ANGIOSPERM, PLANT DEVELOPMENT AND REPRODUCTION BIOSYSTEMATICS

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CHAPTER 1

ANGIOSPERM PHYLOGENY AND INTRAPOPULATION VARIATION ORIGIN

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ABSTRACT:

About 125–100 million years ago, during the late Cretaceous Period, angiosperms began to emerge. In order to attract pollinators and safeguard their seeds, angiosperms have evolved blooms and fruit. Flowers come in a broad variety of hues, forms, and scents, all of which are designed to attract pollinators. Differentiation and Evolution of Species-Based Models Angiosperm ancestors with their times and locations of origin Biologically Simple Angiosperm Angiosperm's relationships with other extant groupings Ecads and Ecotypes describe how population and environment interact.

KEYWORDS:

Allopatric, Angiosperms, environment, Phylogeny, Sympatric.

INTRODUCTION

The study of populations provides the foundation for understanding how species come into being since different populations may share the same gene pool or may have experienced gene pool isolation. Following the study, the terms "Ecads" and "Ecotype" were developed, and the difference between the two is that, in Ecads, morphological variations vanish when they grow in the same habitat, indicating that they are not genetically coded, whereas in Ecotype, the variations persist because the characters are genetically coded. Due to the genetic modification of the characteristics and the resulting speciation process, this population isolation mechanism led to the creation of new species. Both allopatric and sympatric patterns may result in speciation. The Biological Species Concept is a concept of species reflecting about the species that a population or series of populations that freely interbreed here organisms reproductively isolated from other such populations.

Scientists have described various models and concepts of species that help in understanding the species at different levels.Because the fossil record hasn't revealed any definitive evidence on the genesis of angiosperms, the study of the origin of angiosperms is a vast topic with many unanswered questions. However, contemporary science has in some way deduced the relationship between the main groupings, their phylogeny, and the places where they originated. While some botanists show the affinities and origin of Angiosperms with lower group and primitive Angiosperms like Ephedrales, Gnetales, Amentiferae, Ranalesccc, and Isoetalean members, some fossil records show their origin or relation with Pteridospermales, Bennettitales, Cycadales, and Pentoxylanean group[1].

Intrapopulation Variation's Cause

Climate and Population

In general, multiple definitions of the population are used for various reasons. Population is the set of people who often appear together. The term "group of individuals considered to gene-pool together at any one time because of the features they share in common" is one that is often used by taxonomists. It refers to a collection of such plants that grow in a certain location or a group of related plants growing together. In population genetics, the ability of a specific group of individuals to exchange genes is often facilitated by their cohabitation. As a result, "a group of individuals less degree with of crossing and with consequent gene flow" may be used to define a breeding population. Here, two things should be mentioned.

Potential for cross-breeding

Genetic resemblance

Particularly at the gene level, the population is not characterized in terms of physical traits. The term "population" refers to a group of individuals who share a gene pool and so become inbred. Sirels divided the populace into two distinct groups, the plurispecific population and the unispecific population. The plants, animals, and microbes living in the same environment together make up the plurispecific population. That population's territory may be a square yard, a square mile, a piece of wood, or an ant hill. In addition, a unispecific population is a collection of people that share the same species and environment. As populations may differ in size, composition, and area, they are always prone to change. They might become bigger or smaller.Different researchers have conducted a number of tests on the population. The major focus of Turesson's experiment was the differentiation of populations under various ecological conditions. His experimental garden at "A karp" in Sweden collects population samples from various regions and grows them under controlled conditions to study their genetic, morphological, and physiological characteristics. He observed how plants under cultivation reacted during the course of the year in terms of habit, height, and blooming time, among other factors, and discovered that although in some cases the variations noticed in the field vanished, in others they exhibited intergraduation, and they generally survived. He demonstrated how the genetic differences across races often corresponded to ecological variations and how comparable selecting pressures in the ecosystem seemed to result in similar types of adaptation in other animals. These outcomes of the interaction between the genotype and the environment were given the name "ecotype"[2].

Experiment by Clausen, Keck, and Hiersey:

These botanists are well-known for their transect experiment, which included gene ecology investigations of populations of a variety of species, including Achittea milkfolium and Potentilla glandulosa. . In order to examine climate variations, a transect was drawn across Central California. At elevations ranging from around 30 meters to 500 meters and 3300 meters, experimental gardens were built and kept weed-free. These were prolonged for more than 30 years, demonstrating the breadth of the inquiry. The aforementioned species were raised in populations at different elevations, and their reactions to the climate were documented. The morphological and physiological traits of the ecotype acclimated to comparable climatic circumstances shared a superficial similarity or parallelism. Ecotype hybrids were shown to be totally viable and capable of giving rise to new genotypes with fresh adaptive traits. These two studies unequivocally demonstrated that interactions between genotype and environment might conceivably cause ecotype.Gregor's Experiment: At the Scottish Society for the Research in Plant Breeding, Gregor and his colleagues conducted comparable studies. They referred to these researchers as experiment taxonomists, and Gregen, Dowey, and long examined its practical methods. Traditional experimental taxonomy was seen as compatible by them. In order to study race variation unhindered by the abnormalities of their native habitat, they had the races produced under uniform environmental circumstances in the experimental garden. They studied the races of Plantago maritina and came to the conclusion that the gradients in the habitats were reflected in the pattern of ecotype variation, which was more typically continuous than discontinuous.

Ecads and Ecotypes

Ecads

The name "Ecads" refers to plant species that share a homogeneous genetic pool but varies in appearance, particularly in morphological aspects like the size of the vegetative component, the number of stems that are upright, and reproductive vigor. The causes of their variance are environmental factors. These variances vanish when several ecads or ecophenes are introduced into the same environment, as is the case, for instance, with Haplopappus species. The soil type has a significant impact on the appearance of Haplopappus species, an Asteraceae shrub. Haplopappus venetus and Haplopappus decumbens were formerly thought to be two distinct species by many taxonomists, however after being planted in the same habitat and soil type, both species were recognized as ecads rather than distinct species. Analogously, Euphorbia hirta grows prostrately in disturbed areas but erectly in undisturbed areas. A species may inhabit a variety of habitats since these morphological changes are not permanent, and upon transplanting, the prostrate form may grow upright.

Ecological Types

The fundamental unit of biosystematics is the ecotype, which may produce fruitful hybrids with other ecotypes while being tailored to a specific environment. Therefore, genetic barriers do not separate ecotypes of the same species. It is comparable to a number of populations that belong to different species or subspecies.Turesson coined the phrase "ecotype.”. According to his definition, an ecotype is an ecological unit that includes the byproduct of a species' genotypic reaction to a certain environment.Later, Turesson stressed the genetic propensity of ecotypes to cross, followed by Gregor; Clausen, Keck, and Hiersey’s extended the idea and provided the definition as follows: "A population that differs from other ecotypes of the ecospecies in terms of morphological and physiological characteristics, usually of a quantitative nature, interfertile, and constrained from freely exchanging genes by ecological barriers."

Differentiation and Evolution of Species-Based Models

Although the word itself indicates the development of physical distinctions in the phenotypic, speciation is used to the creation and evolution of populations in terms of genetic processes. The creation of separate gene pools for reproduction is the subject of speciation. Today, pretending that these genetically determined units correspond to morphologically defined species is pointless. . Given this, it seems unfortunate that the process leading to the emergence of units that taxonomists would not consider species is known as speciation. Taxonomic species have naturally developed via different genetic processes inasmuch as they represent populations, but they do not all reflect reproductively isolated, intrabreeding units. Contrarily, what taxonomists refer to as species reflect a variety of evolutionary circumstances? Among the numerous situations that have been looked into genetically or biosystematically, it is quite difficult to locate an example of an "ideal" or simple species, as Walters observes. In most cases, apomixis, inbreeding, polyploidy, hybridization, or a mixture of these, or some other complex element, is at work. The study of the link between taxonomic species and the micro-evolutionary conditions or units with which they most closely overlap is one of the most fascinating and engrossing areas of inquiry for taxonomists today. We believe that this argument has to be emphasized quite a bit since there is now tremendous opposition to any ideas that shed light on the evolution and genetic makeup of taxa. However, supporting the practical morpho-geographical use of the word "species" does not diminish the significance of micro-evolutionary, population, and genetic research on the makeup of taxa. It merely views them as distinct but complementary strategies. To argue otherwise is plainly wrong, and to try a workable classification with taxa based on gene pools is simply to misunderstand the fundamentals of practical classification. Genetic basis of species is not crucial for their identification and naming by taxonomists. What does speciation have to do with taxonomy, then? The solution to this question is trickier.

The already-suggested answer is an obvious one: even though such knowledge may not in any way affect their actual classification processes or the units recognized in practice, most taxonomists today seek to understand the evolutionary nature of the species and lower units that they describe in morphological and geographic terms whenever possible. The following considerations must also be made: We cannot assume that the beginnings of taxonomic species are those of reproductively separated populations since this is not the case.By doing this, we could discover that taxonomic species don't really reflect Mendelian populations at all, but rather much more complicated and ambiguous circumstances. They might encompass more than one gene pool, roughly correspond to one, or not represent Mendelian populations at all.A more natural and suitable method of delimiting the species may be discovered as a consequence of such investigations, but this should only be used if the new delimitation is supported by clearly defined morphological traits. In other words, regardless of the likelihood of morphological identification, species should make taxonomic sense and not be recast only to satisfy gene pool requirements. To recognize the various cytodemes as separate species merely because they represent various isolated gene pools may satisfy the needs of some geneticists, but would make little taxonomic sense. Speciation studies may reveal that a taxonomic species comprises diploid and tetraploid that cannot be morphologically separated[3].

The notion that all plants are organized into distinct, reproductively segregated gene pools is untrue. Reproductive isolation is caused by a variety of causes that occur in varying degrees of intensity, develop at varying speeds, and function in diverse populations in various waves and to varying degrees of efficacy.It is sometimes forgotten that studies of speciation assume a categorization into taxonomic species. Even while evolutionary or population taxonomists are often willing to critique the archaic nature of traditional taxonomic practices and units, they are wholly reliant on the presence of a classification before they can begin their own work. It is questionable if we could come up with a more useful strategy than merely attribute grouping that is morphologically expressible if we could start clasisification from scratch. However, as humans do not have this possibility, efforts to redefine species in terms of genetics are ongoing and often unsuccessful. While obviously limiting the significance of speciation studies in categorization, the fact that taxonomically and genetically determined species cannot always be equated opens up an exciting new area of interactions for research.

There are many theories about the origin of the species, but the true theory of speciation makes it obvious how the population has diverged from its predecessors or how the two groups have diverged from one another. Population isolation may take the form of an allopatric or sympatric pattern. The differentiation and full achievement of reproductive isolation of the population that is totally geographically isolated is known as allopatric speciation. As opposed to sympatric speciation, which is the differentiation and full achievement of reproductive isolation of the population that is not fully geographically separated. Their distribution overlaps with other populations.

Species idea according to Biosystems

The goal of biosystemics is to identify natural biotic units, or populations of plants that remain unique from other populations due to biological barriers that physically or genetically separate them from others. Breeding behavior or the difficulty to create viable hybrids with closely related groups may be the causes of these isolated breeders[4].

Concept of Species in Numbers

Another method of taxonomy is to give equal weight to all types of evidence. Numerical taxonomy is the name for this statistical methodology. This method's fundamental principle is that it takes a lot of evidence to distinguish between taxa. For every particular research, between 50 and 300 criteria are considered, ranging from morphological to biochemical traits[5], [6].

Concept of Typological Species

This is the simplest and most frequently accepted theory of species, according to Mayr. The constancy of species is the tenet of typological thought. According to this theory, variation is just an incomplete expression of the idea that underlies all species. Multiple species must be involved if the degree of variety is too vast to be attributed to flaws in our sense organs. Thus, the degree of morphological difference determines the status of the species. The morphologically defined species are produced as a consequence of the typological species notion being applied to practical taxonomy. The standard for determining a species' status is the "degree of morphological difference." On the basis of their discernible morphological distinctions, species are classified.

Chronospecies

In a phyletic lineage that is awarded ancestor and descendant status in accordance with the geological time sequence, successive species are replacing one another[7]–[9].

CONCLUSION

An informal international group of systematic botanists known as the Angiosperm Phylogeny organization collaborates to create a taxonomy for flowering plants that incorporates fresh data on plant relationships discovered via phylogenetic studies. The Pentoxylales are a subclass of Pteridosperm fossils. Pentoxylales, according to Meeuse's theory, are the progenitors of angiosperms. He found notable similarities between the Pentoxylales and the present order Pandanales.

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CHAPTER 2

PHYLOGENY OF ANGIOSPERMS

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ABSTRACT:

An informal multinational organization of systematic botanists called the Angiosperm Phylogeny organization works together to develop a taxonomy for blooming plants that takes into account new information about plant connections found via phylogenetic investigations. An informal worldwide association of botanists called the Angiosperm Phylogeny association was formed to reach agreement on the classification of flowering plants. They intended to base it on plant phylogenetic connections. The result of this partnership is a categorization system that has four iterations.

KEYWORDS:

Ancestors,Amentiferae,Angiosperms, Cretaceous, Phylogeny.

INTRODUCTION

The Evolution of Angiosperms and the Angiosperm Ancestors: The origin of angiosperms has not been definitively shown by the fossil record. Although lacking in early Mesozoic layers, diversified and numerous angiosperms first occur as leaves, flowers, pollen, seeds, and fruits in Cretaceous deposits. These specimens definitely demonstrate angiosperms, hence no information on their genesis has been provided by such fossil remnants. Gymnosperms of several groups have been proposed as the ancestors of angiosperms, although not all scientists agree that these hypothesized predecessors are real. However, there are several species that resemble angiosperms in certain ways. The following are these groups:

Amentiferae:

The amentiferous flowering plants are thought to be the most basic group of blooming plants. This is due to the flowers' simplicity, the absence of colored petals, and the pollination by the wind. The microsporphylls of gymnosperm are thought to be relatively similar to the stamens. Some botanists believe that these flowers' simplicity is the product of specialization and reduction, however[1].

Ranales:

Another theory is based on the alleged strobiloid character of certain angiosperm flowers, such Ranunculus and Magnolia, in which a limited number of stamens and pistils are spirally organized on an axis with small internodes. Arber, Parkin, Bentham, Hooker, Bessey, and Hutchinson all agreed that angiosperms descended from Ranalian ancestors. Families without vessels like Tetracentraceae and Trochodendraceae are also members of this order. Pteridosperm: Lyginodendron oldhamium's fronds were found to contain seeds by Oliver and Scott in 1903. Pteridosperms was the name they suggested for the class of Cycadofilicales that produce seeds.

Some Pteridosperms, such as Lagenostoma, which contain cupulate seeds, may have evolved into angiosperms.

Ephedrales Theory:

Wettstein argued that angiosperm descended from progenitors like Ephedra, which in many ways resemble Casuarina, a member of the Amentiferae. Ephedra and casuarina both have modest, little male flowers. The single central microsporangiophore and megasporophyll that are shared by Ephedra and Casurina, as well as the perianth's location in the axil of a bract that may be in pairs of two or four, are further similarities. The female flower's bracteoles in Casurina harden to produce a covering that serves as protection.

Gnetales:

Wettstein identified the Gnetales as a transitional group between Conifers and Angiosperms and discovered that they are closely connected to angiosperms. Later studies by Markgraf and Fagerlind demonstrated a similarity between Gnetales and Angiosperm blooms. In many ways, the Gnetales resemble angiosperms. The wood is heteroxylous, and the leaves have dicotyledon-like reticulate veining. Gnetum's monosexual inflorescence resembles the catkin of several amentiferous taxa, such as Ephedra and Casurina. Gnetum has two unilocular anthers that often tend to fuse together. Gnetum strobilus and the catkin of Amentiferae are thought to have just passing similarity. This notion, which is mostly focused on morphological characteristics, is refuted by molecular phylogenetic research, which demonstrates that Gnetales are not linked to Angiosperms.

Pteridospermales:

Andrews hypothesized that certain Pteridosperm from the Palaeozoic era, such as Lagenostoma, gave rise to angiosperms, but the cupules of Gnetopsis and Calathospermum are multiovulated. The first integument of an angiospermous seed is said to be generated by the fusing of telomic units, and the second integument is an expansion of the first integument, according to Long. This explanation supports the idea that the carpel originated from the Pteridosperm cupule.

Bennettitales:

The Bennettitales are a group of Mesozoic Gymnosperm plants that were active from the Jurassic through the Cretaceous. Bennettitales strobilus or flowers have a bisexual structure and resemble today's magnolia blossoms. The Bennettital family[2], [3]

Angiosperm Originated

The genesis and early development of angiosperms have baffled botanists for more than a century. The majority of the plant kingdom, known as angiosperms or flowering plants, consists of around 411 families, 8000 genera, and 3,000,000 species. They are thought to be the most advanced plants that exist on Earth's surface. Annual or perennial herbs, shrubs, trees, climbers, twiners, and lianas are all angiosperms. True angiosperm fossils are only discovered in later geological eras, and as a whole, they are more recent than other vascular plants. It is impossible to explain the abrupt emergence of the highly specialized angiosperms during the Cretaceous age. Since this time, angiosperms have dominated the earth's vegetation and are now found everywhere. Angiosperm origin: Angiosperms are thought to have originated in the Arctic area and then moved southward. According to the upland hypothesis proposed by Axelrod in 1970, blooming plants developed in warm uplands at low latitudes. The broad region of South East Asia, close to Malaysia, as the location where angiosperms developed during the early split of Gondwana and Laurasia. Their inception had place in open environments in regions that experienced seasonal drought. Angiosperms are thought to have evolved under environmental stress, most likely as a consequence of adaptation to mild seasonal dryness on steep mountain slopes in monsoon climatic zones, according to a proponent of the neotenous origin of angiosperms. According to the Rift valley system that borders Africa and South America is home to the oldest known angiosperms, which are likely woody, small-leafed plants. Following the early Cretaceous sea level changes, several of these angiosperms adapted to coastal habitats and spread widely. Many writers have proposed that early angiosperms lived near streams and lake edges in recent years, even if they acknowledge the importance of environmental stress. Later, they started to show up in back marsh and channel areas that were more solid, and finally, on river terraces. These areas would have had high levels of nutrients and frequent plant cover loss as a result of recurring disturbances.

DISCUSSION

Biologically Simple Angiosperm

Some blooming plants exhibit primitive traits as a lower group in the early stages of their development. They are known as "living fossils" by scientists. Due to good conditions for them now, these ancient plants have persisted, although now their range is constrained. The families Winteraceae, Magnoliaceae, Degeneriaceae, Himantandraceae, Eupomatiaceae, Annonaceae, Canellaceae, and Myristaceae, which are members of the orders Magnoliales, are home to the earliest extant angiosperms. The families Trochodendraceae and Tetracentraceae, as well as the Austrobaileyaceae, Amborellaceae, Monimiaceae, and Calycanthaceae, are members of the orders Laurales and Trochodendrales, respectively. There are a few more orders that are listed as being primitive members, including Piperales, Nymphaeales, Illiciales, and Ranunculales[4].

The eight families of the order Magnoliales, more than any other order of flowering plants, include the most basic characteristics among flowering plant families. The basic characteristics include lack of a vessel, free floral components organized spirally, large stamens that are not divided into filament and connective tissue, partially closed carpels, and monocolpate pollen similar to gymnosperms. Some people believed the Magnoliaceae to be the most primitive family, while others thought the Winteraceae to be the most primitive. These archaic traits are invariably accompanied with some sophisticated features.

Magnolia

There are 120 species of the Magnolia genus spread across the tropical and subtropical regions of the world. The popular species, M. grandiflora, which is grown in gardens, is one of the 12 that exist in India. Scalariform intervascular pitting is seen in the vessels, which are of primitive type and have scalariform perforations. In wood, the rays and parenchyma are often of the terminal apotracheal type. Due to the existence of several leaf traces, the nodes are multilacunar. They are shrubs and evergreen/deciduous trees. The leaves are pinnately veined, alternating, and whole. The immature buds are enclosed by the sizable deciduous stipules. The blooms are big, actinomorphic, solitary or terminal, bisexual, and hypogynous. Magnolia flowers have spirally organized floral components, which gives them their distinctive shape of a receptacle. The lack of vessels shortens the internodes. The outermost whorl of the perianth, which has 9–12 tepals, is sepalous. In certain species, the calyx and corolla both emerge, although it is unclear how they differ from one another. Stamens with primitive characteristics like three traced, laminar, and generated above the microsporangia are present, and they are numerous, free, and spirally oriented. Magnolia pollen is of the monocolpate type, an ancestor gymnosperm type, and also contains sporoderm that is comparable to certain gymnosperms. The Magnoliaceae family's pollen species may be most primitive in the genus Magnolia. Magnolia is primordial in nature, with a small embryo and plenty of endosperm. The seed-coat's sarcotesta is similarly of a primitive origin[5].

Drimys

In Borneo, New Guinea, New Caledonia, Australia, Tasmania, New Zealand, and South America, there are 70 species of Drimys. Drimys fossils have been discovered in Antarctica, eastern Australia, and the west coast of North America. The members often grew trees and shrubs with simple, whole, pinnately veined, dotted gland, fragrant exstipulate leaves that were alternating or subverticillate. The secondary xylem's lack of vessels is a key characteristic of the trilacunar nodes. The tracheids have thick walls and are initially flanked by big circular pits that are later replaced by scalariform pits. The rays are also diverse. The blooms are produced in fascicles and exhibit very rudimentary characteristics in their structure. They are actinomorphic, bisexual, and hypogynous. The whorled, calyx- and corolla-differentiated perianth has a short floral axis. The calyx, which is divided into two or four sepals, is a membrane bag that encloses the petals. There are two whorls of petals with six or more petals each, placed imbricately. The anthers are dithecous and introrse, and the stamens are organized spirally. The pollen grains advance as they form a permanent tetrad, with the exine reticulate and the distal aperture reduced to a circular pore. Only a few free carpels are organized in a single row. Drimys species from the ancient world have extremely basic carpels that are adaxially folded along the midrib and resemble juvenile leaves. There's also a stock that resembles a petiole. Stigma is pervasive. The seeds of the many-seeded fruits have a little embryo and a ton of endosperm[6], [7].

Degenaria

Degenaria is a monotypic genus of the family Degeneriaceae that is native to the Fiji Islands and has a highly constrained range. Only the little tree species Degenaria vitiensis represents the genus. Scalariform intervascular pitting, thin-walled vessel parts, many perforation bars, and heterogeneous rays are only a few of the primitive structural characteristics that the wood exhibits. It is a pentalacunar node.The blooms are supra axillary and long pedicellate. On the pedicel, there are two to three bracts, and their existence suggests that the single flower may emerge from the inflorescence by the pruning of lateral blooms. The floral axis is brief, the perianth is cyclic, and the calyx and corolla are separate. Twelve to thirteen fleshy, deciduous petals are arranged in three to four whorls and have three persistent sepals. Degenaria's carpels and stamens are quite rudimentary. There are several laminar, filamentous, and connective stamens. Between the median and lateral veins on the adaxial surface of the stamen, there are two long, thin microsporangia that are lodged in the sterile sporophyll tissue. Degenaria therefore possesses the most primitive stamen type among angiosperms. Because they are monocolpate with sporoderm and resemble the gymnosperm members, pollen grains are likewise of the primitive type. Although there are just one carpel in the Degenaria gynoecium. The carpel has a conduplicately folded structure and is quite basic. The carpel's edges are entirely free. Degenaria does not have a fully closed carpel at the time of pollination in early angiosperms. The stigma is persistent and style is lacking. At the moment of pollination, the stigmatic edges are not fused together. The outcurling glandular hairy carpellary edges take in the pollen grains. The carpellary edges' continuous adaxial surfaces become concrescent as fruits mature. Large, leathery, asymmetrical, and indehiscent describe the fruit[8].

Relationships between the main Angiosperm Groupings

The Dicotyledons and the Monocotyledons are the two main classes into which the Angiosperms are typically categorized. The inadequateness of the criteria dividing the two groups from one another had previously been brought up. The Monocots are descended from the Dicots, according to the general morphological evidence. One of the two cotyledons of a Dicot progenitor died, giving birth to the single cotyledon of Monocot; the remaining cotyledon sometimes assumes a pseudoterminal position. There are a number of Dicots, including Trapa natans, Carum bulbocastanum, Corydalis cava, Ranunculus ficaria, etc., in which one of the two cotyledons is partly or completely repressed. Contrarily, in Monocotyledons, the single cotyledon is not only positioned laterally but also exhibits traces of the second cotyledon, the epiblast, in several taxa, including Oryza. The germination of certain members of the genus Peperomia demonstrates how one of Dicot's two cotyledons may have gotten aborted.

The embryo has two cotyledons that are both equally developed. The seed is endospermic, and epigeal germination occurs. After absorbing endosperm, the two cotyledons are lifted above the soil by the extension of the hypocotyl, giving rise to the cotyledonary leaves. However, Hill noted that in a small group of geophilous individuals, one of the cotyledons stays inside the seed and is entirely suctotial, while the other cotyledon escapes from the seed, is carried high by the elongation of its petiole, and takes on the appearance of the distinctive first leaf. According to the author, this might explain why both of the cotyledons from their Dicot forebears are present in the first leaf of a monocot seedling. The single cotyledon of Monocots, according to Miss Sargant, is the consequence of the fusion of the two cotyledons of Dicots, which was caused by the geophilous behavior of the Monocots. Many Dicotyledons, including Anemone coronaria, Erianthis hiernalis, and Podophylum peltatum, exhibit the fusion of the two cotyledons to produce a cotyledonary tube[9]–[11].

CONCLUSION

They focused on population structure in connection to the environment. In general, Ecads are populations in which physical variants that are not genetically coded vanish as they develop in the same environment, but in Ecotype, the variations do not disappear as the features are genetically coded. New species may arise as a consequence of this population isolation process using either the allopatric pattern or the sympatric pattern of speciation. Scientists have discussed several species models or ideas that aid in understanding species at various levels, including biological, ecological, taxonomic, numerical, and traditional, among others. The affinities and origin of angiosperms with lower group and primitive angiosperms like Gnetales, Amentiferae, Ephedrales, Ranales, and Isoetalean members are shown by some botanists to be related to fossil records that show their relation with Pteridospermales, Cycadales, Bennettitales, and Pentoxylanean group. According to several botanists, the Rift Valley system, which borders Africa and South America, the Arctic area, South-East Asia, and the Cretaceous epoch are the locations where angiosperms are thought to have originated. Magnoliales, Laurales, Trochodendrales, Piperales, Nymphaeales, Illiciales, and Ranunculales are the subfamilies of the primitive living angiosperms.

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CHAPTER 3

THE SPECIES CONCEPT AND PLANT NOMENCLATURE

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ABSTRACT:

A species taxon is a collection of creatures that may effectively interbreed and give birth to viable offspring, according to the Biological Species Concept. That idea holds that both interbreeding within a species and reproductive barriers between creatures of various species help to protect the integrity of a species. Principles of hierarchy are employed in the history and evolution of Plant Nomenclature to determine taxa, determine relationships between them, and assign ranks.

KEYWORDS:

Evaluation, Genetic, Genera, Plant Nomenclature, Specimens.

INTRODUCTION

An essential component of taxonomy is the method of naming plants, or plant nomenclature. It deals with selecting the appropriate name to be used for a recognized plant or taxon. It is common knowledge that many plants have a number of common names that are widely used in different regions of the nation frequently, the same common name is used for various plants; and furthermore, some plants have no common names. For these reasons, it is imperative to give a specific plant a specific name that can be used all over the world. These are the fundamental issues that prompted botanists from across the world to get together and create a set of rules known as the International Code for Botanical Nomenclature. The ICBN guidelines were adhered to, and each component was further broken into articles and recommendations. Principles for determining taxa, determining relationships, and attributing rank A natural system of categorization is created by a variety of causes, many of which are independent of past usage. For ease of the three categories of criteria, guides, and practical consideration may be used to group the principles. Although some of them, at least, are generally acknowledged, whether or not they are followed is essentially a matter of taste[1].

Criteria

Of course, discussing criteria without mentioning the personalities that give the criterion is difficult. . However, because characters adequately address some of the issues discussed below: Even John Ray agreed that only genetically fixed variation should be used for classification. It is only at and below the level of species where it is frequently difficult to differentiate between environmental changes and genetically fixed variations in the absence of experimental evidence that this principle presents us with some difficulty. If there is any uncertainty about the character, it should not be taken into account when taxa are being defined in practice. For both the evaluation of connection and the delineation of taxa, natural categorization should be firmly founded on character correlation and discontinuity. To evaluate relationships, as many characters as feasible should be employed. Characters that have the greatest correlation for any classification are those that are most helpful for categorization. More often than not, the vegetative characteristics are employed to define groupings above the species and sectional level. Character, rather than a taxon's "type," determines how different it is from other taxa in great part through its range of variation and the number of intermediates. More significant than rank assignment are the evaluation of relationships and the delineation of taxa. When categorizing a group, all relevant information should be used: When new information becomes available, characteristics that once seemed to distinguish the group well particularly specific and general concepts may no longer hold. The distinctions used to separate species in the pioneer stage of categorization are often broken down by further specimens.

A genus may become too broad and its content too heterogeneous for maintenance as a single genus or, on the other hand, what were initially treated as two genera may have to be merged into one genus as new species described by various authors accumulate in genera originally based on far fewer species. Any taxon that is being reviewed, whether it be a species, genus, or family, should be investigated over its full geographic range: When producing a Flora, it is sometimes hard to accomplish this beyond the species level, but any taxonomic revision that involves redefining taxa's boundaries and changing their ranks should be carried out throughout the range of the group[2].

Treatment uniformity: It is clear that no taxonomic classifications or ranking systems can be applied uniformly over the whole plant kingdom. However, categorization might need some improvement in terms of consistency. The lack of time for one taxonomist to investigate the whole group, psychological variations between taxonomists and between the various conceptions they hold, and revisions based on diverse material are the three primary sources of treatment inconsistency, which is a very serious issue. Within the taxon with which they are working, taxonomists should be as consistent as their understanding of the facts will allow. It may sometimes be necessary to split the genera in one portion of a family and ignore the remainder, but this is poor taxonomy. Consolida should be recognized as a separate genus from Delphinium if Pulsatilla and Ceratocephalus are recognized as genera distinct from Anemone and Ranunculus, respectively. In fact, there are even greater grounds to do so. The presentation of the Floras is inconsistent, which makes comparisons difficult and is a flaw that the Flora Europaea should greatly address for the European continent. Ability to cross: Although the claim's factual basis may be true in most instances, it is no longer acceptable to treat species as such unless at least some of their members are potentially infertile or if a species should be potentially intersterile with other species and interfertile among its constituent parts. For a number of reasons, it cannot be regarded as a general norm.

Lack of genetic link does not indicate an inability to Bridge

Morphological differences may not always result in an impassable barrier. As ploidy levels rise, there is a propensity for polyploidy descendants in polyploidy complexes to be able to cross, unlike the diploids from which they are formed. The derivatives may be morphologically separate from their diploid progenitor, but they are often unable to cross with it. In these situations, cross ability and phyletic connection are at odds. Cross ability can help in delimiting the genus as a natural group of species because species of different genera are typically interstitial, so the inability to cross is of little assistance in separating genera. However, if we shift the emphasis from the differences between genera to the similarities between the species within them, this can help in delimiting the section as a natural group of species[3].

Chromosome morphology and count:

The karyotype may be a very helpful tool for phylogenetic and classification purposes. We've previously spoken about how difficult it is to distinguish between different species using chromosomal numbers, and we came to the conclusion that in order to distinguish between different species, a population must first exhibit consistent morphological distinctions. However, the karyotype may be a particularly helpful tool in defining genera and determining their genetic relationships. This source offers very little assistance in many categories, but in others it either supports the categorization based on gross morphology or offers ideas for how a more natural classification may be accomplished. Despite the lack of a new classification, Gregory's research on the karyotype of the Ranunculaceae family demonstrates how the genera may be more naturally categorized based on chromosomal form and number. It must be emphasized that chromosomal shape and number are a categorization guide, not an absolute standard. They offer more natural groups by displaying plausible evolutionary links. However, a taxonomist must verify these by identifying linked morphological traits in order to adequately describe and delimit a group. Homologous variation: The Vavilov's rule of homologous series. The origin of homologous variation may be traced back to many ancestral genes. Crop plants are a good example of this variety in appearance. Natural selection often removes certain variants in native flora, thus a rare species typically exhibits just a portion of the variety seen in a commonly occurring species. Nevertheless, a taxonomist's work may benefit greatly by understanding the rule of homologous series[4], [5].

Geographical and ecological distribution:

Much has been written on the "geographical method" in taxonomy, particularly by German and Russian botanists. The result of evolutionary history and environment, all taxa have a reasonably well defined global range. Geographical and ecological distribution have a somewhat distinct function in categorization at the level of the species and below. The only way to know whether two plants grown in separate places are interfertile is via experimental proof. However, things change if they develop simultaneously, especially if they do so in the same environment. It is reasonable to presume that there is some kind of reproductive barrier between the two plants if they continue to be separate. This means that information on their distribution and ecology may be crucial if we are unsure about whether to give a certain rank. Phylogenetic factors: Above the level of hybridogenous species, monophyly is a desired criteria for taxa. Monophyly evidence must often be inferred from other evidence and be interpreted in some way. This calls for the investigation of the greatest number of features, taking into account their interrelationships, functional significance, regional distribution, comparative karyology, and interspecies compatibility.

By examining this data, we may conclude that we can discriminate between likeness resulting from convergence and resemblance resulting from patristic affinity. In the latter scenario, we should reexamine the group to see if it can be categorized in a way that is more in line with its most likely evolutionary past. However, phylogenetic factors are interpretive and cannot be used to create a basic categorization. They can only be used to interpret an initial classification in terms of evolution, and by exposing unwanted characteristics, they help us refine it as far as we can without losing sight of the usefulness of categorization. However, we must be very cautious about how we have deduced monophyly or polyphyly. It would be illogical to use these conclusions to change the classification if they had been drawn from the categorization. For example, phylogenetic conclusions from cytology or geographic distribution may only be used to support or enhance a classification if they were not utilized to create it[6].

DISCUSSION

Practical Points of Interest

A generic categorization must be accurate if it is to be widely utilized. The place taxa in higher taxa need to be carefully examined. This implies that in order for systematics to be as useful to science as possible, practical factors that counteract the "objective" component of categorization are crucial. As a result, scientific classification must come to terms with art. Ease of observation: Even though we've emphasized the need of employing a wide variety of characters in classifications, this does not imply that every character is equally good for quick distinction or diagnosis. Botanists have often believed that blooming plants should be distinguishable from one another at least somewhat in terms of gross morphology, even though these distinctions may also be connected to internal variations. These "marker" characters, which are often utilized in the creation of keys, are taken from a much greater number that is taken into account for determining the taxonomic position of the group.

Taxonomic group size is likely one of the most important and underappreciated classification-affecting characteristics. In 1753, none of Linnaeus's genera were very vast; the largest, Carex, had just 29 species, compared to well over 1000 now. De Jussieu recognized 100 families, which suggests that he thought this was a practical number for the division of flowering plants. However, since then, knowledge of plants has greatly improved, and many of the original genera and families have been split apart. Over 400 families are recognized by J. Hutchinson, the majority of which seem to be based on genera that de Jussieu was previously aware of and had accommodated elsewhere. Hutchinson places around a third of de Jussieu's genera in the same families and the other third in distinct families. Although this situation may shock some scientists, it is an unavoidable result of practical convenience and is a fundamental component of categorization; taxonomists should not be embarrassed of it[7], [8].

The morphological distance between two taxonomic groups should be inversely proportionate to the size of the groupings, according to a widely accepted guideline. This is, in fact, a practical need. De Caudate, Bentham, and Hooker all followed this approach, and it kept them from recognizing a sizable number of monotypic genera and families. Two significant families, Gesneriaceae and Scrophulariaceae, vary mostly in their placentation. They should be recognized as distinct families rather than tribes belonging to the same family since they form such large and seemingly natural clusters. The Labiatae and Verbenaceae, Caprifbliaceae, and Rubiaceae are comparable. On the other hand, tiny genera in the Nymphaeaceae or Berberichiceae might be mentioned as potential candidates for distinct families. They are far better as families than the pairs we just discussed in terms of delimitation and degree of divergence, but since they are tiny, there has been an understandable resistance to raising their rank.

It is very likely that a rise in the quantity of material accessible in less-worked regions will ultimately result in a broader definition of particular boundaries. It is difficult to avoid describing minor species during the pioneer phase, and at this time, a too broad species notion may cause more confusion than a too limited one. But it is unacceptable to separate when there is sufficient information to support it, even among sexual groupings. There have been a number of reasons made in favor of separating, but the following appear to be the most pertinent: The two parts of taxonomy are analysis and synthesis. The response will differ depending on the group. Since the family plays a fundamental function, the way that relationships are expressed is of utmost significance. We are mainly concerned about discrimination at certain ranks. In all other respects, binomials are more practical than trinomials due to their lower length. We should be able to assign the majority of our specimens to binomials for communication purposes, provided that some consideration is given for local hybridization. Our species notion is too limited to provide a useful classification if variation is too extensive to enable us to achieve this.

Economic importance: This must have had a significant impact on categorization, similar to blossom size. Some humble groups, like the Urticaceae, wait in vain for a botanist to open the cupboard and give them a good look, let alone study them in vivo. Groups that are economically significant either for their products or for their place in agriculture or horticulture are likely to be extensively studied. It's not that one dislikes the economic significance of the Orchidaceae, Gramineae, Eucalyptus, Nicotiana, or Gossypium; it's only that one wishes all groups were equally significant since placing too much emphasis on economic groupings would always lead to an unbalanced categorization. The broad research of cryptic features in economic groupings, however, has shown to be quite fruitful. The Gramineae provide as a wonderful illustration of what may be done in a challenging group where convergence often obscures phyletic link. The Gramineae are now categorized in a way that is much more logical than ever before, and we also comprehend them far better. The Cyperaceae, which are rather unimportant commercially, cannot be considered to be the same.

Stability: The importance of stable categorization has received a lot of attention. Gilmour has gone so far as to say that this is of the utmost significance. While we agree that stability would be ideal, we do not think that changes, especially significant ones, should not be undertaken. A plethora of information is being provided by discoveries made in the 20th century that should be used in categorization. It would be too expensive to sacrifice stability in order to not utilize this data to enhance a natural categorization. Changes should, of course, be undertaken carefully and only once there is solid proof.

Relationship: Depending on the degree of divergence seen, it should be removed to either another genus that is already approved or to create one of its own if it is discovered that a plant is generally more closely related to another genus than to the one in which it was initially classified. Science won't be benefited by ignoring changes in this direction, which appear inevitable.

Rank: As we've already said, promotions are usually subjective decisions. Tradition, the size of the group, and the level of divergence all affect rank. Changes in rank, however, must be avoided if we want to classify consistently and provide a classification that is well balanced. Since they make up the binomial we must employ to designate species, it follows that the stability of species and genera is especially important in this context. However, when we are searching up plants in a flora or herbarium, changes in family status might be scarcely any more challenging. Tribal, sectional, or sub specific taxon rank changes cause significantly less trouble. Overall however, we oppose rank changes except for reasons of consistency and the creation of a naturally balanced categorization. Raising a taxon's rank has the effect of making it more prominent. Changes in plant names that are not taxonomic are purely nomenclatural and arise from the proper application of the Code's regulations, notably those pertaining to priority of publication. A taxonomist's time would be better spent researching plants than dealing with these laws, which may be quite time-consuming. A more stable nomenclature will ultimately emerge as a consequence of a pretty solid set of norms and their consistent execution. Although we must abide by the laws as they are, we cannot help but believe that name changes made for reasons other than sound taxonomic ones are detrimental to biology[9]–[11].

CONCLUSION

Taxonomic hierarchy may be defined as the systematic listing of a tax on. Major categories are those with a higher level, such as Division, Class, and Order, whereas minor categories are those with a lower level, such as species, variety, etc. Genus, family, order, class, and division are cited by the ICBN as the principal ranks of taxa in the ascending sequence. There are a total of 19 subordinate ranks in the plant kingdom. An essential component of taxonomy, which deals with choosing the proper name to use for a recognized plant, is plant nomenclature. It is commonly known that many plants have a variety of common names that are widely used in different regions of the nation, and that certain plants have specific names that may be used all around the globe. These are the fundamental issues that prompted botanists from all around the world to get together and create a set of guidelines known as the International Code for Botanical Nomenclature. The ICBN regulations, which are adhered to, are separated into parts, which are then further divided into articles and recommendations.

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CHAPTER 4

BIOSYSTEMATICS

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ABSTRACT:

The study of historical and current organism diversification as well as the interactions between those species across geological time is known as biological systematics, or biosystematics. It encompasses the fields of systematics and taxonomy. Therefore, the goal of biosystematics is to classify species according to their evolutionary history and to determine their phylogeny based on the totality of different factors from all areas of study. Plant systematics creates evolutionary connections between various plant groupings. It reveals patterns in plant evolution. The comparison of morphological, anatomical, and cytological features among various structures is supported by plant systematic. The foundation for genetics is also provided by plant systematic.

KEYWORDS:

Genetics, Biosystematics, Morphological, Nomenclature, Taxonomy.

INTRODUCTION

For contemporary plant taxonomy methodologies, Camp and Gilly suggested a project under the heading "Biosystematy." The name "Biosystematics" was later coined by Lawrence in 1965. According to Lawrence, "Biosystematics is a phase of botanical research that approves the study of living population and delimits the natural biotic units, as well as classifies the taxa of different orders of degree." Biosystematics' primary goals are to identify evolutionary units, create new taxa, and determine the range of existing taxa. The history of taxonomy, which includes all early taxonomical effort by many scientists, is mostly covered by the Alpha taxonomy. The fundamental flaws of the alpha taxonomy include the fact that it only takes into account an organism's form and shape and ignores all other characteristics, making it difficult to comprehend how a species evolved. Beta Taxonomy is the stage in which the taxonomist applies all morphological traits that emerge during the lifespan of the organism to the taxa in order to place them in a systematic order. Omega Taxonomy, which has the greatest correspondence of all plant sciences, is based on all the data and information that are currently available for the plant species, including Serological, Computer, and GIS data as well as information from Micro-Morphology, Anatomy, Palynology, Embryology, Cytology, and Phytochemistry[1].

For the first time, Michel Adanson made the argument that when identifying any plant species, all characteristics should be given equal weight. These ideas were initially introduced by him, and they are known as "Adansonian Principles." Since 1960, the Adansonian ideas have gained widespread acceptance and helped to establish new taxonomy techniques that fall under the umbrella of numerical taxonomy, commonly referred to as the "modern classification method." The Numerical Taxonomy is the mathematical or computational examination of different forms of taxonomic data to determine the affinities or similarities between taxonomic units, and then the arranging of these units in the order of higher ranking taxa on the basis of these affinities.

Biosystematics

All connections are included in biosystematic investigations, with a focus on phylogenetic and phenetic links. They are as follows: According to some scientists, biosystematics is the use of genetics, statistics, and chemistry to the solution of systematic issues in order to provide answers about the variety of the organism within the context of the theory of evolution. Researching variation through comparative morphology, anatomy, seed coat microsculptural features, reproductive biology, phytochemistry, embryology, karyotype, and meiotic behavior studies; correlating these characters with adaptation of organisms present in that locality; and describing the diversity of organisms to delimit it in order to assess the evolutionary adoption processes that occur within the population. In addition, biosystematics refers to the development of a theory for the systematized diversity with the goal of finding means to support that hypothesis.

Biosystematics' Objectives

Delineating evolutionary units, creating new taxa, and determining the boundaries of those that currently exist are the major goals of biosystematics. Instead than focusing on speciation itself, the goal is to determine how it works. Phenotype is the end consequence of actions and interactions between genotype and elements of the environmental complex at a certain time period. This connection is highlighted by biosystematics, which also assesses the phenotypic expression that results from the variance in the elements of the genotypic and environmental complex[2].

Fundamentals of Biosystematics

The study of plant variations, differentiation between genotypic and phenotypic variation patterns, and how variation will be converted for adaptation, as well as how polyploidy, particularly allopolyploidy, amphiploidy, aneuploidy, and polymorphism, will promote evolutionary mechanisms, are all included in biosystematics. Different geographical and ecological environments cause an organism to develop certain physiologically heritable adaptive traits that will be chosen by either biotic or abiotic selection. Although the features may be used to identify the species morphologically, they only serve as markers for the genetically defined boundaries. To identify genetically determined species, morphological evidence is needed. Geographical, ecological adaptation characteristics, altered chromosomal data of cytological, and genetic evidences are also employed to clearly define borders surrounding the species in place of morphological limits. For certain groups of species, biosystematics evaluates breeding systems, studies patterns of variation, assesses evolutionary potential, and does the necessary work in the chemical, numerical, cytological, anatomical, embryological, and palynological elements of systematics.

Mayer contends that the subspecies category is inadequate for capturing the population structure of a species, a goal shared by many biosystematists. Furthermore, despite the fact that subspecies are not evolutionary units, they do hide the inter- and intra-population diversity of species, hence he did not advocate abandoning it as a viable unit. By seeking to link the relationships shown by ecology, cytogenetics, gross micro-morphology, palynology, phytogeography, and physiology, the experimental taxonomist hopes to arrive at a comprehensive picture of biological relationships. Each of these approaches has benefits and drawbacks, but it is important to note that the discoveries in taxonomy and biosystematics work in tandem to strengthen each individual field. Lawrence further distinguished experimental taxonomy from biosystematics.

A few researchers compared population genetics to experimental systematics. In order to comprehend the genetic processes underlying its constituent parts, the experimental systematist often starts with a classical understanding of species and works backwards. The population geneticist starts with the unprocessed population, abandoning any traditional notion of a species in his own mind, and moves on to a succession of group notions that may or may not be equivalent to the taxonomist's notion of a species. The term "experimental taxonomy" does not refer to the employment of experimental techniques; rather, it refers to the taxonomic standing of organisms in relation to their populations as a whole, as opposed to to individuals, and to the evolutionary processes that take place within populations[3], [4].

The biosystematist created a classification for experimentally studied natural taxa based on data from cytology, genetics, ecology, and morphology; these categories are not meant to replace the units used in classical or practical taxonomy. Each category offers a single name for a biosystematic scenario; they are not equivalents, although they may be counterparts of them that lack nomenclatural validity. Only until their existence has been empirically shown could the category names be assigned to a population or a plant. A plant or population should not be given any of the category words until its claim to the term has been proved and documented.

Biosystematics's Constituent Parts

A taxon and its populations are investigated or sampled in the first phase of biosystematics, and the chromosomes of several populations within different geographic races, species, genera, and other categories are studied cytologically. Variations in meiotic morphology, chromosomal number, and behavior often point to genetic variances or shared traits with taxonomic importance.

DISCUSSION

The identification of each population's capacity for hybridization, the study of those populations that do so, and the vigor and fertility of the resulting offspring are all important steps in determining whether or not natural breeding barriers exist between various populations. Meiotic behavior of hybrids will define the homologies of chromosomes, and pairing behavior will reveal the level of genetic relatedness in the source material. In order to establish fertility connections by performing certain crossings among geographical races and to analyze the meiotic behavior of homologous chromosomes derived from hybrids, cytological data from various geographical populations and races are collected.

Data from comparative morphology and geographic distribution will be compared to this. When used, it has a higher degree of objectivity than one that is determined just by taking into account morphology and distribution. Biosystematics, according to Clausen, is the application of information from genetics, cytology, comparative morphology, and ecology to the study of organic evolution. The diversity and evolution of species are topics of interest in biosystematics. It is less concerned with categorization itself and more with the evolution process[5].

Biosystematic Classifications

Finding out more about the natural connections of plants, especially those with genus and lower ranks, is the main goal of biosystematic investigations. The units employed in classical or modern taxonomy are not meant to be replaced by these categories, nor are they necessarily comparable to them, but they may be equivalents. Each offers a single word name for a biosystematic scenario, and the term should never be used to refer to a plant or a population unless the situation for which the term stands has been empirically shown to exist for the specific taxon. In order of escalating phyletic importance, the four most commonly recognized biosystematic categories are ecotype, ecospecies, coenospecies, and comparium.

Ecotype:

Gregor et al. provided a clear definition of the term ecotype as "a population distinguished by morphological and physiological characters, most frequently of a quantitative nature; interfertile with other ecotypes of the escospecies, but prevented from freely exchanging genes by ecological barriers." The term ecotype was proposed by Turesson. The fundamental unit in biosystematics is the ecotype. The term "ecospecies" was initially used by Turesson to describe a collection of plants that belong to the same coenospecies and have the ability to exchange genes without harming the progeny. Typically, imperfect genetic barriers that act as additional ecological barriers to keep related ecospecies apart from one another prevent unfettered gene exchange with any other ecospecies. When ecospecies of the same coenospecies are crossed, the resulting hybrids either generate a large number of weaklings in the F2 generation or are largely sterile. Such wimps are incapable of competing and are unable to procreate. Some of these hybrid segregates could have enough strength to survive. By interbreeding into any of the ancestral ecospecies, they may be reabsorbed. Related ecospecies often live in distinct but frequently adjacent ecological or geographic regions, maintaining a fair amount of genetic integrity. Ecospecies often resemble traditional and conservative taxonomic species.

Coenospecies:

According to morphological, cytological, and experimental evidence, a coenospecies is a collection of plants that represent one or more ecospecies that share a common evolutionary ancestor. Genetic barriers between coenospecies of the same comparium are so virtually absolute that all hybrids formed between them are sterile unless amphiploidy takes place. This allows for the existence of different coenospecies without genetic mixing in a same habitat. Coenospecies often follow the taxonomic divisions or subgroups of the genus[6], [7].

The biosystematic unit known as a comparium is often compared to a genus. It is made up of one or more coenospecies that may cross each other. Different comparia are completely genetically incompatible with one another and are unable to cross. However, there are several taxa that are recognized as genera by orthodox systematists and which may include two or more comparia. The recognized and conventional genera in several families do not correspond to comparia or even coenospecies. Turesson and Danser have developed two distinct plans. Three ranks are included in the Turesson system. Danser's method defines the words such that none of the six are interchangeable with one another. While Danser's higher words Comparium and Commiscuum describe the upper and lower parts of coenospecies, respectively, his lowest term convivium includes the definition of both ecospecies and ecotype. Turesson also used a more basic word, the ecophene, to describe the ecological variation, which is solely the result of phenotypic change by the environment. ECAD was the word F.E. Clement used to describe this variant.

Terminology for Deme

Deme Terminology was used with a prefix to refer to any collection of people belonging to a certain taxon. Second order and compound prefixes may also be used to more accurately define relationships. The type of the connection of group of persons or the sort of population unit that they may represent must always be indicated by the inclusion of an appropriate prefix. When used alone, the term "deme" merely refers to a group of people belonging to a certain taxon and does not indicate any additional ties unless explicitly stated in the context. The following fundamental deme terms are listed: Where applicable, the deme terminology counterparts are also mentioned in relation to other ideas presented in this section. Gilmour and Gregor suggested and Gilmour and Heslop- Harrison created a new system of deme nomenclature. In order to create an infinitely flexible series of categories that could be used to define any group of people in accordance with any set of criteria, orthodox categories can be used as a framework into which other classification for a specific purpose can be fitted. In its initial form, this deme terminology system was non-hierarchical and excluded from formal taxonomic classifications. This idea stays away from terms with roots like species and kind, which are connected to the latter.

Taxonomy of alpha, beta, and omega

Classical taxonomy or Alpha taxonomy

Alpha taxonomy is the first stage of classification, when scientists began classifying species based on fundamental concepts, or we may say it is a "Artificial Classification," where the taxonomist identified an entity based on one or two distinctive characteristics. Theophrastus, a scientist, divided plant species into four categories: trees, shrubs, undershrub's, and herbs[8].

The creator of taxonomy, Carolus Linnaeus, created a comparable Artificial System based on the sexual characteristics of plants. The binominal nomenclature system was created by Linnaeus, a taxonomist who continued Caspar Bauhin's work. The history of taxonomy, or alpha taxonomy, encapsulates all of the early taxonomical work done by various scientists. Alpha taxonomy's fundamental drawback is that it only takes into account an organism's form and shape and ignores all other aspects, which makes it difficult to comprehend how a species evolved.

Exploratory or Beta Taxonomies

The phase of taxonomy created following the conflict of the Alpha taxonomy is known as beta taxonomy. The stage when the taxonomist succeeds in doing further investigations and categorizing every species. The majority of morphological traits that are present throughout a taxon's entire life cycle are used by botanists to place the taxa in a systematic order. In this case, we can state that this is a method of categorization where scientists categorized the taxa based on their naturally occurring similarity of vegetative and floral characteristics. Therefore, Beta taxonomy may be thought of as the time period when the "Natural system of classification" was active. Botanists de Jussieu, Augustin Pyramus de Condolle, and Casimir de Condolle were the ones to start this kind of research. It is well known that George Bentham and Joseph Dalton Hooker proposed the Natural System of Classification.

The benefit of the Beta taxonomy is that it makes it simpler to identify different species of plants since it makes extensive use of the morphological characteristics of the plants as well as certain embryological, cytological, and anatomical characteristics. The inquiry and identification phases of tradition are at this point. As science has progressed, plant systematics has also developed as taxonomists have begun to use a variety of modern plant sciences disciplines, including serology, computer and geographic information systems (GIS), micromorphology, anatomy, paleontology, embryology, cytology, and phytochemistry. As a result, the "Omega Taxonomy," which is based on all the information or data that is currently accessible for the plant species, has the broadest correspondence of all plant sciences fields. In addition to physical characteristics, the botanists categorized the plant species during the omega taxonomy era based on the evolutionary and genetic relationships of the plant. The phylogenetic method of categorization was taken into consideration during the omega taxonomy period, which means that the majority of botanists recognized the species with their origin and phylogenetical relationships with other species. With the development of molecular biology, applied computer sciences, and internet data matrix, the current scenario has completely altered, as botanists are now beginning to trace the origin of the species and their phylogenetic relationships with other species. The APG system was developed by Kare Bremer, and it solves taxonomic issues day by day[9].

For the first time, Michel Adanson made the argument that when identifying any plant species, all characteristics should be given equal weight. These ideas were initially introduced by him, and they are known as "Adansonian Principles." Since 1960, the Adansonian ideas have gained widespread acceptance and helped to establish new taxonomy techniques that fall under the umbrella of numerical taxonomy, commonly referred to as the "modern classification method." The mathematical or computational technique aids in the study of different kinds of taxonomic data and aids in determining the affinities or similarities between taxonomic units, which are subsequently arranged into taxonomy based on these affinities. The definition of numerical taxonomy, according to Heywood, is "the numerical evaluation of the similarity between groups of organisms and the ordering of these groups into higher ranking taxa on the basis of these similarities." A growing area of taxonomy, numerical taxonomy, gained prominence with the advent and improvement of computers. This area of research is sometimes referred to as Numerical Taxonomy, Multivariant Morphometrics, Taxometrics, and Mathematical Taxonomy.

The fundamentals of Numerical Taxonomy

The intellectual foundations of the contemporary Numerical Taxonomy were initially put out by the French naturalist Michel Adanson. Adanson disagreed with this notion of giving certain features greater weight and thought that natural taxonomies are founded on the idea of similarity, which is determined by taking all the characters into account. Sneath & Sokal created the Neo-Adansonian principles, which are the foundation for contemporary Numerical Taxonomy. These concepts are based on the current interpretation of the Adansonian principles. A classification will be more accurate the more characteristics it is built upon and the more information is included in its taxonomy. For the purpose of developing new taxa, each attribute is equally weighted. The degree to which any two entities are alike overall depends on how much they resemble each other in each of the several characteristics that are being compared. Because character correlations within a collection of organisms might vary, distinct taxa can be distinguished.

Units of Operational Taxonomy

Operational Taxonomic Units are the fundamental units of Numerical Taxonomy and may be any person, species, genus, family, order, or class. In general, there should be appropriate representation of multiple polymorphic forms when the OTU is supra-individual, i.e., when genera are compared, they should be represented by different species, when families are compared, they should be represented by separate genera, and so on. Always keep in mind that in numerical taxonomy, comparisons of OTUs with equivalent rank are conducted by comparing species to species and genera to genera.

Characteristics of Taxa

A "characteristic that distinguishes one taxon from another" is the traditional definition of a taxonomic feature. Therefore, a species with white flowers may be distinguished from one with red blooms. As a result, the red flower is one character and the white blossom another. According to a second, more applicable definition offered by numerical taxonomists like Micher and Sokal, "a feature, which varies from one organism to another," flower color is a character, and its two character states are white and red.

Characterstate was sometimes referred to as an attribute by writers, although the terms are not necessarily interchangeable. When choosing a character for a numerical analysis, it is just as crucial to choose a unit character as it is to choose a character for the analysis. According to Sokal and Sneath, a unit character is a taxonomic characteristic shared by two or more states that cannot logically be subdivided within the context of the current investigation, with the exception of subdivision resulting from changes in the coding technique. Like, the glandular or eglandular trichome kind. Sessile or stalked glandular trichomes are both possible. Either a branch or an unbranched eglandular trichome may exist. A grandular trichome may be identified as a unit character in this situation. Making a list of unit characters is the first step in managing characters. All characters for whom information is known should be in the list. It is important to weigh each character equally. Some writers argue that some characters should be given more weight than others; nevertheless, when there are many characters present, this argument is usually moot. According to broad consensus, numerical studies should have at least 60 characters, but more than 80 characters are preferred. For practical purposes, there could be certain characters for whose information is either unavailable or irrelevant, or those who exhibit much more variance within specific OTUs. These characters are not included in the list. This results in residual character weighting[10].

Character Coding

OTU analysis involves the usage of several characteristics. As a result, a significant volume is produced, making computer usage necessary. The data must be properly coded before being given into the computer. Two state characteristics, such habit is woody or herbaceous, are the ones most suited for computer handling. All characters, however, may not be in both states. Both qualitative and quantitative multistate characters are possible. It is possible to reduce such multistate characters to only two states. The character could be divided at times. A significant collection of specimens is put together for plant exploration, and this collection is also required to place a particular area in the herbarium. This requires accurate identification of these plant specimens. Identification must start at the family level before moving on to the genus, species, and varietal levels, among others. To demonstrate this damage, several botanists developed keys and offered floras and manuals. Initially, botanists compared the plant specimens with previously identified material that is detrimental for the herbarium sheet.

