning their growth at different times and under different circumstances: whether they grow more during the day time or at night when the chlorophyll-bearing bodies are not in a state of activity; whether it grows more on bright or on
cloudy days, whether it grows more in cool weather or when it is warm. These and similar questions arise which can only be solved by experiment.

For the purpose of solving some of these questions in regard to the Sunflower, a simple auxanometer was arranged, which consisted simply of two grooved wheels over which a thread was passed which was attached by one end to the top of the stem.
of the plant, and had a weight at the other end to keep it taut. The thread passed over the grooved wheels and down by a scale at the side, and as the plant grew upward the weight went down the scale and in this way the difference in its growth at successive spaces of time could be measured. By means of this auxanometer I found, that the plant grew very slowly on a cool day.
whether it was cloudy or bright, also, as a general thing, it grew more in the daytime than at night. Several nights however when quite warm it grew considerably more in the night than during the day. The most it grew at any one space being 3½ millimeters, one very warm night, the most it grew during any one day being 2½ millimeters.
II.

It would appear then that the increase of the plant in height depends upon conditions of temperature rather more than upon any other one cause.
Description of Plate I.

Fig. 1. Shows a seed. — (natural size).
Fig. 2. — Seed enlarged.
Fig. 3. — Seed after embryo began to grow.
Fig. 4. — A thinview from the seed.
Fig. 5. — Cross section of pericarp.
Fig. 6. — Large cell of same.
Fig. 7. — Section of Testa.
Description of Plate II.

Fig. 8. is a longitudinal section of seed.

Fig. 9. is single cell from fig. 8.

Fig. 10. same cell as fig. 8, but later after differentiation has begun.
Description of Plate III.

Figs. 11, 12, and 13 are different stages in the development of the young plants.
Description of Plate IV.

Fig. 14. - Cross section of plane, showing position of fibro-vascular bundles.

Fig. 15. - A single " " " "
Description of Plate V.

Fig. 1b. is a longitudinal section of the stem.
Description of Plate II.

Fig. 17. Cross section of cotyledon showing stômata.

Fig. 18. Section of epidermis from upper side of leaf.

Fig. 19. Same thing from under side.

Fig. 18 a. Single stômata.
Description of Plate VII

Fig. 20. - A diagram of a cross-section of the embryo.

Fig. 21. - is a section of this showing all its parts.

Fig. 22. is one of the parenchyma cells from Fig. 21.
Description of Plate VIII.

Fig. 23 - A longitudinal section of the apical buds.

Fig. 24 - Is the tip of Fig. 23 showing the arrangement of the cells.

Fig. 25 - Same portion of apical cone but at more advanced stage of growth.
Description of Plate IX.

Fig. 26. - Shows the root cap.

Fig. 27. - The trichome.

Fig. 28. - A single cell of a trichome with its nucleus and moving protoplasm.
Description of Plate V

Fig. 29. - Shows the fibro-vascular bundles of the stem.
Description of Plate XI.

Fig. 30. A leaf of the Sunflower.

Fig. 31. One of the scales of the involucre.
Description of Plate XIII

Fig. 82. - Is a dark flower

Fig. 83. - Same thing enlarged.

Fig. 84. - Shows the corolla with its trichomes.

Fig. 85. - One of the thin chaffy scales which surround the corolla.
Description of Plate XIII.

Fig. 36. - The stigmatic.

Fig. 37. - Pollen grains.

Fig. 38. - The stamens.
Description of Plate IV.
The results obtained from the reading of the
Baranometer.
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Plate XIV
Description of Plate XVI.
Continuation of Plate XIV.
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Description of Plate XVI.
Continuation of Plates XIV
and XVI.
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Description of Plate XVII.

Spiral, showing the arrangement of the leaves on the stem.