Botani Pertanian
AGR 3101

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Fakulti Pertanian
Universiti Putra Malaysia
43400 UPM Serdang
Selangor Darul Ehsan
c. Objektif Kursus/ Hasil Pembelajaran
   Pelajar dapat:
   1. Menguraikan asas morfologi, anatomi dan prinsip taksonomi tanaman (C4, LL).
   2. Mempamerkan kebolehan berfikir secara kritis serta berbincang secara berkumpulan (P3, CTPS).
   3. Menunjuk teknik malsal yang lazim untuk kajian berkaitan dengan taksonomi dan botani pertanian (A3).

d. Sinopsis Kursus
   Kursus ini merangkumi morfologi, anatomi dan taksonomi tanaman pertanian dikot dan monokot.

   *(This course covers morphology, anatomy and taxonomy of dicotyledenous and monocotyledenous agricultural crops).*
e. Kandungan Kursus

1. Pengenalan
   - Pengenalan kepada botani pertanian
   - Aras pengkelseyaran

2. Pemuliharaan tanaman
   - Asas pemuliharaan tanaman
   - Kaedah penyimpanan
   - Pengawetan dan pemuliharaan sampel tanaman

3. Morfologi dikotiledon
   - Jenis
   - modifikasi

4. Morfologi dikotiledon
   - Fungsi
   - Pembentukan akar, batang, daun, buah, biji

5. Morfologi monokotiledon
   - Jenis
   - modifikasi

6. Morfologi monokotiledon
   - Fungsi
   - Pembentukan akar, batang, daun, buah, biji

7. Anatomi dikotiledon
   - Jenis dan struktur tisu
   - Anatomi bahagian vegetative dan reproduktif

8. Anatomi monokotiledon
   - Jenis Jenis dan struktur tisu
   - Anatomi bahagian vegetative dan reproduktif

9. Taksonomi- pengkelasan
   - Sistem pengkelasan dan pemberian nama botanikal

10. Taksonomi- pencaman tanaman pertanian
    - Proses pencaman dan kumpulan taksonomi bagi tanaman pertanian terpilih
<table>
<thead>
<tr>
<th>Unit</th>
<th>Tajuk</th>
<th>Cadangan Jam diperuntukkan</th>
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<td>6.</td>
<td>Fruit and seed morphology</td>
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<td>7.</td>
<td>Plant anatomy</td>
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<td>Plant taxonomy and classification</td>
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**Pembelajaran Maya : 1 jam kuliah bersamaan dengan 3 jam pembelajaran Kendiri**
f. Panduan Amali


CONTOH

Perhatian: Secara umumnya panjang laporan tugas/amali individu ialah tidak melebihi 10 muka surat (tidak termasuk kulit) dan panjang kerja kumpulan antara 10 hingga 20 muka surat tidak termasuk lampiran (jika ada). Kesemua laporan hendaklah ditaip selang dua baris (double spacing) pada kertas berukuran A4, menggunakan font Arial saiz 12. Laporan yang hendak dijilid. Tajuk dan maklumat lengkap mengenai tugas akan dimaktumkan pada permulaan bersemuka.

Nama dan No. matrik hendaklah di tulis dengan lengkap dan jelas.

Nota : Penulis tidak perlu memaklumkan tajuk tugas di dalam modul ini.
g. Penilaian Kursus

Penilaian kursus ini terbahagi kepada :

(i) Kerja kursus keseluruhan
   - Tugasana
   - Tugasb 25%
   - Tugasc 25%

(ii) Laporan amali 10%

(i) + (ii) 60%

(ii) Peperiksaan akhir 40%

Jumlah keseluruhan 100%

** Penilaian kursus berubah daripada semasa ke semasa bergantung kepada pensyarah/pengajar kursus semasa.**

Cadangan Jadual dan Aktiviti Pembelajaran

1. Perjumpaan Bersemuka 4 jam
2. Pembelajaran Kendiri 6 jam/seminggu
3. Sesi Amali (2 sesi) 12 jam
4. Pembelajaran Berkumpulan 12 jam
5. Online/Emel/Telefon/LMS/Kelas Maya dengan Pensyarah/Pengajar 14 jam
6. Latihan/Kuiz -
7. Tugasana/Amali dan Projek 28 jam

Jumlah Jam Keseluruhan 154 jam
h. Tugas

Tugas dibeahagi kepada dua. Untuk tugas pertama pelajar perlu menyediakan herbarium untuk sepuluh spesies tumbuhan. Jenis spesies bergantung kepada pilihan masing-masing. Tugas kedua berbentuk ese dimana pelajar perlu menyediakan deskripsi botanikal untuk setiap spesies yang dipilih.

i. Peperiksaan Akhir

Soalan peperiksaan ini akan merangkumi kesemua topik dalam modul, walau bagaimanapun penekanan ialah pada topik yang belum dinilai. Tutor di pusat pembelajaran akan dimaklumkan mengenai topik-topik ini atau pelajar boleh berhubung terus dengan pensyarah kursus untuk mendapatkan maklumat muktahir. Soalan peperiksaan akhir mesti berbentuk kombinasi objektif dan subjektif/esei.

(Perhatian!!: bentuk soalan ini boleh berubah, maklumat terkini mengenai peperiksaan boleh berhubung terus dengan pensyarah/pengajar semasa perjumpaan bersemuka).

Contoh soalan peperiksaan pertengahan atau peperiksaan akhir adalah seperti berikut:

Objektif/ Pelbagai Pilihan

Teknik analisis yang dapat mengasingkan antara punca/sebab masalah dari kesan/akibat dari pelbagai perspektif

a. Rajah Enam Perkataan
b. Analisis Kuasa Kajian
c. Rajah Tulang Ikan
d. Kepner-Tregoe
e. Modified Delphi
   (Jawapannya c)

Struktur/Esei
j. Rujukan Utama


k. Rujukan Tambahan


I. Penerangan mengenai ikon dalam modul

Untuk menolong pelajar memahami dengan lebih mudah kandungan modul ini beberapa ikon telah digunakan. Ikon-ikon ini bertujuan untuk memudahkan ingatan pelajar mengenai struktur modul. Di bawah disenaraikan ikon-ikon tersebut berserta dengan maksudnya.

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UNIT 1

INTRODUCTION OF PLANTS

Introduction to Unit

1. An introductory to plants
2. The evolution, categories and division in plants

Objectives to Unit

1. To explain the origin of plants and their categories.
2. To describe the differences of plants according to their division

TOPICS 1: Plants

The present concept of plants is simply that most plants have leaves, stems, roots and flowers. But in some exceptions such as conifers (pine, spruce and fir) have cones rather than flowers and many cactus has spines instead of leaves. This raise the question of what makes plants or sometimes known as flora different from the fauna (animals).

Plants are immobile therefore are highly adaptive and responsive to changing environments such as weather and nutrient availability. They are at the lowest position in the food chain and have the ability to regenerate easily. For example, broken branches by strong winds or leaves eaten by cows are replace by new shoots, a regenerative capability not seen in animals, all due to the fact than plants are not able to move and protect themselves from harsh environments. Its ability to convert sunlight, water and carbon dioxide into food in the structure known as chloroplast distinctly separates them from animals, bacteria, fungi and viruses.
To understand more about plants, few fundamental concepts can be considered.

1. Plant metabolisms is bases on the principles of chemistry and physics
   The process of photosynthesis follow the basic chemical equation of:
   
   \[ \text{sunlight} \]
   \[ \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{C}_6\text{H}_12\text{O}_6 + \text{O}_2 + \text{H}_2\text{O} \]
   
2. Plants have the mean of storing and using information
   Storing and passing of information to the next generation in seeds

3. Plants reproduce, passing their genes and information on to their descendants

4. Genes, and the information they contain, change
   All plants make copies of their genes during sexual reproduction and changes can also occurs through mutation

5. Plants must survive in their own environment

6. Plants are highly integrated organisms
   The structures of the plant have some impact on the rest of the plants. For example, plant with large leaves have bigger surface area to conduct photosynthesis but big leaves always requires larger root systems to absorb more water and nutrient to sustain the large leaves.

7. An individual plant is the temporary result of the interaction of genes and environment

8. Plants do not have the purpose or decision-making capacity
   All plant movement is control by the environment. For example, plants do not decide when to flower and produce fruits rather by the impact of environmental stress, flowering genes assisted by the flowering hormone sent signals to the vegetative buds to develop into flower buds.

**TOPICS 2: Origin and Evolution of Plant**

The first early living organism during 3.5 billion years ago was simple, like present-day bacteria but over thousands of millions years of evolution the cell gradually increased in complexity. Through natural selection, generations with
features that caused them to adapt and grows well reproduced abundantly and passed beneficial features to the next offsprings. One of the major evolutions was the type of photosynthesis that produces oxygen and carbohydrate. It arose 2.8 billion years ago in a bacterium-like organism called cyanobacterium. Later, cell structures became more efficient as subcellular components evolved. These components, called organelles are small completely closed bags of membranes that give each organelle a unique structure such as cell walls. Eventually, DNA became located in the organelles. Early prokaryotes (bacteria and cyanobacteria) were without DNA later evolved into eukaryote with nucleus. By the time nuclei become established evolution had produced thousands of species of prokaryotes. The newly evolved eukaryotes diversified and some acquired an energy-transforming organelle, the mitochondria and some acquired chloroplast. Those with chloroplast evolved into algae and plants, while those without evolved into protozoa, animals and fungi, which is why all organisms are classified into five major kingdoms: Monera, Plantae, Animalia, Myceteae and Protista.