The primary goal of the key, according to Davis and Heywood, is to identify plant specimens and save time by separating them from other groups using one or two readily apparent characteristics. Punched card keys and Dichotomous keys are the two categories into which the keys fall. For taxonomy issues and identification, schools and colleges often utilize punched card keys, which is a fascinating learning activity, however most botanists prefer dichotomous keys for further research. Punched card keys: These keys are created of cards that are the right size and have the names of all the taxa written on them so that the taxa that are contained in the keys may be identified. A number and one character are printed close to one of the corners of each card. All taxa displaying this characteristic have a hole in front of their name, whereas those without this characteristic have no perforation. As a result, there are as many cards as the intended characters. The plant specimen that was identified shows the one and only card that the specimen needed in order to be recognized. Only one perforation will be allowed by the character combinations included in the specimen, which corresponds to the chosen card set. The specimen is then classified into the family to which the cards' perforations belong. Dichotomous key: These kinds of keys consist of two opposing characters, each of whose statements identifies a certain taxon. The leads are numbered and, to the extent feasible, both start with the same word. The character that was utilized to construct the key should be distinct and consistent. Characters that are more qualitative than quantitative are desired[11], [12].

CONCLUSION

A branch of botanical inquiry known as biosystematics accepts the study of live populations and defines the boundaries of natural biotic units while classifying the species of various orders of degree. Delineating evolutionary units, creating new taxa, and determining the limits of those that currently exist are the major goals of biosystematics. The many stages of taxonomy, such as artificial, natural, and phylogenetic categorization, are called the Alpha, Beta, and Omega taxonomies. The Alpha taxonomy is primarily used to define taxa using only a few morphological characteristics. Beta Taxonomy is the stage in which the taxonomist applies all morphological characteristics that emerge during the whole lifetime to place the taxa in a systematic order. Omega Taxonomy, which is based on all the knowledge or data that is currently accessible for the plant species, has the broadest correspondence to all fields of contemporary plant research. To determine the affinities or similarities between taxonomic units, the Numerical Taxonomy analyzes many forms of taxonomic data using mathematical or computational methods. These units are then arranged in the ordering of higher ranking taxa based on these affinities or similarities.

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CHAPTER 5

TAXONOMIC TOOLS AND TAXONOMIC EVIDENCE

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ABSTRACT:

The information employed in context for a task like identification or categorization is considered evidence in taxonomy. The basis of plant taxonomy was built on a number of traits that plants and plant groupings underwent periodic study. The use of contemporary taxonomic methods such as serology, cytology, anatomy, paleontology, embryology, phytochemistry, and molecular techniques to solve taxonomic difficulties. Characters (or qualities) obtained from several fields are taxonomic evidences. In order to describe patterns of variation at or below the species level, the majority of these traits are employed.

KEYWORDS:

Genetics, Biosystematics, Morphological, Nomenclature, Taxonomy.

INTRODUCTION

Beginning with the classification of the species according to their morphological characteristics. In addition to floral morphological characteristics, which are primarily utilized for categorization, other morphological characteristics are also crucial for identifying certain plant species. But other fields of botany have emerged as a result of the advancement of knowledge. These branches are utilized as contemporary tools to investigate evolutionary connections and provide a systematic location. The majority of the anatomical work with taxonomy in mind. Carlquist has discussed xylem evolution tendencies, particularly for ancient angiosperms. In the systematics of angiosperms, nodal anatomy has a significant role to play. The recepticale's cortex is where the floral components' circulatory systems are beginning to emerge. Floral anatomy has supported the separation of Paeonia from the Ranunculaceae family and into the separate Paeoniaceae family. Because each genus has distinctive characteristics in its pollen wall that assist to define the evolutionary history of angiosperms, the structure of pollen grains is very important in plant taxonomy.

The pollen grain research NPC formula has a significant impact on contemporary taxonomy. Cell Morphology and Karyology are the subjects of cytology research. An essential technique for solving biosystematics problems and drawing conclusions about evolution is the study of the nucleus. For species identification and their systematic location, the chromosomal traits and their behavior during cell division are significant information. When identifying plants, the chemical makeup of the plant is crucial. Alkaloids, amino acids, betalins, fatty acids, carotenoids, flavonoids, polysaccharides, tannins, terpenoids, and aromatic compounds are only a few of the chemical substances that are utilized to define taxonomy. Chemical character refers to the chemical ingredient. Chemotaxonomy, Plant Chemo-systematics, and Chemical Plant Taxonomy are terms used to describe the study of chemical characteristics of plants, which are primarily utilized in taxonomic categorization or problem-solving[1].

DNA polymorphism, DNA hybridization, and electrophoresis are significant molecular methods to investigate at the molecular level to resolve systematic issues and phylogenetic relationships among various species. The findings of DNA hybridization in Triticum, Hordeum, and Secale indicate that Triticum is more closely linked to Secale than Hordeum. The examination of phylogenetic relationships using DNA sequence data is used, and the discovery of distinctive sequences reveals certain differences between various species. Serology is the study of antigen and antibody responses. Serotaxonomy is the study of how serology may be used to solve taxonomic issues. In order to solve and ascertain the degree of similarity between species, genera, families, and other taxa, serology aids in the recognition of similarities and differences among various taxa. Hawkes and Tucker, for instance, found a significant serological association between Solanum, Nicotiana, Lyopersicum, and Datura when researching the serological evaluation of relationships within the Solanaceae.

Morphology

Gross morphological characteristics were formerly the basis for classifying species, as in the case of previous classifications like the Artificial and Natural systems, during the early stages of classification research. Other morphological characteristics are also crucial for identifying certain groupings of plants, in addition to floral morphological characteristics, which are primarily employed for categorization. Following is a conversation of some of the significant morphological traits used to separate the taxa:

Habit

When classifying taxa, plant habit is a crucial trait. In his categorization, Hutchinson, for instance, employed the woody or herbaceous feature to differentiate between the Lignosae and Herbaceae group. These two families are distinguished by their unbranched stems (Arecaceae) and their liana/climber forms (Convolvulaceae). The presence of a bulb can be used to classify some herbaceous plants, such as the Amarylidaceae, Iridaceae, and Liliaceae, while the unbranched stem of the Arecaceae and the underground rhizome of the Araceae, Musaceae, and Zingiberaceae help to distinguish them from other groups. Rhizome presence is a crucial trait for classifying the genus Iris. Similar to this, an essential taxonomic characteristic for identification in the genus Allium is the anatomy of the bulb[2].

Leaves

Another key characteristic for separating one taxon from another is the shape of the leaves. For instance, the Palms, Salix, and Populus species are all distinguished using this characteristic. Due to the presence of unipinnate leaves in Azadirachta species, which are absent in Melia, the two genera have been separated. On the basis of leaf morphology, the genera Sorbus from Pyrus and Sorbaria from Spiraea have also been divided. The family Rubiaceae may be recognized and identified by interpetiolar stipules. Identification of Viola and Salix depends heavily on the stipules. Similar to this, leaf venation is a useful characteristic in identifying the species of Ulmus and Tilia.

Flowers

For the separation of several taxa, floral characteristics are often exploited. The stamens of various plant families, including Lamiaceae, Fabaceae, Malvaceae, Asclepiadaceae, and

Orchidaceae, can be studied, while the carpels are a key characteristic for distinguishing Caryophyllaceae. For example, the calyx in Lamiaceae and the corolla of Fabaceae and Corydalis species. The gynobasic style of the Lamiaceae, the gynostegium of the Asclepiadaceae, the cyathium inflorescence of Euphorbia, and the capitulum inflorescence of the Asteraceae are some of the distinguishing characteristics.

Fruits

For example, the properties of fruits in plants have been frequently employed to identify taxa. Coode categorized the Valerianella genus based on its fruit. Similar to this, Singh et al. categorized Indian taxa of Asteraceae based on fruit shape, namely the number of ribs on the cypsela, the presence or absence of pappus, the presence or absence of a beak, and the presence or absence of scales or bristles. These traits are important defining characteristics. Members of the Caryophyllaceae family include Melandrium, Silene, and Cerastium and are distinguished by the number of valves found in the capsule. Characteristics of the seeds are used to identify the genus Veronica.

Anatomy

The majority of the anatomical work with taxonomy in mind was done by Bailey and his coworkers, Metcalfe, etc. Carlquist has discussed the development of the xylem, particularly in terms of primitive angiosperms. With the development of science, anatomical traits have become more crucial in resolving taxonomic conundrums and comprehending evolutionary connections among various taxonomic groupings.

Wood Morphology

Secondary xylem produced by cambium in a steel is what makes up the wood. The systematic position of primitive vesselless Angiosperm families like Winteraceae, Trochodendraceae, Tetracentraceae, Amborellaceae, and Chloranthaceae is greatly influenced by wood anatomy. Gymnosperms do not have vessels, although certain Angiosperms have. There are two theories, one of which contends that advanced Gymnosperms are where advanced Angiosperms, which lack vessels, are said to have originated[3].

According to studies on the anatomy of wood, Gnetales are not the ancestors of angiosperms and Amentiferae constitute a rather advanced group. Bailey came to the conclusion that vessels in Gnetales originated from tracheids with circular pitting, whilst they did so in angiosperms from tracheids with scalariform pitting. Bailey thus proposed that the origin of vessels in these two groups was different. The division of Paeonia into a new family, Paeoniaceae, and Austrobaileya into a different family, Austrobaileyaceae, is done in accordance with this trait, which forms the foundation for addressing some taxonomic issues.

Nodal Morphology

Bailey and Takhatajan claim that the study of nodal anatomy is very important for angiosperm systematics. For many groups, there are differences in the quantity of vascular traces entering the leaf base and the leaf gap in the vascular cylinder of the node. The most basic type is the unilocular 2 traced node, from which all other types are descended. Amentiferae do not have this kind of node, whereas Magnoliales often have.

Floral Morphology

The bract, bracteoles, sepals, petals, stamens, and carpels are modified leaves, while the flower is a modified stalk. The recepticale cortex displays the vascular system that supplies all floral elements. Floral anatomy refers to the study of a flower's circulatory supply. It is one of the key resources that has helped a great deal in understanding the phylogeny of angiosperms. By gradually reducing the number of ovules until there was only one left, the vascular supply in the carpels of several species within the family Ranunculaceae has shown that achenes originate from follicles. The split of Menyanthes from Gentianaceae into a separate family, Menyanthaceae, is further supported by floral anatomy. The ovules in the genus Centella get circulatory supply from alternating bundles, while the ovules in the genus Hydrocotyle obtain vascular supply from the fusion of two neighboring bundles. Paeonia is separated from the Ranunculaceae family and placed in its own subfamily, Paeoniaceae. Floral anatomy has been used to support the division since sepals and petals each contain several traces, carpels have five traces, and stamens are centrifugal[4].

Trichomes

Trichomes, which may be glandular or non-glandular are extensions of the epidermis. Brassicaceae, Lauraceae, and Moraceae are the most common plant families with non glandular trichomes. Branched dendroid hairs, peltate hairs, and flattened scales, stellate or candelabrum-like, to name a few. Sessile or stalked, glandular trichomes may take on a variety of shapes. Atriplex's glandular hairs are unicellular, bladder-like, and have a few celled stalk and basal cell. They exude salt, however some may also secrete nectar. The Urtica genus contains highly specialized stinging hairs with silica tips that rapidly break when touched. The fractured tip is sharp like a needle and injects stinging skin cell contents.

DISCUSSION

Embryology

Plant taxonomy greatly benefits from information gleaned from embryology. Prior to Maheshwari and Johari, Hafmeister and Strausburger proposed utilizing embryological features to resolve taxonomic issues. Micro and mega sporogenesis, the structure of the pollen grain, the formation of the embryo sac, the development of the endosperm and embryo, and the development of the seed coat are all crucial embryological characteristics for resolving the taxonomic problem. Families are identified by certain embryological characteristics. Certain flowering plant families are distinguished by distinctive embryological traits. As an example, consider the following:

Cyperaceae

The production of a single pollen grain rather than four sets the Cyperaceae family apart from other flowering plants. One pollen grain is created from the surviving microspore after it undergoes meiosis, the process by which microspores are produced from their mother cells.

Loranthaceae

Loranthaceae has been divided into the subfamilies Loranthoideae and Viscoideae based on the characteristics of their embryos. While Viscoideae has spherical pollen grains, Allium type of embryo sac, early embryogeny many tiered, embryo suspensor absent, and viscid layer inside the vascular supply of fruit, Loranthoideae has triradiate pollen grains, Polygonum type of embryo sac, early embryogeny is biseriate, and embryo suspensor is present. Later, these two subfamilies were separated into the Loranthaceae and Viscaceae families.

Onagraceae

The Oenothera type of embryo sac distinguishes the Onagraceae family from other groups of flowering plants. Other Angiosperms do not have this particular form of embryo sac. The micropylar megaspore of the tetrad produced by the meiosis of the megaspore mother cell gave rise to this four-nucleate embryo sac.

Podostemaceae

Members of the Podostemaceae family are aquatic perennial plants. Due to the breakdown of the nucellar tissue, these individuals have an unusual embryological characteristic that results in the creation of a pseudoembryo sac. The pollen grains often appear in pairs, the ovules are bitegmic tenuinucellate, the embryo sac is bisporic, the suspensor haustoria are conspicuous, and triple fusion is not seen.

Paeonia

Originally included in the Ranunculaceae family, the genus Paeonia was moved to the Paeoniaceae family by Worsdell based on embryological characteristics. Centrifugal stamens, pollen with reticulately pitted exine and a big generative cell, and free nuclear endosperm, of which only the periphery portion subsequently becomes cellular and seeds are arillate, are the embryological characteristics that support this theory.

Exocarpos

The Exocarpos genus was formerly assigned to the Santalaceae family. Gagnepain and Boureau proposed moving it to the unique family Exocarpaceae next to Taxaceae under Gymnosperms based on its embryological characteristics. Ram researched the fetal development characters of this genus and came to the conclusion that the flowers exhibit the typical angiospermic characteristics, such as the anther's distinct endothecium and glandular tapetum, pollen grains that shed at the 2-celled stage, Polygonum-type embryo sacs, cellular endosperm, and transverse zygote division. These traits demonstrate that Exocarpos is categorically an angiosperm and a member of the Santalaceae family[5], [6].

Palynology

Because each genus of plant has a distinctive pollen wall, the study of pollen grain structure is crucial to plant taxonomy. This has made it easier to trace the evolution of angiosperms. Taxa with a single morphological pollen type are thought to be stenopalynous, while taxa with several pollen grain types are thought to be eurypalynous. In terms of plant taxonomy, the stenopalynous groupings have significant importance. Taxonomists believe that the following traits of pollen grains may distinguish between several taxa: How many nuclei were there at the moment of dispersion: Pollen from primitive angiosperms is shed at the two-nucleate stage, while pollen from more advanced species is shed at the three-nucleate stage. Pollen grains in most angiosperms have radial symmetry. Only a small number of primitive species, including gymnosperms, have bilateral symmetry. The pollen grains are typically globose in most angiosperm, although they may also be boat-shaped, ellipsoidal, or fusiform in other species.

Initially pollen grains form tetrads and the outside end of grain is considered distal pole, while the inner end where grains unite as proximal pole. The equator is a line that circles the planet at a right angle to the polar axis. Prior to release, angiosperm pollen grains are separated into single particles known as monads. In very unusual circumstances, pollen grains are released in fused pairs or fours, in which case they are referred to as dyads and tetrads, respectively. The pollen grains are connected in clusters of more than four in Mimosoideae's Calliandra. These pollen grains are an example of an 8–10 pollen grain polyad. The pollen grains of certain members of the Orchidaceae family, such as the species Piperia, are joined together in an irregular clump called massulae. In subfamily Asclepiadaceae and many members of orchidaceae, all pollen grains of a theca are merged into a single mass which is referred as pollinium.

Dust Wall

The outer exine and inner intine layers make form the pollen grain wall. Because sporopollenin is resistant to degradation, the exine is hard. The structure known as pollen wall sculpturing is seen on the outside of the exine wall. Baculate, echinate, spinulose, foveolate, reticulate, fossulate, verrucate, gemmate, psilate, and striate are examples of typical sculptural patterns. The pollen tube emerges from the body at the pollen aperture, which may or may not be perforated. Aperturate may have a single pore, one slit that runs perpendicular to the equator, three slits, three pores, three slits with a geminate pore in the centre, or several holes. In accordance with the number of slits, pollen with one or more slits positioned at the polar end is referred to as monosulcate, disulcate, or trisulcate. Syncolpate pollen grains have slits connected at the poles. A noteworthy example of the use of pollen grains in systematics is Nelumbo, which is preserved in a different family from Nymphaeaceae called Nelumbonaceae and is distinguished by its tricolpate pollen as opposed to Nymphaeaceae's monosulcate pollen.

Cytology

Cell Morphology and Karyology are two topics covered by cytology. An essential method for resolving biosystematics issues and drawing conclusions about evolution is the Nucleus research. For the systematics and identification of species, chromosomal traits and their behavior throughout cell division are crucial. The chromosomes differ across species as a consequence of divergent evolutionary histories; these variations are relatively minor among closely related species but may be fairly significant among other related groupings. The cytological variations provide crucial proof of species evolution[7].

In biosystematics and evolutionary research, chromosomal properties are of utmost importance. Solbrig noted that the majority of cytotaxonomic research mostly used the following factors: Chromosome behavior during cell division Numerous studies on the number of chromosomes in various plant species have been conducted by Darlington and Janaki-Amal, Darlington and Wylie, Federov and Löve, and others. The International Association of Plant Taxonomy publishes the Regnum vegetabile series, which consists of 9 volumes and primarily forms yearly lists of chromosomal numbers for the Index to Plant chromosomal Numbers. For information regarding documented plant species, one may look for chromosome number updates from the Missouri Botanical Garden online.

In a somatic cell, the chromosome numbers are recorded as diploid, whereas in a germ cell, the chromosomal numbers are recorded as haploid. In diploid organisms, the gametophytic chromosome number is referred to as basenumber. In a polyploid species, n is always a multiple of x, in contrast to a diploid species where n = x is represented. Thus, species with 2n = 42 in a hexaploid plant will have n = 21, n = 3x, and 2n = 6x. The number of chromosomes in angiosperms varies greatly. Poa littoroa, a member of the Poaceae family, has the most chromosomes, whereas Haplopappus gracilis, a member of the Asteraceae family, has the fewest. Ophioglossum reticulatum, a member of the Pteridophytes, has the most chromosomes of any plant species.The taxonomic relevance of chromosomal duplication is further shown by the presence of hexaploid and tetraploid species in the grass genus Vulpia as opposed to diploid ones. Many scientists sought to find solutions to taxonomic issues for various species based on chromosomal numbers, for example. The initial base number for angiosperms is 7x, according to research conducted by Raven on chromosomal numbers at the family level. Other morphological, anatomical, and embryological characteristics have been used to differentiate the 5x in Paeonia with big chromosomes from others and put them in the family Paeoniaceae. Similar to this, Bambusoideae has 12x whereas Pooideae has 7x in the Poaceae subfamily. The chromosomal counts in the Mentha genus strongly support the separation into Audibertia, Pulegium, Preslia, and Mentha[8].

Chromosome Morphology

In general, chromosomal size, centromere location, and existence of secondary constriction position are taken into consideration when determining the morphology of a chromosome. The centromere location, such as metacentric, submetacentric, acrocentric, or telocentric, determines the varying size of both arms, which sometimes may be equal or unequal. A species' whole chromosomal organization is referred to as its karyotype, and its diagrammatic representation is referred to as an idiogram or karyogram. Each species' idiogram and karyogram is unique, such as those for Lyris, Pseudosago, and Pseudolyris. Agave members are classified as Amaryllidaceae owing to their inferior ovary, whereas Yucca members are classified as Liliaceae due to their superior ovary, making the family Agavaceae an intriguing example of chromosomal morphological use. Because of their similarities, the genera were combined into the Agavaceae family. In addition, the bimodal karyotype supports keeping them in the family Agavaceae.

Chromosome behavior duringCell Division

When examining the relationships between taxa, the behavior of the chromosomes during pairing and the ensuing separation might be helpful. Meiosis may sometimes provide taxonomic information, for example. The Cyperaceae and Juncaceae groups feature unlocalized short chromosomes. The family Ranunculaceae has historically been used to classify the genus Paeonia. According to cytological statistics, Paeonia differs from other Ranunculaceae members because it has a basic chromosome number of 5x, as opposed to those of the other members, which have 6x, 7x, and 8x. Similar to each other, Yucca and Agave have asymmetrical karyotypes with 10 big and 30 tiny chromosomes. Both genera are placed in different families but are kept together in the same family, Agavaceae, based on morphological characteristics such as comparable habit and secondary growth.

Phytochemistry

The chemical makeup of plants is crucial for identifying certain plants. The taxonomy uses a variety of chemical substances. The major examples are alkaloids, amino acids, betalins, fatty acids, carotenoids, flavonoids, polysaccharides, tannins, terpenoids, and aromatic chemicals. Chemical character refers to the chemical ingredient. Chemotaxonomy, Plant Chemo-systematics, and Chemical Plant Taxonomy are terms used to describe the use of chemical characteristics of plants primarily in categorization or in resolving taxonomic issues. In this stage, classification of plants is based on their molecular makeup, or chemical components. Thus, in theory, the approach of chemical taxonomy is precise and easy to understand and involves examining how chemical compounds or groups of biosynthetically related chemicals are distributed in a sequence of related or allegedly related plants. Comparative chemistry was an idea put out by Greshoff for taxonomy. Depending on the compounds they produce, plants may be categorized chemically, according to McNair. Such a chemical classification might be compared to or utilized in addition to morphological classification, and it could play a role in the creation of a real natural phylogenetic tree for angiosperms[9].

Analysis of the Genome and Nucleic Acid Hybridization

Electrophoresis

The molecular method of electrophoresis is crucial for the study of proteins in general as well as for the separation and recognition of proteins. The amphoteric characteristics are based on the ability to separate the proteins owing to the positively or negatively charged in varying degrees depending on the pH of the medium. This reaction is carried out on a polyacrylamide gel. The protein bands that traveled the same distances are often comparable.

Johnson conducted research on hexaploid wheat and established by electrophoresis that Triticum aestivum originated from Aegilops tauschii and Triticum dicoccum. Crawford and Julian investigated the use of data from flavonoids and proteins to evaluate species connections in Chenopodium. Both Chenopodium atrovirens and C. leptophyllum showed similar flavonoid patterns, but their distinct seed protein spectra allowed for their differentiation. Conversely, the flavonoids of C. desiccatum and C. atrovirens were different while having very comparable seed proteins.

Hybridization of DNA and RNA

The degree of ressocation with similarly treated DNA from another taxon that occurs when mixing the two is considered as a measure of the similarity of the nucleotide sequences. DNA is isolated from the organism and converted to a single strand polynucleotide chain. The Scikka bifolia alliance, a collection of plants with a significant basis number x = 9 and scant evidence for substantial structural rearrangement, may probably best illustrate the usefulness and necessity of DNA values in taxonomy. The findings of DNA hybridization in these three genera, Triticum, Hordeum, and Secale, demonstrate that the Triticum is more closely linked to Secale than to Hordeum.

DNA Variation

Utilizing DNA sequence data for phylogenetic relation analysis entails identifying distinctive sequences that exhibit specific variation in various organisms, identifying the target taxa, and ultimately constructing phylogenetic trees.

These sequences can be used as genetic markers. DNA polymorphism or DNA fingerprinting are other names for this process. These days, forensic investigators often use this technique. This polymorphism may be found using a number of strategies, each of which has benefits and limits and is best suited for a certain circumstance. New techniques are always being created. Single Nucleotide Polymorphisms and Restriction Fragment Length Polymorphisms are a few of the often employed techniques.

Serology

Serotaxonomy is the practice of using serology to address taxonomic issues. Antigens are any substances that may cause an antibody to develop, and serology is the study of how an antigen and an antibody interact. The comparison of the immunochemical specificity of serum proteins for a systematic point was first made by Nuttal, while other important serologists include Kowarski, Bertarelli, and Magnus. Dunbar noted that rice pollen, seeds, and leaves had proteins that were serologically unique. Gohlke established a school of serology at Koenigsberg, Germany, in 1914, and this location eventually became the hub of serological research. Serology it is the area of biology, in accordance with Boyden, that "deals with the nature and interactions of antigenic material and antibodies." Serology is the "study of origin and properties of antisera," according to Smith. Agglutinogens are another name for agglutinogen antigens. The degree of resemblance between species, genera, families, and other taxa is also determined by serology, which aids in taxonomy problem solving by highlighting similarities and differences among various taxa. This information aids in the comparison of non-morphological traits and is helpful for taxonomy. Serology methods may compare any single proteins from various plant species. Agglutination is the term for an antigen and antibody response that produces material or living things that are visible clumps. An antigen only combines with its corresponding antibody in a particular reaction, and vice versa. Basic procedures for a serological reaction:

1. Whole molecules, not fragments, react.
2. During these reactions, antibodies or antigens are not subjected to denaturation.
3. Surface-based combination happens and is both firm and reversible.

Antigens and antibodies may mix in different ratios, and both play a role in the development of precipitates or agglutinates.In order to more effectively transmit biological information, it aids in the classification of species. Using hierarchical categorization, taxonomy enables scientists to comprehend and categorize the variety of life on Earth. As they assist us in classifying and identifying creatures, these instruments are referred to as taxonomical aids. A list of the flora and fauna, identifying methods, names, and a system of categorization for both plants and animals are all provided by taxonomy. The most specific primary taxonomic rank is species, which may sometimes be further subdivided into subspecies. However, not all species have several forms that are distinct enough to be classified as subspecies[10], [11].

CONCLUSION

Traditional categorization was based on morphological traits; nowadays, botanists follow the many schools of botany to determine the right systematic position of every taxon and to draw conclusions about its evolutionary ancestry. Without a doubt, morphology is the fundamental need for approaching any taxon directly and identifying it, but in more recent times, the following various contemporary methods have also provided some useful information for identifying the phylogenetic connection. Like the nodal anatomy and floral anatomy, as well as the tendencies of xylem evolution, particularly for primitive angiosperms, the anatomical work for taxonomy perspective. Because each of the genera has unique characteristics in their pollen walls and because it has contributed to the understanding of the evolutionary history of angiosperms, polynology is also now of enormous importance in the taxonomy of plants. The study of cell morphology and karyology is known as cytology. For the systematic identification of species, chromosomal traits and their behavior throughout cell division are crucial. On the other hand, chemotaxonomy refers to the study of chemical characteristics of plants that are primarily employed for taxonomic categorization or problem-solving. The chemical makeup of plants is crucial for identifying certain plants. To solve systematic issues and determine the evolutionary link between various species, advanced methods like DNA hybridization, DNA polymorphism, and electrophoresis must be studied at the molecular level. Similar to how the taxonomy issue is solved, the serological investigation helps to identify similarities and differences among various taxa and also establishes the degree of similarity between species, genera, families, etc.

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CHAPTER 6

TAXONOMIC EVIDENCE AND TAXONOMIC TOOLS - II

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ABSTRACT:

Characters (or qualities) obtained from several fields are taxonomic evidences. In order to describe patterns of variation at or below the species level, the majority of these traits are employed. Taxonomy alone may reveal the relationships between various species. This is possible because it reveals the common ancestry of all living things. It demonstrates how long ago several species were one and the same before diverging from one another.

KEYWORDS:

Botany, Biodiversity, Ecology, Herbarium, Taxonomic.

INTRODUCTION

Man has been dependent on the plants for all his fundamental requirements including food, clothing, housing and medicine since human civilization. It is necessary to pass on knowledge and lifelong experience about how to use plants from one generation to the next in order to create techniques for preserving plants and plant products. Long-term plant collection preservation must have been necessary. Originally, the term "herbarium" referred to a book on dried medicinal herbs. Herba was the Latin word for thin, feeble-stemmed plants. Herbarium refers to a collection of herbs. The name "Herbarium" was used by Tournefort to refer to the gathering of dried plants, a practice formerly known as Hortus siccus. It is believed that the first person to dry plants under pressure and mount them on paper and advocate this technique of preservation was Luca Ghini, Professor of Botany at the University of Bologna in Italy. The earliest herbarium specimen still in existence belonged to Luca Ghini's pupil Gherardo Cibo. The method had gained widespread acceptance in Europe by the time Linnaeus lived.

The first herbarium in the world was founded in Italy thanks to Luca Ghini, who is also credited with creating the first modern botanic garden in the world in Pisa. It's fascinating to see how many early herbaria got their start as part of botanical gardens. The plant specimens were first placed on paper sheets and bound into books-like volumes. Herbarium sheets were first organized individually into categories by Linnaeus. Previously, sheets were sized in accordance with the size of the plants. The combined efforts of botanists from throughout the globe have led to the current notion of herbarium collections. In recent years, there has been a significant shift in the methods used to gather, press, dry, and preserve plant specimens. In addition to plant specimens, herbaria may also store seeds, wood slices, pollen, microscope slides, fluid-preserved blooms, or fruits. All plant categories are included in herbaria.

For certain types of algae, fungus, bryophytes, and pteridophytes, there exist herbaria. Herbariums, according to Jain and Rao, are collections of plant specimens that have been gathered from all over the world, mounted on the proper sheets, organized using a recognized system of categorization, and stored in pigeon holes made of steel or wooden cup boards that are typically particularly made for the purpose. Herbarium, according to Lawrence, is a collection of plant specimens that have typically been dried and pressed, grouped according to a recognized categorization scheme, and are ready for scientific study. A contemporary herbarium is a fantastic repository for knowledge about plants, mainly in the form of real specimens, and secondly in the form of written notes, published articles, and images[1].

Herbarium Does

A herbarium is a repository for information and objects. It is a repository for big collections of plants from many locales. They are very useful in identifying plant ranges, habitats, blooming and fruiting times, abundance, and locations. The straightforward cataloguing of plant specimens in herbaria makes speedy retrieval possible. The herbariums are exceptional and unique sources of knowledge about plants. For investigations in taxonomy, systematics, conservation biology, anatomy, morphology, ecology, biodiversity, ethnobotany, and paleobiology, as well as for use in teaching, education, and training, they give the comparative data that are crucial. Following is a list of some of herbaria's uses:

Plant Identification:

The herbarium is a key resource for plant identification. Taxonomic researchers may individually identify their own collection by comparing it to herbarium specimens that have previously been recognized. Education: Students may learn about many plants without traveling to various areas thanks to the herbarium.

Research:

The herbarium's specimens are accurately recognized and provide visual details on species. It is the fundamental instrument for taxonomic research. It is used as a source of information for studies in entomology, ecology, forestry, anthropology, and other environmental fields as well as anatomy and morphology. A great resource for identifying unprocessed medicines in pharmaceutical research is the herbarium[2], [3].

Biodiversity database:

Herbariums are sources of biodiversity data that are used to estimate biodiversity in various regions of the globe. Herbariums are useful for studying population biology of a species. The assessment of population variations shown by a species throughout its distributional range is made possible by vast herbarium collections of that species from several regions, which aids in population research.

Other Features:

The majority of herbaria include specimens gathered from all over the globe, therefore examining them might provide details on the geographic distribution of species. These extensive regional coverages of the herbarium's collections are useful for locating the origin, migration, and endemism hotspots of various species. An index of specimens on which investigations on chromosomes, phytochemistry, ultrastructure, micromorphology, etc. have been conducted is provided by voucher specimens maintained in different herbaria. Historical collections are stored in herbariums. London has extensive collections dating back to the 17th century in various national and international herbaria, such the one at KEW. A source for finding new genetic material is the herbarium. After adequate handling, herbarium material is sometimes utilized for

DNA extraction. Herbarium encourages and simplifies the sharing of fresh information across organizations. The creation of plant-related computer databases is aided by herbarium. Recently, digital herbaria in the form of information are being prepared, and herbarium content is required.

Herbarium Types

Herbaria are essentially divided into two categories: general and special. General Herbaria may be further categorized at three distinct scales: worldwide, national, and local depending on their state of collections and method of operation.

International Herbaria:

These are exceptionally large herbaria that typically include over 4 million specimens and have a worldwide representation of taxa, i.e., specimens gathered from many nations including a wealth of type specimens. They assist in identifying uncommon specimens, particularly new species, writing floral monographs, and providing facilities for visiting botanists. Upon request, they provide loan specimens to other reputable herbaria. Such as the Kew Royal Botanic Garden Herbarium.

National Herbaria:

Typically, these herbaria encompass the plant material of adjacent nations as well as the plants of the country in question. In these types of herbaria, as many representatives of the nation's taxa as possible are maintained. The majority of national herbaria are historic and have many collections. Writing national and regional floras involves the use of national herbaria. Additionally, they provide accommodations to visiting botanists. Such as the Central National Herbarium in Howrah[4].

Local herbaria:

These herbaria are those that only cover a certain part of a nation, such as a State, District, or even a little patch like a nature reserve. They are quite young and have few type specimens. The creation of local floras benefits from the usage of local herbaria. They support local educational and research institutes' requirements and add to the nation's flora. These are often modest herbaria that have been created with a narrow focus. They come in several varieties. Historic herbaria are highly rich in type specimens and are kept apart from ordinary herbaria, such as the Wallich herbarium at Kew. Herbaria with a specific focus: These herbaria hold the taxa of that plant group. They may be enormous and often belong to huge herbaria or establishments like colleges. For instance, the Forest Herbarium at FRI, Dehra Dun, and the Algal Herbarium at the National Institute of Oceanography, both in Goa.

Herbaria used for instruction:

These herbaria are found at educational institutions like colleges or universities. These herbaria may sometimes be rather big and need to be regarded as local or national herbaria. They meet the requirements for both teaching and research. Typically, these herbaria house species that reflect the local environment as well as commercially significant species like ornamentals and agricultural plants like the herbarium at Rajasthan University. New methods for the quick retrieval of information about herbarium specimens have been implemented with the development of information technology. This comprises digital databases and microherbaria, which are collections of small collections of plants[5].

DISCUSSION

India's and the World's Most Important Herbarium

Herbaria are often connected to academic institutions, museums, and botanical gardens. As previously mentioned, Luca Ghini founded the first herbarium in the world at Bologna, Italy, in 1570. Currently, over 165 nations recognize around 4000 significant herbaria. The International Association for Plant Taxonomy and New York Botanical Garden annually publish Index Herbariorum, a global directory of public herbaria. Patricia Holmgren edited the most current version in 1990. The world's herbaria are listed in Index Herbariorum. Each herbarium in Index is given a recognized acronym that serves as a global standard of reference. The Index Herbariorum entry for a herbarium covers the institution's physical address, URL, contents, and foundation date, as well as the names, contact details, and specialties of any staff members who are connected to the institution. IH only includes collections that serve as long-term scientific repositories. New registrants must show that their collection is actively kept and available to scientists. Since the establishment of IH in 1935, each institution has received a one- to eight-letter code that serves as a permanent unique identification. An estimated 300 million specimens are kept in herbaria across the globe, with more than half of those specimens being in European herbaria.

Howrah's Central National Herbarium

A nationwide collection of around 2 million plant species may be found in the Central nationwide Herbarium. In 1795, William Roxburgh founded this herbarium. This structure is situated along the Hooghly River. The CNH features collections from all around the globe, including from India. It continues trade initiatives with several foreign herbaria. More than 15,000 type specimens, the Wallichian collections, with more than 12,000 specimens, and one of the few lithographed copies of Wallich’s catalogue are preserved in this herbarium. The Linnean Herbarium and 26 other significant herbaria's microfiches are also kept here. There is a huge collection of coloured pictures, with the 2583 coloured illustrations composing the Roxburgh Icones. Photo negatives and Cibachrome prints of kinds and original materials from the Kew Herbarium in England are used to continuously update graphic content[6]. The Herbaria are also maintained by a number of universities, colleges, and research facilities. The Rajasthan University Botany Herbarium was created in 1963 by prominent taxonomist Prof. Shiv Sharma. The herbarium has received formal recognition on a global scale. The collection now consists of 20033 specimens from 157 families, 700 taxa, and 1370 species. It is suggested that the herbarium be updated to contain all angiosperm plants found in every district of Rajasthan.

Advancements in Phytochemistry

Chemotaxonomy is a branch of study that employs chemical data as a taxonomic trait. Let's take a minute to consider the many types of plants in our everyday lives before we examine the theoretical underpinnings of this contemporary movement in plant taxonomy. When we consume tea or coffee, we enjoy the flavor or scent and distinguish the two beverages based on this characteristic. Similar to this, we discover that fruits like the mango, banana, or apple taste differently as we consume them. The cornerstone of chemotaxonomy, which uses chemical traits or chemical contents as the evidence for taxonomy, is that these distinctions are caused by the chemical components of these meals. Both botanists and chemists have proposed the potential use of chemical data in plant taxonomy, and this has emerged as a significant contemporary trend, particularly in light of the development of modern methods for fast study of plant material. Chemotaxonomists contend that since chemical traits are i) stable, ii) unambiguous, and iii) not readily modifiable, they have a particularly high taxonomic significance. Additionally, just as morphological characteristics display morphological connections among plants, chemical characters do the same. Even while modern taxonomy considers chemotaxonomy to be a relatively recent invention, its roots may be seen in very early classical taxonomy. You may remember that the fragrant qualities of the plants used to make spices or the therapeutic worth of the plants were used to identify them. Since ancient times, taxonomists have categorized plants using physical characteristics as well as chemical characteristics to determine its aromatic capabilities or therapeutic usefulness. However, chemotaxonomy has only recently been recognized as a significant area of research.

Chemical information may be gathered from any part of the plant, according to a survey of the vast quantity of material that has been published in this sector. Second, the chemical data may be used to describe or identify plants, or to create links, depending on the investigation's goals. When this information is utilized to distinguish between several taxonomic relationships once at least two hypotheses have been proposed based on morphological characteristics, its relevance increases. Although in theory a taxonomist may find value in every chemical component of a plant, in reality certain types of molecules are more helpful than others. As a result, we may employ chemical characteristics that are physically observable, such crystals, raphides, or starch grains found in many plants. As an alternative, plant material may be chemically examined for various chemical components, and the results can be used for taxonomic reasons. The majority of chemotaxonomists agree that semantides, secondary metabolites, and primary metabolites are three major groups of chemical molecules that are significant from a taxonomic perspective[7].

Basic Metabolites

Primary metabolites are chemicals that participate in important metabolic processes, as their name suggests. They are always present and have little bearing on chemotaxonomy. However, when the abundance of these compounds differs significantly across taxa, they may be used as chemotaxonomic characteristics. For instance, the plant species in the genus Sedum store significant amounts of the sugar "sedoheptulose" as a reserve diet. As a result, the presence of this main metabolite makes it simple to distinguish between individuals of this species. Interestingly, sedoheptulose biphosphate, which is a component of the photosynthetic carbon cycle, does not accumulate at all in the majority of plants. The 22 amino acids are also found in all living things.

They act as the foundation for proteins. For chemotaxonomy, they may provide important macromolecular information. It is possible to examine the amino acid sequence of various proteins, and the degree of similarity is probably related to the degree of genetic link. However, only a small number of the approximately 3 lakh species of angiosperms have had their amino acid sequences examined. For instance, the information on wheat and barley's amino acids supports the link between these genera as proposed by traditional taxonomists.

Additional Metabolites

The macromolecules that lack nitrogen, have a limited distribution, and are consequently of higher taxonomic significance than primary metabolites are known as secondary metabolites or secondary plant products. Flavonoids, terpenes, iridoids, alkaloids, anthocyanins, glucosinolates, cyanogenic glycosides, polyacetelenes, and other types of chemicals are included in this category. They are typically not engaged in important processes and are mostly storage products or pigments[8].

Flavonoids

Flavonoids, the most prevalent phenolic compounds in leaves and among the secondary metabolites, have shown to be particularly helpful for chemotaxonomic objectives. These chemicals, which exhibit structural variety and chemical stability in addition to being widely distributed, have been thoroughly examined in both monocots and dicots. They provide crucial chemical features for taxonomic reasons and may be quickly and readily recognized. For instance, Giannasi looked at the flavonoid chemistry of 80 species of plants from the Ulmaceae family. The majority of species possess flavonols, but only a small number of species also include glyco-flavonols, and no species ever has both of these kinds of flavonoid molecules at the same time. It's interesting to note that the family Ulmaceae is split into the Ulmoideae and Celtoideae subfamilies in most traditional classification schemes. These two subfamilies may be distinguished by their flavonoid chemistry. Therefore, the family Ulmaceae may be divided into two separate families using morphological criteria and the flavonoid dichotomy: family Ulmaceae is characterized by the presence of flavonols, while family Celtaceae is characterized by the presence of glucoflavonols. Through history, plant taxonomy's methodologies and scope have changed. They fall within the categories of Alpha and Omega taxonomy.

1. The empirical and analytical aspects of alpha taxonomy. At this phase, an organism is recognized, described, and given a name based on its morphology. It is also known as formal, classical, or orthodox taxonomy. The categorization provided by the Omega taxonomy is interpretive. It aids in the comprehension of phylogenetical and evolutionary links between species. Other names for it are beta-, neo-, and contemporary taxonomy.
2. The characteristics, character states, and qualities provide helpful inputs for identifying and categorizing plants. Taxonomic evidences are all of them put together. These proofs might be biological, chemical, or physical.
3. Physical taxonomic evidence includes data from morphology, anatomy, embryology, palynology, cytology, and other fields. Metabolites, both primary and secondary, serve as chemical taxonomic evidence. Biological taxonomic evidences are information-carrying biomacromolecules, such as proteins and nucleic acids. They go by the name semantides as well.
4. The DNA of nuclear, mitochondrial, and chloroplast origins may be used to provide molecular data that is crucial for understanding evolutionary systematics. Palynology is the study of the composition, polarity, symmetry, shape, and size of pollen grains. Physical taxonomic information from extant and extinct plants, known as paleontology, is crucial.
5. Chromosomal morphology, karyotype analyses, centromere placement on chromosomes, and chromosomal activity during meiosis are all excellent sources of taxonomic information.
6. Starch grains and crystals, which are directly observable molecules within a cell, may assist identify and classify connections in plants. Secondary metabolic taxonomic evidences are substances such as flavonoids, iridioids, alkaloids, betalains, anthocyanins, glucosinates, polyacetylenes, cyanogeneic glycosides, terpenes, etc. that are gathered for the purpose of properly characterizing, classifying, and identifying plants[9]–[11].

CONCLUSION

Herbariums are collections of plant specimens that have been dried, mounted on suitable sheets, and organized chronologically in accordance with an established system of classification. Herbariums are primary resources for identifying plants, aid in instruction and research, and house historical collections. Herbaria come in generic or specialized types. General herbaria are classified according to the status and method of their collections at many levels, including worldwide, national, and local. Special herbaria are modest collections that were created with a narrow focus. It is important to use certain techniques when pasting specimens onto herbarium sheets, and labels that are glued on the sheet must provide general species information. The specimens that have been given a specific herbarium number and seal as well as accessioned herbarium sheets are divided into family, genus, and species folders.

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CHAPTER 7

CLASSIFICATION SYSTEMS OF ANGIOSPERMS

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ABSTRACT:

Angiosperms are split into two groups based on the sorts of cotyledons that are present. Both monocotyledons and dicotyledons describe them. The monocotyledonous angiosperms have one cotyledon, whereas the dicotyledonous angiosperms have two cotyledons in their seeds. The dicotyledons and the monocotyledons are the two groups into which angiosperms have historically been separated. The division of flowering plants into the two groups of dicotyledons and monocotyledons is no longer accepted since monocots are embedded inside the dicot.

KEYWORDS:

Angiosperm, Dicotyledones, Gymnosperm, Monocotyledonous, Monocotyledones, Phylogenetic.

INTRODUCTION

Three different classifications are shown by the taxonomic literature. The three types of systems are phylogenetic, natural, and artificial systems together. Angiosperm classification history may be split into two main systems, each of which has many subsystems.

Hooker and Bentham's Classification

The categorization scheme proposed by Bentham and Hooker for seed plants is a sophisticated natural scheme. Genera plantarum published the classification. The taxonomy of seed plants, which are split into 202 families, 7569 genera, and 97,205 species, is provided by the Genera plantarum. The specimens are arranged in this way at several significant herbaria across the globe. Dicotyledones, which have cotyledones 2 and a tap root system, are one of three kinds of seed plants. Monocotyledones and Gymnospermae with a single cotyledon, parallel venation, and adventitious root system. The three subclasses of the Class Dicotyledones are Polypetalae, Gamopetalae, and Monochlamydeae. Series, orders, and families were further separated into these subclasses. Monocotyledones and Monochlamydeae are classes and subclasses that are directly characterized through series and families. Figure 1 shows the categorisation in broad strokes[1], [2].Evolutionary conditions support the placement of gamopetalae following polypetalae. Bicarpellatae should always come before heteromerae. Most eminent writers regarded ranales as the most primitive dicots. Identification keys are quite helpful. Each family had an overview that was extremely helpful in identifying them. Families and genera are described in detail. In order to make identification easier, large genera have been separated into smaller ones. Taxa are arranged according to general natural affinities determined by morphological characteristics that are simple to study with the unaided eye or a hand lens[3].

Demerits

The system offers little insight into phylogeny. Dicotyledones and Monocotyledones, which are both very unusual, are separated from gymnosperms. Due to being based only on one whorl of a perianth, the taxon Monochlamydeae is entirely artificial. Unisexuales is a broad term for a collection of various families that have just one thing in common: unisexual flowers. These families are divided into two independent subclasses by Cronquist: Hamamelidae and Rosidae, while Takhtajan is classified under Hamamelididae and Dellenidiidae. The affinities of the families included in the Ordines anomaly were unknown to Bentham and Hooker. The highly developed family Compositae is found in the inferae region towards the start of the Gamopetalae. Although the Orchidaceae family is advanced and has zygomorphic flowers and a subpar ovary, it is considered to be at the beginning of the Monocotyledones. The two series with superior ovaries are situated behind the inferior ovary-containing inferae in gamopetalae. A superior ovary gave rise to an inferior ovary, which is today thought to be an advanced organ. Due to its free and superior carpels, the location of the series apocarpae is undesirable.

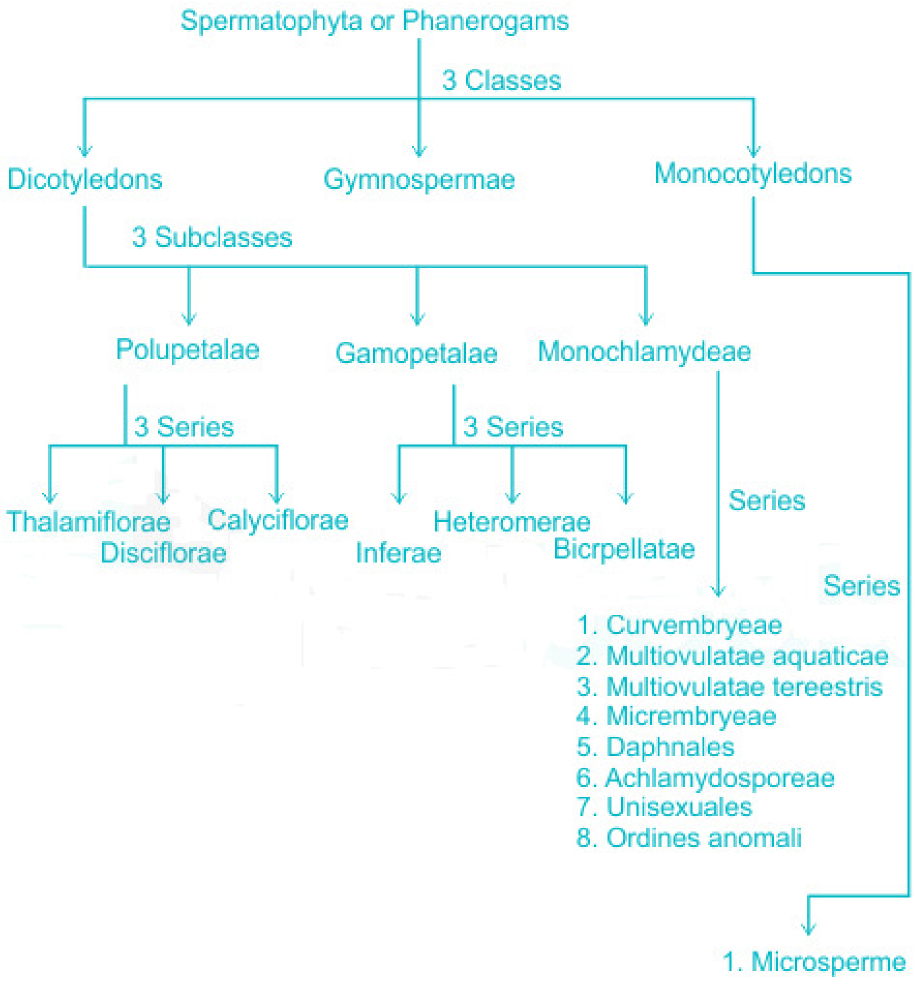

Figure 1: Illustrate the Bentham and Hooker's Classification.

DISCUSSION

Classification by Engler and Prantl

The whole plant kingdom is covered by this categorization scheme. Adolph Engler and Karl A. E. Prantl are the authors of the proposal. The categorization was made public in the enormous 23-volume book Die Naturlichen pflanzenfamilien. It was regarded as the first phylogenetic categorization system. Families are grouped in accordance with the characters' growing complexity. The plants are classified into 13 categories and the groupings are graded according to this method of categorization. Thallophytes are covered by the first 11 divisions of Embryophyta Asiphonogama, whereas Bryophytes and Pteridophytes are covered by the 12th division. The thirteenth division, known as Embryophyta Siphonogama, was for seed plants[4], [5].

Gymnospermae and Angiospermae were the subsequent subdivisions of Embryophyta Siphonogama. A further division of angiosperms is into the classes Monocotyledonae and Dicotyledonae. Pandanceae and Orchidaceae are the first two orders and 45 families under the monocotyledonae division. Dicotyledones are a family that includes 258 families and 44 orders, starting with Casuarinaceae and ending with Compositae. Figure 2 illustrates the initial orders of Monocotyledons and Dicotyledons, respectively, as Order Pandanales and Order Verticillatae.

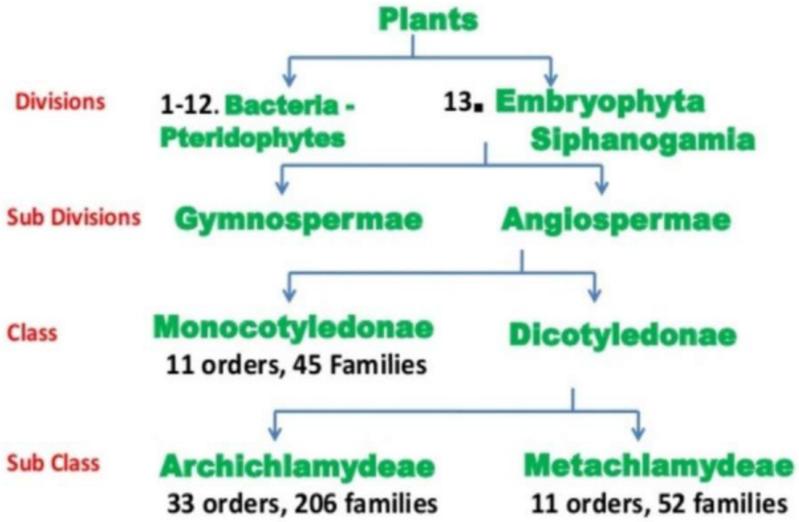

Figure 2: Illustrate the Engler and Prantl's Classification.

The Engler and Prantl Classification System's Traits

The most archaic plants are pollinated by wind, while the most advanced plants are pollinated by insects. The number of sepals and petals grows throughout time, while unisexual plants are more primitive. In reality, bisexual flowers originated from unisexual blooms, making them more sophisticated than unisexual flowers. The sepals, petals, stamen, and carpels of primitive plants are free, whereas those of advanced plants are joined. The plants are primitive since linked calyxes are present. While the union of all floral parts denotes the most advanced stage, the union of the calyx and corolla shows that the plant is progressed. Gymnosperm groups separated into monocots and subsequently dicots, from which angiosperms eventually emerged. Angiosperms were the ancestors of monocots and later dicots. It shows that dicots have more advanced traits than monocots. Engler created the Archichlamydeae family, which comprises dicot plants and has free sepals and petals, by combining the monochlamydeae and polypetalae families. Plants from the Archichlamydeae family have changed into Metachilamydae plants. Male and female flowers are produced by microsporophyll and megasporophyll, respectively. While dictos are divided into 44 orders and 261 families, monocots are divided into 11 orders and 45 families[6].

Dicotyledones are listed after Monocotyledones

Amentiferae with small, unisexual flowers that are borne in catkins and have few floral members were formerly thought to be primitive; nevertheless, new research has shown that they are an advanced taxon. The majority does not accept the idea that dichlamydeous forms evolved from monochlamydeous ones. Recent data that points to a monophyletic origin for angiosperms has made the idea of their polyphyletic origin untenable. Although helobiae is a primitive group, its placement is incorrect.

Classification by John Hutchinson

Associated with the Royal Botanic Gardens at Kew, England, was John Hutchinson. The book "The Families of Flowering Plants" revealed the classification of angiosperms. Volume I included dicotyledones, while Volume II covered monocotyledones, and they were published independently in the years 1926 and 1934. The second version of the classification was released in 1959, and the third edition was released in 1973, one year after his death[7].

Only flowering plants were included in Hutchinson's classification, and Phylum Angiospermae was distinguished from Phylum Gymnospermae. Dicotyledons are split into two divisions with 54 and 28 orders each: Lignosae and Herbaceae. Verbenaceae marks the conclusion of Division Lignosae, which begins with Magnoliaceae. Paeoniaceae and Lamiaceae are the first two genera in the Herbaceae family. The divisions Calyciferae, Coroliferae, and Glumiflorae were created for monocotyledons. Family Poaceae is at the end of the Monocotyledons, whereas Family Butomaceae is at the beginning. Figure 1 illustrates the 24 principles upon which the categorization was built. Following are a few of them:

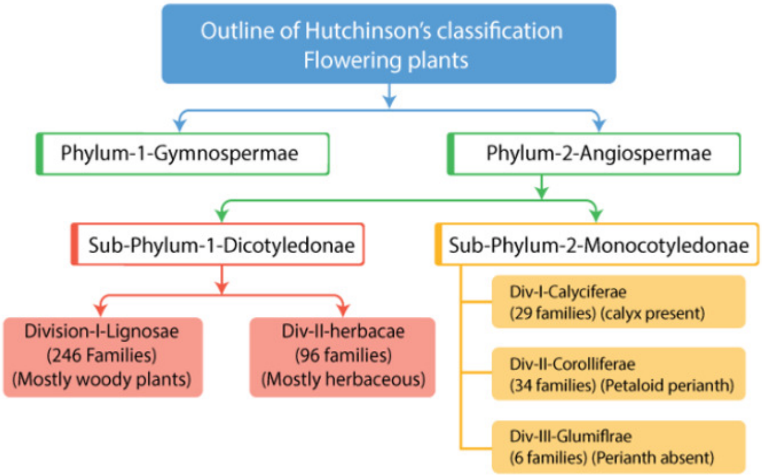

Figure 1: Illustrate the John Hutchinson's Classification.

Evolution occurs both upwards and downwards, or in both directions. All of a plant's organs in all directions may not be involved in evolution at the same time. Comparatively to Monocotyledones, which have dispersed bundles, Dicotyledones have collateral vascular bundles grouped in a cylinder, indicating a more primordial origin. Compound leaves come after simple leaves. Whorled and opposing leaf arrangements are preceded by spiral arrangements of foliage and flowery leaves. Bisexual flowers come before unisexual ones, and the solitary flower is more primitive than the inflorescence. Gamopetalous situations are more advanced than polypetalous ones. Compared to perigyny, epigyny, and hypogyny, the latter is more primordial. Seeds with endosperm are more primitive than those without. Many stamens is primitive than few stamens[8]–[10].

Adolf Engler was a German botanist who co-edited the 23-volume book "Die naturlichen Pflanzenfamilien" with Karl von Prantl between 1887 and 1915. He is most recognized for his work on plant taxonomy and phytogeography. The Engler method, which he developed for classifying plants, is still extensively used by herbaria and embraced by writers of several manuals and floras. Hutchinson divided the angiosperm into two sub-phyla, the monocotyledonae and the dicotyledonae, based on the hypothesis that angiosperms had a monophyletic origin. Plants with two cotyledons in the embryo, reticulate leaf venation, pentamerous blooms, and tap roots.

CONCLUSION

Biosystematics classification is crucial. Botanical classification involves classifying plants according to characteristics. Characters may be included that are morphological, anatomical, cytological, etc. One or two morphological characteristics are the only ones considered in the natural kind of categorization. The finest illustration of this is the classification of Linnaeus. All morphological traits were taken into consideration in the case of the natural kind of categorization, or the Bentham and Hooker's method. Such a categorization is quite useful in practice for identifying plants. All types of characteristics are included in contemporary categorization schemes like phylogenetics. In other words, we may claim that phylogeny is included in phylogenetic categorization. Each categorization scheme has advantages and disadvantages of its own. India and England both adhere to the practical and herbaria arrangement of Bentham and Hooker's classification.

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CHAPTER 8

CONCEPT OF PHYTOGEOGRAPHY

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ABSTRACT:

Phytogeography, which focuses on explaining plant ranges in terms of their origin, dissemination, and evolution, is the study of the distribution of plants or taxonomic groupings of plants. The branch of biogeography known as phytogeography, often known as geobotany, is focused on the geographic distribution of plant species, or more broadly, plants. Phytogeography is concerned with all facets of plant distribution, from the mechanisms that regulate the makeup of whole communities and floras to the forces that regulate the distribution of individual species ranges (at both large and small scales, see species distribution). To research role of regional variables in plant taxonomy. Summary to Endemism includes hotspots and hottest Hotspots.

KEYWORDS:

Endemism, Phytogeography, Phylogeny, Phylogeny, taxonomy.

INTRODUCTION

Nomenclature, categorization, and identification of plants are all made possible by taxonomy. Classifications are generally based on natural relationships between taxa. It should be based on as much information as is available for the building of groups in order to create a categorization that is more acceptable and natural. Only after realizing that related plant species have a similar progenitor and a related geographic distribution can the good relevance of these relationships be grasped. Botany's section of plant geography studies how plants are distributed now and in the past. It was focused on the dispersion of plants and their patterns and processes. Geography is the study and description of the division and distribution of terrestrial occurrences, its climatic conditions, physical characteristics, and living and non-living things. Studying the physical makeup and occupants is crucial for understanding both plant and animal life, especially their dispersal. The area of botany known as phytogeography is concerned with the study of the origin and geographic distribution of plants.

Plant ranges on or near the surface of the planet and its oceans are the subject of plant geography. In other words, phytogeography is a field that has evolved alongside and because of development in fundamental biological sciences. Despite the fact that distributional studies of plants are as ancient as botany itself, phytogeography is still a relatively new field of study. Humboldt developed the first really structured approach to phytogeography. For the study of the interactions between plants and environment, both latitudinally and altitudinally, Humboldt is credited as the "Father of Phytogeography." Plant dispersion processes and patterns are of interest to phytogeographers. The distributions, genesis, dispersion, and extinction of taxa may all be influenced by biotic and abiotic interactions. Traditionally, floristics and its taxonomy have been a major focus of phytogeography[1].

