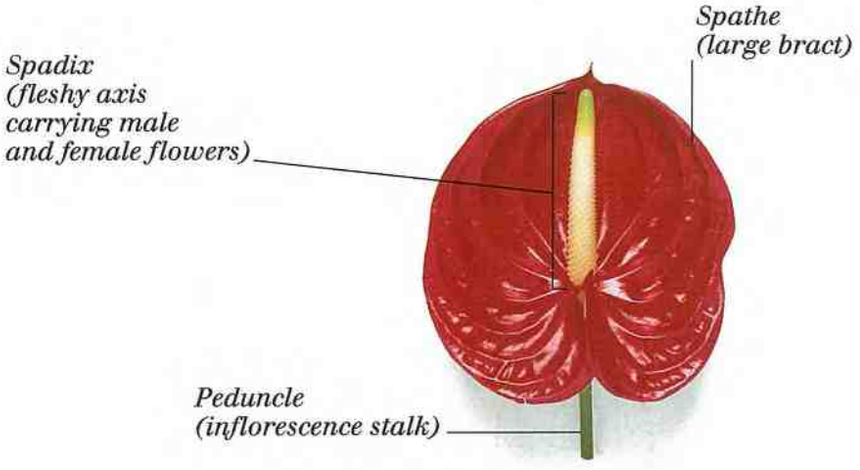
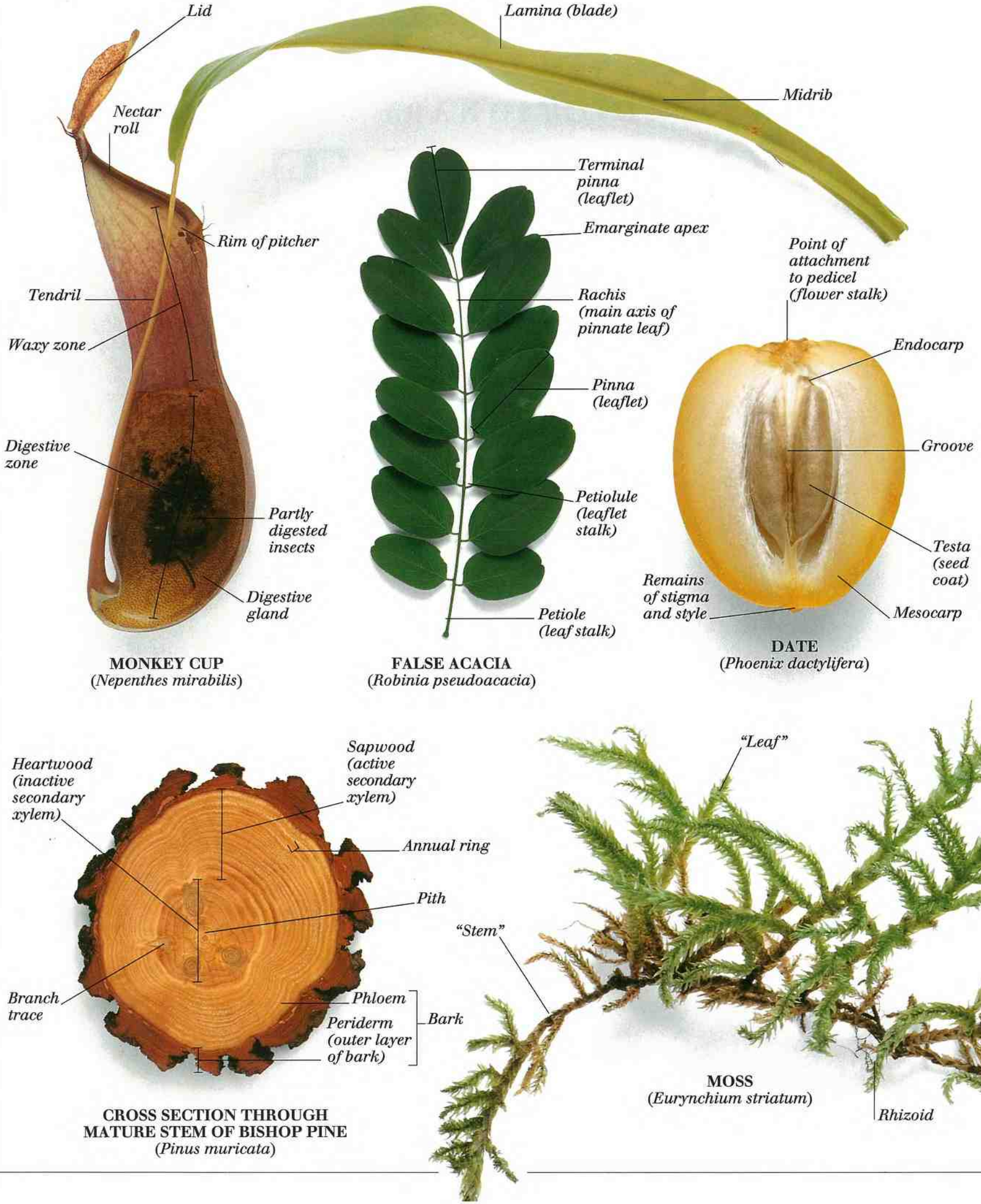
EYEWITNESS VISUAL DICTIONARIES

THE VISUAL DICTIONARY *of* PLANTS



PAINTER'S PALETTE
(*Anthurium andreanum*)



MONKEY CUP
(*Nepenthes mirabilis*)

FALSE ACACIA
(*Robinia pseudoacacia*)

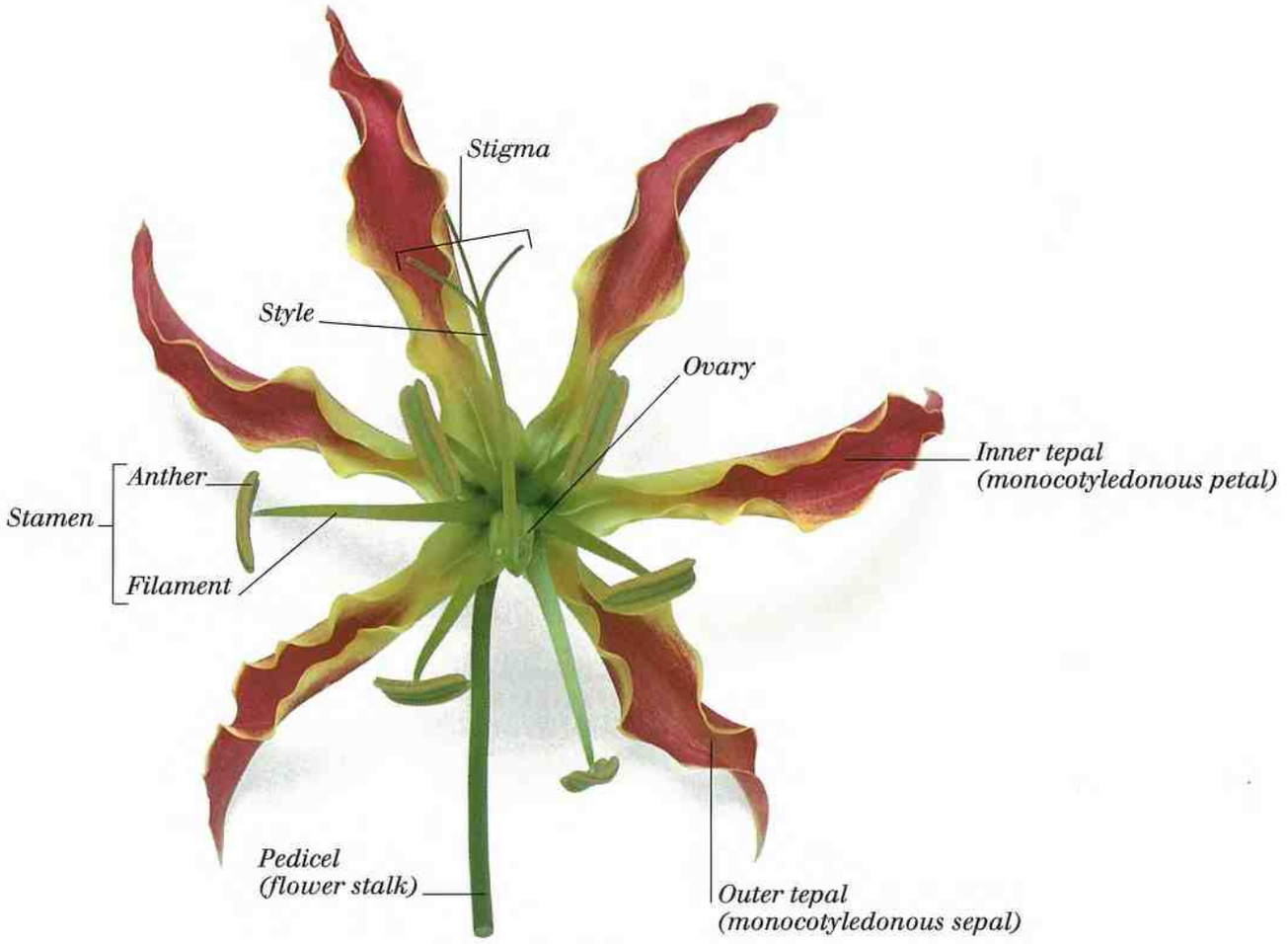
DATE
(*Phoenix dactylifera*)

CROSS SECTION THROUGH MATURE STEM OF BISHOP PINE
(*Pinus muricata*)

MOSS
(*Eurynchium striatum*)

EYEWITNESS VISUAL DICTIONARIES

THE VISUAL DICTIONARY *of* PLANTS



GLORY LILY
(*Gloriosa superba*)

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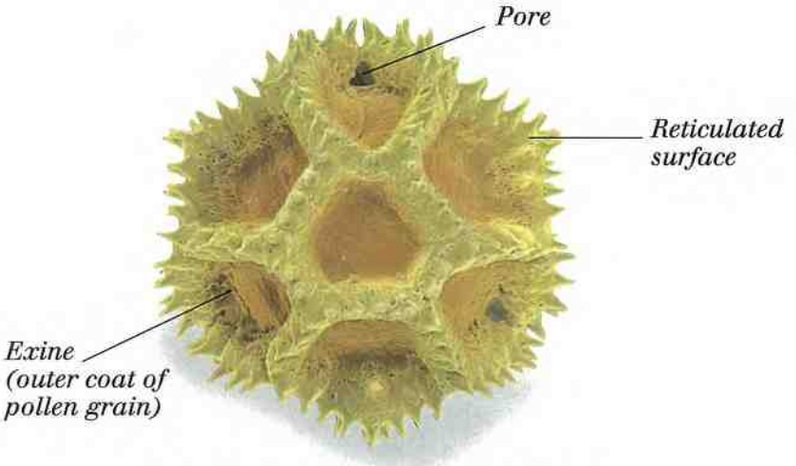

MICROGRAPH OF POLLEN GRAIN

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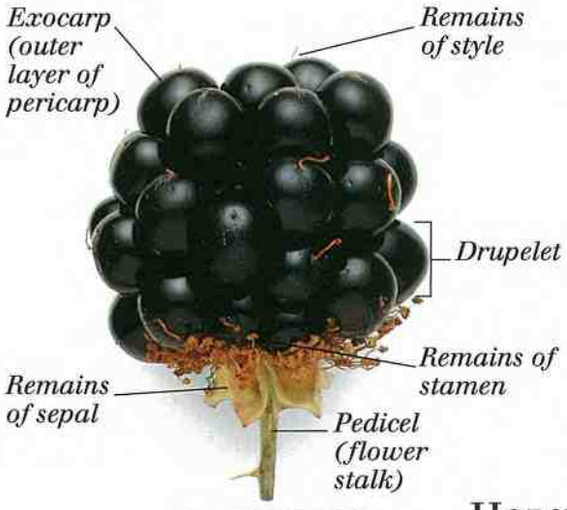
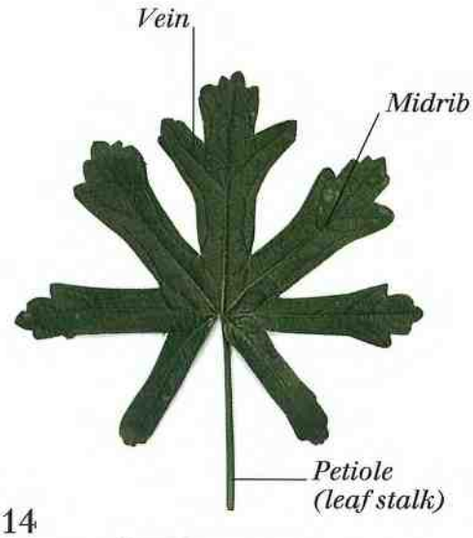