**TOPICS 3: Kingdom Plantae**

The highest level in the taxonomic hierarchy of the living organism is Kingdom. This was later divided into few divisions. In general, plants are organized as non-vascular and vascular plants. There are three main divisions of the non-vascular plants. Vascular plants are divided into two main groups of non-flowering seed (gymnosperms) and flowering seed plants (angiosperms). Here, seeds are referred as spores, seeds and fruiting bodies. There is only one Division in Angiosperms which is the Magnoliophyta and in this course will focus on five divisions from the Gymnosperms.

**TOPICS 4: Non-Vascular Plants**

The non-vascular are non algal plants and have multicellular sporangia (spore producing structure) and gametangia (gamete producing structure). Non-vascular refers to the absent of xylem and floem. The primitive structures for water and food transport consist of hydroid which conducts water and is situated at the centre of the stems, while the food conducting cells called leptoids surrounds the hydroids. There
are three main divisions of non-vascular plants: Byrophyta, Hepatophyta and Anthocerotophyta.

4.1 Division Byrophyta

There are about 15,000 species of mosses and is divided into three main classes of peat mosses, true mosses and rock mosses. The plant structure is consisted of two parts, the vegetative stage called gametophyte and when the reproductive stage developed it is called the sporophyte. The leafy stem or gametophores consist of leaves without any mesophyll, stomata or veins. Male and female structures are borne on separate plants. Female plants developed archegonial head which produced spores while male plants developed antheridial heads which released sperms for sexual reproduction. Mosses out compete most vascular plants as they are able to survive on severe habitats such as open rock surfaces or dead tree trunk. They are considered as the primary successor with the ability to leach rock, the initial step in soil formation.

4.2 Division Hepatophyta

Liverworts are considered advanced than mosses because of their leaf like structures. There are about 8,000 species of liverworts. The most common and widespread liverworts have flattened, lobed and leaflike bodies called thalli or thallus. They are divided into two basic groups according to the nature of their gametophyte: leafy liverworts and thallose liverworts. The thalli or “leafy stage (gametophytes) developed from germinated spores. Male thallus produced male gametophores consisting of a head structure which contained antheridiophore which contained sperms. Female thallus produced female gametophores consisting of a head structure which contained archegoniophore which produced spores.

4.3 Division Anthocerotophyta

Hornworts with mature sporophytes which look like miniature, greenish to blackish rods that may curve slightly leaf structure. It is rare and difficult to find.
TOPICS 5: Vascular Seed Plants: Non-Flowering

Vascular plants which produced seed structure for reproduction but does not produced any flowers. Seeds in this context are referring to seed, spores and fruits. These groups of plants are also referred as gymnosperms. Gymnosperms are those plants with "naked ovules" that is, ovules located on flat sporophylls, not enclose in carpels.

5.1 Division Pteridophyta

One of the ancient vascular plants, ferns first appeared before the dinosaurs. There are approximately 11,000 species of ferns varying in size and shape. It has important role in ecology for soil formation where it appeared after moss during succession. Fern leaves have a highly characteristics development where the young leaves are tightly coiled and uncurl as they expand. This is true not only of the rachis but of the leaflets as well and this only seen in ferns. In most species, the sorus (a cluster of spores) is situated at the back of the leaf, obvious to the eyes and brown in colour.

5.2 Division Coniferophyta

The conifers are the most diverse of the gymnosperms. They are all trees with needle like leaves and produced male and female cones. Males are called pine pollen cone while females are pine seed cone. Pine pollen cone usually occurs at the end of the branch consisting of individuals sporophylls clustered on an axis. Sporophylls produced microscopic sporangium (pollens) which are transferred to pine seed cones by winds. Ovule are developed on the pine seed cone and fully protected by the ovuliferous scale.

5.3 Division Ginkgophyta

This division contains a single living species, *Ginkgo biloba*. Microsporophyll (male) occurs in small, conelike clusters and mixed with foliage. Ovules in pairs at the end of a stalklike megasporophylls which looks like fruits where in actual facts they are naked seeds.
underground and stores food, resembling roots. However, these structures are not to be considered as tuberous roots because it does not have the function of a root i.e. to absorb water and nutrient. These underground stem also bear nodes and internode, the specific characteristics of a stem and not of a root.

**TOPIC 2: Annual Rings**

In regions with strongly seasonal climates, the vascular cambium is inactive during the time of stress, either winter cold or summer drought. But when the cambium becomes active again, the cell division begins. The rings are vascular cambium at its inactive stage and the cells between the rings are the active stage, hence the rings represent the lifetime or age of the tree.

**TOPIC 3: Types of Bark**

*Smooth* When the surface of the bark is without any splits, scale of cracks.

*Crack* The thick surface of the bark splits and cracks

*Peels* The thin surface of the outer bark peels

*Scales* The thin surface splits leaving scales.

**TOPIC 4: Types of Branching**

*Monopodial* The type of branching with only single main axis and one apex meristem. The trunk is erect and does not produce any branch. If the apex is cut off, the tree growth is then terminated. Eg.: All monocots, such as *Elaeis guineensis* (Oil palm).

*Sympodial* Consisting of one main axis and several lateral branches. Eg.: All dicots

*Vines* Stem which are not erected and not self-supporting but climbing or trailing on some support. Eg.: *Vitis* sp. (Grape)

**TOPIC 5: Stem Structures**

*Lenticels* Opening structures on the outer bark or pores for gas exchange.

*Nodes* Point or region where leaf and buds emerged

*Internodes* Stem region between two nodes

*Buds* Young shoot emerging between leaf axil and stem. Can be naked (without scales) or with covers. Type of covers are caps or scales.
Scar Mark indicating the former place of attachment of petiole, bud or vascular bundles. Larger lower region are of petiole attachment and the upper smaller region is from the bud attachment.

**TOPIC 6: Stem Modifications**

6.1 Runners

Modified stem that creeps above or below soil.

**Stolon** Long thin internodes that creep above ground or just beneath the soil surface. At each node, new shoots and roots are produced. Eg.: *Axonopus compressus* (Carpet grass), *Fragaria virginiana* (Strawberry), *Chlorophytum comosum* (Spider plant).

**Rhizome** Short thick internode borne deep underground and is used for food storage. There are two types of leaves. Each node produced scale-like leaf and leaf emerging above ground wrapped tightly with each other to produce a pseudostem (false-stem) and above ground leaves. All the green which are visible above ground are all leaves (not stem). Eg.: *Zingiber officinale* (Ginger/halia), *Curcuma longa* (Tumeric/Kunyit)

6.2 Bulb

Small compact stem surrounded by fleshy leaves. Eg. *Allium cepa* (Shallots, Onion). Adventitious root appears from the stem. The compact parts with the roots are normally discarded and the fleshy leaves are used for cooking. The peels of the onion are scale-like leaves. The stems are able to produce new shoots which are later known as bulblets.

6.3 Corm

Resembles the bulb but does not have any fleshy leaves and is composed of entirely stem tissue. The paerer/scale-like leaf covers the outer layer and adventitious root at the base. The function of this modified stem is mainly for food storage. Eg.: *Crocus* sp., *Alocasia* sp. (taro/keladi), *Dioscorea* sp. (yam/keladi). In the case of *Musa* spp. (banana), the corm is below ground, large and compact. The corm developed above ground leaves where the leaf sheath wrapped with each other to become a compact stem-like structure where the real leaf is borne. The stem-like structures is termed as pseudostem or false stem.
6.4 Culm
Stalk or stem with hollow middle (pith). Internodes are normally long with tough and hardened nodes. The culms of the grasses are shiny, white and wrapped by the leaf sheath. Eg.: *Bambusa vulgaris* (Bamboo), *Imperata cylindrical* (Lalang)

6.5 Tuber
Potato (*Solanum tuberosum*) produced underground stolon. Starches are stored at the end of the stolon to produce a tuber. Potato tuber has several nodes or normally called the eyes. Between these eyes are the internodes and when stored for a long period of time, new shoots will arise from the eyes. Because the tubers are produced from stolon and they have nodes and internodes, they were determined as modified stems instead of tuberous roots.

6.6 Tendril
At the nodes, either new shoots or flower buds are developed. Shoots further developed their own stem which progressed into branches. Sometimes, these shoots are replaced by tendril especially when the plant stem cannot support them self or known as vines. Tendrils will entwine at any other structures including other plants for support driven by the need of sunshine. Eg.: *Momordica charantia* (Bitter gourd/Peria), *Cucumis sativus* (Cucumber/Timun).

6.7 Thorn
With the same principle of instead of shoot emerging from the nodes, thorn are modified stem that becomes compact and having a sharp tip, mainly to protect them self from grazers. Eg.: *Rosa* sp. (Rose)

6.8 Phylloide
This modified stems are specific to *Acacia mangium* (Accasia/Akasia), a legume tree. During the seedling stage, right after germination the shoot are composed of stem enlarged and shaped looking like a leaf. At the end of this structure, the true compound leaf stop to continue growing and fall leaving behind the enlarged and flattened stem called the phylloide. Acacia comes from arid countries such as Africa and Australia. Discarding of leaves is thought to reduce water loss. The phylloide however, resumed the function of the leaf capable of conducting photosynthesis.
6.9 Cladode/Cladophyll
The needle like leaf of the Asparagus (Asparagus officinalis) is not at all leaf but modified stem called cladode. The real leaf is situated at the node, tiny and scale like. Cladophyll is the term used referring to succulent stem of a cactus.

6.10 Pseudobulb
Pseudo is the latin word for false, hence pseudobulb refers to false bulb which can be found on sympodial orchids. It is enlarged and its function is to store food and water.