Divide Phytogeography into Two Groups

Phytogeography that is descriptive or static focuses on the actual descriptions of floristic or vegetational groupings that may be found across the planet. Early plant geographers attempted to categorize the planet into floristic and botanical zones by describing floras. It has to do with how different plant communities are distributed. Both intrinsic and regional variables have an impact. While geographic variables are climatic and barrier elements, intrinsic factors are those that relate to an individual's evolution. The importance of descriptive phytogeography to taxonomy and ecological research cannot be overstated. One may better comprehend plant families, genera, and species by being aware of their distributions. Interpretive or dynamic phytogeography: This kind of phytogeography examines the dynamics of plant migration and evolution. It describes how plant dispersal is caused.

Good proposed the principle of tolerance in plant dispersal. Mason, Cain, and a few others have identified the elements that affect plant dispersion. Another term for interpretative phytogeography is dynamic phytogeography. It is an amalgamation and integration of the acquired and verifiable information from the linked disciplines of cytology, genetics, paleobotany, ecology, evolution, taxonomy, comparative morphology, and phylogeny. According to Cain, while looking for the reasons behind distributional phenomena both historical and modern the material that is more specifically the purview of special sciences provides the answers.

The distinctiveness of interpretive phytogeography as an area of study comes from synthesis and integration. Interpretive phytogeography is a borderline science that relies on the more specialized sciences for some of its resources and ideas. The second stage naturally follows descriptive phytogeography and is known as interpretive phytogeography[2].

India's Phytogeographical Regions

The earth has been split into many phytogeographic regions based on the kinds of soil, climate, and plants that flourish there. Good divided the globe into six kingdoms, each with 37 subregions. An area with an identifiable kind of flora and a consistent climate is referred to as a phytogeographic region. Based on the types of plants present in British India, Hooker identified nine separate zones. India's subcontinent, Burma, Malaya, Sri Lanka, the Maldives, and the Laccadiva Islands were all included.

Eastern Himalayas, North West Himalayas, Indus plain, Malabar, the Deccan, Ceylon, Maldiva islands, Burma, and Malaya are the nine divisions. India's vegetation was described by Calder in 1937. He recognized six phytogeography divisions and later on the divisions are termed as regions which are follows- Eastern Himalayas, Western Himalayas, and Indus plain, Gangetic plain, Malabar and Deccan. In order to investigate the indigenous flora of India, Chatterjee split the continent into eight regions, omitting Burma. The following are these subdivisions:

Deccan:

The states of Karnataka, Tamil Nadu, and Andhra Pradesh, which include Mysore, Chennai, and the majority of Hyderabad. Comparable to the Malabar division of Hooker and Calder, Malabar is made up of the Western Ghat hills and is a short strip of territory that extends from Sind to the southernmost point of the nation.

Endemism

The word endemism is widely used for regular occurrence in a particular region. Endemism is the restriction of a certain species, genus, or groupings of plants and animals to a specific geographic region. Endemism typically applies only if there is a major constraint in the region of dispersion. The dispersion of cosmopolitanism is in stark contrast to endemism. High levels of endemism and species richness may be seen in tropical forests. Endemism refers to the restriction of a tax on to a particular geographic location, such as an oceanic island, a peninsula, a mountain top, etc. Globally, endemic species are abundant in botanically interesting regions, particularly islands. Regions with significant concentration of endemic species are categorized as Biodiversity[3].

Endemic taxa are those that only exist in a certain geographic location. In botany, the word "endemic" refers to a species or other taxon that is unique to a certain area, such as a state, district, city, etc. The region under consideration need to be a smaller one for the precise meaningful. Endemism may be divided into two categories: Neo-endemism and Paleo-endemism. Types include Neo-endemism: Because a tax on just arose, it is evolutionarily young and has not yet expanded throughout the new territory. Common examples include Seneca cumbrances, Crepes fuliginous etc. An ancient taxon with a limited range today owing to climate changes or human impact is said to exhibit paleo-endemism. A typical example is ginkgo biloba, which was previously ubiquitous in the Northern Temperate Zone but is now only grown in China.

Endemism Theories

There are two basic ideas to explain the endemism. According to the first idea, endemic remnants or epibiotics are the final survivors of a once-thriving flora that is now in decline. The second view, however, contends that these are new and young species that will eventually become extinct. The Age and Area Hypothesis is another name for the notion. Examples of Primula, Impatiens, Rhododendron, etc. have been offered to support the age and area idea. Examples of endemic species that were widely dispersed throughout the Cretaceous and Tertiary eras are Sequoia semiperirens of the central valley of California and Oregon and S. gigantea of the Sierra Nevada[4].The area and age theory states that an object's age on the evolutionary scale is precisely related to its area. Therefore, a narrow region of distribution reveals relatively young in age species, such as the two species of Coleus, C. elongatus and C. barbatus, which are scattered on the peak of the parched Ritigala Mountains in Sri Lanka. C. elongatus is endemic while C. barbatus is extensively dispersed throughout tropical Asia and Africa.

Factors Contributing to Endemism

When a species' ability to adapt to various environmental settings remains low. Geographical restrictions like the sea, mountains, etc. cause them to stay confined to a certain location. They are unable to distribute their reproductive cells, such as propagules and seeds, in far locations because their reproductive organs generate less effective reproductive cells. The level of endemism in a given location is influenced by a number of other variables. These include the separation time and the distance from other regions with a comparable geography. The Wulff estimates that 72% of New Zealand, 80% of Hawaii Islands, and 85% of St. Halene's Flora are endemic. Mountains have more endemic species since they are isolated e.g., 70% sp. of Himalayas are endemic. According to Chatterjee, India has more than 50 indigenous species of

Dicotyledone plants. The Himalayas and South India are home to the majority of indigenous flora. There are hardly any indigenous species in the Indo-Gangetic plains. Only 49 genera out of 22 families are indigenous to India, which is the only country where they may be found[5].

The hottest hotspots and Hot Places

The variety of organisms is influenced by geographical locations, physiography, edaphic, and climatic conditions. The flora and wildlife are influenced by these causes. Hot spots are regions with high degrees of endemism, threat, and species richness. When a certain geographic area's biodiversity is under danger, it is referred to as a hot spot or sensitive place. Unique geographic locations, diverse physiographic, edaphic, climatic zones, and gradients are all features of the Indian subcontinent. With a high rate of endemism, this subcontinent is home to a remarkably rich and diversified flora and fauna. It is ranked 10th among the world's plant-rich nations and fourth among Asian ones. Two of the top 25 biodiversity hotspots on earth the Eastern Himalayas and the Western Ghats can be found in India. On the basis of the distinctiveness of the phytogeographical zones and the endemism pattern, 25 Micro Hot Spots have also been found in India. Hot Spots include Mediterranean basin, tropical Andes in South America, Madagascar and Indian Ocean islands, South Africa's Cape floristic region, south west Australia, huge areas surrounding Indonesia, Malaysia and the Philippines and Eastern Himalaya.

In the region of the former Soviet Union, there are no specifically identified Hot Spots. Though huge extent of forest is present but in terms of Bio-diversity priority it is much lower than the tropical rainforests[6]. For the first time, Myers found 10 hotspots in tropical forests with high levels of plant endemism and severe habitat degradation. 8 new hotspots were added by Myers, including 4 with a Mediterranean-style ecology. Myers et al. discovered 25 biodiversity hot areas in 2000, in addition to other hot places. In an area covering 1.4% of the earth's land surface, these 25 hot spots are home to 35% of the terrestrial land vertebrates and 44% of the world's unique plants. 34 Biodiversity Hot Spots have recently been discovered. Hot spots hold more than half of the planet's terrestrial biological variety yet only occupy less than 2% of its geographical area. Ecosystems are most at danger in these hot areas. The remaining other original natural habitat is less than 10%. Only 2% of it is found in the Mediterranean basin.

One feature of the hot spots is that at least 25% of the vertebrate species and over 40% of the terrestrial plant species are indigenous to these regions. In-depth research on the relationship between global warming and the extinction of endemic species from Biodiversity Hot Spots was published in Conservation Biology. 23 tropical hotspots of biodiversity throughout the globe are identified, along with the possible effects of climate change and global warming. Southwest Australia, the Caribbean, New Zealand, Madagascar, the Tropical Andes, and the Mountains of China Hottest Hotspots are among its inclusions. There are five main elements that must be taken into account when determining the "hottest hot spot," including the ratios of endemic plant and animal species to total area, as well as habitat degradation. These variables cannot be merged into a single quantitative rating since they are not equally important. The eight "hottest hotspots," which are represented at least three times in each of the top ten lists for each component, are Madagascar, the Philippines, Sundaland, Brazil's Atlantic Forest, the Caribbean, Indo-Burma, the Western Ghats or Sri Lanka, Eastern Arc, and the Costal Forest of Tanzania or Kenya. The three countries that occur for all five factors Madagascar, the Philippines, and Sundaland are in first place, followed by the Caribbean and Brazil's Atlantic Forest, which also appear for four. The fact that three of these hotspots Madagascar, the Philippines, and the Caribbean have limited territories emphasizes how significant they are[7].

The Tropical Andes and the Mediterranean Basin, two other hotspots, should be taken into consideration as very hot candidates for conservation assistance due to their remarkable numbers of unique plants, at 13,000 and 20,000, respectively. In terms of endemic plants, the Mediterranean is third after Sundaland and the Tropical Andes are first, with 34% more than the fourth hotspot. But they do not rank in more than two of the five factor rankings. Similar to this, Mesoamerica ranks second in terms of endemic animals but only eleventh in terms of endemic flora.

DISCUSSION

Plants, Plant Exploration, and Plant Invasion

In the distant past, during the Rig-Veda era, studies of plant sciences were initiated. The exploration of plants in India by the Portuguese is described in literature. Plants or their components, such as seeds or propagules, are moved to new or different locations for specific purposes. Purpose may be for agriculture, research, food etc. When ideal circumstances exist, naturalization begins. Introduced or migratory species may have a harmful impact on the indigenous flora and fauna. One of humanity's core activities is the discovery and outline of new plants. It's necessary to introduce genes from one origin region to another. This might be a region of a state, a nation, a continent, etc.

Indian plant exploration

According to written sources, the Rig-Vedic period in India's distant past is when the science of botany first emerged. Prior to the advent of Christianity, Parasara's Vrikshayurveda explains the knowledge of medicine. The composition of this paper must have been preceded by extensive plant investigation effort. However, the previous development of taxonomy in India was overlooked after the Renaissance since Indian culture was totally cut off from the development of taxonomy in Europe.

Invasion of plants

Transportation of plants or its components like seed, propagules etc by humans over a substantial geographical barrier is described. When different obstacles to normal reproduction are removed, along with abiotic and biotic barriers to survival, naturalization may begin. Furthermore, for an invasion to occur, imported plants must develop fertile progeny far from the locations of introduction. Taxa that can survive in the local biota and abiotic environment may encroach on damaged, semi-natural populations. A separate group of obstacles must typically be overcome for a foreign tax on to invade succession ally mature, unaltered populations[8], [9].

Plant domestication is a co-evolutionary process in which human selection on the phenotypes of populations of promoted, managed, or cultivated plant species leads to alterations in the genotypes of the population, improving the population's suitability for human use and for landscape modification. Darwin theorized that human selection might be either unconscious or intentional. Selection and management must result in differential reproduction and survival for plant domestication to occur.The degree of change in the targeted demographic might vary:

Wild a population that has naturally developed and whose genotypes and phenotypes have not been altered by human activity? Unintentionally Co-Evolved: A population that chooses to adapt in a world disrupted by humans, maybe going through genetic change, but not under the influence of human selection. Many weeds are instances of species that accidentally co-evolved; these species may also go through the process of domestication if people start to select for their advantageous qualities and begin to control or cultivate them. A population that has undergone human selection and intervention, but whose average phenotype still falls within the wild population's range of variation for the characteristic under consideration. However, since selection has begun to diminish genetic diversity, the variance of this average is probably lower than that of the original wild population.

Semi-Domesticated:

A population that is considerably affected by human selection and intervention such that the average phenotype may diverge from the range of variation present in the wild population for the characteristic subject to selection. Because the phenotypic variety now comprises both kinds that are prevalent in the wild population and types that are new, the variance of this phenotypic average may be greater than that of the wild population. Underlying genetic diversity however, continues to decline because fewer individuals match the selection requirements and are consequently included in the following generation. If human intervention ends, the plants still have enough ecological adaptation to live in the wild, but the phenotypic variety that people have chosen would eventually vanish from the ecosystem[10].

A population of plants that is comparable to the Semi-Domesticated population but whose natural flexibility has been diminished to the point that it can only thrive in human-made habitats, notably in cultivated landscapes. Because of increased selection pressure and the lack of ecological adaption, genetic variability is often lower than in Semi-Domesticated. Depending on the population's life history, size, and the kind of vegetation that overtakes the abandoned location, it may not take long for it to disappear if human activity ends. In clonally propagated crops, a single genotype may be the domesticate, but also gets lost shortly after it is abandoned

Plant Introduction

One of humankind's oldest pursuits is the discovery and introduction of new plants. It was common practice to provide seeds and seedlings in the home. The secret to sustaining and enhancing agriculture is genetic variety. The first people to transport plant material, such as seeds, across locations was an invasion in earlier times. It was initial introduction of plants like cotton, maize, jowar, apple, papaya, cashew nut, potato, groundnut, mustard etc. Tea, litchi, and other items from China were brought to India by the British, as were Mediterranean foods like cauliflower and cabbage. Plant introduction refers to the transfer of a genotype from its original location to a new one. This might be from a distant nation or a state that is a part of your own. Sonara 64 and Lerma Roza wheat varieties were brought to India from Mexico in 1960. If a previously introduced material is hybridized with native material to produce new, enhanced germplasm, such as Kalyan sona and IR8, the introduction becomes secondary. In India, a number of botanical gardens preserve uncommon plants brought in from outside under living conditions or in the form of herbariums. Some notable examples are the Royal Botanical Garden in Kew, the Central Botanical Garden in Howarah, and the National Botanical Research Institute in Lucknow. A number of other horticultural and agricultural institutes are also crucial to the introduction of new plants. It began in 1946 with the creation of IARI's Plant Introduction

Division. Following this, in 1976, division became the National Bureau of Plant Genetic Resources. Currently, NBPGR is engaged in exploration[11], [12],

CONCLUSION

The distribution of plants in historical geographic areas together with an explanation of their evolution, environment-related distribution, and other ecological aspects is known as phytogeography. Calder provided a description of the Indian flora. Endemic taxa are those that only exist in a certain geographic location. High levels of endemism and species richness may be seen in tropical forests. Endemism refers to the restriction of a tax on to a particular geographic location, such as an oceanic island, a peninsula, a mountain top, etc. Endemically diverse regions, particularly islands, are found in botanically fascinating parts of the world. Hot spots hold more than half of the planet's terrestrial biological variety yet only occupy less than 2% of its geographical area. Only 2% of it is found in the Mediterranean Basin. One feature of the hot spots is that at least 25% of the vertebrate species and over 40% of the terrestrial plant species are indigenous to these regions. The Mediterranean basin, the tropical Andes of South America, Madagascar, the islands of the Indian Ocean, the Cape Floristic Province of South Africa, the southwest of Australia, vast swaths of Indonesia, Malaysia, and the Philippines, and the Eastern Himalaya are all hotspots. The world's largest biological variety in both terrestrial and marine ecosystems, as well as an incredible array of human cultures and languages, are found in regions that make up less than one percent of the world's total geographical area and are referred to as hotspots. Overview is the human movement of a plant or one of its elements, such as seed or propagules, over a significant geographic barrier. When different obstacles to normal reproduction are removed, along with abiotic and biotic barriers to survival, naturalization may begin. Furthermore, for an invasion to occur, imported plants must develop fertile progeny far from the locations of overview. One of humankind's oldest pursuits is the discovery and summary of new plants. It was common practice to provide seeds and seedlings in the home. The secret to sustaining and enhancing agriculture is genetic variety.

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CHAPTER 9

SEED GERMINATION AND GROWTH AND PLANT DEVELOPMENT

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ABSTRACT:

The study of how cells, organs, and/or whole plants are controlled and coordinated includes, for instance, how changes in gene expression occur in response to environmental factors like climate change. You will comprehend the distinctive characteristics of plant growth and the stages of seed germination after reading this chapter. Proteins, Nucleic Acid, and Food Reserves are All Metabolized Control of Seed Germination by Tropisms and Hormones

KEYWORDS:

Environmental, Gibberellic Acid, Mega gametophyte, Seed Germination.

INTRODUCTION

Students will learn about the distinctive characteristics of plant growth that set it apart from animal development by studying this topic. Additionally, students will be aware of how germination works, how environmental conditions affect it, and how different hormones govern it. The first step in a plant's life cycle is seed germination. It only happens when the environment is suitable for a plant's survival and development. When a seed germinates, a number of processes happen in a sequential order. Up to the establishment of the self-dependent seedling stage, reserved food supplies are mobilized and eaten. Different plant growth hormones interact with one another and regulate seed germination.

Specifics of Plant Development

The following distinguishing characteristics of plant growth from those of animals are:

Existence of haploid and diploid life stages that are genetically active. Occurrence of double fertilization during sexual reproduction to create both an embryo and an endosperm, which is a nutritional tissue. Plant cells are not able to move. Plant shape and forms are determined by the rate of cell division and the direction of elongation. Although plants have 3 fundamental tissue-systems. They don't rely on gastrulation to generate these layer structures[1].

Fresh organs are created by meristems, which are collections of actively dividing cells, during the course of their whole life cycle. Amazing developmental adaptability may be seen in plants. Lost plant components and even whole plants may be regenerated from just one cell. Environmental elements can have a big impact on how a plant looks overall. Natural selection may occur on the haploid genome of plants because the active gametophyte phase causes harmful alleles to be eliminated from the population, which would otherwise be hidden in diploid organisms. Regarding the germline, plants and animals vary significantly from one another. Only the derivatives of the germ cell go through meiosis to create gametes in animals, which have germ cells that are formed early in the embryonic development process and remain as a separate stem cell population throughout the animal life. While in plants, the stem cell population which makes shoot during vegetative development flips to produce flowers during reproduction. The switch that turns on blooming is triggered by developmental and environmental factors. Conversely, the nonexistence of a germline and the late transfer of plant shoot from somatic lineages into floral development enable genetic alterations to accumulate and be reflected in the gametes. Consequently, plants create higher genetic variety, yet, via haploid selection, impose severe selection than animals[2].

Reproduction is naturally more flexible in plants. Asexual plant reproduction occurs in a variety of ways, from the regeneration of microscopic plantlets on leaf edges to apomixes, in which seeds may form in flowers without fertilization. In vitro, further developmental flexibility is shown since haploid pollens and diploid somatic cells may both grow into embryos in tissue culture. The twofold fertilization event seems to have been an important evolutionary breakthrough given the dominance of flowering plants on Earth today. In Animal life cycle, gametes are created directly by meiosis and gene expression is confined to diploid cells. The germline is early separated from the rest of the embryo, and only these cells are capable of going through meiosis in the adult. Typical flowering plant life cycle, in which meiosis, followed by mitotic divisions, generates two forms of haploid organism that are genetically active the female mega-gametophyte and the male macrogametophyte. Mitotic division in the macrogametophyte results in a pair of sister cells that develop into sperm. In the mega gametophyte, two haploid nuclei merge to create a diploid central cell, which is fertilized by a third sperm cell to become triploid endosperm. A haploid egg develops and is fertilized by one sperm cell to make an embryo. In flowering plants, the endosperm is a terminal nutritive tissue that aids in appropriate embryo development.

Seedling Emergence

When seeds ingest water, a succession of metabolic processes are launched, leading to the eventual appearance of the radicle and the termination of germination. Afterwards, the accumulated reserve foods are activated to assist early seedling development. As a seed germinates, the following processes occur:

Taking In Water

Germination involves activities that start with the intake of water by the quiescent dry seed and concludes with the appearance of the embryonic axis, generally the radicle. Dry mature seed absorbs water in three stages. The initial inflow is caused by the dry matrices of the seed's extremely low water potential. After fast hydration of seed matrices, a plateau is attained. Water is only absorbed until germination is complete, when the embryo turns into a seedling. This kinetics of water intake is modified by the seed shape, for example in cereals water does not enter all regions equally, but is directed preferentially towards the embryo or its radicle. Phase I of water uptake causes temporary structural changes to membranes. It causes the seed to rapidly release ions and low-molecular-weight metabolites. Some seeds are resealed with lectins, proteinase inhibitors, and seed-surface proteins that function as defenses against bacterial or insect invasion[3].

Beginning of Metabolism

Faster metabolic activity is resumed Imbibed seeds. All of the cellular components and enzymatic machinery required to start the metabolism are present in the dry seed. Respiration is one of the first actions to restart. It may be detected within minutes after imbibition. The Krebs cycle and respiratory pathways, including the glycolytic and oxidative pentose phosphate pathways, resume in Phase I. Although the tissues in dry seed have poorly differentiated mitochondria, they also have enough terminal oxidases and Krebs cycle enzymes to produce enough ATP to support metabolism for many hours after ingestion.

Afterwards two separate types of mitochondrial development are observed: 1) Pre-existing mitochondria in starch-storing seeds are fixed and activated. 2) In contrast, oil-storing seeds undergo distinctive mitochondrial biogenesis, including both the mitochondrial and nuclear genomes. Similar to respiratory equipment, ripe dry seeds have all the elements necessary for protein synthesis. Protein-producing elements and ribosomes are recruited onto mRNAs stored in the dry seed minutes after rehydration. Ribosomes are created from scratch and utilized for translation. As time goes on, new mRNA molecules gradually replace the prior pool of transcripts. Most mRNAs are used to make proteins that are necessary for cellular metabolism. New proteins like protein kinases and ATPase's are also created prior to germination[4], [5].

Germination is Finished

Radicle protrusion from the seed finishes germination and signals the onset of seedling development. This occurs as a consequence of cell expansion, which may be followed with cell division. DNA becomes damaged during desiccation process of seed maturation; hence its mending takes occur shortly after the commencement of imbibition, Mitochondrial DNA is also generated. After radicle protrusion, cells that are actively dividing begin to synthesize new DNA. They also produce tubulin protein, a microtubule component necessary for spindle assembly during cell division. The process by which the radicle emerges from the cell is turgor dependent. Expansions work on the cell walls of radicles to dissolve the hydrogen bonds that join the cell wall polymers, making the cells walls more flexible.

Mobilization of the Food Supply

Food reserves are mobilized from the storage organs at the completion of germination to sustain the seedling development until it becomes autotrophic by commencing photosynthesis. Cotyledons and endosperm are the seed storing organs of dicot and monocot plants respectively. High-molecular-weight food reserves held inside them are converted into readily moveable low-molecular-weight metabolites. Thereafter they are guided into the expanding zones. The hydrolysis and exploitation of these reserves often happens parallel. The three primary dietary sources are proteins, oils, and carbs. Seeds contain large quantities of two or more of these key reserves.

The plant hormone gibberellic acid is produced from the scutellum and diffuses to the live cells of the aleuronic layer where it induces the creation of various hydrolytic enzymes. These are secreted into the nonliving cells of the starchy endosperm where the starch and protein reserves are stored. -Amylase and maltase are essential enzymes in the breakdown of starch to glucose, while the proteinases hydrolyze proteins to short peptides and amino acids. The hydrolytic products are absorbed by the scutellum, which is part of the forming embryo. The results of protein mobilization are converted there to the amino acids glutamine and asparagine, while the glucose is transformed into sucrose. These serve as a source of nutrients to encourage development and are distributed throughout the seedling through the vascular system.

Carbohydrates

In the endosperm of grains like rice, wheat, and maize, starch is the main reserve carbohydrate. Amylase initially hydrolyzes the amylose and amylopectin found in starch. This enzyme breaks down the glycosidic bonds between the glucose residues at random. Another enzyme involved in the breakdown of starch is -amylase, which releases huge oligomers from prior -amylase activity by splitting off successive disaccharide maltose residues from the nonreducing terminal. These enzymes convert amylaose into residues of glucose and maltose. In addition to these two residues, limit dextrins highly branched short chains of glucose are also produced from amylopectin. A debranching enzyme- limit dextrinase hydrolyses the branch sites and releases the short chains, which are further cleaved by the amylases. Maltase hydrolyzes maltose into glucose units. In monocots, all the above stated enzymes except amylase are generated in the embryo and surrounding aleurone layer. Thereafter, they are released into the storage cells of the endosperm to breakdown starch following germination. The storage cells already contain amylase, which is turned on when needed. Finally glucose is sent into the expanding embryo through the scutellum and is converted to sucrose for transfer to, and eaten by, the growing areas of the seedling. Starch phosphorylase is present in certain dicot seeds in lieu of amylase. At the nonreducing end of the polysaccharide chain, it adds a phosphate group across the connection between the second-to-last and final glucose residues. The complete hydrolysis of the starch still depends on the other enzymes.

Protein

Proteinases hydrolyze storage proteins. The hydrolytic activity of these enzymes has led to their classification. Short oligopeptides are created by endopeptidases hydrolyzing inner peptide bonds. Peptidase then further cleaves these short oligopeptides into amino acids. A polypeptide's free carboxyl or amino end is where carboxypeptidases and aminopeptidases, respectively, liberate the terminal amino acid. In cereals, the endosperm is the primary location for protein storage, and the aleurone layer produces the aforementioned enzymes following germination. Additionally, the endosperm contains pre-synthesized proteinases that are immediately activated once the seed absorbs water. Small peptides and amino acids, the byproducts of protein hydrolysis, are delivered to the developing axes[6], [7].

The majority of dicot seeds have cotyledons that house store proteins in distinct protein bodies. After germination, the "proteinase A" group of endopeptidases first cuts short-chain peptides from storage proteins, rendering them soluble and susceptible to further proteolysis. Endopeptidases and carboxypeptidases of the "proteinase B" class hydrolyze these vulnerable chains into tiny oligopeptides and amino acids. All of these processes take occur inside the protein bodies. Thereafter, oligopeptides are released into the cytoplasm where aminopeptidases and other peptidases capable of acting on di and tripeptides, degraded them to individual amino acids. Amino acids are transformed to glutamine and asparagine before to their mobilization to the seedling axis. Proteolytic enzymes indicated above are produced on the rough endoplasmic reticulum. The hydrolases are then released to begin acting on the storage proteins after being bundled into vesicles, which are then carried to the protein bodies. The protein bodies merge to produce large vacuoles that are filled with a variety of hydrolases as protein digestion progresses. They eventually mature into autophagy vesicles that are in charge of the eventually degenerating and senescent cotyledons.

DISCUSSION

Hormonal Control of Seed Germination

Gibberellins and ABA are the most critical plant hormones for seed germination which have stimulatory and inhibitory effects on it correspondingly. Brassinosteroids and ethylene also have positive impacts on seed germination. Though auxin by itself may not be needed for seed germination, its interactions and crosstalk with ethylene and gibberellins may impact the processes of seed germination. Roles of several plant hormones in reference to seed germination are as follows:

ABA

ABA is often referred to as the stress hormone. In addition to stress response, it regulates seed dormancy and stomatal activity.

It interferes with the germination process of seeds. It prevents endosperm weakness and radicle growth. It has a suppressive impact on transcription factor expression, which is necessary for seed germination.

Ethylene

Although ethylene regulates fruit ripening, aging, and other plant processes, there are conflicting theories on how it affects seed germination. According to some experts ethylene is essential for seed germination while others say that ethylene is created as a consequence of seed germination. Many plant seeds, including those of rice, maize, and wheat, have been shown to produce more ethylene as they germinate[8].

Ethylene is capable of sprouting latent seeds. Testicles and endosperm may rupture as a result of it. It interacts negatively with ABA's inhibiting effects on seed germination. It has been postulated that ethylene affects the expression of genes which encode enzymes important for digesting seed-storage proteins during the earliest phase of germination. These include the proteasome and cysteine-proteinase.

Gibberellin

Seed germination requires gibberellin. Through breaking coat dormancy, weakening endosperm, and expanding embryo cells, this hormone aids in seed germination. The loosening of the endosperm is achieved by altering the proteins in cell walls. However, ABA may prevent endosperm from deteriorating. Gibberellin stimulates the formation of hydrolases notably amylase. At molecular level, gibberellin activates diversity of genes important for the synthesis of amylase, glucanases and proteases. The aleurone layer, which envelops the endosperm, is where gibberellin signaling takes place. Cross talk between hormones greatly influences seed germination.

Auxin

Autin is not required for seed germination on its own. But it is located in the developing tip of the seedling. It is necessary for the development of young seedlings via the control of phototropism as previously mentioned[9].

Cytokine

All stages of germination continue to include cytokinin activity. By controlling cellular division, seed size, seed production, germination, hypocotyl development, and shoot growth, they manage embryo growth. Cytokinins also increase seed germination via the relief of stressors.

Brassinosteroids

By controlling the inhibitory effects of ABA, brassinosteroids promote seed germination. Gibberellic acid, ethylene, and brassinosteroids promote endosperm rupturing and improve the seed's capacity to produce embryos. They interact with ABA negatively. There are distinct signaling routes used by these hormones. Brassinosteroids promote seed germination by accelerating embryo development, while gibberellins and light alleviate seed photodormancy[10]–[12].

CONCLUSION

Plant life is remarkable in that it lacks the ability to move, has haploid gametophytes that are genetically active, double fertilization, totipotency, and immense developmental flexibility. Water absorption initiates seed germination, which culminates in radical emergence. Food stores found in the endosperm or cotyledons of seeds are mobilized to sustain the seedling's early development until it transitions to auxotrophic growth. Multiple plant hormones, including gibberellic acid, ABA, ethylene, and brassinosteroids, interact with one another to control various processes during seed germination. Environmental elements light, gravity not only impact seedling germination as well as it future development.

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CHAPTER 10

SHOOT DEVELOPMENT MECHANISM

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ABSTRACT:

Shoot development in plants is split into more-or- less separate programs or stages that may be distin- guished from one another by a number of morphological and physiological features. Auxin promotes stem elongation and governs the development, activity, and destiny of meristems, and has consequently been recognized as a significant hormone determining plant architecture. You will be able to comprehend the following things after reading this study: correlations between different plant parts structural variation in stems of different plant group's structural advantage to plant in response to habitat secondary growth in plants and its value.

KEYWORDS:

Dicot, Gymnosperms, Monocot, Shoot Apical Meristem, Vascular Tissues.

INTRODUCTION

The shoot is a crucial component of the whole plant system. Later on, it produces fruit, seeds, branches, inflorescences, flowers, and leaves. When leaf arises from the shoot apex several modifications occurred in adjacent tissues. During the process of stem elongation numerous tissues are created which aid to the plant growth. Secondary growth is crucial because plants need strong tissue to enable them gain weight after reaching a specific degree of development.

Shoot Apical Meristem

The shoot apex is the portion of the shoot that has leaf primordia; here is where the major organization of the shoot begins. It is typically tiny in angiosperms and broader in gymnosperms. There are numerous ideas have been provided by different authors from time to time to explain the kind of growth observed in shoot apical meristem, as illustrated in Figure 1.

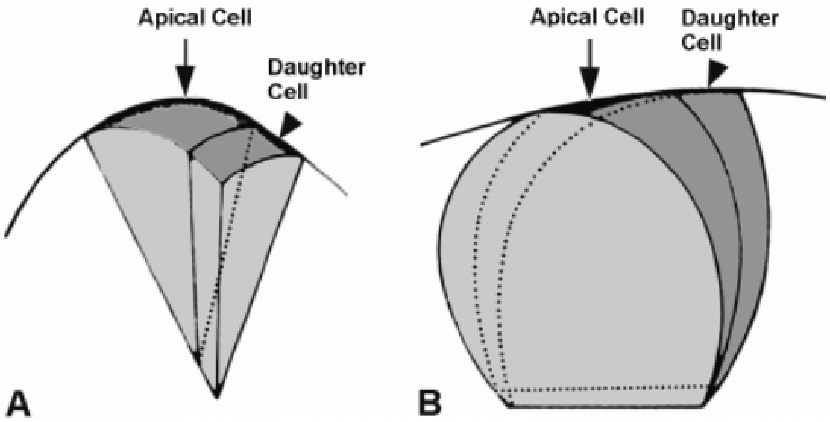

Figure 1: Illustarte Shoot apex showing single apical cell.

Apical cell hypothesis. Nageli agreed with Hofmeister's suggestion, which was made. The hypothesis states that the apical meristem's solitary apical cell serves as both its structural and functional unit and controls the whole growth process. However, phanerogams have not been shown to have such organization; only algae, bryophytes, and pteridophytes do[1].

Histogenesis Hypothesis

Hanstein made the suggestion that the apical origin has three different meristematic zones. Each zone is made up of a different number of histogen or tissue building layers. The mitogens come from discrete set of starting cells and have diverse mechanism of development. The outermost layer, Dermatogen, the intermediate area, Periblem, which is made up of cells, and the deepest layer, Pleroma, are these three histogens. Each histogen serves a specific purpose. Dermatogen cells divide to produce the epidermis, periblem creates the cortex, and Pleroma creates the stele. Later on investigations found that these layers have no morphological relevance since they are not particular in their function. Additionally, these three histogen layers cannot be distinguished between gymnosperms and angiosperm groupings. Therefore, the shoot apical meristem was not subject to this idea. Theory of the Tunica Corpus. This was postulated by Schmidt to explain shoot apex organisation. This idea states that the apical meristem has two zones. Corpus, the center undifferentiated multilayered mass of cells surrounded by tunica, which creates the middle section of the shoot by irregular divisions, and tunica, the outer zone comprised of one or more peripheral layers of cells, producing the outer area by anticlinal divisions. At the apex, the initials of the Tunica and Corpus zones are next to one another. Corpus cells are bigger while tunica cells are smaller. Due to the effect of seasonal growth fluctuations, the number of tunica layers may vary even within the same species[2].

DISCUSSION

Primary Stem Structure: Dicot and Monocot

The plant's life cycle begins with the embryo, which eventually grows into a plant with three crucial organs: the stem, leaves, and root. At the axis' terminals, an apical meristem generates new cells. The body made up of permanent tissues is known as the main body. These cells later develop into permanent tissues. The stem and leaf do not clearly separate in lower vascular plants like Psilotales. The line dividing the stem from the leaves is hazy in seed plants as well. Both parts share a common meristem and rely on one another for growth and differentiation. Here main structure of stem of vascular plants is discussed. Three tissue systems may be identified in the stem's primary structure:

Ground tissue system, vascular system, and Dermal System

The shoot apical meristem's surface layer is where the dermal system begins. The procambium is the source of the vascular tissue system as well as the ground tissue from the flank and rib meristems.

Cutaneous System

An epidermis that is composed of rectangular cells that are grouped densely and have relatively thin main walls surrounds the stem. It comes from the dermatogen, which is the top layer of the shoot apex. Cutin, which are fatty/waxy compounds, are impregnated in the outer tangential and radial walls of epidermal cells. The material makes up the cuticle, a unique layer. The environment in which a plant develops affects the cuticle's thickness. It is often thicker in xerophytes and thin or nonexistent in plants that grow in dense shade and watery settings. The epidermal cells are live cells with heavily vacuolated protoplast containing multiple cell organelles. Epidermal cells typically lack chloroplasts, however they may be found in the epidermis of plants living in settings with plenty of shade and water. The epidemical cells have the ability to grow tangentially as well as divide in the radial plane. This trait permits epidermis to endure the stress during rise in thickness of the stem at the time of secondary growth as detailed further on[3].

Continuity of epidermal cells is broken-up by the presence of stomata. They serve a significant function in gaseous exchange .Various forms of trichomes are also found on the epidermis. The epidermis protects the internal organs against microbial invasion, extreme heat or cold, and desiccation. Cuticle prevents excessive water loss via transpiration since it is water-resistant. In herbaceous plants, epidermis normally survives throughout the life of the stem, but in arboreal species it is finally replaced by a new tissue, the periderm during secondary growth.

Ground Tissue System

In dicotyledonous stems the ground tissue is divided into cortex and pith. However, there is no distinct distinction between the cortex and pith in monocotyledons. The cortex of a dicotyledonous stem is often divided into three separate areas: the outside hypodermis, the middle parenchymatous cortex, and the inner endodermis. In herbaceous stems, the hypodermis normally comprises of a few layers of collenchymatous cells directly below the epidermis. It creates a continuous layer in cylindrical stems[4].

But on angular stems it develops in the shape of patches below the ridges. The principal role of hypodermis supply mechanical strength to the young system against compression and tugging due to wind often the collenchymatous cells of the hypodermis comprise chloroplasts and then they additionally fulfill the function of photosynthesis. The cortex's bordering hypodermis is made up of intercellular gaps between oval, round, or polygonal parenchymatous cells. This area is known as chlorenchyma or assimilatory parenchyma if some of its outer layers contain chloroplasts. The process of photosynthesis is carried out by stems in certain xerophytic plants whose leaves are transitory or drastically reduced, and in these plants, the majority of the cortex is chlorenchymatous. The cortex of many aquatic organisms develops an aerenchyma with a network of substantial intercellular gaps. The cortex typically contains a number of structures, such latex tubes, resin ducts, or storage for waste products. The cortex often contains compounds like tannins as well as calcium oxalate crystals. The cortex serves as a food storage area. It also enhances the lateral transfer of inorganic and organic nutrients and water. In plants, the cortex, which has chloroplasts, serves as an area for photosynthetic activity. Additionally, it offers mechanical support to other stem tissues.Most dicotyledons have an abundance of starch granules in the innermost layer of the cortex, which is known as the starch sheath. However, a typical endodermis with casparian strips is discovered in subterranean stems. Endodermis doesn't form on certain herbaceous stems until the plant is in the blooming stage. The pith is the tissue that is in the axis's center and is surrounded by vascular tissue. It often consists of parenchymatous cells that are dispersed throughout.

The pith cells are devoid of chloroplasts and contain leucoplasts that generate starch. Occasionally, the pith cells may be transformed into sclereids or used as specialized waste storage facilities. Laticifers, secretory cells, sclereids, idioblasts, ergastic substances and crystals of different sorts are also present in the pith. Sometimes the pith's outer layer may be distinguished by its smaller cells and thicker walls. The term "perimedullary zone" or "medullary sheath" refers to this morphologically outer pith[5]. Monccotyledons vary from dicotyledons in that the ground tissue is not divided into pith and cortex, and the vascular bundles are dispersed. However, in other grasses, the center of the parenchymatous ground tissue lacks vascular bundles. The term "pith" is occasionally used to describe this area. Other grasses have a central cavity known as a "pith cavity" that is hollow and located in the middle of the stem. Pith is mostly used to store food. However, it also offers mechanical support when it is fibrous or sclerenchymatous. As a plant becomes older, the pith often dies or disintegrates, ultimately losing all of its functions.

System of Vascular Tissues

Vascular cylinder and peri-vascular tissue are parts of the vascular tissue system. Vascular bundles make up the first, and the pericycle the second. The pericycle, which divides the cortex from the vascular tissue in dicotyledonous stems, appears as a wide cylinder or patches of tissue. It often consists of fibers that are tightly packed. The vascular tissue is present in the form of strands, known as the vascular bundles. A young stem, the pro-cambium at the stem apex gives way to vascular tissue. The main xylem is generated centrifugally throughout this differentiation process, with the protoxylem forming initially and moving toward the center of the stem and the metaxylem forming later and moving toward the periphery. Such xylem is known as endarch[6].

In dicotyledons all the cells of procambium are not divided into phloem and xylem. There is always a residual meristem between the Xylem and the Phloem, and this residual meristem lives on as intra-fascicular cambium within the vascular bundle. The vascular bundles with intra-fascicular cambium are known as open bundles. They may experience secondary growth, which is a dicotyledonous stem trait. While no residual meristem is left in the stem of monocotyledons after the primary xylem and phloem have differentiated. The vascular bundles are referred to be closed because they lack cambium.

A vascular bundle with phloem often seen on the xylem's exterior is referred to as a collateral bundle. However, internal phloem also differentiates on the inner side of the xylem in several families, including the Solanaceae, Cucurbitaceae, and Apocynaceae. Bi-collateral vascular bundles are those that include both internal and exterior phloem. The rhizome of several Nymphaeaceae members bears many steles. Polystely is the name given to this disorder. Each polystele contains two to twenty or“ten more vascular bundles.

Numerous taxa of the amaranthaceae, chenopodiaceae, nyctaginaceae, verbenaceae, etc., include medullary and cortical bundles. Vascular bundles may also be discovered in the pith of certain dicotyledons. Such bundles are known as medullary vascular bundles. They are definite or indeterminate in number. In certain Nyctaginaceae, vascular bundles are also present in the cortex and then they are known as cortical bundles. In the stems of monocotyledons several vascular bundles are present which are normally dispersed throughout the ground tissue. All vascular bundles may be of identical size or the Outer bundles are smaller and get progressively bigger towards the ceatre of the axis. In monocots the vascular bundles are frequently collateral and closed. The xylem is shaped like a letter "Y." The two metaxylem vessels are located at the points of the 'Y's' arms, while the two protoxylem vessels are located at the base of the 'Y'. Due to the juvenile stem's fast extension and formation of a lysogenous cavity, protoxylem often disintegrates, as in the case of maize. The phloem is placed in between the arms of ‘Y’, occasionally somewhat higher towards the outer. There is no phloem parenchyma and it comprises of sieve tubes with tiny partner cells. A noticeable sclerenchymatous bundle cap is often seen. Concentric bundles are another sort of vascular bundles that certain monocotyledons exhibit. In a concentric bundle, either the phloem or the xylem tissue completely encircles the phloem[7].

Dicotyecontous stem Secondary Growth

Secondary thickening or secondary growth is the term used to describe the increase in thickness caused by secondary tissue activity. In dictoylodons, normal secondary development occurs and results in an increase in stem thickness in both the intrastelar and extrastelar regions. Growth in the intrastelar area is caused by the activity of the vascular cambium, while growth in the extrastealar region is caused by the cork cambium. Secondary growth in intrastealer area Secondary Growth in Dicotyledonous Stems The procambium's vascular cambiutu, which is in charge of producing secondary xylem and secondary phloem, is still meristematic even after primary xylem and primary phloem have differentiated. Between the vascular bundle's metaxylem and metaphloem, a narrow strip of meristematic cells makes up this residual meristem. The fascicular cambium is the name given to it. Some of the live parenchyma cells of the medullary rays. Mostly in a line with the fascicular cambium, become meristematic and create new strips of meristem termed interfascicular cambium. A whole cylinder of cambial cells is created when the fascicular and inter-fascicular cambia converge. In other plants like Linum and Tilia, whose main vascular bundles are extremely near to each other and interfascicular cambium is not developed, just the fascicular cambium forms the whole cylinder of the cambium[8].

The vascular cambium is made up of two different cell types: ray initials, which are tiny isodiametric cells, and fusiform initials, which are long, vertically orientated cells with tapering ends that create secondary xylem and secondary phloem. The development of main xylem and phloem is followed by the beginning of secondary vascular tissue. The cambium is now represented by a single layer of cells. The cambium's fusiform beginnings undergo periclinal division, producing two daughter cells. The other creates the xylem and phloem mother cell, which may directly differentiate into xylem or phloem elements without requiring any further division or it may divide one to many times to generate two or more cell types. One of these cells is characterized as meristematic while the other forms the xylem and phloem mother cell. The cambium produces cells both inward and outward; the cells that are generated inward develop into xylem components. Cut plates of parenchymatous cells both inside and externally. Ray initials of the cambium. The secondary medullary rays that connect the pith to the secondary xylem and pbloem are these.

The cambium's activity causes a consistent growth all the way around, and eventually a compact cylinder of secondary tissue is created. However, interfascicular cambium strips in certain plants do not develop secondary vascular tissue, which has the effect of keeping the vascular bundles distinct even after secondary growth. In addition to periclinal divisions, cambium cells also exhibit some anticlinal and/or oblique divisions to keep up with the expanding circumference of the stem. While the cambium is only active for one season in herbaceous plants, it is periodically active in the majority of woody plants. The secondary vascular tissues are interpolated between the primary phloem and xylem as the cambium forms between these fundamental tissues. The pith and the primary xylem are encompassed by the secondary vascular tissues, although they stay largely unaltered as the stem expands in girth. The main xylem is not distorted but occasionally the pith is warped by an inward pressure owing to the expansion of the Secondary tissues outside the pith[9].

Additional Xylem

The majority of the vascular tissue of woody plants is made up of secondary xylem. Its components are identical to those found in the major xylem. Because of how similar the structures of main and secondary xylem are, it may sometimes be challenging to tell the two tissues apart. However, the main xylem contains generally lengthier tracheary segments in compared to the secondary xylem. Two tissue systems in the secondary xylem exhibit various orientations along the plant's longitudinal axis.

System Axial:

It is made up of vertical files of tracheary components, fibers, and parenchyma from wood. Transverse and radial longitudinal sections may be used to examine the components of this system. Another name for this system is the vertical or longitudinal system.

Radial Network:

It is made up of rows of parenchymatous cells that are arranged perpendicularly to the plant's longitudinal axis to produce wood or xylem rays. The radial and tangential longitudinal sections, respectively, provide the best indication of the height and thickness of xylem rays.

Design of Xylem Rays

The xylem rays are sheets of parenchymatous cells that stretch radially throughout the xylem, as was previously mentioned. Due to the cambium's growth along the axis' expanding circle, as the stem ages, the rays move further apart. The breadth and cellular make-up of rays varies. They might be single- or multiple-seriate. A wood typically has both uniseriate and multiseriate medullary rays, albeit one or the other kind may not be present very often. Cells that are upright and/or procumbent make up the medullary rays. Homocellular rays are those composed only of one kind of cell, whereas heterocellular rays are those composed of both types of cells. When compared to advanced woods, which are multiseriate and tend to become homocellular with a sharp reduction in their vertical length, primitive woods have both uniseriate and multiseriate heterocellular rays that are present.

Growth Rings

The cambium exhibits considerable seasonal fluctuations in activity in woody plants from temperate climates. Growing and quiescent phases are adjusted annually. As a result, the portion of wood that is added during a particular growing season may be clearly recognized from the years before and after. In a transverse slice, the seasonal rise in wood thickness appears as a concentric ring. These are commonly referred to as growth rings or yearly rings. Each growth ring represents a season's worth of growth, however under some environmental circumstances, many growth rings may occur in a single season. Dendro-chronology is the study of yearly ring counting as a method of estimating a plant's age. On the basis of variations in the form, structure, and distribution of homologous parts in the two areas, each growth ring may be classified as spring wood or autumn wood.

For instance, the vessels in spring wood are significantly broader and have comparatively thin walls than those in autumn wood. These variations in the structure of wood are made to accommodate the various needs of the plant throughout the spring and winter months. For instance, during the spring, there is a surge in vegetative activity and an increase in the transpiring surface. Therefore, throughout this season of the year, extra water routes are required to fulfill the needs of the plant. Consequently the spring wood has wider vessels. On the other side, there is leaf fall and much less vegetative development in the autumn, thus a complex system for water conduction is not necessary. The autumn wood consequently has rather thin vessels[10]. The thickness of subsequent annual rings may vary, and these variations are brought on by changes in the plant's overall nutritional status as a consequence of severe damage, illness, or unfavorable growing circumstances. Any such difference is therefore permanently captured in the yearly rings as variations in their thickness. These fluctuations may be utilized to reconstruct historical weather conditions. Some plants' growth rings have also been examined for such studies.

Wood with and Without Pores

This classification of wood is based on the presence or absence of vessels. Gymnospermous wood that lacks vessels is non-porous, whereas dicotyledonous wood with vessels in the xylem is known as porous wood. Technically speaking, porous wood is known as hard wood and non-porous wood is known as soft wood. This nomenclature, however, has nothing to do with the relative hardness or softness of the timber, as porous wood from Pterocymbium tinctorium and Bombax ceiba is classified as hard wood even though it is soft, and non-porous wood from Pinus and Cedrus is known as soft wood despite being extremely hard. Hard wood is more complicated structurally than soft wood. A transverse piece of the hard wood reveals vessels in the shape of tiny 'pores,' which may have an oval or round appearance. The arrangement of pores is an essential diagnostic property of timbers. The wood may be categorized into ring-porous and diffuse-porous on the basis of distributions of pores inside a growth ring. Pores are grouped in the shape of a noticeable ring or belt at the beginning of the growth ring in ring porous wood, where early wood pores are noticeably bigger than late wood pores. In diffuse porous wood there is no notable variation in the size of early and late wood pores, and they are scattered more or less equally throughout the development ring. This group includes the majority of the hard woods found in India.

Wooden Pardnasya

The parenchyma associated with the secondary xylem may be distinguished into axial parenchyma, originating from the fusiform initials, and ray parenchyma, which originates from the ray initials. The axial parenchyma's cells are often as long as the fusiform initials they are descended from. But occasionally the fusiform initiais may split transversely and then shorter axial parenchyma cells are formed. The ray parerichyma cells which are normally shorter than the axial parenchyma cells may occasionally acquire secondary thickenings in their walls. A little piece of axial or ray parenchyma that is next to a vessel's pit often penetrates the vessel as a short, blunt protuberance. The parent cell's nucleus and some of its cytoplasm move into the peg-like protrusion. It progressively grows and transforms into a large bladder-shaped vascular lumen; this structure is referred to as tylosis. Tylosis develops and eventually separates from the parenchyma cell it originated from. At the point where it enters the vessel, the dividing wall is placed. The tylosis may sometimes divide repeatedly to create a multicellular structure that entirely fills the vessel lumen. When in touch with other tylosis, the secondary walls of the tylosis may form in the woody plants, and there are often corresponding pits on the surface. Tylosis, like other parenchyma cells, serves as a starch grain storage system in various plants. Usually, the lenticels are located underneath an ancient stomata or collection of stomata. The cpidemis is replaced by the periderm during secondary development. The suberized walls of the dead cork cells make them somewhat gas-impervious. The exchange of gases between the inside of living cells and the outside environment thus becomes challenging. Other names for the lenticels are air pore and cannal. They are somewhat higher than the tissue around them. The lenticels on the bottle cork are plainly visible[11].

Instead of producing normal cork beneath the epidermis, the phellogen produces spherical, colorless, loosely arranged, thin-walled cells on its exterior. These cells are collectively referred to as complementary cells or filling cells and are formed by the division of parenchyma in the substomatal region. The epidermis is torn apart by the new, complimentary cells that push up against it. The outer most cells typically perish owing to the exposure to environment and replaced by new complimentary cells thrown off by the phellogen. Phellogen creates layers of dense cells known as closing layers in temperate plants in addition to the complimentary cells. These block the lenticels and are created throughout the winter. Trees in temperate climates have regrowth and phellogen creates new complimentary cells.

The spring secondary growth closes layers and ruptures them. A slice of lenticels in spring season exhibits torn sealing layers on the side of the complementary cells. Closing layers are not detected in the lenticels formed in tropical plants. Lenticels may sometimes form apart from the stomata. In such circumstances the phellogen devides cork cells for a time and then lose complimentary cells which finally shatter the cork and give birth to a new lenticel. They may stay dispersed or organized in vertical rows. A unique kind of protective tissue known as polyderm forms in the roots and stems of tree groups such as Myrtaceae, Rosaceae, and Onagraceae. It is made up of layers that alternate between partially submerged cells that are one cell deep and cells that are several cells deep. The dead layer is the topmost layer of it. Polyderm is the name given to this sort of tissue.

Wound cork develops when the plant part's live cells are exposed to the air as a result of an injury. Only the damaged regions are allowed to have wound cork. Just below the damaged area, pre-existing phellogen cells quickly produce a new layer of suberized cells. Later, a fresh layer of phellogen forms in the healthy, alive cells. Phellem and phelloderm are normally produced by this phellogen. The new cork layers cover the wound and shield the interior tissue from bacterial and fungal diseases. All plant components, including the fruits and leaves, have the potential to generate wound cork. USl ally wound cork is more readily formed in woody plants as opposed to herbaceous or monocotyledonous plants. Rather from a cold and dry temperature, a moist and warm climate encourages the early growth of wound cork[12].

CONCLUSION

The shoot apical meristem (SAM) creates above-ground aerial organs throughout the lifecycle of higher plants. In order to perform this role, the meristem must maintain a balance between the self-renewal of a pool of core stem cells and organ initiation from peripheral cells. The shoot apex is the emerging point of the plant shoot and performs a key role in morphogenesis: its here that new leaves or flowers emerge and grow swiftly. The stem contains nodes, where leaves develop, and internodes, which are the segments between nodes.

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CHAPTER 11

SECONDARY GROWTH OF DICOT AND MONOCOT STEMS THAT IS ABNORMAL

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ABSTRACT:

Monocots often do not experience secondary growth. Since monocots lack a vascular cambium, if they do expand in size like palm trees and yucca plants, no additional xylem or phloem will emerge. Anomalic thickening is the term used to describe a gain in girth without subsequent development. A sequence of cambia appear outside the oldest phloem in Bougainvillea, one of the dicots with abnormal secondary growth. Ancestral monocots lost their secondary growth, and their stele was altered in a manner that prevented their recovery without very rare dramatic modifications. A sclerenchymatous bundle sheath surrounds a vascular bundle on the monocot stem. Trichomes are seen on dicot stems. The stems of monocots lack trichomes. Because phloem and xylem include cambium, the vascular bundles are constantly open.

KEYWORDS:

Fascicular, Parenchymatous, Phloem, Monocots, Xylem.

INTRODUCTION

The pattern of secondary development deviates significantly from the typical form in many dicotyledonous plants. This altered pattern of secondary development is known as anomalous secondary growth. In actuality, the word "anomaly" just helps to group development patterns that seem to be less typical. Because the tropical flora in which it is usually found has not been well investigated anatomically, abnormal form of growth may be more widespread than is now understood.

A secondary growth that is abnormal may occur for the reasons listed below:

1. An aberrant configuration of vascular tissues results from the normal cambium's unique or irregular behavior.
2. The tissues that were cut off are arranged improperly because the typical cambium is located in an aberrant location.
3. The accessory or supplementary cambial rings take the place of the typical cambium, assuming the normal cambium ever develops at all.
4. Abnormal secondary growth on the stem of a dicot. Dicot plants' abnormal secondary growth may be researched under two categories:
5. Plants have cambium that is normal in type but aberrant in activity, leading in abnormal vascular tissue organization.

Plants where the auxiliary cambium quickly replaces the regular cambium if it does develop. The pericyclic area or the supplementary cambium may be the source of this abnormally active tissue. Although it forms regularly, the cambium ring exhibits aberrant behavior. The following forms of aberrant cambium activity may be identified:

Only in the area of a vascular bundle does the cambium produce vascular tissues. The majority of woody climbers or lianas often exhibit this kind of oddity. Fascicular and interfascicular cambium combine to produce the typical cambium ring, however aberrant activity occurs when either the fascicular cambium or the interfascicular cambium is active. The fascicular cambium is active in cutting off vascular tissue in Cucurbita, but the interfascicular cambium is just cutting off parenchyma in the stems of Vitis and Clematis. But in Aristolochia, the interfascicular cambium and the fascicular cambium separate parenchyma cells from secondary vascular tissue. Cucurbita stem: There are ten vascular bundles on the stem of this plant, divided into two rings of five each. Each vascular bundle has an outer and an inner cambium and is conjoint, open, and bicollateral. Along with the parenchymatous cells of the ground tissue, the outer cambium of both the inner and outer bundles becomes active. The two join together to create a cambium ring that is more or less wavy. This typical cambium functions strangely since it selectively cuts off secondary xylem and phloem in the vascular bundle area, causing the bundle to grow larger[1].

Aristolochia Stem

The stem has a characteristic dicotyledonous structure when it is young. The cortex made up of collenchyma and parenchyma is enclosed by the epidermis after the multilayered collenchymatous hypodermis. A multilayered, sclerenchymatous pericycle follows the endodermis known as the starch sheath. A ring of open, collateral vascular bundles that are spaced apart by interfascicular regions makes up the vascular system. The vascular bundles in between give birth to the median and two lateral leaf traces. The inter- and intra-fascicular cambium become active during secondary development and complete a typical cambium ring. This typical cambium ring, however, functions improperly because it separates parenchymatous cells in the interfascicular area from vascular tissue in the intra-fascicular region. The bundles remain distinct and the secondary vascular tissue is thus not obvious. The pith and rays of older stems are slightly crushed as a result of the growing pressure of secondary tissues and in part as a result of the pericycle's resistance to the developing vascular system. After a while, the pericycle's continuity is disrupted by cumulative pressure, and the neighboring parenchyma cells move into the gaps by invasive expansion and perhaps differentiating into sclereids. Occasionally, the intra-fascicular cambium may act inappropriately and cut off parenchyma cells, causing the xylem to fissure and the bundles to bifurcate.

Various plants, including Bauhnia, Doxantha, Bignonia, Menispermum, and Tinospora, have this unique growth pattern. Varied species of the plant Bauhinia have varied cambial activity levels. The cambium of B. rubiginosa is more active in certain areas while being inactive or hardly active in others. While little to no vascular tissue forms in areas with lower activity, abundant secondary vascular tissue does develop in areas with higher activity. A ridged secondary vascular cylinder forms as a consequence of this aberrant development pattern, and the mature stem also has a ridged exterior. Other Bauhinia species have an extended flattened strap-like shape because the cambium is only active in the two opposing poles[2].

The juvenile stem of the popular garden climber Bignonia venusta has a wavy form with noticeable ridges and furrows. The hypodermis, which is thinly chlorenchymatous underneath the furrows and collenchymatous or sometimes sclerenchymatous in the ridge area, follows the heavily cuticularized epidermis. The endodermis, which is poorly defined and supported by a heterogeneous pericycle, follows the few-layered parenchymatous cortex. Around the protruding pith, the vascular bundles are organized in a ring and are conjoint and collateral. The fascicular and inter-fascicular cambium become active during the beginning of secondary growth and combine to produce a cambium ring. In the beginning, this cambium ring acts properly, cutting more secondary xylem on the inner side and less secondary phloem on the outer side. However, the cambium ring eventually forms cambium monodirectional zones at four diagonal locations. The cambial cylinder's unidirectional area of cambium is the region that mostly generates secondary phloem and little to no secondary xylem. Therefore, at these four sites, less xylem is internally cut off but vast volumes of secondary phloem are outwardly cut off. These phloem masses protrude inward and produce four irregularly shaped deep wedges, which are held up by transverse bands of sclerotic cells. After a short while, the cambial strip's center region, which was previously functioning normally, forms a single patch of cambium and begins cutting off more phloem on the outer side than the inner side. As a consequence, four or more phloem wedges develop and encroach onto the xylem cylinders. As a result, the mature stem of Bignonia contains four large and four tiny phloem wedges that extend into the xylem.

