Proceedings for the training on tree species identification

Bangladesh Forest Department

26 September 2016

USAID FROM THE AMERICAN PEOPLE

Food and Agriculture Organization of the United Nations

The Forest Department of Bangladesh leads actions to improve forest management and conservation, adopting forward thinking, innovative approaches in its management of approximately 1.55 million hectares of land across the country.

In 2015, the Forest Department began a process to establish a National Forest Inventory and Satellite Land Monitoring System for improved forest and natural resource management. The process supports national objectives related to climate change mitigation and provides information in support of the UN REDD programme aimed at Reducing Emissions from Deforestation and Forest Degradation (REDD+). The process also addresses domestic information needs and supports national policy processes related to forests and the multitude of interconnected human and environmental systems that forests support.

The activities implemented under the Bangladesh Forest Inventory process are collaboration between several national and international institutions and stakeholders. National partners from multiple government departments and agencies assist in providing a nationally coordinated approach to land management. International partners, including the United Stated Agency for International Development (USAID), the Food and Agriculture Organization of the United Nations (FAO) and SilvaCarbon are supporting the development of technical and financial resources that will assist in institutionalising the process.

The results will allow the Forest Department to provide regular, updated information about the status of trees and forests for a multitude of purposes including for assessment of role of trees for firewood, medicines, timber, climate change mitigation.

CONTACTS:

Md. Zaheer Iqbal
National Project Coordinator
Bangladesh Forest Department
Email: z.iqbal60@gmail.com

Matieu Henry
Chief Technical Advisor
Food & Agriculture Organization of The United Nations
Email: matieu.henry@fao.org

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EXECUTIVE SUMMARY

Bangladesh National Herbarium (BNH) is a national research organization for plant taxonomic research and museum of dried plant specimens. It deals with the exploration, collection, identification, preservation of plants and floristic publication of the country. BNH has a collection of more than one hundred thousand dried plant specimens. The records that accompanies each dried and pressed specimens includes the name of the species and family, accession number, date of collection, collector's name and collection number, ecology and important note on plant. These specimens are used as the basis of plant identification and plant diversity assessment of the country. This national property goes down to the posterity through generations for hundreds of years and used as reference materials in plant taxonomic research. It plays an important role in the study of botany and conservation of biodiversity and environment.

On the other hand, Bangladesh Forest Department is the lead institution and responsible for conducting forest inventories at regular intervals for the assessment and management of forest resources. The accuracy of such inventory mostly depends on the correct identification of forest species. Recently, BFD has undertaken a project for national forest inventory with the financial and technical help from FAO and a number of national stakeholders including BNH. The main responsibility of BNH has been determined as to prepare a coreect and reliable tree species database of the country and also provide technical support in identification of forest species. Very recently, a LoA has been signed between FAO and BNH in support of the Improved National Tree Species Database to support forest monitoring and assessment under Project GCP/BGD/058/USA.

The project aims are to (i) develop a reliable, consistent and correct tree species list; (ii) increase species identification capacity in the field; and (iii) strength the capacity to manage species data and associated metadata.

2. Conceptual Framework

The project entitled *"Improved National Tree Species Database to support forest monitoring and assessment"* has been designed to result the following outputs: (i) National consultation on tree species identification organized and documented; (ii) National tree and forest species list developed including scientific, local names and meta-data; (iii) National capacities on tree species identification strengthened; (iv) Final report including the identification of discrepancies with global database for tree species and forest resource assessment. The first output of the project will be achievied with the activity *'Strengthen collaboration between national stakeholders involved in plant species identification'.*

Under the above said activity, Bangladesh National Herbarium is going to organize a three days long training workshop entitled **'Herbarium techniques in identification of tree species'** from 26 September 2016 to 28 September 2016 at BNH auditorium, Mirpur, Dhaka. Dr. Md. Abul Hassan, Professor, Department of Botany, University of Dhaka has kindly concent to grace occasion. A total of 25 participants from different universities and Bangladesh Forest Department have been invited to attend the workshop. Senior scientists of BNH including three visiting scientists will deliver multimedia presentation in the workshop. The objectives of the the workshop are to teach about: (i) herbarium techniques (collection of plant sample including associated field data & preparation of herbarium specimens), (ii) characters used in plant taxonomic study, (iii) species identification techniques, and (iv) uses of software in species identification.

The workshop will be divided into five sessions *viz*. (i) inaugural session, (ii) technical session I, Ii & III and (iii) closing session. Brief description of the tentative program is given below:

DAY-1 (26 September 2016)	
Inaugural Session	
9:30-10:00	**Registration**
10:00-10:05	Recitation from the Holy Quran
10:05-11:20	Welcome address and brief presentation on the workshop
11:20-11:25	Address by the Special Guest: **Representative, FAO**
11:25-11:30	Address by the Special Guest: **Representative, Bangladesh Forest Department**
11:30-11:35	Address by the Chief Guest: Dr. Md. Abul Hassan, Professor, Department of Botany, University of Dhaka
11:35-11:40	Remarks by the Chair: **Hosne Ara**, Director (cc), Bangladesh National Herbarium
11:40-12:00	Tea break
Technical Session-I	
12:00-1:00	Definition & utilities of herbarium
1:00-2:00	Lunch & Prayer
2:00-3:30	Plant collecting equipments and collection of plant sample including associated data
3:30-4:45	Field practice
4:45-5:00	Closing & Tea
DAY-2 (27 September 2016)	
Technical Session-II	
9:30-11:00	Pressing & Drying of specimens
11:-11:30	Tea break
11:30-1:00	Mounting & Labeling of specimens
1:00-2:00	Lunch & Prayer
2:00-3:30	Herbarium practice
3:30-4:45	Control and caring of specimens
4:45-5:00	Closing & Tea
DAY-3 (28 September 2016)	
Technical Session-III	
9:30-11:00	Characters used in taxonomic study
11:00-11:30	Tea break
11:30-1:00	Practical work
1:00-2:00	Lunch & Prayer
2:00-3:30	Species identification techniques
3:30-4:15	Uses of Software in species identification
Closing Session	
4:15-4:45	Distribution of certificates among the participants & closing remarks
4:45-5:00	Refreshment

3. Outcomes

The expected outcomes of the workshop are:

(i) Develop a group of people/trainers competent in using herbarium techniques for identifying tree species;
(ii) Training manual and workshop materials;
(iii) Proceedings of the training workshop.

4. Expected results from the training workshop

(i) National capacities on tree species identification strengthened;
(ii) Correct identification of tree species in the field ensured;
(iii) Accurate assessment and sustainable management of forest biodiversity enhanced.

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TECHNICAL SESSION-I

DEFINITION AND UTILIZATION OF HERBARIUM

Definition of Herbarium

A **herbarium** (plural: **herbaria**) is a collection of preserved plant specimens and associated data used for scientific study. The term can also refer to the building or room where the specimens are housed, or to the scientific institute that not only stores but uses them for research. The specimens may be whole plants or plant parts; these will usually be in dried form mounted on a sheet of paper but, depending upon the material, may also be stored in boxes or kept in alcohol or other preservative. The specimens in a herbarium are often used as reference material in describing plant taxa; some specimens may be types. ..... From Wikipedia

A herbarium is a collection of preserved plants stored, catalogued, and arranged systematically for study by professionals and amateurs from many walks of life. .... Kew

A herbarium is defined as a collection of plants that usually have been dried, pressed, preserved on sheets and arranged according to any accepted system of classification for future reference and study. However, a modern herbarium is a research, training, and service institution that serves as a reference centre, documentation facility and data store house.

Utilization of Herbarium

Discover or confirm the identity of a plant or determine that it is new to science
The classification of the world's flora is based mainly on the herbarium materials.
Provide scientific information to the public regarding the plants.
Document the concepts of the specialists who have studied the specimens in the past
Provide material for making morphological measurements
Provide locality data for planning field trips
Provide data for floristic studies
Serve as a repository of new collections
Provide data for revisions and monographs
Verify plant Latin names
Serve as a secure repository for "type" specimens
Provide loans of research material
Facilitate and promote the exchange of new material among institutions
Allow for the documentation of flowering and fruiting times of plants
Provide the basis for an illustration of a plant
Provide material for DNA analysis
Provide information for GIS studies of past and future collecting expeditions
Provide information on rare, extinct species that can no longer be found in nature
Provide modern specimens for comparisons with fossils

To trace the history of usage of binomials for a given taxon in a given area
Provide pollen for taxonomic, systematic, and pollination studies as well as allergy studies
Provide reference samples for the identification of plants eaten by animals
Determine native ranges and document which plants grew where through time
Document what plants grew with what other plants
Provide material for microscopic observations
Document the morphology of individuals of a particular species in different locations
Serve as a repository for voucher specimens
Provide material for chemical analysis i.e. lead-uptake; pollution documentation
Provide information for studies of expeditions and explorers
Provide the label data and field notebooks necessary for accurate data-basing of specimens
Serve as a reference library for the identification of parts of plants found in archeology digs
Provide context for accompanying library and other bibliographic resources
Serve as an archive for related material i.e. field notebooks, letters, reprints, etc.
Provide information on common names and local uses of plants
Provide insect collections that have been incidentally collected along with the plants
Helps to locate rare or possibly extinct species via collecting areas listed on label
Provide information on plant predators
Establish the presence and distribution of plant diseases
Track introduction and spread of invasive species
Document CO2 change over past 10,000,000 years
Provide information for foliar physiognomy studies of leaf form
To document polyploid populations that occurs naturally
To document fungal/vascular plant symbionts
To document biogeography of past plant distributions including regional extinctions
Document the evolution of major groups of vascular plants
Provide material for teaching botany, taxonomy, ethnobotany, forestry
Train local volunteers for specimen handling, scanning, and databasing etc.
Run education courses for the public
Provide a location for government and state agencies to work on specimens
Provide a home for global, regional or local studies
Help establish new museums
Foster good international relations
Interact with the local people to form volunteer groups for conservation efforts
Provide information on the wild relatives of cultivated plants
Facilitate international exchanges of field expeditions
Organize photographs of plants associated with voucher collections

PLANT COLLECTING EQUIPMENTS AND COLLECTION OF PLANT SAMPLE WITH ASSOCIATED DATA

Plant collecting equipments

Plant press: The plant press is designed so that plants can be dried quickly while being pressed flat. It consists of two cross-slatted wooded frames about the size of a folded newspaper (41×27 cm).

Secateur: Pruning secateurs to cut plant parts (e.g., stems, twigs, branches, leaves).

Heavy sheath knife: It is also used to cut plant parts (e.g., branches, bark, fruits).

Diggers: Trowel, heavy sheath knife, geological pick, clipper etc. are used to dig under ground parts of the plants e.g. tuber, root, rhizomes.

Long plant cutter: It is used to cut small twigs from a tall tree. Usually few wooden stick or metal pipes are joined together one by one with clamps & screws and a cutting blade is fixed at the top.

String Tags: These are made of water proof material and are used for labeling plants that are not immediately pressed.

Poly bags: Strong plastic bags of various sizes for storing or carrying fresh plant materials. It protects plant materials from quick wilting.

Seed envelopes: This paper made pocket is used for collecting seeds.

Maps: Maps are necessary for locating places.

GPS machine: A GPS (Global Position system) unit makes fixing an accurate latitude and longitude easy. These are very useful for pinpointing your exact location, especially for measuring elevations.

Digital camera: Taking photos to support your herbarium can be very helpful for showing the habitat and to evidence importance characteristics.

Binocular: It is a pair of identical telescopes mounted side-by-side and aligned to point accurately in the same direction, allowing the viewer to use both eyes when viewing distant objects.

Hand lens (10×): The lens is used in the field for observation of micro-characters i.e hairs, glands etc.

Field note book: Field note book to record information e.g. habitat, location, flower colour, uses, local names etc.

Soft lead pencils & sharpener: Soft lead pencils for writing in rain.

Colour chart: It is used to determine actual colour of plant parts i.e. flowers.

Blotting papers & Old news papers: These are the sheets of heavy blotting papers or of other moisture absorbing material of 41 by 27 cm. Old news papers are also used as driers. **Straps or ropes:** A pair of strong web straps or ropes of about 1.2-1.5 m length are used to tighten the press.

Corrugated aluminum sheet (41 × 27 cm): Sheets of corrugated aluminum are used in between the driers (=blotters) as ventilators when plants are dried. They provide space for the passage of air through the press to remove moisture.

Gardening gloves: Gardening gloves to prevent injury when handling irritating or thorny specimens.

Pictorial hand book: Very often pictorial guide book is helpful for identification plant species in the field.

For safety gear: Hat, long-sleeved shirt & trousers, umbrella, water-proof raincoat, insect repellant, first aid box etc.

Mounting materials	**Identification tools**	**Others**
Dried specimens Drafting table Heavy glass sheet Specimen label Specimen pockets (flimsy paper) Scissors Adhesive e.g. Aica gum, Gum arabic Cellophane tape Glass jar Tissue paper Forceps Needle Brush Old newspaper Linen thread	Dissecting kits Magnifying glass Dissecting microscope Long armed microscope Iconographies Plant identification manual Flora Monograph Revision Checklists Identified herbarium specimens Forceps Needle Brush	Glass Jar Refrigerator Herbarium cupboard Mercuric chloride Formalin Rectified spirit Carbon tetrachloride Aerosol Naphthalene Plant drier

Collection of plant sample with associated data

Reasons for collecting plants: There are mainly two reasons for collecting plant sample.
(i) To obtain records and specimens of plants to be stored in a herbarium. During vegetation sampling, collect representative specimens of all species that are important to meet your collection needs. Your collection may also represent a range extension or contribute to the knowledge of a plant's taxonomic or natural history. These specimens will later be used to confirm identification and provide a permanent record for future reference.

(ii) The major reason for plant collecting is in order to later identify an unknown specimen encountered during fieldwork. Even if you have good knowledge on the local flora, you may not be able to accurately identify all plants in the field. Collection of botanical material involves two activities: (i) gathering the specimens and (ii) recording the information. Be sure to record accurate and consistent habitat information when collecting the specimens—it is generally difficult to remember and accurately record it later. This information may illustrate the variations possible under different habitat conditions.

A complete specimen possesses all parts including root system, flowers and fruits. Therefore, regular field visits are necessary to obtain information at every stage of growth and reproduction of a plant species. To avoid damage during transportation and preservation at least 2-3 specimens of a plant should by collected. The collected specimens are transported in a vasculum (specimen box) to prevent willing, livery collected specimen must be tagged with a field number and necessary information should be recorded in a field note book.

What to look for in a specimen

Specimens should be typical and healthy, with at least some fully expanded leaves where possible. Fertile specimens should be collected because they are essential for identification. Plant material with flowers and fruits is called fertile material. In most cases, ripe fruits and flowers do not usually occur at the same time. Hence, repeated field visits in different seasons are essential to collect flowering and fruiting material from the same species. In the field, take care when selecting the plant material for collection. Avoid taking diminutive individuals because they fit into a press more easily or are easier to reach. Take the plant from its typical habitat. If a species normally grows in woodland, do not collect specimens growing by the roadside or in a clearing. Sometimes leaf shape, flower color and other characters are completely altered on plants growing in full sunlight.

What to collect

The whole of small vascular plants should be collected including the underground portion. Roots, trailing or underground stems and storage organs are often helpful in identifying specimens. When taking the whole plant is out of the question, specimens containing all essential features (all leaf types, twigs, flowers, fruits) must be cut from the plant. A strong knife or small trowel is helpful for digging out a plant. Excess soil can be shaken off, or washed off carefully if water is available. In case of a large herb, shrub, tree or climber, the specimen should include a twig to show the range of stem leaves and flowering and fruiting material. If lower and upper leaves are different, or there is significant variation between a shaded and unshaded side of a tree, then collections should be made from both. To minimize damage to parent trees and to specimens, twigs should always be cut off cleanly with a sharp knife or pruners. Breaking the twig can strip the bark and ruin a specimen or cause unnecessary harm to the tree or shrub from which it was taken.

How to collect

There are at least 3 ways of handling fresh plant materials for processing in to herbarium specimens. (i) Pressing in the field: When time and carrying facilities permit, the most satisfactory method is to press each plant as it is collected, because this produces the best looking specimens. Field presses are rather bulky to carry around and may prove impractical in some cases. We use a collecting scroll made of a rolled-up strip of plastic table covering. Starting at one end, the plants are rolled into the scroll one by one. (ii) Metal collecting can or vasculum: A second method is to accumulate the material in a metal collecting can or vasculum. Professional botanist prefers larger sizes. The vasculum is first lined with a few thicknesses of well-moistened newsprint to retard wilting of specimens, and experience has shown that plants keep better in a full vasculum than in one that is only partly filled. Plants should be pressed as soon as opportunity permits. (iii) Collecting into plastic bags: It is another option. A range of bag sizes should be available. Small plants can be placed singly, or two or three together if necessary, in a suitably sized bag. Plastic bags are not recommended for serious collecting because the risk of damaging the specimen is very great. Petals are likely to be knocked off, and stems will almost certainly be bent or broken. Care should be taken to keep collections as cool as possible and prevent them from being crushed. With each plant, and firmly attached to it if several plants are collected together, should be a label bearing a collection number which corresponds to numbered notes in the collecting book. Tags are an excellent means of labeling plants. The label is often left on the dried specimen, but can be used again.

Some basic techniques for specimen collection:

- Select a typical, healthy, mature plant *viz.* well-developed leaves, stems, roots, flowers, fruits or other reproductive structures.
- Select specimens in good condition, free of insect feeding, fungal infection and any pathological symptom.
- Select specimens that represent the range of variation in the population.
- Take photograph of the plant. Take several close-up shots showing the plant and parts necessary for identification.
- Collect enough material (whole plant or a part of plant) with an average sized leaves, flowers fruits and seeds, because they are essential for identification. Underground parts like root, rhizome, etc. must be included in herbs.
- Collect one to three or four twigs with leaves, flowers or fruits.
- Collect the bark and wood samples of a tree species.
- Collect extra flowers and fruits for later dissection.
- Be careful about collecting rare or endangered. When you need to confirm a rare or protected species, take photograph of the plant and make a good written description or sketch.
- Retain as much of the root system as possible. Remove excess soil as it may cause disfiguration and deterioration of some plants.
- Place all specimens of a single species from one locality into one collection bag.
- Assign a unique collection number for each species and tagged it to each sample of the same species.

Precaution: Specimens should be pressed in the field when ever possible, if not possible, press it immediately after returning to camp in the evening, and preferably daily. If not pressed immediately, some delicate species rapidly lose their colour and structure. For avoiding damage of the specimens following things to be taken care of:

- Expel excess air from large plastic bags and seal.
- Keep collection bags in a cool place, near a stream, in the shade, or in a cooler.
- Sprinkle fresh water into the bags during hot weather, or add a moistened paper towel.
- Shake off excess moisture of plants collected in the early morning or during wet weather.

Collection of associated data

A plant collection without accompanying data is of no use to the scientific community. These notes will aid in identification of the material and later be used to complete the information on the herbarium label. It is far better to take too many notes than too few. The notes should contain the following information:

(i) Name of the plant: Name usually means the botanical name of a plant. It is universal and unique. This is important as it helps the collector remember the individual specimen even if the labels are accidentally lost or mixed. Even If the collector has no idea about the botanical name, it is useful to write down the local name if known. Very often it acts as a clue of botanical name. This has a double advantage in vegetation surveys in that this name can then be applied to other specimens of the same species if they are encountered before the material has been identified. This way there is no need to collect the plant more than once or try to remember if it is "Unknown 1" or "Unknown 2"

(ii) Locality: Locality means the place of occurrence of a species. Provide enough information so that another person can follow the directions to the general area to observe more specimens of the same species. This should be as detailed as possible, including the name of Mouza, village, Upazilla, district and so on. The latitude & longitude, altitude, grid number on the map are also important.

(iii) Note: A brief description about the plant. This should include everything about the plant that is not obvious on the herbarium specimen. Essential items are the height, type of bark, whether the stem is upright, sprawling or drooping, and obvious smells, whether the plant is clumped, single or growing in patches and the presence of creeping or underground stems. Flower and fruit color coluor, diameter, height, abundance, odor should be recorded. Colour chart can be used to record colour of the fresh plant.

(iv) Habitat: Very often it is also included in the notes. This should include the general habitat as well as more specific details of micro-habitat. Important points are elevation, slope, soil or other substrate (sand, clay, granite, dead wood, other vegetation), moisture and aspect (on wet rock, along chara, hill slopes, valley bottom etc), associated vegetation, ecosystem, ecological zones etc. The more careful and detailed such notes are the more useful they become.

(v) Date: Date of collection tells about the flowering and fruiting times of the species. To avoid confusion, write the date in full (August 21, 2016).

(vi) Names of collector(s) and collection number: Record all significant members of the collecting party viz. Sarder Nasir Uddin, Khandakar Kamrul Islam & Naimur Rahman. Collection number is a serial number specific to a collector and a specimen. The number may start at 1 and continue through the collector's life time. As soon as the specimen is bagged, record a collection number in the field notebook. Write the collection number on a waterproof tag and place it in the bag with the specimens, or label the outside of the bag using a permanent marking pen. If you are pressing right away, you can write the collection number on the flimsy (newsprint folder) in a corner or along the border. The collection number makes it easy to reference individual specimens or groups of specimens in a collection.

(vii) Others: Space should be left to note the name of the person who makes the final determination (identification), the date on which it is made and the place were the specimen is sent or stored. The receiving herbarium will add their own accession number to the specimen.

TECHNICAL SESSION-II

PRESSING & DRYING OF SPECIMENS

The two main steps involved in preserving floral collections are pressing and drying. Correct pressing prevents plant parts from curling or wrinkling during the drying process, and allows the requisite plant parts to be visible for identification. Care in pressing specimens will result in more useful and visually appealing herbarium specimens. The process consists of laying the plant specimens in folded sheets of newsprint separated by cardboard sheets, and placing them in a pressing frame, which is then tightened with straps. Drying involves an adequate length of time and exposure to ‘‘dry’’ air, and maintenance of the specimens in the press, e.g., changing the newsprint to speed up the drying process and cinching the press daily as the specimens dry. Specimen should be pressed as quickly as possible after collection. If this is not possible, specimens may be stored in plastic bags, preferably wrapped in damp (but not wet) papers. Bags should not be packed tightly, and should be kept cool and moist. Make sure that each bag is correctly labeled for locality.