**TOPIC 7: Vegetative Reproduction through Stem**
Some modified stem are able to reproduce through vegetative reproduction. Stem on bulb produced bulblets and each node of the rhizome, new shoots with roots are produced. Pseudobulb of sympodial orchids is divided into several sections to produce new seedlings. New shoots arises from the corn of banana below ground and emerged as suckers. The stem of Oryza sativa (paddy) and other grasses produced new shoots termed as tillers.

**Important notes**

8. Stem growth and development by elongation and increase in girth
9. Terms to describe stem structure, the type of branching and bark
10. The nine types of stem modifications and their examples

**Observations/Suggestion/Opinion**
and the tip of the leaf is termed as apex. Vein starting from the tip of the petiole and ends at the tip of the apex with disruption is called the primary vein or midrib. Vein that bifurcate from the midrib is the secondary vein, while vein emerging from the secondary vein is the tertiary vein and so on. Vascular bundles channelling from the stem into the petiole, into the middle main vein (midrib) and continuing into the secondary, tertiary (and so on) veins, creating and intricate veins networks for transportation of water to the leaf and transportation of food from the leaves.

**TOPIC 3: Type of Primary Veins**

Leaf veins of monocot plants are less complicated. Leaf has several primary veins running in parallel from the base towards the apex, never joining at the apex. Simple leaf of dicots leaf is consisted of a midrib with bifurcating secondary and tertiary veins. Some dicot leaves has more than one midrib.

- **Actinodromous** Type of primary veins when it has three or more primary veins diverging radially from a single point. Eg.: *Hibiscus rosa-sinensis* (Bunga Raya).
- **Palinactinodromous** Type of primary veins when it more than five primary veins diverging radially from a single point and leaf are lobed. Eg.: *Acer* sp. (Maple tree).
- **Acrodromous** Three or more primaries running in convergent arches towards the leaf apex, joining back at the leaf apex.

**TOPIC 4: Type of Secondary Veins**

- **Brochidodromous** Secondary vein that goes towards the margin but joined with each other before arriving at the margin.
- **Craspedodromous** Secondary vein reached and terminate at the margin. Never jointed.
- **Eucamptodromous** Secondary vein diminish and terminate within the leaf blade, never reaching margin and not jointed.

**TOPIC 5: Type of Tertiary Veins**

- **Reticulate** Net like vein, joint into polygonal.
- **Sclariform/Percurrent** Vein arrangement parallel to each other
TOPIC 6: Leaf Attachment
The leaf stalk or petiole connects the vascular network from the stem to the leaf blade. It also holds the blade out into the light, prevent shading between leaf blades. Plants that are with petiole are termed as petiolate. Not all plants are having petiole. Plant without petiole is called sessile and sub-sessile if they have with very short petiole. Most monocots are sessile and petiole is replaced with sheath instead because it wrapped around the stem, shielding the stem from sight. Examples of monocot with leaf sheath are Oryza sativa (Rice), Zea mays (corn) and Elaeis guineensis (Oil palm).

Some species varies in petiole structures. The swollen region of the base of the petiole is known as pulvinus and mostly seen in legumes. A pair of leaflike, scalelike or thornlike appendages called stipules are sometime present at the base of the petiole. Gas exchange and water loss from leaf surface through a microstructure called stomata pores. The texture of leaf may be smooth or with fine or coarse hairs called trichomes. Secreting glands that produce essential oil, aromatic scent or was are also called trichomes.

TOPIC 7: Leaf Type
7.1 Simple Leaf
Leaf with/without petiole on point of origin i.e. on the node. Single leaf blade is not divided into small leaf or leaflets.

7.2 Compound Leaf
Blades of a compound leaf are divided in various ways into leaflets.
**Pinnately compound** leaves have the leaflets in pairs along an extension of the petiole called a rachis.
**Bipinnately compound** Leaflets of a pinnately compound leaf further subdivided into smaller leaflets
**Tripinnately compound** Leaflets of a bipinnately compound leaf further subdivided into smaller leaflets
**Palmately compound** leaves have all the leaflets attached at the same point at the end of the petiole.
TOPIC 8: Leaf Development
New leaves develop at the surface of the apical meristem of a shoot as primordia. Variation of leaf morphology during development can occur which is called heteroblasty. Plants with leaf polymorphism or heteroblasty often show shape changes along a shoot. For example, during early growth of Sesamum indicum (sesame) the early leaves have toothed margin and remained. After reaching a certain height, new leaf are without tooth.

TOPIC 9: Variation in Leaf Margin
Entire Not toothed, notched or divided. Continuous or straight margins.
Dentate Toothed along margin, the teeth directed outward rather than forward.
Serrate Toothed along the margin the sharp teeth pointing upwards.
Crenate With rounded teeth along the leaf margin

TOPIC 10: Leaf Arrangement
Leaves are arranged in such a way for optimization in capturing sun lights and so that they do not overlap each other. The term phyllotaxy refers to how the leaf are arranged on the stem node
Basal Leaf positioned at or arising from the base of the stem
Alternate Leaf opposite to each other on a stem with one leaf per node
Opposite Leaf opposite to each other with two leaf per node
Decussate Arrange along the stem in pairs. Each pair at right angles to the pair above or below.
Distichous One leaf per node arranged in two rows. Leaves flattened from side to side, not from top to bottom.

TOPIC 11: Leaf Shape Variation
Acerose : needle-shape, as the leaf of pine or spruce
Cordate : Heart-shaped, with the notch at the base
Deltoid : With the shape of the greek letter delta; shape like an equilateral triangle
Elliptic : In the shape of an ellipse, or a narrow oval; broadest at the middle and narrower at the equal ends
Flabellate : Fan-shaped
Lanceolate : Lance-shaped, much longer wide, with the widest point at the middle
Linear: Resembling a line; long and narrow with more or less parallel sides
Obovate: Deltoid, with the attachment at the pointed end
Oblong: Two or four times longer than broad with nearly parallel sides
Oval: Broadly elliptic, the width over one-half the length
Ovate: Egg-shaped in outline ad attached at the broad end
Obovate: Inversely ovate, with the attachment at the narrower end
Orbicular: Approximately circular in outline
Sagittate: Arrowhead-shaped, with the basal lobes directed downwards
Peltate: Shield-shaped; borne on a stalk attached to a lower surface rather than to the base or margin
Spatulate: like a sputala/spoon in shape, with a rounded blade above gradually tapering to the base
Rhombic: Diamond-shaped

**Important notes**

11. Term for basic leaf structure
12. Type of veins, type of leaf, leaf attachment and leaf arrangement
13. Variation in leaf margin and leaf shape

**Observations/Suggestion/Opinion**
Conclusions
The main function of leaf is as photosynthetic unit. Plant identification based on the leaf morphology is highly dependent on their type and shape of leaf vein, apex, base, margin and shape.

Activity
4. Describe in words for each leaf shape variations.
5. Obtain the illustration for each leaf shape and other terms given
UNIT 5
FLOWER MORPHOLOGY

Introduction to Unit
11. An introduction to flower morphology; basic unit of their reproductive and accessory organs
12. Discuss on the petal modification, flower description and type of inflorescence

Objective to Unit
10. To differentiate the morphology and function of the floral reproductive and accessory organs
11. To identify the petal structure and determine their morphological variation and modification

TOPIC 1: Introduction
There are about 240,000 flowering plants. Flowers are the organs of a plant that go through the sexual reproduction process. Their final product is fruit and seed, a vital structure for the continuation of the next generation. It is consisted of two main part of the gynoecium and androecium, either occurring simultaneously (dioecious) or independantly (monoecious). Gynoecium is the term referring to female reproductive organs consisting of stigma, style, ovary and ovule while the androecium is the term referring to the male reproductive organs consisting of filament, anther and pollen. For transfer of pollen to stigma to occur flowers have to attract pollinators or modified their structures in order for wind or water pollination can take place. The role of
accessory organs is to make pollination possible and displayed wide and extravagant variations in shape and colours. The accessory organs consisted of petal, sepal and bracts. Petal displayed wide variation of colours and is collectively known as corolla. The function of sepal is to encapsulate and protect the petals and reproductive organs at bud stage and in plural is collectively known as calyx. When the petal and sepal are indistinguishable, where the petal looks like a sepal or the sepal looks like a petal, the organs is termed as tepal. All the reproductive and accessory organs sits on a platform called the receptacle supported by a flower stalk termed as the pedicel or peduncle. In solitary flowers either term can be used to refer to the flower stalk. In inflorescence the peduncle becomes the main stalk carrying numerous florets supported by the pedicel.

**TOPIC 2: Petal modification**
Modification of petal brings about more variations in shape and functions. Petals of all legumes flowers are consisted of three main parts. The standard or banner is the largest which enclosed the other petals at bud stage. At each side, two petals are known as wings flanked the keel. The keel protects the reproductive organs. The petals florets of paddy (*Oryza sativa*) are modified into two parts, the larger part called lemma and the smaller called palea. Orchids flower has three sepal and three petals. But because of the similar shape and colour pattern the flowers bear a resemblance of having six petals. It is actually arranged in two whorls, the lower whorl is the three sepals while the top whorl is the petals. However the dorsal petal is modified into a shape of a lip hence called labellum. In most orchids flower the lip is the largest part and the most beautiful part, highly adapted to attracts pollinators. It also provided the platform for the insect to land from flight, and leading into the column for nectar collection. The extreme lip modification is seen in the slipper orchid (*Paphiopedilum* sp.) and the three sepals jointed into one.

**TOPIC 3: Floral asymmetry**
Asymmetry refers to the:
Flowers or florets are actinomorphic when a mirror image is obtained when flower are cross section at any angle while zygomorphic when the mirror image is not symmetrical. Example of actinomorphic flower is sunflower and hibiscus while zygomorphic is orchid and legumes.
TOPIC 4: Petal/sepal division

Terms for petal and sepals are given depending when the petals/sepal are free or united.

