Chapter IV Vegetative Organs of Seed Plants - the Leaf

I. Physiological Functions and Economic Utilization of the Leaf

(I) Physiological functions

1. Photosynthesis: A process in which green plants absorb optical energy and use CO_2 and water to synthesize organic matters and give out oxygen.
2. Transpiration: A process in which water passes the surface of a living plant from inside of the plant in a gaseous state and is vaporized into the atmosphere. It is one of the driving forces to water absorption of the root system, makes for the absorption and transport of minerals and reduces surface temperature of leaves.
3. Other effects: Absorption and reproduction, etc.

(II) Economic utilization: For edible, medical and other purposes.

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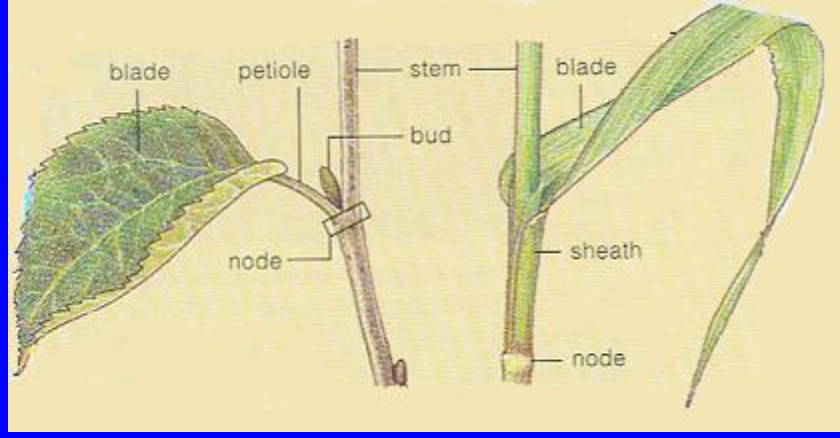

II. Morphology of the Leaf

(I) Composition of leaf

1. Composition

Blade: A green flat body, a major part of a leaf.

Petiole: A narrow and long part of leaf, connecting the blade and stem.

Stipule: Small leaf-like objects growing from the two sides of the petiole base.

2. Type

Complete leaf: A leaf with three parts: blade, petiole and stipule.

Incomplete leaf: A leaf with only one or two parts.

Leaf without stipule:

Leaf without petiole: A leaf without stipule and petiole.

Phyllodium: Without blade, petiole is extended into a shape of flat flake.

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Victoria regia

Raphia taedigera

Great difference in blade size

Musa basjoo

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Syzygium aromaticum

Lactuca sativa

Acacia confusa

(II) Morphology of blade

1. In terms of blade shape

Acicular: The blade is narrow and long, with a sharp apex, such as pine and spruce.

Linear: The blade is narrow and long, with a roughly equal width and nearly parallel leaf margins on the two sides, such as *Oryza sativa*, *Triticum aestivum* and *Allium tuberosum*.

Lanceolate: It is wider than linear blade and gets narrower from the lower part to the apex, such as *Prunus persica* and *Salix babylonica*.

Elliptic: The middle is wide and the two ends are narrow and the leaf margins on the two sides are arc, such as *Cinnamomum camphora*.

Ovate: The lower part is round and wide and the upper part is slightly narrow, such as *Helianthus annuus*.

Rhomboidal: The blade is in a shape of equilateral rhombus, such as *Fagopyrum esculentum* and *Sapium sebiferum*.

Cordate: The lower part is wider than that of an ovate blade, the base is recessed into a pointed shape, such as *Cercis chinensis*

Reniform: The base is recessed into a obtuse shape, the apex is obtuse and round, and laterally wider, such as *Malva crispa*

