Morphology of stamen:

The stamen is the male reproductive organ in angiosperms. It is also known as androecium or microphylls. The stamen composed of slender stalk with a supporting knob. Each anther consists of two lobes connected by a connective. Each anther has two pollen sacs placed longitudinally. The pollen chamber represents a microsporangium that contains many microspores. Each stamen consists of two parts- filament and anther. Some morphologists believed that the stamen consists of three parts-filament, anther and connective. Filament is the midrib, while anther is formed by the union of the margins of the foliage leaves. Various interpretations have been advanced from time to time regarding the morphology of the stamen.

Classical view- Goethe proposed that flowers are like abbreviated vegetative leaves. De Candolle further elaborated the theory and stated that the stamens and carpels are all similar to leaves. Thus, the individual stamen is a leaf which has been modified to form a reproductive organ. The anther represents the lamina and the filament is the midrib and the whole structure may be a set of modification of lamina. Arber and many other reported the homology of stamen parts with the foliage organs.

Telome theory- Wilson stated that Goethe's hypothesis is lacking palaeobotanical evidences. According to him no theory of the origin and morphology can be established based on assumption without fossil evidences. Various studies led to the view that the body of early land plant was the branched axis. The proximal portion becomes differentiated into an absorbing organ and the distal organs evolves a fertile and sterile branched system. These systems probably grow dichotomously, and sporangia are formed terminally. Based upon the fact, the foliar organs and other parts of the angiosperms derived from the sterile branched system and the essential parts the flower from the fertile system. Accordingly, the modern system came into being as a result of extensive reduction and specialization of fertile dichotomous branched system. The four celled anther of the angiosperm stamen is explained by he reduction of ultimate and penultimate branch and then by fusion give rise to paired sporangia. Wilson though believed that the stamen has evolved from dichotomous system, yet the final evidence is lacking. However, he forwarded his opinion as the Goethe's hypothesis is rational.

Revolutionary view- Thomson put forwarded another views on the ontogeny of the flowers. According to him the flower is essentially a heterogenous fertile axis bearing floral parts in the torso. The base is sterile and produces bracteole, bracts and sepals. Rest of the superficial axis is potentially sporogenous which give rise to petals, staminode, stamens and carpels. Work of Thomson is opened for memoir of interpretation.

According to Hunt, the stamen is not homologous to entire leaf but a part of leaf and the term sporophyll may not be applied to modern stamen.

Reviewing all the theories proposed so far, the classical theory looks more convincing, as it stated that flower is a modified shoot and the stamen is a part of it.

Morphology of carpel:

The constituent parts of a gynoecium are known as carpels. According to Goethe and adopted by A. P. De Candolle- "each carpel may be considered as a little leaf folded upon itself". The similarity in form and structure between carpel and leaf has been strongly within recognizing the leaf like nature of carpel. Eames (1961) stated that "the carpel has been called a fertile leaf and the leaf, a sterile sporophyll".

There are two schools of opening regarding the origin of carpel, they are-

(I) **Axial origin** and

(II) **Appendicular origin**.

According to the view that supports the axial origin, a carpel has been recognized as an organ developed from the receptacle on which ovules are borne. The other view holds that the carpel is appendicular in origin and developed like a leaf but in a modified form specialized for reproductive function. But considering anatomy, ontogeny and comparative morphology, the appendicular origin of carpel *i.e.* the carpel is a fertile lateral appendage has been much widely accepted.

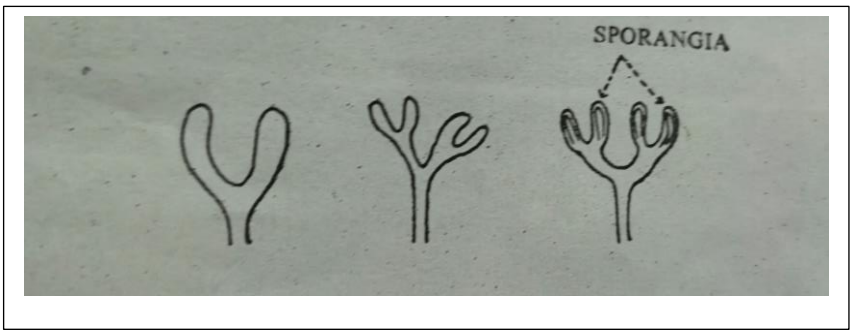
Several theories have been considered in elucidating the nature and morphology of carpel-