BLACKBERRY
(*Rubus fruticosus*)



CHECKERBLOOM
(*Sidalcea malviflora*)

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LIVERWORTS AND MOSSES 12

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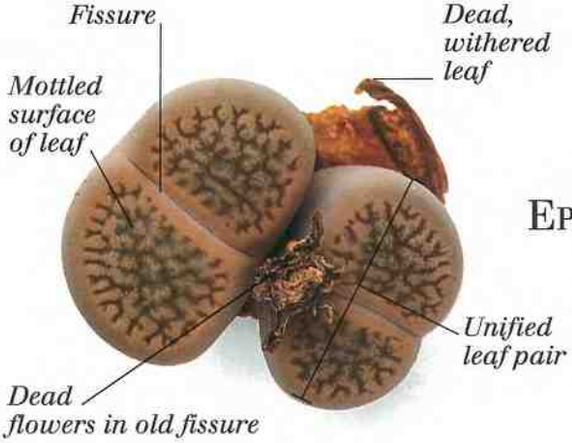
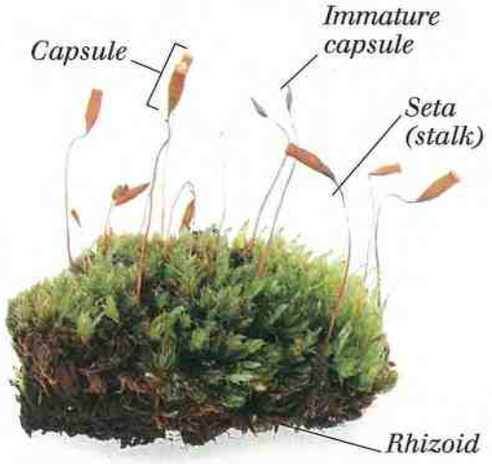
LICHEN
(*Hypogymnia physodes*)

BHUTAN PINE
(*Pinus wallichiana*)



LIVING STONE
(*Lithops bromfieldii*)



MOSS
(*Bryum Sp.*)

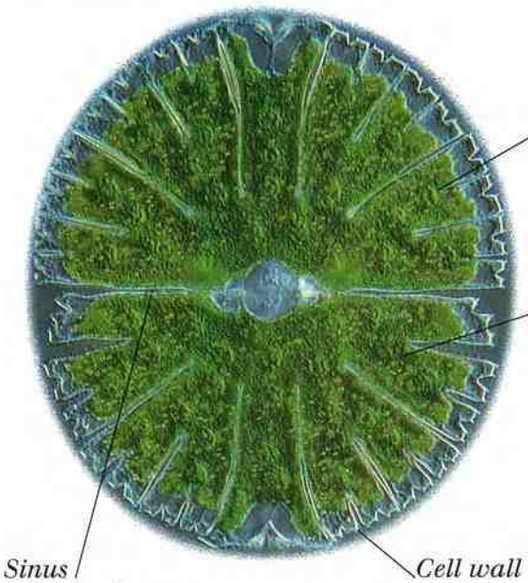
Plant varieties

THERE ARE MORE THAN 300,000 SPECIES of plants. They show a wide diversity of forms, ranging from delicate liverworts, adapted for life in a damp habitat, to cacti, capable of surviving in the desert. The plant kingdom includes herbaceous plants, such as corn, which completes its life cycle in one year, to the giant redwood tree, which can live for thousands of years. This diversity reflects the adaptations of plants to survive in a wide range of habitats. This is seen most clearly in the flowering plants (phylum Angiospermophyta), which are the most numerous, with over 250,000 species. They are also the most widespread, being found from the tropics to the arctic. Despite their diversity, plants share certain characteristics. Typically, plants are green, and make their food by photosynthesis. Most plants live in or on a substrate, such as soil, and do not actively move. Algae (kingdom Protista) and fungi (kingdom Fungi) have some plantlike characteristics and are often studied alongside plants, although they are not true plants.

FLOWERING PLANT
Bromeliad
(*Acanthostachys strobilacea*)

Leaf

GREEN ALGA
Micrograph of desmid
(*Micrasterias sp.*)



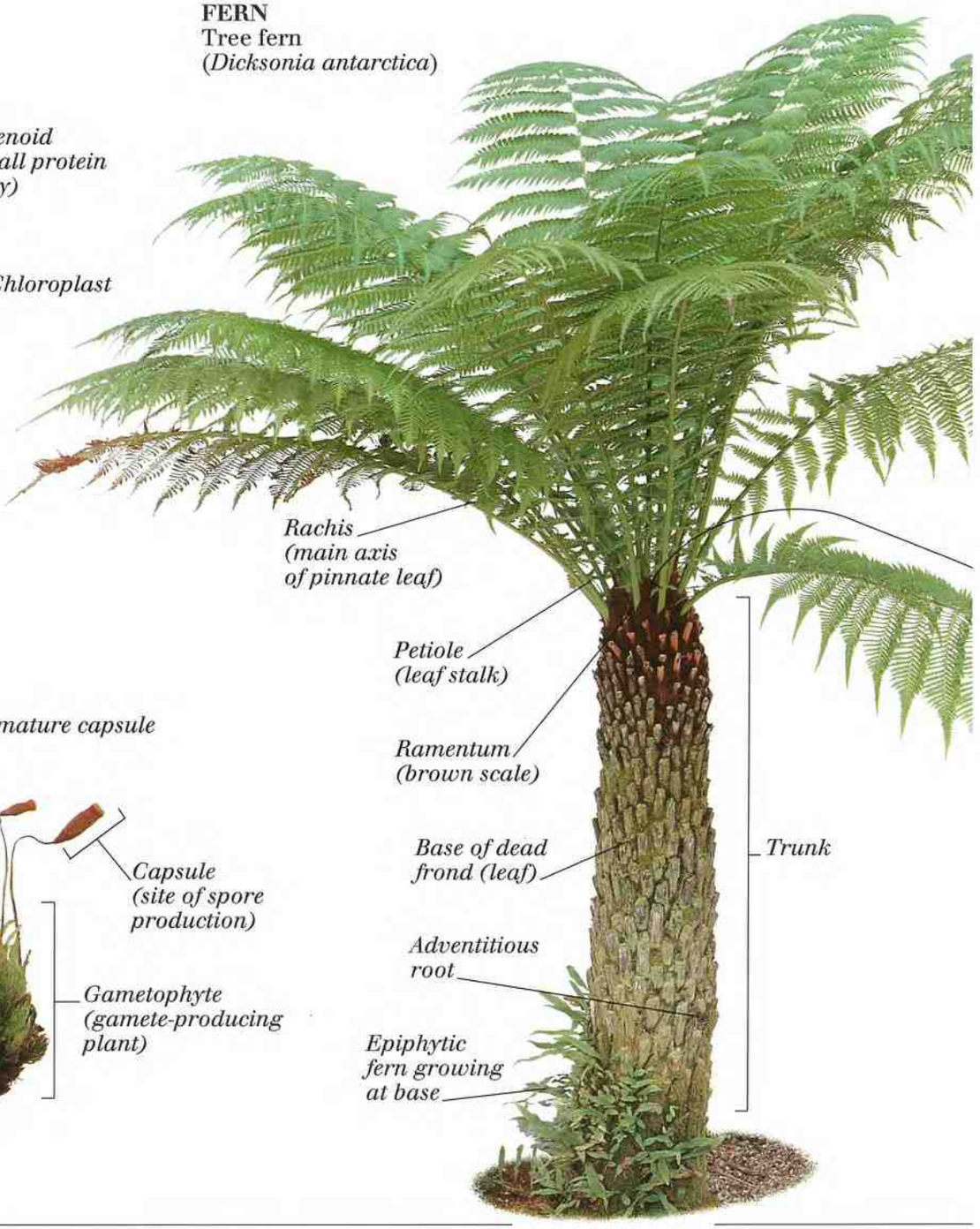
Pyrenoid (small protein body)

Chloroplast

Sinus (division between two halves of cell)

Cell wall

FERN
Tree fern
(*Dicksonia antarctica*)



Rachis (main axis of pinnate leaf)

Petiole (leaf stalk)

Ramentum (brown scale)

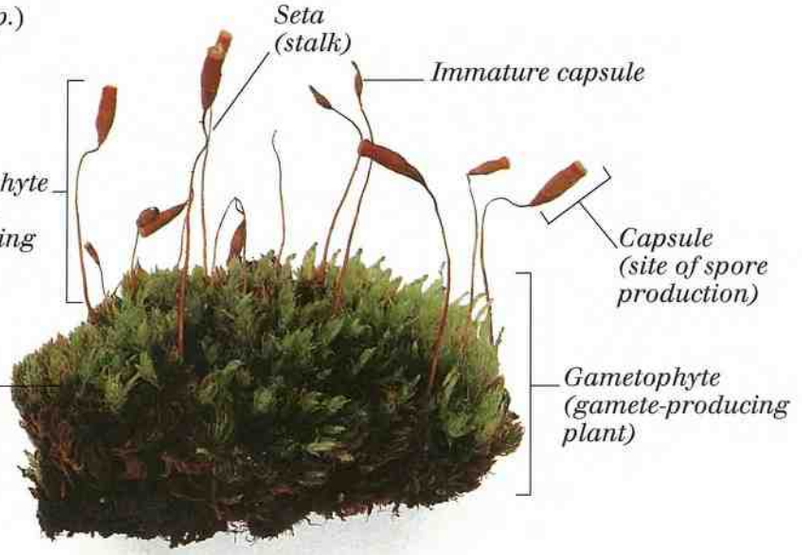
Base of dead frond (leaf)

Trunk

Adventitious root

Epiphytic fern growing at base

BRYOPHYTE
Moss
(*Bryum sp.*)



Seta (stalk)