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Oryza sativa

Narcissus tazetta var. *chinensis*

Triticum aestivum

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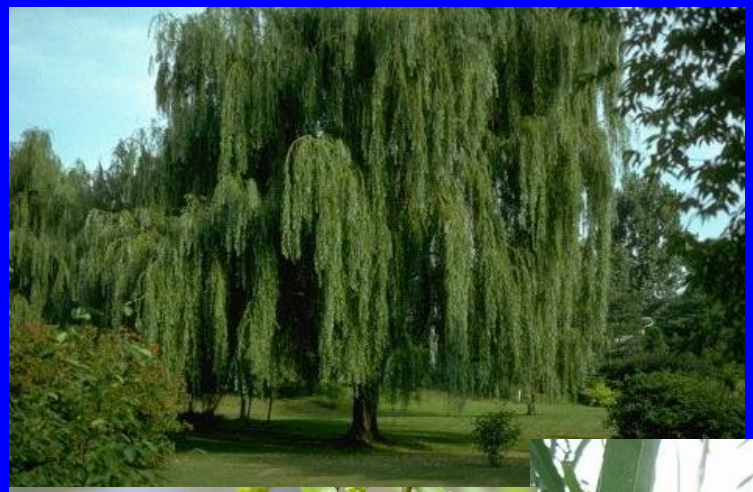
Salix babylonica



Prunus persica

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Daphne genkwa

Cinnamomum camphora

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Helianthus annuus

Boehmeria nivea

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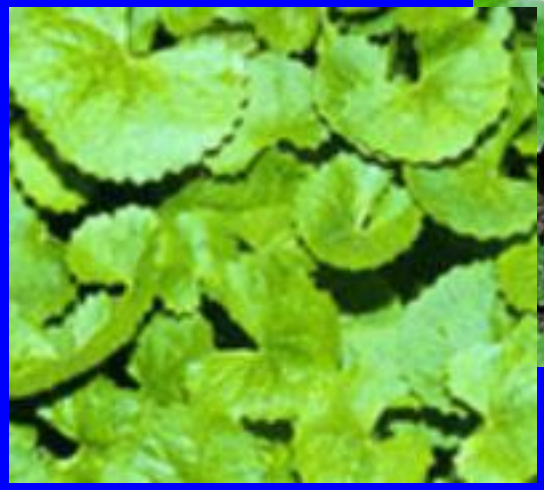
Trapa japonica

Cercis chinensis

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Malva crispa



Centella asiatica

Chapter IV Vegetative Organs of Seed Plants - the Leaf

The shape of a blade is decided mainly based on length/width ratio and the position of the widest point:

- Round: 1:1
- Wide oval : 1.5:1
- Long oval: 3:1
- Linear: 10:1
- Ribbon or sword shaped: 6:1

Peltate leaf: The petiole is at the center or within the margins on the back of the blade, regardless of leaf shape, such as *Nelumbo nucifera* and *Ricinus communis*

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Polygonum perfoliatum

Round

Triangular

Nelumbo nucifera

Sword shaped

Iris tectorum

Sectoral

Gingkgo gingko

2. In terms of leaf apex

Acuminate: Long or gradually sharp, such as *Ficus religiosa*.

Acute: Short and sharp, such as *Fagopyrum esculentum*.

Obtuse: obtuse, nearly round, such as *mangnolia officinalis*.

Truncate: Flat side shape if cut transversely, such as *Vicia faba* and *Liriodendron Chinense*.

Mucronate: Have conules that put forth suddenly, such as *Caragana arborescens*.

Cuspidate: Pointed and hard, such as *Polygonum cuspidatum*.

Emarginate: Have shallow recess, such as *Amaranthus tricolor* and *Medicago sativa*.

Obcordate : Have deep tapered recess and slightly contracted two leaf edges, such as *Oxalis corniculata* is.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Ficus religiosa

Fagopyrum esculentum

Magnolia officinalis

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Liriodendron chinense

Caragana arborescens

Vicia faba

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Polygonum cuspidatum

Medicago sativa

Oxalis corniculata

3. In terms of leaf base, there are mainly acuminate, acute, obtuse, cordate or truncate shape in addition to:

Auriculate: The lobes on the two sides of the leaf base are obtuse and round and droop like ears, such as *Solanum lyratum*.

Sagittate: The two lobes are sharp and point downward, such as *Sagittaria sagittifolia*.

Hastate: The two lobes point outwards to the two sides, such as *Spinacia oleracea*.

Spathulate: The leaf base gets narrower and longer downwardly, such as *Calendula Officinalis*.

Oblique: The two sides of the leaf base are asymmetric, such as *Begonia maculata*.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Sagittaria sagittifolia

Spinacia oleracea

Solanum lyratum

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Begonia maculata

Calendula officinalis

4. In terms of leaf margin

① Entire: The leaf margin is flat and regular, such as *Ligustrum lucidum* and *Cinnamomum camphora*.