Pressing

The most important thing to do with freshly collected material is to dry it out as fast as possible. This prevents fungal infections and preserves Color. Vascular plants must be pressed and dried as soon as possible after they are collected. Usually this means that plants should be pressed the day they are collected. It is an important aspect of plant collecting that enough time be left at the end of the day to process the specimens. If this includes identification, this stage may be quite slow. When plants have to be left overnight they should be put in a cool place. Sometimes woody specimens can be placed in water for a day or so to force buds or restore wilting leaves.

The specimens are spread out between the folds of old newspapers or blotting sheets avoiding overlapping of parts. Pressing is the process of placing specimens between the absorbent drying paper under heavy pressure in a plant press. Pressing is the most important step in the preparation of specimen and need careful attention. The plant press is designed so that plants can be dried quickly while being pressed flat. It consists of two cross-slatted wooded frames about the size of a folded newspaper. Plant specimens are laid in folded newspaper between layers of blotter, foam sheets and corrugated cardboard. The newspaper provides a folder for the plant. The paper, blotter and foam draw the moisture away from the specimen. The cardboard allows air circulation within the press to speeds up the drying process, and helps keep the specimens flat. Plants in their newspaper folders are piled in layers of alternating padding and cardboard on one of the wooden frames. When laying out of the specimens is complete, the second frame is laid on top of the pile which is compressed and strapped as tightly as possible with two adjustable straps. Standing on the press while you fasten the straps helps get them properly tight. You have to be a bit of a acrobat to do this by yourself, but it is quite possible.

Laying out the specimens for pressing

Two important points should be borne in mind when plants are prepared for the press: (i) The dried specimen should fit neatly onto a standard herbarium sheet; and (ii) As many features as possible should be visible on the mounted specimen.

There are a number of tips which, if followed, will help towards producing attractive and worthwhile mounted material.

Place each specimen, with numbered tie-on tag attached, in a fold of several sheets of newspaper, and place in the press, If necessary, occasionally add a sheet of corrugated cardboard to act as a ventilator. As you fill the press, try to keep it level to allow even distribution of pressure. This means the use of alternate corners of the fold for bulky roots and other parts, or packing around a bulky specimen with foam. Close the press and exert pressure with the straps.

Fresh specimens should be arranged within the pressing paper. Place plants on the right half of the newsprint folder so that maximum surface of pressing paper is covered with the plant specimen to be pressed.

When pressing a specimen, carefully spread out structures (i.e. leaves, flowers) so that diagnostic features are clearly evident. Turn over some leaves or part of a single large leaf to show the underside, so that the lower surfaces facing upward. Place foam sheets or a small roll of paper on the top and bottom of bulky or thorny plants to distribute the pressure evenly.

Usually, a single specimen should be pressed in a folded pressing paper. The larger specimen may be folded in V, N, M or W shapes. Plants with many long, narrow leaves such as grasses will bend and press more neatly if a piece of paper with a slit in it is placed over the elbow of the bend to hold all the leaves together. Roots and underground parts should be washed thoroughly before pressing to removes soil particles.

If a specimen is too long to fit in the press or on the herbarium sheet, cut and produce sheet of 1/3, 2/3 & 3/3. This shortens the effective length of the specimen without any of the material being lost.

Too many leaves on a herbarium sheet look untidy and can obscure detail. Where it can be done without destroying information, snip off some of the leaves, but always leave part of the petiole so that it is evident that leaves have been removed.

Branches that are not naturally flat can be made easier to press if the angles or twigs are bent in the appropriate direction before the plant is laid on the newspaper. Care should be taken not actually to sever twigs or leaves.

Fleshy organs should be sliced lengthwise so that they are less bulky to facilitate quick drying. When stems are very thick they can be sliced. Leaves of plants with thick stems do not always get sufficiently pressed and may tend to wrinkle. The end of woody stems should be sliced diagonally so that the color of the wood and pith are displayed.

Leaves or petals which have wilted, or are folded over, will not always lie flat for pressing. A piece of wet newspaper will "stick" them in place. By the time the newspaper is dry the leaf will have stabilized and cause no more trouble.

A few flowers should be pressed separately of the specimens with gamopetalous corolla. Some of the flowers should be split open and then pressed to expose their essential organs and the nature of the thalamus. Place dry, loose seeds or fruits in sealed packets.

Loose seeds and fruit can be placed in a small paper packet and pressed with the specimen by writing the collection number on the outside of the packet. Later this packet will be glued to the herbarium sheet. Some conifers loose most of their needles on dried specimens. Once the material is dried, the needles can be shaken off and placed in a packet.

Arrange the materials in the order they will be used: back panel, cardboard, newsprint, blotter (for damp plants, put on both sides of paper), foam (for large branches put on both sides of paper), cardboard, paper, etc.

Up to three sheets of specimens may be placed together without a cardboard separator if you use blotting paper between them. The number of sheets depends on the thickness and moisture content of the plants.

When the press is full, place two cardboard separators and the other back panel on top. Tighten the straps as much as possible. You can kneel on the press to achieve the desired tension. Make sure the pressure is even.

To avoid discoloration and molding, blotters should be changed frequently depending upon the nature of specimen and humidity. Check and change damp newsprint daily and remove specimens as they become dry (as plants dry the press will become loose).

Once plants are pressed, changing the paper after the first 24 hours not only enhances drying, but allows the collector to make cosmetic adjustments to the specimen while it is still supple. Folded leaves are the main problem. These can be re-opening with a mounted needle and pressed flat the second time round. Sometimes petals stick to the newspaper as they dry and are impossible to remove without damage once they have become brittle. Changing the newspaper before the flower has dried completely helps to prevent this.

Drying

Drying is a crucial step in preserving collected plant material. To ensure that a specimen retains its colour and does not become brittle, the moisture must be removed rapidly, while using only a moderate heat. The essential thing is to dry the plant specimen as quickly as possible before the tissues have time to decay. Good air circulation speeds up the process. Drying techniques are of two types: (i) those accomplished without heat, and (ii) those with the aid of artificial heat.

Drying without heat was the universal until the advent of the present century. In this process, plants are placed in pressing papers between the blotters of a conventional plant press. The press is locked up for about 24 hours. This is known as the 'sweating' period. It is then open, and as blotters are removed each pressing sheet is turned back, the specimens examined, parts rearranged as the situation demands. The difference between a poorly and well arranged specimen usually results from the attention given it at this stages of the process. After rearranging, the folder sheet is lifted onto a fresh dry blotter and covered by another dry blotter. This is repeated for every specimen until all have been examined, rearranged as necessary, and placed between dry blotters. The new pile of blotters and specimens is then locked up in the plant press and allowed to stand for another 24 to 36 hours, when the process of replacing wet or dump blotters with dry ones is repeated. A third change of blotters follows, and the length of the period between this and the previous change will be determined in part by the kind of material being dried, but usually it is after 2 to 3 days. Most of the specimens are completely cured by this technique in about a week, except for fleshy and succulent material. Some disadvantages of this method are as follows:

A minimum of about a week is required for completion of drying.

Blotters must be changed 3 or 4 times.

A large number of blotters must be in hand.

The labour expenditure per specimen is excessively high.

The possibility of damage and fungal infection is high.

Drying with the aid of artificial heat is the prevalent method. It is accomplished by means of heated dry air passing up and through the ducts of the corrugated sheet. The efficiency of the method depends entirely on the presence of open ducts throughout the entire sheet of corrugated material. An

artificial dryer can be made by using four to six 200-watt bulbs inside a wooden box. Even a forced-air heat vent, the back sides of an air conditioner or a hair dryer also get the job done, but they can pose fire hazards. A large commercial dryer is easily regulated, safe, and when properly vented, will not increase the room temperature or allow odors into the room. The total time over the heat will vary with the intensity of the heat source, from a minimum of 12 hours to a day or 2 days.

The following tips are useful in the process of plant drying with the aid of artificial heat:

Plants are pressed in news papers among blotters and corrugated sheets which provide air passage to the plant press for circulation of dry and heated air. Plant press is locked tightly for 24 hours. This is called 'sweating' period. When 'sweating period' is over, press is unlocked, blotters are removed and pressing papers are turned back.
Then the plant press locked up with less pressure than that exerted on the plants when in the plant press, and the press is placed over the heat source. The press is tightened after 6 hours of drying, tightened again after 12 hours and at the same time is turned over so that the cool side faces the heat.

During drying period, blotters should be regularly changed for first couple of days. The specimens must not be left in damp papers. The press should be opened periodically to check the specimens and ensured that they don't become too dry, or become brittle, or specimens lost their glaucescence or waxy bloom and colour.

If using a homemade light-bulb dryer, the pressing frame should be placed at least 15 cm above the bulb.

If plants sheds seeds during the drying process, put the seeds in paper made capsule and mark them with collection number on it. Cones can be dried separately in their paper collection bags.
After 24 hours the press is removed from the heat source, opened, and all folders of dry specimens removed; drying is continued for wet specimens. When the specimens are completely dry, remove them carefully from the press and store them in bundles protected on either side by cardboard sheets. The bundles can be sealed in dark plastic bags. The plastic bag ensures infestation. Under this condition, the plants can be stored for several years in a cool, dry place before they are mounted.

Some disadvantages of this method are as follows:

Lose any waxy bloom or glaucescence that may have been present.
Become brittle during drying.
Do not retain the colouration that is present in specimens dried without heat.
Often permanently marked by ridges of corrugates.

MOUNTING & LABELING OF SPECIMENS

Mounting of specimens

Once material is pressed and properly dried, it is mounted on herbarium sheets of standard size. Mounting is the process of affixing a dried and pressed plant and its label to a sheet of heavy white paper. This provides **physical support and allows the specimen to be handled and stored** with a minimum of damage. Usually one specimen, no matter how small it is, should be mounted on one herbarium sheet. Mounting the pressed plants involves skill and patience. It is a kind of art. Specimens should be laid on the sheet in an attractive, space-filling way. Space should be left in the lower right hand corner for the herbarium label. The sheet should be as full as possible without being crowded. When the arrangement is satisfactory, the specimen may be stuck to the sheet. Flowers remain unglued to allow easy removal of parts for examination.

Prior to attachment, the specimen and its label are laid out on the paper to allow maximum observation of diagnostic (usually reproductive) features as well as the range of variation in vegetative structures, including both sides of the leaves. Plants are generally **positioned in a life-like arrangement** (that is, with roots or lower stem toward the bottom of the sheet and flowers toward the top). When laying out the plant, be sure to leave space on the sheet for the **specimen label**, **annotation labels**, and institutional **accession seal**. A **paper envelope or capsule** should also be attached to the sheet to contain any fragments of the specimen that break off over time. Once the optimum arrangement of the specimen has been determined, it is attached to the sheet using a combination of glue and strips of gummed linen cloth tape. **Glue** is used sparingly to attach the larger portions of the plant, such as stems, large leaves, and fruits. **Gummed linen mounting strips** are then applied to reinforce portions of the plant that might be torn loose as the specimen is used. Large or bulky items may need to be sewn onto the sheet with a **sturdy linen thread**. The objective is to secure the specimen firmly to the mounting paper, while leaving some pieces of the plant loose enough to be removed if necessary. Excessive applications of glue that embed flowers and seeds on the sheet may make it impossible to observe diagnostic features or to remove samples, thus rendering the specimen useless for scientific study. The best way to learn proper mounting procedures are through hands-on training and practice with a variety of plant specimens. Because herbarium specimens are intended for long-term study and storage, it is critical that that all supplies used for mounting be both **durable and archival**. Archival denotes materials that are free of acids and other compounds that may cause them or the specimen to degrade or discolor over time. Consequently, the mounting paper, label paper, packet paper, ink, glue, mounting strips, and storage folders should all be acid free and designed for long-term stability.

Some mounting tips:

Before starting, have ready acid-free mounting paper, cardboard sheets, glue, wooden spacer blocks, weights, needle and linen thread, paper envelopes or capsule for storing loose seeds, identified specimens, and label.

For mounting specimens, a drafting table with an appropriately sized stool should be placed in a separate area from the herbarium to prevent insects from being introduced into the main collection. Natural light makes the job more pleasant.

Wear an old clothes or a lab coat before mounting the specimens because it is a very messy business. Arrange supplies so the work can proceed in sequence, from left to right, or vice versa. Place the specimens to be mounted at one end of the table, with a garbage can nearby ready for waste plants or dirt.

Handle the dry plant specimens with extreme care because dry specimens are brittle and easily damaged. Use scissors or secateur to trim large specimens to fit the sheets. Make sure that important parts are not cut off. Remove any soil clinging to the roots or stems by using a brush or blunt end of the probe.

Place a sheet of mounting paper on a cardboard sheet. It makes easier to move the finished product and stack for drying.

Position the plants, map and label on the mounting paper first. Mount only one specimen on one sheet. Lower part of the plant should be placed at the base of sheet. Label should be attached on the right hand bottom of the sheet. Attach a map marking with red ink that shows the collection position of the plant.

Use glue to attach the larger portions of the plant, such as stems, large leaves, and fruits to the mounting sheet. For extra support, attach the specimen to the mounting paper with thin cellophane tape running from the paper across the plant part to the paper. The tape should not cover any parts necessary for

identification. Sew the thick specimen onto the sheet with a sturdy linen thread (if necessary) and tie a knot on the back. If the knot is bulky, glue a small piece of paper over it, so that it won't damage the specimen beneath.

A dot of glue beneath the flower head should be added if the head is large and cannot be held down with a strap of glue on the petiole. If only one flower is placed on the sheet, protect it by gluing a transparent flexible covering over it. Glue only the top edge of the cover so it can be flipped back to examine the protected parts.

Salvage any valuable loose material, such as seeds or flowers, and place them in a wax paper envelope or capsule. Attach the capsule near the upper sides of the sheet after the specimens are mounted.

Mounted specimen can be stacked to dry by putting down with weights, such as plastic-coated lead bars or large metal washers.

Labeling of specimens

A plant specimen is incomplete or very often useless without label data. A label must contain as much information as possible about the specimen. All the information recorded on the label is as important as the specimen. Label data is a form of field data and must be accurate. Even though a specimen may have been well collected and carefully prepared, it will be of negligible scientific value and in some cases impossible to confidently identify, unless accompanied by basic collecting data and field notes. Labeling means the attachment of all field information to the lower right hand corner on the herbarium sheet. The label must contain the following information:

Scientific name: genus, species, authority, infraspecific information.

Family: the species belongs to what plant family, used for classification.

Local name: name/s of plant given or called by local people.

Detailed location: The location should consist of country, division, district, upazila, village, mouza and a description of the location in reference to roads, road junctions, mile markers and distances from cities or towns. Latitude and longitude, and elevation may also be helpful. A location taken with a Global Positioning System (GPS) is a desirable complement to the locality description. Location is used by researchers on several reasons: (i) for general mapping to region; (ii) for detailed mapping, as in GIS computer applications; (iii) to physically locate the plant(s) in order to obtain further research material.

Habitat: the type of plant community where the plant is growing and, other associated plants (if known).

Plant habit: describes the form of the plant (tree, shrub, climber, herb) and its height.

Frequency: is the plant rare, occasional, frequent or common?

Plant description: describe characteristics of the plant which may be lost upon drying, such as flower/fruit color and fragrance, leaf orientation, aroma etc.

Uses: what is the use/s of the plant?

Name of collector(s): it is recommended to use the collector's full name.

Other collectors: Companion/s present with the collector.

Collection number: a sequential straight forward numbering system (1,2, 3, ...) is preferable.

Date of collection: a format with the month spelled out or abbreviated and 4 digits year will prevent confusion.

Determiner of the scientific name: the name of the person who identified the plant.

Most herbaria have printed labels of about 8 × 10 cm which are filled in and attached to each herbarium sheet. A typical label is shown below and such a label provides room for all the essential information noted by the collector at the time of gathering, plus a catalogue number for the plant in the herbarium register. Most herbaria now keep specimen records in a database and have programs which create labels automatically.

FLORA OF BANGLADESH
BANGLADESH NATIONAL HERBARIUM

Date: 19 May 2014

Name	:	**Hodgsonia macrocarpa** Cogn.
Family	:	Cucurbitaceae
Local name	:	Dhonesh thukri
Locality	:	Karnaphuli Sadar Beat, Karnaphuli Forest Range, Kaptai, Rangamati district.
Latitude & Longitude	:	22˚19.131´N & 92˚13.005´E
Altitude	:	318 m
Note	:	Climber; flowers white; fruit depressed globose, reddish-brown, 12-15 cm diameter. Commonly occurs in deep forests.
Collector	:	Sarder Nasir Uddin
Collection number	:	N-5147
Determined by	:	Sarder Nasir Uddin

CONTROL AND CARING OF SPECIMENS

Control of specimens

Herbarium Curatorial Division acts as the central point in the care and control of collections. Usually it attends six areas *viz*. (a) Accessioning, (b) adequate and appropriate storage space, (c) pest control-prevention and treatment, (d) fire prevention, (e) shipping and receiving, and (f) specimens removed from the collection (De-accessioning).

(a) Accessioning of specimens: Specimens are accumulated by direct collection of BNH staff, as donations or exchange from other institutions or individuals, and as the subject of public and professional enquiries. Specimens are to be registered as the first step in incorporation, with each specimen being given a unique alpha-numeric identification code, with this entered as soon as practicable in the institution's electronic database(s). Database entries are to include details as to source, and full data pertaining to the collection. Acquisition priorities are determined by the following criteria, combining institutional goals with eco-geographic and taxonomic factors: (i) All plant taxa native to or naturalized in Bangladesh; (ii) Voucher specimens used for any phyto-chemical research activities conducted by student/researchers from different universities or research institutions; (iii) Plant taxa not yet in Bangladesh but potentially significant weeds if introduced; (iv) Other overseas plant taxa; (v) Collections of special historical significance.

(b) Space management: At the end of each fiscal year, the curator will prepare an overview of the status of the collections of BNH. This overview will consist of:

A summary of the status of the physical condition of the collections;
A statement about collections which need improvement by the addition of new specimens;
A general summary of the collections acquired in the previous year;
A status report of the collections acquired in the previous year, the percentage accessioned, mounted and incorporated into the permanent collection;
A statement of known or likely opportunities for acquisition in the future years of donations by others; and
A summary of collections rejected during the past year.

The management and recording of all incoming and outgoing specimens is conducted by the Herbarium Curatorial Division. These include space planning, relocation of specimens, mounting and repairing specimens, fumigation and general curation. Protection against theft and vandalism is effected by maintaining limited access to the collections storage areas. Smoking is strictly prohibited in the library and collections storage areas. The Curator will submit these data to the Director along with his detailed request for collection storage space for the next year including a statement on acquisition activities which are projected to occur during the upcoming year.

(c) Pest control-prevention and treatment: A range of pests attack dried plant material. The most common pests are insects and fungi, though rodents and other large animals can cause damage in poor storage conditions. Insects eat the material, the paper surrounding the material, and the adhesives and mounting media. Such insect pests range from Psocids (book lice), which attack mainly the softer parts such as flowers and soft fruits, to tobacco beetles and carpet beetles, which can bore holes through the toughest of specimens. Many insects are particularly sensitive to relative humidity levels and do not thrive at levels below 50%.

The most common and acceptable specimen treatments for insect control are:

Freezing: Place the specimen inside a clear polyester bag, push out excess air, and heat seal, or place inside polythene bags and use parcel tape to seal. This should be placed into a normal domes tic freezer for at least 14 days at a temperature of −18 ºC, or for 72 hours if freezing at −30 ºC.

Anoxia: This method starves the pests of oxygen. Small anoxic environments are created using sealed barrier films (such as Marvelseal™ or Escal™ or reusable aluminium laminate) and placing oxygen scavengers and RH buffers inside before sealing.

Microwave: Specimens may also be treated in a microwave oven to kill any animal life present on them. Microwave treatment is a fast method for small numbers of specimens. The technique is similar to microwave drying of specimens except that a press is not essential for already dry material, and times may be reduced from those required for drying. No absolute guidelines can be given as it is best to use trial and error testing for each set of circumstances and different types of microwave, but times of 1-2 minutes per dried plant specimen should be adequate.

Poisoning: A traditional method of insect control was to poison the specimens with a chemical to make them unpalatable or deadly to pests. However, this is not recommended due to obvious health hazards. Domestic spray-type insecticide is of limited effectiveness and, to avoid staining, should not be sprayed directly on mounted sheets. Sprays may kill surface insects but, for instance, would not penetrate to insects living near the centre of a Banksia infructescence or 'cone'. Many spray insecticides are now regarded as possibly detrimental to human health, so health and safety should be carefully considered before these are used. It is essential that specimens that have been poisoned be so identified, both to warn users of the health risks involved and to avoid misleading any later chemical research using the specimens.

Insect deterrents: A number of chemicals have been used or proposed for use as insect deterrents. Of this naphthalene (commonly found as 'moth balls') is probably the most commonly used in herbaria because of its reputation for reasonable effectiveness in insect control, coupled with low toxicity to human. It should be noted, however, that naphthalene is poisonous if ingested, naphthalene dust can cause eye health problems for people with contact lenses, and chronic exposure is believed to be implicated in the formation of cataracts. There are also reports of naphtha vapour causing allergies and headaches and of possible carcinogenic effects at very high concentrations. Naphthalene in commercial quantities is most commonly available in flake or chip form. If left loose in containers/boxes it is more readily inhaled or ingested and is more likely to case problems to people with contact lenses than is naphthalene in block or ball form or naphtha flakes or chips encased in porous bags or boxes. If naphthalene is used as an insect deterrent the levels around specimens must be maintained at a steady, level to ensure effective insect control. Because of the exposure limits for humans this is best done by storing specimens in boxes or in a sealed cupboard.

Fungal pests: Fungal (mould) attack is mainly a danger to damp specimens, either through incomplete drying during specimen preparation, or to collections that become wet later through flood, other water damage or improper storage conditions. Properly dried plant specimens will not suffer from fungal attack if stored in the correct conditions (see recommendations below) though freeze-dried fungal bodies such as mushrooms have been reported to be very susceptible to mould growth. Specimens with sugary exudations or large quantities of nectar are also particularly attractive to fungi, and need special care during drying to ensure that they dry fast enough to prevent mould growth.

If fungus grows on the specimens these can be brushed with alcohol or methylated spirits (denatured alcohol). However, this may alter the specimen unacceptably for chemical and other investigative research, and only kills the fungus present on the specimen; it does not correct the problems that allowed the fungus to develop. Specimens treated for fungal attack should be clearly annotated as such, including date and treatment given.