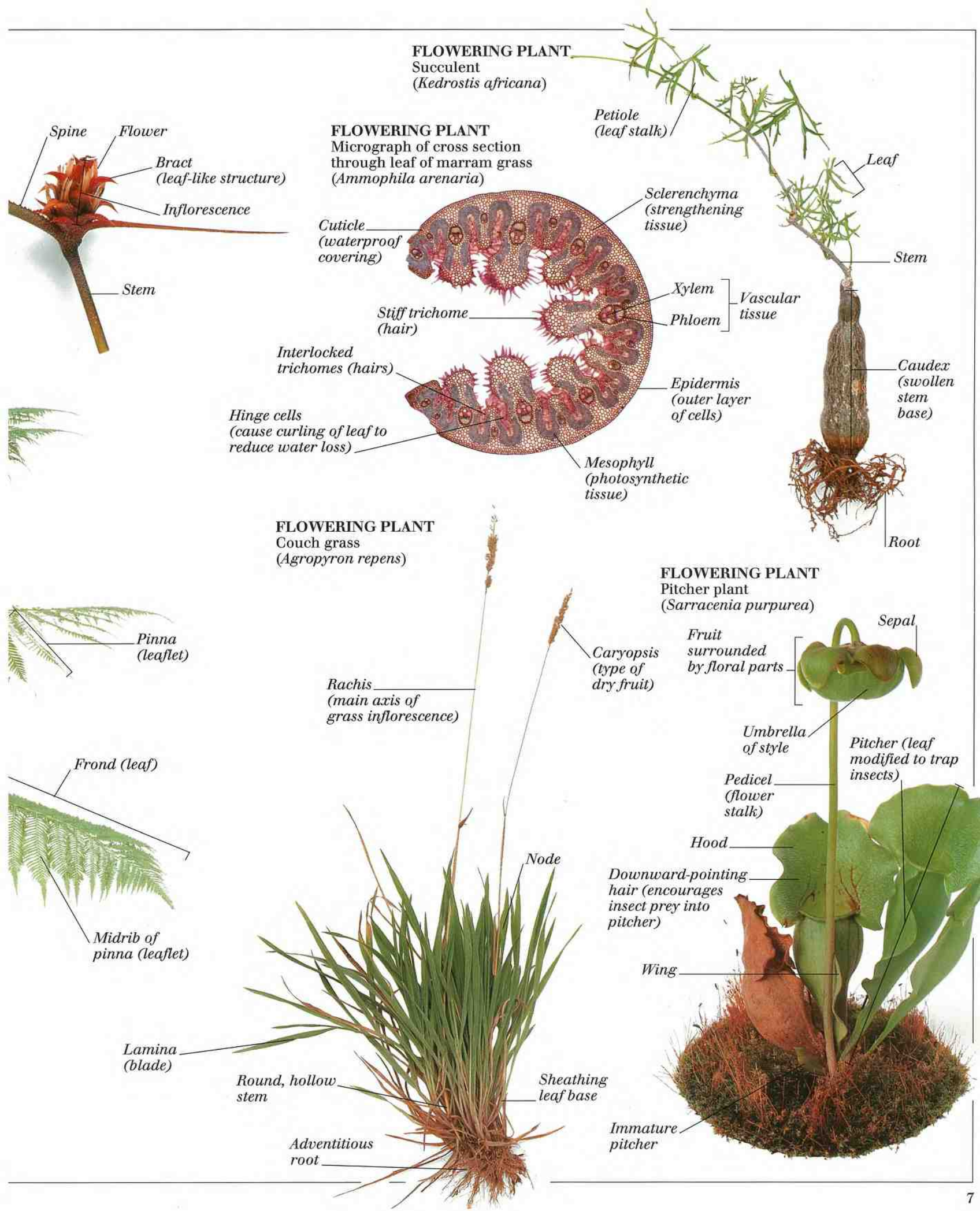
Immature capsule

Sporophyte (spore-producing plant)

Capsule (site of spore production)

"Leaf"

Gametophyte (gamete-producing plant)


FLOWERING PLANT
Succulent
(Kedrostis africana)
Petiole
(leaf stalk)
Leaf
Stem
Caudex
(swollen
stem
base)
Root
Spine
Flower
Bract
(leaf-like structure)
Inflorescence
Stem
FLOWERING PLANT
Micrograph of cross section
through leaf of marram grass
(Ammophila arenaria)
Sclerenchyma
(strengthening
tissue)
Cuticle
(waterproof
covering)
Xylem
Phloem
Vascular
tissue
Stiff trichome
(hair)
Interlocked
trichomes (hairs)
Epidermis
(outer layer
of cells)
Hinge cells
(cause curling of leaf to
reduce water loss)
Mesophyll
(photosynthetic
tissue)
FLOWERING PLANT
Couch grass
(Agropyron repens)
Pinna
(leaflet)
Caryopsis
(type of
dry fruit)
Rachis
(main axis of
grass inflorescence)
Frond (leaf)
Midrib of
pinna (leaflet)
Node
Lamina
(blade)
Round, hollow
stem
Sheathing
leaf base
Adventitious
root
FLOWERING PLANT
Pitcher plant
(Sarracenia purpurea)
Sepal
Fruit
surrounded
by floral parts
Umbrella
of style
Pitcher (leaf
modified to trap
insects)
Pedicel
(flower
stalk)
Hood
Downward-pointing
hair (encourages
insect prey into
pitcher)
Wing
Immature
pitcher

Fungi and lichens

FUNGI WERE ONCE THOUGHT OF AS PLANTS but are now classified as a separate kingdom. This kingdom includes not only the familiar mushrooms, puffballs, stinkhorns, and molds, but also yeasts, smuts, rusts, and lichens. Most fungi are multicellular, consisting of a mass of thread-like hyphae that together form a mycelium. However, the simpler fungi, like yeasts, are microscopic, single-celled organisms. Typically, fungi reproduce by means of spores. Most fungi feed on dead or decaying matter or on living organisms. A few fungi obtain their food from plants or algae, with which they have a symbiotic (mutually advantageous) relationship. Lichens are a symbiotic partnership between algae and fungi. Of the six types of lichens the three most common are crustose (flat and crusty), foliose (leafy), and fruticose (shrub-like). Some lichens (such as *Cladonia floerkeana*) are a combination of types. Lichens reproduce by means of spores or soredia (powdery vegetative fragments).

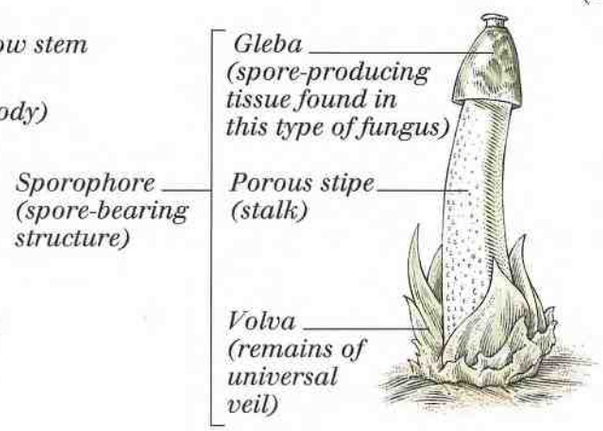
EXAMPLES OF FUNGI

OYSTER FUNGUS
(*Pleurotus pulmonarius*)

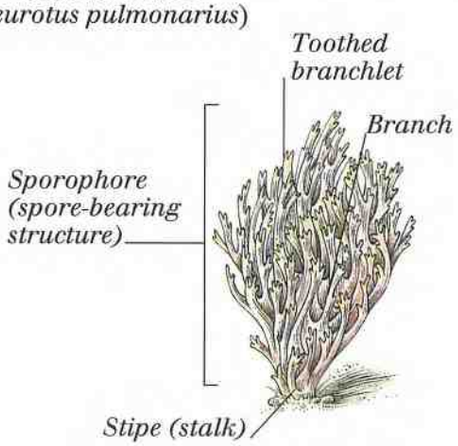
EXAMPLES OF LICHENS

FRUTICOSE
Cladonia portentosa

FOLIOSE
Hypogymnia physodes



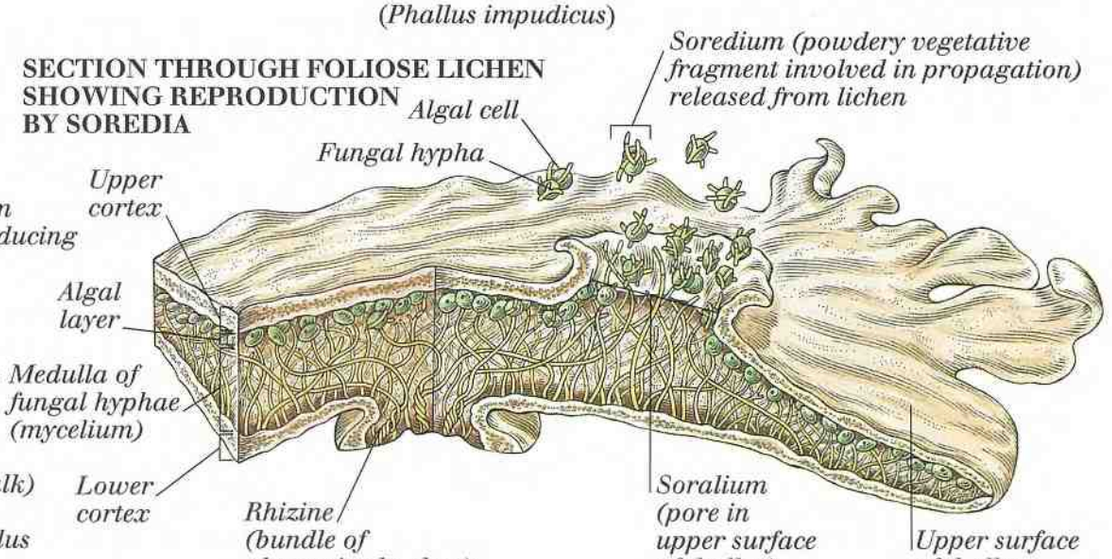
STINKHORN
(*Phallus impudicus*)



RAMARIA FORMOSA

SQUAMULOSE (SCALY) AND FRUTICOSE THALLUS
Cladonia floerkeana

SECTION THROUGH FOLIOSE LICHEN SHOWING REPRODUCTION BY SOREDIA



LIFE CYCLE OF A MUSHROOM
Exoperidium
Endoperidium
Peridium (wall surrounding spore-producing tissue)
Gleba (spore-producing tissue found in this type of fungus)
Scale on exoperidium (outer part of peridium)
Stipe (stalk)
Underground mycelium (mass of hyphae)
Substratum of woodland soil and leaf litter
COMMON EARTHBALL (Scleroderma citrinum)
Fan-shaped pileus (cap)
Sporophore (spore-bearing structure)
Stipe (stalk)
Gill (site of spore production)
HOHENBUEHELIA PETALOIDES
FRINGED CRUMBLE CAP (Psathyrella candolleana)
Pileus (cap)
Stipe (stalk)
Sporophore (spore-bearing structure)
Substratum of woodland soil and leaf litter
Hyphae (fungal filaments)
Velar scale (remains of universal veil)
Pileus (cap)
Gill (site of spore production)
Annulus (ring)
Stipe (stalk)
Underground mycelium
MATURE SPOROPHORE (SPORE-BEARING STRUCTURE)
Sporophore (spore-bearing structure)
Basidium (spore-producing structure)
Discharged spore
SECTION OF GILL
Primary mycelium develops from spore
Spore
Septum (cross wall)
Hypha
Primary mycelia fuse to produce secondary mycelium
Nucleus
SPORES GERMINATE AND PRODUCE MYCELIUM
Immature sporophore
Mycelium
MYCELIUM FORMS SPOROPHORE
Universal veil (membrane enclosing developing sporophore)
Pileus (cap)
Gill
Stipe (stalk)
Underground mycelium
SPOROPHORE GROWS ABOVE GROUND
Expanding pileus (cap)
Partial veil (joins pileus to stipe)
Annulus (ring) being formed as partial veil breaks
Stipe (stalk)
Volva (remains of universal veil)
Underground mycelium
UNIVERSAL VEIL BREAKS

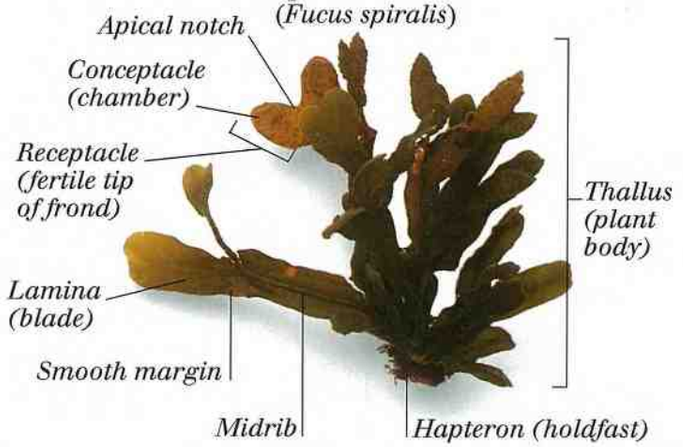
Algae and seaweed

ALGAE ARE NOT TRUE PLANTS. They form a diverse group of plantlike organisms that belong to the kingdom Protista (see p. 58). Like plants, algae possess the green pigment chlorophyll and make their own food by photosynthesis (see pp. 32-33). Many algae also possess other pigments by which they can be classified. For example, the brown pigment fucoxanthin is found in brown algae. Some of the ten phyla of algae are exclusively unicellular (single-celled); others also contain aggregates of cells in filaments or colonies. Three phyla—the Chlorophyta (green algae), Rhodophyta (red algae), and Phaeophyta (brown algae)—contain larger, multicellular, thalloid (flat), marine organisms commonly known as seaweed.