② Undulate: Slightly uneven, and corrugated, such as *Elaeagnus angustifolia*.

③ Crisped: More wavy and zigzag than undulate shape, such as *Brassica oleracea*.

④ Tooth-like: Uneven, cracked into a finely toothed shape.

Serrate: The teeth are sharp, and tooth tips face leaf apex, such as *Eucommia ulmoides*;

Serrulate: The serration is fine and small, such as *Actinidia chinensis*;

Dentate: The tooth tips straightly face outwards, such as *Najas marina*;

Emarginate: The tooth margin is in the middle and the tooth base is round and obtuse;

Double serrate : Small serration on serration, such as *Primula sieboldii*;

Crenate : The teeth are not sharp but obtuse and round, such as ***Fagus grandifolia***

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Chapter IV Vegetative Organs of Seed Plants - the Leaf

Brassica oleracea

Elaeagnus angustifolia

Cinnamomum camphora

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Actinidia chinensis

Eucommia ulmoides

Primula sieboldii

Fagus grandifolia

Najas marina

Chapter IV Vegetative Organs of Seed Plants - the Leaf

⑤Incision: Blade margins are uneven, and the concav and convex dgrees are larger and deeper than dentate margins'.

- Pinnate incision: Lobes are arranged in a pinnate shape, such as *Taraxacum mongolicum*;
- Palmate incision: Lobes are arranged in a palmate shape, such as *Platanus*.

- Lobate: Very shallow, reaching ½ of the blade at most, such as *Firmiana platanifolia*.
- Parted: Deep, exceeding 1/2, such as *Capsella bursa-pastoris*.
- Divided: Very deep, as deep as to midrib or blade base, such as *Cycas revolute*.