(d) Shipping and receiving: Primary responsibility for the care and control of the collections rests with the Curator. This responsibility includes: (i) the monitoring of the removal of specimens from the collections for the purpose of outgoing loans or in-house research, (ii) the transportation of specimens between institutions (this should be undertaken in the safest and most efficient manner practicable), (iii) all shipments of specimens are securely packaged and sealed, (iv) all incoming material is fumigated prior to entering the collection storage area to minimize the potential for insect infestation and (v) periodic checks are conducted in the collections storage area to detect signs of infestation. If such signs become evident, then the affected areas are treated in the appropriate manner.

(e) Fire prevention: Fire could originate from either external or internal sources. External sources include the risk of bush fire and lightning strikes. Internal risks of fire are ever-present with our widespread reliance on the use of electrical appliances, such as desk lamps, heaters, computers, power boards and other equipment within the collection buildings. Other possible sources of fire could include chemical spills. Fire prevention measures and protection equipment is in place (e.g. fire wardens appointed, smoke detectors, alarm systems and fire extinguishers are in place and maintained).

(f) **De-accessioning:** Occasionally, it will be necessary to remove and discard or exchange specimens from the collections owing either to deterioration and lack of adequate data or duplication of collections and collections numbers. Specimens thus removed from the collections are mostly used in exchange with other institutions. Exchanges with individuals or with non-cultural and non-scholarly organizations will not be made without the written approval of the Director. Suggestions for specimens to be deaccessioned may be made by any scientific staff member to the Curator. The Senior Herbarium Technician maintains all records of specimens handled in this way. Deaccessioned speicmens are never sold. Upon recommendations from scientific staffs, inadequately labeled and/or sterile specimens can be removed from the collection and physically destroyed.

Caring of specimens

Storage: Dried and pressed plant specimens can be stored in cardboard or plastic boxes, or tied in bundles in light-weight cardboard folders placed in 'pigeon holes'. Alternatively, they can be placed in protective plastic jackets and displayed in ring folders which is recommended if they are to be frequently handled, such as for a reference collection.

Filing: Specimens should be filed in a systematic order if a relatively permanent collection is being made. The major groups, i.e. ferns and fern allies, cycads, conifers, dicotyledons and monocotyledons, are best kept separately or according to some classification scheme, such as that given in a flora or handbook. Similarly, the genera within each family and the species within each genus may be filed alphabetically or following some such classification

***Safe Handling*:** Herbarium sheets are very fragile. To minimize any risk the folder should be completely removed from the cabinet and placed on a flat surface. Open the folder flat out and always keep it horizontal. The herbarium sheets should always be held with both hands at the sides of the sheet, and never turn the sheets as though they were the pages of a book. Leaning on herbarium sheets, writing notes on top of them or placing heavy items or elbows on them can cause serious damage. Older herbaria specimens may have been treated with toxic chemicals, including lead, mercury and arsenic, to prevent pests. When working with specimens prepared earlier than 1989, wear nitrile gloves in a well ventilated room. The card on which the specimen is mounted and the specimen its elf may contain the chemicals. The dust on herb aria sheets ma y be contaminate d, so if cleaning the sheets use a dust extract or/fume cup boar d and wear a dust mask.

Dust and dirt: Dirt can be removed from the herbarium sheets by using a smoke sponge. Gently rub the place where the dirt is and then softly remove any excess with a fine brush. Do not use the smoke sponge on pencil labels, as it will rub out the pencil. Be careful when rubbing on the sheet close to the specimen. Al ways wear gloves and a dust mask.

Broken /unattached specimens: Plant specimens can be reattached to the herbaria sheet using thinly cut strips of archival, pregummed linen tape. Detached material such as seeds , leaves, etc., can be placed in an acid-free card fragment packet, which is secured onto the specimen sheet with the original specimen.

Spirit collections: Check the fluid levels in jars and check that the fluids are not discoloured or contaminated. Fluid levels should be checked annually and advice should be sought about topping up. Fragile or loose labels can be archived in polyester envelopes and the data recorded onto new labels, using pigment ink, to be stored inside the jar. If your venue is not equipped to work on serious conservation problems for spirit collections, please contact a conservator or curator for advice.

Microscope slides: Specimens can be mounted in short-term mounting media which can rapidly deteriorate by contracting, darkening or crystallising and thus destroying the specimens. Slides should be checked annually, and if serious deterioration is noticed, a microscope slide conservator should be contacted. Slides can be cleaned of surface dirt using wool swabs or buds dampened with deionised water.

TECHNICAL SESSION-III

CHARACTERS USED IN TAXONOMIC STUDY

Pteridophytes

A **fern** is any one of a group of about 20,000 species of plants classified in the phylum or division **Pteridophyta**, also known as **Filicophyta**. The group is also referred to as polypodiophyta, or polypodiopsida when treated as a subdivision of tracheophyta (vascular plants). The study of ferns is called pteridology, and one who studies ferns is called a pteridologist. The term "pteridophyte" has traditionally been used to describe all seedless vascular plants, making it synonymous with "ferns and fern allies". This can be confusing since members of the fern phylum Pteridophyta are also sometimes referred to as pteridophytes. Ferns are vascular plants differing from the more primitive lycophytes by having true leaves (megaphylls), and they differ from seed plants (gymnosperms and angiosperms) in their mode of reproduction - lacking flowers and seeds. Like all vascular plants, they have a life cycle, referred to as alternation of generations, characterized by a diploid sporophytic and a haploid gametophytic phase. Unlike the gymnosperms and angiosperms, the ferns gametophyte is a free-living organism. The life cycle of a typical fern is as follows:

1. A sporophyte (diploid) phase produces haploid spores by meiosis;
2. A spore grows by cell division into a gametophyte, which typically consists of a photosynthetic prothallus;
3. The gametophyte produces gametes (often both sperm and eggs on the same prothallus) by mitosis;
4. A mobile, flagellate sperm fertilizes an egg that remains attached to the prothallus;
5. The fertilized egg is now a diploid zygote and grows by mitosis into a sporophyte (the typical "fern" plant).

Gymnosperm

Gymnosperm - (Latin *gymn-,* “naked”; Greek *sperma,* “seed”), common name for any seed-bearing vascular plant without flowers. There are several types: the cycad, ginkgo, conifer, yew, and gnetophyte. Gymnosperms are woody plants, either shrubs, trees, or, rarely, vines (some gnetophytes). They differ from the other phylum of seed plants, the flowering plants (Angiosperm), in that the seeds are not enclosed in carpels but rather are borne upon seed scales arranged in cones. The gymnosperms are the most ancient seed plants; they appear to have arisen from fern ancestors in the Devonian Period. Cycads retain the most primitive characters of the extant seed plants. Gnetophytes are considered from morphological and molecular evidence to share a common ancestry with the flowering plants. Living gymnosperms are distributed worldwide, with a majority, particularly the conifers, in temperate and subarctic regions. Cycads and gnetophytes are mainly tropical to subtropical. There are about 70 genera with 600 species of living gymnosperms, far less than many families of flowering plants.

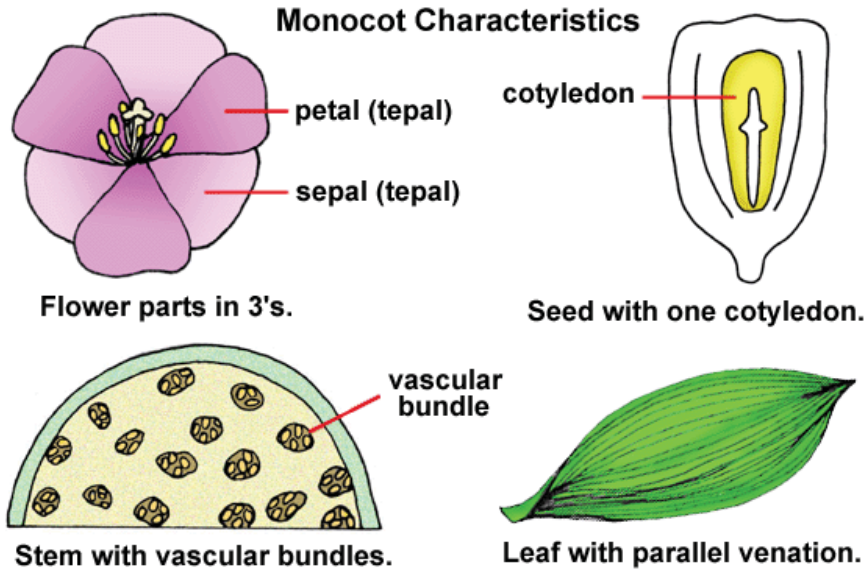
Angiosperm

Angiosperm - (Latin *angi-*, "enclosed"; Greek *sperma*, "seed"), common name for the division or phylum comprising flowering plants, the dominant form of plant life. Members of the division are the source of most of the food on which humans and other mammals rely and of many raw materials and natural products. Included in the division are most shrubs and herbs, most familiar trees except pines and other conifers, and specialized plants such as succulents, parasites, and aquatic types. Although about 230,000 species are known, many remain obscure. Flowering plants occupy almost every ecological situation and dominate most natural landscapes. About two-thirds occur in the Tropics, where they are rapidly being exterminated by human activities. Only about 1000 species are of major economic importance, and the bulk of the world's food supply is derived from only 15. Many hundreds more could be useful if properly investigated and developed.

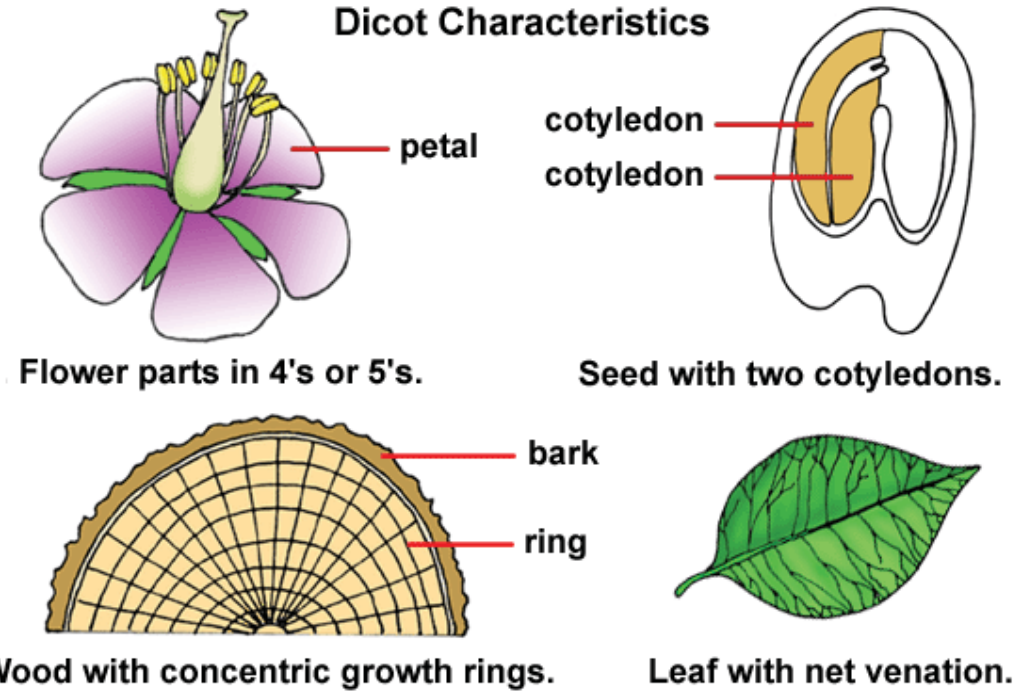
The characteristic feature of angiosperms is the flower, the function of which is the reproduction of the plant through the development of seeds. Flowers are highly modified shoots made up of four fundamental parts arranged in separate series, or whorls, on specialized stem tips. The outer series consists of the sepals, which are modified leaves or bracts that are usually green. The next inner series, the petals, are also modified leaves, but they are usually finer textured and more conspicuously colored. The third series consists of the stamens, the pollen-producing male portion of the flower. The innermost series is the carpels, female structures that produce the seeds. Carpels are often fused into a structure called the pistil.

The seeds of angiosperms develop in an ovary, a part of the carpel that surrounds and protects the egg-containing ovules. Seeds develop from the ovules after pollination and fertilization of the eggs. Ovules and seeds are not exclusive to angiosperms. The "nakedseed" plants, which include the conifers, cycads, and ginkgo, have ovules that lie exposed on the surface of specialized, scale like leaves arranged into cones. The development of seeds from ovules enclosed in an ovary, which enlarges into a fruit as the fertilized seeds grow, is a feature unique to the angiosperms.

Monocolyledons



Diocotyledons



The classification of the angiosperms is mostly based upon comparative studies of the structure of their flowers and fruits. However, features of their ecology and physiology, as well as vegetative characters can also be extremely useful in identification.

Habitat

Certain habitats are associated with distinctive adaptations and some families are known for occurring in restricted habitats and not in others. For example, plants associated with aquatic habitats have often become greatly modified and there are several families which are only found in such habitats - Lemnaceae and Lentibulariaceae in fresh water, and Cymodoceaceae in the sea.

Lifeforms and growth forms

This includes the length of time a plant lives.

1) ***Ephemerals:*** complete their life cycles in a very short period (a matter of weeks rather than months) and are characteristic of habitats such as disturbed areas (weeds in fields) and dry areas (deserts and semi-deserts).
2) ***Annuals:*** only live for one growing season and usually do not develop woody stems or roots, or storage organs. Under tropical conditions the distinction between ephemerals and annuals is often arbitrary.
3) ***Biennials:*** grow for two growing seasons and develop special storage organs to carry them over unfavorable periods between two seasons. Typically a biennial reproduces only in its second season. Under tropical conditions where two or more growing seasons can occur within 12 months, a biennial may complete its life cycle within one calendar year.
4) ***Perennials:*** are plants that continue to grow for two or more growing seasons and usually develop woody parts and/or specialized perennating organs such as bulbs and rhizomes. Generally perennials do not start sexual reproduction until several growing seasons have passed and the

plant has reached a certain minimum size. Most perennials produce flowers and fruits at regular intervals throughout their lives and are termed polycarpic. However, some such as **enset**, *Ensete ventricosa*, and **sisal**, *Agave sisalana*, only flower once and then die; such plants are termed monocarpic or hapaxanthic.

Habit

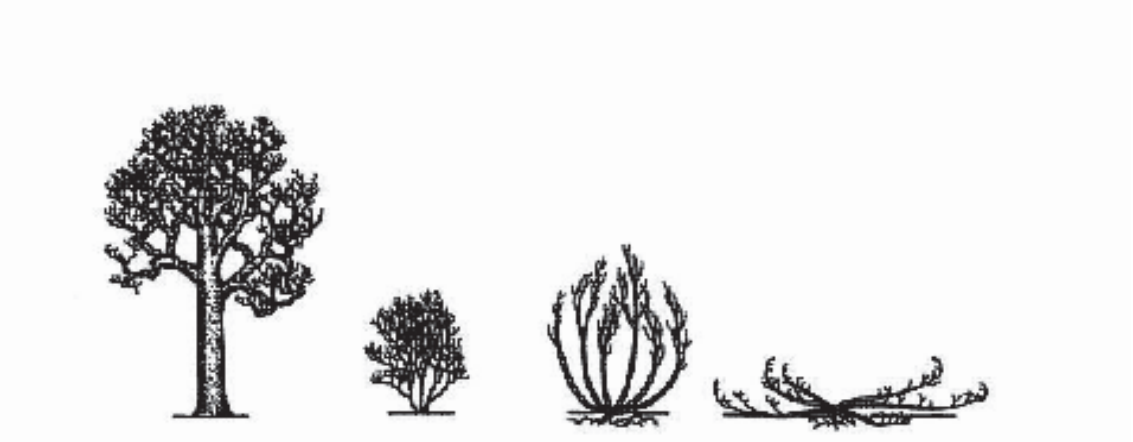
Although there are no clear-cut distinctions between each of the following habit forms, it is convenient to use the terms as they describe the overall impression given by a plant.

Trees: are plants which usually have a single main stem, the trunk arising from the ground and growing for some distance before it branches: trees are always woody and perennial.

Shrubs and bushes: are also woody plants but here a few to several branches arise from or just above ground level.

Herbs: are generally considered to be plants which do not develop woody stems. Most herbs are small plants, but under tropical conditions where growth can continue throughout the year, some herbs can be large. The mountains of East Africa and Ethiopia carry some striking giant herbs, species of *Lobelia* and *Senecio*, which can be up to 4 m tall. At the other extreme, semi-arid areas are often covered with very short plants, the size of herbs but woody and much branched like shrubs. These are called sub-shrubs or suffrutescent plants.

Climbers: (can be woody, when they are called lianas, or herbaceous) are plants that cannot support themselves in an upright position but which grow over other plants and/or non-living structures. Many climbers have organs which assist in the plant catching and holding onto its support. These include spines and prickles, tendrils and twining stems. Some climbers do not produce specialized organs but simply grow up and fall over other plants.



Tree **Shrub** **Ascending** **Decumbent**

Morphology

Root

A root is an organ which does not bear other structures and which arises from within an axis next to the vascular tissue in contrast with a stem which arises from the cortex and which partly because they are often ignored being under the ground.

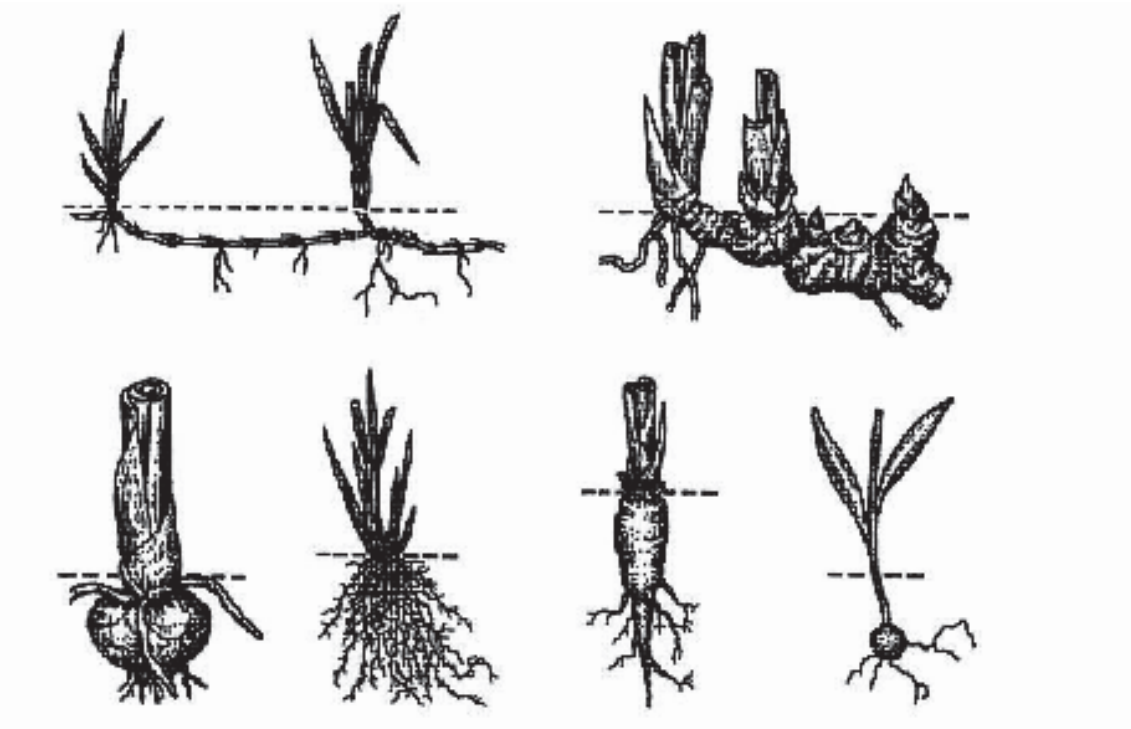


Fig: Stoloniferous rhizome (top left); Rhizome (top right); Corm; Fibrous; Tap; Tuberous

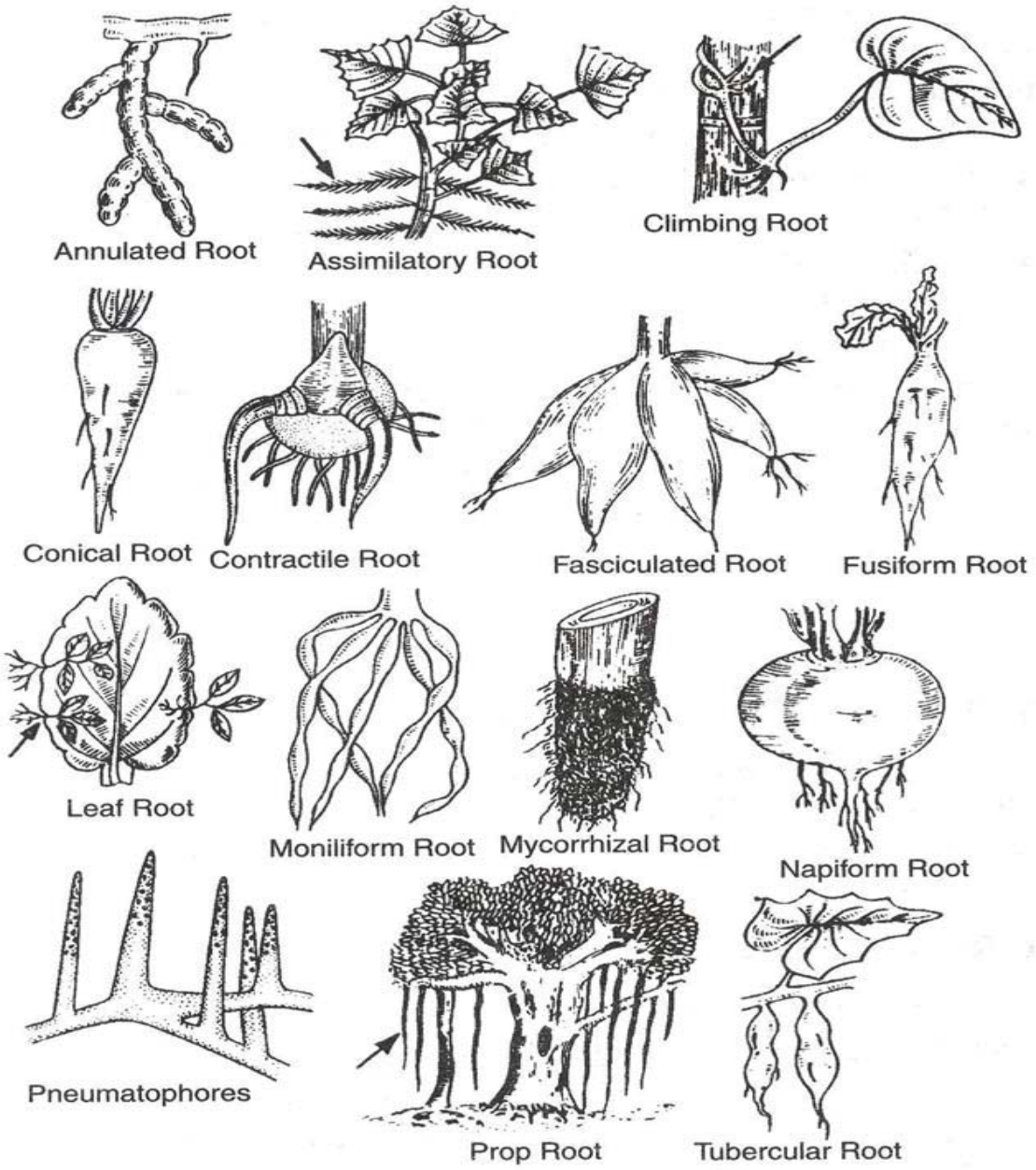


Fig: Modified root

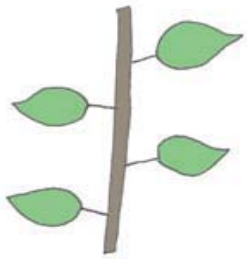
Leaves

These organs contribute many useful characters for identification at the family, genus and species levels. Leaf arrangement is a very convenient character for use in identification keys and is often a constant feature in a family. The commonest arrangement, generally termed alternate, is one in which only one leaf is found at each node. Two leaves are found opposite each other at a node they are called opposite. Often the stem bears two sets of opposite leaves at right angles to each other resulting in a stem which has four angles and is square in cross- section. If more than two leaves

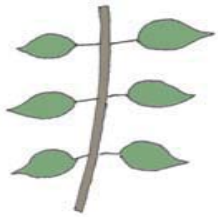
occur at a node the arrangement is described as whorled. This arrangement must not be confused with the situation where the leaves are in irregular clusters, such an arrangement is called fasciculate. When leaves are whorled they occur all round the stem while fasciculate leaves are usually clustered on one side of the stem. There are two basic types of leaf: (i) Simple leaf and (ii) Compound leaf.