1. **Axial nature theory**- According to this theory, organs like sepals, petals, stamens and carpels are considered as originated from the axis- and basically the telomes *i.e.* the elements of the thalloid body. As the axial nature of the carpel cannot be interpreted in the light of this theory, hence the axial nature of carpel is also doubtful.
2. **Acarpy theory**- According to this theory, the carpel is not recognized as a morphological unit but as an emergence of stem tip. Under this theory, the flower is considered as a determinate stem tip with emergences- the lower ones being sterile and form bracts, sepals and petals and the upper fertile ones form stems an carpels.
3. **Organs "Sui Generis"**- This theory also does not recognize the carpel as a morphological unit. According to this theory, the carpel is an organ "Sui Generis", which means an organ neither leaf nor leaf like in nature, an organ produced as it is.
4. **Carpel Polymorphism**- An entirely new theory regarding the morphology of the carpel was put forwarded by E. R. Saunders in 1923 and termed as carpel polymorphism. According to this theory three basic types of carpel- solid, valve and semisolid were recognized. The valve carpels were commonly described as open and sterile. The solid carpels were fertile which bear one or more ovules. The semisolid types were somewhat intermediate between the two which generally approach the valve type. The theory of carpel polymorphism was founded on the basis of anatomical studies, that included the number of vascular strands supplying the gynoecium as well as to the carpels.

   Many morphologists comment against this theory. The morphology of other similar structure such as the leaf cannot be interpreted in the light of this theory. Secondly, the theory was forwarded neglecting the basic vascular structure of the plant body. Considering all these aspects, the polymorphism theory seems to fail to explain clearly anything particularly about the morphology of the carpel.

Telome theory:

This theory was proposed by Wilson (1937). According to this theory the foliar organs and essential parts of the flower of angiosperms evolved by the modification of fertile, terminal and dichotomously branched axis *i. e.* the telome. Studies on the fossil plants have led to the view that the body of early land plant was a branched axis. The proximal portion of the axis eventually become differentiated into an absorbing organ and the distal region evolves into a

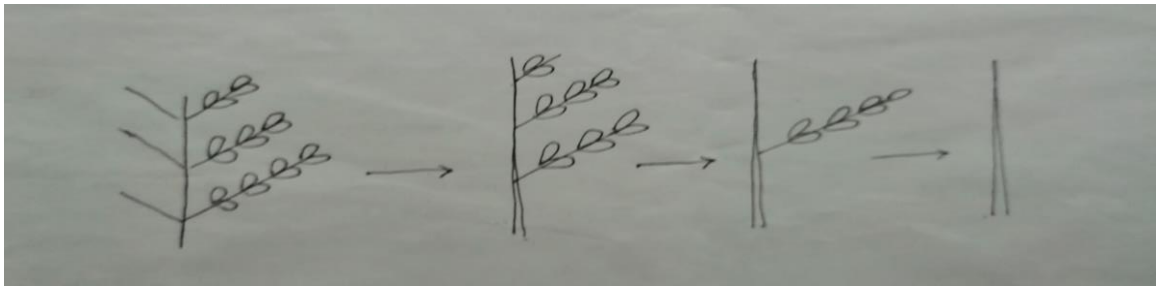


sterile and a fertile branched system probably grow dichotomously, and the sporangia were terminal in position. But Wilson's proposition of the origin of stamen from dichotomous system is also lacking in concrete evidence.