When free or not united it is known as polyysepalous or polypetalous while united is known as gamosepalous or gamopetalous.

TOPIC 5: Flower descriptions

Botanical descriptions for flower merged the two terms above, giving four categories of corolla forms of (1) Actinomorphic and polypetalous (2) Actinomorphic and gamopetalous, (3) Zygomorphic and polypetalous and (4) Zygomorphic and gamopetalous. These groups are further divided into few examples depending the characteristics of the corolla.

5.1 Actinomorphic and polypetalous

i. Cruciform - The cruciform corolla consists of four free petals, each divided into sections, arranged like a cross. Eg. : Brassica rapa

ii. Caryophyllaceous - Corolla consists of five petals with long claws, petals are right angle – Eg. - Dianthus sp.,

iii. Rosaceous - Five petals, short claw or none at all, outward regularly.
Eg. Camlia sinensis, Prunus domestica

5.2 Actinomorphic and gamopetalous

i. Campanulate - Corolla resembles a bell. Eg. - Convallaria majalis, Campanula grandifolia, Digitalis purpurea

ii. Tubular - When the corolla is cylindrical or tube-like that is equally expand from base to apex, apex may split to form tiny forks. Florets of the disc florets in Helianthus annuus

iii. Funnel-shaped - When corolla look like a funnel, corolla gradually spreading outwards from a narrow base. Eg. Ipomoea reptans

iv. Rotate or wheel-shape - Corolla narrow and short, ending with corolla look like a wheel. The united long corolla formed tube that is known as corolla tube. Eg. Ixora javanica
5.3 Zygomorphic and polypetalous
i. **Papilionaceous** - Look like a butterfly, five petals, consist of standard, wing and keel. Leguminosae/Fabaceae family

5.4 Zygomorphic and gamopetalous
i. **Bilabiate** - Two lips. Corolla tube but divided into two portions of lips at the apex, upper and lower lip. Eg. Basil – *Ocimum basilicum*
ii. **Personate** – Masked. Two-tipped but lips near each other, lower lip close the mouth of flower. Eg. Snapdragon – Figwort
iii. **Ligulate** - Strap-shaped. Whole corolla form a short, narrow tube below, but is flattened above like a strap. Eg. Ray florets of *Helianthus annuus*

**TOPIC 6: Floral Aestivation**

![Diagram of floral aestivation types](image)

Figure 1: Four corolla aestivation types.

1. Valvate : Members of whorls make contact with each other by their margins, or, petals or sepals next to each other without overlapping. Eg. Anona sp.
2. Twisted : Margin sepal or petal nest to each other, and overlapping, maybe clockwise or anti clockwise. Eg. *Hibiscus rosa-sinensis*
3. Imbricate – One of the sepal or petal is internal, overlapping on both margins, one of them is external, and the rest overlap at one margin next to each other. Eg. *Cassia biflora*
4. Vexillary – Five petals of the posterior (outside) is larger almost covers the two lateral petals and the latter in their turn, nearly overlaps the 2 interior (inside) smallest petals. Legume flowers
TOPIC 7: Type of bracts

7.1 Bracts
In the chapters of leaf morphology, bracts are modified leaf or leaves that always accompanied flower or inflorescences. At times, bracts will have the appearance of petal or sepal.

2. Epicalyx – accompanied calyx, and calyx-like appearance. Eg. Hibiscus rosa-sinensis
3. Spathe – Large boat shaped bract enclosing a cluster of flowers or Inflorescences (spadix). Flowers of Araceae, Musaceae and Bird of Paradise.
4. Involucre – Bracts in whorls, present around cluster of flower. Asteraceae
5. Bractole and bracteolule – Bracteole is at the base of the individual ray florets of the Asteraceae flower, thin, membranous, scale while bracteolule accompanied disc florets
6. Glume – Accompanied the individual paddy single florets

7.2 Reproductive Organ
The reproductive organs are the important floral structures, protected by the accessory organs. Terms referring to the female reproductive systems include gynoecium, pistil and carpel. The structures include the stigma, style, ovary and ovule. The role of stigma is to catch and germinate pollen, while the role of style appears to be giving support to stigma conduction of the pollen tubes to the ovary. The texture of stigma surface are either undulating, having micro hairs or waxy provides sticky surface for pollen to adhere. The failure of pollen germination may be associated with failure of pollen enzyme system to break down cutin covering the stigma which brings about the occurrence of self-incompatibility. Longer style not only ensures higher exposure and chances of receiving pollen, it also serves as a sieve where incompatible pollen tubes, through inhibition, are screened from compatible tubes. The ovary are structures that protects the ovule and once fertilisation has taken place it will become the fruit while the ovule is like the egg in animals and once fertilisation has taken place will become the seed.

How the accessory organs, style, filament are arranged on the receptacle will determine the type of ovary.
Ovary superior — Flower is hypogynous and without hypanthium. The sepals, petals and filaments sit on the receptacle at the base of the ovary, with the appearance as if the ovary is outside of the receptacle. The term superior was given because the ovary is superiors over the other parts.

Ovary superior — Flower is perigynous and with hypanthium. A structure called the hypanthium developed and protruding from the receptacle, pushing the accessory organs, and filament upwards and their base is at the same level of the base of the style. Ovary still superior because the hypanthium is not attached to it.

Ovary inferior - Flower is epigynous and with hypanthium. Here, the hypanthium is a attached with the ovary, covering the ovary making it looks like that the ovary is inside the receptacle.

The male which comprises of the filament and anther is known as androecium. The filament is the connective part and extends between thecae. Theca is one half of an anther containing two pollen sacs or male sporangia. The compartment in the anther is known as the locule containing pollen sac or male sporangium which carried the pollen or young gametophyte.

Anthers attached on the filaments in two ways, as basifixed when anther attached at its base to apex of filament or as dorsifixed when anther attached dorsally and medially to apex of filament.

To release the pollen, slits and pores occurred. The type of dehiscence includes longitudinally where dehiscence occurs along long the axis of the theca. If it dehisced longitudinally outward it is known as extrorse and if it dehisced longitudinally inward it is called introse.

Filaments can occur as multiple of singles or joint into groups. Stamens united in one group by their filaments or all the stamens are united into a single tube is known as monadelphous while if into two groups as diadelphous.

**TOPIC 8: Botanical Floral Description**

Complete flowers are made up of calyx, corolla, stamens, and a pistil or pistils (the four "regular parts").
Incomplete flowers lack one or more of the four regular parts of a complete flower as in all of the Fagaceae (oak family), Betulaceae (birch family) and Juglandaceae (walnut family).

Perfect flowers have both stamens and pistils, but not necessarily sepals or petals.

Imperfect flowers lack either stamens or pistils, and may or may not have sepals or petals

Naked flowers are without petals (apetalous) or sepals (asepalous) as in Zantedeschia sp. (calla lily).

Apetalous flowers lack petals as in Elaeagnus pungens (silverthorn) Hydrangea sp.

Staminate (male) flowers have a stamen or stamens, but no functional pistils.

Pistillate (female) flowers have a pistil or pistils, but no functional stamens.

Staminode – male structures that are sterile (pollen not viable)

Pistillode - female structures that are sterile (ovule not viable)

In hemaphrodite flowers, the presence of gynoecium may be accompanied by staminode, and androecium by pistillode. In the flower of Alpinia galanga the functional male and female parts are accompanied by staminode and pistillode.

**TOPIC 9: Flowering Characteristics**

Monoecious plants bear both staminate and pistillate flowers on the same plant as in Quercus sp. (oak) and Zea mays (corn).

Dioecious Plants bear staminate flowers on one plant and pistillate flowers on a different plant, hence the terms male and female plants. Garcinia mangostana, Salacca zaratca, Ilex species (holly) and all cycads and many conifers are examples.
**Polygamous** Plants bear staminate, pistillate, and hermaphroditic (bisexual - both sexes present and functional in the same flower) flowers on the same plant. An example is *Acer rubrum* (red maple).

**TOPIC 10: Type of Inflorescence**

**Solitary** A single flower on a stem

**Spike/Spikelet** Unbranched inflorescence with sessile flowers (no pedicels).

**Raceme** Unbranched inflorescence with flowers on pedicels

**Panicle** A branched or compound raceme (i.e. main rachis with branches bearing flowers on pedicels).

**Corymb** Flat-topped inflorescence with youngest flowers at the end of main axis or rachis

**Cyme** Flat-topped inflorescence with oldest flowers at the end of main axis. Single simple cymes groups into compound cyme or scorioid cymes

**Umbel** Flat-topped inflorescence with all the pedicels arising from a common point. Single simple umbel groups into compound umbel

**Catkin or Ament** A spike-like inflorescence of unisexual, apetalous flowers, often pendent and falling as a unit.

**Spadix** A thick, fleshy spike of unisexual, apetalous flowers, often surrounded by a vase-shaped or funnel-like modified leaf or spathe which is often brightly colored. The male flowers are typically clustered above the female flowers on an erect, phallus-like spike.

**Capitulum or head** The characteristic inflorescence of the sunflower family (Asteraceae). Depending on the tribe, the inflorescence may consist of ray flowers,
disk flowers, or both ray and disk flowers. The ovary of each flower is situated below the attachment of the corolla and stamens, a condition referred to as epigynous or inferior.