Simple leaf: A simple leaf has only one leaf stalk, petiole, in the axil of which can be found a bud, branch, flower or inflorescence. The lamina of a simple leaf is never completely divided into parts each with its own stalk.

Compound leaf: The parts of such a leaf are called leaflets; each leaflet may have its own stalk, the petiolule. If the leaflets are arranged along a continuation of the petiole, care must be taken to differentiate between such compound leaves which are large with large leaflets and young branches with soft stems and simple leaves. The best way of telling the difference between these two situations is to look at the apex - if it is a compound leaf growth will have stopped at the end of the leaf, but if it is a branch one will find a bud or evidence of continued growth. Leaflets in angiosperms are never associated with buds, or branches, or flowers or inflorescences.



Alternate



Opposite

Palmate

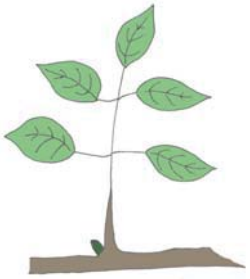
Simple

Tripinnate

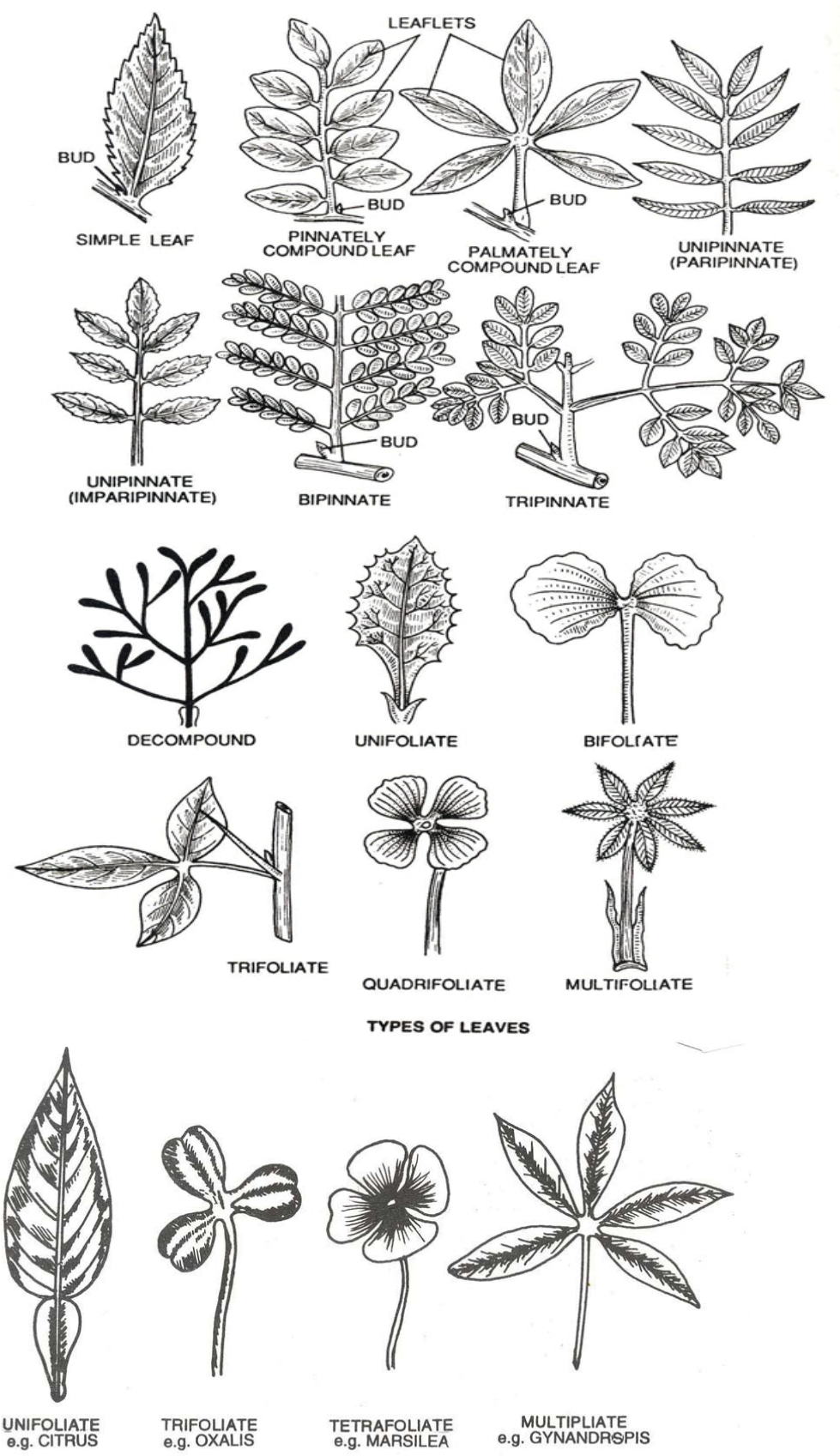
Whorle

Bipinnate

Even Pinnate

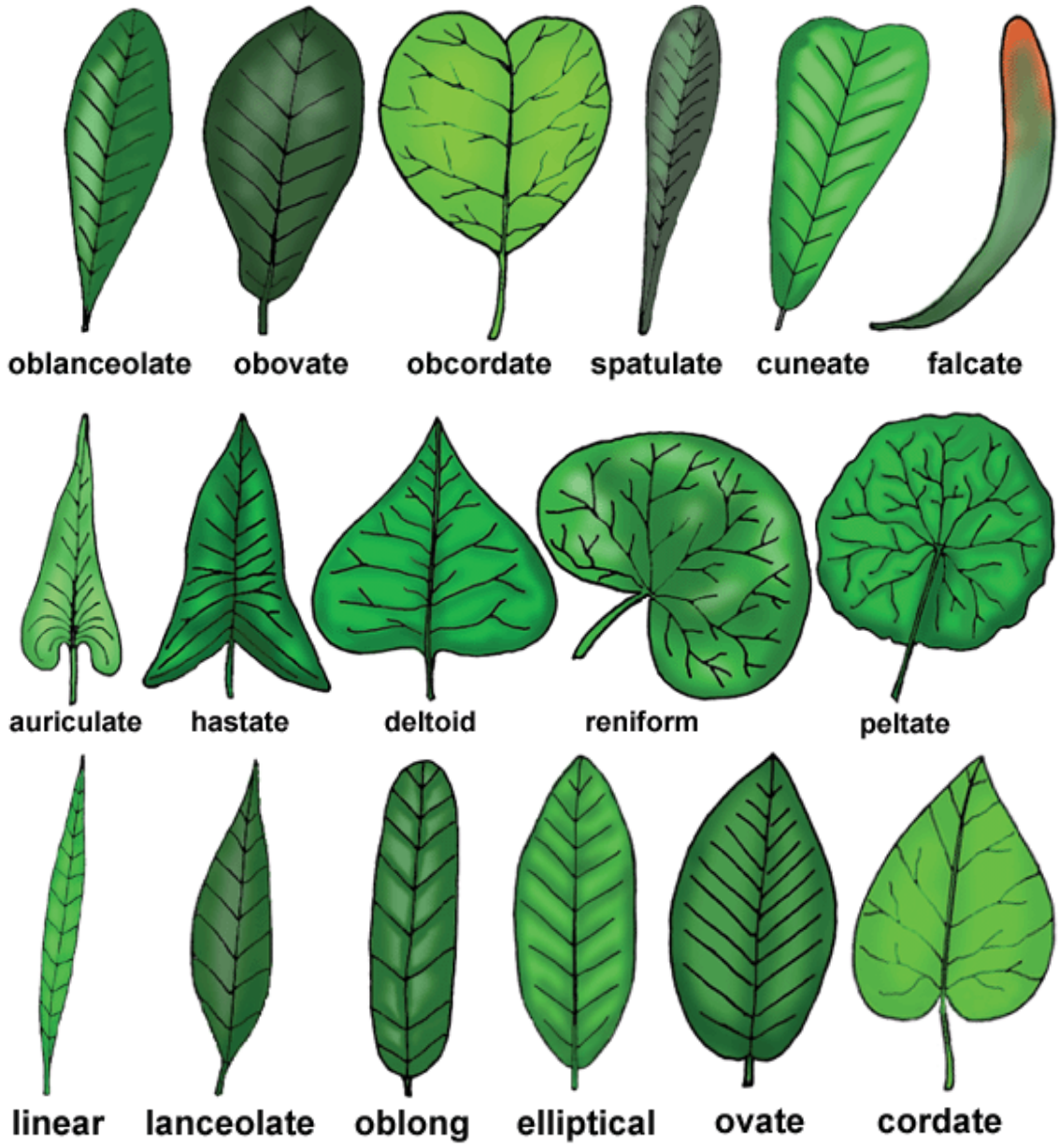


Compound

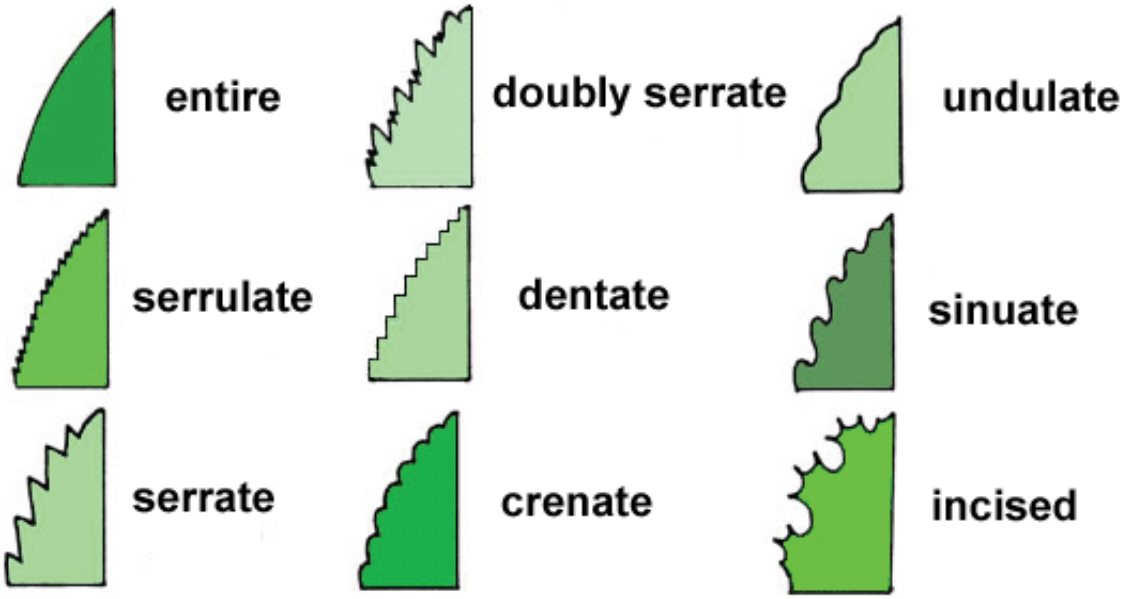

BUD
SIMPLE LEAF
LEAFLETS
BUD
PINNATELY COMPOUND LEAF
BUD
PALMATELY COMPOUND LEAF
UNIPINNATE (PARIPINNATE)
UNIPINNATE (IMPARIPINNATE)
BUD
BIPINNATE
BUD
TRIPINNATE
DECOMPOUND
UNIFOLIATE
BIFOLIATE
TRIFOLIATE
QUADRIFOLIATE
MULTIFOLIATE
TYPES OF LEAVES
UNIFOLIATE e.g. CITRUS
TRIFOLIATE e.g. OXALIS
TETRAFOLIATE e.g. MARSILEA
MULTIPLIATE e.g. GYNANDROPIS

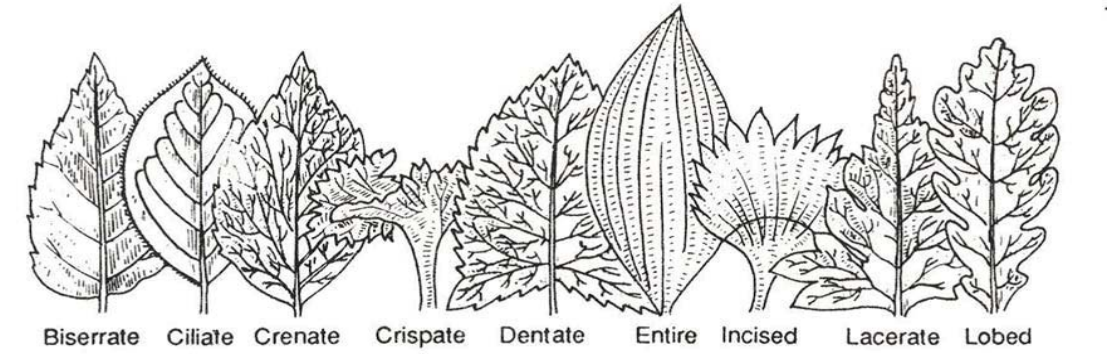
In simple leaves, the venation pattern can be important in identification. Most dicotyledons have a pinnate venation pattern in which there is a midrib and a series of secondary veins to either side of this. In palmate or digitate venation three or more main veins arise from one point at the base of the lamina. Parallel venation is typical of many families of monocotyledons.

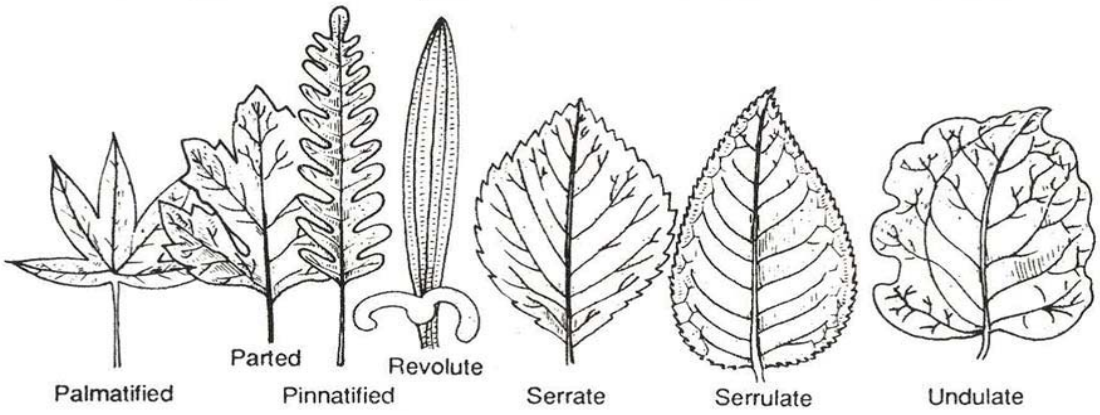
Leaf shape



Leaf margins

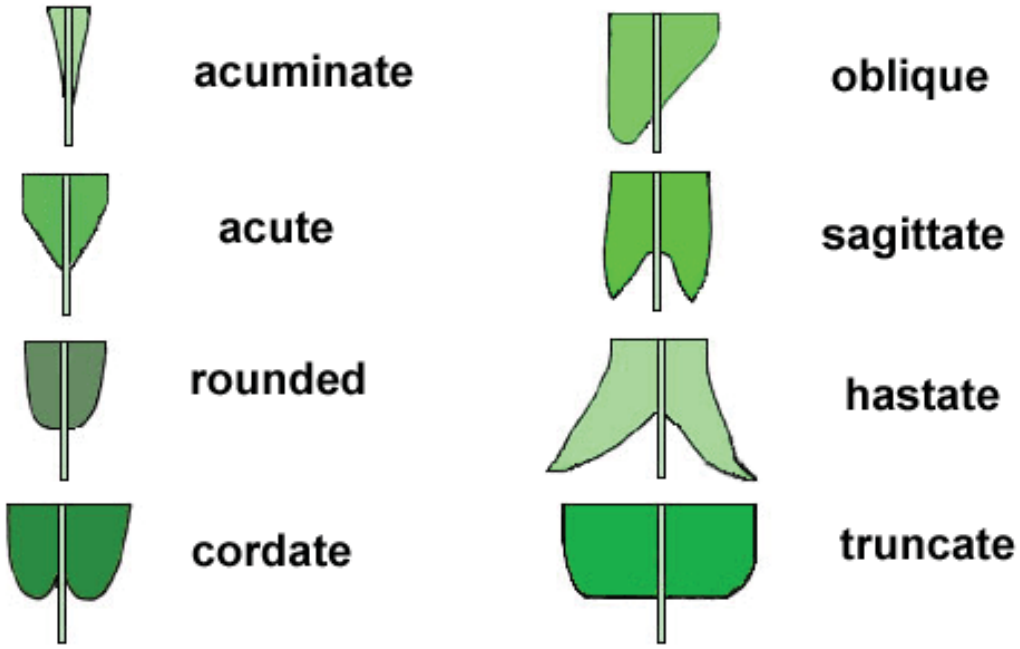






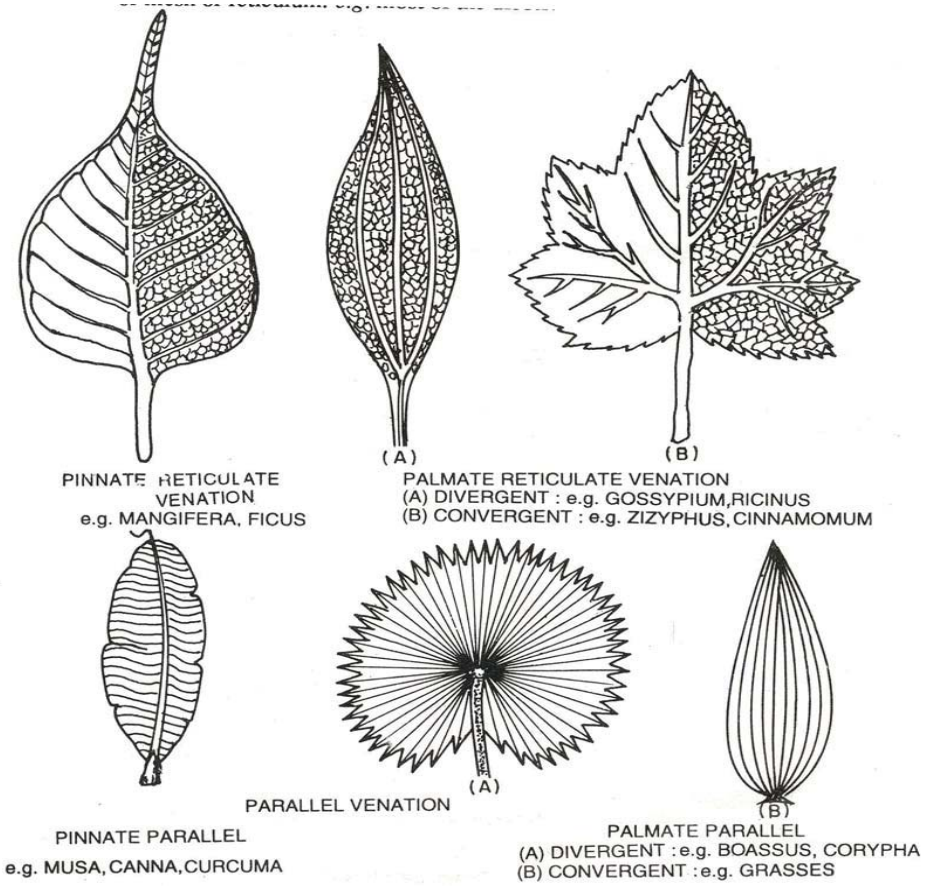
Leaf base

The base of the leaf stalk can be associated with a pair of small flattened appendages called stipules. Stipules can be small or large, attached firmly to the leaf stalk as in many **Rosaceae**, or falling off as or soon after the leaf unfolds as in ***Ficus*** (**Moraceae**). If stipules are associated with opposite leaves they may join-up across the stem forming an interpetiolar stipule. This is a distinctive feature of the **Rubiaceae** where such interpetiolar stipules may develop to the same size as the leaves, as in ***Galium***, or be reduced to a line or linear scar. Stipules might be fused to surround the entire stem above the node, and such a structure is called ochrea or stipular sheath. The base of a petiole or sessile leaf can surround or tightly wrap a part of the stem, and such a base iscalled sheath, while the free flat part of the leaf is called blade or lamina. In compound leaves, each leaflet may bear a pair of small stipules.