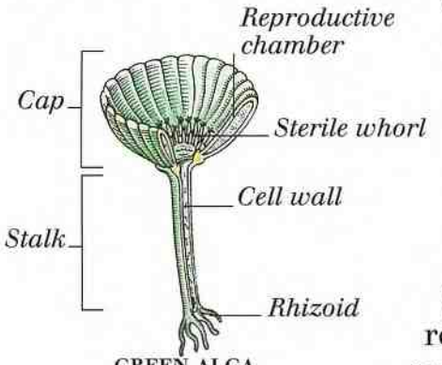
Most algae can reproduce sexually. For example, in brown seaweed *Fucus vesiculosus*, gametes (sex cells) are produced in conceptacles (chambers) in the receptacles (fertile tips of fronds); after their release into the sea, antherozoids (male gametes) and oospheres (female gametes) fuse. The resulting zygote settles on a rock and develops into a new seaweed.

BROWN SEAWEED
Channeled wrack
(*Pelvetia canaliculata*)

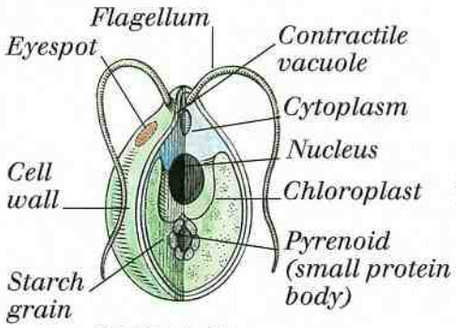
BROWN SEAWEED
Spiral wrack
(*Fucus spiralis*)



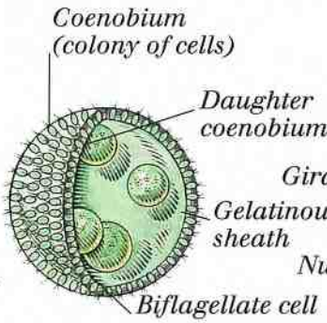
EXAMPLES OF ALGAE



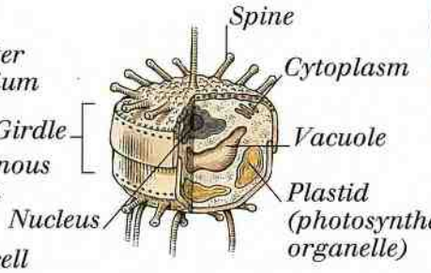
GREEN ALGA
Acetabularia sp.



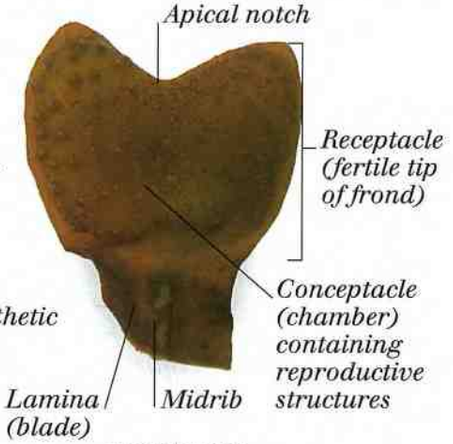
GREEN ALGA
Chlamydomonas sp.



GREEN ALGA
Volvox sp.

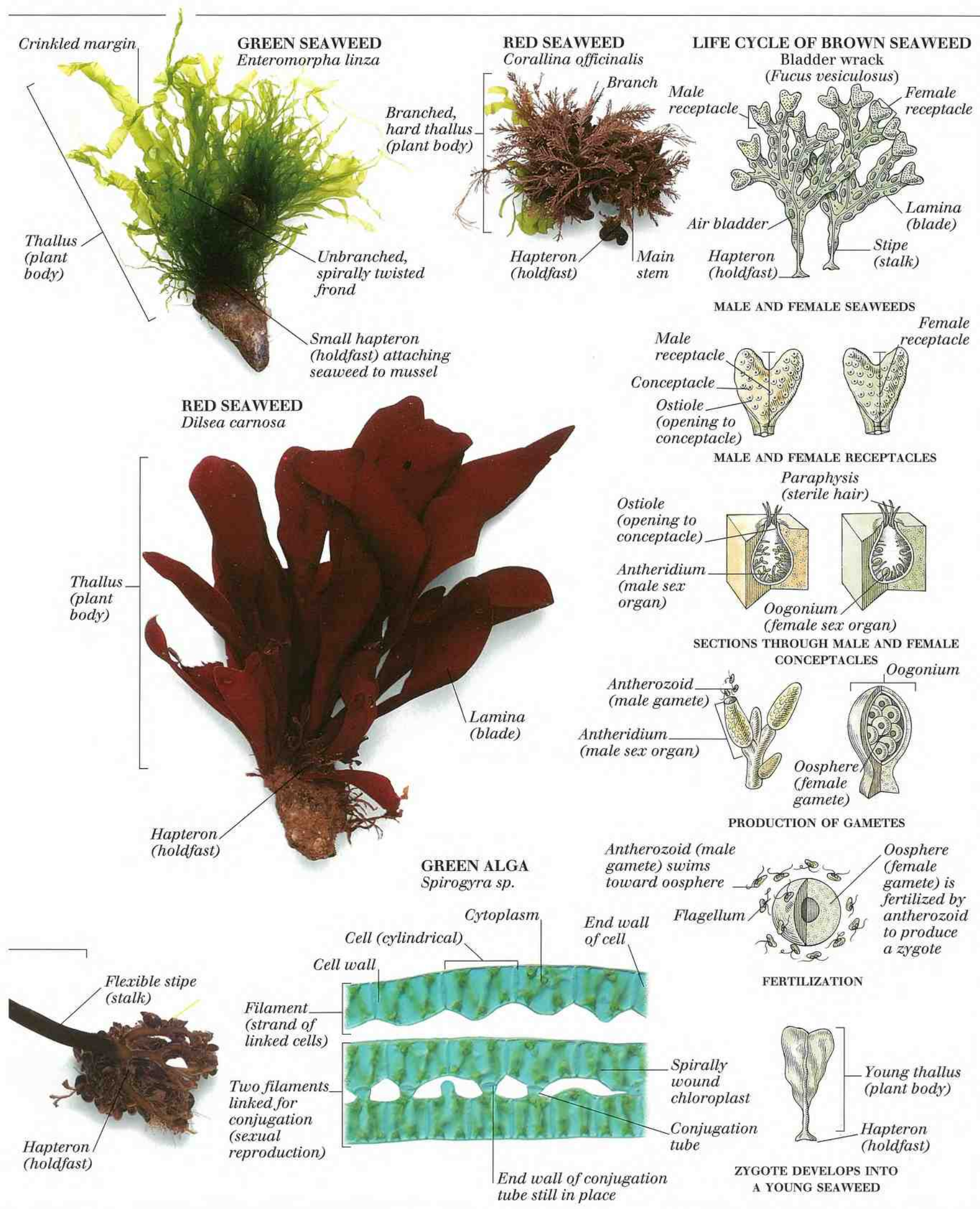


DIATOM
Thalassiosira sp.



RECEPTACLE
Spiral wrack
(*Fucus spiralis*)

BROWN SEAWEED
Oarweed
(*Laminaria digitata*)

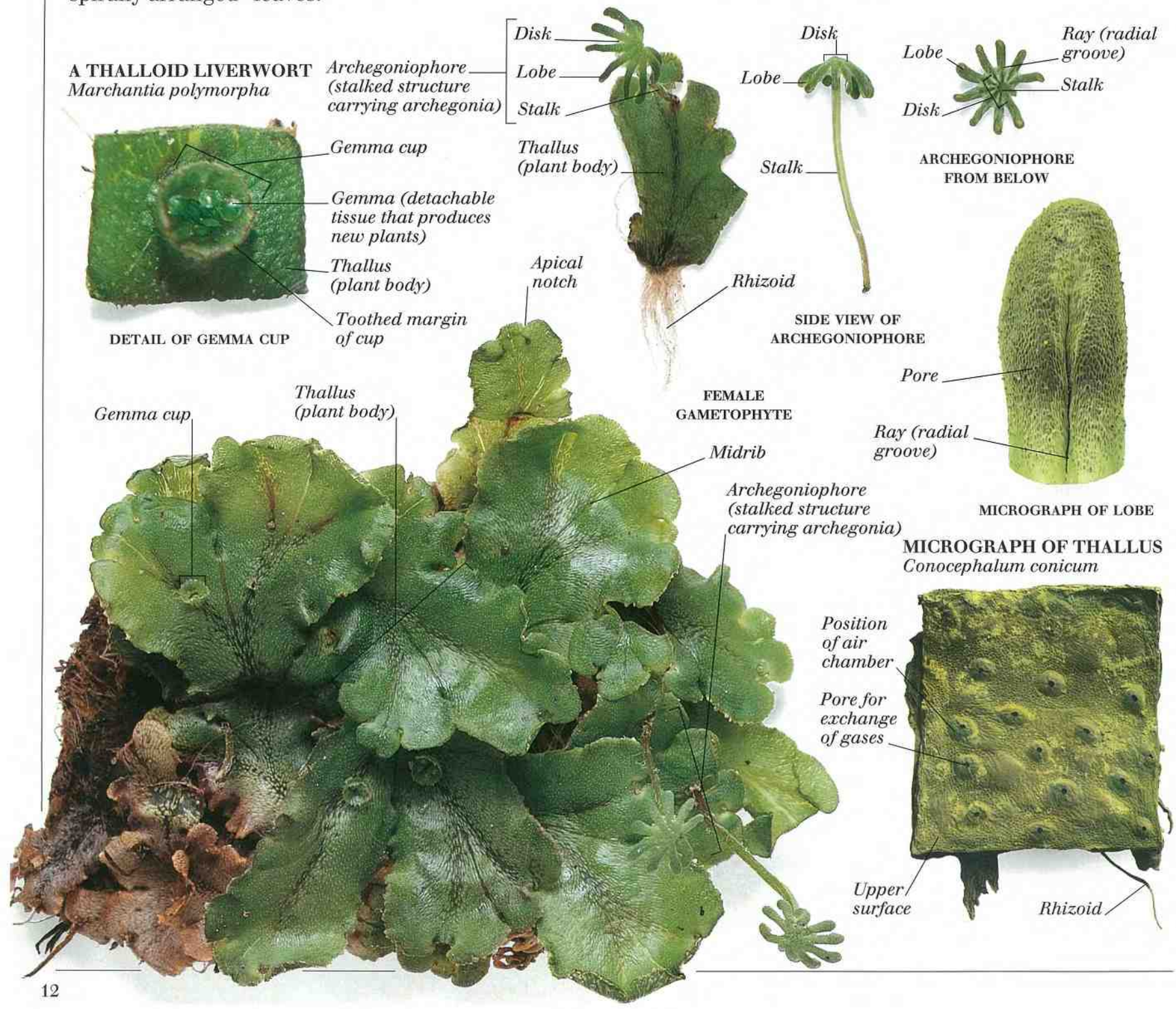

Crinkled margin
GREEN SEAWEED
Enteromorpha linza
Thallus (plant body)
Unbranched, spirally twisted frond
Small hapteron (holdfast) attaching seaweed to mussel
RED SEAWEED
Corallina officinalis
Branched, hard thallus (plant body)
Branch
Hapteron (holdfast)
Main stem
LIFE CYCLE OF BROWN SEAWEED
Bladder wrack
(Fucus vesiculosus)
Male receptacle
Female receptacle
Lamina (blade)
Air bladder
Stipe (stalk)
Hapteron (holdfast)
MALE AND FEMALE SEAWEEDS
Male receptacle
Female receptacle
Conceptacle
Ostiole (opening to conceptacle)
MALE AND FEMALE RECEPTACLES
RED SEAWEED
Dilsea carnosa
Thallus (plant body)
Lamina (blade)
Hapteron (holdfast)
Paraphysis (sterile hair)
Ostiole (opening to conceptacle)
Antheridium (male sex organ)
Oogonium (female sex organ)
SECTIONS THROUGH MALE AND FEMALE CONCEPTACLES
Antherozoid (male gamete)
Antheridium (male sex organ)
Oogonium
Oosphere (female gamete)
PRODUCTION OF GAMETES
GREEN ALGA
Spirogyra sp.
Flexible stipe (stalk)
Hapteron (holdfast)
Cytoplasm
Cell (cylindrical)
End wall of cell
Cell wall
Filament (strand of linked cells)
Two filaments linked for conjugation (sexual reproduction)
Spirally wound chloroplast
Conjugation tube
End wall of conjugation tube still in place
Antherozoid (male gamete) swims toward oosphere
Flagellum
Oosphere (female gamete) is fertilized by antherozoid to produce a zygote
FERTILIZATION
Young thallus (plant body)
Hapteron (holdfast)
ZYGOTE DEVELOPS INTO A YOUNG SEAWEED

Liverworts and mosses

LIVERWORTS AND MOSSES ARE SMALL, LOW-GROWING PLANTS that belong to the phylum Bryophyta. Bryophytes do not have true stems, leaves, or roots (they are anchored to the ground by rhizoids), nor do they have the vascular tissues (xylem and phloem) that transport water and nutrients in higher plants. With no outer, waterproof cuticle, bryophytes are susceptible to dehydration, and most grow in moist habitats. The bryophyte life cycle has two stages. In stage one, the green plant (gametophyte) produces male and female gametes (sex cells), which fuse to form a zygote. In stage two, the zygote develops into a sporophyte that remains attached to the gametophyte. The sporophyte produces spores, which are released and germinate into new green plants. Liverworts (class Hepaticae) grow horizontally and may be thalloid (flat and ribbon-like) or "leafy." Mosses (class Musci) typically have an upright "stem" with spirally arranged "leaves."