**Cyathium** Inflorescence of the Euphorbiaceae Family. Bracts surround clusters of small, greenish, cup-shaped structures called cyathia. Each cyathium is actually a flower cluster or inflorescence containing unisexual, apetalous male and female flowers. The inconspicuous male flowers occur in clusters and are reduced to a single red stamen, while the female flower consists of a single ovary (pistil) on a stalk (pedicel).

### Important notes

14. Terms of flower structures, bracts and
15. Descriptions of flower basically combined the four characteristics of actinomorphic, zygomorphic, polypetalous and gamopetalous.
16. The type of inflorescence

### Observations/Suggestion/Opinion
Conclusion

Flower is the reproductive structure of a plant. It can be described into two component of the reproductive (stigma, style, ovary and ovule) and accessory (petal and sepal) organs. Flowers can be male, female of having both structures named hermaphrodite. If the flower or inflorescence is accompanied by leaf structure, this leaf structure is termed as bracts (modified leaf normally resembling part of a flower). If a single flower is produce on stem node, the flower is considered as solitary and multiple flowers or florets are grouped into an inflorescence.

Activity

6. Search for the pictures of modified petals.
7. Name and describe stigma variations.
UNIT 6
FRUIT AND SEED MORPHOLOGY

Introduction to Unit

13. An introduction to fruit and seed morphology
14. Description of fruit and seed parts, placentation and their terms
15. Description of fruit type and categories

Objective

12. To introduce the terms used in fruit and seed morphology
13. To explain pollination, pollination type and mode of fertilization
14. To describe the fruit type and categories

TOPIC 1: OVULE
Early stage and before fertilization seed is in the form of an ovule. Ovule attached to placenta by the structure called funiculus and the point of attachment on ovule is the hilum. Junctions of intergument and nucellus are the chalaza. The main body of an ovule is the nucellus which contained an embryo sac carrying eight fundamental cells. The nucellus is surrounded by the inner and outer interguments. At the end of the interguments an opening called the microphylla allows pollen tube to enter.

TOPIC 2: TYPE OF PLACENTATION
An ovule attached to the ovary wall on a placenta. Placentation is the manner/way placenta is distributed in the cavity of the ovary. The origin of ovule or group of ovule determines the position of placenta.
Marginal Ovary is one-chambered. Placenta along the junction of the two margins of the carpel (suture)
Axile Ovary, two-chambered (or more). Placenta bearing ovules develop from central axis
Parietal Ovary one-chambered and placenta bearing ovule on the inner wall of the ovary
Central Partition or septa walls in young ovary breakdowns, so ovary becomes one-chambered and placenta develop from the central axis
Free-central Placenta arises from base of ovary, swollen central axis and ovules all over the axis surface.
Basal Ovary uni-locular and placenta develops directly on receptacle, single ovule on base of ovary
Superficial Multiocular, carpel numerous, similar to axile but placenta and ovule develops all round the inner surface of the partition wall.

**TOPIC 3: POLLINATION AND POLLINATION TYPE**
Pollination is defined as transference of pollen grain from anther to stigma, with the aid of pollinators such as wind, insects, water and human.

**Autogamy** (self-pollination) Pollination within a single flower (complete/bisexual flower) or between two flowers borne by same parents, or neighbouring flowers of same plants. Autogamy occurs in two ways, homogamy (Homos – the same). Anthers and stigma of a bisexual flower mature at the same time. Cleitogamy (Kleitso – closed). Bisexual flowers never open and ensure no contamination. Even so, self fertilization is not favourable because of heterosis and declining in genetic variability. Plants are able to avoid self-fertilization through various ways.

**Decline or unisexuality** The term Di bears meaning of two and kline as bed. Flowers which are unisexual or dieocious where stamens and pistil are on separate flowers makes exchanging of pollens more difficult.

**Self-sterility** Pollen of a flower has no fertilizing effect on the stigma of the same flower. Some orchids notably Dendrobium, pollen causes phsyiological injury to stigma. When pollen is put on the stigma the stigma dries up and falls off.
**Dichogamy** In bisexual flowers or hermaphrodite, self-fertilization is avoided by having anther and stigma matures at different time. Who matures first depends whether it is:

a. **Protogyny** Gynoecium matures earlier than androecium

b. **Protandry** Androecium matures earlier than gynoecium

**Heterostyly** One plant with flowers of two different form. One flower with long stamens, and short style while another flower with short stamen and long style.

**Herkogamy** Floral parts were modifies as obstructions to self-pollination. In *Iris* sp., the style expands to form petaloids style or petaloid filament which creates a wall between the stigma and anther.

**Allogamy** (cross-pollination) Pollination between two flowers (bisexual or unisexual) borne by two separate plants of the same or different species. Cross pollination is effective when stamens and style of the same length or known as **homostyly**.

**TOPIC 4: FERTILIZATION**

Fertilization is defined as union of the male gamete (haploid sperm) carried by pollen and the female gamete (haploid egg cell) in the ovule to form a diploid zygote. Anthers produce haploid. When pollen lands on a stigma, through physiological responses the pollen germinates and produce pollen tube that will be able to penetrate the stigma epidermis and grows in the style until it reached the micropyle in the ovule. The tip of the pollen tube burst releasing two make gametes into the embryo sac.

**TOPIC 5: DOUBLE FERTILIZATION**

One haploid male sperm will unite with the haploid egg cell to form diploid zygote and another male sperm unite with the two haploid polar nuclei to form the triploid endosperm. From there the zygotic embryo continue to develop into globular, heart and torpedo-shape embryo until the cotyledons are fully developed.
TOPIC 6: FRUIT

The fruit is defined as ripe ovaries, displaying varies characteristics with one aim of being dispersed and to continue the next generation through germination of seeds. Fruit parts can be divided into three main parts epicarp, mesocarp and endocarp all collectively known as pericarp. Pericarp is actually the fruit wall which enclosed and protects the seed. Epicarp is mostly thin playing the role as skin or peel. The mesocarp in the middle part in most fruits is the flesh and suitable for consumption. The endocarp can be a thin layer or thick, a layer that becomes the locules wall which separate the seed from the fruits.

TOPIC 7: FRUIT TYPE

The fruit type is much depended on the flower type. Solitary flowers will produce simple fruits where fruit is consisted of only one ovary. Aggregate fruit derived from a solitary flower bearing various ovaries. These ovaries will develop into fruits after fertilization and as they developed they fused to formed one aggregate fruit. Multiple fruits come from an inflorescence. In the example of Ananas cosmosus, Artocarpus integer and Pandanus the individual flowers will form fruitlet but as they enlarged they will fused to form one multiple fruits.

TOPIC 8: FRUIT CATEGORIES

Three fruit categories were identified as:

1. Pericarp dry and dehiscent Fruit dry and split or open at maturity
2. Pericarp dry and indehiscent Fruit dry but do not split at maturity
3. Pericarp fleshy Fruit juicy, fleshy or with juice sac

Each category are further divided into few section according to their characteristics

8.1 Pericarp dry and dehiscent

1. Legume or pod. Mainly in Fabaceae. Fruit comes from single carpel and dehisces along both suture (Suture is the line or slit that split)
2. Follicle. Develops from a single carpel and opens along one suture
3. Capsule. Derives from compound carpels and with few to many seeds. Dehisces in various ways and at all sutures.
4. Silique. Mainly in Brassicaceae. Superior ovary, two locules, dehisces along two sutures, central persistent partition with splitting begin from base of the silique. Is term silicula when the fruit is wider.
5. Loment. Similar to pods of legume but separates transversely between seed sections.

8.2 Pericarp dry and indehiscent
1. Achene. One seeded, attached to fruit wall at one point mainly having basal placentation, fruit derived from a one-located superior ovary.
2. Cypsela. An achene derived from one-located ovary but inferior ovary
3. Caryopsis. One seeded with seed coat adnate/stick to the fruit wall. Poaceae family
5. Samara. With outgrowth of the ovary wall, which forms a wing-like structure
6. Schizocarp. Consisting of two carpels that splits, when mature along the midline into two one seeded indehiscent halves. Apiciaceae family: Carrot (Daucus sp)

8.3 Pericarp Fleshy
1. Berry. Compound ovary with many seeds (ovules), fleshy, juicy, difficult to differentiated between endocarp and mesocarp
2. Hesperidium. Type of berry, thick leathery rind/peel (skin), numerous oil glands, thick juicy sac. Peel is exocarp and mesocarp outgrowth from endocarp wall.
3. Pepo. Berry from inferior ovary. Outer wall (rind) consist of receptacle tissue that fused with exocarp. The flesh is mesocarp and endocarp. Endocarp juicy and edible.
TOPIC 9: SEED MORPHOLOGY
Aril Outgrowth of funiculus, raphe or interguments or fleshy interguments or seed coat, a sarcotesta
Chalaza Funicur end of seed body
Embryo Young sporophyte, consist of epicotyl, hypocotyl, radicle and one or more cotyledone
Endosperm Food reserve tissue is seed

TOPIC 10: EMBRYO PARTS
Coleoptile Protective sheath around epicotyl in grasses
Coleorhiza Protective sheath around radicle in grasses
Cotyledone Embryonic leaf or leaves in seed
Epicotyl Apical end of embryo axis that gives rise to shoot system
Hypocotyl Embryonic stem in seed, below cotyledone
Plumule Embryonic leaf or leaves in seed, derived from epicotyl
Radicle Basal end of embryo axis that gives rise to root system

TOPIC 11: TYPE OF GERMINATION
Epigeal germination Cotyledones are pushed upwards by rapid elongation of the hypocotyl epi (upon) ge (earth). Cotyledones becomes flat (look like leaf) and dries up and fall after leaves appears

Hypogeal germination Cotyledones remain in the soil, epicotyl pushes the plumule upwards. Hypo (below) ge (earth)
Important notes

17. Botanical terms for fruit and seed parts.
18. Definition of pollination, pollination type, fertilization and germination
19. The fruit type and categories.