Capsella bursa-pastoris

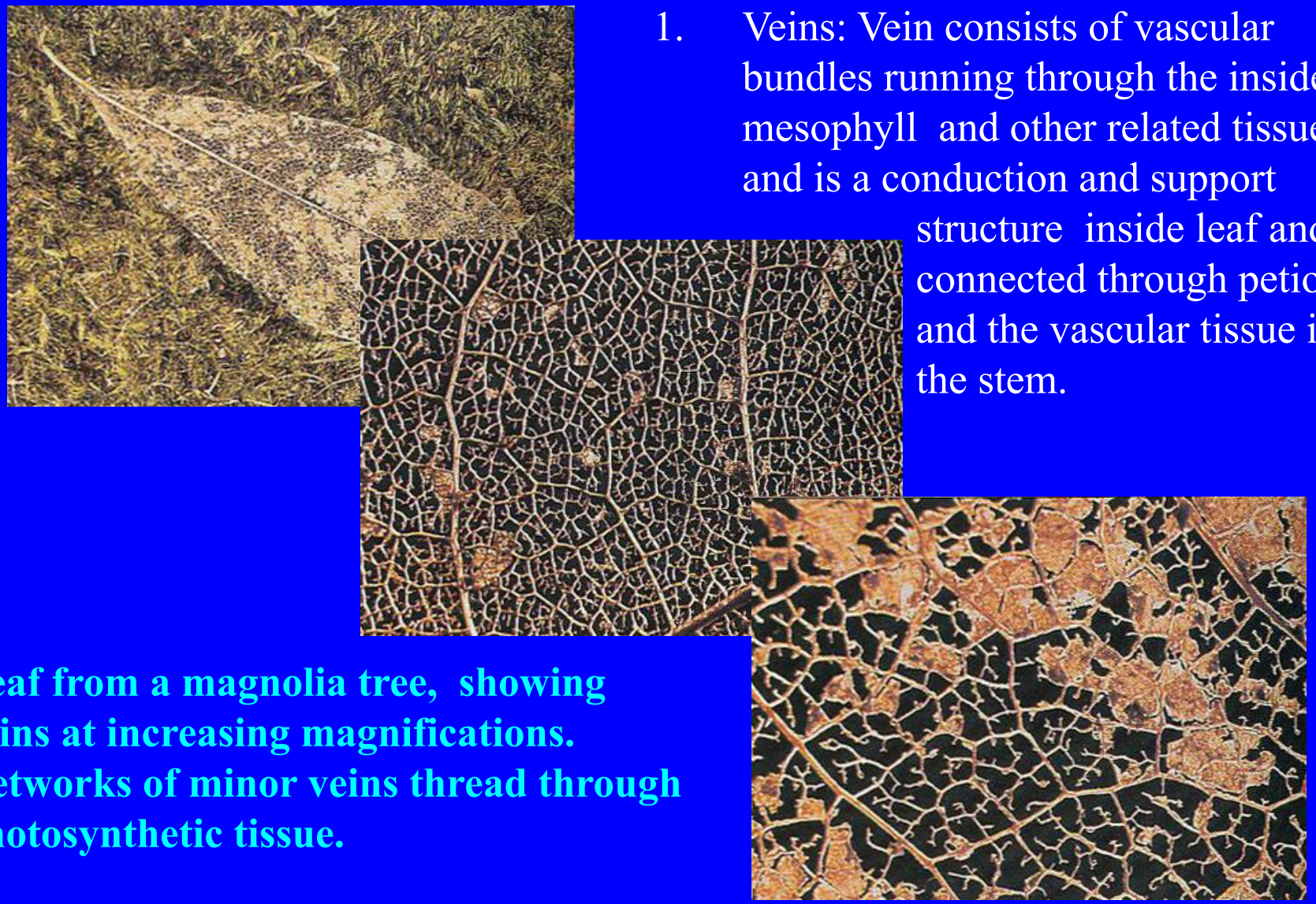
Cycas revoluta

Firmiana platanifolia

Chapter IV Vegetative Organs of Seed Plants - the Leaf

(III) Venation

1. Veins: Vein consists of vascular bundles running through the inside of mesophyll and other related tissues, and is a conduction and support structure inside leaf and connected through petiole and the vascular tissue in the stem.



Leaf from a magnolia tree, showing veins at increasing magnifications. Networks of minor veins thread through photosynthetic tissue.

2. Venation: Various regular vein distributions of veins on the blade.

3. Venation type

(1) Parallel venation: Veins are arranged in parallel.

- Straight parallel venation: Veins reach leaf apex from leaf base in parallel, such as *Oryza sativa* and *Triticum aestivum*;
- Lateral parallel venation: The central main vein is significant, and lateral veins are vertical to the main vein and parallel with each other and directly reach the leaf margins, such as *Canna indica* and *Musa basjoo*;
- Radiant parallel venation: Veins set out from the basal part in a radiant form, such as *Trachycarpus fortunei*;
- Arc parallel venation: Veins set out from the basal part in parallel, but they are gradually apart from each other, in a slightly arc shape, and eventually converge at the leaf apex, such as *Plantago asiatica*.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Oryza sativa

Trachycarpus fortunei

Musa basjoo

Plantago asiatica

(2) Reticulate venation: There is an obvious main vein, many lateral veins come out towards the two sides, and there are joint veins branched out among lateral veins to form a net.

Pinnate reticulate venation: There is an obvious main vein, many lateral veins come out from two sides, and joint veins come out among lateral veins for many times, such as *Ligustrum lucidum* *Prunus persica* and *Prunus salicina*.

Palmate reticulate venation: Multiple main veins come out from the leaf base and are branched out to form joint veins, such as *Helianthus annuus* and *Ricinus communis* .

(3) Dichotomous venation: Veins are branched out in a binary way, a relatively primitive type, such as: *Gingkgo gingko*.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Helianthus annuus

Gingkgo gingko

Eucommia ulmoides

Chapter IV Vegetative Organs of Seed Plants - the Leaf

(IV) Simple leaf and compound leaf

1. Simple leaf : One blade grows on a petiole.

2. Compound leaf: Many leaflets grow on one petiol. Primary petiole (rachis), leaflets and small petioles.

3. Types of compound leaves:

   (1) Pinnate compound leaf: Leaflets are arranged on the left and right sides of the rachis, similar to a feather shape, such as *Wisteria sinensis* and *rosa chinensis*.

   Imparipinnate leaf: The total number of leaflets on one compound leaf is odd, such as *rosa chinensis* and *Robinia pseudoacacia*.