A LEAFY LIVERWORT
Scapania undulata

A THALLOID LIVERWORT
Marchantia polymorpha



DETAIL OF GEMMA CUP

FEMALE GAMETOPHYTE

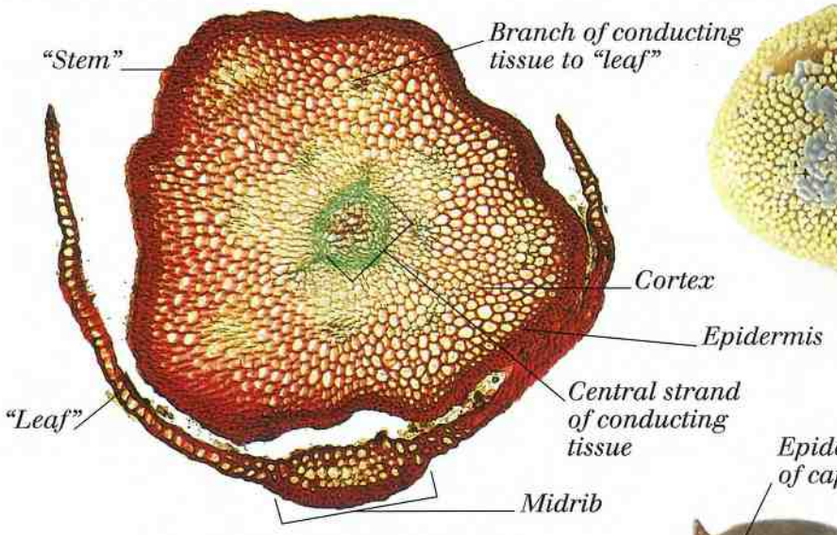
SIDE VIEW OF ARCHEGONIOPHORE

ARCHEGONIOPHORE FROM BELOW

MICROGRAPH OF LOBE

MICROGRAPH OF THALLUS
Conocephalum conicum

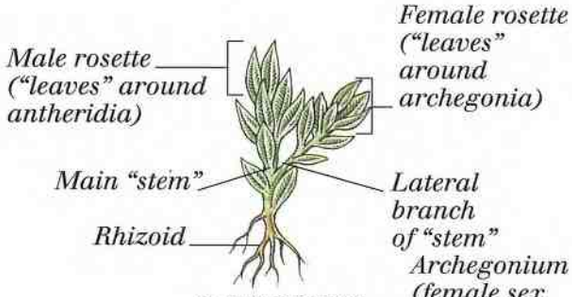
A COMMON MOSS
Polytrichum commune



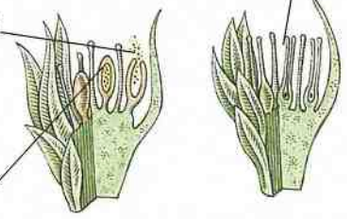
MICROGRAPH OF CROSS SECTION THROUGH STEM AND LEAF

MICROGRAPH OF MOSS SPORE
Funaria hygrometrica

LIFE CYCLE OF MOSS
Funaria sp.

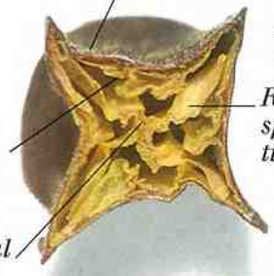


GAMETOPHYTE

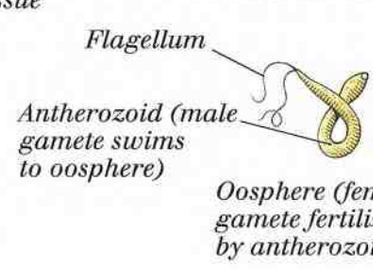


SECTION THROUGH MATURE MALE APEX

SECTION THROUGH MATURE FEMALE APEX

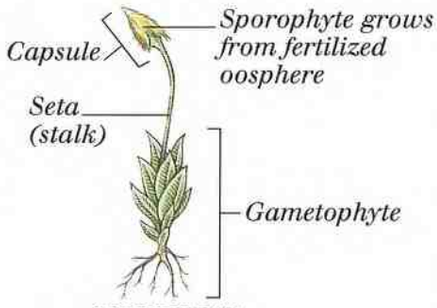


CROSS SECTION THROUGH CAPSULE

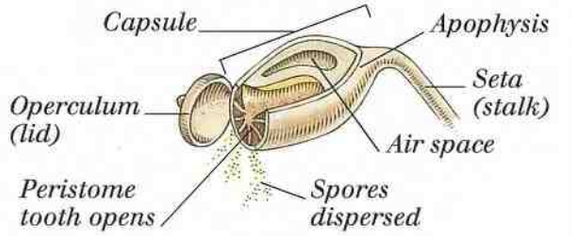


FERTILIZATION

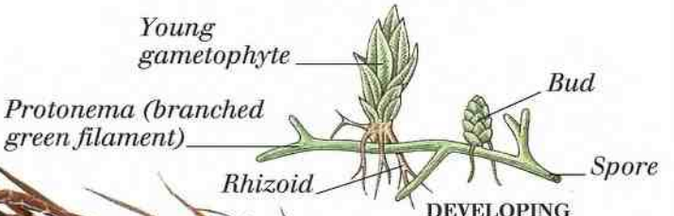
EXTERNAL VIEW OF MOSS



SPOROPHYTE



RIPE CAPSULE



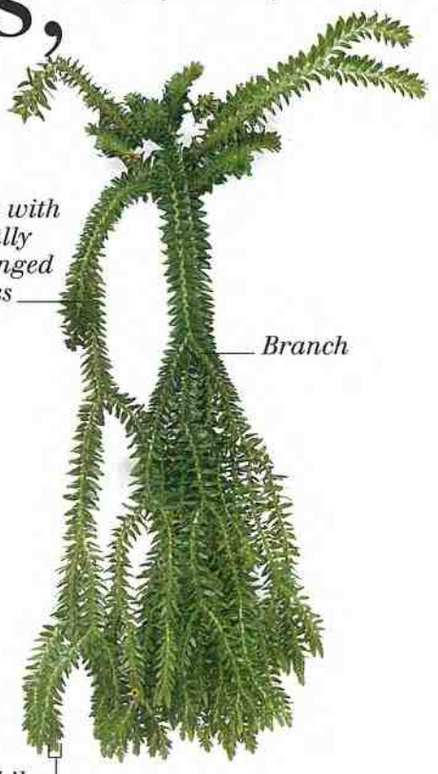
DEVELOPING GAMETOPHYTE

Horsetails, club mosses, and ferns

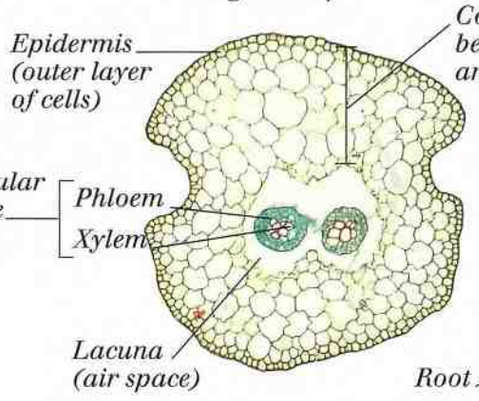
FROND
Male fern
(*Dryopteris filix-mas*)

HORSETAILS, CLUB MOSSES, AND FERNS are primitive land plants, which, like higher plants, have stems, roots, leaves, and vascular systems that transport water, minerals, and food. Unlike higher plants, however, they do not produce seeds when reproducing. Their life cycles involve two stages. In stage one, the sporophyte (green plant) produces spores in sporangia. In stage two, the spores germinate, developing into small, short-lived gametophyte plants that produce male and female gametes (sex cells). The gametes fuse to form a zygote from which a new sporophyte plant develops. Horsetails (phylum Sphenophyta) have erect green stems with branches arranged in whorls. Some stems are fertile and have a single spore-producing strobilus (group of sporangia) at the tip. Club mosses (phylum Lycopodophyta) typically have small leaves arranged spirally around the stem, with spore-producing strobili at the tip of some stems. Ferns (phylum Filicinophyta) usually have large, pinnate leaves called fronds. Sporangia, grouped together in sori, develop on the underside of fertile fronds.

CLUB MOSS
Lycopodium sp.

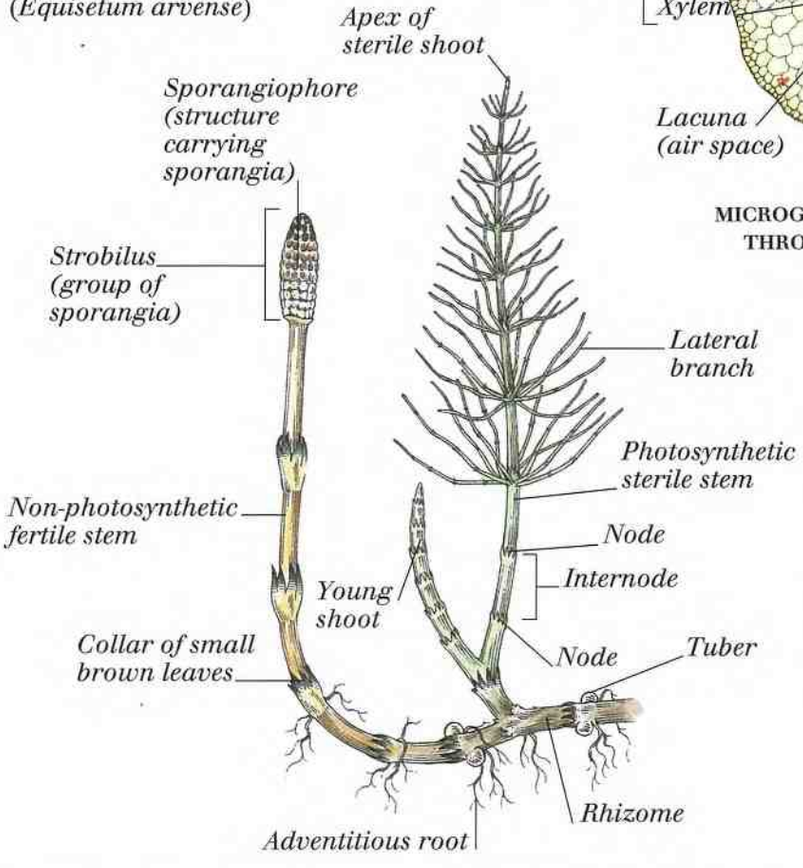


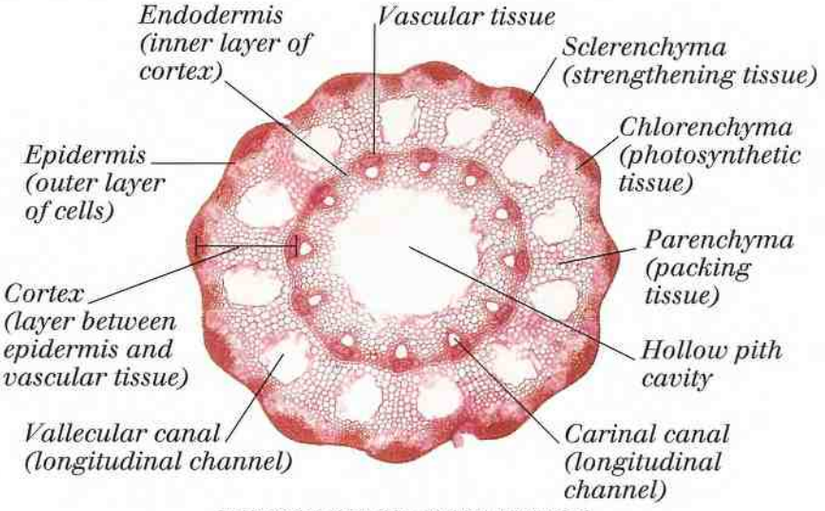
CLUB MOSS
Selaginella sp.