Observations/Suggestion/Opinion

Conclusion

The description of fruit and seed has to be synonymous to the flower as fruit is the ripe ovary and seed is the fertilized ovule. Simple fruits derived from solitary flower while aggregate come from inflorescences. In general there are three fruit categories, each category with different type and forms. Embryo parts differ between the monocot and dicot and there are two type of germination, epigeal and hypogeal.

Activity

1. Determine the eight cells type in the embryo sac.
2. Observed a pineapple and determine the single fruitlets and its bracts.
3. Acquires examples for each section of fruit categories.
UNIT 7
PLANT ANATOMY

Introduction

16. An introduction to basic plant anatomy
17. The definition and description of cell and tissues
18. The description of simple and complex cell and their function

Objective

15. To provide definitions to simple and complex cell and tissues
16. To explain the function of cell and tissue

TOPIC 1: INTRODUCTION

Plant anatomy deals with the internal plant structures in term of the morphology and function of cell and tissues. Cell is a single unit of living organisms, which divides repeatedly to form tissue until develops into organism and tissue are aggregate or clump of cells which form differentiated organs.

TOPIC 2: PLANT CELL STRUCTURES

i. **Cell wall** The outer layer of the cell. Plant cell wall differs from the animal cell in term of rigidity.

ii. **Protoplasm** Except for the wall, everything in the cell is a protoplasm, composed of organelles

iii. **Nucleus** Storage of genetic information, DNA
iv. **Vacuole** Single membrane which contain water and salts or electrolites
v. **Mitochondria** cellular respiration, release of energy
vi. **Plastids** Structures that only exist in plant cell for the purpose of phytosynthesis

**TOPIC 3: CELL WALL**
Cell wall is made of two layers. The primary cell wall contained cellulose, hemicellulose, and pectin while the secondary contained more cellulose and replaced the pectin with lignin and suberin. Pectin, lignin and suberin are organic materials and soluble fibres and determined the rigidity of the cell wall. Cellulose is bind by hemicelluloses by pectin, lignin or suberin to form microfibrils and finally fibers. Cells are separated from each other by a thin membrane called the middle lamella.

**TOPIC 4: PLASTID**
Plastids are responsible for photosynthesis, storage of products like starch and for the synthesis of many classes of molecules such as fatty acid and terpenes which are needed as cellular building blocks and/or for the function of the plant. Chloroplast is the more familiar plastid with the most important function i.e. to carry out photosynthesis.

**TOPIC 5: MERISTEMATIC TISSUES**
The important regions that ensure growth, meristem regions at the apical and lateral meristem are always actively dividing. Cells are small, six-sided boxlike cell, large nucleus and with tiny vacuole.

**Apical meristem** Found at, or near the tips of root and shoot. The apical meristem increase in number of cell which makes the plant elongates. This is known as the primary growth, and from the apical meristem, three primary meristem also called primary tissue. The protoderm will differentiated into epidermis, the outer ground meristem into cortex region, the inner ground meristem into pith which is separated
by the procambium. Procambium are starting materials for formation of vascular cambium, xylem and phloem.

**Lateral meristem** After the cell has divided the sister cell will enlarged and increase in term of width or girth. This is known as the secondary growth. Vascular cambium produces secondary tissue for support and conduction function with thin cylinder and brick shaped cells. The cork cambiums are thin cylinder cell outside the vascular cambium, just below cork cell.

**TOPIC 6: INTERNAL ORGANIZATION OF THE PLANT BODY**

The plant body consists of many different types of cell, each enclosed in its own wall and united with other cells by means of a cementing intercellular substance. Within this united mass certain groupings of cells are distinct from others structurally or functionally or both. These groupings are referred to as tissues. The structural variations of tissues are based on differences in the component cells and their type of attached to each other. Some tissues are structurally relatively simple in they consist of one cell type; others, containing more than one cell type, are complex.

**TOPIC 7: COMPOSITION OF VASCULAR PLANT BODY**

The body of a plant is composed of three tissue systems, the dermal, the vascular and the fundamental ground tissue. The dermal tissue comprises the epidermis that is the primary outer protective covering the plant body and the periderm, the protective tissue that supplants the epidermis mainly in plants that undergo a secondary increase in thickness. The vascular tissue system contains two kinds of conducting tissues, the phloem (food conducting) and the xylem (water conduction). The epidermis, periderm, phloem and xylem are complex tissue. The fundamental tissue system (or ground tissue system) includes the simple tissues that in a sense form the ground substances of the plant but the same time show various degrees of specialization.

7.1 **SIMPLE TISSUE**

1. Parenchyma cell
Parenchyma tissue composed of parenchyma cells. This type is most common and abundant and found in almost of the major parts of plants. They are characteristically living cells, capable of growth and division. They are spherical (round) when new and when increasing, pushed up against each other and become thin and flattened at point of contact. Parenchyma has large vacuole, thin cell wall, may contain starch, oils, tannins, crystals or secretions. Parenchyma in leaf that contained chloroplast is known as chlorenchyma.

2. Collenchyma
They are fairly similar to parenchyma but cell wall are thicker and having uneven thickness. The Uneven is due to extra primary wall at the corners and usually occurs just beneath the epidermis. They are typically longer than wider and mostly found at shoot tips and young petiole.

3. Sclerenchyma
Has both primary wall and a thick secondary wall that is usually lignified (contain lignin). Most sclerenchyma cell are dead at maturity. There are two types the sclereid and fiber. Sclereid is also called the stone cells found in pear and guava that causes grittiness. Fiber has very think cell wall and often group to form fibrils.

7.2 COMPLEX TISSUE
Two or more simple tissue comes together to form complex tissue.

1. Xylem
Water conducting tissues which consisted of vessels, tracheids, parenchyma, fiber and ray cells. Vessels are short, large with rounded opening, with both ends open, while tracheids are long, thin with both end tapering and close. At the end of the opening of vessels, it is close with perforated plates allowing only certain size molecules to pass i.e. water. Vessels and tracheids rarely occur together where tracheids are mostly found in primitive plants such as pine tree. Both vessels and tracheids have pits i.e. pores or minute opening
that allows water to pass through. Water move from end to end and also through pits in vessels while trachieds only allows water to pass through pits as both ends are close. There are four types of vessels: spiral, annular, reticulate and pitted. Early season xylems are called protoxylem where they start as spiral and eventually matured to form annular and reticulated. Late season vessels arelarged and pitted is called metaxylems.

2. Phloem
There six elements in phloem which include parenchyma, ray cells and fibers. The most important element for food transportation are the sieve tube members and sive tube plates. In between sieve tubes small and cylindrical companion cells are situated. The sive tube plates are perforated large enough to allow water and food such as carbohydrates.

3. Epidermis
The epidermis is the only layer that has direct contact with the environment. In general, it is single layer (uniseriate) and white velamen that covers orchid roots is multiseriate. It can secrete fatty substance called cutin within and surface of outer wall to form a protective layer called cuticle. Leaf has two layers of epidermis as leaf has upper and lower surface. On the surface of leaf epidermis hairs or trichomes are produced and pores called stomata are also found.

4. Periderm
In woody plants, epidermis is replaced by a periderm. The outer bark that consist of boxlike cork cells which are dead at maturity and cork cells can secrete fatty substance called suberin which is water proof. Some part of cork cambium from pockets of loosely arranged parenchyma cell called lenticels which are use for gas exchanged.

5. Secretory cells
Derived from parenchyma cells and secrete oils (citrus), nectar (flower), mucilage (sundew), latex (rubber) and resin.
TOPIC 8: APICAL MERISTEM

The term apical meristem refers to a group of meristematic cells at the apex of shoot and root that by cell division lay the foundation of the primary plant body. The change from apical meristem to adult primary tissues is gradual and involves the intergrading of the phenomena of cell divisions, cell enlargement and cell differentiation. The initial region of the apical meristem consists of the (1) tunica, one or more peripheral layers of cells that divide in planes perpendicular to the surface of the meristem i.e. anticlinal divisions (2) corpus, a body of cells several layers deep in which the cells divide in various planes. The corpus add bulk to the apical meristem by increase in volume, the one or more layer of tunica maintain their continuity over the enlarging mass by surface growth.

TOPIC 9: VEGETATIVE SHOOT Apex

The vegetative shoot apex is a dynamic structure that in addition to adding cells to the primary plant body, repetitively produces units, or modules called phytomers. Each phytomere consist of a node, with an attached leaf, a subjacent internode and a bud at the base of the node.

TOPIC 10: ROOT ANATOMY

Epidermis has contact with soils or air (for adventitious roots). Cortex are made of parenchyma cells hence refers as parenchyma cortex to differentiated them from the parenchyma pith. In roots, parenchyma functions as food storage and through very high magnification the round starch granules are obvious. Endodermis separates the cortex regions to the vascular bundles and pith which is consisted of the casparian strips that allow water from the soil to flow into the vascular bundles. Just beneath the endodermis is the one layer pericycle cells which is highly important for secondary and tertiary roots development. The pith are predominantly made of parenchyma cells and the arrangement of vascular bundles in monocots are neatly arranged in circle while in dicot the vascular bundles is centred in the middle with the phloem at the four corner separated by the xylems.
**TOPIC 11: STEM ANATOMY**

Epidermis has contact with the air and in matured trees is replaced by periderm which is the composition of the bark. Outer bark is dead cork cells while the inner bark is still active. Stem does not have an endodermis, where the vascular bundles act as the border to separate the pith and cortex regions. In dicots, the vascular cambium developed in circle and from there, the protoxylem and phloem develops following the circle pattern. In monocot the vascular bundles are randomly scattered leaving less defining pith or cortex regions.