DISCUSSION

The cork cambium, which develops from the cortical cells, gives birth to the cork cells. Later on, following its activity, the pericycle fibers are shed, and the stem takes on a circular form. These phloem wedges serve as shock absorbers and are an adaptation to the mechanical needs of the plant[3]. Dobbins identified the peculiar pattern of secondary development in D. unguis - cati's doxantha stem. In the first phases, a typical cambial ring forms, after which unidirectional and bidirectional cambium zones form. At first, the cambium operates normally, cutting off secondary xylem and phloem, which are shaped like cylinders. However, later on, four cambium arcs are defined, one close to each of the four main principal vascular bundles. The cambium in these four arcs is active only in one direction. i.e., there is little to no secondary xylem production, but there are large masses of secondary phloem that grow inward in the shape of four grooves or furrows. With the exception of these four arcs, parts of the cambial ring show bidirectional cambial activity in the later phases, which means they generate as much or more secondary xylem than secondary phloem.

The secondary xylem is divided by the wedges of phloem created by the unidirectional arcs of cambium, which also reach the outside cylinder of the secondary phloem. Additional phloem furrows may develop in older stems of Doxantha, either next to or in between the earlier existing wedges. The phloem wedges serve as shock absorbers and enable the liana stems to bend in the face of heavy gusts. In the xylem, the cambium creates erratic parenchyma patches. The stem of Urtica dioica exhibits this kind of aberrant activity. Urtica dioica stem - A ring of conjoint, open, and collateral vascular bundles is seen on the young stem of Udioica, which exhibits a characteristic dicotyledonous structure. Early in the development process, a typical cambial ring forms, cutting off secondary xylem toward the inner side and secondary phloem toward the outer side[4].

After some time, however, the cambium starts to act abnormally in a few select locations, cutting off parenchymatous cells on the inner side in lieu of secondary xylem. The cambium continues its regular behavior and activity after cutting off a group of parenchymatous cells, creating secondary xylem above the parenchymatous group. As the process is done repeatedly, islands of parenchyma that are enmeshed in secondary xylem or wood begin to develop. The parenchyma cells seem to be phloem but are really uneven in form, unlignified, and extended tangentially. Usually, spring wood has been associated with increasing island size and quantity.

Cambium exhibiting aberrant activity is Abnormal

A new cambium ring or supplementary cambium emerges from the cortex or pericycle in a number of dicot families, including Amaranthaceae, Chenopodiaceae, Nyctaginaceae, etc., when the older, vascular cambium has ceased to function or when the regular cambium ring does not grow at all. When improperly positioned, the cambial ring performs abnormally, which might take one of the following forms: Vascular bundles form rings that are imbedded in parenchymatous tissue. This kind of secondary growth has been seen in Amaranthus, Mirabilis, Bougainvillea, and other plants, and it happens in the way that follows. In the pericycle area, the first cambium ring develops from scratch. Extra-stelar cambium is the term used to describe this kind of cambium that develops outside the vascular bundle[5].

On the inner side, the extra-stelar cambium cuts off patches of alternating xylem and parenchymatous tissue, whereas on the outer side, it first removes continuous layers of parenchyma before removing patches of phloem over the parenchyma and xylem at the remaining locations. The cambial ring becomes inactive and stops working after a full ring of vascular bundle has developed. The parenchymatous cells that the initial cambium externally chopped off now form a fresh ring of cambium. Similar to the preceding cambium, this one likewise exhibits aberrant behavior and separates a ring of vascular bundles by parenchyma. It subsequently stops working and turns into a passive entity. Similar to this, the formation of additional auxiliary cambia results in the formation of successive rings of vascular bundles.

Amaranthus stem:

An atypically positioned cambial ring on the amaranthus stem indicates aberrant activity. The juvenile stem contains a single layer of epidermis on the outside, which is followed by many layers of collenchymatous hypoderm, parenchymatous cortex, endodermis, and pericycle in irregularly shaped patches. There are just two medullary bundles that make up the stele. The cambial ring does not develop because the characteristic dicot ring of vascular bundles is missing. However, a layer of pericycle cells becomes active and develops into a cambium ring. This extrastelar cambium exhibits aberrant activity as it begins by chopping away at regions of secondary xylem and parenchyma alternately on the inner and exterior surfaces. On the outside, it separates parenchyma from secondary parenchyma and cuts secondary phloem above secondary xylem. These lead to the development of conjoined, collateral vascular bundles that are wrapped in parenchyma and organized in a ring[6].

The cambium ceases working after the development of these vascular bundles. But from the supplementary parenchymatous cells that the first extra-stelar cambium severed, a second accessory cambium forms. It acts similarly to the first cambium ring by severing vascular bundles that are lodged in parenchyma. The first and second rings of the vascular bundle alternate positions. Similar to this, more supplementary cambia grow one after the other, generating concentric rings of vascular bundles that seem to be dispersed throughout the surrounding tissue. However, the last cambial ring operates a little differently because it removes secondary xylem alternately with sclerenchyma on the inner side. So it seems that the last ring of vascular bundles is encased in sclerenchyma. The two medullary bundles, together with a tiny amount of parenchyma, dissolve in adult stems to create a hollow. The cork cambium produces cork and secondary cortex regularly.

Mirabilis Stem

The immature Mirabilis stem features two parallel grooves that carry a lot of multicellular shoot hairs. The stem's internal anatomy is characteristic of a dicotyledon, with a cuticularized epidermis that is one layer thick, a few layers of collenchymatous hypodermis, and then many layers of parenchymatous cortex. A constant layer of epidermis and a pericycle with sclerenchyma patches separate the extra-stelar zone from the stelar region. The stelar area is littered with many vascular bundles. De Barry claimed that instead of a typical cambium ring forming, a totally different ring forms from pericycle cells that are located outside the vascular zone. Mikesell and Popham's discovery that the inner cortex or pericycle cells are the source of the first cambium lends credence to this theory. Maheshwari, on the other hand, has a different perspective and claims that the first cambium ring forms in the vicinity of the outermost vascular bundle. From the secondary parenchyma that the previous cambial ring severed, successive rings of accessory cambia are created, and they act similarly to the first one. The last cambial ring removes sclerenchyma, secondary xylem, and parenchyma alternately on the inner and outer sides, respectively. As a result, the last rings of vascular bundles are encased in lignified tissue and provide the stem mechanical strength[7].

Vascular bundles form rings and get enmeshed in connective tissue. The cambial ring develops in the extra-stelar area and separates secondary xylem, thick-walled conjunctive tissue, and conjunctive tissue on both the inner and outer surfaces. A mass of conjunctive tissue, such as Bougainvillea, Boerhavia, etc., seems to contain the vascular bundles. Stem of bougainvillea a single layer of heavily cuticularized epidermis, several layers of collenchymatous hypodermis, and a fully developed parenchymatous cortex make up the round contour of a juvenile Bougainvillea stem. The pericycle is a heterogeneous collection of parenchyma that alternates with sclerenchymatous patches, and the endodermis is unclear. The procambium strand-derived primary vascular bundles seem to be dispersed erratically in the ground tissue's core region.

These bundles, which are really the leaf trace bundles connected to the leaves, may experience little secondary growth and a modest enlargement. Belfour claimed that the whole secondary tissue is generated from a single cambium, despite the fact that the initial cambial ring is extra-stelar in origin and emerges from the pericycle. On the inner side, secondary xylem and secondary parenchyma alternately get cut off by the cambial ring. On the outer side, secondary phloem gets cut off above secondary xylem and parenchyma gets cut off above parenchyma. Fusiform, more or less radially oriented, and typically developing lignified, thicker walls, the cells of the secondary parenchyma. Conjunctive tissue or ground tissue are the terms used to describe this. Concentric layers of vascular bundles are created imbedded in conjunctive tissue as a consequence of successive rings of cambia forming that act similarly to the initial ring. Due to the large veins in the xylem and the crushed cells in the earliest section of phloem, this layering is obvious. The fact that the new cambium forms in the shape of strips that connect to the older cambium rather than a full ring around the vascular cylinder is an intriguing characteristic.

As a result, there is continued ontogenetic continuity. Because the conjunctive tissue in certain species of Bougainvillea is made completely of sclerenchyma and cannot be distinguished from the xylem of the embedded vascular bundles, the secondary phloem appears as islands or isolated groups that seem to be surrounded by conjunctive tissue. They shouldn't be confused for phloem that has been added. The two medullary bundles and the middle ring's bundles do not experience much secondary growth, which only slightly increases their size. These bundles' intra fascicular cambium functions properly, developing secondary xylem on the inner side and secondary phloem on the outer side. As secondary growth advances, the primary phloem is crushed, resulting in the formation of a cap-like structure of dead cells over the newly formed phloem. However, the cambial activity of the outer ring of bundles is what causes the majority of the secondary development of the stem. A cambium ring is created when the intra- and inter-fascicular cambiums converge. According to Maheshwari, the ring develops secondary xylem in the intra-fascicular area, lignified conjunctive tissue in the inter-fascicular region, and secondary phloem above the secondary xylem on the outer side. The cambium stops functioning after the development of secondary tissue, and a new cambium ring forms as a result of the union of secondary parenchyma cells, which are located in opposition to conjunctive tissue, and pericycle cells outside of the phloem. Similar to the vascular cambium, this initial accessory cambium cuts off secondary xylem in alternation with lignified conjunctive tissue on the inner side, secondary phloem in opposition to secondary xylem on the outer side, and parenchyma above the conjunctive tissue. As a consequence, a fourth ring of conjoint, collateral bundles of secondary origin, is formed. This extra cambium quickly stops working, and a new auxiliary cambium emerges that functions similarly. Until four or more concentric rings of vascular bundles are created, the process of forming accessory cambium rings and secondary vascular bundles may be repeated. The concentric rings of vascular bundles divided by thin-walled parenchymatous zones and imbedded in thick conjunctive tissue create the appearance of growth rings[8].

Cambium's primary aberrant position displaying Abnormal Activity

The cambium is unusually positioned, exhibiting aberrant activity, and resulting in the creation of anomalous structures during secondary growth in a variety of stems, including Thinouia, Serjania, Paullinia, and others.

Thinouia ventricosa stem –

The cambium does not take the shape of a ring when the plant is young; instead, it appears as a folded structure. The cambium divides at the folds and creates distinct groups of vascular tissues when the secondary growth begins. The oddly positioned cambial rings create their own distinct vascular tissue, giving the stem its distinctive lobed shape.

Paullinia and Serjania corrugata

Specific vascular tissue subgroups are cut off from the main vascular cylinder in these tendril climbers. These cut-off, restricted vascular tissues form their own cambium strips. When secondary growth begins, each cambium strip matures into a full, independent cambium ring. This ring acts properly to produce secondary xylem on the inner side and secondary phloem on the outer side. As a result, the mature stem is made up of several distinct vascular cylinders, each of which sprouts periderm. The stem seems to be made up of multiple tiny stems that are compressed against one another and resemble rope when it is grown.

Phloem formation with inclusion

Groups of phloem cells are formed as a result of the cambium's aberrant activity and get entrenched in the secondary xylem. This is referred to as interxylary phloem or incorporated phloem. There are two ways that included phloem is formed: Arc cambium formation and aberrant activity. In an atypical way, the extra-stelar cambium acts, creating secondary xylem and sclerenchyma on the inner side while developing secondary phloem over secondary xylem and parenchyma in opposition to sclerenchyma on the outer side. After a while, the cambium under the phloem area stops functioning, and new arcs of cambium are created from the parenchyma located above the phloem. The secondary xylem and sclerenchyma on the inner side of this arc cambium alternate with secondary phloem and parenchyma on the outer side. As a result, the xylem and sclerenchyma cut off by the arc of the cambium surround the secondary phloem created by the first cambium. Included phloem or interxylary phloem are two names for this enclosed phloem. The residual cambium at the other locations keeps up its initial activity until it ultimately reaches the cambium arcs' level. The concentric kind of included phloem production has been documented in Achyranthes, Chenopodium, Bougahwillea Celosia, Bosea, Pupalia, Strychnos, and other plant species[9], [10].

The juvenile stem of an achyranthes has a wavy appearance that alternately shows ridges and furrows. The hypodermis, which is collenchymatous under the ridges but chlorenchymatous behind the furrows, is the next layer beneath the cuticularized, single-layered epidermis. The pericycle, which has many layers and sclerenchymatous patches on the outside, supports the endodermis. In the pith area, two medullary vascular bundles are decussately organized in subsequent internodes and located across from one another. Srivastava examined the location of the medullary bundles in a aspera. He saw that the two bundles may be fused in the lower internodes and only be free in the few higher internodes, or they could be free throughout the whole length of the plant. An amphixylic structure is shown by the two joined bundles.

Other species, like A. coynei, may have four medullary bundles, which fuse to create two bundles. Though the supplementary cambium arises from pericycle cells, the usual cambium ring is absent. On the inner side, secondary xylem alternates with conjunctive tissue, while secondary phloem grows above secondary xylem and parenchyma opposes conjunctive tissue on the outer side. Once dormant, the cambium strip under the phloem is replaced by new arcs of cambium that grow from the parenchyma above. Similar to secondary xylem and conjunctive tissue on the inner side, secondary phloem and parenchyma on the outer side are shut off by this freshly created arc of cambium. As a consequence, the first cambium's secondary phloem, also known as included or interxylary phloem, is surrounded by secondary xylem and conjunctive tissue.

It has been noted that in certain species, the cambium's activity may fluctuate, creating secondary xylem where conjunctive tissue was growing and conjunctive tissue where secondary xylem was forming. As a result, the secondary vascular bundles and any associated phloem are found randomly dispersed. Chenopodium stem: The stem has a noticeable ridged appearance and a single-layered, cuticular epidermis on the outside. Under the ridges and furrows of the hypodermis are a few collenchymatous cells and cells that contain chlorenchyma. Following a well defined endodermis and pericycle with areas of sclerenchyma, the cortex is parenchymatous in character. A ring of vascular bundles surrounds the parenchymatous pith. The extra-stelar cambium, which arises from the pericycle cells, starts secondary growth since the typical cambium is not generated. Some researchers claim that this initial ring of extra-stelar cambium develops secondary vascular bundles after first forming a layer of ground tissue with thin walls.

Due to pressure from the surrounding tissue, the principal vascular bundles are forced into the center and appear as medullary bundles. Due to the intrafascicular cambia that results in the creation of secondary tissue, these main bundles may have restricted expansion. The initial extra-stelar cambium cuts off secondary phloem and parenchyma on the outside while cutting off secondary xylem and conjunctive tissue on the inside. It is debatable where the extra-stelar cambium came from and what it does. While some workers observed that the cambium is limited in its activity, resulting in the formation of succeeding arcs or rings of cambium that are responsible for forming secondary vascular tissue, other workers observed that the cambium remains active throughout the life of the plant and continuously forms secondary vascular tissue and conjunctive tissue. The outermost cambial cells now go on with their secondary growth, internalizing xylem vessels and sclerenchyma fibers. A cluster of phloem cells surrounded by lignified tissue is created by a small number of cambial cells that are slightly outside the xylem vessels in the meristematic zone. The isolated phloem cell clusters that are left behind are implanted in the conjunctive tissue as this meristematic zone eventually expands outward and continues to function. Included phloem or interxylary phloem are the names given to these discrete collections of phloem cells. Thus, the meristematic cells that make up secondary vascular tissue are ontogenetically connected[11].

Internal anatomy of the bougainvillea stem and the development of extra-stelar cambium and secondary vascular tissue have previously been studied. Additionally, Bougainvillea exhibits the existence of phloem that has been integrated and was created via the arc cambium process. On its inner side, the last ring of accessory cambium develops secondary xylem and conjunctive tissue; however, on its outer side, right below the phloem area, it remains dormant. Consequently, the parenchyma cells that are lying externally give rise to arcs of cambium. These cambium arcs or strips operate similarly to accessory cambia, causing the previously created secondary phloem to be surrounded by the freshly generated xylem and conjunctive tissue. This phloem is known as interxylary or included phloem.

Strychnos Stem:

The stem has a spherical shape and consists of a cuticularized epidermis layer on the outside and one or two layers of collenchymatous hypodermis below. The underlying cortex may be divided into two halves, the outer of which is made up of chlorenchymatous cells and the inner of which is made up of parenchymatous cells. Intercellular gaps may be seen in the cortex's deeper layers. The pericycle, which is made up of one or two layers of sclerenchymatous cells, supports the endodermis, which is well delineated. The parenchymatous pith is surrounded by a ring of vascular bundles. Phloem inclusion is produced by a shift in the cambium's activity. Phloem inclusion is formed in a number of dicot families, including the Combretaceae, Malphigiaceae, Salvadoraceae, Asclepiadaceae, Acanthaceae, and Gentianaceae, among others, by a brief alteration in the cambium's activity. The accessory cambium typically develops secondary xylem on the inner side and secondary phloem on the outer side under normal circumstances, but sometimes the cambium in specific locations acts abnormally and a brief shift in activity takes place. Instead of cutting off secondary xylem, the inner side of these tiny strips of cambium now removes thin-walled parenchymatous tissue or secondary phloem. Later, they return to their previous activity, which was the formation of secondary xylem on the inner side.

Since it removes more cells toward the inner side, or the center of the stem, than toward the outer side, this cambium's activity is aberrant. While the cells cut off toward the inner side are partially vascular and partially parenchymatous in nature, the cells cut off toward the outer side are parenchymatous in nature. Conjunctive tissue is made up of the parenchymatous cells that are cut off on the inner side and have had their cell walls lignified. Cells from one or more of the cambium tiers often take part in the development of the secondary vascular bundle. Sometimes, cells from a single row make up the middle portion of the bundle, while cells from neighbouring rows make up the lateral portion. The secondary vascular bundle, on the other hand, has been shown to originate from a single cell that has been severed by the cambial initial. This cell multiplies twice by anticlinal divisions to create a row of two or three colis, serving as the vascular bundle's starting cell. Peripheral cells are created by subsequent periclinal divisions of these cells. Divisions made afterwards are erratic. While the peripheral cells of this group develop into xylem elements, the centrally located cells undergo metamorphosis to become phloem cells. Amphivasal vascular bundle refers to the mature structure made up of peripherally positioned xylem components encircling a core mass of phloem cells. The freshly created vascular bundle is subsequently pushed toward the center by the cambium's subsequent cutting of parenchyma cells on the inner side. After a while, the cambium resumes its anomalous behavior, but this time the location of the vascular bundle cut off has changed. In these areas where it was producing parenchyma, the cambial initial, which is to build the vascular bundle, is now forming vascular elements; as a result, the second row of vascular bundles is generated, alternating in place with the first ring. Similar to this, when vascular bundle activity and location change, rings of vascular bundles are grouped in concentric rings by varying in position. The final ring's vascular bundles are enmeshed in a mass of lignified conjunctive tissue. Cork cells may also grow on the outside of the cork cambium during normal development[12].

The development process is largely the same in Kingia, with the exception that the xylem is U-shaped and only covers the phloem on three sides. Tracheids and xylem parenchyma are the sole components that make up the xylem of the vascular bundle. A thin or thick sheath surrounds the vascular bundles. In the case of Xanthorrhoea, a significant amount of resin is released in the parenchyma cells that are cut off on the outside, causing a resin sheath to surround the vascular bundle. In Yucca brevifolia, cambium forms from pericycle cells that take on meristematic activity. Periderm formation has been seen in various monocots, similar to Aloe and Cocos. Some monocots, such as palms, Musa rhizomes, Tulipa bulbs, and Galanthus nivalis, have a specific form of meristem known as a main thickening meristem that increases the stem's thickness. Only the cells immediately below the leaf and sheath primordia contribute to the development of this meristem during embryonic development. It resembles a flat zone when it is embryonic. It is concave and resembles a cane in the early seedling stage, flattens out in the later seedling stage, and then returns to being concave in the young plant. The main thickening meristem, which contributes to the height and girth of the stem, is formed by the meristem divisions caused by periclinal divisions. The procambial strands of Musa's palms and rhizome often come from this meristen. The procambial strands produce the vascular bundles that increase the stem's thickness. It has been stated that there is another way to thicken the stem in palms. The undifferentiated cells of the bundle sheath and the parenchymatous cells in the stem center of Roystonea continually proliferate and enlarge. The intercellular gaps also enlarge, causing the stem's thickness to rise. Diffuse secondary growth is the term used to describe this sort of development and increase in stem thickness.

Environmental influences on the development of Wood

Both dicot and monocot species of woody plants have the porous and fiber-structured tissue known as wood.Humanity uses this sort of wood for both building and fuel.It is essentially a natural composite made of cellulose fibers embedded in a lignin matrix.Here, lignin resists compression while cellulose fibers create significant tension.In terms of anatomy, wood is mostly made up of secondary xylem, which forms during secondary growth.It serves a supporting role in a live tree by allowing woody plants to develop broadly and sustain themselves in a healthy manner. It has been shown that in temperate regions, the cambium exhibits a clear seasonal change in activity. It has been discovered that compared to autumn wood, spring wood's containers have substantially larger and comparatively thin walls.It has been noted that these variations in wood structure may accommodate the various needs of the plant over the spring and winter seasons.

For instance, the vegetative activity is at its greatest in the spring, increasing the transpiring surface. Therefore, to accommodate the demand during this time, more water channels are needed.The spring wood therefore has wider vessels. The environment is completely different in the fall, with little vegetative development necessitating a less complex water conduction system because of the absence of vegetative growth.

CONCLUSION

The shoot is a crucial component of the plant system.Later on, it produces leaves, branches, inflorescences, flowers, fruit, and seeds. Some alterations take place in associated tissues as a leaf emerges from the shoot apex. Plants sometimes need strong tissues to aid in weight gain, hence the function of secondary growth is crucial. The secondary growth pattern of plants deviates from the typical pattern. This altered pattern of secondary development is known as anomalous secondary growth. Secondary growth is often absent in monocotyledonous plants. However, several plants, like Dracaena, Yucca, Lomandra, Xanthorrhoea, and Kingia, show secondary growth that is abnormal in both origin and function. The cambium's activity varies noticeably throughout the year in temperate regions. It has been discovered that compared to autumn wood, spring wood's containers have substantially larger and comparatively thin walls.It has been noted that these variations in wood's structure may accommodate the various needs of plants in spring and winter seas.

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CHAPTER 12

PRINCIPLES OF ROOT DEVELOPMENT

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ABSTRACT:

The Function of P and K Nutrients. The three primary nutrients for plants are nitrogen, phosphorus, and potassium. As previously mentioned, potassium and phosphorus are the ideal nutrients for root development. In a plant, potassium aids in the movement of water and nutrients. They provide three main functions: they absorb water and minerals, they anchor and support the plant, and they store food. Water and mineral absorption to effectively absorb water and dissolved minerals from the soil, root hairs and thin-walled epidermal cells are ideally adapted. After completing this course, you will be able to comprehend: the structural variance in the roots of diverse plant groups; the structural alteration in the root's anatomy as a result of habitat; and the secondary growth in the roots of plants and its use.

KEYWORDS:

Fascicular, Parenchymatous, Phloem, Monocots, Xylem.

INTRODUCTION

Roots, an essential component of plants that are often found in the soil, grow toward gravity and grow away from light. Its primary function is to absorb water, nutrients, and everything else that is present in the soil, just as artificial fertilizer does. It has a non-green surface. The seedling's first organ to develop after germination is the radical, which eventually develops into the main or tap root system. Anchoring the plant is crucial at all stages, from the seedling stage through the mature tree. The next paragraphs detail the various anatomical adaptations of such a sort of plant that are useful in all of its activities.

Apical Root Meristem:

Organization Root Apex:

As seen in Figure 1, the apices of shoots and roots are thought to be the first examples of self-replicating promeristems composed of uniform meristematic tissues. Later, contemporary researchers claim that the promeristem's immediate derivatives can clearly distinguish a zonation. They claim that there is unique zonation of separate regions that vary from one another in terms of the kind of cells, the plane of cell division, and the placement of the beginning cells. Because there are no nodes, internodes, or lateral appendages, the root apex structure is often less complicated than the shoot [1].

This idea was put out by Nageli, who claimed that growth is caused by a single tetrahedral apical cell in the root apices. It contains three cutting faces that help to develop the root's body tissues. Its base gives rise to the root cap. Angiosperms were not found to support such a claim. A schematic representation of the many forms of root apices seen in angiosperms is illustrated in figure. Histogenesis hypothesis. This theory was put out by Hanstein, who claimed that three different histogens may be identified in the root apex areas. The plerome gives birth to the vascular cylinder, the periblem to the cortex, and the dermatogen to the epidermis. Later, Haberlandt suggested the names protoderm, ground meristem, and procambium for these histogens, respectively. Theory of Körper-Kappe. This idea was put out by Schuepp, and it is claimed by them that the cells at the root apex split into two planes. The area divided by an inverted "T" was known as the Körper, whereas the area divided by a straight "T" was known as the Kappe. The hypothesis largely echoes the tunica corpus notion of the shoot apex, and in a similar vein, it also falls short of explaining the behavioral variations across species[2].

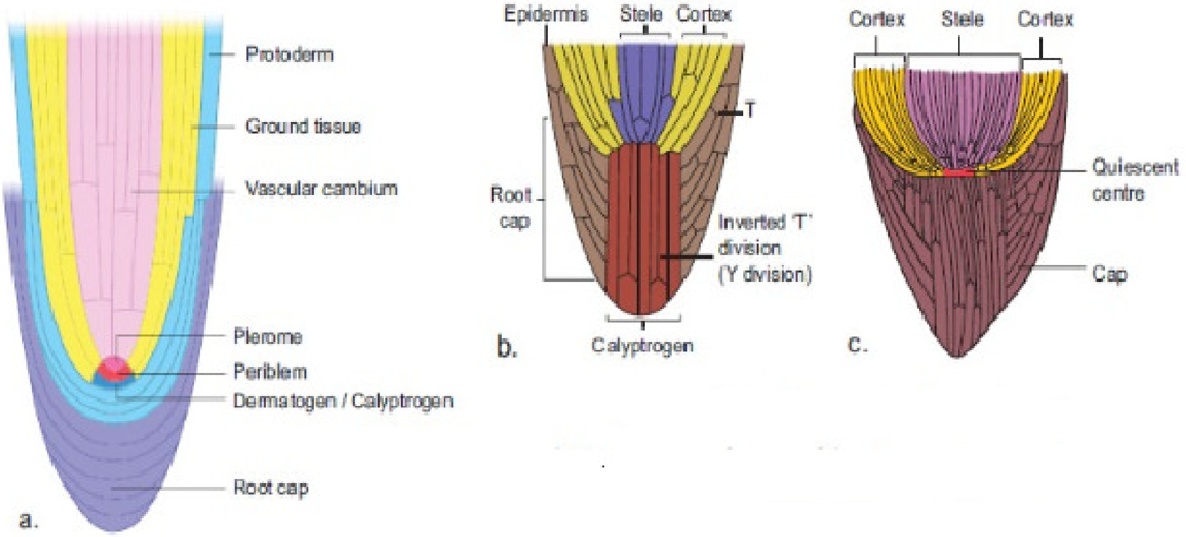

Figure 1: Illustrate theRoot Apical Meristem.

Idea of the Quiescent Zone

In his autoradiographic investigations of DNA synthesis in the root tip of Zea mays, Clowes discovered a central cup-shaped area whose cells lacked many mitochondria and ER, had tiny nuclei, and synthesized DNA and proteins at a slow pace. He called this dormant area the quiscent center. Since then, numerous other plants have been found to contain these zones. There are around 500 cells in Zea mays, 600 in Sinapsis Alba, and 1100 in Faba victoria. Quiescent cells typically do not divide, but they may become active if the active initials are harmed. As a result, this area serves as a cell reservoir. These cells are not actively dividing, but they are more resistant to harm and radiation than actively dividing cells are. In certain circumstances, they may also actively divide. According to Clowes, the quiscent center's cells remain dormant not because they lack the capacity to divide, but rather because of where they are located in the apical meristem.

DISCUSSION

Root's Basic Structure: Dicot and Monocot

Primary Root Structure

Since the environment under the soil is almost consistent, roots have a simpler internal organization than stems and lack of lateral appendages, internodes, and nodes.

Circulatory System

The epidermis, sometimes referred to as an epiblema, is a continuous layer made up of closely spaced, thin-walled, uncutinized cells. The outer tangential walls of epidermal cells are cutinized in certain herbaceous perennials where the epidermis is long-lived and serves as a primary layer. Except for the aerial roots of certain orchids and epiphytic aroids, where it is multiseriate and termed a velamen, it is often unseriate.The velamen is made up of tightly packed dead cells with secondary wall thickenings on several occasions. It serves as a mechanical tissue that guards against and controls water loss from the cortex in addition to being largely an absorptive tissue. In the dry season, the velamen's cells are filled with air; in the wet season, they are filled with water. The velamen also contains certain specialized cell clusters with extensive spiral thickenings. These aid in the exchange of gases and are referred to as pneumatodes. Young roots have a lot of unicellular root hairs on their epidermis.A few millimeters from the root apex is where the root hairs begin to grow. Hairs that were present on the more mature areas of the root often die and dry up as the root matures, while relatively youthful parts of the root continue to create new hairs. Sometimes, such as in Eupatorium purpun, root hairs are persistent[3], [4].

Only a select fraction of the root's epidermal cells actually produce root hairs, yet all of them are capable of beginning them. Sometimes, the epidermal cells that grow into root hairs are morphologically different from the other cells. Trichoblasts are the name for these cells. A bump on the epidermal cell serves as the beginning of a root hair, and it contains cytoplasm and a nucleus at its tip. Cortex. It is immediately internal to the epidermis, simple and uniform in type, and composed of diametric, parenchymatous cells with thin walls and many intercellular gaps. It is mostly aerenchymatous and encloses air spaces in aquatic plants, such as Hydrilla. Air cavities may sometimes form in the root as a result of certain cortical cells rupturing. Starch is often kept in cortical cells. However, certain aquatic plants, such as Trapa, may have cortical cells that contain chloroplast.

The cortical cells of certain aerial climbers, including Tinospora, contain chloroplasts and have photosynthetic roots. As an example, the cortical cells of the Avena sativa plant are organized in different radial rows. The inner cortical cells of Commelina are organized in concentric rings. Several gymnosperms' cortical cells as well as several members of the Cruciferae and Rosaceae families have lignified reticulate thickenings in their roots. The sub epidermal cortical layers develop into a protective tissue termed exodermis, which is composed of suberised wall, in the majority of monocotyledons, some dicotyledons, and gymnosperms. Exodermal cells with Casparian strip are present in some of them. Diverse Iris species have diverse exodermis development[5].Endodermis, it is the cortex's deepest layer and has rather recognizable roots. In roots, endodermis is always present and is made up of densely packed live cells. There are two different kinds of cells: one with the radial and transverse walls thickened in a distinctive casparian manner, and the other with thin walls that is located on the other side of the protoxylem points. Passage cells are another name for these cells with thin walls. Suberin and lignin deposition lead to the Casparian thickening's formation. Secondary growth in dicot roots causes the endodermis and cortex to be shed.

Pericycle:

It lines the outside edge of main vascular bundles and develops on the inner side of the endodermis. Though mostly uniseriate, multiseriate pericycles have been identified in Smilax and Salix. In other instances, however, such as in a small number of hydrophytes and some parasites, it may even be missing. Most of the time, it is parenchymatous in nature, however in Smilax, this layer is made up of cells with thick walls. Members of the Umbelliferae have been observed to have schizogenous secretory tubes in their pericycle. The procambial strands that give rise to the pericycle maintain their meristematic characteristics fairly early. It serves as the place where lateral roots first appear, particularly before secondary development. It is a component of the fascicular cambium during secondary growth and contributes significantly to the cambial ring's completion, especially in the area opposite the protoxylem points. In addition, it is the source of the whole first cork cambium[6].

Vascular System:

The vascular bundles in roots are arranged in radial fashion. Element of Xylem exhibits exarch state. Centripetal type 1 xylem development. Dicotyledonous roots have one to eight vascular bundles, whereas monocotyledonous roots have eight to twenty. Roots may be classified as monarch, diarch, triarch, tetrarch, or polyarch according on how many xylem bundles or patches they contain. Typically, there are just a few protoxylem components per bundle, and each bundle only has one protoxylem vessel with an annular or spiral thickening. The vessels in the metaxylem are polygonal. Protoxylem and metaxylem vessel counts may vary, for example, Sisyrinchium contains a single, substantial core metaxylem vessel surrounded by five to seven strands of protoxylem vessels. A single metaxylem vessel may be seen at the base of each protoxylem strand in Gladiolus and Freesia. Sieve tubes, companion cells, and phloem parenchyma make up phloem.Conjunctive tissues made of parenchymatous cells divide the vascular bundles from one another. The pith, which is located in the tiny center portion of the stele, is made up of parenchymatous cells with thin walls and intercellular gaps. Older dicot roots don't have any pith at all. Monocotyledonous roots, which may also include a few tannin cells, have a well-developed form of it. Some Iridaceae members have sclerenchymatous pith[7].

Diagram of the Dicot Root

Young roots of Cicer, sunflower, etc. are often used as the research material for the anatomical characteristics of a typical dicot root. The typical dicot root exhibits the essential anatomical characteristics listed below.

Epidermis: It is the outermost uniseriate layer and is made up of parenchymatous cells with thin walls that are tightly packed and lack intercellular gaps. Ridace view epidermal cells sporadically give birth to single-celled root hairs. Absence of the cuticle and stomata is a hallmark of epiblema of the roots. Minerals and water are absorbed from soil via root hairs.

Cortex: It is uniform and well-developed, and it is located under the epidermis. It is made up of parenchymatous cells with thin walls, irregular arrangements, and many intercellular gaps. However, the first few layers may be grouped closely. Amyloplasts are present in these cells, which also store starch as starch grains.

Endodermis: The stele is surrounded by the cortex's deepest layer. The endodermis is made up of parenchymatous, cylindrical cells with no intercellular gaps. The majority of the cells have Casparian strips, which are strip-like thickenings of suberin and lignin on their radial and tangential walls, with the exception of those that are located opposite the protoxylem point. Thin-walled cells that are next to the protoxylem components are known as passage cells because they let water to travel from the cortex to the xylem. Stele. It is a tetrarch actinostele made up of vascular bundles and pericycles. The following components are typical.

Pericycle: The pericycle is the layer that is on the inner side of the endodermis and the outermost part of the stele. It is made up of a single uniseriate layer of parenchymatous cells with thin walls and thick protoplasm. It typically has two to three layers and is located opposite the protoxylem components. It reveals where the lateral roots originate.

Vascular bundles: There are four of them, and they are organized in a ring-like pattern. Vascular bundles are of the radial kind, where phloem and xylem are alternately positioned on distinct radii. Conical in form, the xylem is exarch in nature and has metaxylem vessels near the center and protoxylem at the periphery. The pith is destroyed when the metaxylem parts meet in the center of mature, well-developed roots. There are no fibers or xylem parenchyma. The vessels are surrounded by Xylem tracheids. Phloem is made up of partner cells, sieve tubes, and pholem parenchyma, and it is located next to xylem patches on distinct radii. Phloem fibers are not present. Phloem is found in the shape of tiny patches, with protophloem on the outside and metaphloem on the inside[8].Conjunctive tissue is parenchymatous in nature and is found between xylem and phloem patches.

Pith: The pith, which is the center portion of a juvenile stele, is made up of a small number of parenchymatous cells that are tightly packed together and lack intercellular gaps. The pith in elder roots may completely disappear.

Root hairs and lateral roots

Growth of Lateral Roots

Initiation of lateral roots normally occurs in the zone of maturation, behind the apical meristem. However, the lateral root primordia are generated very near the root apex in certain aquatic plants, such Eichhornia crassipes. Gymnosperm and angiosperm lateral roots often begin in the pericycle across from the xylem ray and extend into the root cortex. The location of the vascular strands in the parent root affects where the lateral root is located. In tri-, tetra-, and pentarch roots, it appears between the phloem and xylem strands, opposite the protoxylem, and in polyarch roots, opposite the protophlocm strands. Lateral root primordia develop just beyond the area of root hairs. The pericycle's cells undergo meristem development and periclinal division at the location of the eventual primordium. Following these early divisions, divisions in both the periclinal and anticlinal planes occur. These divisions create the lateral root's primordium. Endodermis may sometimes have a role in the development of lateral root primordia, such as those seen in Daucus carota and Zea mays. In these situations, the endodermis mostly divides anticlinally, while some periclinal divisions may also take place. Growing through the cortex and epidermis, the young lateral root eventually reaches the earth. The cortex's cells are pushed aside and crushed during this process. Although enzymes may also help lateral roots develop through the cortex, mechanical penetration is the primary method by which they pass through the cortex. Through the pericycle cells, the vascular components developing in the lateral roots are linked to those of the parent root. The lateral root's root cap and promeristem form while it is still within the cortex. The lateral roots typically grow in aero- petal order, with older roots growing toward the apex and newer roots at the base. Lateral roots often begin in the cambium of adult roots, when the pericycle has been shed.

Root-Microbe Relationships

It has been discovered that bacteria are in charge of nitrogen fixing in the roots of many plant species. Blue green algae perform this function in certain tropical trees, whilst actinomycete-like organisms do it in other species.Rhizobium bacterial species are in charge in legumes. Aerobic Rhizobia bacteria live in the soil saprophytically until they infect a root hair.When a bacteria invades, root hair often responds by enclosing it in an athread-like structure known as an infection thread. This infection thread is made up of the folded and expanded plasma membrane of the invaded cell, as well as fresh cellulose that has developed on the inside of this membrane. Inside the tread, which extends inside and permeates through and in between the cortical cells, the bacteria proliferate widely[9].

The bacteria are discharged into the cytoplasm of the inner cortical cells, where they cause certain cells to divide.These divisions result in a mature nodule known as a root nodule, which is composed of diploid and tetraploid cells that contain bacteria.The term "bacteroid" refers to each larger, immobile bacteria.The bacteroid often appears in cytoplasmin groups, with a membrane known as the peribacteroid membrane enclosing each group.The peribacteroid space is a space located between the peribacteroid membrane and the bacterial group. Leghhaemoglobin is a protein found in the plant cytoplasm outside the peribacroroid region.This pigment imparts a pink hue to the legume nodule.

It is assumed that it delivers O_2 to the bacteroid.The nitrogen fixing enzyme is rendered inactive by an excess of oxygen. Within bacteroids, nitrogen is immediately fixed. Bacterioid receives carbohydrates from the plant, which they oxidize to produce energy. The root hair displays irregular curling development in response to the bacteria's factors, and rhizobia cells multiply within the coils. Infection arises through localized root hair wall disintegration, and the infection thread is created by the root cells' Golgi secretory vesicles. When the infection thread reaches the cell's end, its membrane unites with the root hair cell's plasma membrane. Rhizobia are released into the apoplast and pass through the middle lamella of the compound to the plasma membrane of the subepidermal cell, starting a second infection thread that joins the first to create an open channel.

Unusual Dicot Root Secondary Growth

Gymnosperms and dicotytedons often experience secondary development in their roots to support the spreading shoot system and to accommodate the expanding requirements for food material absorption and conduction.

The majority of monocotyledons' roots do not exhibit secondary growth and are always in their primary stage. However, certain monocots do exhibit secondary thickenings of the roots. Even yet, the root's secondary development process begins in a different way. Secondary tissues are created with a basic structure that resembles the stem. The following two secondary meristems are in charge of root secondary growth:

Cambium that is fibrous or vascular. It is located in the stelar area, and when it is active, secondary xylem and secondary phloem are produced. Cork cambium or phellogen. It grows in the extra-stelar area, and via its action, periderm is formed. Vascular cambium begins to form and become active before cork cambium does[10].

Vascular Cambium Initiation and Activity

The radial distribution of the vascular strands in the root is distinctive. Along the inner borders of the phloem groups, a few parenchyma cells undergo meristematic development and produce crescent-shaped strips of cambium.These cambium strips generate secondary phloem centrifugally and secondary xylem centripetally. As a result, vascular tissue collateral strands develop in-between the major xylem bundles. Small strips of cambium are also generated outside the xylem when the activity of these cambial strips progresses and the pericycle cells next to the protoxylem begin become meristematic. The phloem strands below the first cambial strips that develop link with the xylem strands outside the freshly created strips. As a consequence, a cambium ring that runs within the phloem strands and outside the xylem is completely produced. Before the later created cambium from the pericycle, the first generated cambial strips along the inner face of the phloem begin to operate.

The cambium is forced outward as a consequence of the development of secondary xylem opposing the phloem. As a result, the cambium rings wavelike shape changes to a circular one. This cambium ring generates secondary phloem on the outside and secondary xylem on the inside. The secondary vascular tissues that are formed in the root have a continuous cylinder-like shape and are basically identical to those in the stem. The primary xylem bundles remain in the secondary tissue cylinder where they were originally located. Therefore, in the secondary stage, exarch primary xylem strands may be used to identify the root from the stem. The original phloem, endodermis, and cortex are often crushed as a result of the secondary tissue's massive volume expansion. Many roots lack secondary vascular tissues as a result of the cambium cells that form in the pericycle opposing the principal xylem poles.

They serve as ray initials and generate broad primary vascular rays that radiate outward from the terminals of the protoxylem into the secondary xylem and phloem. Additionally, the secondary vascular tissue also develops small, thin secondary vascular rays in a similar manner. Despite having the same types of materials in their xylem, the root and stem vary from one another in terms of their relative quantities. For instance, roots contain more parenchyma, fewer fibers, bigger or more numerous rays, and vessels with thinner walls as compared to stems. Similar to this, the phloem in roots contains more storage parenchyma and less sclerenchyma.

Cork cambium initiation and Activity

Herbaceous dicotyledon roots have very little secondary growth, which means the tissues outside the stele are virtually completely unaltered. In these plants, the exodermis, which has robust walls and serves as protection, suberizes into cortical layers under the epidermis.However, in woody roots, a large number of secondary tissues are created as a consequence of the vascular cambium's intense activity, which puts pressure on the root's peripheral tissues until they finally fall off. They are replaced by the periderm, a more effective protective layer created by the cork cambium or phellogen. Periderm development begins quickly after secondary vascular tissue creation commences. The pericycle's outermost layers are where the phellogen begins. On the outside, it generates cork, while on the inside, it forms secondary cortex, or phelloderm. The cork or phellem becomes the outermost protective layer as the tissue from the endodermis to the exodermis is sloughed off. Roots may develop lenticels as a result of secondary growth. New phellogen layers may develop in the deeper layers after the older ones have been lost, and the first created phellogen may last for a long time. The periderm, which is composed of both suberized and non-suberized cells, is found in the roots of several angiosperms, including those in the Myrtaceae, Onagraceae, and Rosaceae families. Suberized cells that are one cell deep alternate with non-suberized cells that are several cells deep. These later ones handle storage. Polyderm is the term for such periderm.

Secondary Growth in Dicot Roots Is Abnormal

Many dicot plants have modified roots that serve as store roots.In nature, these organs generate significant parenchyma storage. As an adaptation to their storage role, secondary development in these roots often takes the form of anomalous growth. The roots of members of the Umbelliferae, Cruciferae, Chenopodiaceae, Compositae, Convolvulaceae, etc. display abnormal secondary growth. Tinospora's aerial root exhibits typical secondary development, but its medullary rays are noticeable, enormous, and store food reserves.This main cambium ring demonstrates aberrant activity, forming alternating clusters of secondary xylem and parenchyma cells on the inner side while secondary phloem on the outer side. A ring of conjoined, collateral vascular bundles implanted in parenchymatous tissue was created as a consequence. The parenchymatous cells serve as a kind of tissue storage. Following the formation of the ring of vascular bundles, the cambium stops functioning. Outside of the initial cambium ring, a second one soon appears.

The inner cells severed by the pericycle or, less often, the phloem parenchyma cells give rise to this auxiliary or secondary cambium. A second ring of conjoint, collateral vascular bundles is formed outside of the first ring of bundles as a consequence of the secondary cambium's aberrant behavior, which is identical to that of the first cambium ring. Wide gaps inhabited by parenchymatous cells divide these circulatory bundles into different segments. A third cambium ring, or second accessory cambium, now forms outside of this second ring of vascular bundles when this first ring of auxiliary cambium fails to function. This cambium ring functions similarly and originates from the pericycle cells. A few layers of pericyclic cells, which are meristematic in nature and quickly proliferate to generate layers of parenchyma cells, are subsequently encircled by the growing cambial ring. These cells act as store tissue by being stocked with extra nourishment.

The vascular bundles later become wider apart as more and more proliferating parenchymatous cells are generated. The succeeding cambial rings result in alternating layers of vascular bundles and proliferative, food-reserve-filled parenchymatous cells. Transverse sections show that the vascular bundle rings are lighter in color and the parenchyma rings are darker in color. The growth of vascular bundles and proliferating parenchyma cells, which are rich in sugar, causes the root of Beta vulgaris to enlarge. In fully developed roots, a cork cambium, also known as a phellogen, arises, producing cork cells on the outside and secondary parenchyma on the inside[11].

The cambium ring that forms during the secondary development of the storage root initially functions correctly, but as it progresses, it starts to act abnormally, creating distinct strands of secondary xylem and phloem embedded in the parenchymatous ground tissue. Individual rings of secondary cambium that develop from the parenchymatous cells of the ground tissue surrounding the xylem vessels surround these strands of xylem. The secondary cambium that surrounds the xylem vessel acts abnormally, creating a small amount of secondary xylem toward the center and a little amount of sieve tubes and laticiferous components distant from the center. Additionally, the cambium produces a large number of parenchymatous cells on both the inner and outer side. These cells act as store tissue by being stocked with extra nourishment. Tyloses often form in the bigger vessels in later phases. The cork cambium, which creates the periderm, emerges from the pericycle. The roots of Raphanus sativus are fleshy and have the usual diarch main xylem. A typical cambium forms during the start of secondary growth, cutting off secondary xylem toward the inner side and secondary phloem toward the outer side. The secondary tissues are considerably increased as a result of the xylem cells' composition of xylem parenchyma, which repeatedly divides and proliferates in all directions.

The secondary cambium is formed when some of these parenchymatous cells undergo meristematic development. These cambia partially or fully encircle the secondary xylem strands dispersed throughout the ground tissue. The secondary cambium's activity is atypical since it produces a lot of parenchyma both within and outside the cambium ring but few xylem components.

As the root develops, the parenchymatous ground tissue is dotted with multiple patches of secondary xylem surrounded by secondary cambium. These parenchyma cells act as store tissue and a repository for reserve nourishment. Thus, the development of circular patches of secondary xylem and the mass of multiplying parenchymatous storage cells are the causes of the increased root girth[12]. With enough secondary phloem linked externally, the original cambium is still present and visible in the periphery. A few layers of cork cells with thin walls compose the cork cambium.

CONCLUSION

A cap protects its tip, and the apical meristem is located sub-terminally. From the embryos radical, the root grows. Meristematic tissues underwent a predetermined process of progressive differentiation before maturing. There are three tissue systems that make up the main body. Dicot and monocot roots vary structurally in several ways. Herbaceous dicots, all gymnosperms, and woody dicots all exhibit secondary root development, which results in an increase in root thickness. The majority of monocot roots are exclusively primary in origin.

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CHAPTER 13

GROWTH AND DIFFERENTIATION OF LEAVES

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ABSTRACT:

The leaf serves as the foundation for the development of the whole plant via its photosynthetic ability. It is crucial to establish a mechanistic knowledge of leaf growth and development, as well as the influence of genetic and environmental variables, in order to enhance crops for greater production and resilience to future climatic scenarios. Both the fundamental components of a leaf and the regulatory units that incorporate environmental and genetic information into the developing process are cells. Therefore, reconstructing the developmental route of individual cells from the stem cell niche to their ultimate place in the adult leaf is essential for understanding the fundamentals of leaf formation. To provide the framework for such comprehension. The leaf is a crucial component of the plant, and this unit will help you understand the nature, ecological functions, and positioning of the leaf on the axis. Xerophytic leaf morphology structure of hydrophytic leaves.

KEYWORDS:

Dicotyledonous, Morphology, Photosynthetic, Shoot Apical, Xerophytic.

INTRODUCTION

An essential goal in biology is to comprehend how plants' internal organs and development are regulated. It serves as the foundation for agricultural productivity, ecosystem turnover, and the ability of the plant to adjust to its surroundings and receive experimental treatments. Dicotyledonous plant species undergo an unusual process during the formation of their leaves, one that is the consequence of the intricate interaction of several regulatory mechanisms. On the one hand, it is so rigorously controlled that the resulting leaf shape is a trustworthy trait for taxonomic categorization. On the other hand, the process is so flexible that the environment may have a significant impact on the size of mature leaves. Curiously, despite genetic variances in hundreds of genes, leaf form is often highly retained across related species, yet sometimes a single mutation may cause morphological differences like those that separate species and even families.

These fascinating traits and the significance of leaves for plant performance and function have led to substantial research on a number of leaf development-related topics. Through the use of molecular and genetic methods, significant progress has been achieved in recent decades in understanding the control of leaf growth. At all organizational levels, the growing utilization of high-throughput technologies is also continuously generating new biological knowledge. Systems biology offers a way to incorporate the growing body of information into comprehensive mechanistic models to fully comprehend biological processes in this situation. In order to evaluate how well these models match the actual situation and further our knowledge of its mechanical underpinnings, they are often used via computer simulations of normal and/or experimentally disturbed systems[1].

A comprehensive knowledge of the regulatory networks that regulate cells' developmental choices and activities as they move through space and time from the shoot apical meristem to their ultimate location in the leaf is necessary for a mechanistic understanding of leaf formation. In light of this, we examine the ensuing developmental networks that direct individual cells as they go from the SAM to their differentiated state somewhere in a fully differentiated leaf. Based on this explanation, we determine the degree to which we comprehend how changes in cell-level regulation impact the overall form and size of the leaf, as well as the consequences for incorporating this understanding into comprehensive simulation models.

Mechanisms that Regulate Leaf Growth

In a dynamic process, component cells at various stages of development are given instructions to alter their differentiation and control the speed at which developmental processes are carried out via distinct regulatory pathways. To direct the formation of certain cells, each of these regulatory control points is crucial. A leaf's development, and eventually its size and form, are emergent qualities that may be likened to those of actual leaves when distributed throughout the whole cell population of a leaf. It is crucial to comprehend how developmental cues are incorporated into the leaf growth process since these signals are interpreted and carried out at the level of individual cells. This may be done by simulating the journey taken by a single cell from the SAM to the mature leaf. Although many of the linked pathways have undergone thorough reviews, in our opinion, the viewpoint of the individual cells has not been well investigated. To convey this cellular viewpoint on leaf development is the primary goal of the current review[2].

Shoot Apical Mesoderm

All of the cells that eventually comprise the shoot, including the subgroup that develops into the leaves, come from the SAM. Typically, cells in the SAM's outer zone divide more quickly and differentiate into organs like leaves, axillary nodes, and floral components whereas cells in the SAM's core zone divide more slowly and stay in an undifferentiated form. The SAM in dicots has three layers, L1, L2, and L3. The inner layer is known as the corpus, while the epidermal and sub epidermal layers are known as tunica.

Cytoplasmic Expansion

The ultimate size and form of the leaf varies greatly across species, in contrast to the morphology of the leaf primordium. Differences in leaf outgrowth are often explained by the production of a certain number of cells through cell division, followed by the cells' subsequent expansion to determine their final size. But this is an unduly straightforward viewpoint. First of all, there is a complicated link between cell division and growth, and the two processes may balance one another out. Green hypothesized that cell growth and partitioning are two processes that co-occur in proliferating cells, but cell-growth continues in expanding cells without partitioning, offering a theoretical framework to describe this occurrence. It is clear that this framework permits growth to continue until cells become too tiny or too big to function correctly, regardless of whether cell division activity is blocked or boosted.

However, it is unduly simple to assume that cell growth in proliferating cells is identical to that in expanding cells. It is evident that growing cells predominantly increase their internal volume by expanding their vacuolar volume, in contrast to dividing cells, which develop by extending their cytoplasmic volume. Growth in the cytoplasm is mostly reliant on macromolecular synthesis, which uses a lot of energy. The Target of Rapamycin pathway plays a key function in providing an adequate supply of fundamental building blocks. TOR, a member of the family of kinases related to phosphatidylinositol-3-kinase, is crucial for controlling cytoplasmic development and metabolism in plant cells[3].

DISCUSSION

Shredded Tissue

Parenchymatous cells with discrete intercellular gaps make up ground tissue. Sclerenchymatous cells are sometimes seen in the ground tissue, much as in Mangifera. The ground tissue of the petiole often contains laticifers and resin channels. Air chambers are also seen in the ground tissue of several aquatic plants.

Vascular Bundles

The way that vascular tissue is organized in the petiole varies greatly. It is organized with adaxial xylem and abaxial phloem into a ring or girdle. A ring of distinct vascular bundles with their xylem towards the pith may be seen in Oxalis corniculata. Cucurbita's petiole features two bicollateral vascular bundles, the bigger of which is located across from the ridges and the smaller below the grooves. Many Leguminosae and Oxalidaceae have a pulvinus, or joint-like swelling, near the base of the petiole.Anatomically, the pulvinus is mostly composed of intercellular gaps in thin-walled parenchymatous tissue. Even though there are several bundles present above and below the pulvinus, the vascular tissue in this area is only represented by one concentric thread. Through variations in the turgor and concomitant changes in the size and form of the ground parenchyma cells, the pulvinus is engaged in the motions of the leaves[4].

Lamina Anatomy

Adaxial Surface refers to the side of the leaf that faces the axis; morphologically, this is the top side of the leaf. Abaxial surface refers to the surface that faces away from the axis. The following three groups of leaves may be distinguished histologically. The dorsoventrally or bifacial leaves. They have distinct top and bottom faces as a result of being stretched at an angle to the direction of the most intense diffuse light.The spongy parenchyma is located immediately within the lower epidermis, whereas the palisade tissue is mostly restricted below the top epidermis. The palisade may sometimes be seen adjacent to the lower epidermis. Inverted bifacial leaves are the later varieties.

Epidermis

Typically, a single layer of densely packed cells makes up both the top and below epidermis of a leaf. However, other plants, including Ficus, Piper, and Nerium, have a multiseriate adaxial epidermis. Protodermal cells undergo periclinal divisions, which results in its formation. The top epidermis of succulent species of Begonia has three layers, whereas the bottom epidermis has two layers. The epidermal cells' radial walls might be straight or sinuous. Sometimes the epidermal cells may contain papillae, which are little, convex protrusions. A leaf's epidermal cells are uniform throughout, or they are narrower along the coast. Some xerophytic leaves, particularly those of grasses, have enormous epidermal cells with thin, flexible walls that are arranged in longitudinal furrows. In dry conditions, it is believed that these cells, often referred to as motor cells or bulliform cells, aid in the rolling of leaves. The cuticle thickness varies across species, and the epidermal cells are cutinized. Xerophytic organisms often have a cuticle that is rather thick. Stomata: The existence of stomata, which may be found on one or both sides of a leaf, is a crucial component of the epidermis of leaves. The term "amphistomatic" refers to a leaf with stomata on both sides. "Epistomatic" refers to a leaf with stomata only on the upper side, while "hypostomatic" refers to a leaf with stomata only on the bottom side[5].

Structure

Each stoma consists of a hole that is enclosed by two guard cells, which are specialized epidermal cells that typically have the form of kidneys. The walls of the guard cells are irregularly thickened. While the inner wall away from the aperture is thin and extendable, the inner wall confronting the aperture is heavily thickened. The cuticle that lines the inner wall of the guard cells and forms the border between the pore and the sub-stomatal chamber is also present there. The guard cells include mitochondria, dictyosomes, ribosomes, and endoplasmic reticulum. They also contain grains of starch. Guard cells, in contrast to other epidermal cells, have chloroplasts. Studies using electron microscopy have shown that guard cells contain tangential extensions that extend into the cell cavity as well as fewer and less organized lamellae than monocotyledons. Arm-palisade cells are these types of palisade cells. Palisade cells' projections in the cell wall provide the cell wall's chloroplast arrangement the greatest amount of exposed area. Some Gesneraceae and Pipcraceae species that live in damp environments have palisade cells that resemble cones, having a broad upper end and a somewhat small lower end. The term "funnel cells" refers to these cells. Large air chambers or air canals are present in the mesophyll tissue of aquatic plants. There are very few chloroplasts in the cells that make up the air chambers. The partition walls of air chambers include stellate cells, which provide mechanical support. Mesophyll also contains many idioblast forms, including lithocysts, oil glands, and laticifers[6].

Vascular Tissue

The vascular cylinder of the stem on which they are borne provides the leaves with their circulatory supply. Each leaf gets one, two, three, or more vascular traces, which may either branch and anastomose or continue unbroken the full length of the leaf. The leaf's veins are its vascular bundles, and by branching out farther, they create a network known as the venation. In dicotyledonous leaves, there is often a single main vein that runs through the lamina's center and branches out into gradually thinner branches to create a netted pattern across the lamina. Reticulate venation is the name of this vein system. The veins of monocotyledonous leaves are oriented lengthwise, converging, and joining at the leaf's apex. Parallel venation is the name given to such venation. However, the venation is reticulate in certain monocotyledonous leaves, such as those of the orchidaceous family. Some dicotyledons, including Plantago and Trgopogon, may also exhibit parallel venation. Dicotyledonous leaves with reticulate venation veins may be classified into several size groups or "orders" according to their size.

The thickest veins on a leaf are those of primary order, which may be found individually or in lateral pairs of nearly similar thickness. The secondary order veins are formed by lateral branches that emerge from the principal vein. The secondaries are readily distinguished from the primary because they are a little bit thinner. Higher order veins are formed by the additional ramification of the secondaries. The veins of higher order may further split several times and either stay separate or merge into the reticulum. In the majority of dicotyledons, the midrib or midvein is made up of a typical collateral bundle that includes an adaxial xylem and an abaxial phloem. Between the xylem and phloem, a slender strip of cambium is also visible. The midrib sometimes has multiple vascular bundles that are dispersed unevenly, organized in a ring, or in a semicircle. Midvein and bigger veins have vascular tissue with arteries in the xylem and sieve tubes in the phloem. Tracheids serve as the xylem representation in smaller veins, while a few sieve components serve as the phloem representation. Some woody dicotyledons' bigger leaf veins exhibit just a little degree of secondary growth as a consequence of the cambium's activity between the xylem and phloem. The vascular bundles are likewise lateral in monocotyledonous leaves, although there is a lot of diversity in the components' sizes and locations. In the leaves of monocotyledons, the following primary kinds of vascular bundles are identified based on the form of xylem and phloem groups and fiber characteristics: extended bundles Oval bundles with a fibrous cap, sclerenchymatous cap, rather linear Phloem, two to three sets of xylem parts of moderate size, and one massive metaxylem element. A typical grass type bundle with a noticeable V or U shaped curve in which the xylem and phloem connect is surrounded by a few relatively modest xylem components meeting with phloem along a slightly convex surface.