Phyllode theory:

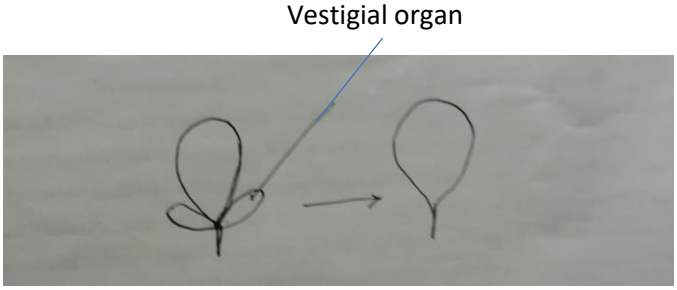
In some plants the petiole gets flattened, photosynthetic deep green coloured pinnae proper is lost or vestigial, then such modification of petiole is called phyllode. 'The low of lost' proposed by Dole centers round the fact that the structure when lost during the process of evolution, it is never regained. The phyllode theory is proposed by A. Arber, based on this concept. Main sources of this theory are the monocot leaves which are like the dicot petiole.

It is important to consider some of the modification found in dicot *Acasia malangen* **(**Australian Acacia) has bipinnate compound leaf during the seedling stage. The petiole exhibits reduction

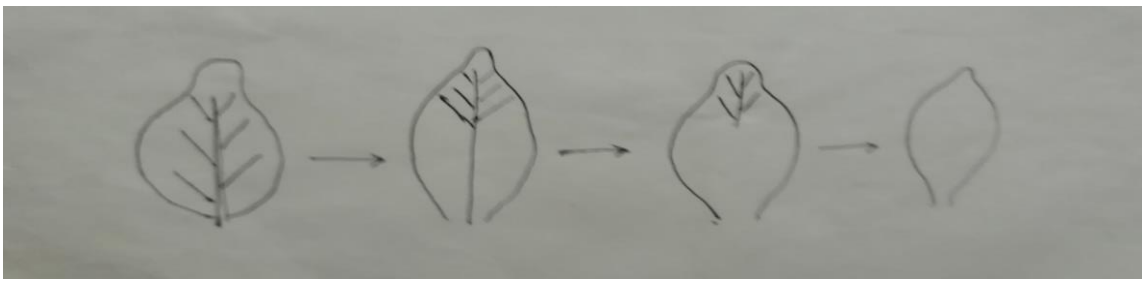


Development of phyllode in *Acasia malangen*

of leaflets. In extreme cases it is only a phyllode with no trace of leaflet. A transverse section of the petiole shows a radially symmetrical organs with vascular bundle situated on both sides pointing towards the center. In *Eryngium* the vestigial leaf on the lateral side of the phyllode are always seen. In *Clematis* leaflet petiole gets flattened during the process of evolution with the lamina gradually reduced.

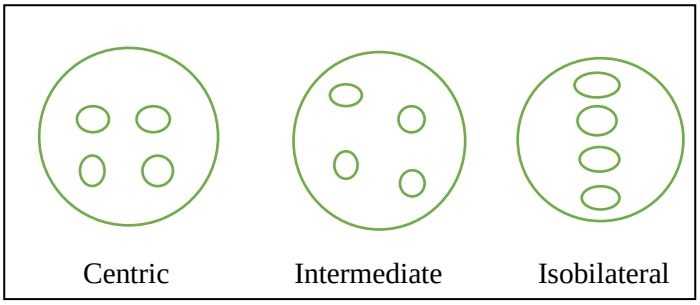


Eryngium

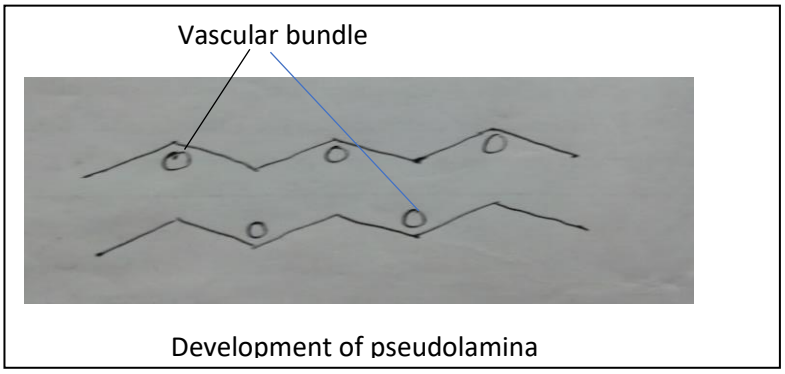


Development of phyllode in *Clematis*

The phyllode can be divided into two main categories- centric and isobilateral. Centric phyllode are radially symmetrical. This may be derived from the petiole. But in most of the monocots, it is isobilateral. They posses a row of bundles. In the genus *Cymodosia* various types of phyllode are observed, in *C. isoetefolia*, the phyllode is centric, while in *C. nodosa* it is ribbon shaped and in *C. natan* the phyllode is an intermediate type.