**TOPIC 12: LEAF ANATOMY**

Epidermis is at both side of the leaf the upper leaf (adaxial) and lower leaf (abaxial). In dicot leaf, beneath the adaxial epidermis, the palisade mesophylls are found. They are long cylindrical cells arranged neatly side by side to each other. Beneath the abaxial epidermis, the spongy mesophyl which loosely arranged leaving gaps between them. Gaps are filling with water which is important for carbon dioxide transportation from the guard cells to the chloroplast. Stomata which are pores and their opening controlled by the guard cells are mostly found at the abaxial surface but in some plant species it is also found on the adaxial surface. The main and largest vascular bundles are actually the midrib which interconnected with the smaller vascular bundles or leaf veins. The pattern of vascular bundles much rely on the type of leaf vein and in monocot they are relatively similar in size and is arranged in parallel as all the veins are parallel primary veins. Monocot leaves are mainly made of spongy mesophyll and some grasses in monocot contained bundle sheath and is known as krantz anatomy.

**Important notes**

20. The basic component of the plant cell
21. Meristematic tissue, its characteristic and functions
22. Type of simple cell: parenchyma, sclerenchyma, collenchymas
23. Type of tissue: xylem, phloem, epidermis, periderm, secretory cells
24. The basic unit of each organs
Observation/Suggestions/Opinion

Conclusion

Plant cell wall are lignified and simple cells consisted of parenchyma, collenchymas and sclerenchyma. Combination of these simple cells with other components will make the xylem, phloem, epidermis, periderm and secretory cells. The most important region of a plant is the meristematic tissue as this tissue is always producing new and primary and secondary growth occurs through cell division and expansion.

Activity

4. Acquires a diagram of a plant cell and identify each component.

5. Finds out what food is manufactured from pectin.

REFERENCE AND FURTHER READING:
UNIT 8
PLANT TAXONOMY AND CLASSIFICATION

Introduction to Unit

19. An introduction to plant identification and classification
20. History on nomenclature and ranks of taxa
21. Definition and differences in identification, classification and plant relationships
22. Description of characteristics of selected families

Objective

17. To explain the terms and definition in plant taxonomy
18. To explain the ranks of taxa
19. To make understood the differences between identification, classification and relationships
20. To describe the distinct characteristics of selected families

TOPIC 1: INTRODUCTION

Plant taxonomy is defined as a study of the principles and practise of classification (Heslop-Harrison, 1963). It is the science that finds, describes, classifies and names plants. Taxonomy is often defined as a science dealing with the study of classification, including its bases, principles, rules and procedures. The general purposes of all taxonomy us to arrange elements, components, objects, or taxa in a way that gives the possible command of knowledge, makes the most effective use of
information, and leads most directly to the acquisition of pertinent data, information and knowledge.

**TOPIC 2: HISTORY**
The history in plant classification began as early as the existence of man where collection of plants were done for food and shelter, and naming of plant for further identification for the next generation. However, the scientific classification began as early as 370-285 b.c. by Theophrastus, a Greek botanical writer and grandfather of modern botany. His work showed the distinction between external and internal structures, the classifications of plants into four groups of trees, shrubs, subshrubs and herbs, the distinction of flowering (phanerograms) and non-flowering plants (cryptograms), a basic understanding of gross anatomy, that is that the calyx and corolla are modified leaves and the recognition of the fruits in its modern and technical sense.

Systematic botany began with collection and identifying of herbals used mainly for medicinal purposes of the sixteenth century. Botanist like Brunfels, Fuchs, and Bock went back to nature to collect herbs and wrote careful descriptions where these careful descriptions led to arrangement and groupings. They recognized that several plants were of the same kind: several species of the same genus and wider resemblance of habit, genealogical characters of leaf, stem and branches led to establishment of larger groups. A botanical terminology was appeared by Leohard Fuchs, Father of English Botany is William Turner, Kaspar Bauhin determined that genera and species are distinguished by name and a binary nomenclature was frequent and Andrea Cesalpini established the arrangement in classes based on characters of the seed and embryo.

**TOPIC 3: PLANT NOMENCLATURE**
Gaspur Bauhin (1560-1624) devised a plan of adopting two names only for each plant but it was Linnaeus (1707-1778) undertook the task of methodically naming and classifying the whole living world from buffaloes to buttercups that the dual name system became permanently established. The latin or scientific name of plants are italicized as *Cucumis sativus* (in print) and underline when type or hand written (*Cucurnis sativus*). Initial letter of the generic name is capitalized the remainder small. The name of the genus is a noun and singular, the specific epithet is usually
an adjective. Eg: *Quercus alba* (*Quercus* means oak and *alba* means white). When species is unknown it is written as *Quercus* sp. referring to a single specimen while *Quercus* spp. refers to several species. The name should always come with their authority (those that find, describe and name) for example, *Quercus alba* L., L is the abbreviation to Linnaeus, the founder, author of the species. Not all are ended as L. as they are other authorities such as *Garcinia hombroniana* Pierre. Other known authorities are Ridley, Holttum, King and Roxburgh.

**TOPIC 4: RANKS OF TAXA**

The accepted system of nomenclature provides a hierarchical arrangement of the ranks of taxa. The ending on the name of the taxon indicates its rank (Table 1).

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**DEFINITIONS**

**Species** Set of individuals closely related by descent from a common ancestor. Member of a species can interbreed with each other but cannot interbreed with other species.

**Genera** A group of closely related members of species. Singular: genus.

**Family** Composed of one or several genus; often with many genera.

**Subspecies** Depending on geographical separations. When a member of an established population escape or migrate through dispersal or geographical separation, a new colony will develop. If the new colony sexually reproduced and gives rise to seedlings with the same traits as the original populations, it is considered as the same species. If the new populations change in traits by mutation and environmental influences, and has slight different in morphological characteristics then it become a sub-species. Over time, through infraspecific variation and speciation it will eventually developed into a stable new species.

**Ecotypes** Sometimes called ecospecies, describes a genetically distinct geographic variety, population or race within species (or among closely related), which is adapted to specific environmental conditions. Typically, ecotypes exhibit phenotypic differences (such as in morphology or physiology) stemming from environmental heterogeneity and are capable of interbreeding with other geographically adjacent ecotypes without loss of fertility or vigour.
**Genotypes** The genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms. The combination of alleles located on homologous chromosomes that determines a specific characteristic or trait. Traits are controlled by genes.

**Phenotypes** A phenotype is an organism’s observable characteristics or traits: such as its morphology, development, biochemical or physiological properties, behaviour, and products of behaviour (such as a bird’s nest). Phenotypes result from the expression of an organism’s genes as well as the influence of environmental factors and the interactions between the two.

**Landraces** A landrace is a local variety of a domesticated animal or plant species which has developed largely by natural processes, by adaptation to the natural and cultural environment in which it lives. It differs from a formal breed which has been bred deliberately to conform to a particular standard type. Landraces are usually more genetically and physically diverse than formal breeds.

**Accessions** Accession refers to the general idea of joining or adding to Accession number: a catalogue number assigned to an object when it becomes part of a

**TOPIC 5: PLANT IDENTIFICATION**
Recognition presupposes a personal familiarity with the organism or object. Identification is the determination of the group to which a specimen belongs, which assumes that organisms have been distinguished from one another, classified, as well named by a professional taxonomist. Recognition involves recall by association. Identification usually includes a direct comparison of the unknown species with classified, circumscribed and named taxa or use device such as using Identification Key or Dichotomous Key based on the fundamental of morphological knowledge. Dichotomous or taxonomic key works by offering two (or sometimes more) alternative at each juncture, and the choice of one of those alternatives determines the next step. For each level of distinction, there is normally a further indent. Since most plants have been catalogued in monographs, national museums, arboretum and herbarium including easy access databases, plant identification are easily done through comparison of descriptions, photographs and even DNA. Taxonomic keys and herbarium however does not classified plants.
TOPIC 6: PLANT CLASSIFICATIONS
Classification is the placement of objects into groups and categories for effective organization. Plant classification is the ordering of groups of plants into a hierarchy of taxa in positional compartments according to phonic similarities, phylogenetics relationships or artificial criteria. Traditional classification relies heavily on morphological descriptions which is subjective to the describers. Numerical taxonomy has the power to integrate data from variety of sources such as morphology, physiology, chemistry and DNA sequences.

The basic purposes of classifications are:
1. To order organisms into name taxa on the basis of their relationships
2. To provide an orderly arrangement which expresses those relationships in a practical or natural way
3. To produce a system for efficient and effective storage, retrieval and use for the taxa included in the classifications

TOPIC 7: SPECIES RELATIONSHIPS
Cladistic approach Method of examining natural relationships among organism which are based on characteristics shared by the organism. Relationship are usually portrayed in straight line diagrams or evolutionary tree called cladograms.

Systematics Systematics is the science of organismal diversity. It entails the discovery, and interpretation of biological diversity, as well as the synthesis of information on diversity in the form of predictive classification systems.