Leaf venation

The venation patterns found in simple leaves are paralleled by the arrangement of leaflets in compound leaves. When compound leaves are pinnate, the leaflets are arranged on either side of the rachis. The end of the rachis may end in a pair of leaflets, in which case the leaf is described as even-pinnate or paripinnate, or in a single leaflet, when it is described as odd-pinnate or imparipinnate. In some groups of plants, such as ***Acacia*** and ***Albizia*** of the **Fabaceae** (**Leguminosae**), each leaflet is replaced by a rachis bearing small leaflets, i.e. the leaf is twice compound and is termed bipinnate. In pinnate leaves, each leaflet is termed a pinna, while in bipinnate leaves, the leaflets are called pinnules. A special and distinctive case of imparipinnate is the trifoliolate leaf which has three leaflets. This situation must not be confused with a group of three leaves, trifoliate, at a node. When the leaflets are arranged as in the fingers of a hand, the arrangement is called digitate or palmate and twice compound leaves with this arrangement are termed bidigitate or bipalmate.



Stems, leaves, leaflets and stipules can all be modified to form specialized structures. Tendrils are slender coiling organs. Sharp leaves are called spines, sharp shoots are called thorns and sharp outgrowths at the sides of stems or petioles are called prickles. In some plants, notably those adapted for extreme ecological conditions, leaves may be greatly reduced or lacking. The functions of the leaf can then be carried out by leaf-like structures called cladodes or cladophylls if they are modified stems, or phyllodes if they are modified leaf stalks. Cladodes are found in many **Cactaceae** such as ***Opuntia*** while phyllodes are typical of Australian species of ***Acacia*** introduced into Ethiopia, e.g. ***Acacia melanoxylon***. Other extreme adaptations of leaves include the large petal-like bract, the spathe, typical of the **Araceae**. The leaves associated with inflorescences are usually reduced and/or modified and are refered to as bracts. Bracts may be colourful and petal-like as in ***Bougainvillea*** and ***Poinsettia***, ***Euphorbia pulcherima***, or highly reduced as phyllaries enclosing and surrounding the capitulum of the **Asteraceae (Compositae)** and the glumes enclosing the florets of **Cyperaceae** and **Poaceae**.

Both texture and the covering, indumentum, of leaves and other parts can assist in identification, particularly at the genus and species level. But these characters can also be useful at family level. Thick, leathery-textured leaves are typical of the families **Balanitaceae** and **Salvadoraceae**: star-shaped (stellate) hairs are a conspicuous feature of plants belonging to the **Malvaceae**, **Tiliaceae** and some genera of **Solanaceae**. Smell is another very useful character in identification. Some families are easily recognised by their smell, for example the **Lamiaceae (Labiatae)** and **Apiaceae (Umbelliferae)** contain many plants used as spices while the **Burseraceae** is the family which provides incense and myrrh. The juice or sap produced by a plant can be important for identification: plants of ***Euphorbia*** have milky sap while in the **Cactaceae** the sap is clear.

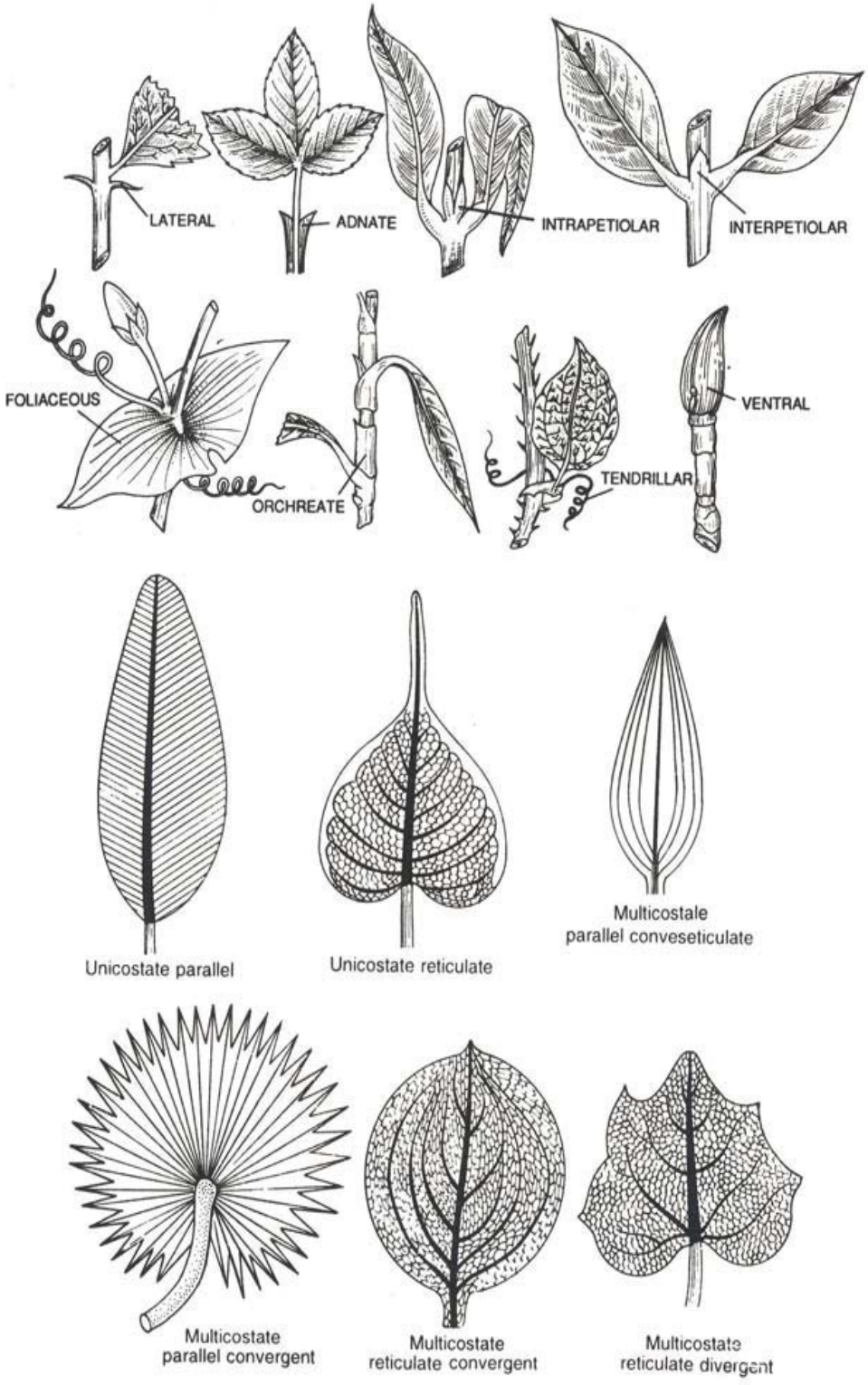
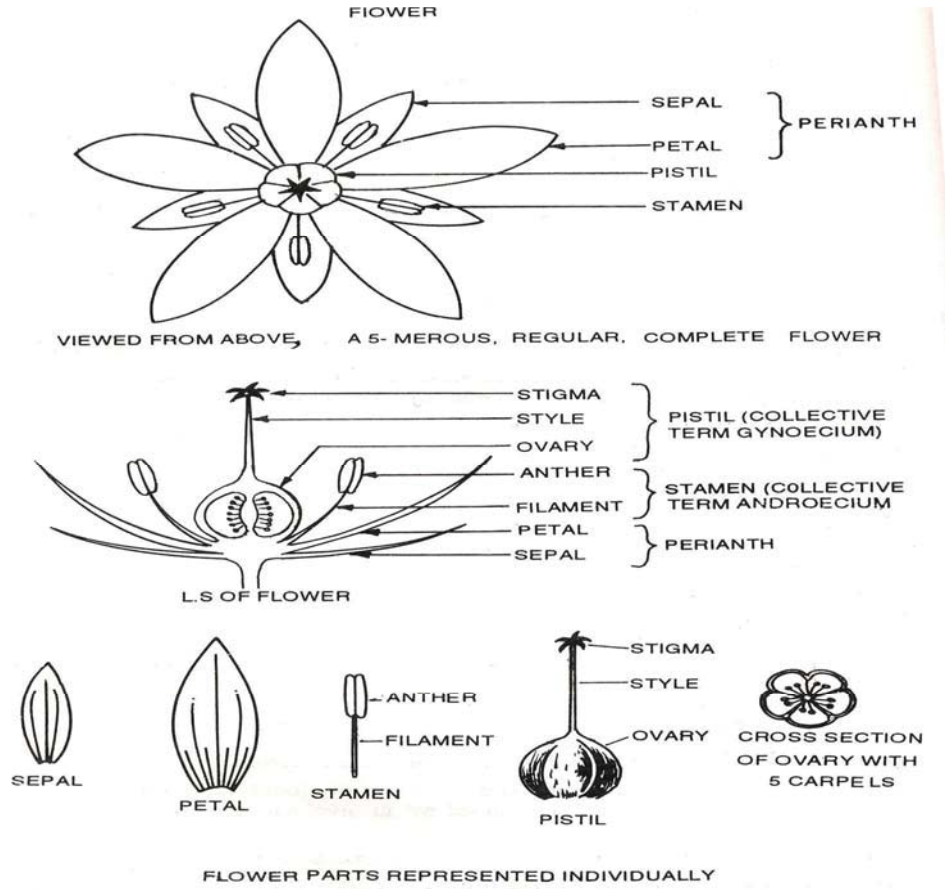


Fig.: Stipules & leaf venation

Reproductive characters

These characters are all associated with the flower. They can be divided into characters associated with the arrangement of flowers, the inflorescence, the sexuality of a flower, and the parts of the flower. The parts of the flower can be further divided into two groups; the accessory or sterile appendages and the essential or fertile ones.



Parts of a Flower

All flowers share several basic features. Sepals, protective coverings that are closed over the bud before it blooms, are the outermost flower parts. One step inward lies the petals, which serve to attract pollinators using both coloration and scent-producing glands. Inside the petals are the flower's sexual organs, the stamens and pistil. Each stamen, the pollen producing part of the flower, includes an anther and a filament. At the center of the flower is the pistil, composed of a stigma, a style, and an ovary. Within the ovary is a small cavity that contains the ovule, an egg-shaped structure that, when fertilized, eventually becomes a seed.

Inflorescence

A flower may be solitary if it is produced by itself from the axil of a leaf or at the end of a branch. However, flowers are usually grouped together into inflorescences which can be either terminal and/or axillary. The terms for different types of inflorescence are explained in the `Glossary of Terms'. The stalk to an individual flower is termed a pedicel while that of an inflorescence is a

peduncle. Leaves in an inflorescence are called bracts. They are usually smaller than the ordinary vegetative leaves but might also be large and coloured. Characters from inflorescence types are more important in identifying genera and species than families, but there are some families with distinctive inflorescence types. These are the capitulum, where many small flowers are densely grouped together to resemble a single flower (typical of the **Asteraceae (Compositae)** and **Dipsacaceae**); the umbel where the small flowers are all borne at the same level (typical for A**raliaceae**); several umbels can, in their turn, be arranged into a larger umbel, called compound umbel (typical of the **Apiaceae** (**Umbelliferae**)); the spadix with its thickened axis bearing densely crowded and reduced flowers inside the spathe (typical of the **Araceae**); the spikelet of a few to several very small and reduced, wind-pollinated flowers (typical of the **Cyperaceae** and **Poaceae**); and the fig (syconium) of unisexual flowers embedded in a swollen receptacle (typical of Ficus). Most families have flowers which contain both stamens and pistil and are, therefore, bisexual or hermaphrodite, but other families have unisexual flowers. Unisexual flowers are either staminate when they have functional stamens, or pistillate when they do not have functional stamens. Staminate flowers may have a non-functional pistil called a pistillode while pistillate flowers may have non-functional stamens called staminodes. One way to distinguish between unisexual flowers is to see how they mature. Flowers which are only male in function soon wither and drop off after the pollen is shed and nothing resembling a developing fruit can be found, while in flowers which are functionally female some evidence of a ripening ovary will be found after the perianth parts have withered.

A plant may have three kinds of flowers, male and female as well as bisexual. Neutral flowers can also be found in some plants; these are particularly frequent in ornamental plants which have been selected by man for their showy flowers. Monoecious plants have unisexual flowers of both kinds on the same plant. This situation is typical of some families including the **Euphorbiaceae** and **Urticaceae**. In dioecious plants an individual plant is either male or female. This situation can cause special problems in identification as the male and female plants may appear somewhat different from each other or one may find plants of only one sex which restricts the number of characters available for the identification exercise. Dioecious plants are characteristic of the **Cucurbitaceae** and **Salicaceae** and are common in families of woody plants more typical of temperate than tropical regions.

Many botanists believe that the flower has been derived from a modified branch which has been greatly compressed and its leaves modified into the parts of the flower. Thus plants which have an elongated central axis, the receptacle or torus bearing numerous, spirally arranged parts are considered primitive. Such flowers are found in the **Magnoliaceae, Annonaceae, Nymphaeaceae** and **Ranunculaceae** and are found in Volume 2 of the Flora of Ethiopia. In the majority of flowering plants the receptacle is flattened or even concave with the parts arranged in whorls, each with a fixed and definite number of components.

Some special notes:

The inflorescence is racemose or cymose, or special types, or flowers are solitary.

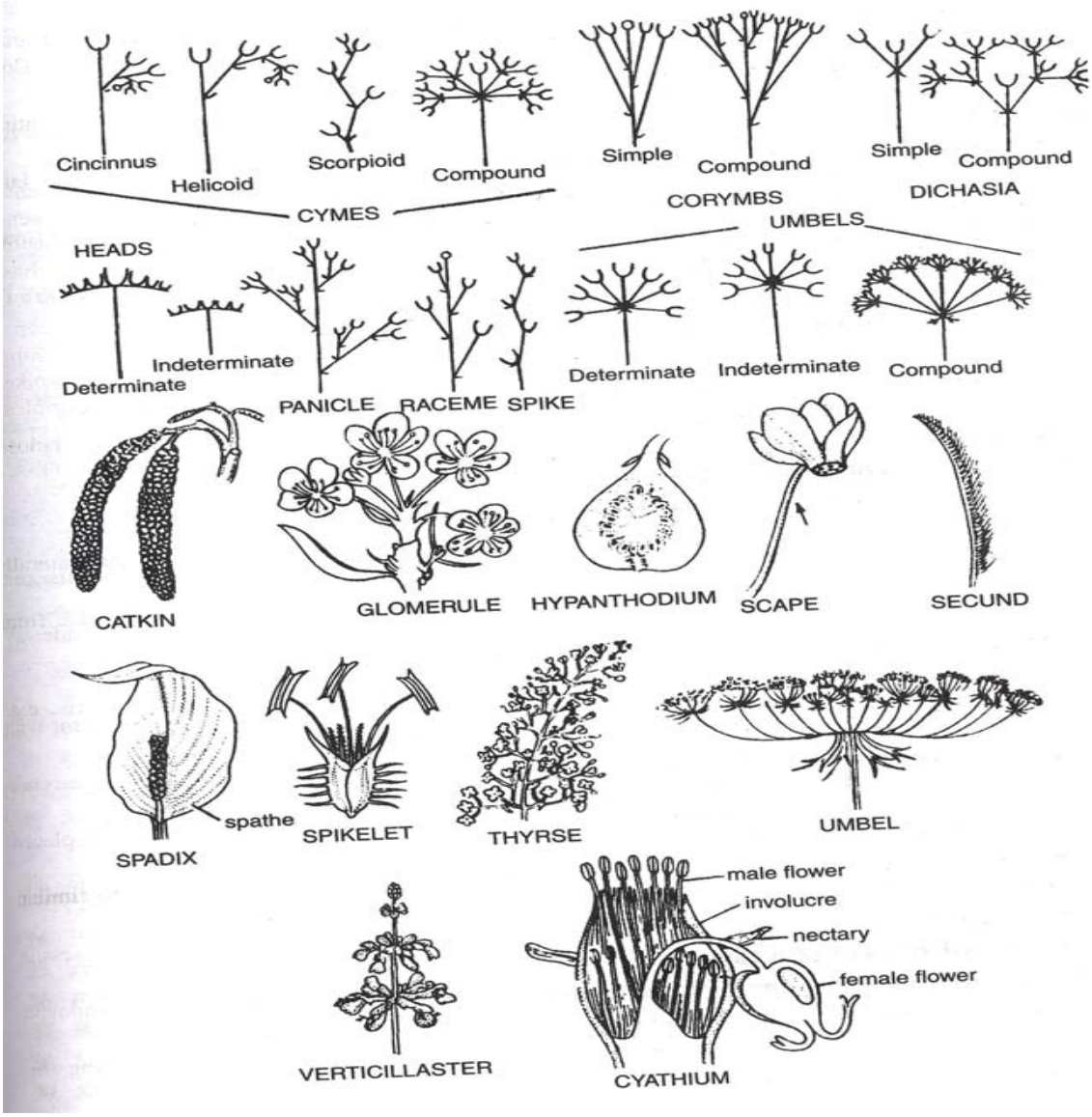
If racemose, then note whether it is a raceme, spike, spikelet, panicle, catkin, spadix, corymb, umbel or capitulum, fascicle

If cymose, then note whether it is a monochasial, dichasial or polychasial cyme.

If special type, then note whether it is a cyathium, or verticillaster, or hypanthodium.

Inflorescence compound, sympodial or monopodial (panicle, thyrsus etc.).

Inflorescence a head, simple and monopodial.

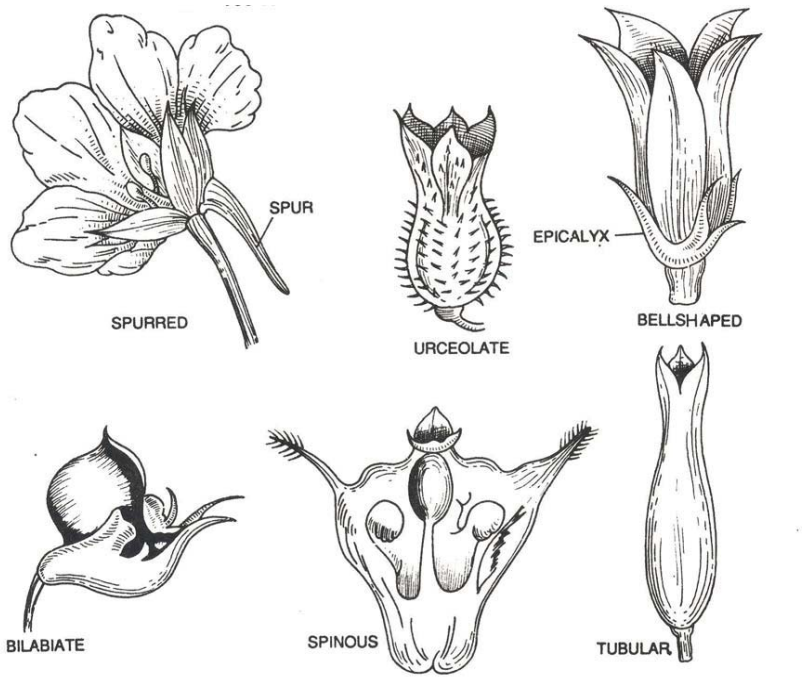


Perianth

The accessory or sterile parts of a flower are called the perianth. If all the parts of the perianth look alike they are called tepals. This situation is found in some monocotyledonous families like the **Liliaceae, Amaryllidaceae and Orchidaceae**. In most dicotyledons the perianth is made up of two distinctly different whorls - an outer calyx composed of sepals which are usually green or dull-coloured and protect the flower in bud, and an inner corolla composed of petals which are usually colourful and arranged to attract pollinators. The individual sepals and petals may be free from each other, then the flower is discribed as polypetalous or polysepalous, or united forming a sepal and/or petal tube, when the terms are gamopetalous or gamosepalous. Similarly all parts of the perianth may be fused to form a perianth tube. When the fused, tubular part of the flower appears to be formed from receptacle tissue carrying sepals, petals and stamens, it can be referred to as a hypanthium as

found in Punica, the pomegranate (`roman' in Amharic). The receptacle can form a pad of tissue around the base of the ovary or from the base of the stamens. This is called a disc and may or may not be responsible for the production of nectar. The receptacle can also form additional structures within the flower - a gynophore is a stalk-like structure found under the ovary while an androphore is a column bearing only stamens (in male flowers) and an androgynophore is a column bearing both stamens and pistil. All these structures are found within the perianth and are always associated with a superior ovary. Other important characters of the perianth useful in identification of families are the position of the parts in the bud (aestivation), and their symmetry when the flower has opened. Contorted aestivation is having several parts in a whorl or close spiral with one margin overlapping and the other under lapping the adjacent structures, while in convolute one perianth part is rolled inside another and usually twisted apically. Imbricate is a general term for all arrangements where the parts overlap each other while in valvate, the margins of the adjacent parts touch only at the edges. A few flowers have no plane of symmetry (amorphic) or all the parts are spirally arranged (haplomorphic), but most can be divided along one or more lines into two equal and opposite halves. When a flower is only bilaterally symmetrical it is termed zygomorphic or irregular while actinomorphic or regular flowers are radially symmetrical.

Some important features to be remembered: (i) Number of sepals and/or petals; (ii) Attachment of the sepals and/or petals (free or united above the base); (iii) Aestivation of perianth (e.g. valvaet, twisted, imbricate, quincuncial or vexillary); (iv) Colour of sepals and/or petals; (v) Shape of corolla, i.e. cruciform, caryophyllaceous, rosaceous, tubular, compannlate, rotate, funnel shaped, papilionaceous, bilabiate, ligulate or personate; (vi) Appendages (if any) present on coralla such as nectary, corona, spur etc.