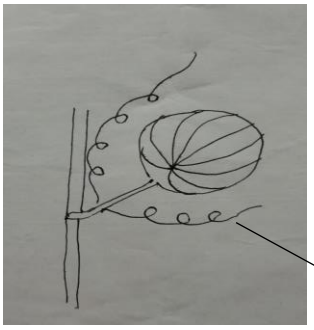


In some species of Palmae the phyllode is formed from the petiole part and the leaf blade is called pseudolamina. It is due to invagination which penetrate into the thallus between the vascular bundle creating a fan like phyllode.



Development of pseudolamina

Considering all the histological evidences we may say that in the petiole the vascular bundles are in a ring but in the leaf, xylem passes the upper sides and the phloem to the lower. If a flat organ is to be derived by flatting of the radiating symmetrical structure, origin of the bundle will not be constant as in direct lamina. This proved that the phyllode is nothing but a modified petiole.



Tendril in stipule

Arber feels that this theory is applicable to *Smilex* and *Dracena*. Origin of tendril is similar to that of stipule. Goebel says that this is the universally accepted theory and concluded that phyllodes are nothing but stipule- the decomposed petiole.

Carpel Polymorphism:

An entirely new theory regarding the morphology of the carpel was put forwarded by E. R. Saunders in 1923 and termed as carpel polymorphism. According to this theory three basic types of carpel- solid, valve and semisolid were recognized and found in most of the species in multiplied numbers. The gynoecia of the leguminous plants consisted of one carpel were described as having two carpels- one solid and other valve type. Similar conditions were found in some other plants also. The valve carpels were commonly described as open and sterile. The solid carpels were fertile which bear one or more ovules. The semisolid types were somewhat intermediate between the two which generally approach the valve type.

The theory of carpel polymorphism was founded on the basis of anatomical studies, that included the number of vascular strands supplying the gynoecium as well as to the carpels.

Many morphologists comment against this theory. According to them, the morphology of other similar structure such as the leaf cannot be interpreted in the light of this theory. Secondly, the theory was forwarded neglecting the basic vascular structure of the plant body. Considering all these aspects, the polymorphism theory seems to fail to explain clearly anything particularly about the morphology of the carpel.

Inferior ovary:

From the evolutionary point of view, the superior condition of the ovary is considered as primitive than inferior ovary. Three theories have been proposed regarding the origin of the inferior ovary. They are-

(i) Appendicular theory

(ii) Receptacular theory

(iii) Axial theory

Appendicular theory- This theory was put forwarded by De Candolle, Van Teighem and others and supported by Eames (1961). According to this theory the inferior ovary has developed as a result of the fusion of the bases of sepals, petals and stamens and as such appended to the axis of the flower which has nothing to do with the formation of the ovary wall. Eames stated that due to evolution, inferior ovary was developed from the superior one by the process of gradual fusion of the bases of sepals, petals and stamens and adnation of the same to the gynoecium wall which indicate the superiority of inferior vary over inferior ovary.

Receptacular theory- According to Schleiden and others, the receptacle of the flower has become the instrumental in the formation of the inferior condition of the ovary. This has achieved through the gradual sinking of the ovary to the deep cup shaped receptacle with the process of invagination of the tip of the thalamus. After sinking down of the ovary the bases of sepals, petals and stamens have been fused much in the same manner as in case of the appendicular theory.

Axial theory- According to this view, the inferior ovary is a sporogenous axis produced out of the much rapid growth of the receptacle over that of the apical growth resulting in the formation of the inferior condition of the ovary. On the other hand, the ovary may be superior when the apical growth dominates the receptacular growth. This view indicates that the condition of the ovary will be superior or inferior depending upon the relative dominance of the growth of apical or receptacular tissue over the other.