Bundling Sheath

The cells that surround the vascular tissue of leaves in the majority of angiosperm are morphologically different from mesophyll cells. In dicotyledons, these cells make up the bundle sheath. Parenchymatous cells with thin walls that stretch in a direction parallel to the veins surround the vascular bundles. Chloroplasts may or may not be present in these cells. Dicotyledons often have a parenchymatous bundle sheath that reaches the leaf's epidermis on one or both sides. It presumably has a significant impact on how dietary material is transported between the vascular bundle and the epidermis. In monocotyledons, one or two bundle sheaths, each made up of a single layer of cells, entirely or partly encircle the vascular bundles. The parenchymatous sheath on the outside is transparent or might include chloroplasts. The inner sheath's cells are smaller, have thicker walls, and lack chloroplasts. Numerous physiologists are interested in the bundle sheath cells of certain monocotyledons because they participate in an alternative photosynthesis process. Slack and Hatch It was noted that the bundle sheath cells' chloroplasts are morphologically different and devoid of grana in all grasses. Instead of the 3-carbon atom compound of the Calvin cycle, the first stable product of photosynthesis in such plants is a 4-carbon atom molecule[7].

Phyllotaxy

It refers to how the leaves are arranged on the stalk. It is quite mathematical and regular. In a certain species, the leaves are placed on the stem in a specific way. The arrangement is often regular, and the leaves are seldom arranged carelessly on the stem. Most foliage leaves have long or short internodes between them and are distributed widely along the stem; this arrangement is known as cauline. This kind of arrangement, known as radical, occurs in certain plants when the leaves emerge from the stem in a group or rosette slightly above the roof. Each node in cauline leaves may have one, two, three, or more leaves.Spiral, alternating, or acyclic are all terms used to describe a leaf layout with just one leaf. The phyllotaxy is known as Cyclic if each node has two or more leaves.

Periodic Phyllotaxy

The leaves at each node form a whorl in this kind of phylotaxy, and they are arranged on a circular with equal angles between neighboring leaves. Therefore, if a whorl has two leaves, they will be positioned across from one another. The angle between leaves in the same whorl is 1200 for three leaves, 900 for four leaves, and so on.The phyllotaxy is known as verticillate when there are more than two leaves in a whorl.

Contrary Phyllotaxy

When consecutive pairs of leaves are arranged at a right angle to one another, the arrangement is known as an opposing decussate. In this form, the two leaves at each node are opposite to one another. Calotropis, Ixora, and other places have this kind. When consecutive pairs are stacked precisely on top of one another, all of the leaves lay in one plane, but when seen from above, the leaves seem to be arranged in two vertical rows. This form of arrangement is known as opposing superposed phyllotaxy and is present in the guava and quisqualis.

Phyllotaxy Verticillate

Nerium odorum exhibits this sort of phyllotaxy, with three leaves forming a whorl at each node, while Alstonia scholar has three leaves or more forming a whorl at each node. This kind is also known as whorled phyllotaxy.

Differentiation of Mesophyll and Epidermis

The three types of tissue systems that make up a leaf are the epidermis, mesophyll, and vascular tissues.The number of layers, structure, stomata, trichome arrangement, and presence of specialized cells, if any, all vary in the epidermis of leaves. Mesophyll cells make up the parenchymatous tissues found within the epidermis of leaves.It goes through differentiation to create the tissues needed for photossynthesis. Meyer reviewed the numerous types of mesophyll tissues. Palisade parenchyma and spongy parenchyma may be distinguished in the mesophyll of the majority of dicot plants. Common palisade parenchyma cells are elongated and organized in rows. While the palisade cells in certain plants are shaped differently from the usual ones.There are tiny papilla-like projections and constrictions that run around the cells in several Xanthorrhoeaceae species. The palisade cells of Lilium have wide lobes and seem to be branching. Although a hypodermis may sometimes exist between the epidermis and palisade tissues, the palisade cells are located just underneath the uni or multiseriate epidermis[8].

Environmental Structure of Hydrophytic and Xerophytic Leaves

Ecological physiology

Warming categorized plant groups as hydrophytes, mesophytes, xerophytes, etc. based on how dependent and related plants were to water. Plants known as hydrophytes are those that live entirely or partially immersed in water or in very moist environments. Mesophytes are plants that thrive in environments with adequate or ideal water availability. These consequently fall somewhere in between xerophytes and hydrophytes. Xerophytes are plants that can only survive in arid environments with little water supply. These are drought-resistant plants because they can endure prolonged dry conditions. Several plants with various gradations are discovered between hydrophytes and mesophytes as well as severe xerophytes and mesophytes. In addition to these three species, epiphytes, saprophytes, parasites, halophytes, and other forms are also found in nature. Epiphytes are plants that grow on other plants but do not take nutrients or minerals from them. While parasites grow alongside host plants and feed on them, saprophytes develop on decaying organic debris. In salty soil or water, halophytes may thrive. In order to maintain a balance for optimal development, plants adapted architecturally and physiologically to their surroundings as they grew in various environments. Studying these adaptations is very interesting. Here, a few of these plants' anatomical characteristics are explored.

Hydrophytes

The term "hydrophyte" refers to plants that survive in water or in environments where there is more water than they need. The hydrophytes may be roughly categorized into three types based on how they interact with water and air: submerged, floating, and amphibious.

Marine Plants

These plants may develop as connected submerged plants or submerged suspended plants, growing totally immersed in water. Hydrilla, Valtisnaria, Zostera, Ceratophyllum, Myriophyllum, Elodea, Najas, and Potamogeton are typical examples of plants in this group. These plants have undergone a number of morphological and anatomical changes in response to their surroundings. The epidermis of leaves is made up of a single layer of cuticle-free, tangentially elongated, thin-walled chlorophyllous cells. Stomata are completely missing, seldom non-functional, and sometimes vestigeal. The cells can synthesize food, as well as absorb water and minerals. Although the mesophyll tissues are still undifferentiated, they continue to contain huge air chambers in the stem. Many times, one or two celled thick diaphragms are used to divide the air chambers. Chloroplasts are in large numbers in mesophyll cells. Phloem makes up the majority of the vascular tissues, with a few thin-walled parts serving as xylem. Some leaves are membranous, such as the ones in Elodea, which are just two cells thick save for the mid-rib area[9].

Plants that Float

Three different types of floating hydrophytes exist: free floating plants like Spirodela, Lemna, Wolffia, Wolffiella, and Azolla; plants that are rooted in mud and only have leaves and flowers that float on the water's surface like Nymphaea, Nelumbium, Victoria, and Limnanthemum; and plants with fixed roots that float freely in the water like Pistia, Trapa, and Eichhornia. Eichhornia may also be observed floating freely.

Different adaptations are seen in different regions of these plants.

Leaves: The larger, more specialized petiole and wider lamina are typical characteristics of floating leaves. Some floating forms, like Spirodela, Lemna, Woiffia, etc., lack leaves. In this instance, the stem serves as the leaf. Petiole: In most floating leaves, the petiole is a well-developed component. It is quite long and cylindrical in Nymphaea and bloated and spongy in Eichhornia. The epidermis has just one layer and is made up of cells with thin walls. Cells are tightly packed together and often have no cuticle. Collenchyma makes up the two to three layers of the hypodermis. The cortex is fully formed and contains many air chambers, which are bigger in the center and smaller at the edges. The thin and fragile walls of air chambers are typically supported mechanically by trichosclereids. The spaces between the air chambers are filled by vascular bundles. Phloem is often developed but xylem is underdeveloped and typically reduced to a single big part in each bundle[10].

Lamina: The epidermis in lamina is fully grown and consists of a single layer of cells with thin walls. On their top surface, cells contain a thick cuticle or wax. Amphistomatic leaves often have stomata that are solely functional on the top surface. However, the leaves of Nymphaea are of the epistomatic kind. Palisade and spongy parenchyma are often distinguished from the mesophyll tissues. Trapa has a single layer where the palisade cells are organized, but Nymphaea has many levels. Large air chambers and a few dispersed trichosclereids are features of sponge-like cells. Trichosclereids offer mechanical support for the leaves while air chambers provide them buoyancy. The vascular bundles feature substantially highly developed phloem and few xylem components.

Amphibious Vegetation

Amphibious plants often flourish in muddy or waterlogged soils. These are capable of withstanding floods or wet conditions throughout the rainy season. The Eclipta, Lippia, Ranunculus, Sagittaria, Typha, Marsilea, and others are typical examples of aquatic plants. The bottom portion of these plants grows in an environment with plenty of water, while the top portion is exposed to the sun and hence thrives in scorching temperatures characteristics of hydrophytes in general the exterior and internal aspects of hydrophytic characters may be investigated separately as two major areas.

Outside Features

The roots are small, undeveloped, poorly branching, and sometimes almost nonexistent. In contrast to Eichhornia, Spirodela, and Lemna, which have poorly formed roots, Nymphaea, Cyperus, and Typha have well-developed roots. Woiffia, Wolffiella, and Ceratophyllum have no roots at all. Utricularia's leaves serve as the plant's roots. Adventitious roots form in Eichhornia and Pistia to offer buoyancy. Negatively geotropic spongy respiratory roots are seen in Jussiaea. There are no root caps or root hairs at all[11].

The hydrophytes' thin, flexible stems have a spongy appearance

The leaves are either thin or much dissected. They often have a spongy coating in plants that are submerged. Waxy covering, leaf hairs, or a leathery feel may be seen on newly emerged floating leaves. Amphibious hydrophytes exhibit heterophylly, or distinct morphological leaf types. While emerging leaves have a wide lamina, submerged leaves are furcated. In rooted plants, the leaves' long, fragile petioles enable the lamina float on the water's surface. Petioles in floating plants may be missing or drastically reduced. Eichhornia produces a buoyant, bulbous petiole.

Caltropis and Ricinus: A leaf's stratified epidermis may sometimes be found on either surfaces, as in the instance of Nerium, or only one surface, as in the case of the dorsal surface of Ficus. Waxy coating on epidermal surfaces and a multilayered epidermis both contribute to a reduction in water evaporation through the epidermis. Since leaves are hypostomatic and often have a hollow, they have sunken-type stomata. To prevent the air in the stomated cavities from coming into direct contact with the wind currents, the stomated cavities are often covered with a thick layer of stomatal hairs. Sometimes wax or resin deposits may obstruct the stomata of certain desert plants, like Capparis spinosa and Aristida ciliata. The loss of water during transpiration is observed to be decreased by all of these changes. Bulliform cells or motor cells, which are present in the epidermis of certain grass leaves, are crucial for the rolling of the leaves during the dry season. These cells have a thin wall, are significantly expanded, and are delicate to changes in turgor. The leaf stays flattened while these are turgid, and when flattened, the lamina rolls or reduces the exposure of the transpiring surface. Most xerophytes' hypodermis is made up of mechanical tissues known as sclerenchyma. Both the stem and the leaves may have sclerenchymatous hypodermis that is one to several cell thick. Sclerenchyma may sometimes be observed in patches; for example, a T-shaped sclerenchymatous hypodermis can be discovered under the ridges of a casuarina stem. Sclerenchyma not only offers mechanical support but also shields inside tissues from intense light, minimizing injury.

Mesophyll Tissues: In xerophytes, mesophyll tissues are well-differentiated and well-developed. These have a clearly discernible distinction between well-formed, loosely organized spongy tissues and compactly produced palisade tissues. To reduce direct light penetration, palisade cells stay radially long. These are typically grouped in a single layer and located at the dorsal surface. However, the densely packed palisade tissues are present on both the adaxial and abaxial sides of a leaf in Nerium, Ficus, and Atriplex, while spongy tissues are found in the spaces between the palisade layers. In certain xerophytes, such as Capparis, Salvadora, and Casuarina, the leaves are drastically reduced, and the stem fills the role of the leaves. In some instances, the outer cortex of the stem has densely packed palisade cells. In palisade cells, the chloroplasts often have a relational distribution. These continue to be lined up in a cell that is nearer the light. In a palisade cell, chloroplasts may relocate themselves in response to variations in light intensity[12].

CONCLUSION

The leaf is the plant organ that varies the most morphologically and anatomically. It is crucial to the processes of photosynthesis. On the surface of the leaf, stomata display variety in their form and distribution and aid in the categorization of plants. In terms of ecological diversity, its structure also exhibits a variety of variations. Xerophytic leaves are better suited for settings with less water availability.

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CHAPTER 14

THE IDEAL FORM OF A LEAF PETIOLE

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ABSTRACT:

A petiole and a leaf blade make up a plant leaf's basic structure. The petiole, which links the leaf blade to the plant stem, resembles a cantilever beam from a structural perspective. When designing petioles, consideration is given to how little material is needed to endure a combined torsion and bending force. The cross-section has a grooved appearance and a transverse dimension that decreases longitudinally. The structural effectiveness of the petiole shape is examined in this research. Dicotyledonous plant petioles from ten different specimens have been studied. The stiffness characteristics of the petioles are modeled using continuum mechanics and dimensionless variables. On maps that compare petiole efficiency to that of reference cross-sections, the findings of the characterization are shown.

KEYWORDS:

Leaf Petiole, Structural Effectiveness, Optimized Shape, Torsional Compliance, and Bending Stiffness.

INTRODUCTION

The leaf is the most crucial component of a plant's system. It is the stem's lateral appendage that is carried at the node and has a bud positioned at its axil. These grow on the stem in acropetally order and often have a flat, thin expanded structure. Leaf growth is of a restricted kind.

Primary Leaf Structure

These are vital vegetative organs that are primarily involved in photosynthesis and transpiration processes. The three kinds of tissue systems dermal ground vascular are present in leaves just as they are in stems and roots. The top epidermis and lower epidermis make up the dermal tissue system. Despite being more common in the lower epidermis, stomata may be found throughout the epidermis. Mesophyll tissue is the name for the ground tissue system that exists between the two epidermal layers of a leaf. On the adaxial side, it is often separated into palisade parenchyma, and on the abaxial side, spongy parenchyma. Dorsiventral refers to the leaf displaying this mesophyll difference. In dicot leaves, it is typical. Isobilateral mesophyll is defined as having no differentiation and consisting only of spongy or palisade parenchyma. The spongy parenchyma cells, in particular, in the mesophyll tissue, surround air gaps. One unique characteristic of spongy cells is the existence of air gaps. Through the stomata, this area promotes the exchange of gases between the internal photosynthetic tissue and the outside environment. Vascular bundles make up the vascular tissue system. These are closed collateral. Kranz anatomy is also seen in the leaves of C4 plants. Veins are the vascular tissue that makes up the leaf's skeleton. The photosynthetic tissue receives water and nutrients from the veins[1], [2].

Petiole's structure

The portion of the leaf that is still connected to the stem is known as the petiole, as was previously stated. With a few minor changes in how the vascular tissue is organized, it has a lot of similarities with the main stem in terms of internal anatomy, as shown Figure 1. The petiole's outline in a transverse section might be round, triangular, or flattened. Prunus, Citrus, etc. have a characteristic groove on the petiole's adaxial side. The petiole of Cucurbita features ridges and grooves similar to the structure of stems.

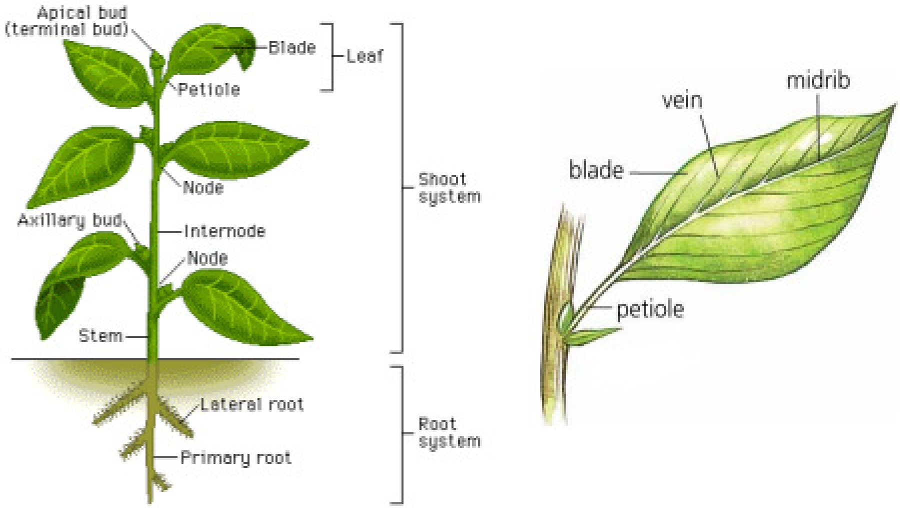

Figure 1: The structure of an angiosperm and a zoom of its leaf.

Tissue Systems in Plants

The tissue is a mass of grouped comparable cells. Dermal, vascular, and ground tissue systems all develop continually throughout a plant. The meristems, or growth points of a plant, are where new tissues are created. Skin Care System. The epidermis is a part of the dermal tissue system. The dermal tissue is a layer of densely packed cells that shields plant organs, just as human skin does. Its cuticle, a waxy covering that prevents water loss via evaporation, covers it. In the summer when it is dry, this protection is essential. The stomata, or pores, regulate the flow of gases between the plant and its environment. The periderms, or dead waterproofed cells, replace the epidermis of a plant that is undergoing secondary development. System of the veins. There are two circulatory systems: phloem and xylem. The former carries nutrients and water from the roots to the shoots. The second one supports the structure and is in charge of moving food from mature leaves to the roots as well as to other components of the shoot system, such as growing leaves and fruits. Surface System. The ground tissue controls the metabolic processes in addition to providing storage, support, and photosynthesis. The parenchyma is mostly composed of cells with thin walls. This tissue makes up the bulk of the plant by bridging the gap between the dermal and vascular tissues[3].

DISCUSSION

Plants Moving

An organ's body form changes as a result of plant motions. The tropisms and turgor are two categories. The former is the plant's curvature's reaction to stimulus. The tropism is positive while moving toward the stimulus, but it is negative when moving away from it. The turgor movements, on the other hand, are rapid and reversible and are often brought on by changes in the condition of the cells that are being stimulated due to pressure. The Tropisms the bending of a plant toward or away from a light source is known as phototropism. It guarantees that photosynthesis will occur. A plant's reaction to gravity is known as gravitropism. In the event that it is favorable, the roots expand deeply into the ground to snag water and other nutrients. If the outcome is negative, the shoots grow upward toward the sun for photosynthesis. A directed growth in response to touch is known as tigmotropism. Vine tendrils, for instance, coil when they come into contact with an item, in contrast to stems that grow straight. Turgor motions, in 4.2 moving leaves quickly. Mimosa leaves and those of other plants fold over and collapse under severe gusts. It is hypothesized that the quick movement increases plant water absorption by decreasing leaf surface area. In reaction to variations in light throughout the day, sleep movements vary. For instance, the leaves of legume and bean plants rise horizontally in the morning and fall vertically after dusk. 5 reactions of plants to environmental stress Plants adapt morphologically, but they also alter their morphology in reaction to environmental changes. For instance, a lack of water triggers the hormone abscisic acid, which causes pore closing and lowers evaporation. Cells get less turgor and expose less surface to sunlight as a consequence[4]–[6].

Another factor that speeds up the formation of air tube cells in certain roots to improve oxygen delivery is oxygen shortage. Cold, heat, salt, and compressive forces are further catalysts for form alterations. The plant produces more unsaturated fatty acids when the temperature is cold. Above a particular temperature, heat stress drives the synthesis of unique proteins called heat-shock proteins. Furthermore, too much salt is harmful to plant growth. Even when the soil is saturated in water, salt may cause roots to lose water. This happens when the surrounding water's osmotic pressure is lower than that of the root tissue. The second significant form adaptation, meantime, is brought on by compressive pressures. A plant adapts its size and form in response to these. Cells proliferate in areas where compressive stresses, which cause the thin walls of the material microstructure to become unstable, are present. For a plant, strength in compression is lower than strength in tension due to the shape's susceptibility to buckling stress.

Petiole of the Leaf

The critical activities of a plant, its organs, and the reasons for morphological changes have all been covered in earlier sections. This section focuses on the leaf petiole, one of its organs, and analyzes the effectiveness of its form. This is not meant to imply that form efficiency is the only important factor; all other critical functions are necessary, but they are not the main topic of this article. The approach is grounded on conventional mechanics, albeit it has limitations when used in the context of biology. Functions, shape, and biomaterial of the petiole are discussed prior to efficiency modeling[7].

Loadings

A leaf's structural capabilities are comparable to those of a cantilever beam. The petiole has enough bending stiffness to withstand surface stresses such as the weight of the blade as well as any other, including wetness from rain, snow, or even insects. But there are other loads than bending. The petiole twists due to the wind's aerodynamic force. The petiole also coils to reach sunlight and react to it. As a result, the entire loading may be thought of as a mix of bending and torsion. Building morphology. In contrast to typical engineering cantilevers, which are intended to be rigid, the petiole responds to compressive stresses brought on by the linked load by becoming flexible. The petiole is longitudinally tapering and often has an asymmetric cross-section that is grooved at the top. A form like this reduces torsional stiffness without sacrificing deflection resistance under gravitational loads. [8], [9]the groove has two advantages. First, more twist flexibility enables the leaves to cluster together and lessen wind resistance. Second, the leaf has the ability to position itself downwind and even lessen the need for flexural rigidity.

Bio-material

Exploiting form and material qualities allows for increased torsion compliance without sacrificing bending resistance. Petiole microstructure is inhomogeneous and anisotropic, which contrasts with the majority of engineering materials. It is composed of thin elongated cells at its top and thick liquid cells supporting compression at the petiole bottom[10]–[12].

CONCLUSION

There are several purposes served by the leaf petiole. Its construction is designed to withstand bending caused by gravity force and torsion caused by wind drag. The structural effectiveness of petiole forms has been investigated in this work. Dicotyledonous petioles were the subject of a case study to get insight on shape performance. In order to compare biological design to traditional engineering cross-sections, efficiency maps have been created. The graphs demonstrate how the petiole's size and shape are used to reduce the need for flexural rigidity while also easing twist.

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CHAPTER 15

OVERVIEW OF PLANT REPRODUCTION

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ABSTRACT:

You will be able to comprehend the ideas related to angiosperm reproduction after completing this lesson. Features of plant reproduction that are introduced. The value of artificial vegetative reproduction in agriculture. Flower development and morphological features. Evolutionary and genetic elements of sex determination Arabidopsis homeotic mutations and the present state of research on them.

KEYWORDS:

Angiosperms, Flowering Plants, Plant Reproduction, Phylum, Sex determination.

INTRODUCTION

Angiosperms make up the majority of the plants that we encounter every day. The 250,000 species of flowering plants come in a variety of shapes and sizes, from cactus, grasses, and daisies to aquatic pondweeds. Their sizes vary from virtually tiny herbs to enormous Eucalyptus trees. This phylum includes the majority of trees and plants. Due to the many applications for humans, this section concentrates on angiosperm reproduction. In reality, over 90% of the calories we eat originate from only a little over 100 kinds of flowering plants, from which almost all of our food is obtained, whether directly or indirectly. Additionally, angiosperms provide a source of food, clothing, and construction supplies. Although the other plant phyla also provide resources, the angiosperms outweigh them seven to one. For instance, there are only around 750 species of gymnosperms left today! Africa and South America were still linked when flowering plants first appeared, as were Antarctica, India, Australia, and New Zealand through Antarctica. These continent-sized land masses came together to create the vast Gondwanaland. Another supercontinent named Laurasia was created in the north after the union of Eurasia and North America. The enormous continent that resulted from the union of South America and Africa stretched across the equator and likely had an inner climate typified by very high temperatures and aridity. Currently, the innards of the main continents have climates that are similar. It's possible that pockets of drier and less ideal environment located in the interior of Gondwanaland had a significant role in the early development of angiosperms[1].

Numerous characteristics of blooming plants seem to be related to their ability to thrive in arid and semiarid environments. It assures outcrossing when pollen is moved between blooms of different plants, often across great distances, and this process may have contributed to the early success of angiosperms. The success of angiosperms was also significantly influenced by the many strategies for efficient fruit dissemination that developed within the group. Another aspect was the short life cycles of certain angiosperms (Arabidopsis may grow from a seed into an adult blooming plant in only 24 days, for example). Many invading species have an advantage over native species due to asexual reproduction. The biological success of angiosperms is correlated with the presence of xylem vessels and other structural and morphological traits. All of these beneficial traits were further developed and refined as early angiosperms grew, and the rate of their diversification quickened. Numerous characteristics of blooming plants seem to be related to their ability to thrive in arid and semiarid environments. Since the beginning of time, people have had a close affinity with flowers. Flowers have long been used as symbols for significant human emotions including love, affection, happiness, sadness, and mourning. They are objects of aesthetic, decorative, social, religious, and cultural worth. A biologist sees flowers as wonders of morphology and embryology as well as sexual reproductive locations. It is possible to relate flowering plants' amazing evolutionary success to their reproductive methods. Here, we look at several characteristics of angiosperm reproductive methods and how their distinctive fruits and flowers have helped them succeed. The process of vegetative reproduction allows for the clonal propagation of individuals. In certain blooming plants, sexual reproduction is unusually followed by senescence and the parent plant's demise[2].

Plant Reproduction:

Biological Reproduction

Asexual reproduction creates genetically identical individuals since only mitotic cell divisions take place, while self-pollination minimizes genetic variety. For the same reasons that self-pollination is preferred, individuals who are well adapted to a generally stable environment survive in the absence of meiosis. For instance, most potatoes and roses are propagated vegetative. New plant people are simply created by cloning adult components in a process known as vegetative reproduction, which is a particularly popular kind of asexual reproduction. Plants may reproduce vegetative in a wide variety of ways.

Vegetative Reproduction Naturally

Stolons: Stolons are long, thin stems that grow over the soil's surface and are used by certain plants to reproduce. For instance, every other node on the runner of a grown strawberry produces leaves, blossoms, and roots. The runner's tip turns up and thickens just past each second node. The adventitious roots that grow from this enlarged area are followed by a fresh shoot that continues the runner.

Rhizomes: Rhizomes with specific functions for storage and reproduction include corms, bulbs, and tubers. Each node on rhizomes may produce a new flowering shoot, and they spread into regions close to the parent plant. e. g. White potatoes are intentionally reproduced using pieces of tubers that have one or more "eyes" on them. The new plant is created from the eyes, or "seed pieces," of the potato.

Suckers: Some plants, such cherry, apple, raspberry, and blackberry, grow "suckers," or sprouts, at the base of their roots that develop into new plants. Banana commercial variants are propagated through suckers, which grow from buds on subterranean stems and do not generate seeds. Each root fragment may produce a new plant if the dandelion's root is damaged, which might happen if you try to pick it up by the roots[3].

Adventitious Leaves: In a small number of species, the leaves themselves are fertile. The houseplant Kalanchoe daigremontiana, sometimes known as the "maternity plant" or "mother of thousands," is one example. The origin of the popular names of this plant is the proliferation of plantlets from meristematic tissue found in leaf notches. These little plants, which grow and fall to the ground and establish root, are often used to propagate the maternity plant.

Apomixes: The embryos in the seeds of certain plants, such as some citrus, some grasses, and dandelions, may be generated asexually from the parent plant. Asexual reproduction of this sort is referred to as apomixes. This method of seed production results in offspring that are genetically identical to their parents. Consequently, despite the fact that these plants clone diploid cells in the ovule to reproduce asexually, they also acquire the benefit of seed dispersion, a characteristic normally connected to sexual reproduction. In general, apomixes, vegetative reproduction, and other asexual methods of procreation encourage the precise replication of individuals that are exceptionally well adapted to a given habitat or environment. Plants that live in severe or marginal habitats, where there is limited room for diversity, are far more likely to reproduce asexually. For instance, compared to temperate environments, the arctic has a higher percentage of asexual plants.

Vegetative Artificial Reproduction

Fruit plant asexual propagation techniques are divided into two primary types and six subcategories: Rooting for Vegetative Propagation

Stock Division

When the plant generates plenty of rooted stems, this technique is used. Depending on the number of rooted stems, we may split the plant in the late growth season and at the beginning of the dormant period to create numerous new specimens. The old portion of the plant need to be taken out during this operation. Banana propagation typically uses this method.

Runner

The strawberry is the most well-known plant whose propagation via runner division. The strawberry starts to sprout many runners after ripening. The runner will take root and grow a new plant wherever it comes into touch with the soil. Before the start of the cold season, we may transplant the young plant after separating it from the mother plant. The next year, when the new plant's potential output of fruit is at its peak, fruit will be produced[4], [5].

Layering

The primary goal of layering is to provide the mother plant's stem a place to take root. Until it can live on its own, the young plant will remain connected to the mother plant. The mother plant will then be severed from the young plant in this situation. The most popular way to propagate pear, quince, and apple rootstock is by banking up. There is considerable setup work required for this procedure. We prune the mother plant back every two to three years to the level of the soil, which produces a larger root neck. A lot of stems will sprout from this thick root neck. The plant must then be banked up to a height of 10 to 15 cm. At the conclusion of the growth season, we may then harvest the rooted stems.

Simple Layering:

This method is often used to propagate hazelnuts. Stems are buried in a trench that is 20–25 cm deep and covered with dirt during the dormant season. The uppermost portions of the stems, which often contain two to three buds, are still visible. In the instance of radial or Chinese layering, the whole stem is bowed down into a trench that is 10 cm deep and then filled with dirt. The suckers must then be regularly banked up to 2/3 of their height. When the sucker extends 10 cm above the surface, just the top third of the plant is left free. Gooseberry, currant, and hazelnut plants are propagated primarily using this technique. When stems are typically less than one year old, the branch tip is employed for air layering. On the stem, around 20 cm from the tip, a 2 cm broad piece of bark is removed. After the strip has been sliced, a rooting hormone is administered, and rooting material is positioned underneath the strip. The incision is then sealed with a tiny plastic bag that has been opened on both ends.

Using rooted cuttings to multiply

Cuttings with Some Wood

Rooted Cuttings:

Because it may be used on both fruit and vegetable plants, this approach is one of the most often used vegetative propagation methods. The mother plant's stems must be cut off while it is dormant in order to utilize them for cloning. Cuttings from the growth of the previous season are always used in this approach. Hardwood cuttings come in two different varieties. They were extracted from deciduous plants. Early in the winter, after the leaves have fallen from deciduous plants, hardwood cuttings are taken. Simple Cuttings: This straightforward cutting is performed on a stem that typically has four to six buds. The stem's upper portion has an angled cut off. If the cutting came from an evergreen plant, the lowest two leaves need to be pulled off and planted right away. The gooseberry, currant, quince, fig, and olive are typical examples of plants that may be used using this technique[6].

Torn Cuttings:

This cutting is conducted at the lowest section of the stem where there is a union with the mother plant. This is a very outdated method, and it is hardly used nowadays. Cuttings from hammers in this instance, the stem and a section of twig are chopped together. Some plant cuttings, such as gooseberry cuttings, are challenging to root, and the extra bit of twig aids in the development of the root system.

Truncheons

Truncheons are branches that may be grown into new plants and are roughly as thick as a human arm. There are around 170-180 cm of branches. In order to keep the truncheon from decaying, cut the branch's top at an angle. The truncheon has to be maintained in the shade for a few days before to planting so that a hard layer may form on the cut end. The truncheon may not root if the cut end is not protected by this dense covering. The truncheon has to be inserted into a small, deep hole that is around 60 cm wide. The conclusion of the dormant season, when the plant is still growing slowly, is the optimal time to use this strategy. Most trees that flow white sap when chopped may be utilized with this technique.

Cuts of Roots

Remove root cuttings from the tree 1 meter or so from the trunk. These slices need to be 20–25 cm long and 1-2 cm thick. Till they sprout, plant these cuttings horizontally into the ground at a depth of around 10 cm. This method is effective for growing guava, breadfruit, apples, blackberries, and raspberries[7].

Grafting for Vegetative Propagation

Bud Grafting or Budding for Vegetative Propagation:

The most popular method for plant proliferation in industrial nurseries is the budding method. A 2 cm long vertical cut and a 7-8 mm long horizontal cut are made on the stock, creating a "T" shape, 20–25 cm above the surface. The two flaps of bark may be opened with a small twist of the budding knife. The bud should next be pushed downward and put between the two flaps of bark. Additionally comparable buddings are the inverted T and chip buddings.

Grafting for Vegetative Propagation:

Cultivar and seedling rootstocks are the two forms of rootstock that may be used for grafting. Producing the cultivar rootstock involves vegetative means, often layering and cuttings. Rootstock seedlings are grown from them. The apple and the mango are two of the greatest examples of cultivar and seedling rootstocks, respectively. Plants that readily graft together benefit from whip grafting. Apples, mangoes, and pears may all be prepared using this technique. It may be used to transplant the top, stem, or root. The rootstock and scion should have identical diameters that range from about the size of a pencil to around 10-15 mm. Additional divisions include root tongue grafting, tongue whip grafting, and simple whip grafting. Cleft grafting is best for growing apples and pears, but it may also be used to grow mango and avocado trees in tropical climates. This technique is also used by citrus and guava plants. The scaffold limb is often broader than the scion when doing top and side work. Both the rootstock and the scion should be the same size for propagating trees. Top cleft grafting and Side cleft grafting are the subcategories[8].

Bark Grafting:

When the stock is too big for whip grafting, bark grafting is utilized. It is among the trickiest grafting methods. This procedure demands a lot of effort and skill to be applied properly. This method is often used for grafting pear, apple, and other nuts. Different varieties of bark grafting exist, including green grafting, bridge grafting, wedge grafting, top grafting, and side grafting.

DISCUSSION

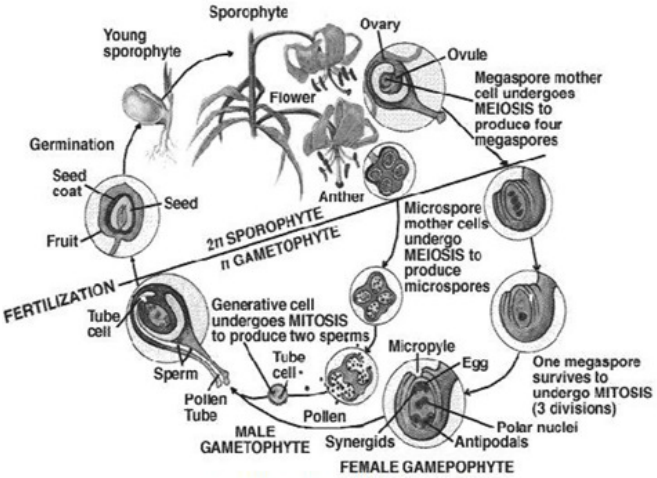

Figure 1: Illustarte the life cycle of angiosperm plant.

Sexual Reproduction

There are two generations that make up a plant's life cycle: sporophytic and gametophytic. The sexual generation is the gametophytic generation. The spores in angiosperms are known as androspores when meiosis takes place in an additional sporangium. Gynospores are what they are known as when they appear in seminal rudiment sporangia, Figure 1. Male and female gametophytes, a generation that generates male and female gametes, are both sexually active. However, they are independent from one another and exhibit unisexuality. They create the new sporophytic generation and the xenophytic generation by multiple fertilization[9].

Development of flowers

An increase in Flowering Plants

It's possible that pockets of drier and less ideal environment located in the interior of Gondwanaland had a significant role in the early development of angiosperms. Numerous characteristics of blooming plants seem to be related to their ability to thrive in arid and semiarid environments. Outcrossing is ensured by the transport of pollen between blooms of different plants, often across great distances, and may have played a role in the early success of angiosperms. The success of angiosperms was also significantly influenced by the many strategies for efficient fruit dissemination that developed within the group. Another cause was certain angiosperms' short life cycles.

Many invading species have an advantage over native species due to asexual reproduction. The biological success of angiosperms is correlated with the presence of xylem vessels and other structural and morphological traits. All of these beneficial traits were further developed and refined as early angiosperms grew, and the rate of their diversification quickened. Around 80–90 million years ago, in the second part of the Cretaceous Period, angiosperms started to predominate temperate and tropical terrestrial habitats. In a brief period of time, terrestrial ecosystems in the tropics and temperate zones gave rise to angiosperms. Pollen, leaves, flowers, and fruits of several still-existing families started to emerge around the time those angiosperms started to occur often in the fossil record[10].

Development of Flowers

The pollen grain and the ovule do not come into direct touch during the pollination process in angiosperms. Insects, birds, and other animals often carry mature pollen from the anthers to the stigma of other flowers. Pollen that has made it to the stigma germinates, and as a result, a pollen tube that carries the sperm nuclei to the embryo sac develops downward. The development of the embryo and endosperm starts after double fertilization. Within the ripening fruit, the seed matures, and its germination begins a new life cycle. In order for pollen to be transmitted between plants of the same species, many angiosperms rely on the frequent attraction of pollinators like insects, birds, and other animals. Animals serve the same purposes for blooming plants when they spread pollen as they do for themselves when they actively look for mates. The interaction between a plant and a pollinator may be quite complex. Reproduction may be impeded by mutations in either partner. A plant may not have a pollinator if it blooms at the "wrong" time. Physical obstacles to pollination may exist if the shape of the flower or pollinator is changed. It is obvious that floral morphology and pollinators have coevolved since the end product is far more complicated and diversified than the beginning of four separate whorls of organs[11].

Floral Evolution's Characteristics

The development of a wide range of floral phenotypes that may improve pollination efficiency is one reason for the diversity of angiosperms. It is believed that leaves are the source of all floral organ evolution. These structures preserve the spiral phyllotaxy often seen in leaves in early angiosperms. There have been four separate whorls as the trend. An incomplete flower lacks one or more of the whorls whereas a full bloom contains four whorls of components. The calyx, which is often the outermost whorl in both full and partial flowers, is made up of flattened appendages called sepals that shield the flower in the bud. The corolla is made up of the petals, which may be fused together. Pollinators are drawn by petals. These two outer whorls of floral organs are sterile, yet they may aid in successful reproduction. The word "stamens" is used to refer to all of a flower's stamens collectively. The angiosperm microsporangia are carried by stamens, which are specialized organelles. In the pollen cones of gymnosperms, similar structures carrying microsporangia may be seen. The majority of live angiosperms contain stamens with thin, sometimes threadlike filaments and four microsporangia that are visible at the apex in a swelling part, the anther. The sporangia of some of the most primitive angiosperms are produced from the top or bottom surface of flattened, leaf-like stamens.

All of the feminine components of a flower are collectively referred to as the gynoecium. The gynoecium, which is only found in angiosperms, may be a single carpel or two or more fused carpels in most flowers. Simple or complex pistils, respectively, are often used to refer to single or fused carpels. A single carpel may give rise to several to many distinct pistils. The ovary, the lower, swelling region of the pistil that typically narrows at the top into a thin, neck-like style with a pollen-receptive stigma at its tip, is where ovules are generated. When the stigma is split, the number of stigma branches corresponds to the number of carpels in the specific pistil. Ovules are located along the borders of the coiled flower leaves that serve as carpels. It is believed that the original carpels were folded leaf blades that had hairy borders. These hairs did not fuse until the fruit formed, but they interlocked and were receptive to pollen before the fruit formed. There is evidence that during the course of evolution, the hairs localized into a stigma, a style developed, and the carpel edges fused to create a pistil. Unless the pistil is cut apart, the carpels of many contemporary blooming plants have undergone significant modification and are no longer physically identifiable from one another[12].

CONCLUSION

Asexual and sexual reproduction are the two methods of reproduction in plants. Asexual reproduction may occur via a number of processes, including fragmentation, budding, spore development, and vegetative propagation. In order to reproduce sexually, male and female gametes must fuse. A little plant called an embryo develops within a seed after fertilization. The seed stores sustenance for the embryo and protects it. The seed is released or dispersed by the parent plant. The embryo may germinate and develop into a new plant if the seed falls where the circumstances are favorable. The success of the whole agricultural economy depends on plant reproduction, which is also essential to the fitness of plant species. The majority of agricultural tasks performed on a farm start and conclude with seeds. The beginning of reproduction, or flowering, is a crucial factor in controlling the life cycle and senescence.

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CHAPTER 16

BAT POLLINATION AND FLORAL SPECIALIZATION IN THE SUBTRIBE CEREINAE

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ABSTRACT:

Numerous species of Cactaceae are pollinated by vertebrates, and some genera in the subtribe Cereinae are said to be pollinated by bats. We found phenotypic specialization in this subtribe for floral morphological traits linked to chiropterophily, enabling very accurate identification of this pollination strategy. However, only a few number of taxa have had bat in situ pollination reports verified having a focus on species having chiropterophilous characteristics, we researched the floral biology of 14 columnar cacti of the Cereeae-Cereinae family using a morphological method in this context, and we were able to validate the function of bats that are trained to consume nectar as pollinators of these taxa. By examining the overlap in the floral morphospace, it can be shown that the researched species have commonalities in their floral bauplan.

KEYWORDS:

Cereeae, Chiropterophily, Floral Biology, Morphological, Lonchophyllinae.

INTRODUCTION

Diurnal and nocturnal pollination systems are distinguished by the time of anthesis. In 30% of the Angiosperm families, night pollination takes place among the nocturnal systems, bats and sphingid moths are the primary pollinators. More than 520 species of tropical plants, or chiropterophilous species, are pollinated mostly by bats, which are found in 67 families and 28 orders of Angiosperms. Although most species of pollinator bats are specialized nectar eaters, other species that are not normally nectarivorous may also encourage pollination. Plants that are pollinated by bats exhibit specific traits like floral zygomorphy, which allows pollen to be deposited on specific areas of the bat's body, relatively large and robust flowers, which allow access to and contact with the bat's body, and tubular or campanulate, or occasionally brush-like shape. Large amounts of diluted nectar are generated, along with pale or white (sometimes greenish or dull) colors and an unpleasant smell of rotting plant waste that is rich in sulfurous chemicals[1].

Chiropterophily entails intensive phenotypic specialization, which permits the great accuracy of this system's determination in plant species. Because they can carry a lot of pollen and move the grains over great distances, bats are thought to be very effective pollinators.About 1,500 species of mostly succulent plants in the family Cactaceae many of which have been shown to be pollinated by bats. About 128 genera make up the Cactaceae, which interact with several guilds of pollinators and have a broad variety of growth patterns and flower shapes, sizes, and colors. Regarding chiropterophily, interactions between bats and plants have been documented for at least 172 plant species spread over 37 genera. A derived lineage of Cactaceae pollination seems to have transitioned from a diurnal system, including species that were pollinated by bees, to a nocturnal one. Hummingbird pollination is likewise seen as derived within the family, along with nighttime pollination. While sphingid and bat pollination is thought to be irreversible, certain research on Cactaceae have shown a transition from bat to hummingbird pollination[2], [3].

Despite having a fundamental design that is the same across the family, cactus flowers show significant variety in floral morphological specialization, spanning several pollination systems. In comparison to sphingophilous species, bat-pollinated species have shorter flowers with stronger tissues, resistant floral structures, are campanulate to tubular, produce powerful odors, and exude considerable amounts of nectar. Such traits are observed in columnar genera of Cactoideae grouped in various tribes, such as Cereeae (Pilosocereus), Pachycereeae (Carnegiea, Pachycereus, Neobuxbaumia, Stenocereus), and Hylocereeae (Weberocereus), where bat pollination was proven. The BCT clade corresponds to several species of arborescent, columnar, and shrubby cacti with a distribution in South America (including the tribes Browningieae, Cereeae, and Trichocereeae). The primary tribe of eastern Brazilian cactus under clade BCT is Cereeae, which is now known as subtribe Cereinae. This category includes 136 species in Brazil, 108 of which are native to the nation, which may be found in the six major biomes (Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pantanal, and Pampa). Relationships between Cereeae-Cereinae and other conventionally recognized subdivisions, like Browningieae and Trichocereeae (Trichocereinae), are still unclear, and studies of the genera that tried to establish monophyletic groups were unsuccessful in naturally circumscribing them. Although it has been shown that the subtribe Cereinae is monophyletic, the generic delimitation is still unclear from a phylogenetic perspective. This emphasizes the necessity to apply various methodologies, such as focusing on non-coding areas to improve phylogenetic resolution [4], [5].

Cereeae-Cereinae exhibit a variety of growth types, including globose plants like Melocactus and Discocactus as well as tree-like, columnar (Cereus, Pilosocereus), unbranched, or basally branching columns (Coleocephalocereus) columns. The species' floral morphology is very diverse, and it uses a variety of pollination methods. One of the larger genera in the subtribe, Pilosocereus, contains blooms that are often pollinated by bats, much as Cipocereus and Xiquexique do. Only a small number of species from these genera, which make up a significant portion of the subtribe, have received evidence of bat pollination. The same is true for other genera in the subtribe that exhibit floral characteristics linked to chiropterophily. We explored the floral biology of columnar species with a focus on those that demonstrate floral characteristics related with bat pollination from a morphological standpoint, taking into account the necessity for floral biology research in Cereinae. Our idea is that, taking into account the fundamental structure of the Cactaceae floral morphology, chiropterophilous species of the subtribe share the same floral morphospace despite existing variances in bloom size and form. As a result, we anticipate that contact with bats will still be possible even if species exhibit form variation. To test our theory, we chose 14 Cereinae species from various Caatinga regions of northeastern Brazil[6].

DISCUSSSION

Floral Biology

Focused observations of individuals of the researched species were used to record the frequency of open flowers each night as well as the timing of anthesis. Observations were made on days other than consecutive ones, according on the availability of flowers for each taxon. Per taxon, anthesis was seen in one to three blooms. (One flower per individual). Another dehiscence was seen by direct observation, and hydrogen peroxide 3% was used to assess the responsiveness of the stigma by monitoring the stigmatic response through the development of bubbles. Soon after the flower's complete anthesis, standing crop nectar measurements were recorded in the blooms of several people. A graduated microsyringe (250 microliters, Hamilton, Reno, Nevada, EUA) was used to measure the amount of nectar, and a pocket refractometer (Master Refratometer 0-52%, Atago, Tokyo, Japan) was used to determine the sugar content (percentage of saccharose, mass/mass).

Morphometry and Floral Features

We gathered flowers in the field and preserved them in 70% alcohol to assess the floral morphology of each taxon. Depending on the availability of flowers during the observation nights, blooms of each taxon were taken during the same reproductive episode. Using one blossom per plant from several people, measurements were made in the lab using a digital caliper (Table 1). (Starrett model 799, Athol, MA, USA). The length and breadth of the flower, the diameter of the flower opening, the length and width of the pericarp, and the length of the flower tube were among the seventeen floral characteristics that were measured. The identification literature was used to choose those quantitative floral characteristics[7].

Among chiropterophilous taxa of the subtribe Cereinae, floral biology and floral morphology variations have been observed. The flowers of the Cereinae studied share a number of traits with other flowers that are related to bat pollination, such as robust floral structures that can withstand the ferocious visits of bats seeking nectar, nocturnal anthesis, disagreeable floral scents (to the human nose), dull-colored outer perianth segments/bract scales contrasting with much paler to white inner segments, and nectar chamber protected by stamen filaments basally incurved towards the base. These characteristics are corroborated by studies of other genera of Cactaceae, such as those involving Cipocereus (Cereinae); Carnegiea, Neobuxbaumia, Pachycereus, Stenocereus (Pachycereeae); and Weberocereus (Hylocereeae), all of which have similar floral morphology and are likewise pollinated by bats. Overall, the taxa reviewed here have characteristics with other cactus species pollinated by bats, including the availability of open flowers throughout the night, time of anthesis' onset, stigma receptivity, and pollen release from anthers.

In general, the species of Cactaceae display floral specializations consistent with the different guilds of pollinators and in accordance with their pollination syndromes, despite the fact that some species can show variations in the timing of anthesis as well as traits suggesting transitions towards other types of pollinator. Hummingbirds visited several of the species evaluated in this article during the early phases of anthesis, indicating that these taxa may exhibit a duality or a transitional position between nocturnal and evening flower pollinators. In contrast to the other taxa under study, two of these taxa had fewer bat visits recorded (Stephanocereus luetzelburgii had one visit, and Micranthocereus purpureus had three), and their floral odors were not as overpowering as those of some of the other taxa. In particular, Micranthocereus purpureus's outer tube and perianth segments exhibit a vivid magenta color, which is often connected to hummingbird pollination[8], [9].

The flowers of the family Cactaceae have a fundamental bauplan that is shared by all of its species, in addition to commonalities in their floral biology. Our findings show that, while there is some variation in the size and shape of flowers across the Cereinae under study, there is often overlap in the morphospace and a common overall structural design. Size, whether longer or shorter, wider or narrower, is the primary distinction between the flowers of the Cereinae family. Measuring floral length and width is crucial for distinguishing the chiropterophilous syndrome from other pollination systems in species that are pollinated by bats. There is a need for mechanisms that preserve reproductive isolation through reproductive barriers in species with floral similarities that share the same pollinators. The process relating to floral morphology is mechanical isolation. In order to prevent heterogeneous pollen admixtures, species in bat-pollinated plant communities often vary by the location on the bat on which pollen is deposited. The Cactaceae family includes species whose blooms display a profusion of stamens and tightly clustered anthers, enabling the bat to deposit a lot of pollen on its body with each visit. Given the physical similarities, it seems sense to assume that the size of the flower and, in particular, the width of the opening to the blossom, are crucial factors in determining where the pollen is deposited on the bat. For the species we looked at, we saw that flowers with a wide opening, like Pilosocereus catingicola, deposit pollen over the bat's face, neck, and thorax, whereas flowers with a small opening, like Coleocephalocereus goebelianus, only deposit pollen on the face. The species examined here exhibit strong similarities and overlap in part of their morphospace despite the short or long, narrow or wide floral extremes. This might indicate that pollen is deposited in the same areas of the pollinator's body, leading to pollen admixtures. When sympatric species share the same guild of pollinators, in this instance bats, diverse pollen is likely to mingle, opening the door to hybridization. Natural hybrids are common in the Cactaceae and have been observed in a number of genera of Cereeae-Cereinae, as is the case with Xiquexique heptagonus, where we believe sympatric populations of X. gounellei and X. tuberculatus that were affected by moths and bats came into contact led to this hybridization event[10].

Bats' Involvement in Cereinae's Pollination Systems

All the species under study benefit from bat pollination, according to our findings. According to estimates from 53 different bat species, there are countless varieties of blooming plants that are pollinated. Bats have a tight relationship with cacti in the Neotropics and are known to be "cactophilic". The bats exhibit a typical behavior of quick, hovering visits, often following predefined routes between the plants visited, as described in prior investigations. The Caatinga is one of the most significant cacti in Neotropical vegetation, which is primarily found in wooded drylands. Cacti play a crucial part in preserving populations of nectar-eating bats in these habitats. The Cereeae-Cereinae are the dominant group of cactus in these seasonally dry woods in the Caatinga. Here, we demonstrate the close association between the examined cacti and the bats that use them; hence, it is probable that these species represent significant resources for maintaining bat populations. As would be predicted given the chiropterophilous condition, the nectar provided is secreted in great volume and with low sugar content.

Additionally, this energy source is consistent with what Scogin established.We have documented hummingbird visits in some of the species in addition to bat visits. The characteristics of the nectar may also be a factor that permits the visit of other guilds to the species, as occurs between the species Ipomoea marcellia and I. vespertilia (Convolvulaceae), where in both species, bats and hummingbirds act as pollinators. These characteristics include bright, contrasting colors typically associated with hummingbird pollination and the relative length of the tubular flowers, allowing bird access to floral resources. According to Scogin, several Cactaceae species exhibited overlapping quantities of sugar in flowers visited by diverse pollinators, such as bats, hummingbirds, and moths. As a result, by sharing pollinators, such overlap in this trait may favor the pollination of the species[11], [12].Regarding the preservation of cactus and bats, we are aware that Eastern Brazil is one of the three regions where cacti are threatened by habitat loss brought on mostly by local farming, agroindustry, and mining, and is, regrettably, regarded as a hotspot for threatened cacti. Except for the perhaps vulnerable limited endemic Pilosocereus catimbauensis from PARNA Catimbau, a protected area that is still being completely formed, none of the species under study are threatened. Curiously, we discovered that P. catimbauensis was solely dependent on five bat species, indicating a narrower dependence of the cactus upon the presence of bats, when we studied pollination guilds involved in the pollination of P. catimbauensis and other four species of columnar cacti in this location . The other species depend on a combination of bats and moths as effective pollinators. Given that they are frequently available during the dry season and allow the pollinator to feed between flowering booms of angiosperm species that are more water-dependent than cacti, the resources provided by all studied cactus species to nectarivorous bats are essential to maintaining bat populations in the Caatinga. Unfortunately, we are presently unable to accurately identify the bat species that are responsible for pollinating the species under study. However, it is well recognized that the region's current and future bat populations are being impacted by habitat deterioration and destruction.

CONCLUSION

In general, chiropterophily is the most frequent method of pollination among Cereinae. This research has confirmed chiropterophily in five genera of the subtribe, and we highlight new records for bat pollination here. The fact that Cactoideae grow in a columnar habit, which favors bat contact, may explain why bat pollination is so common. It is clear that the pollination systems in the subtribe Cereinae differ between genera and within the species of a given genus, reflecting different evolutionary pathways, even though some genera have specialization towards one pollination system while others have variation between diurnal and nocturnal systems. Given that pollinators were crucial for floral diversification and may help to explain the great range of pollination systems within the family, ongoing future research integrating phylogeny and floral biology data may provide light on how these routes arose throughout the family. These investigations will provide significant insights into the development of Cactaceae's night pollination systems.

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CHAPTER 17

FLORAL SPECIALIZATION TRENDS

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ABSTRACT:

The success and variety of angiosperms have long been assumed to be enhanced by plant reproduction via flowers. However, it is still unknown how this accomplishment came about. Do flowers' ability to perform specific tasks lead to higher or lower rates of speciation or extinction? Is floral specialization essential to the diversity or just incidental? According to several research, the inferences we make about the contribution of flowers to the diversity and rise in phenotypic disparity of angiosperms depend on the system. For orchids, for instance, specialized pollination may have accelerated speciation rates due in part to the fact that most orchids store their pollen into distinct units, enabling precision pollination that aids in reproductive isolation.

KEYWORDS:

Angiosperm, Flowering Plants, Floral Components, Phenotypic, Pollination.

INTRODUCTION

The enormous variety of contemporary flowering plants is the result of two main evolutionary trends: Distinct floral components have merged or gathered together, and floral components have been altered or lost. The number of components in each whorl has often been decreased from many to few in the more developed angiosperms. The rudimentary floral components' spiral attachment patterns. The most numerous and varied group of autotrophic organisms on earth are flowering plants. One of the primary reasons of this evolutionary success is sometimes attributed to the use of fruits and flowers for reproduction, although the processes behind this apparent causal relationship between numerous angiosperm innovations and the group's evolutionary success remain enigmatic. The following review makes an effort to understand the function of pollinators, flowers, and their interactions in the diversity and evolutionary success of plants by examining both old and new theories and pointing out potential mistakes[1].

Numerous traits have been linked to the angiosperms' ecological dominance and evolutionary success. They used animals to move pollen between blooms, which is perhaps the most often mentioned claim. Extreme floral specialization is hypothesized to have enhanced rates of diversity and broadened the area of pollen and seed distribution, creating new chances for further specialization and diversification. To create a software for evaluating the reliability of their constituent parts, further research into these age-old concepts is required. The kinds, causes, and impacts of floral specialization and pollination syndromes have been the subject of debate in more recent years. Uncertainty concerning the basic idea of plant fitness trade-offs, where adaptation to one kind of pollinator incurs costs in the form of diminished efficacy of another type, is at the heart of many of these arguments. Is this pervasive, typical, or uncommon? Although there are certainly too few research to make any firm findings, the general consensus, if there is any, appears to be that trade-offs are typically minimal or nonexistent.

Phenotypic variety and Evolutionary Success

The number of species in a clade is a typical indicator of evolutionary success, often in conjunction with the ecological and morphological diversity of those species. Lineages with a large number of extant species are seen as more successful than those with a small number. It is anticipated that lineages with larger phenotypic difference would succeed because they may be better able to diversify further. The term "adaptive" is often used to describe the interaction between relatively quick diversification and significantly increasing disparity. Then, we may evaluate characteristics known as "key innovations" that are linked to evolutionary success, such as powered flight in insects, birds, and bats, or possibly blossoms in flowering plants[2].

Differential trait transition rates, differential extinction rates, and differential speciation rates are three distinct processes that can cause variations in evolutionary success in relation to key innovations. The first of these processes is micro evolutionary, while the other two are essentially macro evolutionary. Consider a clade of plants where three-quarters of the species have flowers with petals despite the basal need for blooms to be without petals to better understand how these mechanisms work. If petals are adaptable, multiple transitions between states could occur, leading to lineages with flowers missing petals sometimes evolving them; but, once developed, they are seldom lost. As a result, petals are an important novelty from an adaptive standpoint since they increase reproductive success in both individuals and populations, which often results in micro evolutionary changes of the state. If we have enough phylogenetic data, we may be able to identify the parallelism pattern that this process produces. If the species are closely related, the phylogenetic tree is poorly defined, there are missing taxa, or intermediate lineages have disappeared, numerous transitions to possessing petals could also be cryptic under these circumstances. When many transitions have really happened, there may only be one origin that has been recognized.

DISCUSSION

Differential extinction may also result in variations in the number of petaliferous and apetalous species within a group. This is technically a macro evolutionary feature, such as when astronomically produced mass extinctions "clear the decks" of biological species. However, there is a plausible connection to typical micro evolutionary processes if extinction has happened over long periods of time rather than in a single pulse. Lineages with petals would thus typically have reduced odds of extinction if petals attract more pollinators, resulting in greater pollination and lower rates of reproductive failure. Finally, petals may accelerate speciation rates by encouraging pre-pollination reproductive isolation from related species if they attract certain types of pollinators. In order to achieve this, petals may force specialized handling, encourage associative learning, or otherwise improve constancy. Alternatively, petals may cause pollen placement and stigma contact in areas of the pollinator that are not used by other species, attracting and rewarding a group of pollinator species that are not used by related plant species[3].

The enormous variety of contemporary flowering plants is the result of two main evolutionary trends: Separate floral components have merged or clustered together, while other floral components have disappeared or diminished. The number of components in each whorl has often been decreased from many too few in the more developed angiosperms. In early angiosperms, all floral elements were attached in spiral patterns; however, during time, a single whorl has replaced each spiral at each level.