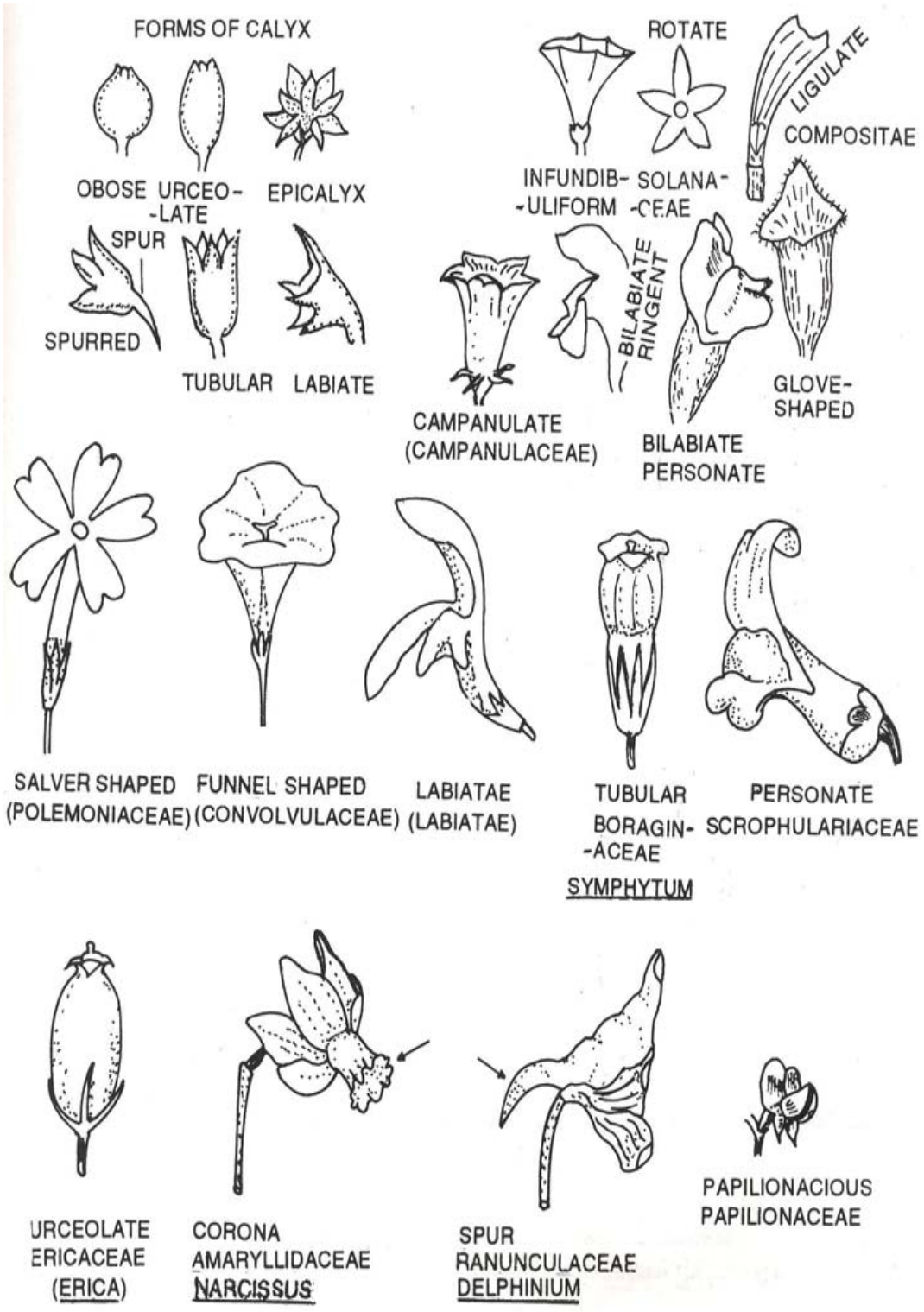
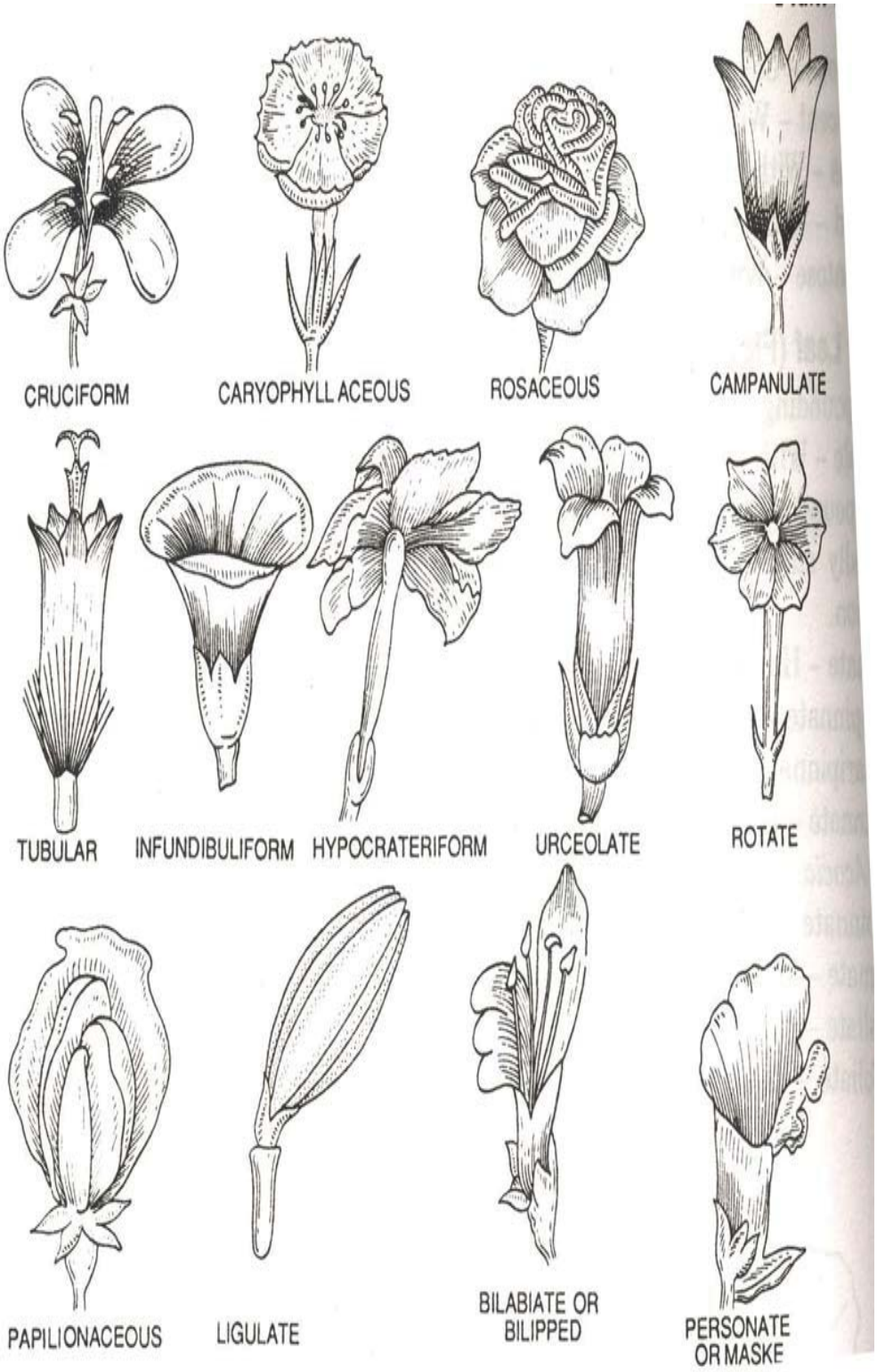
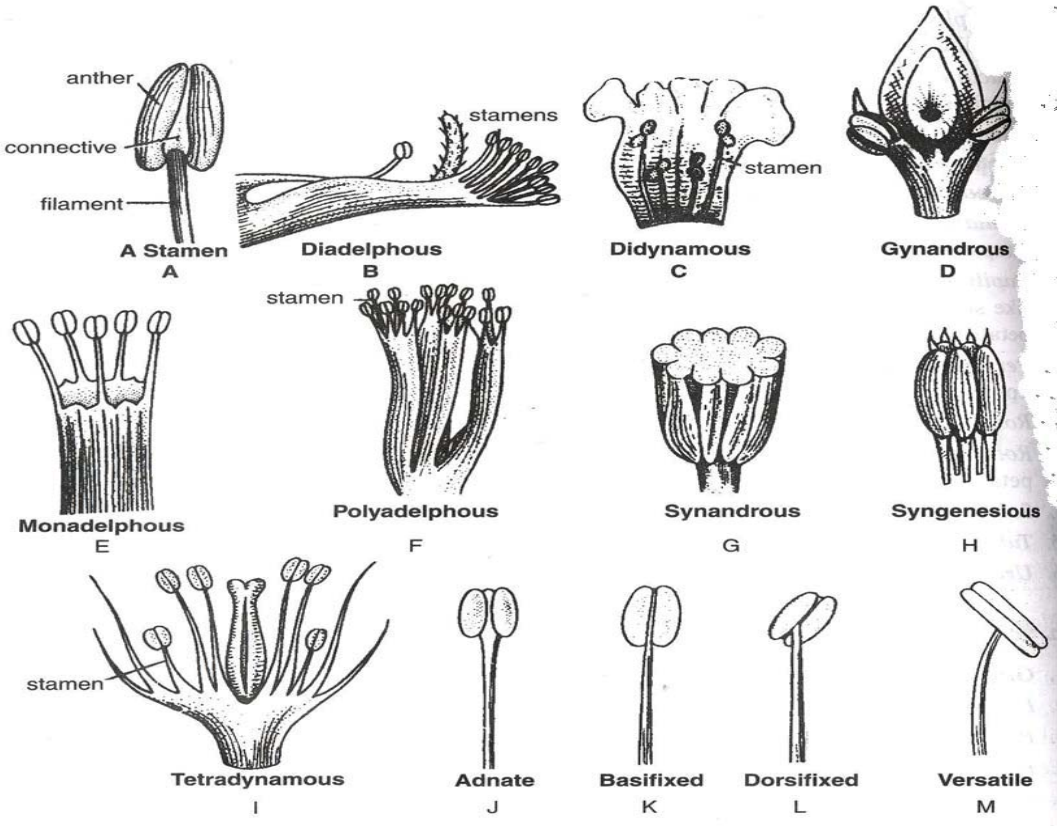


Fig. 2.12 Calyx and corolla types.


CRUCIFORM
CARYOPHYLLACEOUS
ROSACEOUS
CAMPANULATE
TUBULAR
INFUNDIBULIFORM
HYPOCRATERIFORM
URCEOLATE
ROTATE
PAPILIONACEOUS
LIGULATE
BILABIATE OR BILIPPED
PERSONATE OR MASKE

Androecium

The androecium (male house) is made up of the stamens which produce the male spores (pollen grains) which contain the male gametes. Typically a stamen consists of a stalk - the filament - bearing an anther made up of 4 pollen sacs arranged in 2 thecae. The tissue between the thecae is called the connective. The filament may be attached to the base of the anther (basifixed) or the back of the anther. If the anther stays rigid it is termed (dorsifixed), but if it moves readily on the filament it is called versatile. Most thecae open by longitudinal slits but in some families they open by transverse slits, or pores (**Ericaceae** and some **Solanaceae** and **Viscaceae**) or valves (**Lauraceae**). Stamens may have their filaments free or united. If united this can be in groups as in Hypericum or to form a tube around the pistil as in the ***Pisum*** and ***Vicia***. In the **Asteraceae** and ***Lobelia*** the filaments are free but the anthers are united (syngenesious). In epipetalous flowers, the stamens are borne on the corolla, and they may be sessile. The position of the stamens in relation to the perianth parts is important in identification: they may be antisepalous (opposite the sepals) or antipetalous (opposite the petals). When there are two whorls of stamens they may be diplostemonous with the outer whorl opposite the sepals and the inner opposite the petals, or obdiplostemonous in which the reverse arrangement is found. The stamens can be all the same length with the anthers borne at the same level or the lengths can vary. In the **Lamiaceae (Labiatae)** there are usually two long and two short stamens (didynamous) while in the **Brassicaceae (Cruciferae)** there are 4 long and 2 short stamens (tetradynamous).



Some important features

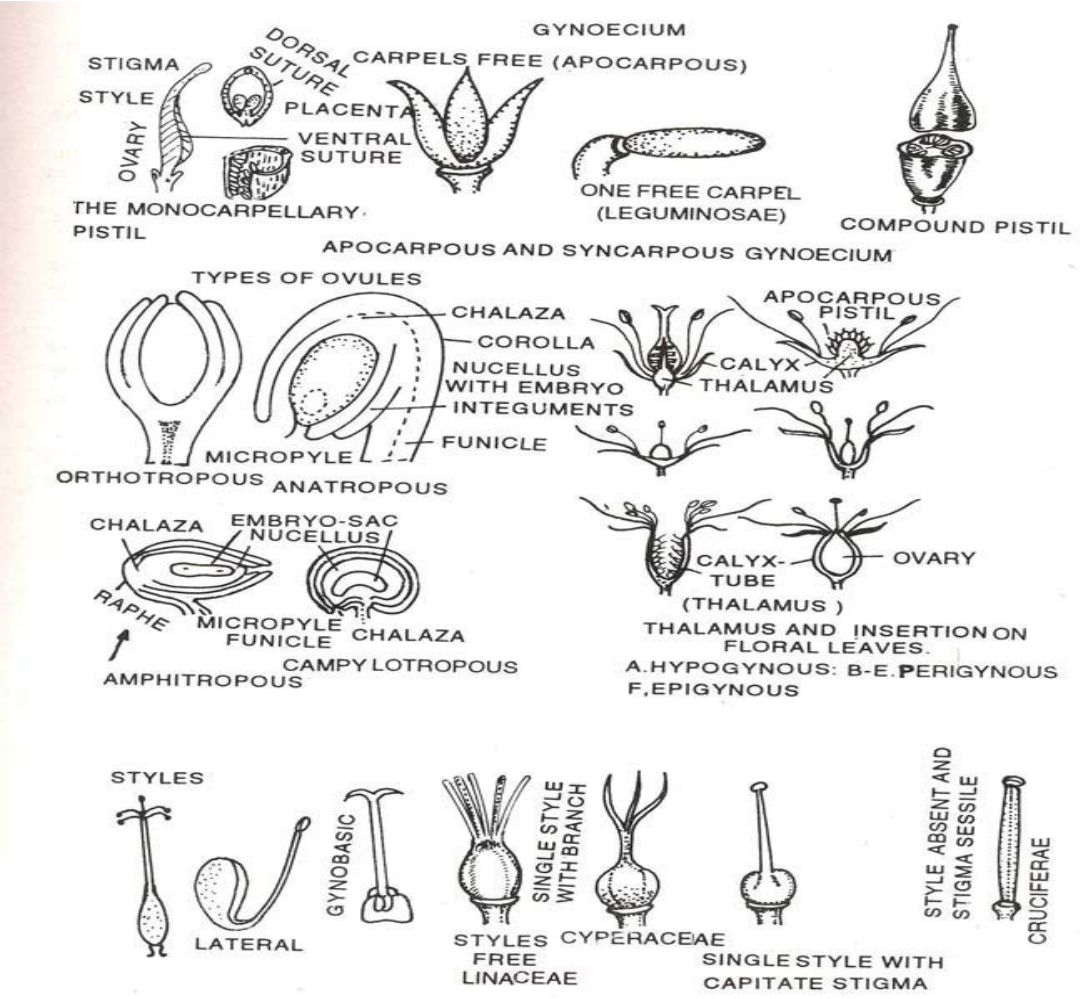
Number of stamens, number of whorls of stamens, presence of any staminodes, free or united, nature of cohesion (e.g. monadelphous, diadelphous, polyadelphous, syngenesious or synandrous), nature of adhesion (i.e. epipetalous, gynandrous), position of stamens (e.g. alternipetalous), inserted or exerted into corolla tube,

length of filament, number of theca, attachment of the anthers (i.e., basifixed, adnate, dorsifixed or bersatile), presence of appendages (e.g. hair, scales. staminal corona), present of disc outside etc.

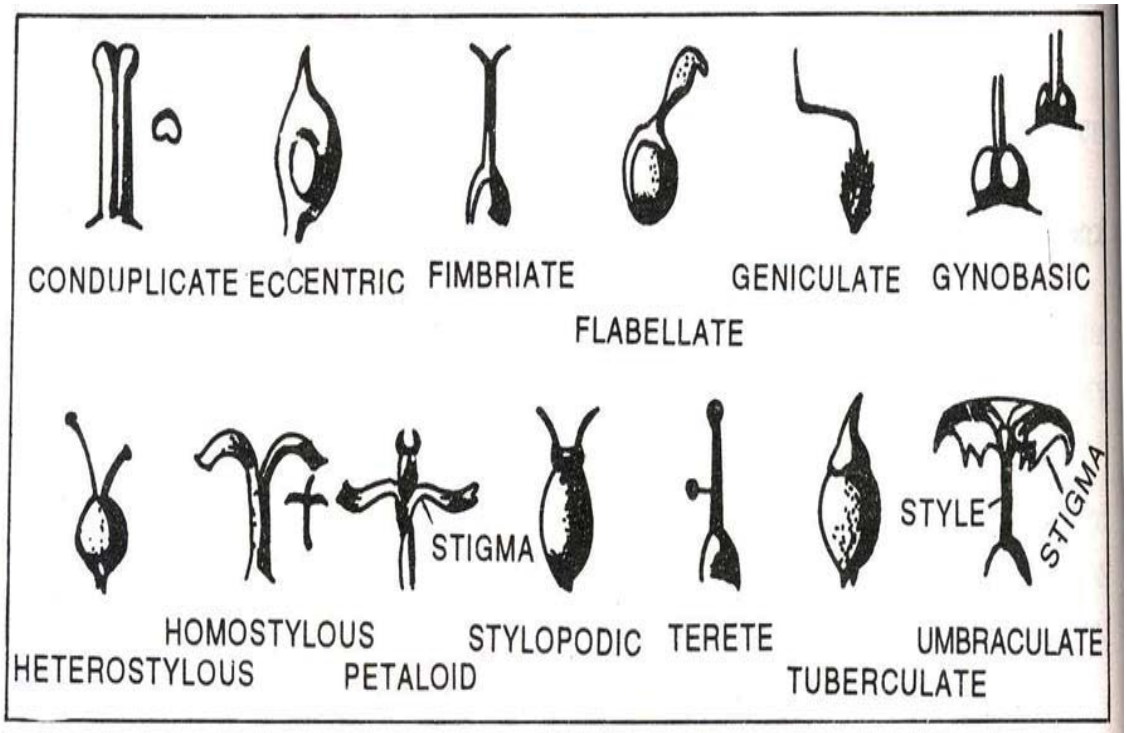
Gynoecium

The gynoecium contains one or more pistils each made up of a basal ovary containing one or more ovules where the female gametes are produced and fertilization takes place. Pollen is caught on the stigma which is usually held by the style above the ovary in an appropriate position to receive pollen. The ovules develop into seeds while the ovary forms a true fruit (in a false fruit other plant parts are also included). The position of the ovary in relation to the other parts of the flower is important in both identification and classification of families.

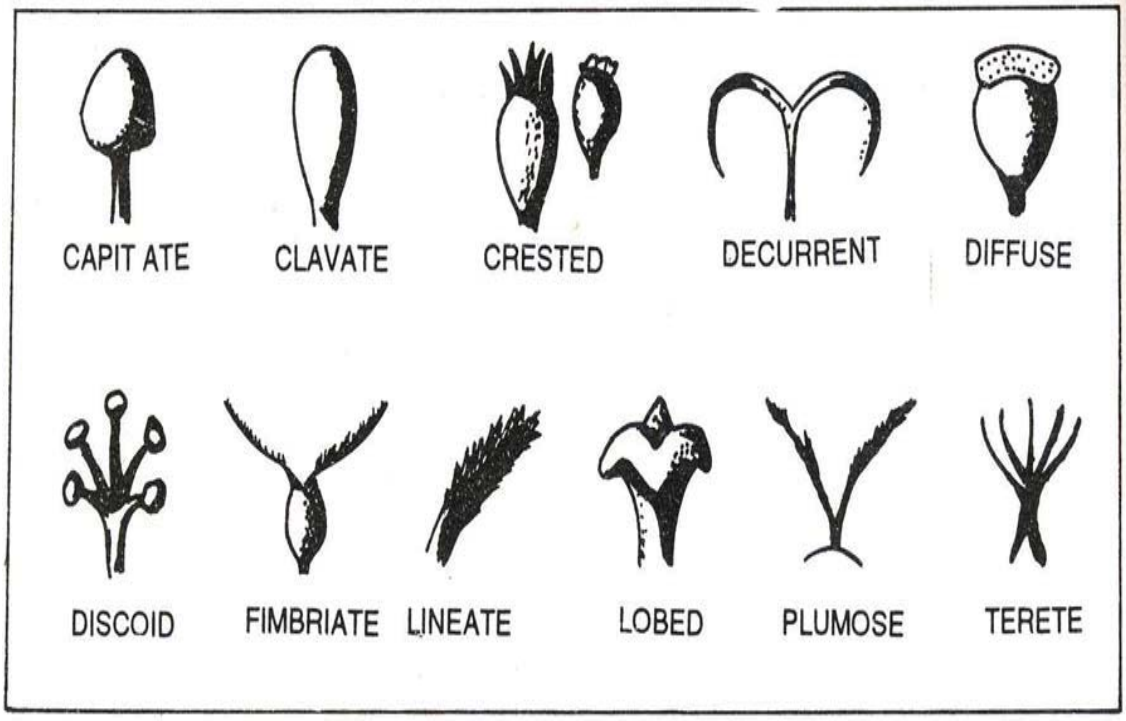
Some important features to note: Number or carpels, free or fused, position of ovary (i.e. superior, inferior or semi-inferior), number of locules (i.e., unilocular, bilocular or multilocular), number or ovules in per locule, type of placentation (i.e., marginal, axile, parietal, free-central, bassal or superficial), number of styles, Stigma number, shape & type etc.