Role of Morphology in Taxonomy:

The study of morphology means the study of forms and features of different plant organs, such as roots, stems, leaves, inflorescences, flowers, fruits and seeds. Both external and internal morphology of plants play a significant role in the classification of angiosperms which was seen from the very beginning of the study of systematic botany as taxonomy. Plants on earth are not only numerous but also of varied type and as such it is impossible to study them unless they are arranged in some orderly manner. So, the object of classification is to describe the name and classify plants in such a way that their relationship with regards to their descent from a common ancestry may be brought together. Plants are classified on the basis of habit, nature, number of cotyledons, forms and arrangement of leaves.

Habitat as criteria- The number of species of woody plants of any temperate flora is usually fewer than the number of herbaceous plants. Thus, the species of temperate woody may be separated from herbs. For this reason, the habitat of plants is useful criteria in classifying the angiosperms of temperate zone.

Phylogenetic characters as criteria- In the modern classification of angiosperms by Hutchinson also selected some of the morphological characters in classification though it is based on phylogeny. For instance, he considered different habit, nature of plants and evolution in his classification. He took following important morphological characters-

a) Trees and shrubs are more primitive than herbs.
b) Dicots are more primitive than monocots.
c) Simple leaves are more primitive than compound leaves.
d) Bisexual flowers are more primitive than unisexual.
e) Solitary flowers are more primitive than inflorescence.
f) Polypetalae (separate petals) is more primitive than gamopetalae.
g) Regular flowers are more primitive than irregular flowers.

Cotyledon as criteria- The dicotyledonous plants has two cotyledons in the seeds whereas in monocotyledons there is only one, so that the plants are easily recognizable by counting their number of cotyledons. The dicots usually have reticulate venation, but monocots have parallel venation in their leaves. The dicots have tap root system as compared to fibrous root system in monocots. The flowers of dicots are usually pentamerous or tetramerous whereas in monocots the flowers are usually trimerous. Among some families of dicots, the ovary position is either superior or inferior.

Inflorescence as criteria- It is important to understand how to use the inflorescence in the classification of angiosperms and to know what type of inflorescence is primitive or recent. Generally racemose is considered as primitive than cymose. Racemose has several forms, some of which are distinctive characters of some families, like presence of umbel inflorescence indicates the family Umbelliferae, head on inflorescence indicate the family Asteraceae, verticillaster indicates the family Lamiaceae etc.

Reproductive structure as criteria- The floral structure along with different characters was thoroughly studied from the time of Linnaeus for classification of angiosperms. Presence of perianth is a distinctive character for classification. Again, petals may be pentamerous, tetramerous or trimerous. Dicot in general, are pentamerous or tetramerous whereas monocots are always trimerous. On the basis of sepals and petals characters, flowers may be polypetalae, gamopetalae and polysepalous or gamosepalous. Stamens may be free, monadelphous, diadelphous or polydelphous. For instance, monadelphous stamens are found in the family Malvaceae, diadelphous stamen in Papilionaceae and polydelphous stamen is the characters of Rutaceae. The anther may be basifixed, dorsifixed or variable according to their mode of attachment to the filament. The flower may be unicarpellary, bicarpellary or polycarpellary. The ovary may be superior or inferior bearing one or more chambers containing ovules which is the important criteria for classification. The mode of arrangement of ovules in the ovary is known as placentation and basal placentation is one of the important characters of the family Asteraceae. By considering the style character, gynobasic style is a classifying feature for the family Lamiaceae. The number of stigma usually represent the number of carpels. For example, in the family Malvaceae the number of carpels and number of stigma is equal i.e. five stigma and five ovary chambers.

Fruits and seeds as criteria- Fruit characters also play a very important role in classification, for example, presence of legume fruits indicates Laguminosae family. Presence of siliqua fruits indicates the Brassicaceae family.

Now a days, the biosystematists as well as modern taxonomists start to consider the evidences from morphology, ecology, cytogenetics, phytogeography and physiology towards building a single discipline- the modern plant taxonomy.