Many flowers have a shorter central axis, and the whorls are close together. Members of one or more whorls have sometimes fused together creating tubes in certain evolutionary lineages. There may be fusion of various whorls in other species of flowering plants. Flowers that lack sepals, petals, stamens, carpels, or other combinations of these components may even lose their whole whorls. Changes often affect pollination processes, and in certain instances, such as with grasses, wind has taken the position of mammals in the pollen distribution process. While pollination-related natural selection is responsible for most of the floral variety, it's crucial to acknowledge the influence that breeding has had on flower form.

Floral Symmetry Trends

The symmetry of the flower has been impacted by other patterns in floral development. Buttercups are an example of a primitive flower that is fundamentally symmetrical, meaning that you could draw a line through the center of it and have two fairly equal halves. Numerous highly developed groups have flowers that are bilaterally symmetrical, or divide evenly into two sections along just one plane. Such flowers include snapdragons, mints, and orchids, as examples. Both violets and peas often have blossoms that are bilaterally symmetrical. These groups often have extremely developed and accurate pollination systems. Many times, bilateral symmetry has developed independently. The Cyclodia gene controls floral symmetry in snapdragons; without it, blooms are more radial. In this case, a single gene's evolutionary introduction is enough to result in a significant alteration in morphology. It is unclear if the same gene or functionally related genes emerged simultaneously in different animals[4], [5].

Angiosperm Flower Development

Modern dicotyledons and monocotyledons have developed from early flowering angiosperms. Angiosperm flower development may be examined under the following headings. The form of flower that exhibits the least change from the original primordial flower during adaptive evolutionary alteration is one that is now widely acknowledged as being morphologically simple. The notion that the ancient flower was bisexual, with multiple stamens and carpels, without a perianth, or with a uninervate perianth of simple, bract like parts, seems to be substantially supported by evidence as of late. The flower was symmetrical and had no fusion between any of its sections, and all of its appendages were organized in spirals.

The "pattern flower" of pre-evolutionary taxonomy has evolved along numerous lines from this conceptually simple flower, with reduction creating varieties with fewer and simpler types of organs and elaboration producing more complicated forms. The following developments are the main concepts of evolutionary adaptation, on which the recognition of this kind of flower as morphologically simple and primitive among living species is based: From numerous pieces with an unknown number to a small number with a known number one pair of appendages instead of three or four, including the perianth, androecium, and gynoecium a whorled arrangement of appendages from spiral from floral components' independence to their fusion connation and adnation Bilateral symmetry follows radial symmetry.

Reduced Flower Size

The flower may experience reduction in any or all of its components, simultaneously in various areas, or gradually from one area to another. Loss may affect individual organs or whole whorls of organs; it can be trivial, such as the loss of a single petal or stamen, or it might affect the entire flower, leaving only the receptacle and a single or small number of one kind of sporophylls. In closely related species, all phases of function loss and size decrease may be seen. Vegetative anatomy may help in the interpretation of vestigial structures when identification is ambiguous. Vestigial organs, which are in the process of being reduced through evolution, can be identified by their abortive shape and structure as well as their location in the flower. Even after the organ itself has vanished, the vascular remnants of lost organs may still be present in the receptacle when outward shape is decreased. Organs may undergo reduction, which changes their shape, structure, and functional characteristics. The most frequent alterations are probably those that convert petals, stamens, and staminodia into glands and staminodia, respectively. The location of the glands and the nature and origin of the vascular supply are often clear indicators of the transformation of petals and stamens into glands. When the petals are still there but only in a vestigial or drastically diminished form, as in the Proteaceae family, a plant is said to be apetalous[6].

Lessening of the Stamen

Reduction of the stamen happens at every step, from sporangia-only abortion through the organ's total elimination. Two sporangia aborting, one of each pair, is common; aborting three of the four is uncommon. The stamen persists as a sterile, laminar or filamentous organ that may be petaloid when the complete anther is lost, as happens often. The majority of families' petals seem to be a perfect representation of petaloid stamens. The genera of the Scrophulariaceae demonstrate stages in the loss of the stamen by gradually reducing the size of a staminodium. The vascular trace of the destroyed stamen is still visible in the receptacle in genera when there is no remaining outward sign of the lost stamen.

Lessening of the Carpel

The size and quantity of ovules are predominantly reduced in the carpel. The carpel initially held a large number of ovules. There have been much too few ovules, and just one of the achene kind. Ovule loss may occur gradually from either end, and the ovules that remain may be proximal or distal. A median ovule's persistence seems to be unusual. As in the Proteaceae, the distal or proximal location of the solitary ovule may provide a strong generic character. The placement of abortive ovules and the existence of ovule traces in areas where no ovule remnants remain serve as evidence for the order in which ovules are lost. The Ranunculaceae and Rosaceae carpels exhibit this sequence in ovule loss well. When there is just one remaining ovule, vestigial ovule traces are sometimes the only way to determine where that ovule was located in the original follicle[7].

Basic Flower Structure

Rarely is the morphological foundation of the flower highlighted in definitions; instead, the flower is simply referred to as "the reproductive structure of the angiosperms." From a morphological perspective, it is a determinate stem tip with sporophylls and often additional sterile appendages, although this description also works for many cones, those of gymnosperms, and even some lower vascular plants. It is vital to compare these structures and their sporangia with those of other groups if the word "flower" is to be limited to the fertile stem tip of the angiosperms and its appendages. The difficulty in identifying the structure is partly due to the botanists' vague usage of the word "flower." The angiosperms are often meant when we refer to "the flowering plants," but we also regularly hear expressions like "the flowering of the conifers," "the flowers of the gymnosperms," and "the flowers of the seed plants."

The Container

The flower is initially and foremost a stem tip, the receptacle, with ontogeny and basic structure similar to a vegetative tip. It has appendages and nodes as well as internodes. The nodes are often compressed by shortening and frequently brought closer by internode suppression. Early in fruit development, apical growth is restricted, although other growth is sometimes allowed to proceed. The receptacle is often significantly altered and unstem-like in shape, size, and structure. As the fruit grows, it may also become even less stem-like. Both fertile and sterile appendages are normally carried on the container. The appendages are brought together, either in spirals or whorls, by the shortening and suppression of internodes.

Sterile Whorls

Sepals and petals, which together make up the calyx and the corolla, are the two main types of sterile appendages. The calyx is located underneath the corolla and these appendages are below the fertile appendages. Sepals and petals often vary from one another in shape, size, and other attributes. They may resemble one another rather closely in certain families, like the majority of Liliaceae, while transitional forms may be seen in others, like the Magnoliaceae. Where the organs, which may range from one to many, are arranged spirally and where the perianth is only represented by one or a few appendages that act as a cap resembling a bud scale, the interpretation of the perianth as a calyx or corolla may be challenging and irrelevant. Sepals often resemble leaves or bracts in appearance and structure, particularly in respect to the stem's vascular system. In terms of shape, they resemble modified leaves[8].

The Fertile Cylinders

The two forms of fertile appendages, also of leaf rank, are microsporophylls and megasporophylls, which both carry sporangia. The androecium is made up of the stamens; the gynoecium is made up of the carpels. If a flower only has one kind of sporophyll, it is unisexual; if it contains both, it is bisexual. The taxon is monoecious if the staminate and pistillate blooms are borne on the same plant, while the taxon is dioecious if they are borne on different plants.

Organ Differentiation in Flowers

Calyx differentiation

Sepal development, which was covered by a thin uniseriate protoderm, was the first stage of flower formation. Sepal differentiation begins near the edge of the rounded floral apex. Simultaneously begin the sepal. Procambial strands of the sepal are visible, and tracheary components appear on the vascular bundles. Sepals are coated with uniseriate protoderm with thick cytoplasm as well as 4-5 layers of mesophyll cells when buds go into their winter dormant condition.

Differences between Corollas

Following sepal initiation, four primordia for the four petals begin to form concurrently at the floral meristem's edge, alternating with sepals. Sepal initiation precedes the beginning of the creation of the petals. The basal portion of the petal primordium undergoes many mitotic divisions during the early stages of petal development. Procambial threads were initially present in the petals' basal region, which was thin. At this point, the petals also cover the growing gynoecium and androecium. Provascular bundles gradually give way to vascular bundles with tracheary components and expanding petals.

Differences between Andrecium

The formation of the stamen primordial, which has abundant cytoplasmic meristematic cells, begins throughout the blooming season. Following the differentiation of the stamens into anthers and filaments, procambial threads are generated. After it uniseriates, layers of sporogenous tissue may be seen, provascular bundles are generated within the connective tissue, and the protoderm can be seen. Sporogenous cells undergo anticlinal and periclinal mitosis on the parietal side of the anther. The dense cytoplasmic sporogenous cells go through meiosis. Throughout the season, anthers continue to vary. Sporogenous tissue differentiates into pollen mother cells at the time of pollen maturity, and these pollen mother cells create microspore tetrads by meiosis and mitotic cytokinesis. At the same time, the intermediate layer and tapetum started to deteriorate. The endothecium thickens its secondary cell walls at this time. The stomium cells exhibit changes as well. Stomium cells become amorphous and the space between them widens. The stomium underwent dehiscence in the days that followed[9].

Simple Stamen

There is no differentiation between filament and anther in the early stamen. The stamens of some of the woody Ranales are arguably the oldest stamens in extant angiosperms. These are large organs that resemble leaves in some ways, with little or no differentiation between fertile and sterile regions. In Degeneriaceae, Annonaceae, and Himantandraceae, the sporangia are borne close to the center of the sporophyll; in Austrobaileya, Magnolia, and other primitive taxa, they are borne on the adaxial side. Other primitive or rather primitive families including Ceratophyllaceae, Lardizabalaceae, Eupomatiaceae, Lactoridaceae, and Nymphaeaceae also include stamens with a semi-laminate structure. The sterile tissues have shrunk together with the marginal regions in the specialization of tilts simple stamen. The lamina has become gradually smaller. The middle region containing the sporangia and the distal part formed the anther, while the proximal part developed into the filament. The connective and the appendage's sterile, distal portion were generated in the anther by the midvein area.

Additional Development

The anther exhibits a wide range of forms and relationships with the filament. Due to the significant reduction and intricate shape of the substantially reduced kinds, its morphological characteristics are difficult to ascertain. The anther may have a variety of shapes, including linear, arrow-shaped, subglobose, and highly four-angled. It has two lobes typically, and the more specialized varieties have deeper lobes. The lobes are also known as anther sacs and anther lobes. As in the Commelinaceae, Melastomaceae, and many Labiatae, another lobes may be widely spaced when the connective tissue is enlarged on the side.

Creation of Filament

The filament comes in a variety of shapes, including wide and winged, terete, and thread-like, as well as short and long. In general, the more basic kinds are the ones that are wider and shorter. Sessile anthers can occur, like as in Juglans. Lack of the filament may come from less adaption to unique environments or pollination techniques, as in several aquatic taxa. Najas, Zostera, or the outcome of the filament adhering to the perianth, where the filament is seemingly missing but not lost anatomically, are examples of this. Some Proteaceae and Loranthaceae are often represented by their vascular supply. It could be much larger and have appendages at the top called Mahonia and at the base called Viola. The morphological makeup of the appendages is unclear and obviously diverse. Depending on the kind of pollination, certain appendages have glandular excrescences or shape alterations. As in certain Amaryllidaceae, when they petaloidize and connate, producing a corona, lateral appendages may be conspicuous. In order to ascertain the function of these appendages, anatomical structure and comparison with comparable taxa are required.

Decrease of Another

Reduction of the stamen happens at every step, from sporangia-only abortion through the organ's total elimination. Two sporangia aborting, one of each pair, is common; aborting three of the four is uncommon. The stamen persists as a sterile, laminar or filamentous organ that may be petaloid when the complete anther is lost, as happens often. The majority of families' petals seem to be a perfect representation of petaloid stamens. The genera of the Scrophulariaceae demonstrate stages in the loss of the stamen by gradually reducing the size of a staminodium. The vascular trace of the destroyed stamen is still visible in the receptacle in genera when there is no remaining outward sign of the lost stamen. Individual organs or complete whorls may disappear in an androecium that is reduced. The inner whorl may be lost in certain families of related taxa, such as the Iridaceae, whereas the outer whorl may be lost in other families, such as the Burmanniaceae and Haemodoraceae. One family that has been lost from both ancestral whorls is the orchidaceae[10].

AndroeciumFusion

Both whorled and fasciculate androecia often congregate members of whorlontogenetic or phylogenetic groups. A monoadelphous androecium has a single cluster of stamens, a diadelphous androecium has two clusters, and a polyadelphous androecium has more than two clusters. Where there is no connation, it is adelphous. A syngenesious androecium is one that has its anthers fused together. Connate anthers are uncommon or unusual in several Typhaceae and Cucurbitaceae species. The Lobelioideae's anthers seem to display phases from cohesion to connation. Monadelphous or diadelphous filament fusion may include one, two, or even more whorls. It happens often when two whorls combine to produce an apparent one, as in several legumes and the Thymelaeaceae.

Anther's Adnation

Androecium's Adnation It is typical for stamens to fuse with other flower parts, particularly the corolla. Fusion to the calyx is less frequent than fusion to the Proteaceae corolla. Fusion to the carpels, whereby the gynoecium and all of the exterior organs are fused together in perigyny and epigyny, is a frequent occurrence. Sarcandra, a Monimiaceae plant, seldom has fusion to carpels alone. The Orchidaceae and Stylidiaceae are distinguished by the fusion of the styles and stigma, resulting in the creation of a gunostemium. When the anthers are sessile on other organs, adnation may occur via filaments that are partially or completely throughout their length. The degree of the anther's adnation to other organs may range from a small base-only attachment to union by the complete dorsal or ventral surface. In many Proteaceae, the dorsal surface of a sepal, whereas in orchids the whole ventral surface of the gynoecium.

Unity of Another

In both whorled and fasciculate androecia, connation of individuals of a whorl ontogenetic or phylogeny is prevalent. A monoadelphous androecium has a single cluster of stamens, a diadelphous androecium has two clusters, and a polyadelphous androecium has more than two clusters. Where there is no connation, it is adelphous. A syngenesious androecium is one that has its anthers fused together. Monadelphous or diadelphous filament fusion may include one, two, or even more whorls. It happens often when two whorls combine to produce an apparent one, as in several legumes and the Thymelaeaceae.

Differences between Gonoecium

The gynoecium is made up of the carpels or megasporophylls, which are the flower's ovule-bearing organs. They come in a variety of numbers from many to single and arrangements from spiral to whorled. Gynoecium apocarpous, in which the carpels have not fused together, or gynoecium syncarpous, in which they have fused to varying degrees. It is challenging to make a distinction between apocarpy and syncarpy since fusion may be minimal or may happen later in ontogenesis. The key changes in the development of the flower are arguably better shown in the gynoecium than in the androecium and perianth. The transitions from spiral to whorled layout, from free to fused members, and from several to one pseudoterminal are particularly notable.

Simple Carpel

The primordium of the basic carpel emerges from the floral meristem with a form resembling a crescent, which is rapidly widened by lateral development. Its length and breadth are increased by the early appearance of apical and marginal meristems. Only at the beginning of the 20th century was the existence of peripheral meristems in the carpel acknowledged. It was often thought that the apparent lack of peripheral meristems was proof that the carpel was different from the leaf. The lateral "wings" bend upward and come together as a result of differential development, eventually being suppressed and forming a more or less complete histological union. It seems that no comparative studies of the standard procedure of carpel closure have been done. Although little attention has been paid to specifics of contact from the stand point of location of the marginal meristems, earlier descriptions of carpel closure as an upfolding or inrolling seem to be broadly true. The ventral sides of the two lamina halves are in touch, with the edges placed side by side, according to histological investigations of the formation of certain primitive carpels, particularly Degeneria. The decrease of the border strips and a retreat of the margins, together with the ventral, half-inverted placental bundles, have been responsible for the frequent occurrence of the conduplicate type in primitive species and its simplicity. However, carpels with deeply inrolled edges and margins are complicated and do not seem to have descended from the conduplicate kind [11].

Carpel Complex

The ovary, style, and stigma gradually diverged from the basic, primordial carpel across a number of lines, with the development of the style and stigma occurring at varying speeds. In certain Winteraceae and Euptelea, the stigma is sometimes sessile while the style is still in its infancy; in other cases, the style may be fully developed while the stigma still has a primitive stigmatic crest that is decurrent on the style, as in Cercidiphylium. The style is often the distal portion of the primitive carpel morphologically. Several families exhibit a slow transition from ovary to style, including vestiges of ovules and signs for lost ovules in the transitional area. Numerous taxa have elongation of the style. The stigmatic crests of primitive carpels, notably those of the woody Ranales, such Degeneria and the Winteraceae, are clear indications of the stigma's nature. The stigma's pollen-receiving surface is often papillose and frequently secretory. The papillae cover the edges of the carpel and narrow neighboring bands of the lamina surface when this region covers the whole length of the carpel, generating an undifferentiated stigma, a stigmatic crest. The papillae fill the slit loosely or compactly if the peripheral portions are only approximated or appressed and the carpel is still open.

Gynoecium Apocarpous

The several carpels that make up an apocarpous gynoecium are dissociated from one another. A rose is an example of an apocarpous flower, which has several little carpels grouped together in the center. A solitary ovarian chamber with placentation parietal, free central, or basal is seen in gynoecia in which the carpels are unfused from one another for instance, the Ranunculaceae, Asclepidiaceae, and Rosaceae.

Either Coenocarpous Gynoecia or Syncarpous Gynoecium

There have been attempts to replace "syncarpous" by coining the terms coenocarpous, paracarpous, and redefiniting syncarpous. In the new method, gynoecia with joined carpels is referred to as coenocarpous, whereas syncarpous gynoecia is merely defined as having two or more distinct chambers and incomplete longitudinal fusion. According to this description, syncarpous gynoecia may have three structural zones: a fertile base, the ovary, which is syncarpous; a middle section, the style; and a stigma, which is apocarpous. Coenocarpous and syncarpous, as they are now used, are bad terminology since they essentially signify the same thing, and the categorization is useless because "paracarpous" and "syncarpous" forms are thought of as morphologically different kinds. For gynoecia, where the attachment of carpels to a cup-shaped receptacle links together ordinarily free carpels, see Hydrocharitaceae, Pomoideae, and Butomus, the name false coenocarpy has been suggested.

CONCLUSION

Some overarching tendencies as flowers have changed and diversified include a number of adjustments in blooms that attract certain pollinators: a decrease in the quantity of floral components floral pieces coming together. Precise in both the amount of floral components and design. Cell development and division work together to drive plant growth. Through cell mitosis, cell division increases the number of cells, while cell expansion increases the size of the cells. Meristematic phase, elongation phase, and maturation phase are the three stages that make up the growth phases.

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CHAPTER 18

SEX DETERMINATION IN PLANT

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ABSTRACT:

The mechanisms that underlie plant sex determination are mostly unclear. The dioecious Silene latifolia species, which has distinct male and female individuals, has XY chromosomes and serves as a key paradigm for how sex is determined in plants. Recent research on the genetic and epigenetic variety of elements involved in defining the sex of flowers or individuals has been successful in establishing how sex is determined in many plant species, from ferns to maize. Significant progress has been made in identifying mutations that change sex expression in organisms that are genetically susceptible. Images of how sex-determining signals are seen to activate or repress male- or female-specific genes are emerging from the study of the interconnections among these genes.

KEYWORDS:

Bisexual, Genes, Sex Determination, Pollination, Unisexual Flowers.

INTRODUCTION

Both heterosexual andHomosexual Flowers

Cross-pollination occurs often during plant reproduction in the majority of flowering plant species. Outcrossing enhances heterozygosity, genetic diversity, and genetic exchange benefits that are beneficial to a species' long-term survival and capacity to adapt while avoiding the harmful effects of inbreeding depression. In order to encourage allogamy, plants have developed a variety of strategies, such as the development of unisexual staminate or pistillate blooms on the same or distinct plants[1].

Control over Unisexuality

Selective activation or inactivation of homeotic gene activity may be used to regulate the production of unisexual blooms. Data based on mutational research of the Arabidopsis and Antirrhinum bisexual blooms do not seem to support this claim. In essence, homeotic genes regulate the development of two or more whorls of organs. Mutant alleles of these genes often cause the floral organs of two neighboring whorls to undergo homeotic transformation into distinct structures. For instance, changes in homeotic genes that affect region B result in the conversion of stamens into carpels and petals into sepals. These patterns are characteristic of unisexual blooms, which typically only impact one whorl and are prevalent in natural plant populations. The function of homeotic genes may be selectively influenced by sex determination genes in one whorl, altering, for instance, the development of stamens without having a negative impact on carpel formation. The Arabidopsis homeotic mutation flo70, also known as superman, replaces stamens with carpels; the Digitalis heptandra mutants selectively affect whorl2 replacing petals with stamens; and some petunia mutants, such as green peta/ and ph3, also show defects in just one whorl. These are just a few examples of homeotic genes acting in a single whorl. To our knowledge, a method for determining sex in naturally occurring populations has not been identified for the accomplishment of unisexuality in flowers via homeotic transformation.

The decrease or abortion of sex organ primordia is often the cause of unisexuality in plants; however, given the facts at hand, it seems more likely that sex determination genes work downstream of or independently from homeotic activities. The extensive morphological analyses of several unisexual plants that have shown that unisexual blooms often go through a "bisexual stage" in which all floral organs are begun are in agreement with this theory. The floral primordia only lack any signs of abnormal sex organs in Mercurialis and Cannebis. Sex determination genes must be active for this bisexual meristem to produce unisexual flowers. These genes have been found in maize via the investigation of mutants that improperly control the unisexuality program[2].

Dioecious Plant Sexuality Genetics

Active-Y Sex Determination System

Despite being uncommon in angiosperms, heteromorphic sex chromosomes have been discovered in a variety of plant species, including Rumex, Cannabis, Humulus, and Silene. Males are the heterogametic sex in the dioecious Silene, whilst females are the homogametic sex. Silene has an active Y system for determining sex, similar to mammals, with dominant male factors and female suppressing factors mapped to the Y chromosome. The fact that only monoploid females can be produced using in vitro procedures suggests that the X chromosome is crucial in both men and females. Hormone application, including the use of GA, auxins, and cytokinins, does not cause sex change. However, when three X chromosomes are present, the presence of a single Y chromosome may restrict female development. The masculinization impact of the Y chromosome is overridden by higher X copy numbers. Autosome ratios have no significant impact on the Y chromosome's sex-determining elements. This shows that in Silene, sex is mostly determined by the Y chromosome. The Y chromosome has three distinct regions, each of which is known to have a unique role in determining sex. A male fertility factor is present at one end, a genetic factor that inhibits the development of the gynoecium is present at the other, and a gene or genes necessary for the commencement of a further pregnancy are present in the center.

As a result, Silene's Y chromosome fully links the crucial male sex genes to the female-suppressor genes. Asparagus is often a dioecious plant, with the homomorphic chromosomes that define sex designating the males as the heterogametic sex. According to genomic data, asparagus is "male dominant" and has the same genetic determinants associated with SiIene: male-activator-female-suppressor. Genetic modifiers may also have an impact on the stage of stylar degeneracy in addition to these key sex determination genes. Male plants with a few perfect blooms may sometimes be seen in the dioecious populations.

These blooms have the ability to self-pollinate, creating homogametic males. Due to their greater vigor, males are preferred in commercial applications; thus, chosen YY male and XX female plants are employed as parents to produce all male F1 hybrid seed. In conclusion, the lack of heteromorphic chromosomes and the survival of the YY genotype imply that asparagus's dioecy may have developed lately[3].

System of determining sex based on X-to-Autosome Balance

In contrast to Silene, there are around 10 dioecious species in the genus Rumex, subgenus Acefosa, where sex determination is thought to be influenced by the X-to-autosome ratio. Males are XYlY2 and females are XX, whereas viable female diploid plants have the genotypes XXY and XXYlY2. The Y chromosomes are heterochromatic and late replicating. Female polyploids have an X-to-autosome ratio of at least 1.0, whereas males have an X-to-autosome ratio of at least 0.5. Ratios between 0.5 and 1.0 result in intersexes or hermaphrodites. Even in plants with trisomy for one autosome, sex is determined by X-to-autosome ratios. In Rumex, the Y chromosomes are necessary for pollen fertility but not, it seems, for stamen formation. For the correct passage of microspore mother cells during meiosis, both Y1 and Y2 seem to be necessary. Unlike Silene, Rumex's Y chromosomes do not prevent the formation of the female gynoecium. As a result, the situation in Rumex is very similar to that in Drosophila and Caenorhabdifis elegans, where the X-to-autosome ratio is the main factor in determining sex. There are two dioecious species in the genus Humulus, and they use a method of sex differentiation similar to Rumex. Two species have heteromorphic sex chromosomes, and like Rumex, the X-to-autosome ratios rather than the presence or absence of the Y chromosome decide whether an individual is a female or a man. An XX female-XY male system is discovered in cultivated hops, and Japanese cultivars have numerous X systems. In the genus Fragaria, a peculiar example of sex determination was discovered. One of the plant species in which the heterogametic sex is female and the sex chromosomes are heteromorphic is this one. A polyploid Series S of Fragaria species has 2n = 14, 28, 42, and 56. Wild polyploid species are dioecious, while all diploid species are hermaphrodites. Sex is decided late in floral development, just before meiosis but after the production of the microspore or megaspore mother cell[4].

In conclusion, processes established in the animal world may be used to genetically influence how plants determine their sexual orientation. The sex-determining process of certain dioecious species, such Silene and asparagus, is similar to that of mammals in that the Y chromosome actively participates in male activation and female repression. Similar to Drosophila and C. elegans, other dioecious species including Rumex and Humulus have floral primordia whose sexual destiny is determined by the X-to-autosome ratio. However, it should be highlighted that while sexuality is determined by the X and autosomes in both Drosophila and C. elegans, the underlying molecular processes that control sexual dimorphism are quite different. So, it stands to reason that the molecular underpinnings of plant sex determination will likewise be species-specific. The physiological regulation of sex determination in plants reflects the variability in the underpinning mechanisms.

Arabidopsis Homeotic Mutants

The mustard family includes Arabidopsis thaliana, which has a widespread geographic range over Europe, Asia, and North America. It is possible to do experimental study on a wide variety of ecotypes that have been gathered from wild populations. The established benchmarks for genetic and molecular investigations are the Columbia and Landsberg ecotypes. In six weeks, the full life cycle seed germination, rosette plant development, main stem bolting, blooming, and maturity of the first seeds is finished. Almost all aspects of Arabidopsis are diminutive in scale. Flowers are 2 mm long, self-pollinate as soon as the bud opens, and may be crossed by dabbing pollen on the stigma's surface. At maturity, seeds are 0.5 mm long and are formed in siliques, which are thin fruits. Depending on the development environment, seedlings grow into rosette plants with a diameter of 2 to 10 cm. Trichomes, which are the little unicellular hairs that cover leaves, are useful models for examining morphogenesis and cellular differentiation. On a greenhouse or a laboratory with fluorescent lighting, plants may be cultivated on petri plates or kept alive in pots. About three weeks after planting, the plant begins to bolt, and for many weeks before senescence sets in, the ensuing inflorescence develops in a straight sequence of blooms and siliques. Four white petals, six pollen-bearing stamens, an inner whorl with four green sepals, and a central gynoecium that forms the silique make up a flower's structure[5]. The roots are basic in structure, easy to study in culture, and do not form symbiotic partnerships with nitrogen-fixing bacteria. Mature plants reach 15 to 20 cm in height and often generate several hundred siliques with more than 5000 total seeds. A wide range of insects, bacteria, fungus, and viruses are examples of natural pathogens. Recent morphological and genetic investigations have established systematic connections within the Brassicaceae and among Arabidopsis' closest relatives. About 10 species of the genus Arabidopsis are indigenous to North America, North Africa, and Eurasia. A. lyrata and A. halleri, which are self-incompatible diploids with eight chromosome pairs, are the closest wild relatives of A. thaliana. Within this N=8 taxon group of closely related species, there occurs interbreeding. Since A. thaliana only has 5 chromosomes, diploid mapping crosses with wild relatives are not conceivable. Figure 1 illustrates that Arabidopsis suecica is thought to be an allotetraploid developed from A. thaliana and A. arenosa[6].

Figure 1: Illustarte the Arbidopis thaliana.

DISCUSSION

Relatives in the wild of Arabidopsis

A. thaliana's natural range was studied recently using molecular markers in 142 accessions, and statistically significant isolation was discovered by distance, perhaps representing migrations throughout the Pleistocene era across Asia and Europe. Although there is little doubt that human interference affects the biogeography of A. thaliana, there is evidence that glacial refugia in Asia and the Mediterranean region were used as post-Pleistocene migration routes to colonize Europe.

Few ecotypes of A. thaliana from central Asia are known, but those that are exhibit intriguing patterns of genetic diversity for both molecular and phenotypic features. Among the investigated Arabidopsis ecotypes, there is no evidence of distinct subspecies. Additionally, research on amplified fragment length polymorphisms and nucleotide variation reveals evidence of historical gene recombination that was both modest and significant, which means that ecotype evolution does not happen in a bifurcating, tree-like fashion. Instead, nucleotide polymorphisms that segregate across people show historical outcrossing and recombination. In order to adapt to a wide range of settings, Arabidopsis and Arabis species have developed a diverse range of life-history, developmental, and physiological features. Numerous ecological issues in these species may be addressed by researchers using genetic methods and biological data from A. thaliana. In the temperate zones, A. thaliana may be found in undisturbed rocky areas, woodland openings, and agricultural fields in addition to disturbed settings. It is possible that populations of A. thaliana in Europe and Asia predate human agricultural disturbance due to significant isolation by distance across their native range. As a result, these populations have long ecological and evolutionary histories in association with insects, pathogens, competitors, and abiotic environmental factors.

Arabidopsis Plant Transformation Techniques

Plants undergo genetic change spontaneously. Since the middle of the 1970s, scientists have been able to manipulate plants in a controlled manner using certain genes. Agrobacterium tumefaciens bacteria and swiftly propelled, DNA-coated tungsten microprojectiles are the two most popular ways to introduce DNA into plant cells. There have also been attempts to use electroporation, microinjection, and viral delivery. The DNA of interest is often cloned next to DNA for a selectable flag gene, such as nptII, to enable physiological selection of cells that have undergone successful transformation. Transformed cells may or may not develop into gametes that carry genetic information to next generations, and genetic transformation may be temporary or permanent. For quick investigations of gene function, transformation of protoplasts, callus culture cells, or other isolated plant cells is often simple. The use of single-cell tests may sometimes be increased by the transformation of leaf mesophyll cells or other cells inside whole plants. For certain investigations, innovative novel techniques like virus-induced gene silencing may also be useful. These quick tests will be more crucial than ever in the genomics age. The production of a consistently altered plant, on the other hand, with the transgene present in the nuclear genome as a single Mendelian locus, is often desired or required.

The transformation of plant cells and regeneration of complete, reproductively competent plants from those changed cells have traditionally provided two distinct challenges for the production of genetically homogenous plants bearing the identical transformation event in all cells. Despite the fact that several effective plant regeneration techniques have been created, these techniques often need extensive protocol modification and the concentrated work of knowledgeable practitioners. It is regrettable that mutations ranging from single base alterations or minor rearrangements to the loss of whole chromosomes often result during plant regeneration from single altered cells. Significant epigenetic alterations may also take place. To select lines with low genetic damage and those carrying a straightforward insertion event, it is sometimes essential to create and test a dozen or more independent plant lines transformed with the same construct. It is possible to transform 1 The North Central Soybean Research Program funded plant transformation research in the author's lab on a variety of plant species, although agreement of the aforementioned restrictions was necessary[7], [8].

Arabidopsis Transformation Mechanism and Process

It was early shown that the majority of primary transformants have hemizygous T-DNA insertion events in the vacuum infiltration and Arabidopsis seed transformation procedures. After the divergence of the male and female germ lines, plants are maintained for a few more weeks until they are mature, at which point progeny seeds are harvested. Seeds are then germinated on selective medium to identify successfully transformed progeny fertilization, as the presence of the T-DNA on only one of two homologous chromosomes suggests productive transformation occurs late in floral development. The transformants derived from a particular plant often have separate T-DNA insertion events, which further defines the transformation target. According to this, metamorphosis happens after the separation of several pollen or egg cell lineages inside a flower. It is also possible to hypothesize a developmental end point for the conventional objective of transformation. Although the outcome is less clear, typical primary transformants appear to carry the transgene throughout the entire plant, indicating that transformation took place prior to the independent meristem cell divisions and other distinct adult plant cell lineages in a fertilized embryo. As a result, transformation seems to take place in growing flowers after distinct gametophyte cell lineages have formed but before the embryo has undergone considerable development. In the middle of the 1990s, Arabidopsis researchers concentrated on developing the empirical transformation technique.

Understanding how the new transformation process worked had to wait until practical incentive to continue with the creation of transformants was satisfied, which was understandable. Nevertheless, via meetings, informal communication, and the Arabidopsis electronic forum, protocol changes, thoughts, and anecdotal findings were widely disseminated. This communal effort produced several important results, such as the fact that plants didn't need to be removed, treated with Agrobacterium, and then replanted. Only the protruding inflorescences needed to be treated to produce transformants; Silwet L-77, a potent surfactant with low plant toxicity; transformation reliability was frequently improved; numerous Arabidopsis ecotypes and Agrobacterium strains could be used, though there were noticeable differences in efficacy. The most significant discovery was that plants may be converted while immersed in Agrobacterium solution without the need for vacuum infiltration, which led to the replacement of the term "vacuum infiltration." Later, some employees switched from dipping in Agrobacterium to spraying it on. Other mechanistic hints and procedural advice were provided[9].

The Main Target of Transformation is Ovules

Once again, three study teams collaborated to solve the subject of the cellular target of transformation, and they have recently presented their findings. It appeared plausible that the male germ-line would be the focus of transformation given that transformation may occur simply by dipping flowers in an Agrobacterium solution and that anthers and pollen are accessible but ovules are not. But all three teams discovered that the female germ line is the transformation's main target. In one set of trials, just the pollen donor or pollen receiver was Agro-inoculated, and transformants were created via outcrossing. No transformants were found among the more than 14,000 seeds generated after the pollen donor's inoculation, while 71 transformants were found among the nearly 14,800 seeds produced after the pollen recipient's inoculation. In a related investigation, ye and colleagues saw 0 and 15, respectively, transformants. The idea that pollen is converted after it germinates on the stigmatic surface of the pollen recipient is not ruled out by our results, which seem to rule out transformation of pollen while it grows inside anthers. When constructs incorporating a GUS marker gene were employed to track the locations where T-DNA was delivered, ovule transformation was successfully shown. Additional promoters employed for GUS fusions were Arabidopsis ACT11, an oilseed rape Skp1-like promoter, or a Figwort mosaic virus promoter since 35S and other typical promoters are weakly expressed in gametophyte tissues. Both mature blooms and younger flowers that hadn't yet achieved pollination had stained ovules[10].

It also created cases in which closed locules were filled with blue stain, indicating that locules may host significant populations of Agrobacterium. These examples were found on the stigmatic surface and in numerous flower fissures. Transformants have been extracted from siliques spread throughout the inflorescence at various locations. However, in one research, transformants were not divided at random among each silique or each plant. In a different investigation, more than one and up to seven transformants were present in around half of the transformant-bearing siliques.

Homozygous Mutants

Bell mutants undergo an integument to carpel conversion. The bicarpelloid gynoecium of an adult wild-type flower of Arabidopsis thaliana houses around 50 ovules. Ovules begin their development as tiny, finger-like primordia on the inside surface of carpels. Each primordium develops an inner and an outer integument, the location of which marks the division between the apical nucellus and the ovule's supporting stalk. The nucellus is covered by the integuments, which expand to meet at the tip and leave a little aperture. Megasporocytes undergo meiosis inside the nucellus, where one meiotic product matures into a seven-celled megagametophyte. The nucellus then degenerates, and the endothelium that encircles the embryo sac is formed from the innermost cell layer of the integuments.

The ovule will mature into a seed after fertilization, with the integuments producing the seed coat. We hypothesized that abnormal AG expression could be to blame for the homeotic transformation of bell mutant ovules due to the link between the location of AG expression and the eventual emergence of carpels or carpelloid structures. By in situ hybridizing ovule sections with 35S-labeled anti-AG cDNA, we validated this theory. The findings of Bowman et al. are supported by the high levels of AG expression in endothelial cells and low levels in other integument layers in late-stage wild-type ovules. In contrast, at this same developmental period, a large amount of AG message is discovered evenly distributed among the bell-1 ovules of flowers. On sections of a number of wild-type and bell-i ovules, we quantitated the in situ hybridization signal[11].

When background was taken into account, the difference in the levels of AG mRNA between the collar of tissue that makes up the integuments in mutant ovules and the wild-type integuments became much more dramatic. We come to the conclusion that the integument-replacing collar of tissue in a mature bell ovule contains cells that actively produce AG, and we suggest that Bell may have the ability to directly or indirectly inhibit AG expression in integument development. The outcome of ectopic AG expression is a bell mutant phenotype. While the aforementioned research shows a connection between the bell mutation and ectopic AG expression in the integuments, it does not necessarily follow that this expression is responsible for the ovules' homeotic transformation. Through forced overexpression of AG in normally wild-type plants, the contribution of AG expression to the Bell phenotype may be experimentally examined. The powerful "constitutive" 35S promoter of the cauliflower mosaic virus is used to induce the expression of the Brassica napus homolog of AG in wild-type Arabidopsis plants. The offspring of two distinct transgenic lines only generated ovules that were bell-shaped or in which the integuments had completely transformed into carpels, whereas the ovules of the main transgenic lines were wild type. The transgenic plants were otherwise typical. As a result, AG overexpression is sufficient to mimic the consequences of BELL gene function loss and results in a phenocopy of the bell mutant[12].

CONCLUSION

Unique mechanisms are available in plants to research sex determination. Numerous plant species have separately developed the ability to produce unisexual blooms, therefore various novel methods may be in use. Therefore, it is unlikely that sex determination in plants can be explained by a single, general process. The study of the genetics, molecular biology, and biochemistry of the genes mediating sexual determination in plants will further our knowledge of sex determination. For these studies, there are many very good model systems for monoecy, dioecy, and bisexual floral development available. The crucial unanswered concerns relate to the sex determination genes' mode of action and their potential interaction with homeotic genes, which control the sexual identity of primordia of floral organs. Although strong associations have been found, the physiological relationship between hormone signaling and sexuality is not fully understood. Finally, new methods for controlling plant sexuality should emerge after the genes that control these processes have been discovered, cloned, and investigated.

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CHAPTER 19

STRUCTURE AND DEVELOPMENT OF MALE GAMETOPHYTE

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ABSTRACT:

At the two-celled stage, the pollen grains are expelled from the pollen-sacs. Two male gametes are created by a second division of the generating cell. To fuse with the egg and the central cell, these male gametes are discharged into the embryo sac. The anthers of the stamens contain the male gametophyte, whereas the ovules of the pistil contain the female gametophyte. Many microspore mother cells are found in the four pollen sacs (locules) of the anther, and each of these cells undergoes meiosis to produce four microspores in a tetrad. You will be able to comprehend the following ideas about angiosperm reproduction after studying this unit: description of the microsporangium and microsporogenesis in detail. Microgametogenesis at various levels. Microspore or pollen grain ultrastructure. Several factors may trigger a pollen allergy, emergence of embryo sacs resembling pollens

KEYWORDS:

Angiosperm, Gametophyte's, Microspore, Microsporogenesis, Meiosis.

INTRODUCTION

An alternation of generations, in which a diploid sporophyte generation gives birth to a haploid gametophyte generation, characterizes the sexual life cycles of plants. Angiosperms have a relatively tiny gametophyte generation that is entirely encased in the tissues of the parent sporophyte. Pollen grains make up the male gametophytes, also known as microgametophytes. The embryo sac is the female megagametophyte or gametophyte. The angiosperm flower produces the embryo sac and pollen grains in distinct, specialized structures. Usually, a single bloom will have both male and female components. Seasonal periods of the year when pollination conditions are optimal are when flowers and reproductive organs grow. The two pollen sacs seen in the anther are where pollen grains develop.

Specialized chambers are found in each pollen sac, where the microspore mother cells are contained and safeguarded. Four haploid microspores are created by the meiosis of the microspore mother cells. Four pollen grains are subsequently formed during mitotic divisions. A vegetative nucleus and a generative nucleus are both present in each pollen grain. Later on, the generative nucleus splits by mitosis to produce two male gametes.

The formation of vast amounts of pollen grains during the blooming season, which then flew into the air and caused allergies in people and animals, is a downside of pollen production. On the other hand, pollen grains are haploid and are employed in tissue culture to create haploid plants. Haploid plants are one of the most helpful tools for creating new and better types for the benefit of humans[1].

Arrangement of Anthers

Androecium, the male essential whorl, is found in most angiosperm flowers. Each stamen in this whorl has an anther visible at the upper end, and anthers have another lobes. The male gametophyte and microspores are both produced by Microsporangium. The mega sporangium, also known as the ovule, is where both the female gametophyte and the megaspores are formed. A normal anther has four elongated microsporangia, but as it matures, the partition between the two sporangia on each side dissolves, causing the two to merge into one. Early anther has a clump of uniform meristematic cells encircled by the epidermis. It quickly develops a modest four-lobed shape, with rows of hypodermal cells that may be identified as archesporium by their increased size, radial elongation, and more obvious nuclei in each lobe. The archesporial tissue's extent varies greatly both longitudinally and laterally. In a cross section of the anther, one archesporial cell or a plate of these cells may be seen in each lobe. In order to create a primary parietal layer and a primary sporogenous layer, the archesporial cells divide. The former cells divide along periclinal and anticlinal walls to produce a sequence of concentric layers, often three to five, which make up the anther wall. The original sporogenous cells either carry out their role as spore mother cells directly or go through further divisions to produce more cells[2].

Anthers of Monothecous and Dithecous

The stamen is a flower's microsporophyll and the male reproductive component. It is made up of filament and an anther. The filament has a long, thin stalk. It carries an anther distally and is joined proximally to a thalamus, petal, or tepal. The fertile portion of the stamen is the larger knob-like anther. Anthers are classified as monothecous or dithecous depending on whether they have one or two anther lobes. The two anther lobes are connected on the back by a sterile parenchymatous tissue known as connective, while being separated in the anterior area by a deep groove. A vascular thread is present in connective tissue. In monothecous stamen, connective is missing. While monothecous stamens are bisporangiate, dithecous anthers are tetrasporangiate.

Epidermis

A distinct common epidermis of the anther covers the outside of each microsporangium. At maturity, epidermal cells often stretch and shrivel off. The epidermis, which is the anther's outermost layer, only experiences anticlinal divisions. In order to keep up with the growth of the anther, its cells are considerably stretched and flattened. In many plants, particularly those that grow in arid environments, these cells ultimately lose touch with one another, leaving only their withering remnants visible when the plant reaches maturity[3].

Endothecium

The endothecium is the layer of cells just under the epidermis. It reaches its peak growth just as the pollen grains are ready to fall off. The cells enlarge radially, and from their inner tangential walls, fibrous bands rise, coming to rest just beyond each cell's outer wall. The fibrous thickenings happen as normal in aquatic plants with aerial flowers like Utricularia and Wolffia, but they don't develop and have no unique mechanism of dehiscence in many Hydrocharitaceae species and some cleistogamous forms whose flowers never open. The endothecium may not produce any fibrous thickenings in plants whose anthers open via apical pores, and dehiscence occurs here by the dissolution of certain cells at the apex of the anther. Another oddity in Erica, a representative of this kind, is that the "apical" pores are really basal. Other examples are Musa sesamum, Anona, and Ipomoea, which lack fibrous thickening but do have universal cutinization and lignification of the epidermal cell walls throughout the whole surface. Ditepalanthus and Balanophora are unusual in Oryza because during the formation of the anther, the parietal layers, which are one or two in number, get crushed and disordered. As a result, a fibrous layer is lacking, and the epidermis abuts the tapetum directly.

Center Layers

There are typically one to three layers of meristematic tissue just below the endothecium. Layers in the centre. When the microspore mother cells divide during meiosis, they are crushed and flattened. There are three to four intermediate layers in Holoptelea, with the outermost layer lasting the longest. The inner layer of the Ranunculus has two middle layers, of which the outer one lasts longer and sometimes develops dense protoplasmic cells that resemble those of the tapetum. In Gloriosa, the outermost middle layer develops fibrous thickenings comparable to those of the endothecium. In Lilium, there are numerous middle layers, of which those lying next to the endothecium remain for a long period. The intermediate layer is missing in Wolffia[4].

DISCUSSION

Smog Chambers

Angiosperm anthers are typically bilobed, with each lobe possessing two theca, or being dithecous. A longitudinal groove separates the theca throughout its length. The transverse segment of an anther clearly demonstrates the bilobed morphology of an anther. The anther is a four-sided structure with four pollen chambers, or microsporangia, that are each covered by two tapetum-like cells at the corners. These are filled with pollen grains and stretch lengthwise the whole length of an anther.

Structure and Use of Tapetum

Given that all dietary components entering sporogenous cells must pass through it, the innermost wall layer, or tapetum, is significant physiologically. The cytoplasm of tapetal cells is densely packed, and the tapetal nuclei themselves may divide briefly at the start of meiosis. Early botanists believed that the tapetum is produced by sterilizing the outer sporogenous cells due to the similarity in appearance and behavior between its cells and microscopic sporogenous tissue. But detailed developmental investigations have almost always supported its parietal genesis. It was formerly thought that the nuclear divisions in the tapetum were amitotic, but further research has shown that this is false and that the appearances of amitosis are really generated by mitotic abnormalities and nuclear fusions. According to current theories, a tapetal cell's nucleus may split in one of the following ways:

By free nuclear division: The mitotic division proceeds as usual, but there is no establishment of a cell plate. The cell's two diploid daughter nuclei are still present. Restitution nuclei are created in this process, and the chromosomes act properly up to the early stages of anaphase. Following this, one or more of them fail to split, resulting in the formation of chromosomal bridges that endure both throughout the telophase and the resting stage. As a consequence, a single tetraploid nucleus in the shape of a dumbbell develops, with the central region being either wide or narrow depending on the quantity of chromosomal bridges present[5].

Endomitosis: In this process, the nuclear membrane and nucleolus are both still in place and there is no spindle development. The chromosomes shorten and divide longitudinally, but the same nucleus, which now contains four chromosomes, remains intact. In a tapetal cell, the first nuclear division is often followed by further divisions. Nuclear fusions may occur along with some of the divisions, producing one or more massive polyploid nuclei. The latter might, however, split once again and produce smaller nuclei. It is not necessary to provide particular cases since this kind of activity occurs often in tapetal cells.

Oenothera rubricalyx haploid and diploid plants have been found to have an intriguing state. The tapetal cells are uninucleate in the former and binucleate in the latter, a difference that is undoubtedly connected to the overall shrinkage of tissues in haploid people. The considerable disparity in form and structure of the tapetal cells belonging to the same anther is harder to understand.

The tapetal cells on the inner side of the loculus in Lathraea, Salvia, and Moringa have a distinct radial elongation and are much bigger than those on the outer side. Additionally, in Lathraea, the cells closest to the connective are binucleate whereas those on the outside side are uninucleate. The tapetal cells of Lactuca sativa that are located on one side of the loculus may be binucleate, while those located on the other side may be quadrinucleate. Nearly usually, binucleate cells are shorter and wider than quadrinucleate cells. These variations may be caused by the different rates at which nutritive substances enter the cells[6].

Spherical Tissue

The microspore mother cells develop from the main sporogenous cells. In order for the primary sporogenous cells to directly serve as the microspore mother cells, some plants' sporogenous cells divide several times, whereas others only divide a few times or never at all. The emergence of sterile septa causes the microsporangia in several members of the Loranthaceae, including Dendrophthoe, Elytranthe, and Amyema, to become vertically partitioned. In Viscum, these partitions develop both in the vertical and horizontal planes. A few other plants are also known to form sterile septa. Each lobe of the anther in Quamoclit has a single row of sporogenous cells, but one or two of them lose the ability to keep up with the others and stop functioning. These result in the formation of two or three sterile partitions that divide the loculus. There may be less than four sets of sporogenous cells in certain plants.

The anthers are universally bisporangiate in the Malvaceae family, and the two loculi finally combine to produce a single loculus. There are two microsporangia in Elodea, Styphelia, Wolffia, and Moringa as well. These two microsporangia may subsequently fuse together as a result of the breakdown of the intervening cell layers. Najas' anthers are said to be unilocular, although the steps of development have not been clearly tracked. There are many grades of Vallisneria, ranging from a unilocular to a tetralocular state. Due to the presence of a sterile septum in the sporogenous tissue, typically two loculi develop. However, sometimes the septum is imperfect, leading to a unilocular state, and usually each of the two loculi gets divided into four loculi. The stamens of Piper betle are unusual in that from the moment the sporangia begin to develop until the anther is mature, the number of microsporangia in an anther may be four, three, two, or one. The sporogenous tissue does not fuse secondarily. A cross section of the flower in Korthalsella reveals six microsporangia organized in a ring. Korthalsella has three stamens, each of which is made up of two microsporangia[7].

Microsporogenesis

In the two pollen sacs present in the anther, pollen grains or microspores develop. Specialized chambers are found in each pollen sac, where the microspore mother cells are contained and safeguarded. Four haploid microspores are created by the meiosis of the microspore mother cells. Four pollen grains are subsequently formed during mitotic divisions. The vegetative nucleus and the generative nucleus are each found within a pollen grain. In a subsequent mitotic division, the generative nucleus splits into two sperms or male gametes. For some flower species, pollen grains have distinctive morphologies. Mother cells of microspores may undergo consecutive or simultaneous cytokinesis during meiosis. After the first meiotic division in the former, a cell plate is laid down, and after the second meiotic division, one is put down in each of the two daughter cells. On the other hand, in the simultaneous type, no wall is built up after the first division, and the mother cell splits into four pieces all at once when both meiotic divisions are complete. There is still another distinction in the cytokinesis process, according to research by C. H. Farr and others. The consecutive type divides the cell into two equal halves by centrifugally extending the cell plate on both sides from the center.

Contrarily, in the simultaneous type, the mother cell is often divided into four sections by centripetally progressing constriction furrows that meet in the middle. Farr conducted a thorough study of Nicotiana tabacum. The microspore mother cell's nucleus first becomes larger, and the mother cell wall initially thickens. Following Meiosis I, no cell plate is put down, and the spindle fibers from this division vanish during the metaphases of Meiosis II. For an explanation of the nuclear alterations in meiosis, the four daughter nuclei acquire a tetrahedral structure after being organized, and a spindle is reformed between every two nuclei. However, spindles are unrelated to the mother cell's quadripartition, and no centrifugally expanding cell plates are laid down, as is typical of other dividing cells. Instead, constriction furrows now begin at the perimeter and move inward until they meet at the center, causing the protoplast to divide into four cells—the microspores at the same time[8].

Vacuoles seem to have a prominent role in cytokinesis in Melilotus Following Meiosis II, hyaline patches seem to form between the four nuclei as a consequence of the denser cytoplasm migrating toward the nuclei and sap being extruded into the spaces between them. Small vacuoles that are produced in this way quickly join together to generate bigger ones, which effectively separate the cytoplasm into four masses. Now, the surface-originating furrows move within and quickly intersect the vacuoles. A thick coating of callose or some other gelatinous substance is secreted by the mother cell in the meanwhile. This layer moves inward with the cleavage furrows and finally completes the division of the mother cell into the four microspores. As an illustration of the successive kind of microspore development, Reeves researched Zea mays. Towards the equatorial area of the cell, towards the conclusion of Meiosis I, thickenings are generated on the spindle fibers. They enlarge progressively, come into touch with one another, and fuse to create the cell plate. The spindle's diameter continues to grow as new spindle fibers keep forming just beyond the plate's edge. In order to complete the splitting of the protoplast into two halves, the cell plate stretches centrifugally and connects to the mother cell's wall. Following the second meiotic division, a new partition wall forms in each cell similarly to how it did after the first meiotic division, creating a tetrad that displays the bilateral arrangement of microspores[9].

In general, monocotyledons tend to be sequential in type, whereas dicotyledons tend to be simultaneous in type. However, there is no absolute rule, and there are many exceptions. Thus, the simultaneous type is found in a few monocotyledonous families, namely the Iridaceae, Taccaceae, Juncaceae, and Dioscoreaceae, as well as several genera of the Liliaceae, Palmaceae, and Orchidaceae, while the successive type is found in a few dicotyledonous families, such as the Asclepiadaceae, Podostemonaceae, and Isobilateral tetrads in Magnolia are generated via furrowing rather than by cell plates.

After Meiosis I, a cleavage furrow begins to form, but its growth is stopped during the second meiotic division. At the conclusion of Meiosis II, it starts to develop again and creates a partition across the mother cell's equatorial area. The two dyad cells now split into four microspores as additional furrows start to form at the same moment at the periphery.

Tetraspore Spores

Microspores are often grouped in a tetrahedral or isobilateral pattern, however there are few exceptions. In many other plants, including Comas, Atriplex, Magnolia, and many more, a decussate arrangement of the cells has been seen. Mother cells divide transversely in several genera of the Asclepiadaceae and Hydrocharitaceae, resulting in linear tetrads.

Additionally, T-shaped tetrads may sometimes be seen in Aristolochia and Butomopsis. When meiosis occurs in the elongated microspore mother cells of Zostera, which measure 5 by 60 microns, they divide in a plane parallel to the longitudinal axis of the cell, producing a cluster of four filiform cells that continue to elongate and eventually reach a mature length of around 2000 microns. The fact that one species of Musa, Neottia, Agave, Habenaria, and Ottelia may exhibit two or three different dispositions is of particular importance. Occasionally, the microspore mother cell may divide and produce either less than four spores or more than four. The former state results from one division failing, or from the initial division producing a "restitution nucleus," or from an uneven wall development producing one binucleate and two uninucleate spores. The latter scenario, in which there are more than four spores produced, is often caused by lagging chromosomes that group together to create micronuclei[10].

However, these anomalies in the amount of microspores are often only seen in hybrids with a high level of sterility, and the pollen grains produced in this fashion are inert. However, in other plants, the microspores stick together in tetrads to create the so-called "compound" pollen grains, which often detach from one another after a short period of time.Several members of the Ericaceae, Apocynaceae, Asclepiadaceae, Juncaceae, and Orchidaceae may be used as examples, as well as Drimys, Anona, Drosera, Elodea, Typha, and Furcraea.

There are bigger units in the Mimosaceae family made up of 8 to 64 cells, and in a few genera of the Asclepiadaceae, all the microspores in a sporangium stay together to form a single mass known as the pollinium. In this context, the family Orchidaceae is of particular significance. The microspores in several genera, including Cypripedium and Vanilla, detach from one another and become free. In Pogonia, a complex pollen grain is created when a tetrad's four cells stick together. This tendency is further developed in the tribes Ophrydeae and Neottieae, where the complex grains are kept together by their own tiny massulae. Finally, all of the microspore mother cells and their offspring continue to develop as a single entity in Coelogyne and Pholidota[11], [12].

CONCLUSION

It is their responsibility to transport the twin sperm cells to the embryo sac where they will fuse with the egg and the central cell. The functional specialization of the male gametophyte and this twofold fertilization event are regarded as two crucial changes in the evolutionary success of flowering plants. The male gametophyte's first cell, the microspore, subsequently develops into a multicellular organism. The microspore splits into a prothallial cell and a central cell. Microsporogenesis is the process by which a diploid microsporocyte undergoes meiosis to divide into four haploid microspores.

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CHAPTER 20

DEVELOPMENT OF MALE GAMETOPHYTE

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ABSTRACT:

Male gametophyte development is sometimes broken down into two main stages: an early stage that includes microspore and bicellular pollen, and a late stage that includes tricellular and mature pollen. The transcriptome profiles of these phases reveal differences between them. The anther is where pollen grains male gametophytes develop. When specialized cells microsporocytes begin to differentiate in immature anthers, pollen formation may begin. Each microsporocyte, which often numbers hundreds or thousands, undergoes meiosis to create four haploid microspores.

KEYWORDS:

Cytoplasm, Gametophyte, Meiosis, Plasmalemma, Vegetative Cell.

INTRODUCTION

The initial cell of the gametophytic generation is the microspore. The microspore's nucleus splits mitotically during gametogenesis to create a larger vegetative cell and a smaller generative cell. The generative cell first adheres to the pollen grain's wall but eventually moves to the cytoplasm of the vegetative cell where it may move around freely. The microspore nucleus is moved from the cell's center to one side prior to the onset of pollen mitosis. At this point, the cytoplasm on the side of the vegetative cell that will be cut, between the nucleus and the wall, becomes heavily vacuolated. Two plasma membranes initially divide the cytoplasm of the generative cell from that of the vegetative cell. The generative cell's wall quickly forms in the space between the two cell membranes and adjoins the intine on both sides. Until the two ends of the wall meet and fuse and the cell is ultimately pinched off, the wall of the generative cell develops inward between the generative cell's plasmalemma and the intine. The generative cell's wall soon vanishes, leaving its cytoplasm encased in two plasm membranes: its own and the detached invagination of the vegetative cell's plasmalemma. After separating from the intine, the generative cell proceeds to a point where it is totally surrounded by the vegetative wall. The generative cell undergoes mitotic division to produce the sperm cells. The tapetum degenerates while the outer endothecial cells become fibrous in a mature anther. The dehiscence of the anther and release of the pollen grains occur at this stage. Either the pollen grains are tri- or bicelled when they are shed[1].

Generative and Vegetative Cell Formation

The vegetative and generative cells are produced during the microspore's first division. Geitler observed that the metaphase spindle often exhibits a strong asymmetry, with the free pole being sharp and the wallward pole blunt. According to studies, this asymmetry is related to how the prophase nucleus is formed. The asymmetry is quite prominent in Allium, where the nucleus is severely flattened on the wallward side; however, it is considerably less pronounced in

Pancratium, where it is only barely flattened; and Tradescantia has an intermediate state. The wallward or generative pole developed more slowly than the vegetative pole, perhaps due to the lesser volume of cytoplasm connected with the former, and this difference in development time has been credited as the primary source of the asymmetry. The asymmetry gradually lessens as the anaphase begins. The vegetative chromosomes create a slightly hemispherical pattern in the telophase, whereas the generative chromosomes are arrayed on a flat surface parallel to the inner wall of the microspore. Occasionally, symmetrical spindles have been seen. Asclepias and Anthericum both have blunt spindle poles, whereas Adoxa has more or less pointed spindles, and in Podophyllum, both symmetrical and asymmetrical spindles are claimed to occur in the same loculus, to name a few instances. Furthermore, the spindle is virtually the whole width of the pollen grain in Adoxa, Myricaria, Sambucus, Colylanthera, and Uvularia rather than being located close to the wall of the latter. The cells that come from division are always uneven, regardless of the circumstances, however it is unclear what causes this. The daughter cells of Cuscuta and Slrychnos may sometimes have the same size, which is plainly abnormal and results in the creation of twin microspores, each of which will divide several times to produce vegetative and generative cells. In Podostemon subulalus, double pollen grains made up of two units, each with its own generative and vegetative cells, have also been investigated[2].