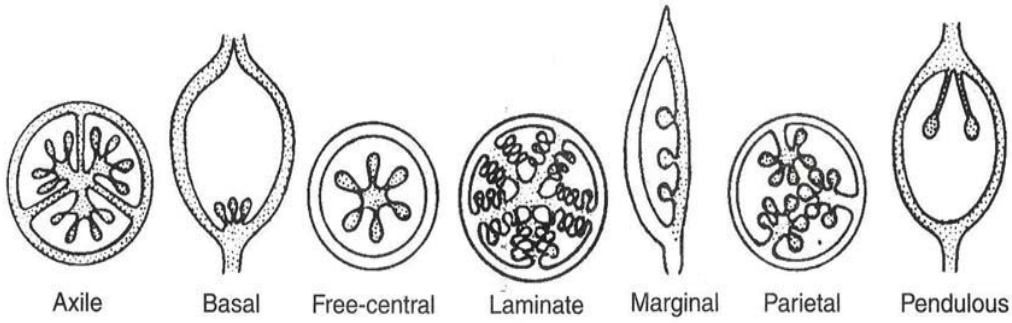
Types and shapes of stigmas



THE MAIN FORMS OF STIGMA (after Radford et al., 1974)



Types of placentation



Fruits

Although most of us have a good idea about fruits is when we eat them. For a botanist, the definitions are easier; a fruit is a reproductive structure of an angiosperm which develops from the ovary and accessory tissue, which surrounds and protects the seed. Fruits are important in seed dispersal. The process of fertilization initiates both seed and fruit development. While seeds develop from the ovules, the ovary tissue undergoes a series of complex changes which result in the development of the fruit. Many fruits are "fleshy" and contain sugars which attract animals who then disperse the enclosed seeds to new locations. Other, non-fleshy, fruits use other mechanisms for seed dispersal. In some plants, fruits can develop without fertilization. This is called parthenocarpy, and such fruits are seedless. As the ovary develops into a fruit, its wall often thickens and becomes differentiated into three, more or less distinct, layers. The three layers together form the pericarp, which surrounds the developing seed or seeds i.e., exocarp, mesocarp and endocarp.

A simple key to classifying fruits is provided here.

A. **Simple Fruits**

Simple fruits develop from a single matured ovary in a single flower. Accessory fruits have some other flower part united with the ovary.

1. **Fleshy Fruits:** pericarp fleshy at maturity.

a. **Berry:** consisting of one or more carpels with one or more seeds, the ovary wall fleshy.

Pepo (an accessory fruit), a berry with a hard rind, the receptacle partially or completely enclosing the ovary
Hesperidium, a specialized berry with a leathery rind

b. **Drupe:** a stone fruit, derived from a single carpel and containing (usually) one seed. Exocarp a thin skin

c. **Pome** (an accessory fruit): derived from several carpels, receptacle and outer portion.

d. **Hip** (an accessory fruit): several separate carpels enclosed within the fleshy or semi-fleshy receptacle

2. **Dry Fruits:** pericarp dry at maturity.

a. **Dehiscent fruits:** those which dehisce or split open when fully mature.

Follicle: composed of one carpel and splitting along a single suture
Legume: composed of a single carpel and splitting along two sutures
Capsule: composed of several carpels and opening at maturity in one of four ways: (a) Along the line of carpel union (septicidal dehiscence), (b) Along the middle of each carpel (loculicidal dehiscence), (c) By pores at the top of each carpel (poricidal dehiscence), (d) Along a circular, horizontal line (circumscissle dehiscence).

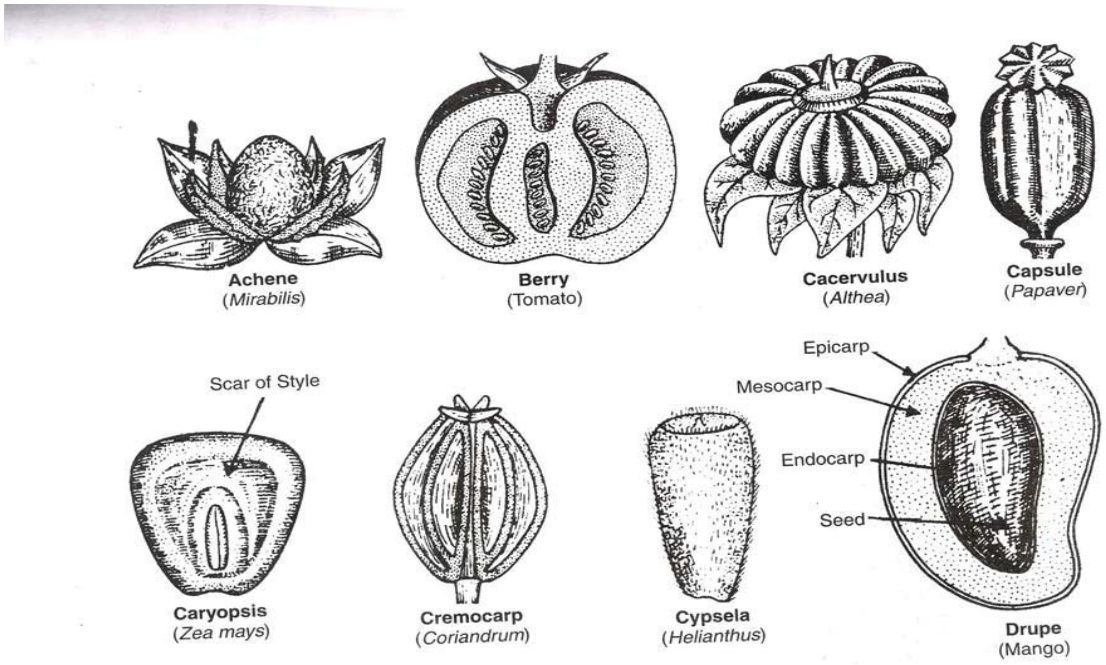
Silique: composed of two carpels which separate at maturity, leaving a persistent partition between them

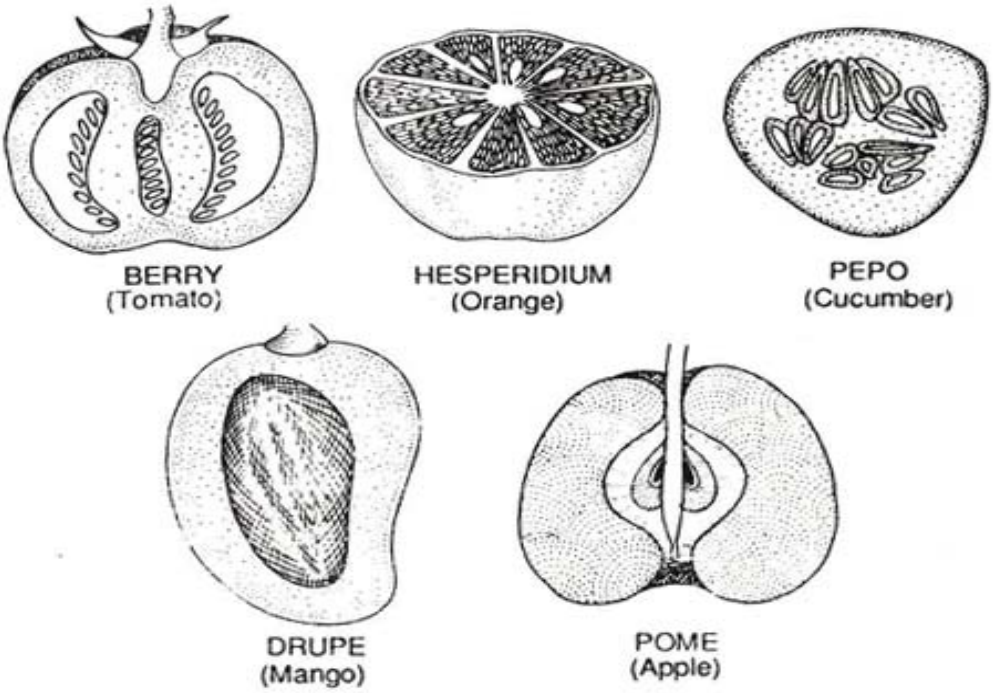
b. **Indehiscent fruits:** those which do not split open at maturity.

Achene: a one-seeded fruit with the seed attached to the fruit at one point only
Caryopsis: a one-seeded fruit in which the seed is firmly attached to the fruit at all possible points
Samara: a one- or two-seeded fruit with the pericarp bearing a wing like outgrowth. A modified achene
Schizocarp: consisting of two carpels which at maturity separate along the midline into two one-seeded halves, each of which is indehiscent
Loment: having several seeds, breaking into one-seeded segments at maturity
Nut: a hard, one-seeded fruit, generally formed from a compound ovary, with the pericarp hard throughout

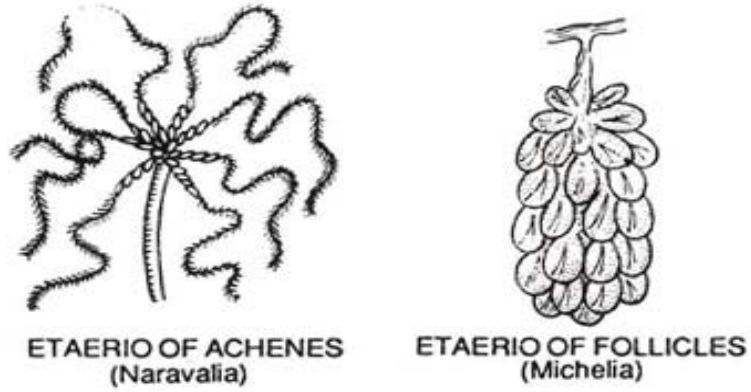
B. **Aggregate Fruits:** Aggregate fruits consist of a number of matured ovaries formed in a single flower and arranged over the surface of a single receptacle. Individual ovaries are called fruitlets.

C. **Multiple Fruits:** Multiple fruits consist of the matured ovaries of several to many flowers more or less united into a mass. Multiple fruits are almost invariably accessory fruits.

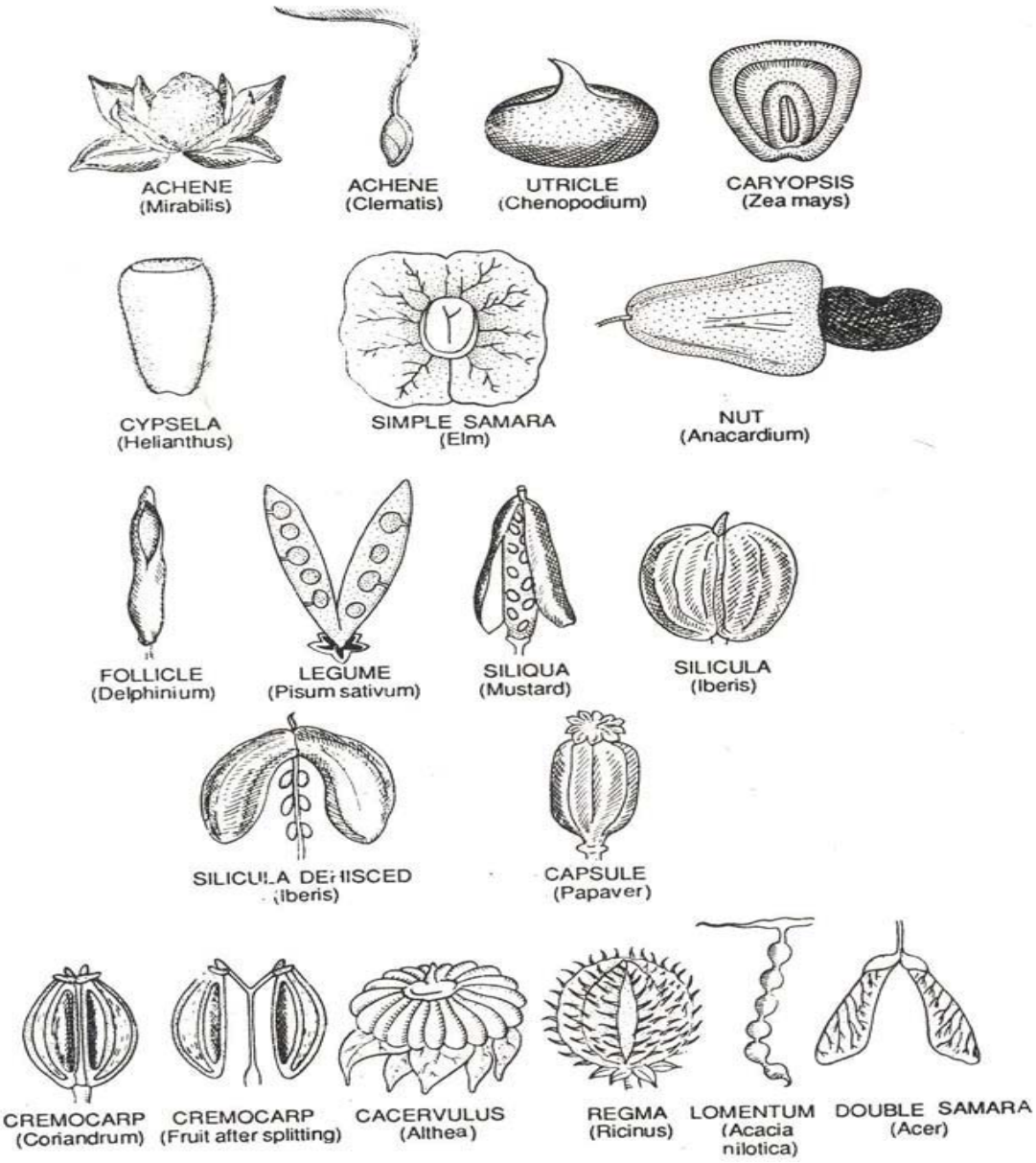

Achene
(Mirabilis)
Berry
(Tomato)
Cacervulus
(Althea)
Capsule
(Papaver)
Scar of Style
Caryopsis
(Zea mays)
Cremocarp
(Coriandrum)
Cypsela
(Helianthus)
Epicarp
Mesocarp
Endocarp
Seed
Drupe
(Mango)



FLESHY SIMPLE FRUITS



AGGREGATE FRUITS



Seeds

An in depth knowledge of botany of a plant as well as its seed is necessary, for correct identification of a particular species. In systematic botany or taxonomy the closely related or similar type of plant are grouped into a single category. These groups are: family, genus, species etc. In seed identification the particular seed in question must be identified up to the species level. The seed, a mature ovule consists of an embryo a protective covering and stored food as endosperm. The identification of seed is usually by comparison, comparing the seeds with a mental image of what something should be, with specimens in a reference collection or with illustration of seeds. In most cases, the useful clues for the identification of seed came from the following characters: (i) the size, shape and color of seeds; (ii) the nature, arrangement and pattern of markings that is lines, ridges, pits, projection on the seed surface; (iii) the shape and position of the attachment scar; (iv) the

presence of wings, hair or scale, spines etc.; and (v) the internal structure, position and size of the embryo, presence or absence of the endosperm.

Seed keys are developed on the basis of characters pertaining to family, genus, and species. Once the seed is characterized for a particular family, identification of the seed could easily be made by studying the above mentioned seed characters. The original seed sample of the species is always helpful in identification of unknown unconventional crop and weed seeds.

Fig: Different bean seeds

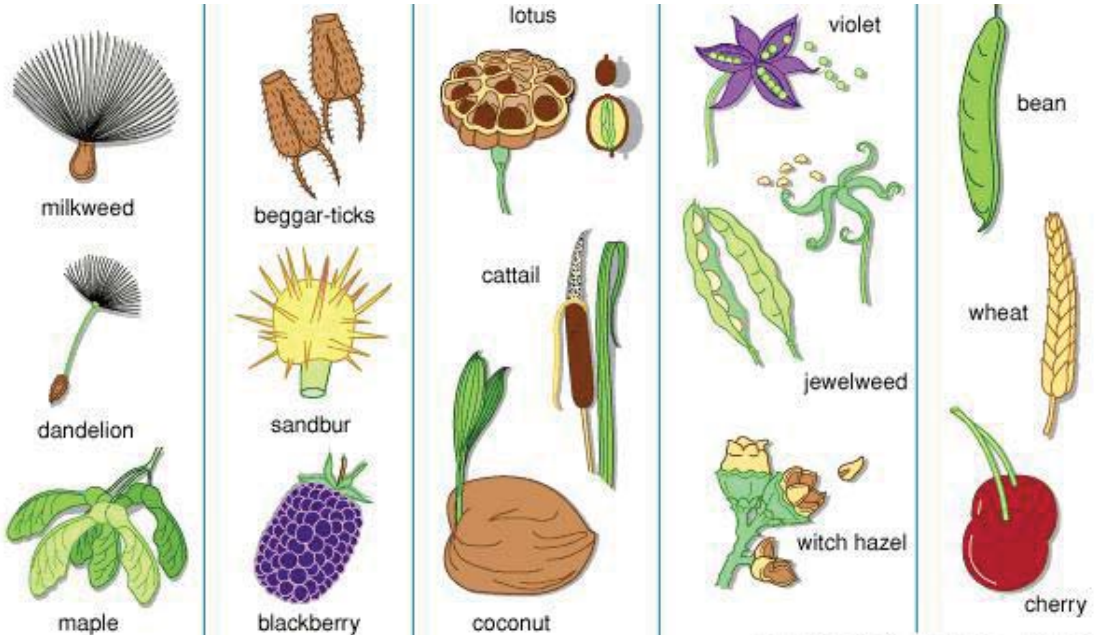


Fig: Different types of seed

Plant species identification techniques

Identification is a basic activity and one of the primary objectives of systematics. Although identification is a separate activity or process, in practice it involves both classification and nomenclature. Identification is simply the determination of the similarities or differences between two elements, i.e., two elements are the same or they are different. The comparison of an unknown plant with a named specimen and the determination that the two elements are the same also involves classification, i.e., when one correctly decides that an unknown belongs to the same group (species, genus, family., etc.) as a known specimen, the information stored in classification systems becomes available and applicable to the material at hand. Both processes-identification and classification-involve comparison and judgment and require a definition of criteria of similarities. Identification is, therefore, a basic process in classification with nomenclature playing an essential role in the retrieval of information and as a means of communication. In practice one commonly identifies a plant by direct comparison or the use of keys and arrives at a name.

TRADITIONAL IDENTIFICATION METHODS

The methods of identification include (1) expert determination, (2) recognition, (3) comparison, and (4) the use of keys and similar devices.

Expert determination: In terms of reliability or accuracy the best method of identification is expert determination. In general the expert will have prepared treatments (monographs, revisions, synopses) of the group in question, and it is probable that the more recent floras or manuals include the expert's concepts of taxa. Although of great reliability, this method presents problems by requiring the valuable time of experts and creating delays for identification. This is based on extensive, past experience of the identifier with the plant group in question though in some groups this is virtually impossible.

Comparison: This method involves comparison of an unknown with named specimens, photographs, illustrations or descriptions. Even though this is a reliable method, it may be very time consuming or virtually impossible-due to the lack of suitable materials for comparison. The reliability is, of course, dependent on the accuracy and authenticity of the specimens, illustrations, or descriptions used in the comparison.

Use of keys and similar devices: The use of keys or similar devices (synopses, outlines, etc.) is by far the most widely used method and does not require the time, materials, or experience involved in comparison and recognition. Keys in the traditional sense are a type of taxonomic literature. Keys are devices consisting of a series of contrasting or contradictory statements or propositions requiring the identifier to make comparisons and decisions based on statements in the key as related to the material to be identified. The first modern type keys dichotomous) clearly designed for identification were those of Lamarck in his Flore Francaise in 1778.

The following lists of suggestions are for the use of traditional dichotomous keys.

1. Select appropriate keys for the materials to be identified. The keys may be in a flora, manual, guide' handbook, monograph, or revision. If the locality of an unknown plant is known, select a flora, guide, or manual treating the plants of that geographic area. If the family or genus is

recognized, one may choose to use a monograph or revision. If locality is unknown, select a general work.

2. Read the introductory comments on format details, abbreviations, etc. before using the key.
3. Read both leads of a couplet before making a choice. Even though the first lead may seem to describe the unknown material, the second lead may be even more appropriate.
4. Use a glossary to check the meaning of terms you do not understand.
5. Measure several similar structures when measurements are used in the key, e.g. measure several leaves not a single leaf. Do not base your decisions on a single observation. It is often desirable to examine several specimens.
6. Try both choices when dichotomies are not clear or when information is insufficient, and make a decision as to which of the two answers best fits the descriptions.
7. Verify your results by reading a description, comparing the specimen with an illustration or an authentically named herbarium specimen.

Types of Key: Keys used in floras are usually diagnostic, that is , identifying an unknown plant by the conspicuous features. Diagnostic characters are sometimes referred to as key characters. A key may be short and limited to a single pair of contradictory statements or propositions. A single pair of contradictory statements or each pair of choices is called a couplet. Each statement of a couplet in a key is called Lead.

Keys are two types one is Punched card keys and other is dichotomous keys.

Punched cards keys: Punched card keys consist of cards of suitable size with names of all the taxa(all families, genera or species for which the key is meant) printed on each one of them. Each card has a number and any one characters printed near one of the corners. All the taxa showing this character are indicated by a performation in front of their names, while those lacking this characters are without any perforation.This type keys are used in the School, colleges etc. by the students.

Dichotomous keys: These keys consist of pairs contrasting characters or couplets, each statement of which is a lead. Both the leads are numbered, and begin with the same word as far as possible. Dichotomous keys are of two types: (i) Indented key and (ii) Bracked key.