TOPIC 8: TAXONOMY OF SELECTED CROPS
1. Oil Palm
Taxonomic rank:
Class : Liliopsida
Order : Arecales
Family : Areaceae
Genus : Elaeis
Species : guineensis, oleifera
Binomial name : Elaeis guineensis Jacq.
Botanical descriptions:
Habitat, cultivated, origin Africa. Habit, evergreen, large tree with fibrous root system. Stem monopodial, erect, 60-80 ft in height in nature, but is rarely more than 20 or 30 ft in cultivation. Leaf, pinnate, up to 25 ft in length, with leaflets numbering 200-300 per leaf, about 3-4 ft long and 1.5 - 2.0" wide, with entire margins. Leaflets cover the distal 2/3 of the leaf, and the lower 1/3 is with spine. Inflorescence monoeocious, producing male and female inflorescences in leaf axils. The inflorescence of both sexes is a compound spadix with 100-200 branches, initially enclosed in a spathe or bract that splits 2 weeks prior to anthesis. Fruit are drupes. The mesocarp and endocarp vary in thickness, with dura types having thick endocarps and less mesocarp, and tenera types the opposite. The exocarp color is green changing to orange at maturity in virescens types, and orange with brown or black cheek colors in the nigrescens types. Fruit range in size from <1" to 2", and are obovoid in shape. The mesocarp, from which palm oil is derived, is fibrous and oily, and the seed is opaque white, encased in a brown endocarp; palm kernel oil is derived from seeds. The female infructescence contains 200-300 fruit, and fruit set is 50-70%. Fruit ripen about 5-6 months after pollination.

2. Rubber

Taxonomic rank:
Order : Malpighiales
Family : Euphorbiaceae
Subfamily : Crotonoideae
Tribe : Micrandreae
Subtribe : Heveinae
Genus : Hevea
Species : brasiliensis

Binomial name: Hevea brasiliensis (Willd. ex A. Juss.) Müll.Arg

Botanical descriptions:
From Amazonian South America, only known from cultivation, evergreen, tap root system, 20 m tall with smooth grayish trunk, latex white. Leaf : alternate, trifoliolate, stipules not seen, petiole 3–23.2 cm long; petiolules 5–10 mm long; leaflets elliptic
or obovate, 5-23.5 by 2.2-8.8 cm, length/width ratio 2.3-2.7, reclinata, base attenuate, apex acuminate to cuspidate, both surfaces glabrous, venation distinct on both sides, nerves 14-27 till apex, flat above, raised underneath. **Inflorescence** : axillary panicles, up to 31 cm long, glabrous to hairy, branches up to 6.2 cm long, peduncle 1-4.6 cm long; bracts 5-8 by 2-4 mm. **Staminate flowers** : 4.5-5 mm diam., yellowish, sweet scented; pedicel 0.6-3.2 mm long; calyx 4.5-6.2 mm long, lobes 2-4.5 by 0.5-1.5 mm; androphore 2.2-2.8 mm long, stamens 10, united in two layers, anthers 0.5-0.8 by 0.2-0.3 mm; disc glands absent; pistilloide 0.8-1 mm long. **Pistillate flowers** : 5-5.6 mm diam.; calyx 5-7.4 mm high, lobes 3-4.5 by 1-1.8 mm; disc glands absent; ovary 2-2.4 by 1.8-2.1 mm, hairs on ovary; stigmas c. 0.2 mm long. **Fruits** : 4-5 by 3.2-4.8 cm, wall 3-4 mm thick, unripe green, brown when ripe; pedicel 0.6-2.5 cm long; column 25-32 mm long. **Seeds** : 2.3-2.6 by 1.9-2.1 by 1.4-1.6 cm.

3. **Jathropha**

**Taxonomic rank** :

- **Class** : Magnoliopsida
- **Order** : Malpighiales
- **Family** : Euphorbiaceae
- **Genus** : Jathropha
- **Species** : curcas
- **Binomial name** : Jathropha curcas L.

**Botanical descriptions:**

**Habit**: perennial, monoecious shrub or small tree up to 6 m high; bark pale brown, papery, peeling; slash exudes a copious watery latex. **Leaf**: alternate, palmate, petiolate, stipulate; stipules minute; petiole 2-20 cm long, blade 3-5 lobed, 12.5-18 x 11-16 cm, lobes acute or shortly acuminate at the apex, margins entire or undulating, leaf base deeply cordate, glabrous or pubescent only on the veins below, basal veins 7-9, prominent, venation reticulate. **Inflorescence**: a cyme formed terminally on branches and complex, monoecious and flowers are unisexual; occasionally hermaphroditic flowers occur; 10 stamens arranged in 2 distinct whorls of 5 each in a single column in the androecium and in close proximity to each other. In the gynaecium, the 3 slender styles are connate to about 2/3 of their length, dilating to a
massive bifurcate stigma. Female flowers with sepals up to 18 mm long, persistent; ovary 3-locular, ellipsoid, 1.5-2 mm in diameter, style bifid. Fruit: ellipsoid capsule 2.5-3 cm long, 2-3 cm in diameter, yellow, turning black. Seeds black, 2 per cell, ellipsoid, triangular-convex, 1.5-2 x 1-1.1 cm.

**TOPIC 9: RECOGNITION OF PLANTS ACCORDING TO SPECIFIC TRAITS IN THEIR FAMILY**

**BRASSICACEAE (THE MUSTARD FAMILY)** The original latin family name was Cruciferae based on the four petals arrangements. Flowers are cruciform (actinomorphic, polypetalous, with siliquae fruit. Mustards are condiment popular among the European and Japanese. Dijon mustard (France) and Colmans (English) are yellow mustard made from *Sinapis hirta* while the wasabi used in sushi is from *Wasabia japonica*.

**ROSACEAE (THE ROSE FAMILY)** There are about 3,000 species of tree, shrubs and herbs in this family. The main characteristics of this family is the stones fruits, pome fruits and aggregate fruits. Mostly used as ornamentals and perfume industry. The fruit of rose (pips) is high in vitamin C. The flowers are actinomorphic and polypetalous with rosaceous petals.

**FABACEAE (THE LEGUME FAMILY)** Originally referred as Leguminosae, this is the third largest family. Very distinct floral characteristics for Fabaceae are the irregular and zygomorphic standard, wing and keel; the pulvinus petiole and the bean and lomentum pods.

**EUPHORBIACEAE (THE SPURGE FAMILY)** Mostly are tropical plants with stamen and pistils in separate flower. The florets lack corolla but Eupohbiceae bears species producing latex.

**CACTACEAE (THE CACTUS FAMILY)** Native only to the Americas, it is mostly used as ornamental. There are about 1,500 species in drier subtropical region or arid and most are with spines. Some are spineless and known as peyote. Leaves are
modified into spines and stem into cladophylls all evolve to conserve water in arid regions.

**LAMIACEAE (THE MINT FAMILY)** Previously known as Labiatae, there are about 3,000 species, plants with angular stem, opposite leaf, irregular flower and bilabiate but most have aromatic oil in leaf and stem.

**SOLANACEAE (THE NIGHT SHADE FAMILY)** Solanaceae is a family that includes important agriculture crops such as potato as well as many toxic plants. Although there are different genus in this family such as *Solanum, Capsicum, Physalis, Petunia, Datura* and *Nicotiana* they are all grouped in this family based on the similar floral morphology.

**MALVACEAE (THE MALLOW FAMILY)** Include 200 genera and about 2300 species with Hibiscus having the largest genera. Cocoa and jute is also in this family. The main characteristics are the five showy petals and long style with filaments at the end of the style. The presence of epicalyx is also one of the main features in Malvaceae.

**APIACEAE (THE UMBELLIFERS)** Both Apiaceae and Umbelliferae is accepted by ICBN. They are svory-aromatic herbage, leaves are generally dissected and the main characteristics are the small and numerous florets arranged in umbels or compound umbels.

**CUCURBITACEAE (THE PUMPKIN FAMILY OR CUCURBITS)** Most are annual vines with tendrils, flowers with fused petals and inferior ovary and all are unisexual. Fruits pepo.

**ASTERACEAE (THE SUNFLOWER FAMILY)** The largest family of vascular plants is also known as Compositae. All Asteraceae have two types of florets, the disc and ray florets grouped neatly to form a head and resemble the sun. The lettuce (*Lactuca sativa*) is not in Brassicaceae as the flowers are made of ray and disc florets.

**POACEAE (THE GRASS FAMILY)** Formerly known as Graminae, contained some most important crops such as *Oryza sativa, Zea mays, Triticum aestivum, Hordeum*
vagare, *Avena sativa* and *Saccharum officinarum* which includes all grasses. Poaceae have hollow stem or culm, with modified petal known as palea and lemma.

**LILIACEAE (THE LILY FAMILY)** Flowers often large, their parts are multiple of 3, Sepals and petals usually resembling each other. Several have bulbs while others have rhizomes.

**ORCHIDACEAE (THE ORCHID FAMILY)** Largest family of the flowering plants. Mainly tropical such as *Dendrobium*, *Vanda*, *Bulbophyllum*, *Oncidium*, *Cattleya*, *Vanilla*, *Phalaenopsis*, *Paphiopedilum*, *Arachis*, *Arundina*, *Aerides* etc with *Dendrobium* as the biggest genera.

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**Important notes**

25. Ranks of taxa and the ending of name for each taxa
26. Taxonomic key is used for plant identification and not classifications
27. Distinct characteristics is used to identified the family of plants

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**Observation/Suggestion/Opinion**
Conclusion

History of plant collection is important for identification and nomenclature as some species name adopt early botanist. For example, *Bauhinia purpurea* by Bauhin. Nomenclature and taxonomy explains the naming of plants while classification explains their relationships. The categorization of plants follow the ranks of taxa and for each families, distinct characteristics is used for identification.

Activity

1. List out the taxonomic rank and the botanical descriptions for
   *Oryza sativa* L., *Zea mays*, *Brassica chinensis*, *Durio zibethinus*,
   *Garcinia mangostana*

REFERENCE AND FURTHER READING:
1. Albert E.R., Fundamental of Plant Systematics