Only one of the two pollen grains creates a pollen tube despite having pitted walls that separate them, with the other likely acting as a source of sustenance. It should be noted that unlike reduction divisions, which roughly coincide in all the microspore mother cells of an anther, microspore divisions typically occur independently, and the same loculus may exhibit various but closely spaced stages of division and development. All four cells of a tetrad, but not all the tetrads of an anther, are typically at the same stage of division in plants where the microspores stay together in a tetrad. Only when the microspores are combined into pollinia can a perfect synchronization be anticipated, since the cells there are likely to interact with one another through the uncuticularized walls that separate them. Even in these situations, however, there are exceptions. One microspore is in prophase, another has the tube and generative cells produced, while the other ones are in different intermediate phases, as shown in the pollinium of Acacia baileyana.

According to Goebel, the generative cell of angiosperms is permanently severed on the ventral side of the microspore. The generative cell may take a wide variety of shapes. Typically, it is elliptical, lenticular, or spindle-shaped, but in Cuscuta and Ottelia, it lengthens to the point where it fills the full pollen grain's width and is relatively near to the latter's inner wall on both sides. It is only accommodated in the pollen grain in Monochoria by the curvature of its whip-like ends, which is 1.5 times longer than the pollen grain's diameter. The two ends of Campanula ranunculoides are different, with one being pointy and the other being more or less blunt and swollen to resemble a "head." There have also been sporadic reports of generative cell shape alterations. But more often than not, these looks are only the result of the sectioning plane. When sliced straight across, a spindle-shaped cell seems round, and when cut obliquely, it looks oval. The cytoplasm of the generative cell may typically be distinguished from that of the vegetative cell in preserved material by its hyaline appearance and overall dearth of food components.

However, certain research on live pollen grains and pollen tubes have shown the existence of plastids and chondriosomes, as well as a vacuome and mitochondria, in the generative cells and sperm of Narcissus, Asclepias, Vinca, Crinum, and Lilium. The "colored bodies" Kostriukova referred to in live pollen tubes of Lilium martagon may also be mentioned. At each end of the generative nucleus, he saw two light greenish structures. These entities were discovered to divide and occupy comparable places in the sperm cells at earlier stages. In fixed material, they were undetectable, but little areolae that stained black with osmic acid were visible in their positions. Additionally, it is concluded that they most likely match the structures referred to as Golgi bodies, although more research is obviously required to validate this[3].

Starch and fat are the two most noticeable elements in the vegetative cell's contents. Long known as having different properties from fatty and starchy pollen, their potential ecological relevance has drawn a lot of attention. Luxemburg determined that the starch grains and fat bodies in the pollen grains of some Malvaceae species originate from plastids, and he theorized that these plastids themselves either develop from already existing plastids or from chondriosomes. When pollen grains are extremely young, their reserve food is nearly completely made up of fat droplets, and starch production doesn't start until the pollen grains have grown in size. Pollen grains and pollen tubes have also been shown to include some proteinaceous substances, however it is still unclear what exactly caused this. They most likely start off in plastids but quickly escape and end up in the pollen grain and pollen tube's overall cytoplasm[4].

Generative Cell Division

Either in the pollen tube or the pollen grain, the generative cell might divide. Though three-celled pollen grains have been documented in numerous genera recently, it appears probable that many of the earlier records were based on a study of immature pollen. Previously, it was thought that the second state was more common. The generative nucleus is already in the prophase stage and the process of division is only carried out in the pollen tube in those plants where the pollen grains are discharged in the two-celled state, according to a substantial amount of data. The only characteristics that separate a pro-metaphase stage from a conventional metaphase are the structure of the spindle and the delay in the disintegration of the nuclear membrane. The cleistogamous blooms of Viola, Dionaea, Circaeaster, Nicotiana, and Iris are just a few examples of plants that have sometimes been found to produce both two- and three-celled pollen grains, however this is likely the result of environmental factors.

In Holoptelea integrifolia, the generative cell splits on the stigma's surface before the pollen tube has even begun to form, yet the pollen grains are shed at the two-celled stage. Depending on whether the generative cell divides in the pollen tube or the pollen grain, different aspects of the process are involved. Spindle fibers and a typical metaphase plate have been consistently detected in the former situation, and the process does not seem to vary much from a typical mitosis. Cytokinesis, which causes the cell to divide into two halves, may occur either by a furrowing process, as in Juncus, or by the laying down of a cell plate, as in Asclepias and Portulaca. A distinct cell plate was initially put down in certain pollen grains, but it quickly withered away, leaving the ultimate sperm separation to an emerging constriction furrow. In other cases, the cell plate survived, and the constriction furrow's advancement was halted in this location even if it was visible on either side of it. Here, the cell plate split, dividing the generative cell before the constriction could advance very far. Understanding the process of the division when it takes place in the pollen tube has proven to be more challenging[5].

Vegetative Core

The vegetative nucleus, also known as the tube nucleus, was crucial in controlling the development of the pollen tube. But current data tends to suggest that its functional significance had been significantly overstated. The vegetative nucleus typically resides behind the male gametes rather than at the distal end of the pollen tube. When the tube splits into many branches, as it does in Aconitum, Cucurbita, and Papaver, each branch continues to develop for a noticeable amount of time even if only one of them has the vegetative nucleus. It degenerates in Ulmus, Senecio, Crepis, and Secale even before the pollen grains start to germinate and completely avoids entering the tube, yet the tube still functions correctly. In Musa and Senecio, it breaks into minute pieces that seem to be completely functionless, whereas it appears to break up and disperse into the surrounding cytoplasm in Chenopodium, Atriplex, and Salsola. The vegetative nucleus also takes on a highly unusual form in several other plants. For example, it increases in length relative to width in the pollen tubes of Viola odorata by 4 times, Cymbidium bicolor by 18 times, and Vallisneria Americana by 27 times. The extension is sufficiently severe in certain members of the Labiatae and in Nicotiana to give it a filamentous shape. Based on these and other information, the vegetative nucleus is regarded as a relic that serves no significant role in the development of the pollen tube. This viewpoint was investigated in Crinum pollen grains. It is said that shortly after forming, the vegetative nucleus enlarges and transforms into an amoeboid. Later, it shows that the chromatin has broken down. Thus, it serves no significant role in the pollen tube's life and is a degenerating structure. The traditional theory that the vegetative nucleus had a major role in the development and orientation of the pollen tube has to be modified, albeit further evidence would be useful. These tasks are likely really carried out by the generative cell's nucleus, followed by the nuclei of the two male cells produced by its division[6].

Cyperaceae's Pollen Development

All angiosperms, including dicotyledons and monocotyledons, typically follow the same pattern of development, with the family Cyperaceae being the one significant exception. One of the four microspore nuclei formed during meiosis grows further, while the other three are pushed to one end of the mother cell, according to research by Juel, Stout, Piech, and others. The spindle of the functional nucleus, which is located in the middle, splits with respect to the cell's long axis. A continuous plasma membrane develops as a result of the cell plate, which surrounds the generative nucleus and is positioned between it and the vegetative nucleus. The generative cell quickly splits into two spindle-shaped sperm cells.

DISCUSSION

Pollen Organization

Protoplasm and Pollen Walls

It often has a spherical form, although there are different shapes as well. 25 to 50 m is the diameter. Cellular contents are within and a very strong wall is on the exterior. Sporoderm is the name for the pollen grain's wall or outer layer. It has two layers: an inner layer and an exterior layer. Intine's composition is pecto-cellulosic. It sometimes includes enzymatic proteins. Exine is comprised of sporopollenin, a very resilient fatty molecule. A single enzyme does not break down sporopollenin. High temperatures, strong acids, or strong alkalis have little effect on it. Pollen grains are highly preserved as microfossils because of sporopollenin.

Exine contains proteins for enzymatic and compatibility processes in certain sites. Exine may be divided into inner endexine and outer ektexine. An inner continuous foot layer, a middle discontinuous baculate layer, and an outermost discontinuous tectum layer make up the remainder of ektexine. On the surface of the pollen grain, tectum creates distinctive sculptures or patterns, such as ridges, tubercles, spines, and reticulations. The ability to recognize the pollen grains and classify them by family, genus, or species may be helpful to specialists. Palynology is the study of the exterior morphology of mature pollen grains[7].

The exine of pollen grains produced by insect pollination is spiky and coated with a pollenkit, a viscous, sticky, and oily covering that is yellow in color. Lipids and carotenoids make up pollenkit. The exine is thin or nonexistent in certain areas. The sites could have callose buildup or thickened intine. They are also known as germinal furrows or germ pores. In general, pollen grains are monocolpate in monocots and tricolpate in dicots. Starch and unsaturated fatty acids are abundant in its cytoplasm. The latter guard against radiation damage to the chromosomes. When pollen grains are released, their protoplasts are initially uni-nucleate but later develop into 2-3 celled structures.

Viability of Pollen

It is the time frame within which pollen grains may still germinate. When flowers are pollinated while still in the bud stage, the pollen viability is poor. In Rice and Wheat, it takes 30 minutes. Others have lengthy viability periods, perhaps even months in certain members of the Leguminosae, Solanaceae, and Rosaceae families. However, it is dependent on the temperature and humidity of the surrounding environment. For use in plant breeding programs down the road, pollen grains may be stored for years in pollen banks using liquid nitrogen.

Pollen Embryo and Pollen Allergy

A disorder known as an allergy is characterized by a heightened immune system response to allergens. Pollen grains may behave as an allergen, which is a material from outside the body that may trigger an allergic reaction in certain individuals. Animal dander, household dust, feathers, and other foods are some more frequent allergies. Allergens from a broad range of plants, including trees, shrubs, grasses, grains, herbs, and less commonly flowers, may cause pollen allergies. A number of allergy symptoms are often brought on by airborne pollen grains. The majority of important pollens for allergy reactions are wind-borne and too tiny to be seen with the naked eye. If the pollen is clearly visible, it is often too big and heavy to be a significant allergy. Most wind-pollinated plants have dull, unnoticeable blooms[8].

Pollen Allergy Causes

In general, insects are needed to convey the abundant pollens of showy plants with vibrant, fragrant blooms. Tree pollens are the first to arrive in the Northeast in the spring. They start to show up around the middle of March and continue until June. The first pollens appear in April and are from maple, poplar, and ash. Birch and oak pollens may be seen in the air in late April, early May, and early June. Each kind of tree has a unique pollen production process, varying in pollination strength, length, and seasonal rhythm. People often notice their automobiles are coated with yellow pollen in the spring. From an allergy perspective, the big, waxy pollen discharged by pine trees is not very harmful. The fuzzy seed balls that are visible in the air in May and June do not worsen allergy symptoms.

Even light breezes may transport pollen kilometers and generate large concentrations in metropolitan areas, far from their rural and suburban origins, throughout the pollen season. It has been discovered that air purification by rainfall and precipitation duration correspond well. Utilizing air conditioning may significantly reduce the quantity of pollen in both the automobile and the space. Antihistamines sold over the counter may be beneficial, but they might also make you sleepy. Numerous non-sedating antihistamines are prescribed and accessible. There are medications that may help reduce symptoms, including anti-inflammatory nasal sprays, antihistamine nasal sprays, decongestant products, and eye drop solutions. Immunizations against allergies may significantly lessen sensitivity to pollen[9].

Major allergens such as grass pollen start to develop in late May. The peak of this season often occurs in June, after which there are generally modest quantities of pollen present all summer long. The bulk of grass pollen in the northeastern states originates from red top, blue top, orchard top, and timothy grass. Many folks at this time of year will refer to having "rose fever," a phrase that has been used for decades. Actually, grass pollen is the culprit at this time of year since rose pollen is too light to manifest symptoms. During the time when hay is being baled, which is from mid-August through September, ragweed pollen becomes airborne. Not hay but ragweed, which is pollinating in the late summer and early autumn, is connected with "hay fever." In our area,

Symptoms

Symptoms of a pollen allergy include runny nose and watery eyes. Asthma is often exacerbated by allergic reactions. Asthma and allergic rhinitis common symptoms. Not all of these seasonal ailments, however, are caused by pollen. Runny noses may occur in the autumn and spring due to the same rhinovirus that causes colds. It might be difficult to determine whether an allergy or a typical cold is to blame for these symptoms, but there are certain indicators that can assist. For instance, symptoms lasting more than two weeks point to allergens rather than allergies, and a fever points to a cold rather than an allergy[10].

Hay fever is really known as seasonal allergic rhinitis. The phrase "hay fever" is still often used even though it has been known since the early 1800s that pollen, not hay, is what causes the condition. The body's immunological reaction to inhaled pollen triggers allergic rhinitis symptoms, which include persistent inflammation of the eyes and nasal passages. A frequent and incapacitating illness called allergic rhinitis causes the following symptoms: People with allergic rhinitis are more likely to get recurrent sinus infections. Due to inadequate sleep, people with allergic rhinitis often feel tired. The quality of life may be significantly impacted by moderate or severe allergic rhinitis because it affects learning and performance in children, increases absenteeism and productivity in adults, and reduces productivity in adults. Eight out of ten asthmatics also have allergic rhinitis, which may make it more challenging to manage asthma. In addition, pollen may cause asthma. Asthma may be brought on by pollen. Some patients who suffer from moderate to severe allergic rhinitis think that their condition "turns" into asthma or causes them to wheeze or feel tight in the chest. However, allergic rhinitis and asthma may also be directly brought on by pollen. Small allergen particles may go far into the lung's airways.

Additionally, thunderstorms may be a factor in this:

Some individuals get allergic rhinitis and asthma from starch granules that are generated when pollen grains in touch with water because they are so tiny that may be inhaled into the airways. Anyone who wheezes mostly in the spring or summer should see a doctor for the best course of action. Several months might pass between pollen seasons. The kind of plant and its location both affect when pollination occurs. For instance, trees pollinate in the early spring and late winter. The next to bloom are the grasses, and the weed blooms from August to May. Additionally, there are more grass pollen particles in land regions since there are no physical obstacles to wind propagation there.

Controlling Factors Drugs:

The intensity of pollen allergy symptoms may be lessened with the use of several over-the-counter and prescription drugs. Sneezing, eye and nose irritation, and other allergic symptoms may be treated with antihistamines, which can be consumed or applied topically. Additionally, they lessen nasal stuffiness and, to a lesser degree, runny nose. Older antihistamines have a history of sleepiness, lack of coordination, and attentiveness as adverse effects. Newer, more efficient antihistamines have fewer or no negative effects.

Corticosteroids for the Nose

Nasal corticosteroid sprays are analgesics that reduce inflammation and reduce allergic responses. They are often regarded as the most successful form of allergy treatment and may lessen all symptoms, including nasal congestion. Nasal corticosteroids have fewer negative effects than oral or intravenous corticosteroids. Nasal antihistamines and nasal corticosteroids together tend to be more efficient than administering either spray alone. It is unclear, nevertheless, whether combining an oral antihistamine with a nasal corticosteroid is beneficial.

Decongestants

Nasal congestion is reduced through the use of oral and nasal decongestants, which assist to thin the lining of the nasal passages. Decongestant nasal sprays and drops are only meant to be used temporarily. These medications may cause significantly greater nasal congestion and edema when used for more than a few days. Antihistamines do not have a powerful decongestant effect, thus doctors may advise taking decongestants in addition to them[11].

Like pollen grains, pollen embryos or embryo sacs

Nemec observed in 1898 that pollen grains sometimes form huge eight-nucleate formations in the petaloid anthers of Hyacinthus orientalis that surprisingly resemble embryo sacs. He thought they emerged from three divisions of the vegetative nucleus and a degradation of the generative nucleus. Other kinds of Hyacinthus orientalis that had been treated to very specific circumstances in order to produce early blooming possessed this so-called "Nemec-phenomenon" in their anthers. He suggested that a duplication of the generative nuclei was the cause of the anomaly. Stow discovered identical pollen granules, or "pollen-embryo sacs," in the anthers of the "La Victor" cultivar, whose bulbs had been heated to 20°C. When meiosis began, they were further "forced" into a greenhouse. More thoroughly than Nemec or De Mol, he followed their progress. The microspores first grow larger to resemble huge sacs, and then the nucleus undergoes three sequential divisions to produce eight daughter nuclei.

These are distributed as follows: 3 at the intact exine end, 3 at the other end, and 2 in the center. While the remaining two fuse in the middle, the six nuclei at the two poles form into cells. Stow believes that the three cells at the exine end correlate to the egg and synergids and the three cells at the other end to the antipodals since the three cells at the exine end were shown to stay healthy for a much longer period of time than those at the opposite end. The following organizational kinds of a few aberrant pollen-embryo sacs were also observed. Stow claims that the divisions of the microspore nucleus rather than those of the vegetative or generative nucleus are what give birth to the pollen-embryo sacs. There are no pollen-embryo sacs generated once the vegetative and generative cells have differentiated, and subsequent development is perfectly normal. Stow hypothesized that the pollen-embryo sacs emit a "necrohormone" that causes the remaining pollen grains to develop abnormally since the pollen-embryo sacs were usually accompanied by a significant proportion of dead pollen grains. Stow also noticed that the pollen tubes made from the typical pollen grains of a different kind curled around the pollen-embryo sacs when they were put on an agar medium with them. A sperm nucleus was once seen on the verge of entering the pollen-embryo sac, while in another instance, the pollen-embryo sac displayed 16 nuclei that were thought to be the result of a triple fusion nucleus' separation into its component parts. Stow claims that all pollen grains have the capacity to assume either the male or female form. When necrohormones are released abnormally, the female potency takes control and leads to the formation of structures resembling embryos. Under normal circumstances, the "male potency" dominates the "female potency," resulting in the formation of the generative cell and male gametes[12]. After Stow, Naithani discovered pollen grains that resembled egg sacs in the cultivar "Yellow Hammer" whose bulbs had received early blooming treatment. He agrees with Stow's discoveries on the mechanism of growth of these aberrant pollen grains, but he thinks that temperature effects, rather than the release of necrohormones, are responsible for their formation. He contends that the hypertrophied development of the more favored pollen grains, which use all the available nourishment for their own growth, is the result rather than the cause of the other pollen grains' degeneration. More recently, the plant Orniihogalum nutans has also been shown to produce pollen-embryo sacs with 8 and 16 nuclei. Contrary to Stow, Geitler considers the three cells at the exine end of the pollen grain as the counterparts of antipodals and the other three as the equivalents of the egg and synergids. Those with eight nuclei had the characteristic embryo-sac-like arrangement.

CONCLUSION

Microsporogenesis is the process by which a diploid sporocyte undergoes meiosis and cytokinesis to produce four haploid spores. Tetrads come in a variety of shapes, including tetrahedral, tetragonal, decussate, rhomboidal, T-shaped, and linear. Each microsporocyte generates four microspores that are organized in varied patterns. The two patterns of simultaneous type and sequential type are recognized under the current typological standard for microsporogenesis. Each microspore undergoes microgametogenesis, a process in which the nucleus splits during mitosis to create a larger vegetative cell and a smaller generative cell. A trinucleate microgametophyte is eventually generated when the generative cell splits during mitosis and produces two male gametes. In terms of allergies, grass-related allergenic activity is present all year long, proving that aeroallergens persist outside of the pollen season. The amounts of airborne pollens may be a factor in allergy patients' symptoms. This information should be considered in the clinical and preventative care of allergic patients.

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CHAPTER 21

FEMALE GAMETOPHYTE MEGASPOROGENESIS AND MEGAGAMETOGENESIS: TYPES, STRUCTURE AND PROCESS

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ABSTRACT:

Megasporogenesis is the process by which diploid megaspore mother cells divide during meiosis to produce haploid megaspores, which later undergo megagametogenesis to produce haploid female gametophytes. The microspore is the second kind of spore. The functioning megaspore's nuclei split into two nuclei during mitosis and go to the other end. In order to create a 4 nucleate and subsequently an 8 nucleate embryo sac, two further mitotic cell divisions take place. The female gametophyte is generated after the eighth nucleate stage, when the cell walls are organized.

KEYWORDS:

Cells Divide, Embryogenesis, Gametophyte, Fertilization,Megasporogenesis, Mitosis.

INTRODUCTION

Students will gain knowledge of the anatomy and growth of ovules, which are the sites of megasporogenesis, embryo sac formation, fertilization, and embryogenesis, by studying this unit. Additionally, students will be aware of how different ovule types differ from one another in terms of their position inside the ovary, the quantity and thickness of integuments, the thickness of the nucellus, the direction and degree of curvature, etc. Students will also learn more about the processes known as megasporogenesis and megagametogenesis, which produce the megaspore and female-gametophyte, respectively. They will also learn about the several ways that the embryo sac develops and its structural makeup.

Ovule Structure

Ovules are crucial organs in flowering plants because they are the developmental forerunners of seeds. Their development may be linked to the first seed plants. Ovules of angiosperms differ in terms of their position inside the ovary, the quantity and thickness of integuments, the thickness of the nucellus, the direction and intensity of curvature, and histological characteristics. Ovules go through a unique developmental process, although their location in the ovary affects some of their structural characteristics, such as symmetry and curvature[1].

The basic structure of angiosperm ovules is a nucellus surrounded by two integuments. They might be connected to the placenta through the funiculus or be sessile. The chalaza, or the area just under the base of the nucellus where the integuments set out, is where a vascular bundle often extends from the placenta via the funiculus. As intercalary structures, the chalaza and the funiculus are less well defined than the integuments and nucellus. The nucellus is analogous to the megasporangium, where a megaspore mother cell undergoes meiosis and produces four megaspores, only one of which typically develops into an embryo sac. The megagametophyte is represented as an embryo sac. Depending on how many mitotic divisions have occurred in the developing embryo sac, it typically has four or eight nuclei that are organized into four or seven cells. The egg cell, together with two synergids, forms the egg apparatus, which also consists of three antipodal cells and a central cell with one or two nuclei. The inner or both integuments come together to produce the micropyle, a tiny opening through which a pollen tube passes to reach the nucleus. Pollen tube enters the nucellus and embryo sac via the micropyle and grows there before entering one of the synergids. Two male gametes are included in the pollen tube; one fertilizes the egg cell that develops into the zygote, while the other fuses with the nucleus of the central cell, resulting in the development of the endosperm. The center cell in traditional embryo sacs with seven cells integrates two nuclei, which merge to form a diploid nucleus, and the endosperm transforms into triploid. In angiosperms, it is the most prevalent kind of embryo sac.

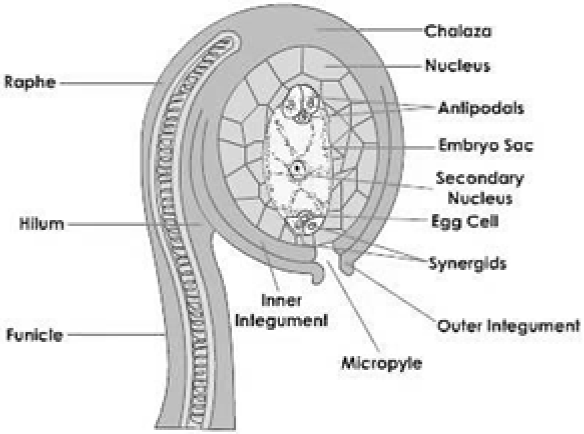

Figure 1: Structure of an Ovule.

Various Ova Types

Ovules may be categorized based on a number of factors. Size, degree of curvature, nucellus thickness, integument number and thickness, development of the micropyle, funiculus length, degree of vascularization of the ovule, and numerous histological differences are the key characteristics of ovule variety. Ovules in angiosperms are typically 0–5 mm length when they are fertilized. However, they may range in length from around 0 to 15 mm or grow to a size of more than 2 mm. The degree of ovule curvature varies. Ovules that are orthotropous and atropous are radially symmetric. Both anatropous and campylotropous ovules are curved, although the nucellus in the former is straight and contributes to the curvature in the latter. The ovules of hemitropous plants are hardly curled. Mirbel came up with the terminology "orthotrope," "anatrope," and "campulitrope" to describe the various degrees of curvature. Bent ovules may be asymmetric or monosymmetric depending on how they are twisted. Anatropous ovules are most likely primordial in modern angiosperms. In addition to orthotropous, anatropous, and campylotropous, additional types have also been established, however it is uncertain how significant they are in a systematic sense[2], [3].

The micropyle may be formed by any or both integuments. In other cases, the mature ovule lacks the micropyle, and nearby components may come into touch with the integuments or the nucellus. On the placentae in the carpels, ovules grow. They might be sessile or stalked. Stalk length varies as well. In the majority of ovules, a vascular bundle runs from the placenta via the funiculus and raphe to the chalaza. Vascular bundles also extend into one of the integuments in certain angiosperm clades with big seeds. On the other hand, some ovules only have a single, undifferentiated procambial strand or none at all. These ovules are often tiny or decreased.

DISCUSSION

Growth of the Ovule

Ovules are produced from the placenta of the ovarian wall, as previously mentioned. They serve as special structures for the megasporocyte production and are the locations of megasporogenesis, embryogenesis, fertilization, and embryo sac creation. Megasporogenesis and the creation of the embryo sac go hand in hand with ovule development. Ovule primordium creation is the first step in ovule development. The megasporangium, or nucellus, grows from the apical portion of the sporangium. A single subdermal nucellar cell that is below the apex of the nucellus swells shortly after the ovule is formed and has an obvious, sizable nucleus. There might be more than one archesporial cell. Both mustard and soybean include a multicellular archesporium, but only one of the archesporial cells generates the megagametophyte. It is yet unknown what controls the growth of the archesporium and determines the megasporocyte's identity[4].

The development of an anatropous ovule with a Polygonum-type embryo sac is depicted in stages. Ovules with one megasporocyte seen immediately after start (Figure A). Nucellus, please. Ovule following the initiation of both integuments. Meiosis I has occurred in the megasporocyte. The nucellus' axis is momentarily perpendicular to the funiculus' axis. Inner integument (ii) and outer integument (oi). Ovule after meiosis. The nonfunctional megaspores are defenerated, and the functional megaspore at the chasal end has grown. Due to uneven development, especially of the integuments, the axis of the nucellus is now parallel to the funiculus. Degenerate megaspores are dm. Following megagametogenesis, the ovary. Eight nuclei and seven cells make up the embryo-sac.

Megasporogenesis and Female Development

Gametophyte

Different plant species have very different patterns of embryo sac development. First, the process of megasporogenesis itself varies greatly. The four distinct megaspore cells often stop growing. Polygonum-type embryo sac formation has been seen in roughly 70% of plant species. In this arrangement, a functioning megaspore that is situated chalazally develops into an embryo sac. The spindle's orientation is parallel to the nucellus' micropylar-chalazal axis during meiosis-I of megasporogenesis. The formation of the cell wall is at an angle to this axis. Another transverse wall is created during meiosis-II division, resulting in four megaspores that are organized in a linear fashion. The adjacent megaspore to the chalaza is still operational. The three surviving megaspores deteriorate and are eventually trampled by the expanding, functioning megaspore. It is thought that callose is crucial in choosing a functioning megaspore. After megasporogenesis, callose is discovered in the walls of nonfunctional megaspores, while the walls of functional megaspores either have no callose or very little callose. Perhaps only the functioning megaspore receives nutrients from the nucellus thanks to the selective deposition of callose. Megasporogenesis' pattern is reflected in the pattern of callose deposition. For instance, in

Oenothera, where the functional megaspore is located, the callose is thinner near the micropylar end of the ovule. Meiosis does not include cytokinesis in tetrasporic species, and the single tetranucleate megaspore's walls do not retain callose[5].

Megagametogenesis is the process by which the female gametophyte is produced from the active megaspore. As previously mentioned, the functional megaspore at the chalazal end of Polygonum-type embryo sacs grows prior to three rounds of free nuclear divisions. The two nuclei travel to opposite ends after the first mitosis, and the smaller vacuoles combine to create a giant central vacuole. Before further divisions, the nuclei must be properly positioned, which depends on the formation of this central vacuole. There are then two further divisions of each of the two nuclei, culminating in the creation of four nuclei at each pole. A secondary nucleus with two nuclei is formed when one nucleus from each pole merges with the other in the embryo sac's center. At the micropylar pole, membranes wrap three nuclei. The cell in the center of the group enlarges and develops into an egg cell. The neighboring cells develop synergids. This trio of cells makes up the egg machinery. At the chalazal end, three antipodal cells develop. As the embryo develops, a sac containing 8 nuclei and subsequently 7 cells is formed.

Various Embryo Sac Development Types

Different stages of plant embryo sac development occur. The primary variations relate to the quantity of spore nuclei participating in embryo sac creation, the quantity of nuclear divisions occurring during megasporogenesis and embryo sac growth, and the configuration of nuclei in the final embryo sac. There are basically three different forms of embryo sac development:[6]

Type of polygonum:

Usually found in plants. But Polygonum provided the first precise description of it. As a result, it is also known as the polygonum type. In this form, the nucellus's sole functioning megaspore located towards the chalazal end is where the female gametophyte develops. Oenothera type: Oenothera develops monosporically, but the functional megaspore is situated near the nucellus' micropyle, and only four rather than eight nuclei form.

Allium or Bisporic Type

In Allium, meiosis I occurs in the megaspore mother cell, producing two haploid cells, one of which degenerates while the nucleus of the surviving cell performs meiosis II, producing a cell with two nuclei that migrate in opposing directions. These nuclei divide twice during mitosis to produce eight nuclei, which are organized to create an embryo sac of the polygonam type. Consequently, the bisporic embryo sac has 8 nuclei. There are several monocot and dicot groups that exhibit this kind of evolution[7].

Type Tetrasporic

Many times, meiosis does not occur concurrently with cytokinesis and cell wall production, and as a result, the typical separate megaspores are not generated. The embryo sac is developed by all four of the haploid megaspore nuclei. The following embryo sac might have 8 or 16 nuclei. As a result, the embryo sac is tetrasporic because it contains the nuclei of all four megaspores in a single cell. The tetrasporic embryo sac comes in a variety of forms, including the following: Plumbago species: The four megaspore nuclei assemble themselves into a cross-like shape in this kind. One is located at the chalazal end, while the other is at the micropylar end. At each side of the embryo sac, the other two are positioned. Once every nucleus splits. Four pairs of nuclei are created as a result. Each pair's nucleus travels one to the center, where they combine to create a 4n secondary nucleus. The egg cell is made up of the micropylar nucleus. The remaining three nuclei decay. Therefore, the mature embryo sac is devoid of antipodals and synergids.

Three of the four megaspore nuclei in this form of fritillaria move to the chalazal end, while the fourth nucleus remains at the micropylar pole. Two haploid nuclei are created when the micropylar nucleus splits in two. The two triploid nuclei are created when the three chalazal nuclei merge and divide once. Currently, the embryo sac has two triploid chalazal nuclei and two haploid micropylar nuclei, totaling four nuclei. Each nucleus splits later. As a result, the micropylar end forms four haploid nuclei while the chalazal end forms four triploid nuclei. From each pole, one nucleus moves toward the center. When they fuse, a tetraploid secondary nucleus is created. The nuclei near the micropylar end create the egg machinery, whereas those at the chalazal end give birth to antipodal cells.This is a scaled-down version of an embryo sac of the Fritillaria kind. In four megaspore nuclei, the arrangement is 1 + 3. To create the 3n nucleus, three chalazal nuclei combine. The embryo-sac now has two nuclei, one triploid and the other haploid. They both split to create a 4-nucleate stage. No more divide exists. While one triploid nucleus forms a single antipodal cell, a haploid micropylar nucleus organizes into an egg. The last two nuclei combine to generate a secondary nucleus that is tetraploid.

Penaea type: In this instance, there are four groups of four nuclei each made up of 16 nuclei total. In the embryo-sac, there are two groups on the sides and one group at each end. A polar nucleus is formed when one nucleus from each quadrant advances toward the center. Each quarter's three nuclei divide to become cells. As a result, there are four triads and four polar nuclei in this kind of embryo-sac. The micropylar triad's one cell serves as the egg. The only functioning cell is this one[8].

Drusa type: Following the development of four megaspore nuclei, one moves to the micropylar end while the other three go to the chalazal end. Twice each nucleus splits. As a result, the micropylar end produces four nuclei whereas the chalazal end produces twelve. From each, one nucleus moves toward the embryo sac's center. To create a secondary nucleus, they combine. Three nuclei construct the egg machinery at the micropylar end. Eleven nuclei form antipodal cells at the chalazal end.

Adoxa type: Although the growth of the megaspore mother cell is tetrasporic, in Adoxa, 8 nuclei are generated and these nuclei become organized like the typical type.The four megaspore nuclei in this instance split twice according to the peperomia type. It produces 16 nuclei. At the edge of the embryo sac, they are evenly dispersed. An egg and a synergid are formed by two nuclei at the micropylar end. To create a secondary nucleus, eight nuclei fusion. The rest of the nuclei remain on the outside edge of the embryo sac.Given the details of how different embryo-sacs develop, it is obvious that the final appearance of the female gametophyte may vary greatly. For example, the egg apparatus may only contain one synergid, the fusion nucleus may involve one or more than two polar nuclei, the number of antipodals may range from none in the Oenothera type to many, and so on.

Egg Cell

The zygote is created when the egg cell, which is located at the micropylar end, unites with the sperm nucleus. In between the two synergids is the egg cell. Egg cells are divided from synergids by the plasmalemma or by cell walls that are not complete. At the micropylar end of the egg cell, a sizable vacuole is present. As a result, the egg cell's cytoplasm is distributed unevenly. The majority of the cytoplasm and the nucleus are restricted to the chalazal end of a large vacuole.

Synergids

For fertilization, the synergids, which are located on both sides of the egg cell, are crucial. Before the sperm nuclei and the egg and central cells fuse, the pollen tube lets one of the synergids have its interior. Filiform apparatus is present in synergids. This is a structure that forms finger-like extensions into the cytoplasm of the synergid cell near the micropylar end of the cell wall.

Primary Cells

This cell is located in the center of the embryo sac, as its name indicates. It has several organelles, a large vacuole, and two polar nuclei. The formation of the polar nuclei occurs at the extremities of the embryo sac, and following cellularization, they travel to the middle. Before being fertilized by a single sperm nucleus, they may partially merge, creating a 3n main endosperm nucleus[9].

Agonal Cells

The chalazal end of the embryo sac contains these cells. They don't have a specialized role in reproduction, although it's thought that they help transport nutrients to the embryo sac. Numerous ribosomes and mitochondria may be found in synergids, central cells, and antipodals. It implies that they have active metabolisms. In contrast, the egg cell seems to be very dormant and contains few ribosomes, plastids, and other organelles.

Structure of the Embryo Sac

The vertical arrow on the left indicates the embryo sac's position in relation to the chalazal-micropylar axis of the ovule. The micropylar end, where the pollen tube enters the embryo sac, is home to the egg machinery, which includes the egg cell and synergids. Two nuclei may be seen in the central cell. The embryo sac's chalazal end contains three antipodal cells. The egg cell is really located next to the two synergids rather than in the middle of them. Keep in mind where the vacuole is located in the egg cell[10].

CONCLUSION

A haploid gametophyte and a diploid sporophyte alternate generations throughout the life cycle of terrestrial plants. Animal gametes are created immediately after meiosis, while plant gametes are not created until the multicellular haploid gametophyte has grown. The haploid generation's morphological complexity spans from the microscopic moss gametophytes, which dwarf the sporophyte, to the three-celled male and seven-celled female gametophytes that are typical of the majority of flowering plants. The latter is regarded as a crucial development in the evolution of flowering plants and arose via a drastic decrease from the female gametophytes of the gymnosperms, which sometimes contain over a thousand cells. The female gametophytes that are "stripped down to essentials" endow the blooming plants with two key distinguishing traits. They are initially tiny enough to fit within an ovary as a bundle. Second, they create two gametes that are doubly fertilized to form endosperm, a nutritive tissue that grows alongside the embryo and enables for more effective resource distribution to fertilized seeds. Because flowering plants have a smaller female gametophyte than gymnosperms, they can lay seeds considerably more quickly, enabling them to adapt to their habitats' short reproductive cycles and filling a variety of ecological niches.

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CHAPTER 22

POLLINATION, INTERACTION BETWEEN POLLEN AND PISTILS AND FERTILIZATION

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ABSTRACT:

From the moment pollen grains touch the stigma, a number of subtle and complex processes must be completed in order for fertilization to be successful. Pollen grains are fed by the nutritional components of the stigmatic exudate, which causes them to germinate. The pollen tubes that are created during this process pass through the stylar matrix to reach the ovary, find an ovule, and then emerge in the embryo sac where the sperm cells are released. These incidents represent the progamic phase, or interactions between pollen and pistils, together.

The zygote is created in the embryo sac when one of the two sperm cells fuses with the egg, and the major endosperm nucleus is created when the second sperm fuses with the diploid polar fusion nucleus. Although real fertilization is indicated by the union of the egg and the sperm, the term "double fertilization" refers to the occurrence of two fusion events involving both sperm cells. The principles of pollination and fertilization after completing this unit: introduction to the fundamentals of pollination in angiosperms multiple pollination vectors and pollination method types. The pistil's structure and function the method through which pollen tubes enter ovules and embryo sacs fertilization twice. In-vitro fertilization in angiosperms is self-incompatible.

KEYWORDS:

Angiosperms, Endosperm, Germinate Fertilization, Pollination.

INTRODUCTION

Pollen is applied to the stigma by the act of pollination. Pollen may be transported to the bloom by the wind, by animals, or it may even come from inside the specific flower. Self-pollination is the act of a flower's stigma being fertilized by its own anther's pollen. When pollen from one plant is transmitted to the stigma of a flower on another plant, cross pollination takes place. Pollen is often delivered by insects and other animals, but it may also be carried by wind or water. The pollen grain creates a pollen tube as it reaches the stigma, which descends through the style to the ovary. This makes it possible for male and female gametes within the ovule to mate.

This is what fertilization entails. In the embryo sac, the nuclei of the two male gametes unite. The egg is fertilized by one sperm, creating the zygote. In the center cell, the additional sperm fuses with the two polar nuclei to create a triploid nucleus. The endosperm, a seed component that stores nutrients, will develop from this substantial cell. Double fertilization refers to the joining of two sperm cells from the embryo sac that have separate nuclei. The occurrence known as triple fusion includes the fusing of polar nuclei to generate a secondary nucleus in the embryo sac and two fertilizations[1].

Pollination

Indirect pollination, which occurs when ovules are placed within the ovary and pollen falls on the stigma, occurs in angiosperms. Because the ovules of gymnosperms are bare, pollen falls directly on them, giving direct pollination its name. The following subtopics may be used to describe angiosperm pollination.

Early seed Plant Pollination

Early seed plants were pollinated by the wind in a passive manner. Similar to modern conifers, a lot of pollen was released and flown about, sometimes getting close to the ovules of the same species. For such a system to function well, individual plants of any particular species must grow relatively near to one another. Otherwise, there is extremely little likelihood that any pollen will reach its intended location. Most pollen carried by the wind goes little more than 100 meters. This tiny distance is important when contrasted to the large distances that many insects, birds, and other creatures regularly transport pollen.

Self-Pollination

All of the pollination techniques we have discussed so far have a propensity to result in outcrossing, which is both very beneficial for plants and beneficial for eukaryotic creatures in general. Nevertheless, angiosperms also self-pollinate, especially in temperate areas. The majority of plants that self-pollinate have tiny, hardly noticeable blooms that deposit pollen straight onto the stigma, sometimes even before the bud opens. If outcrossing is as crucial to plant genetics as it is to animal genetics, one could naturally wonder why there are so many self-pollinated plant species. Self-pollinated angiosperms are often found for two main reasons: Given that self-pollinators do not need animal visitation in order to generate seed, self-pollination is ecologically favorable in certain situations. Self-pollinated plants are able to flourish in environments like the Arctic or high altitudes when the sorts of insects or other animals that would visit them are missing or very uncommon because they need less energy to produce pollinator attractants[2].

In terms of genetics, progenies from self-pollination are more uniform than those from outcrossing. Keep in mind that recombination still occurs since meiosis is involved, therefore the progeny won't be genetically identical to either parent. However, such offspring may include a sizable percentage of people who are acclimated to a given area. Because it combines harmful recessive genes, self-pollination in typically out-crossing species often results in a large number of ill-adapted individuals; nevertheless, some of these combinations may be quite useful in certain settings. The plant may find it beneficial to continue self-pollinating indefinitely in such settings. Because people have standardized weed habitats and dispersed weeds globally, this is the major reason many self-pollinating plant species are weeds.Autogamy is the act of transferring pollen from an anther to the stigma of the same flower. It may be found in both chasmogamous and bisexual flowers, including clitogamous blooms. Geitonogamy: Geitonogamy is the transfer of pollen grains from an anther to a stigma between two blooms that are part of the same plant[3].

Implementations for Self-Pollination

Although it seems that nature favors cross-pollination, there are several situations when self-pollination is guaranteed. Unlike most flowers, which exhibit chasmogamy, the blossoms in these instances never open. The pollen of cleistogamous flowers is shed within the closed blossoms, making self-pollination necessary. The little, unnoticeable subterranean blooms of Commelina benghalensis exhibit cleistogamy. Additionally, this plant displays its typical chasmogamous blue blooms above. Chasmocleistogamous plants are those that produce both normal and cleistogamous blooms. Numerous rice types are also cleistogamous, meaning that pollination is finished before the flowers open since the anthers in them lose their pollen. Other plants that exhibit cleistogamy or chasmocleistogamy include Oxalis, Portulaca, Impatiens balsamum, and Viola tricolor.

Homogamy

Homogamy simply refers to a flower's stamens and carpels maturing at the same time, as opposed to dichogamy. Self-pollination is thus more likely, while it is not required. However, certain homogamous flowers exhibit unique self-pollination methods. In order to accomplish self-pollination in Mirabilis Jalapa, the filaments recoil as the stamens develop and move the anthers close to the stigma. Argemone mexicana has a few resemblances in its adaptations. Grewia subtnaequaus and others.

Dichogamous Flowers Displaying Self-Pollination Adaptations:

The mouth of the corolla tube is where the anthers are located in flowers of Ixora, Gardenia, Vinca, and other species. These already-ripe anthers are forced out through by the stigma as it lengthens from below, pollinating the flower as it does so. Protandrous flowers include Compositae. When the anthers of sunflowers mature and release the pollen contained in the tube, the bilobed stigma is still immature and concealed inside the syngenesious tube. Self-pollination is not feasible at this time since the stigmas' receptive surfaces are still developing and concealed. The bifid stigma pushes pollen out via the anthers in the second stage before emerging above. At this point, insects often play a role in cross-pollination. However, if cross-pollination is unsuccessful, it is seen that the stigma lobes fold back, allowing the receptive surfaces to come into contact with any pollen that is still on to its surface and be self-pollinated. Many agricultural crops spontaneously self-pollinate, as can be demonstrated in real farming. These include Corchorus capsularis, rice, wheat, barley, oats, potato, peas, and beans in addition to tobacco, linseed, and tomatoes[4].

Cross-Pollination

Cross pollination, also known as allogamy, is the transfer of pollen grains from the anthers of one flower to the stigma of another bloom within the same species. Chasmogamous flowers contain it. The following are cross-pollination-supportive vectors:-

Angiosperms with Wind Pollination

It is a hallmark of early seed plants that many angiosperms, representing a variety of diverse groupings, are wind-pollinated. Common plants including oaks, birches, cottonwoods, grasses, sedges, and nettles are among them. These plants have little, unscented, greenish blooms that lack corollas altogether. These blooms may hang down in tassels that swing in the breeze and discharge pollen freely. They are often gathered together in pretty big numbers. The blooms of many wind-pollinated plants, which comprise stamen and carpels, are dispersed among individuals or on a single plant. Separating the pollen-producing and ovule-bearing flowers ensures that pollen shed into the wind will always end up on a bloom other than the one that produced it, which dramatically encourages outcrossing. Some plants that are pollinated by the wind, particularly trees and shrubs, blossom in the spring before the growth of their leaves may obstruct the windborne pollen. The survival of wind-pollinated organisms is not reliant on the presence of a pollinator.

Animals Pollinating Flowers

Pollinators that visit the blooms of certain angiosperm species transport pollen from plant to plant, which has been crucial to the group's evolutionary success. Since insects and plants have coevolved for more than 100 million years, it is now apparent that the earliest angiosperms and maybe their progenitors as well were pollinated by insects. In addition, increasing floral specialization has resulted from these interactions. Flowers' interactions with certain animal species and bug species change as they grow more specialized.

Insects that pollinate include bees

The groupings of insect-pollinated angiosperms with the greatest diversity are those that are bee-pollinated. Like the majority of insects, bees first discover food sources by odor before orienting themselves toward a bloom or cluster of blossoms based on form, color, and texture. Bees often visit flowers that are blue or yellow in color. Many of them feature stripes or lines of dots that show where the nectaries are, which are often found in the throats of specific flowers. Some bees gather nectar, which is sometimes utilized by larvae as well as adult bees as a food source. The majority of the 20,000 or so species of bees visit flowers to collect pollen. In cells where bee larvae finish developing, pollen is utilized as food. There are just a few hundred species of bees that nest in social or semi-social arrangements. Similar to the well-known honeybee, Apis mellifera, and the bumblebee, Bombus, these bees live in colonies. Such bees must change their focus as the season passes to various types of flowers since they generate many generations every year.

They also need to utilize many types of flowers as a food supply at any one moment in order to sustain huge colonies. The vast majority of bees at least 18,000 species are solitary, with the exception of some sociable and semi-social bees and roughly 1000 parasitic species that live in other bees' nests. In temperate areas, it is typical for solitary bees to have only one generation every year. They often spend just a few weeks a year active as adults. Solitary bees often rely nearly entirely on the blooms of a particular assemblage of plants for the nutrition of their larvae. Since these bees and those flowers have such enduring interactions, both the blooms and the bees may change over time. The bees' mouthparts may lengthen in proportion to tubular flowers, their pollen-gathering tools may become suited to the pollen of the plants they often visit, or the time of day when the flowers open may correspond with the bees' appearance. When these connections are made, the flowers are effectively pollinated, and the bees that "specialize" in flower pollination have a steady supply of food[5], [6].

DISCUSSION

Insects that visit flowers other than bees fall into a few distinct categories. Frequently frequented by butterflies, flowers like phlox offer flat "landing platforms" where butterflies may perch. They also often possess long, thin floral tubes that are full of nectar and reachable by the long, coiled proboscis typical of the order of insects known as Lepidoptera, which includes butterflies and moths. Jimsonweed, evening primrose, and other flowers that are often frequented by moths are frequently white, yellow, or another light hue. They also frequently have strong scents, which makes them simple to find at night.

Birds Pollinate Flowers

Birds often visit and pollinate a number of fascinating plant species, including the hummingbirds of North and South America and the sunbirds of Africa. Such plants must generate a lot of nectar since birds will stop coming to the plant's blossoms if they cannot find enough food to sustain themselves. Insects have no benefit when they visit flowers that produce enormous quantities of nectar since an insect might meet all of its energy needs at a single blossom and wouldn't cross-pollinate it. How can flowers that are "specialized" for hummingbirds and sunbirds handle these many selecting forces? For insects, ultraviolet light is quite apparent. The pigments known as carotenoids, which are widely present in plants, give many flowers their distinctive hues, including mustard and sunflowers.

Carotenoids reflect in both the yellow and ultraviolet ranges, combining to produce the unusual hue known as "bee's purple." Such yellow blossoms may also include identifying markings that are often undetectable to humans but very noticeable to bees and other insects. These markers may take the shape of a landing strip or a bull's-eye. For the majority of insects, red does not stand out as a distinctive hue, but for birds, red is a highly noticeable color. Poinsettias' crimson top leaves seem to most insects to be identical to the plant's other foliage. As a result, insects prefer to avoid the blooms even though they generate copious amounts of nectar and attract hummingbirds. As a result, the red hue both alerts birds to the presence of plentiful nectar and renders that nectar as unnoticeable to insects as possible. Fruits that are spread by birds also display red once again[7].

Various Animals

Bats, snails, and tiny rodents are a few more species that might help with pollination. Here, too, there are species-specific signals. The seeds and fruits that are produced as a consequence of pollination are also distributed by these animals. Orange and yellow fruits will effectively disperse thanks to monkeys' attraction to them.

Cross-Pollination Mechanisms

Cross-pollination seems to be preferred by nature over self-pollination. What so strongly intrigued Darwin was a study of this predilection on the side of Nature? Cross-pollination occurs spontaneously in all unisexual flowers and a significant portion of bisexual blooms. The following special mechanisms for guaranteeing cross-pollination stand out sharply:

Dicliny

When it comes to diclinous plants, or those with unisexual blooms, cross-pollination is the norm. Nothing else is possible with dioecious plants. Geitonogamy is the sole option for monoecious plants, yet it has the same result as self-pollination.

Self-Sterility

When a flower cannot be fertilized by pollen from another flower of the same species or, sometimes, from another flower, this situation exists. If an orchid is pollinated by its own pollen, part of its blooms may wither. Due to genetic factors, many Solanum and tea plant species are self-sterile. In such plants, cross-pollination is necessary.

Dichogamy

Ineffective pollination occurs when the stamens and carpels of a bisexual flower develop at separate periods. However, it is sometimes discovered that if cross-pollination is unsuccessful, self-pollination may occur at a later stage. Dichogamy comes in two varieties:

Protandry:

In most Compositae, many Umbelliferae, Malvaceae, etc., the anthers mature first. Because of this, when an anther bursts, it pollinates other flowers' stigmas but not its own, which is still developing. In several species of the Annonaceae and Magnoliaceae, as well as in Arum maculatum, the carpel develops first. It must rely on outside pollens since the stigma is responsive and its own pollen is not mature.

Herkogamy:

A physical barrier between the anther and the style in certain flowers may make it difficult or even impossible for pollination to occur between them. Many Cruciferae and Caryophyllaceae have stigmas that extend much beyond the stamens, making it unlikely that pollen from the latter will get to the former. Gloriosa's extrorse anthers split open the anthers far from its own stigmas. Where pollen is gathered in pollinia, as as in Calotropis and orchids, pollination is totally dependent on insects.

Heteromorphism:

Some plants have blooms that come in two or three distinct forms, each with a different arrangement of anthers and stigmas. Beterostyly and heteroanthy are often involved in this dimorphism or trimorphism. One fascinating example of dimorphism may be seen in the primrose (family Primulaceae). The stigma is at the entrance and the anthers are positioned deep inside the corolla tube in the first version. This type's stigma papillae are bigger and pollens are smaller. In the second form, the stigma is buried deep within and the anthers are situated near the entrance. Additionally, the stigma papillae are smaller and the pollens are bigger in this instance. Due to the different lengths of these insects' organs, different kinds of insects traveling around these flowers would naturally contact floral organs at the same level, resulting in cross-pollination between low anthers and short styles. Pollens and stigmas with comparable luxuriance and growth will be included. Jasmine and other sweet-scented flowers of the Oleaceae family, Linum, Fagopyrum of the Polygonaceae, etc. also exhibit this dimorphism. Trimorphism is seen in several Oxalis, Linum, and Lythrum species. There is cross-pollination involving three heights because the three different flower types have anthers and stigmas in three different places. Tischler claims that altering diet may affect disorders that are dimorphic or trimorphic[8].

Human pollination

When natural or open pollination is inadequate or unfavorable, mechanical, human, or artificial pollination is a method utilized. For instance, the Cucurbitaceae family has poor pollination and low maturity. Small market gardeners employ anthrophily in these situations as a superior alternative. This straightforward procedure involves collecting pollen from male flowers using a brush, cotton swab, or forceps and applying it to the stigma of female flowers of the same species. Male flowers sometimes have their corollas removed, and the bloom is then rubbed against the stigmas of female flowers.

Pistil's Structure and Function

Pollen and Pistil Interactions

Pollen and stigma maturation parameters are implicated in the development of reproductive function, according to a developmental examination of pollination responses. In the pistil, the capacity to sustain pollen germination and tube formation extended throughout a large developmental window, and pistils during anthesis showed plentiful as well as effective pollen tube development. On the other hand, pollen tube development on immature pistils was seen to occur with poor efficiency, slower growth rates, and no discernible orientation. Temporally controlled signals coming from specialized cells of the pistil are assumed to be active in each of the four phases of pollen tube formation based on the pattern of pollen tube growth at various stages of pistil maturation. These signals guided the course of intra-specific pollen tubes as well as pollen tubes in the stigma and the stylar transmitting tissue. Contrarily, in the ovary, the ovule's communication was limited to intra-specific pollen tubes, which was why it was determined that this was the cause of inter-specific incompatibility. In addition, it was discovered that the development of reproductive function included a hitherto unknown developmental constraint in the ability of the flower's epidermal surfaces to support the creation of pollen tubes.

Pollen Emergence

The enlargement of the pollen grain by liquid absorption from the wet stigma surface and the emergence of the intine through a germ hole is the first stage of germination. The little tubular structure that develops in this manner then keeps growing, moving along the stigma and style tissues. Only the distal section of the tube is alive with cytoplasm, and when the nuclei move forward, the empty spaces behind them are filled with callose plugs. Some pollen grains, including those of the Malvaceae, Cucurbitaceae, and Campanulaceae, are polysiphonous, although the majority of pollen grains are monosiphonous, meaning that only one pollen tube emerges from each pollen grain. It is reported that 10 tubes in Althaea rosea and even 14 tubes in Malva neglecta may emerge from a single pollen particle. However, only one of them ultimately advances farther. The single pollen tube may sometimes split into one or more branches.

The Amentiferae, where the branching tubes resemble a proliferating fungus mycelium, seem to be prone to this disease often. Several pollen tubes are formed simultaneously in plants whose pollen grains are organized into tetrads or pollinia. Pollen germination is thought to be significantly influenced by the stigma, however in many plants, germination may also be triggered in an adequate sugar solution. Trifolium pratense pollen on a hog's bladder that had been soaked with distilled water revealed that the stigma's only function is to regulate the water flow. According to this theory, the stigmatic secretion's main purpose is to prevent pollen and the stigma from drying out. In her tests, the stigmatic secretion was applied to the stump and the latter was kept wet for a while, allowing the pollen to germinate even on the style's cut surface[9]. Other than the stigma, pollen grains may also germinate on other regions of the flower. Germination occurs in the anther loculi of cleistogamous flowers and, in the case of Aeginetia indica, even on the wet corolla tube surface. Pollen grains often germinate on foreign stigmas, especially stigmas from distinct species. In the event that fertilization occurs, interspecific and intergeneric hybrids are created.

The Pollen Tube Course

The tube enters the tissues of the style after emerging from the pollen grain and passing via the stigmatic papillae. The latter's length varies greatly. In certain plants, the stigma is so little that it is referred to be sessile, while in Zea mays, the so-called "silk" may grow as long as 50 cm. Styles have been divided into three basic categories named open, half-closed, and closed depending on the presence or absence of the transmitting tissue and the degree of its development. As in the Papaveraceae, Aristolochiaceae, Ericaceae, and many monocotyledons, the first kind has a broad stylar canal and the inner epidermis acts as the pollen tube's nutrition and conductor. Similar to numerous Cactaceae members, the second kind of canal is bordered by a crude transmission tissue made up of two or three layers of glandular cells. The pollen tube develops downhill via a solid core of long, densely protoplasmic cells in the third or closed form, which is exemplified by Datura and Gossypium, in place of an open channel. Finally, there are other plants with solid styles but no particular transmission tissue, including Salix, Acacia, and several grasses. The pollen tube develops in solid styles through the intercellular spaces between the cells of the transmitting tissue, enlarging the spaces by the hydrostatic pressure of its contents and secreting some enzymatic substances that cause a dissolution of the middle lamellae. In open styles, the pollen tube develops on the surface of the cells lining the stylar canal. The pollen tube seldom passes directly through the cells.

Pollen Tube Entry into Megasporangium

The tube may enter the ovule via the micropyle or a different opening after reaching the apex of the ovary. The former is the norm and is referred to as porogamy, although even in plants that are often categorized as porogamous, there are a number of variants. In Acacia, the integuments are still below the apex of the nucellus at the time of fertilization, preventing the formation of a micropyle; in Philadelphus, Utricularia, Vandellia, and Torenia, the embryo sac protrudes out of the micropyle, coming into contact with the pollen tube. There is no integument, and hence no item that can be referred to as a micropyle, in a number of members of the Loranthaceae family. Here, the embryo sacs experience an extraordinary extension and eventually meet the pollen tubes in the stylar area.

The path the pollen tube took as it entered the ovule used to be given significant phylogenetic significance, but this point is now considered to be of physiological rather than phylogenetic importance because we occasionally find significant variation in this regard even within one and the same species. The tube often enters Brassica oleracea by the micropyle, although it might sometimes do so through the chalaza. Shattuck describes the branching, seemingly arbitrary meandering of Ulmus through the funiculus, integuments, and even the nucellus. Although the tube enters the body via the micropyle in Boerhaavia, it first travels horizontally through the funiculus. In Gossypium, it often moves from the funiculus to the base of the ovule before moving up the ovule's wall and into the micropyle[10].

The so-called obturator, which Hofmeister had earlier mentioned in the year 1849, is a particular organ that facilitates the passage of the pollen tube into the ovule. Usually, the placenta swells in the direction of the micropyle and fits over the nucellus like a hood or canopy, acting as a type of bridge for the pollen tube. The obturator's cells are often significantly enlarged or may resemble glandular. The word "obturator" may also be used to refer to several additional structures with a different origin but the same function. In the Thymelaeaceae, the cells at the stylar canal's base enlarge and descend as hairy processes that reach the nucellus.

Coming into close proximity to the latter. On the other hand, in Myriocarpa and Leucosyke, the inner integument cells lengthen upward and enter into the stylar canal to produce what is perhaps an integumentary obturator. The cells lining the micropylar canal are mostly unaltered, but sometimes, as in Berkheya Grevillea and Cynomorium, they become mucilaginous or glandular and seem to contribute to the pollen tube's feeding. In Cardiospermum, a mucilaginous mass that promotes the entrance of the pollen tube is produced by both the cells that make up the apical region of the nucellus and those that belong to the inner integument. In plants like Beta that have a multi-layered nucellar tissue, the cells that are in continuity with the micropyle become elongated and rich in protoplasm, giving the appearance that they were created with the pollen tube's route of least resistance in mind. It's interesting to notice that the pollen tube often moves between the cells, not through them, even when it passes through the nucellus. However, in a few families, including the Lythraceae, Sonneratiaceae, Onagraceae, and Cucurbitaceae, the tubes are so broad that they destroy the cells that get in their way and result in a permanent break in the tissues. In most families, it only slightly disturbs their position, and they quickly return to their original shape.