An indented key: In the indented key, each of the couples is indented a fixed distance from the left margin of the page. The indented key is the one most widely used in manuals for the identification of vascular plants. An example of the indented keys is given below in the form of identification:

Leaf simple	
Parts of the flower not alter in fruit	
Carpels 5, rarely 4 or 6, but only one fertile; stamens 8-10	**Buchanania**
Carpels solitary; stamens 1 only	**Mangifera**
Parts of the flower alter in fruit	
Petal accrescent	**Swintonia**
Petal not accrescent	
Ovary inferior, drupe sunk in the fleshy calyx	**Drimycarpus**
Ovary superior; drupe set on a much enlarged apex of peduncle	**Semecarpus**
Leaf pinnately compound	
Drupe 1-celled, 1 seeded; ovules not pendulous	
Tree; styles 3	**Lannea**

Climber; style 1	**Pegia**
Drupe 2-5 celled, 2-5 seeded; ovule pendulous	**Spondias**

Bracked key or Parallel Key: In the bracket keys or parallel key, the two couple is always next to each other in consecutive lines on the page. At the end of each line in the key, there is either a number or a name refering to a couplet. An example of the bracket key is given below:

1.	Nest leaves present	**Drynaria**
+	Nest leaves absent	**2**
2.	Fronds simple	**3**
+	Fronds pinnate or pinnately lobed	**Microsorium**
3.	Fronds covered with stellate hairs when young	**4**
+	Fronds not having stellate hairs	**5**
4.	Frond dimorphic; sori continuous along the margin of linear fertile frond	**Drymoglossum**
+	Fronds monomorphic or dimorphic; sori round and distinct, or more or less continuous on linear monomorphic fronds	**Pyrrosia**
5.	Fornds dimorphic, sporangia acrostichoid	**Leptochilus**
+	Fronds monomorphic, sporangia never acrostichiod	**Colysis**

RECENT AND NEW IDENTIFICATION METHODS

POLYCLAVES: Polyclaves of various kinds allow one to select the characteristics for use in identifying each specimen, taking his choices from some character set and repeating an elimination process until a tentative identification is made. A printed data table, chart, or matrix giving the status of various taxa for useful characteristics is readily used as a polyclave by listing the possible taxa on scratch paper and crossing out those which do not agree with the specimen's characters. Polyclaves are readily mechanized, as shown by the familiar edge-punched cards and the less familiar window keys, as well as various mechanical devices.

Automatic plant species identification techniques: Automatic species identification has many advantages over traditional species identification. Currently, most plant automatic identification methods focus on the features of leaf shape, venation and texture, which are promising for the identification of some plant species.

(a) DNA barcodes: Methods for identifying species by using short orthologous DNA sequences, known as “DNA barcodes,” have been initiated to facilitate biodiversity studies, identify juveniles, associate sexes, and enhance forensic analyses. The nuclear internal transcribed spacer region and the plastid *trnH-psbA* intergenic spacer as potentially usable DNA regions for applying barcoding to flowering plants.

(b) Computer-aided identification techniques: Computer can efficiently match leaf shape for identification of plant species.

(c) Leafsnap: It is a mobile app for identifying plant species using automatic visual recognition. The system called Leafsnap, identifies plant species from photographs of their leaves. Key to this system are computer vision components for discarding non-leaf images, segmenting the leaf from an

untextured background, extracting features representing the curvature of the leaf's contour over multiple scales, and identifying the species from a dataset.

Botanical Glossary

Accession Number: The number applied to each lot of specimens received by the herbarium or the sheet number assigned to a specific specimen.
Accessioning: Recording the receipt and origin of lots of specimens coming into the herbarium
Adnate: Attached fully to petiole as wings.
Alternate: Bearing one leaf at each node.
Actinomorphic: Flowers with radial symmetry; or flowers which can be bisected into similar haves along two or more planes.
Amorphic: Flowers without symmetry.
Androecium: All stamens of a flower.
Acecular: Needle shaped.
Auriculate: Ear shaped.
Androgynophore stripe: Bearing both androphore and gynophore together.
Aestivation: The way in which sepals and petals are arranged in the bud condition.
Annotation: A note written on or attached to a herbarium sheet indicating a correction or change in identification or a point or points of interest about the specimen; any note attached to a specimen.
Annotation labels: A small slip of paper on which an annotation may be written and then glued to a herbarium sheet (see also determinavit and approbavit slips).
Anther: Pollen-bearing portion of stamen.
Approbavit slip or label: A special annotation label, indicating that the name on the label is correct.
Arrangement (of specimens in the herbarium): The system of classification or scheme followed in the placement of specimens in the herbarium; e.g., Bentham and Hooker, Engler, Cronquist, Alphabetical, etc.
Archer method: Affixing specimens to mounting sheets by means of small strips of liquid plastic extruded from a container with a narrow nozzle.
Board (of plant press): One of the two stiff sheets of wallboard, cardboard or wood between which the blotters or ventilators, and the folders of plants are laid and which are tied together to form a press.
Bisexual or hermaphrodite: Flowers having both the sex organs.
Bract: Modified leaf which develops in the axil of the flower.
Bracteate: With bract.
Bracteolate: With bracteole.
Bracteole : Small leaf borne on pedicel of flowers.
Bilabiate: Consisting of two lips.
Carpological Collection: Separate collection of fruits and seeds.
Case: The cabinet in which herbarium specimens are stored.
Capitate: Like a cap or head.
Clavate: Club-shaped.
Crested: Possessing a terminal tuft or ridge.
Catkin: A spike-like, deciduous, elogate, inflorescence, with scaly bracts, and unisexual, apetalous and sessile flowers.
Cincinnus: A modified helicoid cyme having the short pedicels on the developed side.
Compound Corymb: A branched corymb having pedicellate flowers.
Compound Cyme: A branched cyme having pedicellate flowers.
Compound Umbel: A branched umbel having primary rays srising at a common point with a secondary umbel arising from the tip of the primary rays.
Corymb: A raceme whose lower stalks are longer than the upper ones, so the inflorescence has a flat top.

Cyathium: A cup-shaped involucre containing nectar-secreting glads, a centrally-placed large female flower, and many male flowers.

Collecting: The gathering of specimens in the field.

Collection: The accumulation of specimens in a herbarium; the specimens collected on a single expedition; a single gathering of a particular species at a given time and place; a specimen plus its replicates (many would prefer the term "duplicate" rather than "replicate.").

Collection number: The number assigned to a collection in the field, when it is collected or when the notes are written up, the same for all of its replicates; it is associated with the specimens and identifies them from then on, and refers to the data recorded in the collector's notebook. (This is often also called the collector's number and should not be confused with the sheet number which is assigned to a particular specimen in the herbarium).

Compound leaf: A leaf, in which the leaf blade or lamina remains divided into smaller, bladelike parts or leaflets is callled a compound leaf. A compound leaf may be palmately compound or pinnately compound.

Corrugate: A sheet of pasteboard or thin metal with fluted ducts extending across the sheet (not lengthwise) used in presses when drying plants by means of artificial heat; these are often called ventilators.

Carpel: A unit of gynoecium; or floral organ that bears ovules.

Cordate: Heart shaped.

Complete florwers: having all the four floral whorls, i.e. sepals, petals, androecium and gynoecium.

Corolla: Whorl of petals

Cymose: In this type the growth of the main axis is checked soon by the development of a flower at the apex, and the lateral axis below the terminal flower also ends in a fower, and thus its growth is also checked. In cymose inflorescence, the terminal flower is the oldest and the young flowers are present on the lower side. Helicoid, circinnus, rhipidium, dichasium and polychasium are some of the examples of cymose.

Ciliate: Margin bearing hair.

Crenate: With blunt, low rouded teeth.

Crenulate: Finely crenate.

Crispate: Curled and extremely undulate

Determination: Ascertaining the correct name for a specimen; identification.

Determinavit slip: A type of annotation bearing the name of the plant and the name of the person who identified the plant; date of identification should also be included.

Distribution: A confusing term used to refer to filing of specimens as well as the sending out of duplicates on exchange, loan, etc.

Dichasium or simple cyme: Determinate, dichotomous inflorescence of pedicellate flowers having pedicles of equal length.

Documentation: The deposition of or reference to voucher specimens in an herbarium.

Dryer or plant dryer: An apparatus for drying plant specimens by artificial heat; term used for a sheet of blotting paper used in drying plants.

Dummy sheet: A blank herbarium sheet or manilla paper of the same size as a herbarium sheet or genus cover inserted in the herbarium for cross reference purposes.

Duplicate: One of two or more specimens collected at the same time and place, under the same collection number, to represent a particular species; more appropriately called a replicate if the collection contained more than two sheets; an extra sheet of a collection.

Decurrent: Long and extending downward.

Diffuse: Spread over a wide surface.

Discoid: Like a disc.

Dimerous, Trimerous, Tetramerous and Pentamerous: Flowers in which various floral parts are arranged in groups of two, three, four and five, are called dimerous, trimerous, tetramerous and pentamerous, respectively.

Dissected: Cut or deeply divided into many segments. Dentate with sharp, marginal teeth pointing outward.

Envelope: Another name for packet, or pocket, a piece of paper folded and affixed to a specimen to contain fragments.

Entire: With a continuous smooth margin; lacking any teeth, lobes or indentations.

Exchange: The process of distributing duplicated (replicates) or other materials to other institutions in return for their duplicates, etc.

Ebracteate: Without bracts

Epicalyx: Leaves resembling sepals below the true calyx.

Epigynous: Flowers with inferior ovary; or those having the floral parts situated above the ovary.

Ellipitical: Oval in outline, being narrowed to form rounded ends and widest at the middle.

Hastate: Like an arrowhead.

Felt driers: Sheets of heavy blotting paper or builder's "deadening felt," cut 12 x 17 inches, used to absorb moisture in a press, with or without corrugated metal ventilators; also for tying piles of plants in folders to make light packages.

Felt: Felt is good for speeding up drying of damp specimens and foam is useful for bulky branches or stems is good for speeding up drying of damp specimens and foam is useful for bulky branches or stems.

Fide: Ablative sungular of fides, 'according to or by assurance of' a term used to refer to another author; *e.g.*, *Neptunia pubescens* Bentham fide Windler, 1966.

Field book: A notebook used to record data in the field at the time of collection or a book containing data collected in the field. Each collection usually is assigned a number which refers to notes in the field book.

Field label: A special label for recording data in the field.

Field notes: Information recorded about collection or specimen in the field and usually includes locality, habitat, description, as well as those features of the plant not discernible from the dry specimen; e.g., height, if entire plant is not collected; bark and branching characteristics, if a tree or shrub; flower color; odor; etc.

Field press or portfolio: A light plant press carried in the field when collecting, into which the specimens may be placed as they are gathered.

Filing: The insertion of mounted specimens, dummy sheets, and other materials into the herbarium cases.

Flimsies: Folds of thin absorbent paper into which plant specimens are collected and in which they may be dried and stored.

Fragment: A part of a plant; any detached portion of a specimen, also used to refer to an incomplete or poor specimen; e.g., a sterile twig with a few leaves; extra materials collected for dissection and placed in the packet or envelope on a mounted specimen.

Fumigant: A volatile substance used to kill insect pests in the herbarium.

Fumigation: The process of killing or getting rid of insect pests by subjecting them to a lethal concentration of a volatile poisonous chemical.

Filament: Stalk of the stamen.

General herbarium Synonymous with general collection; all materials excluding special collections.

Genus cover: A heavy manilla folder slightly larger than an herbarium sheet in which specimens belonging to one genus are filed; often in various colors indicating geographic regions.

Glomerule: An indeterminate inflorescence having dense cluster of sessile or subsessile flowers

Glue: An adhesive used to affix specimens to the herbarium paper; see also white glue.

Gluing: Fastening specimens to mounting sheets by means of glue or other adhesive.

Herbarium: A collection of dried plants; an institution built around a collection of dried plants.

Herbarium abbreviation: The abbreviation assigned an herbarium in Index Herbariorum.

Herbarium number: The sheet number on a specimen.

Hastate: Like an arrowhead.

Head or capitulum: A dense cluster of several sessile or subsessile flowers on a compound receptacle or torus.

Helicoid cyme: Curved and unbranched inflorescence of pedicellate flowers having the branches only on one side.

Hypanthodium: An inflorescence having sessile flowers on the wall of a concave capitulum opening by a small ostiole. Male flowers are situated near the periphery and female flowers in the centre, e.g. Ficus.

Incised: Provided with sharp and irregular incisions.

Iconography: Books with drawings (black and white or color) of plants of the certain region, arranged according to their systematic affiliation, can also be used..

Imbricate aestivation*:* Out of the five sepals or perals, one external, one intemal, and other three are partly cxternal and partly internal

Index herbariorum: A series of indices to herbaria and collectors published in Regnum Vegetabile by the International Association for Plant Taxonomy, Utrecht.

Lineate: In the form of small lines.

Lobed: Divided into some lobes.

Lanceolate: Much longer than broad; or lance-shaped; or widening above the base and tapering towards the tip.

Linear: Long, flat, and narrow with almost parallel sides.

Lorate: Strap-0shaped, or like a narrow trip of leather.

Lyrate: Like a lyre, i.e. having a big terminal lobe and several smaller lateral lobes.

Lobed: Provided with many lobes extending one third to one-half the sistance between the midrib and the margin.

Petiolate: Leaf with a distinct stalk or petiole.

Petiolulate: Leaflets with a stalk.

Manilia or manila: A coarse, unbleached paper of which folders are made.

Mass collection: A population sample, composed of a number large enough to be statistically significant, of critically selected corresponding plant fragments collected at a particular time and place, to show the range of variation in selected characteristics of the population sampled.

Merrill case: A cardboard container 48 cm. long, 34.5 cm. wide and 24 cm. high (outside dimensions) with a door on one end. Used as temporary storage for filing of specimens; developed by E. D. Merrill; not dust or insect proof.

Microfiche: Greatly reduced transparent positive photographs of printed material or herbarium specimens designed for ready filing and for reading with a special magnifying projector (reader) or with a binocular microscope.

Mounting: The process of affixing dried and pressed specimens of plants to herbarium sheets of heavy paper.

Newsprint: The paper on which newspapers are printed and often used for pressing plants; also called specimen paper.

Numbering: The process of stamping or printing sheet numbers (accession numbers) on mounting paper or herbarium specimens.

Pack frame: A light wooden frame with a shoulder strap for back-packing.

Mounting Paper: The heavy herbarium paper to which specimens are affixed.

Packet: An envelope folded and mounted on a herbarium sheet to contain extra materials and fragments.

Palmately compound leaf: If the leaflets diverge from a common opint at the end of the petiole, in the same way as the fingers from the palm of the hand, the leaf is called pamately compound. Insuch leaves, if a single leaflet is articulated to the petiole, it is called undifoliate; if two, three or four leaflets are articulated to the petile, it is called bifoliate, trifoliate or quadrifoliate, respectively; and if five or more leaflets are ariticulated to the petiole, it is called multifoliate.

Panicle: With pedicellate flowers arranged in the form of number of racemes.

Obcordate:Inversely cordate.

Oblanceolate: Broad at the middle and tapering towards both the ends.

Oblique: When two havlves of the lamina are unequal.

Oblong: Long, wide, with the parallel margins.

Obovate: Upper terminal half broader than the lower basal half; opposite to ovate.

Opposite: Bearing leaves paired at each node on opposite sides.

Opposite decussate: When two successive opposite pairs of leaves occur at right angle in each other.

Opposite superposed: When all the successive opposite pairs of leaves occur at the plane

Paper folder: A smooth strip of bone (wood), rounded at all corners, used in creasing paper,pressing down glued paper, etc.

Para-dichlorobenzene (PDB): An insecticide or repellent commonly used in herbaria.

Parallel: When the veins run parallel to each other in the lamina of the leaf, the venation is called parallel, e.g. monocots. In this type of venatio, if only one principal vein is present, it is called unicostate, and if several principal veins are present, it is called multicostate.

Perianth: A collective term used together for calyx and corolla when there is no distinction between the two, as in monocotyledons

Petal: An individual unit of corolla.

Palmatifid: Cut about halfway down in a palmate form.

Parted: Dissected or cut almost to the midrib.

Pigeon-hole: Compartment in a herbarium case in which the folders of specimens are inserted.

Pinnately compound leaf: If the leaflets are attached on both sides of one central rach….. the midrib, the leaf is called unipinnate. A unipinnate leaf having even number of pained leaflets is called paripinnate, while that which contains an odd terminal leaflet is called imparipinnate. Such a pinnately compound leaf, in which the midrib produces secondary axis, and on the latter are present the leaflets, is called bipinnate; if the midrib of pinnatly compound leaf produces secondary axis, and the latter produces the lertary axis which bears the leaflets, it is called tripinnate. If the leaf is more than thrice pinnate, it is called decompound.

Plant dryer: An apparatus for drying plant specimens by artificial heat (commonly consists of a frame to support the presses and an electric heater or series of light bulbs).

Plant press: An apparatus for flattening and drying plant specimens, usually consisting of two lightweight boards or frames and a pair of straps or sash cords.

Pocket: An envelope that is pasted to a herbarium sheet with the specimen to contain extra pieces or detached fragments of the specimen.

Pohl's softening agent: An excellent detergent solution for softening flowers and fruits for dissection.

Pedicel: the stalk of the flower.

Pedicellate: Flower with pedicel.

Peranth: When there is no differentiation of calyx and corolla.

Petynous Flowers with half-inferior ovary; or those having floral parts situated around the ovary.

Petal: Individual unit of corolla.

Portfolio or field press: A light plant press for carrying in the field while collecting, into which the specimens may be placed immediately as they are gathered.

Preparation: The process of getting specimens mounted and ready for insertion in the herbarium.

Press: An apparatus for flattening and drying plant specimens.

Protectant: See repellent.

Quire: A number of sheets of paper folded once, resulting in a number of folds one inside another

Quincuncial aestivarion: Out of the five sepals or petals, two external, two internal, and remaining one is partly external and partly internal.

Raceme: An indeterminate, unbranched inflorescence with a single axis and the flowers arranged along the main axis on pedicels.

Racemose: In this type, the main axis does not terminate into a flower, but it keeps on grwing continually and gives off flowers laterally in acropetal succession. Here the youngest flower is present at the apex and the older flowers towards the base. Ranceme, spike, spikelet, panicle, catkin, spadix, corymb, umberl and capitulum or head are some of the examples of racemose.

Reniform: Kidney-shaped.

Registration of specimens: The recording of each specimen to be inserted in the herbarium, a procedure now rarely followed.

Replicate: One of the specimens of a series or suite collected at the same time and place, under a single collection number, to represent a particular species, often called a duplicate; an extra sheet of a collection.

Reprint: A separate copy of a journal article, specially printed for private distribution.

Scheda, Schedule: A label; *in scheda* -- on an herbarium label; *ex confusione schedae* - from confusion of a label.

Reticulate: When the pattern of the veins in the lamina of the leaf is like a network, e.g. dicots

Sagittate: Like an arrowhead or triangular.

Secateurs (clippers): A small hand clippers for cutting tough or woody stems.

Set (of specimens): When a collection is made with more than one sheet (replicate) of each number, these are sorted into lots containing one sheet of each number, called sets.

Sessile: Without petiole.

Sewing: Reinforcing the attachment of herbarium specimens to mounting sheets by loops of thread around the stem and through the paper.

Sepal: Individual unit of calyx.

Sessile: Without stalk.

Stamen: Individual unit of androecium.

Sheet: A standard sheet of heavy paper 11 1/2 x 16 1/2 inches (29 x 41 cm.) or other standard size on which a dried plant specimen is mounted; often used colloquially to refer to the specimen that is or will be attached to a sheet.

Simple leaf: A leaf with the blade in a single part is called simple leaf. The single blade may, however, be variously divided.

s.n. (sine numero): Literally without a number, a designation for citing collection lacking a collection or collector's number; e.g., John J. Doe, s.n.

Sorting (of specimens): Arranging of specimens for insertion in the herbarium.

Special collection: Any material kept apart from the general collection; e.g., wood specimens, carpological collection.

Species cover: A light manilla folder in which specimens belonging to one species are filed within a genus cover.

Solitary axillary: Single-flowered; flower attached in the axis.

Solitary terminal: Single-flowered; flower attached at the apex, and not in the axis.

Spadix: A fleshy or thick, spikelike inflorescence with very small flowers usually enclosed in a spath.

Spike: Elongate, unbranched, indeterminate inflorescence with sessile flowers.

Spikelet: A small spike, the basic inflowrescence unit of Cyperaceae and Graineae.

Spathulate: Spoon-shaped

Stamen: Pollen bearing floral organ of angiosperms.

Specimen: A plant or fragment of a plant, taken and preserved to represent a species or other taxon or a population, or to serve as a voucher to document observations made on a plant or population of plants.

Spirit collection (liquid): Separate collection of plants or plant parts preserved in liquid preservatives.

Staff: Collective term to apply to all the employees of a herbarium.

Sterile specimen: A specimen lacking reproductive parts (flowers, fruits, sporangia).

Strapping: Affixing specimens to herbarium sheets by means of strips of gummed cloth, plastic, or glue.

Stripping: Colloquial term applied to strapping, particularly when plastic is used.

Stripping or Strapping plastic: A plastic used to affix specimens to herbarium sheets.

Tepal: Individual unit of perianth.

Tubular: Like a tube; cylindrical.

Type: See type specimen.

Type collection: A special or separate collection of type specimens (holotypes, isotypes); the type specimen (holotype) and its duplicates.

Type specimen: The specimen to which a name is permanently attached.

Twisted aestivation: When margins of each part are overlapped regularly, i. 3. one edge of the sepal or petal are overlapped by the preceding part.

Umbel: A inflorescence in which all the pedicels are of the same length and arise from the same point.

Umbellet: A secondary umbel in a compound umbel.

Verticillaster: Whorled dichasial cymes arranged at the nodes of an elongate axis, e.g. Labiatae.

Venation: The pattern of veins on the surface of a leaf.

Undetermined (undet.): Refers to unidentified materials in the herbarium; special genus covers may be so marked.

Vasculum: A collecting container or can, which is usually made of sheet metal; standard vascula are 18-24 inches long, 8 inches wide and 10 inches high and have a hinged door provided with a secure fastener on one side.

Ventilated press: A plant press so made that warm air may pass through it to hasten the drying process.

Ventilator: A 12 x 17 inch sheet of corrugated metal, preferably aluminum, or of corrugated cardboard, or of lattice bamboo splints, which are laid between blotters and folders of plants to facilitate the passage of air through the leaves.

Voucher: A specimen preserved to substantiate recorded observations, and to which reference may be made in the future to verify the identity of the plant on which studies were made.

V-shaped rest: A frame for holding genus covers and specimens when in use in the herbarium. Large ones on wheels are excellent for holding and moving specimens about the herbarium whe

Valvate: When the sepals or petals meet edge to edge withour overlapping each other.

Vexillary: Out of the five sepls the posterior one is the largest and covers the two lateral sepals or petals, the latter in turn overlap the two smallest and anterior sepals or petals. e. g. Papilonceae.

White glue: Gelatin base or synthetic liquid used to paste specimens to herbarium paper; e.g., Elmer's Glue, Wilhold, Fish Glue.

Webbing strap: A strap made of heavy cotton or linen fabric used on plant presses.

Wetting agent: A variety of solutions used to soften flowers, fruits etc. for dissection.

Whorled or verticillate: Bearing three or more leaves at each node.

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