MICROGRAPH OF CROSS SECTION THROUGH CLUB MOSS STEM

HORSETAIL
Common horsetail
(*Equisetum arvense*)





MICROGRAPH OF CROSS SECTION THROUGH HORSETAIL STEM

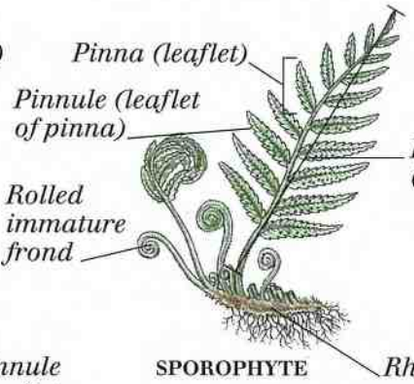
SPORE PRODUCTION IN FERN

Bracken
(*Pteridium aquilinum*)

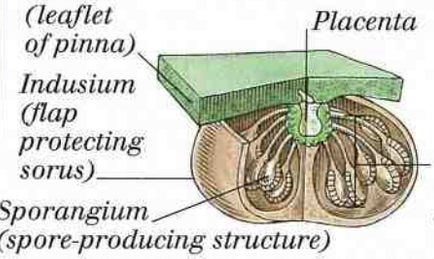
MICROGRAPH OF LOWER SURFACE OF FERTILE PINNULE

MICROGRAPH OF SPORANGIA ON LOWER SURFACE OF FERTILE PINNULE

LIFE CYCLE OF FERN

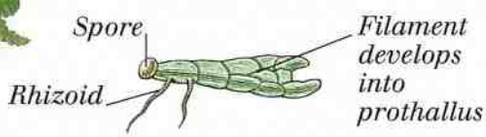


SPOROPHYTE

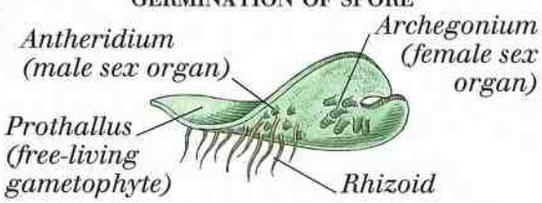


SECTION THROUGH MATURE PINNULE

RELEASE OF SPORES FROM SPORANGIUM

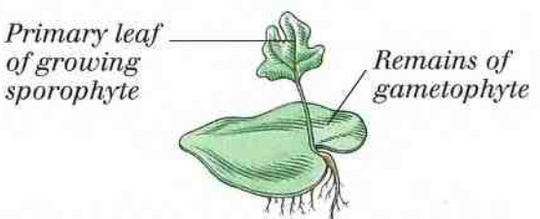


GERMINATION OF SPORE



GAMETOPHYTE PRODUCES GAMETES

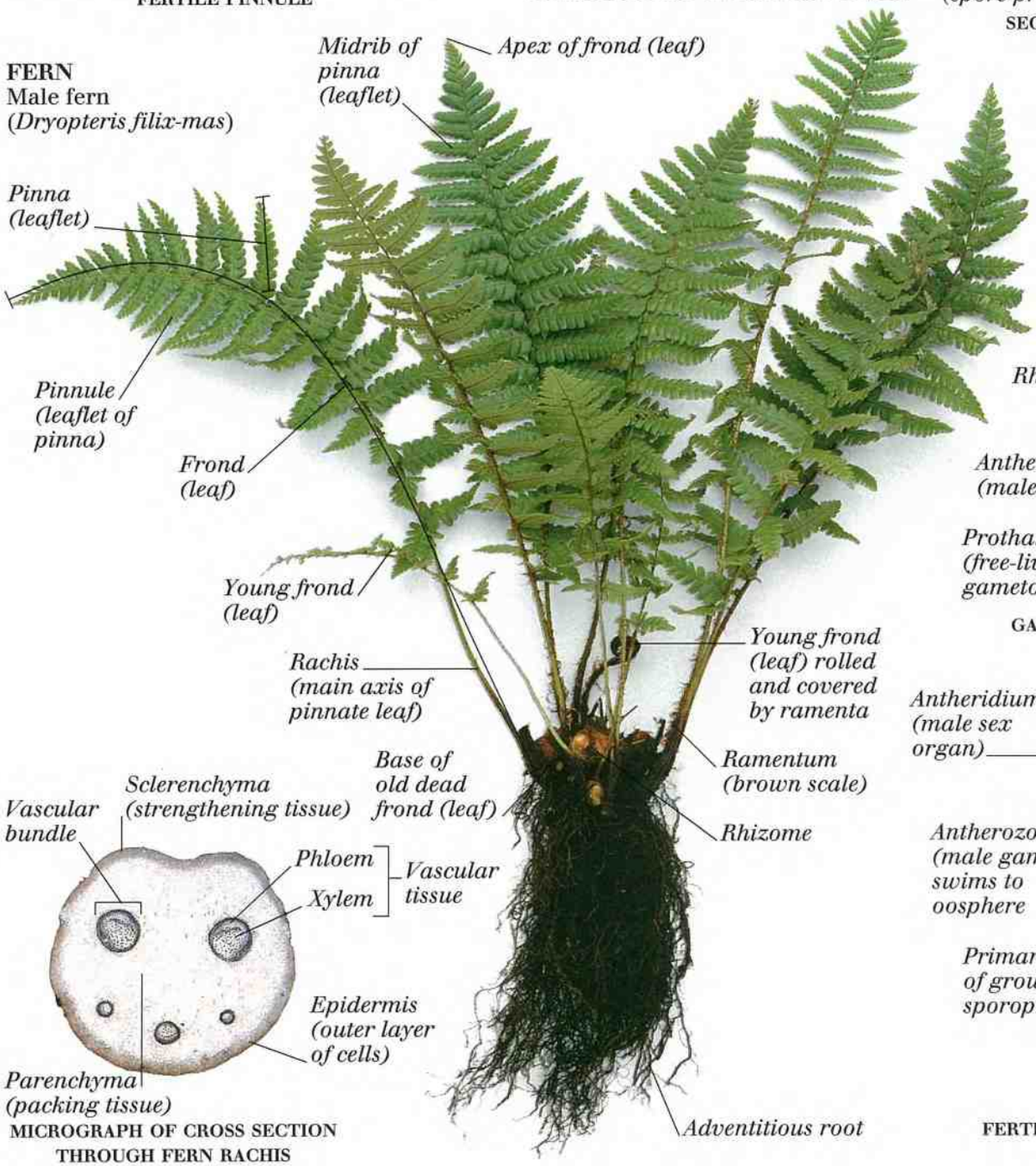
FERTILIZATION



FERTILIZED OOSPHERE GROWS INTO NEW SPOROPHYTE PLANT

FERN

Male fern
(*Dryopteris filix-mas*)

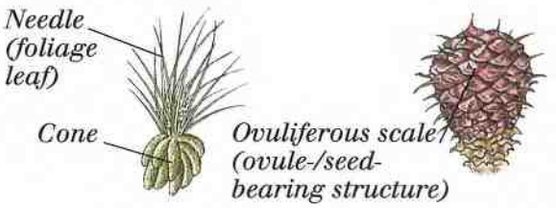


MICROGRAPH OF CROSS SECTION THROUGH FERN RACHIS

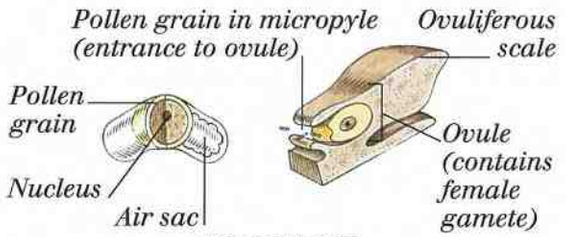
Gymnosperms 1

THE GYMNOSPERMS ARE FOUR RELATED PHYLA of seed-producing plants: Their seeds, however, lack the protective outer covering which surrounds the seeds of flowering plants. Typically, gymnosperms are woody, perennial shrubs or trees, with stems, leaves, roots, and a well-developed vascular (transport) system. The reproductive structures in most gymnosperms are cones. Male cones produce microspores in which male gametes (sex cells) develop; female cones produce megaspores in which female gametes develop. Microspores are blown by the wind to female cones, male and female gametes fuse during fertilization, and a seed develops. The four gymnosperm phyla are the conifers (phylum Coniferophyta), mostly tall trees; cycads (phylum Cycadophyta), small palm-like trees; the ginkgo or maidenhair tree (phylum Ginkgophyta), a tall tree with bilobed leaves; and gnetophytes (phylum Gnetophyta) a diverse group of plants, mainly shrubs, but also including the horizontally growing welwitschia.

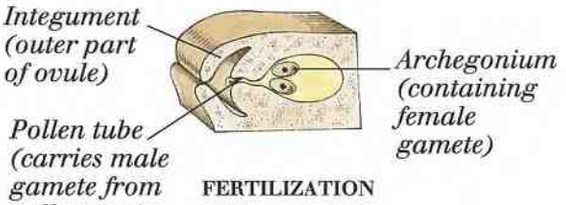
LIFE CYCLE OF SCOTS PINE
(*Pinus sylvestris*)



MALE CONES YOUNG FEMALE CONE

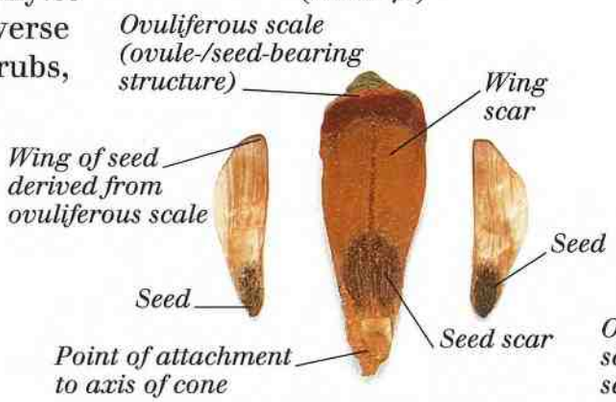


POLLINATION

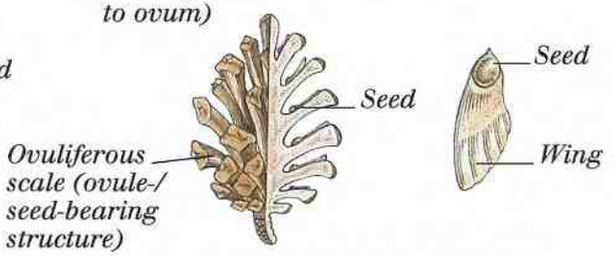


FERTILIZATION

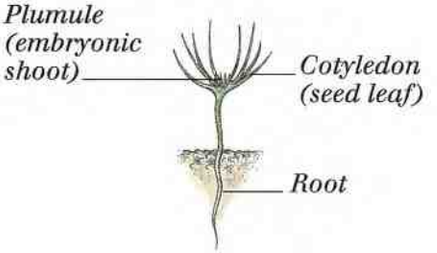
SCALE AND SEEDS
Pine
(*Pinus sp.*)