   Paripinnate leaf : The total number of leaflets on one compound leaf is even, such as *Arachis hypogaea* and *Gleditsia sinensis* .

   By branching and branching condition of rachis, pinnate compound leaves are further classified into simple compound leaf, bipinnate leaf, tripinnate leaf and multiple pinnately compound leaf.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Arachis hypogaea

Wisteria sinensis

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Robinia pseudoacacia

Nandina domestica

Albizia julibrissin

(2) Palmate compound leaf : All leaflets are on the tip of rachis and arranged in a palm shape, such as *Aesculus chinensis*.

(3) Ternate compound leaf : On each rachis, three leaflets grow out.

- Ternate palmate leaf : Three small petioles are equally long, such as *Hevea brasiliensis*.
- Ternate pinnate compound leaf: The apical small petioles are long, such as *Medicago sativa*.

(4) Unifoliate compound leaf : Only one blade grows out on a rachis, such as citrus sinensis.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Hevea brasiliensis

Aesculus chinensis

Medicago sativa

4. Difference between simple leaf and compound leaf (how to differentiate rachis and twig?)

(1) There aren't apical buds on rachis apex, while twigs often have apical buds;

(2) The leaf axils of leaflets don't have axillary buds, and buds appear only inside the axils of rachis, while the leaf axils of twigs all have axillary buds;

(3) When a compound leaf falls, the leaflets fall at first and the rachis last, while on twigs, only leaves fall;

(4) The leaflets on the rachis are on a same plane of the rachis. The leaves on the twig form a specific angle with the twig.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

(V) Phyllotaxis and leaf mosaic

1. Phyllotaxis

(1) Concept: Leaves are arranged on a stem in a regular pattern.

(2) Types of phyllotaxis:

- Alternate: Only one leaf grows on each node. Leaves grow alternately, such as *Cinnamomum camphora*, *Platanus* and *Populus*.
- Opposite: Two leaves grow on each node and are arranged oppositely, such as *Mentha haplocalyx*, *Ligustrum lucidum* and *Dianthus caryophyllus*
- Whorled: Three or more leaves grow on each node and are arranged in a radiant way, such as *Nerium indicum* and *Lilium brownii*.

2. Leaf mosaic: Leaves on a same branch are arranged in a mosaic way without overlapping.

Chapter IV Vegetative Organs of Seed Plants - the Leaf

Galium aparine

Polygonum hydropiper

Dianthus caryophyllus

Boehmeria nivea

III. Development of the Leaf

1. Generation and differentiation of leaf primordium

(1) The generation of leaf primordium results from mitosis of superficial cells at specific locations of the growing points, or one or a few layers of cells under the surface layer.

(2) After formation of leaf primordium, at first the apex grows, and leaf primordium stretches out quickly and then margins grow, the overall rudiment of a leaf is formed and blade, petiole and stipule are divided. The subsequent growth relies on intercalary growth .

2. Division and differentiation of mesophyll cells

(1) After all layers of leaf primordium cells are formed, anticlinal division is conducted to enlarge leaf area and not increase thickness.

(2) During anticlinal extension and division of palisade tissue cells, the cells of spongy tissues also conduct clinical division, though less. The cells are almost isodiametric .

(3) During anticlinal and division of palisade tissue cells, adjacent epidermal cells stop division and are enlarged. A few palisade tissue cells are attached to one epidermal cell.

(4) Palisade tissue cells are mutually separated along anticlinal wall, resulting in formation of intercellular space. This phenomenon happens even earlier in spongy tissues.

(5) Spongy tissue cells are separated and locally grow. Branched or brachiate cells are developed.

3. Development and differentiation of vascular tissues

(1) The vascular tissues in leaves start from differentiation of the procambia at the future midrib, and are connected to the procambia of leaf trace on the stem.

(2) Lateral veins are germinated from the cells derived from marginal meristem. Larger lateral veins start earlier and are closer to marginal meristem.

(3) The lengthways differentiation of the midrib is from the basal part to the apex. Stage-1 lateral veins are developed from the midrib to margins.

(4) Smaller veins are developed among larger veins, usually near leaf apex at first, then continuously and gradually downwards.

Assignments

- What is simple leaf? What is compound leaf? How to differentiate them?