Pollen Tube Entry into the Embryo Sac

The pollen tube may enter the embryo sac wall, as in Cardiospermum, the embryo sac wall and a synergid, as in Fagopyrum, or it may enter the synergid directly, as in the case of Oxalis Elodea and Daphne. In Viola, it allegedly pushes through the base of a synergid in addition to entering one. Normally, only one synergid is killed when the pollen tube strikes it, and the other one survives until thereafter.

However, in the cases of Mimusops, Achras, and Bassia, both are destroyed, whereas Phryma and Tropaeolum seem unaffected. Synergids degenerate in certain genera, including Tacca, Wormia, and Nelumbo, even before the pollen tube enters the plant, while they never develop in others, including Plumbago, Vogelia, and Plumbagella. This tends to suggest that they are not necessary for fertilization, and the idea that they emit chemicals that have chemotactic effects on the pollen tube or that they serve as shock absorbers against their impact is unfounded.

Pollen tubes from Zauschneria latifolia were discovered to penetrate even ovules with embryo sacs that were almost completely deteriorated. There is a dearth of specific knowledge on the precise process by which the male gametes are released. The pollen tube tip "wedges in" between the egg and the polar fusion nucleus in Crepis capillaris and Taraxacum koksaghys, causing both male gametes to discharge near their partners. In certain Peperomia embryo sacs, Fagerlind observed that the tube tip had split into two little branches, one of which was pointed in the direction of the egg.

Cooper suggests that the two male gametes travel along these distinct branches because of a similar bifurcation of the pollen tube tip in Portulaca, Phryma, and Petunia, where one branch becomes closely appressed to the egg and the other extends in the direction of the polar nuclei. The pollen tube of Coffea arabica does not divide into two halves; instead, it has two subterminal apertures via which the two male gametes are released into the embryo sac's cavity.

CONCLUSION

Events leading up to fertilization begin as soon as the pistil recognizes and accepts the suitable pollen. The pistil rejects the pollen that is incompatible, preventing fertilization from taking place. The pollen grain emits chemicals as it approaches the pistil, which the pistil recognizes.

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CHAPTER 23

DOUBLE FERTILIZATION

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ABSTRACT:

In the process of double fertilization, one of the two pollen nuclei unites with the polar nucleus and the other with the egg. As a result, there are two different types of fusion: triple fusion and fertilization. Thus, double fertilization is the term used to describe fertilization in an angiosperm. When a sperm and a female engage during sexual contact, an egg is created and deposited in the female's uterus, resulting in fertilization. The sperm enters the fallopian tube, passes through the ovum's zona pellucida layer, and combines with the egg to create the zygote.

KEYWORDS:

Angiosperms, Double Fertilization, Embryo Sac, Fusion, Zygote.

INTRODUCTION

Discovery of Double Fertilization

It is possible to trace the unmistakable evidence for the real fusing of the male and female gametes involved in fertilization in blooming plants to a monographic publication by Strasburger. The majority of this research was focused on the nuclear cytology of pollen grains and pollen tubes from a wide variety of plant families, as well as the fate of male gametes delivered by pollen tubes in the embryo sacs of Gloxinia hybrida, Himantoglossum hircinum, Orchis latifolia, and Monotropa hypopitys. On M. hypopitys, the most comprehensive, illustrative details were given, in which it was shown that one of the two male gametes transported by the pollen tube merged with the egg's nucleus. Male gametes were then referred to as generative nuclei, and it wasn't known whether they were actual cells or just bare nuclei. The discovery that a male gamete bonded with the egg during fertilization, however, was in opposition to the perplexing earlier finding that this action was facilitated by the diffusion of the pollen tube's cytoplasmic contents. Despite the fact that Strasburger's research established the embryo as the result of fertilization, understanding the fate of the second male gamete released by the pollen tube and the endosperm's origins remained significant obstacles to gaining a thorough understanding of the dynamics of fertilization in angiosperms[1].

The first evidence of double fertilization was presented by S. Nawaschin in Russia, who demonstrated that both male gametes from the pollen tube penetrated the embryo sac in ovules of Lilium martagon and Fritillaria tenella. While one of them fused with the nucleus of the egg cell, the other fused with the polar fusion nucleus floating in the central cell, resulting in a second fertilization event. The outcomes of this experiment were verbally presented on August 24, 1898, to the botanical section of the "Naturforscherversammlung" in Kiew, Russia. The abstract of this research was published the following year, and a few months later, the whole paper was published. Therefore, Nawaschin deserves to be given the utmost credit for discovering the two fusion processes that take place during fertilization in flowering plants. L. Guignard in France independently verified the occurrence that Nawaschin had found in Lilium pyrenaicum and L. martagon. On April 4th, 1899, the Academy of Sciences in Paris received a communication on this work, which was immediately published in its report. The exact identical work was also published in another journal in the same year with a footnoted reference to the prior study with volume number and middle page number. The work detailed in these two articles, which also cited Nawaschin's 1899 abstract, was supported by a number of line-drawn graphics illustrating the two fusion occurrences. The second sperm fuses with the upper polar nucleus in a precise two-step sequence of events that is followed by the integration of this fusion result into the lower polar nucleus, according to Guignard's explanation and illustrations. Within a few months following the publication of Guignard's publications, E. Sargant in England reexamined previously produced slides of fertilized ovules of L. martagon, providing complete confirmation of the surprising finding of fusing of the second sperm with the polar fusion nucleus.

Because of the relatively large size of the embryo sac and its equally obvious nuclei as seen in microscopic preparations of ovules of these two genera, it is not surprising that researchers working in three European countries chose ovules of species of Lilium and Fritillaria as the classic experimental system in these pioneering studies. Slides showing the development of embryo sacs in different Lilium and Fritillaria species have become common in the teaching of general plant biology because of this and other benefits. Species of these genera have also become favorites of subsequent researchers because the development of embryo sacs in these species appeared to be a simplified version of a complex series of nuclear fusions and divisions that did not have analogs in other plants studied. Guignard, in an apparent act of vision, used the terms "double copulation" in the titles of the first two works and "Double Fecondation" in subsequent publications to refer to the two fertilization events that take place at the beginning of the sporophytic phase in flowering plants. The above-mentioned researchers also came to the correct conclusion that the endosperm is produced by the fusion of the second sperm with the polar fusion nucleus.

The endosperm is typically composed of cells with chromosomes of biparental origin from the coalescence of three nuclei, dispelling the common belief that the endosperm was generated by the fusion of the two polar nuclei. The discovery of double fertilization in the liliaceous species, and the confirmation of its occurrence in many other angiosperms, including both monocotyledons and dicotyledons, within a period of just over a year for example, additional species within the Liliaceae such as Fritillaria meleagris, Scilla bifolia, Lilium candidum, Tulipa celsiana, Tulipa gesneriana, and Tulipa sylvestris ; Himantoglossum hircinum, Orchis latifolia, Orchis maculata, and Orchis mascula of the Orchidaceae; Erigeron philadelphicus, E. strigosa, Guizotia oleiflora, Helianthus annuus, Heliopsis patula, Rudbeckia grandiflora, Rudbeckia laciniata, Rudbeckia speciosa, Silphium integrifolium, Silphium laciniatum, S. terebinthinaceum, and Spilanthes oleracea of the Asteraceae ; Hibiscus trionum of the Malvaceae; Anemone nemorosa, Caltha palustris, Clematis viticella, Delphinium elatum, Helleborus foetidus, Nigella sativa, and Ranunculus flammula of the Ranunculaceae; Reseda lutea of the Resedaceae; Juglans sp. of the Juglandaceae, and Monotropa hypopitys of the Pyrolaceae[2], [3].

Universality of Double Fertilization in Flowering Plants

The momentum created in the waning years of the nineteenth century to establish double fertilization as a ubiquitous feature in the reproductive biology of flowering plants was followed by a sustained effort in the twentieth century leading to the discovery of this phenomenon in additional members of the Ranunculaceae, Liliaceae, Juglandaceae, and Pyrolaceae , as well as in plants belonging to Poaceae, Najadaceae, Solanaceae, Gentianaceae , Asclepiadaceae , Brassicaceae , and Ceratophyllaceae . In their seminal work on the "Morphology of Angiosperms," Coulter and Chamberlain and Guérin refer to 16 families of angiosperms, encompassing about 40 genera and over 60 species that are positively known to have undergone a second fertilization event. These two publications reviewed the literature up to the end of 1902. From that point forward, the occurrence of multiple fertilization was acknowledged as a common characteristic of the reproductive biology of angiosperms, together with the existence of a reduced female gametophyte and embryo-nourishing endosperm. In fact, under this supposition, there were only sporadic mentions of double fertilization in the numerous works on the diversity and variability of reproductive processes in flowering plants, with special reference to their embryogenesis and endosperm development, that have been published from the early 1900s to the present. The earliest images of twofold fertilization in a number of plants, including cotton, maize, barley, spinach, and Plumbago zeylanica, were first seen during this time period, however[4].

Gametic Fusion

One male gamete fuses with the egg, and the other with the two polar nuclei, after the pollen tube has released its contents into the embryo sac. There haven't been many thorough explanations of the process published up to this point because of the technological challenges associated in studying it. It is difficult to "catch" the material at the proper stage since the gametic fusions take place over such a little period of time. Since the embryo sac is often big enough at this time to run into numerous sections and thick sections do not stain adequately, there is also a chance element involved in getting good median sections. Besides, even if the material has been carefully chosen and the relevant phases are truly at hand, extensive observations may still prove problematic for the following reasons: The embryo sac that envelops the egg is extensively stained by a substance released by the pollen tube, making the egg less visible. At this point, one or both synergids disorganize, and their contents are transformed into a sticky mucus-like substance that stains heavily. The male gametes can be mistaken for the vegetative nucleus and the synergid nuclei, which "wander" into the upper portion of the embryo sac. Given these challenges, it is not surprising that we have not made significant progress in our understanding of the processes involved in fertilization since the turn of the century. Several employees have stated with a sense of sadness that, in spite of repeated attempts [5].

DISCUSSION

A Lychnis ovule containing two embryo sacs that had each been punctured by a pollen tube was described by Compton. Two pollen tubes were accepted by another ovule containing a single embryo sac, but only one of them entered the sac, leaving the other one in the nucellus. He came to the conclusion that there is a quantitative relationship between embryo sacs and pollen tubes, with two embryo sacs producing enough chemotactic material to draw in two pollen tubes as opposed to one. Pope also saw a Hordeum ovule with one pollen tube within the micropyle and four at the mouth; nevertheless, it was unclear how the embryo sac accepted the first and rejected the others. Although one pollen tube to an embryo sac may therefore be characterized as the normal circumstance, the introduction of supplementary tubes is not unusual. Extra male gametes are spontaneously released from the embryo sac when more pollen tubes are introduced. One pollen tube may very rarely contain more than two sperms. The pollen tube or the pollen grain may be the source of this anomaly. Three and four sperms, respectively, have sometimes been seen in the pollen grains of Cuscuta epithymum, Helosis cayennensis, Vinca herbacea, Parthenium argentatum, and P. incanum, to name a few. Allium rotundum, A. zebdanense, Crepis capillaris, and Polygonatum canaliculatum all have pollen tubes that contain four sperms. If there are excess sperms within the embryo sac, whether they come from one pollen tube or many, there might be two different types of problems. A polyploid progeny is produced either when part of the extra sperm reach the egg or when more than one egg apparatus cell is fertilized, producing numerous embryos.

Fertilization of more than one cell of the egg apparatus has been recorded in various plants of which Sagittaria graminea and Crepis capillaris may be given as examples. Fertilization often happens regularly in Sagittarius, with the female gamete joining the egg and the male gamete joining the two polar nuclei.

However, the synergids often take on the appearance of eggs, and sometimes a second pollen tube reaches the embryo sac, releasing two extra sperms. The existence of two pollen tubes and three proembryos in the top portion of the embryo sac leaves little question that this may happen, even if an actual fertilization of the synergids was not seen. In Crepis capillaris, Gerassimova found some embryo sacs containing two to five eggs in addition to the two synergids. Typically, just one egg gives birth[6].

Single Fertilization

Although double fertilization is the norm in angiosperms, it is unclear if development can still occur with only one fertilization, or if syngamy can occur without triple fusion or vice versa. Cooke, Shively, and Anderson noted that endosperm development starts prior to fertilization in Epiphegus virginiana, and Anderson noted the same in Martynia louisiana. Syngamy occurs often in Ramondia nathaliae and R. serbica, however triple fusion is thought to be "facultative" and is frequently missed.

According to Wiger, endosperm development in certain Buxaceae and Meliaceae species occurs fully independently of fertilization. All these stories are, however, of a questionable character. Without getting into specifics, it may be argued that some of the aforementioned employees seem to have missed the pollen tube and that others mistaken the initial pair of endosperm nuclei for the unfused polar nuclei. It is extremely seldom that development may take place without triple fusion.

When the polar nuclei were still lying unfused and the second male gamete hadn't yet been expelled from the pollen tube, Guignard described a case in Vincetoxicum nigrum in which the zygote had split many times. Dahlgren has observed several-celled embryos associated with an undivided secondary nucleus in the embryo sacs of Mitella pentandra and Zostera marina, and Johansen has noted comparable occurrences in Taraxia ovata and Zauschneria latifolia. However, such embryos are likely to terminate growing such that no viable seeds are generated. The second of the two options i.e., the occurrence of triple fusion without an accompaniment of syngamy has been documented in various plants, but the ovules rapidly begin to deteriorate. If seeds are generated, they are lacking embryos and consequently nonviable. Rarely, though, the unfertilized egg may grow into a haploid embryo. Such cases will be discussed in connection with apomixes.

Self-Intolerance

Self-incompatibility is a genetically regulated cell–cell recognition mechanism that functions as a barrier to self-pollination in a broad variety of flowering plant species. When a pollen grain from a plant that is self-incompatible reaches the stigma of that plant or another plant with a similar genotype, the pollen germination, pollen-tube growth, ovule fertilization, and embryo development processes are stopped at one of their stages, and as a result, no seeds are produced. Various self-incompatibility mechanisms have been found[7].

The best-studied SI mechanisms prevent pollen on stigmas from germinating or pollen tubes in styles from lengthening. These systems depend on interactions between proteins, and the best-understood mechanisms are regulated by a single locus called S, which has a wide range of alleles in the population of the species. These processes, although having comparable physical and genetic expressions, have independently developed and are based on various cellular components, each of which has its own distinct S-genes.

Two fundamental protein coding areas are found in the S-locus, one of which is expressed in the pistil and the other in the anther and/or pollen. These are inherited as a group because they are genetically related and are close in proximity. The units are termed S-haplotypes. Two proteins that are the translation products of the two areas of the S-locus interact with one another to stop pollen germination and/or pollen tube elongation, which in turn triggers a SI response that prevents fertilization. However, no SI is produced and fertilization occurs when a female determinant interacts with a male determinant of a different haplotype. The overall process of SI, which is more complex and in certain species the S-haplotype comprises more than two protein coding areas, cannot be described in this manner. Following are the types of self-compatibility:

Self-incompatibility of Gametophytes

The pollen's phenotype in this case of self-incompatibility is dictated by its own gametophytic haploid genotype. This sort of self-incompatibility is more prevalent and is often seen in Solanaceae, Rosaceae, and Papaveraceae. Following are two mechanisms of GSI:

The Mechanism of RNase

Pollen tube elongation is stopped in this process when it is about one-third of the way into the style. In the event of identical male and female S alleles, the female component ribonuclease, known as S-RNase, likely causes degradation of the ribosomal RNA within the pollen tube, which stops pollen tube elongation and causes the pollen grain to die.

The S-Glycoprotein Mechanism

In Papaver rhoeas, it was extensively discussed. In this process, pollen development is halted within minutes after its deposition on the stigma. The male determinant's identification is yet unknown, however it is most likely a cell membrane receptor. The female determinant is a tiny, extracellular molecule that is expressed in the stigma. The pollen tube experiences a high influx of calcium ions as a consequence of the interaction between the male and female determinants, interfering with the intracellular concentration gradient of calcium ions that is necessary for the pollen tube's elongation.

Within 1-2 minutes, the calcium ion influx stops tube elongation. Pollen inhibition is still reversible at this point, and by using certain manipulations, elongation may be restored, leading to ovule fertilization. The cytosolic protein p26, a pyrophosphatase, is then blocked by phosphorylation, presumably causing the production of the molecules needed for tube elongation to stop. Within the pollen cytoskeleton, actin filaments are depolymerized and reorganized. The pollen begins a process that results in its death 10 minutes after being placed on the stigma[8].

Sporophytic Self-Incompatibility

The diploid genotype of the anther in which the pollen was produced determines the SI phenotype of the pollen in this self-incompatibility. A diploid genotype, or two male and two female determinants, determines SSI. The pollen and pistil both express the translation products of two distinct alleles.

There are often dominance connections between allele pairs, which leads to complex patterns of compatibility/self-incompatibility. The development of people who are homozygous for the recessive S allele is also made possible by these dominance relationships. The families Brassicaceae, Asteraceae, Convolvulaceae, Betulaceae, Caryophyllaceae, Sterculiaceae, and Polemoniaceae are typically where it may be found. At the molecular level, the mechanism of SSI has been thoroughly explained in Brassica.

The Brassica SI Mechanism

The translation products of the two S alleles are carried by the pollen coat in Brassica, which is made of the tapetum tissue of the anther. These are little proteins with plenty of cysteine. The male determinant, also known as SCR or SP11, is expressed in the microspore, pollen, and anther tapetum. A transmembrane protein known as SRK, which has an intracellular kinase domain and a changeable extracellular domain, is the female determinant of the SI response in Brassica. Since SRK is produced in the stigma, it is likely that it serves as a receptor for the pollen coat protein SCR/SP11.

In terms of sequence, a second stigmatic protein known as SLG is quite similar to the SRK protein. It seems to work as a co-receptor for the male determinant, enhancing the SI response. The intracellular kinase domain of SRK is autophosphorylated as a consequence of the interaction between the proteins SRK and SCR/SP11, and a signal is then sent into the papilla cell of the stigma. The serine-threonine kinase MLPK, which is linked to the plasma membrane from its intracellular side, is another protein that is crucial for the SI response.

Self-incompatibility loci for Gametophytes

The gametophytic self-incompatibility system in the Poaceae family consists of two unrelated loci known as S and Z. The pollen grains are regarded as incompatible if the alleles expressed at these two loci in the pollen grain and the corresponding allele in the pistil are identical. Heteromorphic incompatibility with oneself. This self-incompatibility (SI) mechanism, also known as heteromorphic SI, may be found in heterostylous flowers. Strong ties exist between the alleles causing floral polymorphism and the loci causing SI in heterostylous flowers, and both features are inherited simultaneously. A single locus with two alleles determines distyly; two loci, each having two alleles, determine tristyly. Both alleles in the male plant control the heteromorphic SI response in the pollen, making this kind of heteromorphic SI sporophytic. In both pollen and the pistil, SI loci always have only two alleles in the population, one of which is dominant. Diversity in SI alleles mirrors the diversity in flower morphs, hence pollen from one morph may fertilize only pistils from the other morph. Each of the two different forms of stamen found in tristylous flowers generates pollen that can only fertilize one of the three flower morphs that exist[9].

Self-incompatibility in the crypts

Only a few species exhibit this self-incompatibility, including Silene vulgaris and the Caryophyllaceae family. According to this process, when cross and self-pollen are present on the same stigma at the same time, cross pollen produces more seeds than self-pollen. Contrary to complete or absolute SI, however, CSI uses self-pollination without the presence of competing cross pollen to produce successive fertilization and seed set, ensuring reproduction even in the absence of cross-pollination. CSI affects pollen tube elongation, at least in certain species, and causes cross pollen tubes to elongate more quickly than self-pollen tubes.

Late-Acting Self-Incompatibility

A different name for it is ovarian self-incompatibility. Self-pollen grows in this method and gets to the ovules, but no fruit is produced. Pre- or post-zygotic LSI are both possible. In pre-zygotic LSI, the embryo sac deteriorates before the pollen tube enters, as in the case of Narcissus triandrus. Asclepias, Spathodea campanulata, and other zygote or embryo malformations are examples of post-zygotic malformations. A large portion of the interference from somatic tissues and the nearby maternal gametophytic cells is eliminated by the in vitro fertilization procedure, in which separated sperm and egg cells are encouraged to unite under controlled circumstances. The use of IVF in higher plants is consequently a major modern study subject in plant developmental and reproductive biology with potentially substantial scientific applications.

In his study, Cass revealed the cellular properties of male gametes of barley that were isolated by shattering anthesis pollen grains in a 20% sucrose solution. This was one among the first reports of the isolation of a live male gamete. Following the initial bulk separation of sperm cells in 1986, many angiosperms successfully isolated male gametes with modifications. Hu et al. and Huang and Russell published the first reports on the isolation of live egg and central cells in tobacco and plumbago, respectively. The basic mechanisms of these processes in angiosperms are poorly understood, and despite their essential significance, the control of early embryonic development is also poorly understood. According to new research, the asymmetric division of the zygote separates the factors that determine apical and basal cell fates, and transcriptional programs are started in the domains of individual early embryonic cells[10].

In-vitro Fertilization

With the help of an in vitro fertilization technique, it has been possible to create maize zygotes that can undergo zygotic embryogenesis and develop into asymmetrical two-celled embryos, proembryos, and embryos in the transitional phase, just like they would in the plant. The ability to directly see the initial uneven division of zygotes and utilize the zygote and two celled embryo as research materials is a key advantage of in vitro gamete fusion and subsequent zygote cultivation. It has recently been possible to separate the apical and basal cells from two-celled maize embryos. Using these separated cells as a starting point, it has been possible to identify genes that are up- or down-regulated in the apical or basal cell. Genes expressed in apical and basal cells or zygotes of maize and Arabidopsis are described, single cell manipulation and IVF techniques are described, and prospects for additional research on early higher plant embryogenesis are summarized. It is obvious that challenges with isolating higher plant gametes have hampered our understanding of gamete physiology, development activation, and early embryogenesis in flowering plants.

However, there are now more instruments accessible to control the male and female gametes of higher plants, opening up a wide range of possibilities for scientific and biotechnological advancement. Modern cellular and physiological probes allow for the direct examination of isolated gametes during IVF, and techniques for controlling sexual reproductive development are being improved. As a result, research on the reproductive biology of angiosperms has entered a new phase in which molecular biology techniques will enable the resolution of several queries about the basic processes of fertilization and early developmental activation. Molecular characterisation of male and female gametes and zygotes is predicted to become a new focus of plant molecular knowledge and bioengineering, which will integrate cell hybridization methods with transformation and regeneration of transgenic plants. It's interesting to note that parallel methods are also being used on gymnosperms to reveal potential benefits of using gametic cells in IVF as founder populations for transgenic plants and as fertilization models.

The isolation of male and female gametes, particularly the isolation of egg cells, for the manipulation of living gametic cells, has proven to be the biggest barrier to IVF currently. Although early results have been confined to just two species, both are vital agricultural plants. The knowledge gained from studying these plants may also serve as a model for studying many other angiosperms, including other molecular and agricultural models, in order to gain understanding of fertilization and the activation of development. To validate findings from maize and wheat using IVF, successful experimental systems for IVF in other plants will be required. Our two most advanced models at this time are both grasses, which are a highly specialized angiosperm. Developing IVF in other plants, especially dicotyledonous models and crops, may offer vital information that will improve our understanding of the crucial molecular processes involved in fertilization and methods for growing fertile sporophyte plants and novel, highly effective genetic combinations[11], [12].

CONCLUSION

In order to draw a conclusion, it may be important to stress that, until a few years ago, the male gametes of angiosperms were often thought of as naked nuclei. However, it is clear from recent research on the issue that the cytoplasmic sheath is preserved at least while the male gametes are in the pollen tube. Finn suggested that the entire sequence of events should be studied in living material in order to decide the issue with certainty, but this appears to be impractical with most plants because the embryo sac is enclosed in several opaque layers that prevent a direct and in-depth examination of its contents. There is no other choice except to search for a good substance where numerous fertilization stages can be identified, the process proceeds slowly, and the gametic cells are not only sizeable but also more amenable to our staining techniques.

Angiosperms need on pollination and fertilization to complete their life cycle. The two main types of pollination are cross pollination and self-pollination. The human itself is the vector in which nemophily, hydrophily, entomophily, zoophily, and other traits play a part in pollination. Gametes enter the pistil after pollination and eventually reach the female gametes. The location of double fertilization is in the embryo sac. Only angiosperms have double fertilization, which alternates with pollination, micsporogenesis, and megasporigenesis. Plants employ self-incompatibility as a means of verifying cross- and intraspecific pollination. Plant breeders employ in-vitro fertilization as an artificial means of improving species or creating new variations.

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CHAPTER 24

SEED DEVELOPMENT AND FRUIT GROWTH

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ABSTRACT:

A crucial stage in an angiosperm's life cycle is seed development. The process of double fertilization, which results in the growth of the endosperm and the embryo, serves as its catalyst. Recent research suggested that histone acetylation may have an impact on the early stages of seed formation. Following completion of this lesson, you will have a basic understanding of: forms of endosperm development Monocot and dicot Embryogenesis development of fruit. Fruits and seeds are created through fertilization. In angiosperms, double fertilization results in the formation of two structures: a diploid zygote and a triploid main endosperm cell. While the endosperm cell gives birth to endosperm, the zygote develops into an embryo. It supplies nutrients to the developing embryo.

KEYWORDS:

Double Fertilization, Endosperm, Embryogenesis, Mega gametophyte, Seed Development**.**

INTRODUCTION

Students who study this lesson will gain knowledge of the distinctive characteristics of endosperm, embryo, and fruit development. Fertilization is the catalyst for all of these developmental stages. In the form of a tiny embryo, embryogenesis builds the fundamental body plan of the plant. The establishment of the endosperm creates a nutritional store for the developing embryo until it becomes independent. Gynoecium produces fruit to aid in the spread of seeds. These processes are all closely related to one another. Several plant hormones are crucial for fruit growth, mobilizing the endosperm's food store, and embryo development.

Endosperm Development and Types

The angiosperm seed's endosperm is a food-storing component that develops during a second fertilization of the Secondary media of the control cell with the male nucleus within the embryo sac. Endosperm cells are often triploid and tightly structured. These cells store lipids, proteins, and carbohydrates, albeit the amounts of these reserves vary depending on the species. At first, endosperm was thought to be a separate tissue that emerged from a second fertilization event that is typical of angiosperms. Two explanations for the evolutionary genesis of the angiosperm endosperm were proposed after the discovery of double fertilization, and both of these theories are still in use today. In one, it was considered that the endosperm began as an altruistic twin embryo that later transformed into a caring endosperm for the embryo that survived, while in the second, it was thought that the endosperm was a continuous development of the mega gametophyte that was triggered by fertilization. After the second male gamete nucleus fertilizes the secondary nuclei, the endosperm forms. Nuclear, cellular, and helobial endosperm development are the three kinds that are recognized[1].

Nuclear

The most typical method of endosperm formation is the first one, the free nuclear type. In this, cell wall production and cytokinesis are absent, and the triploid nucleus divides repeatedly. The main endosperm cell's central vacuole develops simultaneously and undergoes expansion, causing the nuclei to be arranged peripherally and the cell to grow. The endosperm coenocyte is created when the quantity of peripheral nuclei increases by free nuclear divisions. The vacuole then contracts and eventually vanishes as the cytoplasm and nuclei grow. Finally, cellularization of the coenocytic cytoplasm results in the formation of a multicellular tissue. Examples include several Monocots and Archichlamydeae plants[2].

Different Endosperm Development Types

Cellular

Every nuclear division in this type is followed by the creation of a cell wall, making the endosperm cellular from the beginning. Examples include most gamopetalae plants, petunias, and datura.

Helobial

Rarely does endosperm grow in this manner. It is a form that exists between cellular and nuclear kinds. After the initial division in this kind, a horizontal cell wall develops between the two nuclei. The cell at the chalazal end of the embryo sac later grows endosperm following the cellular pattern, but the cell at the micropylar end does so along the nuclear pattern. Chalazal cells typically only divide once or twice. Example-Helobiales. The nucellus is crushed by the growing endosperm. The food reserve is kept in the cotyledons and the endosperm may stay in the seed or it may be totally absorbed by the developing embryo.

DISCUSSION

Cellularization Mechanism during Endosperm Development

In the development of nuclear endosperm, an array of microtubules radiating from the membrane of each endosperm nucleus serves as the catalyst for the cellularization of the endosperm coenocyte. The radial microtubular system is the name of this arrangement. RMS are widely known to be present in the nuclear endosperm and have been seen in the endosperm coenocyte of a variety of species, including rice, wheat, barley, Arabidopsis, etc. Microtubules from nearby nuclei may initially overlap, but eventually they detach from one another, delineating cytoplasmic interzones between individual RMS. In these RMS interzones, phragmoplasts develop, which then leads to the construction of anticlinal walls. Each nucleus is soon surrounded by walls. These walls encircle each nucleus, forming an alveolus-like structure. The alveolus walls spread out in all directions. Alveoli undergo mitotic nuclei division, and a new layer of alveoli is created along with one peripheral layer of cells and a periclinal cell wall. Cell files finally fully enter the central vacuole when the same sequence of events is repeated. Thus, the process of cellularization is finished during the first few days after fertilization[3].

The fertilized triploid nucleus is located at the proximal end of a cytoplasm that encircles a large central vacuole in the central cell. The endosperm coenocyte is produced when mitotic divisions take place without cell walls forming. It has many nuclei and a big central vacuole. RMS begin to develop on the surface of endosperm nuclei, which starts the process of endosperm cellularization. The interaction of RMSs from each nucleus that make up the cytoplasmic phragmoplast promotes the creation of the cell wall, which surrounds each nucleus and has an open end that faces the central vacuole. Alveoli continue to expand toward the central vacuole, and periclinal cell divisions inside the alveoli with the creation of walls between the daughter nuclei result in two cell layers: one full layer outside the alveoli and a new layer of alveoli within. Two layers of peripheral cells are created after one round of the alveolation process and a mitotic division, with the new layer of alveoli reaching almost to the center of the central vacuole. The central vacuole is entirely closed after further centripetal development of the cell files. Please take notice that just one layer of endosperm cells is shown in the picture, which has not been drawn to scale[4].

Endosperm Cell Types and Their Functions

The completely developed endosperm contains four main cell types: the embryo surrounding region, the transfer cells, the aleurone layer and the starchy endosperm.

The Area around the Embryo

The lining of the endosperm cavity, where the embryo grows, is created by the cells in this area. They typically contain a dense amount of cytoplasm. Their purpose is yet unclear, but it's likely that they contribute to embryo nourishment or act as a physical barrier during seed formation between the endosperm and the embryo.

Transfer Cells

These cells are found across the vascular tissue of the maternal plant, where they carry out transfer of photosynthate into the endosperm. In cereals, endosperm transfer cells are characterized by the presence of noticeable secondary wall ingrowths. Latter on the early stage of the grain, these cells possess a vast and extensive endomembrane system.

Aleurone Cells

The transfer cell region is not included in the aleurone layer's coverage of the endosperm's entire periphery. The aleurome layer may be one, three or many cells thick. The aleurone cells contain several aleurone grains and small vacuoles with inclusion bodies. As a result, their cytoplasm is granular and dense. Aleurone cells may include two primary forms of inclusion bodies — protein-carbohydrate bodies and the globoid bodies packed with a matrix of lipid, phytin and protein. The aleurone grains are surrounded by lipid droplets. The aleurone comprises highly developed endoplasmic reticulum and many mitochondria. The anthocyanin pigments that give corn its colorful grains are found in mature aleurone cells. The aleurone cells may be extremely polyploidy as shown in barley[5].

Starchy Endosperm Cells

The starchy endosperm constitutes the primary portion of the endosperm. These cells retains bulk quantity of starch generated inside amyloplasts by the four enzymes, ADP-glucose pyrophosphorylase, starch synthases, branching enzymes, and debranching enzymes. The second most important element of starchy endosperm cells that is cell-specific is prolamin storage proteins.

These cells undergo endo-reduplication after the period of cellularization and cell fate determination. The starchy endosperm cells undergo a process similar to programmed cell death in animals when the grain-filling stage is completed.

Embryogenesis

Fertilization in plants results in the development of the embryo, endosperm, seed, and fruit. The process of embryogenesis involves turning a single-celled zygote into a tiny, multicellular embryonic plant. The processes of embryogenesis occur in an organized manner. Cell division, differentiation and growth are tightly regulated. This fact indicates that transformation of zygote into embryo is genetically programmed. The sporophyte's fundamental body layout is developed during development. The principal difficulties in embryogenesis are:

To determine the fundamental body plan. Axial patterning forms the apical-basal axis, whereas radial patterning creates three distinct tissue systems. To reserve meristematic tissue for the body's post-embryonic elaboration. To develop an accessible food store for the germinating embryo until it becomes autotrophic. In all angiosperms, the basic process of establishing the basic body design occurs during embryogenesis. The elaboration of patterns varies. Different species have varying levels of endosperm, cotyledon, and shoot meristem development as well as cell division pattern accuracy[6].

Axial patterning:

All plants have an exact arrangement of their tissues and organs along the linear apical-basal axis. At the opposing extremities of the axis are the shoot apical meristem and the root apical meristem. In angiosperms, the shoot apical meristem is followed by one or two cotyledons attached to the axis. Following this connection hypocotyl, root, root apical meristem and root cap are identified in succession. Embryogenesis establishes this axial pattern. Radial patterning: A plant organ's various tissues are arranged in a certain way. Epidermis, cortex, endodermis, pericycle, phloem, and xylem, for instance, are radially arranged in roots and stems from the periphery to the center. Radial patterning is built upon the foundation of three meristem types: protoderm, ground meristem, and procambium.

There are four stages in the development of an embryo

The process of embryogenesis has been explored exhaustively in Arabidopsis. The most significant phases of embryogenesis in angiosperms including Arabidopsis are: Globular stage: In the zygote, the apical and basal cells are created following the initial division. An octant globular embryo is created by a series of exact cell divisions that occur in the apical cell. Furthermore, orderly divisions expand the embryo's cell population.

Heart stage: On each side of the eventual shoot apex, two regions experience rapid cell divisions. The cotyledons are later produced as a result of further division and growth in these two regions. At this stage, embryo becomes bilaterally symmetric. The embryo develops into the torpedo stage as a result of cotyledon development and cell elongation along the embryo's axis[7].

Stage of maturation: After the embryogenesis process is complete, the embryo and seed go through desiccation and become metabolically inert before beginning the period of dormancy. It is illustrated as a typical dicot; a monocot would only produce one cotyledon. Angiosperm embryogenesis follows some basic patterns, but there is a lot of morphological variation between species.

Embryogenesis in Dicots and Structure of Dicot Embryo

Polarity is created in the first cell division after fertilization. After zygote elongation, an asymmetrical cell division occurs, resulting in two unequal cells: a terminal cell and a big basal cell. This is the beginning of embryogenesis. The final cell creates the actual embryo. The basal cell undergoes few transverse divisions and creates a filamentous suspensor of 6-10 cells. The embryo is pushed into the endosperm by the suspensor. The suspensor is situated at the absorptive surface of the embryo toward its food source and aids as a nutrition pathway for the developing embryo. The suspensor cell, which is close to the micropylar end, swells, grows wall ingrowths, and functions as a haustorium. The suspensor cell situated close to the embryo at the opposite end of suspensor is known as hypophysis. It later produces the radicle and root cap. Filamentous suspensor degenerates later in embryogenesis. Experiments done on embryo cultivation in scarlet runner beans indicated the necessity for a suspensor through the heart stage in dicots[8].

The epibasal cells give rise to the two cotyledons and the plumule. Later on during embryogenesis, the hypocotyl develops from the hypobasal cells. The developing form of the embryo is governed by orientations of the planes of cell division and cell growth. At the globular stage, three tissues dermal, ground, and vascular that are in charge of radial patterning, appear. The eight cells of octants go through periclinal division. Protoderm is produced by the outer layer's cells, while the inner layer's cells continue to differentiate to form procambium and ground meristem. Epidermis is created from the protoderm which functions as outmost protective layers of the plant. The cortex and pith of a mature plant are produced by the ground meristem, which is situated underneath the protoderm. The procambium, which is located in the center of the embryo, is in charge of directing the growth of the vascular tissue in adult plants. The differentiation of each tissue system is partially independent. Proembryo is another name for the radially symmetric early stage of an embryo. The formation of cotyledons marks the end of the globular stage of embryogenesis. Dicots have two cotyledons, which give the embryo its heart-like shape. They extend immensely with strong development rate while plumule also develops as little mound of undifferentiated tissue in apex area of embryonic axis. The axial patterning becomes visible with the development of cardiac stage. The transition from radial to bilateral symmetry is mediated by plant hormones specially, auxin. Single cotyledon arises in monocots.

Following germination, the cotyledons of certain plants help the plant by turning into photosynthetic cells. Though in some species, they do not emerge from the ground. However, in some plants, like peas, the food stored in the endosperm is consumed prior to germination, and the cotyledons supply the nutrients to the seedling that is undergoing germination. Even in the presence of a prolonged endosperm, the cotyledons acquire carbohydrates, lipids, and proteins. In many monocots, the single cotyledon helps in nutrient transfer to the seedling. The embryo has a torpedo form due to vertical cotyledons. The cotyledons of some plants can grow and bend to fit inside the boundaries of the seed coat. By this point, the suspensor is degenerating[9].

During embryogenesis, two clusters of stem cells that correspond to the shoot apical meristem and root apical meristem are produced. They survive in the postembryonic plant and constructed much of the sporophyte body. The root meristem is partially derived from the hypophysis in some species. Genetic data suggests that the foundation of the shoot and root meristems is regulated separately. The shoot apical meristem not only gives birth to leaves following germination and but ultimately generates reproductive structures. In Arabidopsis, the cotyledons are formed from general embryonic tissue, not from the shoot meristem. Similarly in cotton, the cotyledons and the first two true leaves are derived from embryonic tissue rather than an organized meristem. Most embryonic cells are pluripotent and meristems possess this capacity in the postembryonic plant body.

A typical dicot embryo is made of of an embryonic axis and two cotyledons. The terms "epicotyl" and hypocotyl refer to the portions of the embryonic axis that are situated above and below where the cotyledons attach. On the embryonic axis, the plumule and radicle are located at opposing ends. A root cap covers radicle end. The ovule changes into the seed as the embryo develops. Eventually, its integuments develop into tough protective coatings. At this point the embryo comes into resting stage in seed[10], [11].

CONCLUSION

Angiosperms need on pollination and fertilization to complete their life cycle. The two main kinds of pollination are cross pollination and self-pollination. The human itself is the vector in which nemophily, hydrophily, entomophily, zoophily, and other traits play a part in pollination. Gametes enter the pistil after pollination and eventually reach the female gametes. The location of double fertilization is in the embryo sac. Only angiosperms have double fertilization, which alternates with pollination, micsporogenesis, and megasporigenesis. Plants employ self-incompatibility as a means of verifying cross- and intraspecific pollination. Plant breeders employ in-vitro fertilization as an artificial means of improving species or creating new variations. In flowering plants (angiosperms), the process of double fertilization kick-starts the development of the two major seed components, the embryo and endosperm, by fusing two male gametes (sperm cells) with two female gametes (egg and central cell).

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CHAPTER 25

EMBRYOGENESIS IN MONOCOTS AND STRUCTURE OF MONOCOT EMBRYO

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ABSTRACT:

Two cells are created when the terminal cell splits by a second transverse wall. The top cell eventually divides into a plumule and a single cotyledon after a series of divisions. The scutellum, a cotyledon that is rapidly growing, pushes the terminal plumule to one side. Monocot and dicot embryos are fundamentally different from one another because monocot embryos only have one cotyledon, while dicot embryos have two. The two categories of flowering plants known as angiosperms are monocots and dicots. They are the most numerous and productive plant species in the whole world.

KEYWORDS:

Angiosperms, Embryogenesis, Monocot, Shoot Apex, Terminal Cell.

INTRODUCTION

To create the basal and terminal cells, the zygote lengthens and then splits transversely. The basal cell produces suspensor cells, which is similar to how dicot embryogenesis occurs. It may serve as a haustorium. The terminal cell divides once more transversely to produce two cells. The top cell divides in turn, producing a plumule and a single cotyledon while the bottom cell creates a hypocotyl and radicle. The scutellum is the solitary cotyledon. The terminal plumule is pushed to one side as a result of its fast expansion. On the side opposite the embryonic axis is where the scutellum is located. Above the scutellum's attachment point, epicotyl is located. The coleoptile contains a few leaf primordia and the shoot apex. Second cotyledon rudiments are known as epiblast[1].

Fruit

Only blooming plants known as angiosperms, whose name means "hidden seed," produce true fruits. Despite the fact that many of the structures we consider to be fruits are really made up of a range of tissue types, fruits are often characterized as being formed from mature ovaries that contain seeds. The floral gynoecium gives rise to true fruits. Fruits have developed to help in seed distribution and protection. There are many different types of fruits found in angiosperm species, and these variations can be seen in both "dry" fruits that split open to release the seed through abiotic dispersal mechanisms and fleshy fruits that have evolved with an enlargement of the tissue surrounding the seed to create appetizing flesh for seed dispersing animals. The many fruit varieties seen in angiosperms may be divided into groups based on a variety of criteria[2].

Fruit Variety

Based on their floral source, fruits may be divided into three categories: simple, aggregate, and multiple. Sometimes just one fruit grows from a single bloom. This is the case since the single bloom only had one pistil, which eventually turned into a straightforward fruit. Either a simple or complicated pistil may exist. In certain species, a single blossom gives rise to a cluster of fruits. This occurs as a result of the fact that one flower had several pistils, each of which developed into a fruit. Raspberries and strawberries are two instances of aggregation fruit. In still other species, fruits grow when a large group of flowers known as an inflorescence are pollinated. However, when these many fruits mature, they come together to form a single fruit body. It is referred to as a multiple fruit because several blooms generate fruits that combine into just one single body. Mulberries and pineapple are a few of examples.

On the basis of composition

Fruits may also be divided into groups based on the elements of the blossom that make up the fruit as a whole. There are just two categories included here. A fruit that is made entirely of ovary wall is a real fruit. The fruit body has no further contributions. Cherry and peach are a nice illustration. All of the other components of the bloom here detach from the pedicel following pollination. Only the ovary is left after even the style and stigma have vanished. Ovarian wall thickening. The ovary's exterior layers get fleshy and crimson, while the inner layers, which enclose a single seed, harden and stone. A fruit is said to be accessory if it has more of the fruit body than just the ovary wall. Along with the ovary wall swelling, other components of the flower also enlarge. The container often takes part. There are often accessory tissues encircling or subtending the primary fruit in inferior or perigynous ovaries. A watermelon is an excellent illustration of an accessory fruit. When fully grown, the real fruit is red, while the adornment is white. Apple is another example. The white tissue you like to eat is an accessory; the cartilaginous center is the actual fruit[3].

According to Fruit Repining

This is yet another method of fruit classification based on physiological ripening. Climacteric fruits, which include tomatoes, peaches, bananas, apples, and melon, have a high ethylene demand for ripening. Non-climacteric fruit is defined as fruit that requires less ethylene to mature, such as grapes and citrus. During the ripening period, climacteric fruits exhibit increased respiration rate whereas non-climacteric fruits do not. Fruits that are climacteric may also ripen after being detached from the tree, but non-climacteric fruits can only ripen on the tree. In both climacteric and non-climacteric fruits, the ripening graph depicts growth curve, respiration rate, and ethylene hormone levels at various phases of fruit development.

Set of Fruits

The first stage of fruit growth is known as fruit set, and it is initiated during or shortly after fertilization. From gynoecium, fruit grows. The center of the flower is where the gynoecium develops from the union of carpels. The fact that several regulators of carpel development have been shown in Arabidopsis to also play a part in leaf development supports the theory that carpels evolved from modified leaves. The fertilization of ovules that occur along the placenta is necessary for the developmental switch that transforms a gynoecium into a developing fruit. The gynoecium in the majority of angiosperms senesces and dies if it is not fertilized[4].

Traditionally, it has been believed that phytohormone activities are involved in the fruit initiation process. A signal from the seed known as auxin is produced during fertilization and is hypothesized to promote the manufacture of the hormone gibberellin. As a result, gibberellin signaling is activated in the ovary and ovules, promoting the formation of fruit. Tradition has it that the three hormones auxin, gibberellin, and/or cytokine are what because fruit set. The interaction of these hormones is essential for fruit development and fruit set. Fruit development is influenced by the developing seed. According to the "seed control" theory, the seeds interact with the surrounding tissue via hormones in order to encourage fruit development through cell division and subsequent cell expansion. The primary discoveries at the molecular level are how auxin and gibberellin pathways interact to enhance fruit set. Gibberellin and auxin levels are elevated in the fruits of parthenocarpic plants, and auxin levels rise during seed development while gibberellin levels rise in the ovaries after fertilization.

Hormones are produced by the growing seeds within the ovary. First, they create auxins, which are hormones that stimulate cell division in the ovary wall and are expelled from ovules following fertilization.

Fruit's pericarp is made up of the ovary wall. The expanding fruit's wall becomes a little bit thicker as a result. Additionally, auxin stimulates the ovary to create gibberellic acid, which causes each of the cells in the ovary wall to rapidly expand. The ovary's size increases dramatically as a result of both increasing and more cells. Abscisic acid, a different hormone that the mother plant also releases, makes the developing seeds' embryos inactive. In the warm, wet fruit, this stops the seed from sprouting, which is adaptive. The figure above shows this series of events[5].

Growing and Ripening

The growing seed insulates its surroundings by varying the hormone concentrations in the surrounding tissue and the seed itself. Numerous studies have shown both increases in auxin, cytokinin, gibberellin, and brassinosteroid during fruit set as well as their participation in fruit development. Auxin transport from the seed is inhibited for fruit maturity, and ABA levels rise. As a result, the ripening/senescence program is activated, increasing the production of ABA and/or ethylene and the resulting reaction in the surrounding tissue.

Fruit Expansion

There is often a positive association between the number of seeds and fruit size since the growing seed continuously stimulates the surrounding tissue to enlarge. In order for the growing fruit to get adequate nutrients and not abort, it must also communicate with the rest of the plant. The amount of fruit development from anthesis to maturity varies greatly across species; some species' fruit expand very little, while others may multiply in volume by a million. The buildup of storage products and a rise in sugar accumulation are specific to fleshy fruit and occur along with cell development.

A crucial development stage for the fruit is its enlargement. Both a weakening of the cell wall and an increase in turgor pressure are required for cell expansion. Auxin, along with gibberellins, is assumed to play a significant role during the growth phase by affecting cell enlargement. This is because auxin primarily regulates cell division during fruit set. During the fruit's growth phase, several cell wall-related proteins as well as sugar transport proteins and other glycolytic enzymes are up-regulated. In tomato, auxin, gibberellin, or both have been demonstrated to influence several genes from the families of pectate lyases, endo-xyloglucan transferases, and expansions[6].

Fruit Maturation

Fruit reaches fruit maturity at a stage in its growth when it is capable of ripening but has not yet begun the ripening process. Key regulators of fruit maturity seem to be auxin and maybe cytokinin. As the seeds become dormant, auxin production or transport to the rest of the fruit is likely restricted, enabling the mature fruit to ripen. During fruit development, auxin levels in the seed are greater than in the surrounding fruit tissue. Since adding auxin to mature fruit always causes ripening to be delayed, this seems to be supported across fruit species.

Fruit maturation and Senescence

Fruit ripening or senescence is a complicated process that involves modifications to the fruit's physiological and metabolic characteristics. In the tissue enclosing the seed of all fruits, the color and content of the cell walls change, leading to either a dehiscence or a softening. Particular to fleshy fruit, there is often a conversion of sugars from stored carbs, a reduction in acidity, and a rise in taste and scent volatiles. The ripening hormones ABA and ethylene, with ethylene being the most investigated, seem to be the main means of controlling ripening. When it comes to ripening, climacteric fruits need ethylene, but non-climacteric fruits seem to benefit more from ABA. The tomato serves as a useful metaphor for illustrating how fleshy fruit mature.

DISCUSSION

Dicots and monocots store food stores in their seeds in different ways. The single cotyledon of monocot plants like maize and wheat is referred to as a scutellum, and it is directly attached to the embryo through vascular tissue. The huge endosperm stores food reserves. The aleurone, a single layer of cells immediately under the seed coat that encircles the endosperm and embryo, secretes enzymes during germination. The stored lipids, proteins, and carbohydrates are broken down by the enzymes, and the end products are taken up by the scutellum and delivered to the growing embryo through a vascular strand. The scutellum may therefore be seen to be an absorptive organ rather than a storage organ[7].

Additionally, the dicot seed has vascular connections between the two cotyledons and the embryo. The food reserves in endospermic dicots are kept in the endosperm. The two cotyledons function as absorptive organs to absorb the enzymatically generated food stores during germination, much as in monocots. Examples of endospermic dicots include tobacco, tomatoes, and pepper. When multiple fertilization occurs in non-endospermic dicots, the triploid endosperm develops normally, but the endosperm food stores are swiftly remobilized and transferred into the growing cotyledon for storage. The split peas in split pea soup and the two halves of a peanut seed are both independent cotyledons that are stocked with nourishment.

The seed coat, which is made of the integuments of the ovule sac, protects the seed and ovule. The seed coat of dicots is further separated into an inner coat called the tegmen and an exterior coat called the testa. The plumule, radicle, and hypocotyl are the three components that make up the embryonic axis. The hypocotyl is the area of the embryo between the cotyledon attachment point and the radicle. The radicle, where the embryonic axis ends, is the area from which the root will grow. In dicots, the hypocotyls grow above the soil to form the plant's stem. Because monocots do not display stem elongation, the hypocotyl is not visible above ground in monocots. The epicotyl is the portion of the embryonic axis that extends above the cotyledons. The epicotyl, juvenile leaves, and the shoot apical meristem make up the plumule[8].

When dicot seeds germinate, the epicotyl takes the form of a hook with the plumule pointing down. The plumule hook is the name for this morphology, which endures as long as germination takes place in the dark. The plumule is therefore guarded from harm while the epicotyl pushes through the hard, abrasive soil. When exposed to light, the epicotyl keeps growing longer, the leaves of the young foliage turn toward the sun and enlarge, and the hypocotyl hook straightens out. The radicle is developing and creating the major root at this time as well. The normal dicot tap root system is created when the lateral root system branches out to all sides as it develops downward to produce the tap root.

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Biochemical alterations that occur when fruit ripens

Color shift and the conversion of chloroplasts to chromoplasts. Fruit ripening causes a change in fruit color. Loss of chlorophyll and the formation of secondary color metabolites like carotenoids and anthocyanins work together to accomplish this. Although certain intermediates may be formed in the absence of ethylene, the generation of secondary color metabolites is heavily controlled by ethylene in tomato. The transformation of chloroplasts into chromoplasts is one of the most important developmental processes connected to ripening and palatability. The conversion of chromoplasts is accompanied by a number of significant structural alterations. The fruit's nutritional and taste makeup are significantly impacted by these changes. As the thylakoid structures break down, the chloroplast's ability to perform photosynthetic activity is lost. Plastoglobules gather within the chromoplast. These are the locations where significant amounts of carotenoids, primarily lycopene and -carotene, accumulate in the form of crystal formations. The buildup of these carotenoids serves as a visual cue that the fruit is fully grown and ready for ingestion.

These carotenoids are crucial for human health because they provide the body rich antioxidants and the precursor to vitamin A. numerous species' chromoplast and plastoglobule proteomes have been studied. The enzymes necessary for the production and metabolism of carotenoids, amino acids, and fatty acids may be found in the tomato chromoplast, which has a high metabolic activity. These structures include the enzymes necessary for the production of carotenoids. The primary and irreversible characteristics of the ripening transition of tomatoes and many other fruits are the conversion of chloroplasts to chromoplasts, along with the related loss of chlorophyll, membrane structure/photosynthetic function, and subsequent carotenoid buildup. Phytoene synthase, the main enzyme controlling flow into the carotenoid pathway, is strongly positively controlled by ethylene during ripening, pointing to a connection between chromoplast formation and the main ripening hormone. Repression of the gene producing the lycopene cyclase enzyme, which would normally convert red lycopene to orange carotene, is also regulated by ethylene[10].

Biochemistry of flavor and Fragrance

The majority of fruits, including the tomato, have developed to attract animal seed dispersers. When tomato seeds are completely developed, the fruit undergoes chemical modifications that make it more attractive to animals. Cell walls soften as a consequence of textural changes. Large levels of carotenoids, mostly lycopene and -carotene, are generated when chloroplasts are converted to chromoplasts, giving visual clues that the fruit is ripe. Changes in glycoalkaloid concentration are also brought about by ethylene. Immature fruits have high quantities of -tomatine, which peak at mature green. Levels drastically decrease as fruit ripens in an ethylene-dependent way. Given that -tomatine is associated with a bitter taste, ripening has the effect of making a plant more palatable. Finally, some of the compounds that affect flavor start to assemble. Acids, volatiles, and sugars are the three main chemical groups in tomatoes that contribute to taste. Although sugars and acids are a need for flavor, a tomato's distinctive flavor is mostly determined by its volatile compounds. Numerous studies have described the changes in metabolism that take place throughout maturation and ripening.

Acids and Sugars

Starch that has accumulated during development is converted to glucose and fructose, the two primary sugars in a ripe fruit, at the start of ripening. These two sugars may make about 2%–4% of a fruit's fresh weight. Malic and citric acids are the two most prevalent organic acids. A mature fruit's pH is normally between 4 and 5. Even though various people have varying tastes in sweetness and acidity, both sugars and acids are essential for optimum flavor. It's interesting to note that current research has demonstrated that malic acid affects starch content via redox controlling the starch production enzyme, ADP glucose pyrophosphorylase. Malic acid level of the immature fruit is projected to be negatively connected with lowering sugar content of the ripe fruit given that starch synthesis is positively correlated with reducing sugar content in ripe fruits.

Volatiles

A group of 20–30 volatile compounds, which are present in sufficient amounts to visibly excite the olfactory system, favorably contribute to the taste of tomatoes. They are a varied group of substances made from carotenoids, fatty acids, and amino acids. Despite having different chemical compositions, they all have one thing in common: they are all produced from substances that are necessary for the human diet. Therefore, necessary amino acids and essential fatty acids are the source of volatiles. The direct precursor of one of the most significant taste volatiles, -ionone, is -carotene, the predecessor of retinal. Animals have evolved to detect and seek out the chemicals that signal the availability of significant nutrients because plants produce the compounds that are appealing to them.

The majority of taste volatiles in a tomato start to rise at the beginning of ripening and peak at or just before full ripeness. This time implies that flavor volatile production is well controlled. At least a portion of the regulation happens at the transcriptional level. For instance, a small family of aromatic amino acid decarboxylases performs the rate-limiting step for the production of numerous Phe-derived volatiles, such as 2-phenylethanol, phenylacetaldehyde, and 1-nitro-2-phenethane. During ripening, some of the genes that encode these enzymes are activated, and increased expression of AADC enzymes causes an increase in metabolic flux into this pathway for the manufacture of volatile compounds. Ethylene is necessary for the synthesis of the volatiles that are produced in greater amounts during ripening. These might appear as a dehiscence zone or as a softening of the fleshy tissue, depending on the kind of fruit. A group of genes involved in cell walls are up-regulated in each occurrence, and many of these genes exhibit differential regulation. Control of ethylene production and ethylene signaling during fruit development.

With just two carbons and four hydrogens, ethylene is the most basic plant hormone. It is a gas that diffuses easily. Fruit development and ripening as well as organ abscission are both mediated by ethylene. The synthesis of ethylene is tightly controlled. The biosynthetic route is straightforward and only requires two enzymes. ACC synthase transforms S-adenosylmethionine into 1-aminocyclopropane-1- carboxylate. ACC is then transformed into ethylene by ACC oxidase. The rate-limiting phase is the formation of ACC. Although ripening induces ACO, there is significant ACO activity existing before ripening begins, hence ACO is not often the limiting factor for the synthesis of ethylene. At the level of ACS transcription, ethylene production is significantly regulated. Multiple ACS genes are active during the start of fruit ripening, which increases ethylene production. A network of transcription factors that control ethylene production and other ripening processes has been identified via the analysis of ripening mutants. Some of them are transcription factors from the MADS-box family, and many fruit species share them[11].

Following synthesis, ethylene binds to receptors located on the ER membrane that serve as dimers. A copper ion cofactor is necessary for ethylene binding. When ethylene binds to ethylene receptors, these proteins become inactive and allow ethylene signaling to continue. These receptors function as negative regulators of ethylene signaling. The binding of ethylene also results in the inactivation of the related negative regulators CTR 1, which then triggers the activation of a MAP kinase pathway, changing how the ethylene-regulated ripening genes are expressed. The ripening of the fruit, which was previously discussed, also impacts a layer of cells in the pedicel, which is located close to the plant's stem. Because this layer finally splits and the fruit falls from the plant, this layer of cells in the pedicel is sometimes referred to as the abscission zone. The cells in this cross-sectional layer of the pedicel get the ethylene signal from the ripening fruit in a manner similar to that of the cells within the fruit. The signal is received, and new enzymes are produced as a result. Cells in the abscission zone get unglued by pectinases enzymes. The cell connections weaken to the point where the weight of the fruit causes the fruit to fall off the plant. So that it may be picked up and moved by an animal to spread seeds.

CONCLUSION

A nutritive tissue called endosperm is created during multiple fertilization. The production of coenocytes, which comes about as a consequence of free nuclear divisions, is the first stage of endosperm development. Later, RMS creation, cell wall synthesis, and alveoli development start the coenocyte's cellularization process. Mitosis continues and the periclinal cell wall is deposited after the first layer of alveoli has formed. Cellularization has ended. In addition to the free nuclear type of growth, angiosperms also exhibit cellular and helobial types of development. Endosperm contains four different kinds of cells: cells that surround the embryo, transfer cells, aleurone cells, and starchy endosperm cells.

It is possible to think about embryogenesis as a series of interconnected processes that lead to the development of a morphologically complex structure. The embryo's polarity creates an axis on which the plant body is developed, which may represent the asymmetric arrangement of the egg cell. Domains that seem to be involved in developing the structure of the plant body are started off by an early compartmentation of the embryo. Early in development, further processes divide the progenitors of the shoot and root apices and arrange the embryonic tissue and organ systems. During development, the embryo takes on various forms at various stages. In both dicots and monocots, embryogenesis involves comparable basic processes such the development of embryonic polarity, pattern creation, and shoot and root apices. The blooming plants produce a wide variety of fruits. Although the luscious fruit is fully grown, it is still green and immature. As the fruit begins to ripen, it becomes more alluring and profitable for an animal to take it away, distributing the seeds.

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