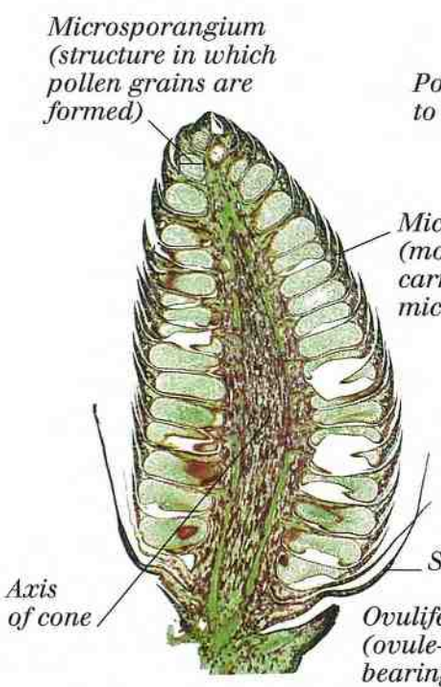
OVULIFEROUS SCALE FROM THIRD-YEAR FEMALE CONE



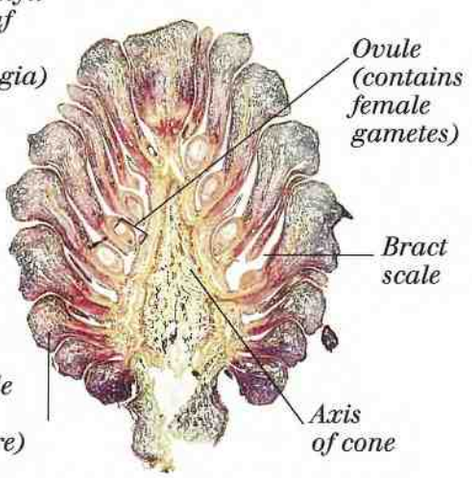
MATURE FEMALE CONE AND WINGED SEED



GERMINATION OF PINE SEEDLING

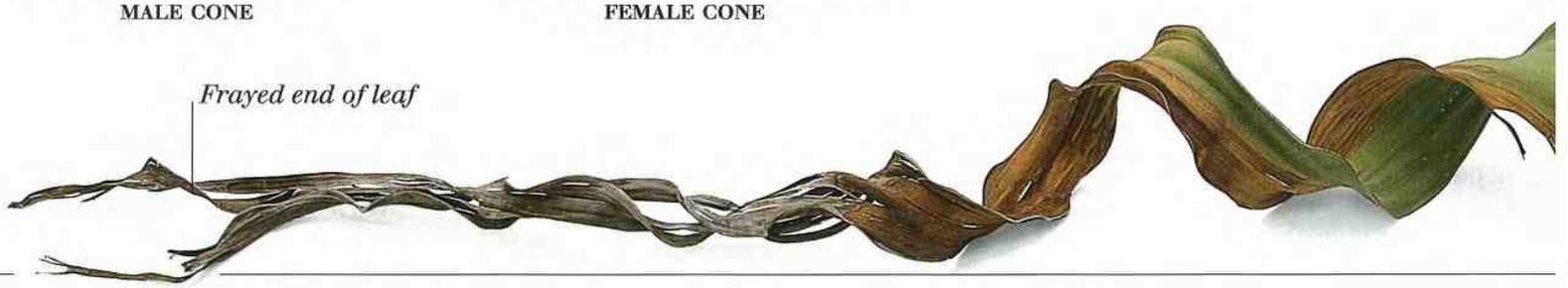


MICROGRAPH OF LONGITUDINAL SECTION THROUGH YOUNG MALE CONE



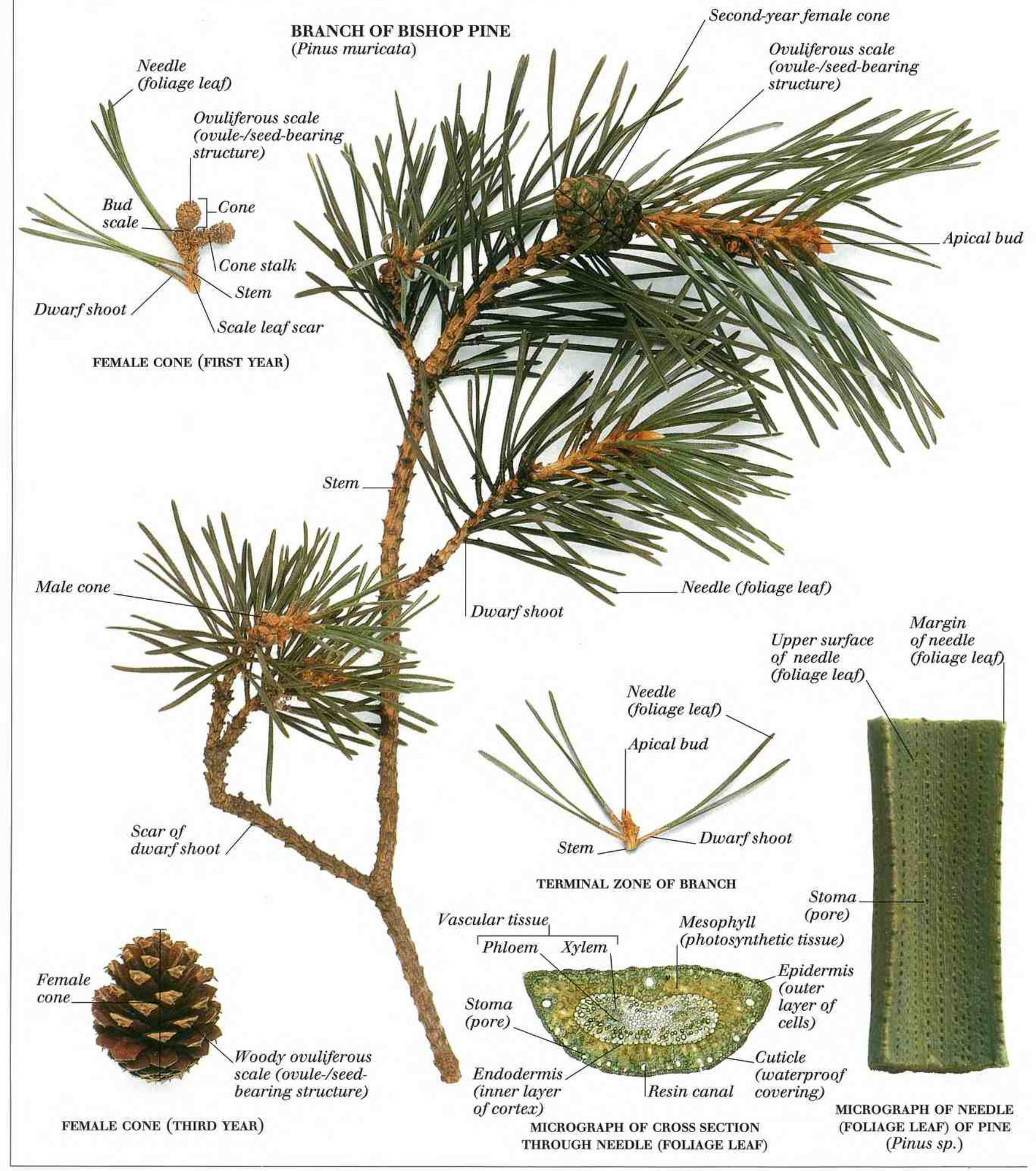
MICROGRAPH OF LONGITUDINAL SECTION THROUGH SECOND-YEAR FEMALE CONE

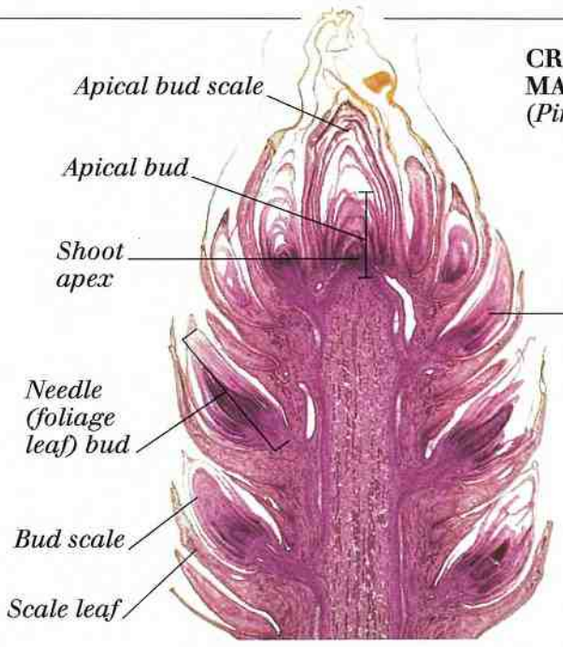
WELWITSCHIA
(*Welwitschia mirabilis*)




SMOOTH CYPRESS
(Cupressus glabra)
Immature female cone
Ovuliferous scale (ovule-/seed-bearing structure)
Scalelike leaf
Mature female cone
Immature male cone
Ovuliferous scale
Ovule (contains female gamete)
CROSS SECTION THROUGH IMMATURE CONE
Ovuliferous scale (ovule-/seed-bearing structure)
Seed
CROSS SECTION THROUGH MATURE CONE
Woody scale
Opening between woody scales through which seeds are released
DISCARDED CONE
YEW
(Taxus baccata)
Single ovule (contains female gamete)
Scale
Female "cone"
Scale
Developing seed
Scale
FEMALE "CONES" AT VARIOUS STAGES OF DEVELOPMENT
Seed
Aril (fleshy outgrowth from seed)
Stem
Needle (foliage leaf)
CYCAD
Sago palm
(Cycas revoluta)
Pinna (leaflet)
Pinnate leaf
Scale leaf
Old leaf base
Stem covered by scale leaves
GINKGO TREE
(Ginkgo biloba)
Girdle scar
Stem
Petiole (leaf stalk)
Bilobed leaf
Continuously growing leaf
Site of cone growth
Adaxial (upper) surface of leaf
Immature cone
Stalk scar
Woody stem
Abaxial (lower) surface of leaf
Frayed end of leaf

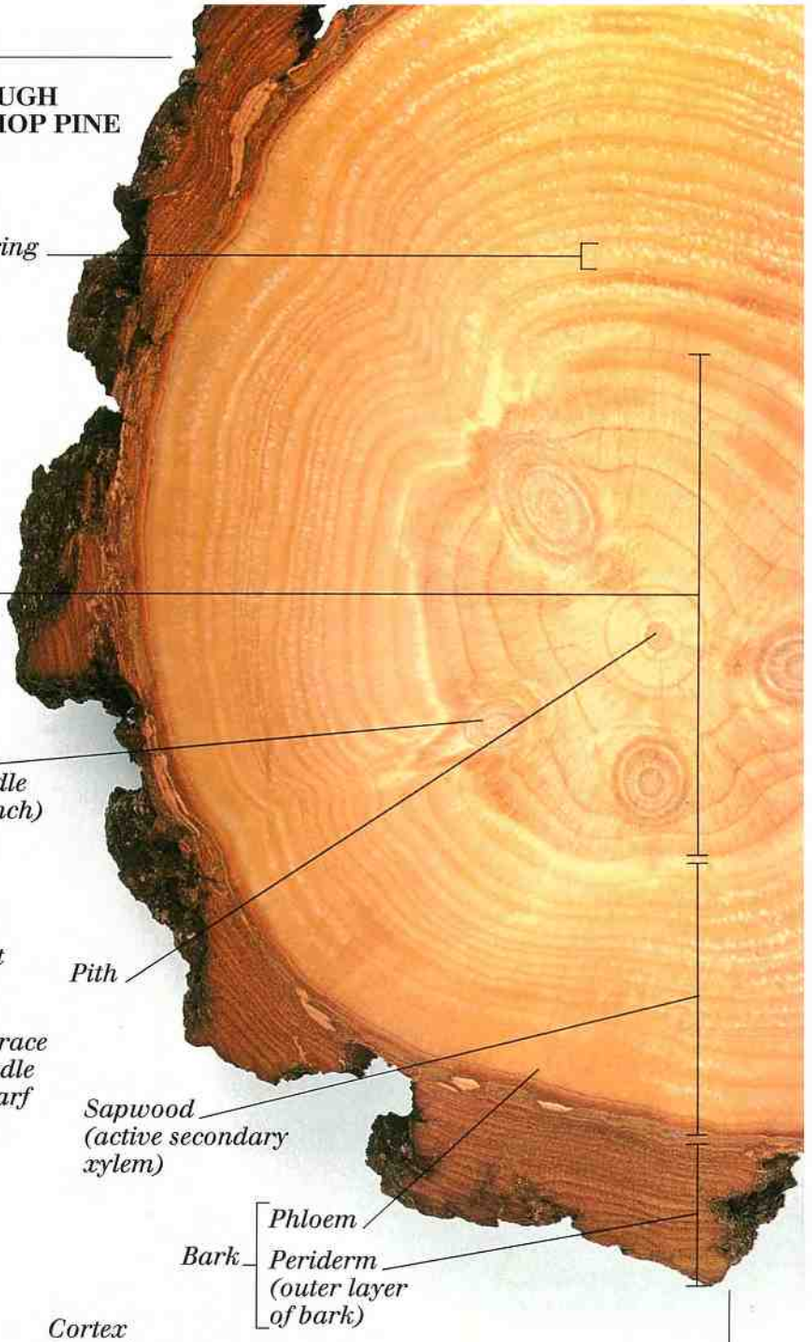
Gymnosperms 2

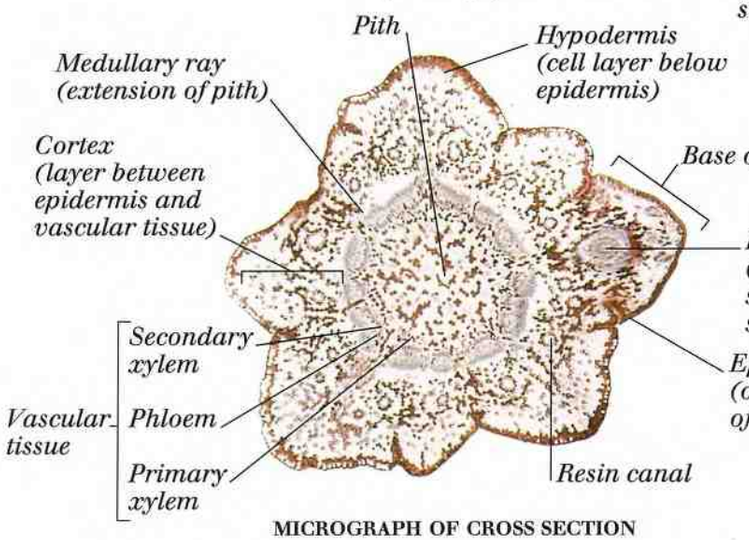




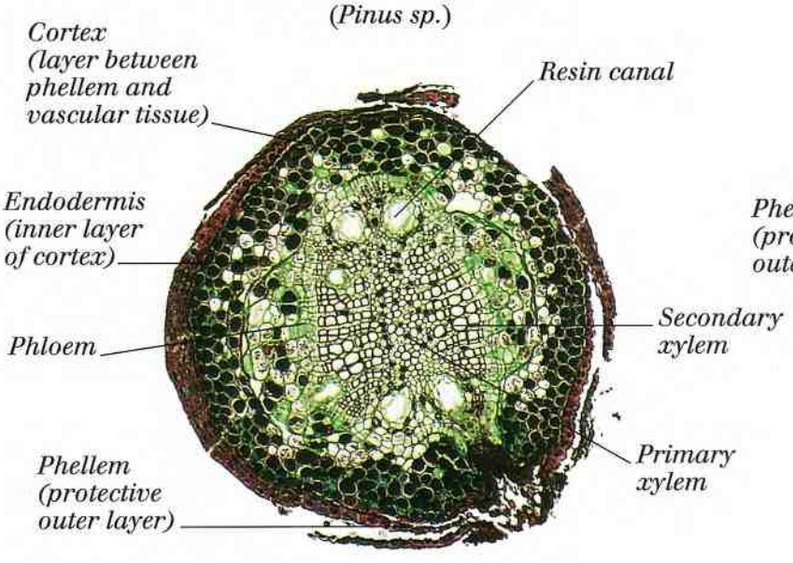
MICROGRAPH OF LONGITUDINAL SECTION THROUGH SHOOT APEX OF PINE (*Pinus sp.*)

CROSS SECTION THROUGH MATURE STEM OF BISHOP PINE (*Pinus muricata*)

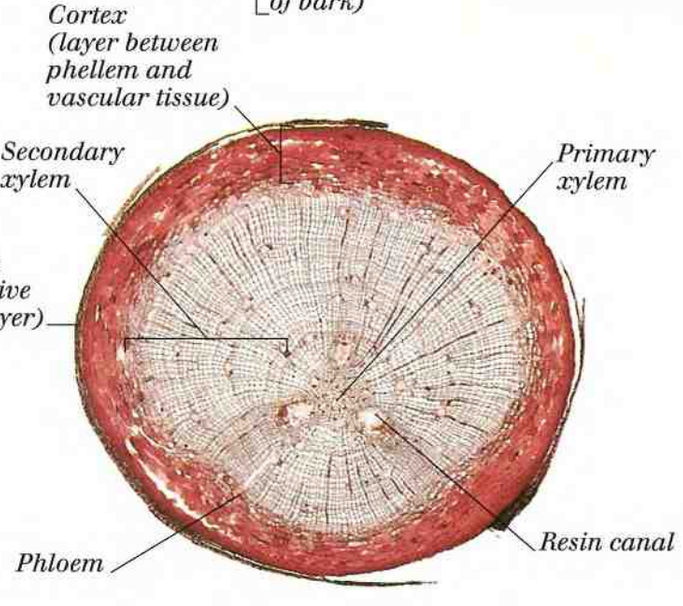




MICROGRAPH OF CROSS SECTION THROUGH YOUNG STEM OF PINE (*Pinus sp.*)



MICROGRAPH OF CROSS SECTION THROUGH YOUNG ROOT OF PINE (*Pinus sp.*)



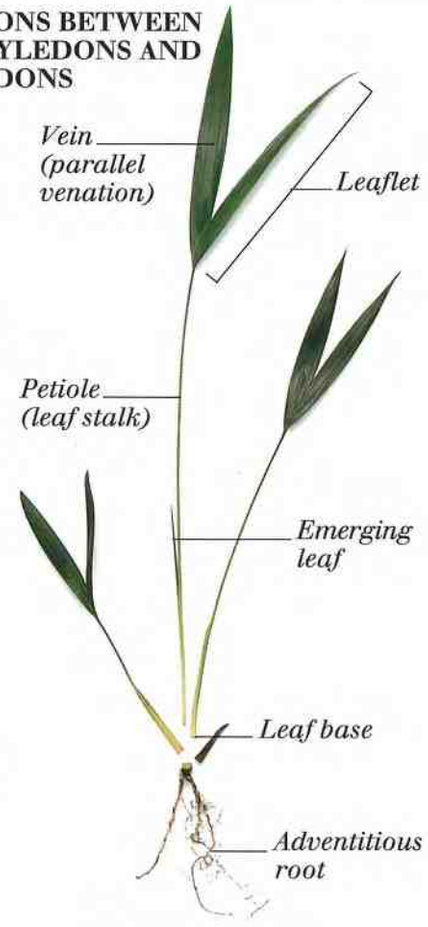
MICROGRAPH OF CROSS SECTION THROUGH MATURE ROOT OF PINE (*Pinus sp.*)

Monocotyledons and dicotyledons

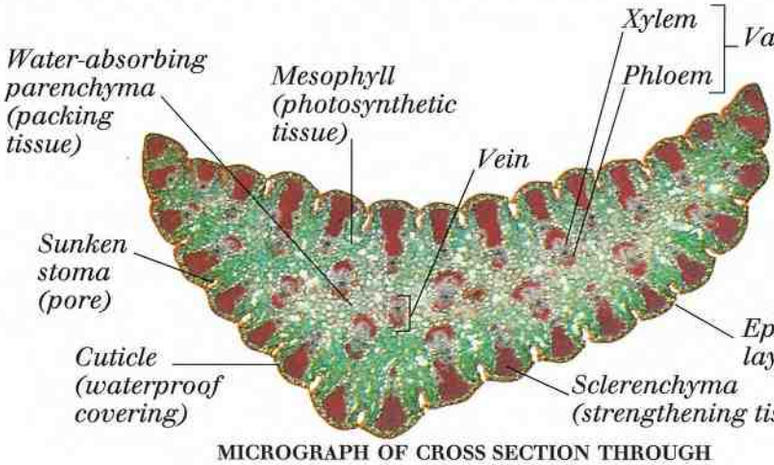
FLOWERING PLANTS (PHYLUM ANGIOSPERMOPHYTA) are divided into two classes: monocotyledons (class Monocotyledoneae) and dicotyledons (class Dicotyledoneae). Typically, monocotyledons have seeds with one cotyledon (seed leaf); their foliage leaves are narrow with parallel veins; the flower components occur in multiples of three; sepals and petals are indistinguishable and are known as tepals; vascular (transport) tissues are scattered in random bundles throughout the stem; and, because they lack stem cambium (actively dividing cells that produce wood), most monocotyledons are herbaceous (see pp. 22-23). Dicotyledons have seeds with two cotyledons; leaves are broad with a central midrib and branched veins; flower parts occur in multiples of four or five; sepals are generally small and green; petals are large and colorful; vascular bundles are arranged in a ring around the edge of the stem; and, because many dicotyledons possess wood-producing stem cambium, there are woody forms (see pp. 24-25) as well as herbaceous ones.

CROSS SECTION THROUGH MONOCOTYLEDONOUS LEAF BASES

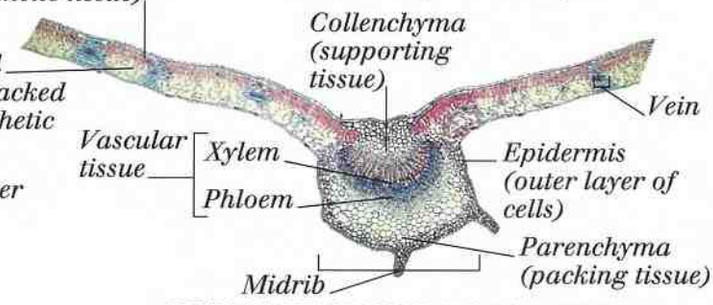
COMPARISONS BETWEEN MONOCOTYLEDONS AND DICOTYLEDONS



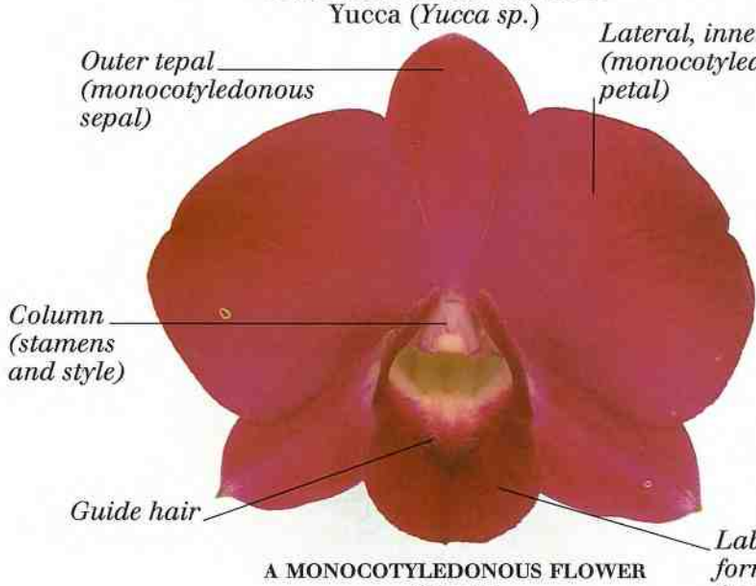
A MONOCOTYLEDON
Paradise palm
(*Howea forsteriana*)



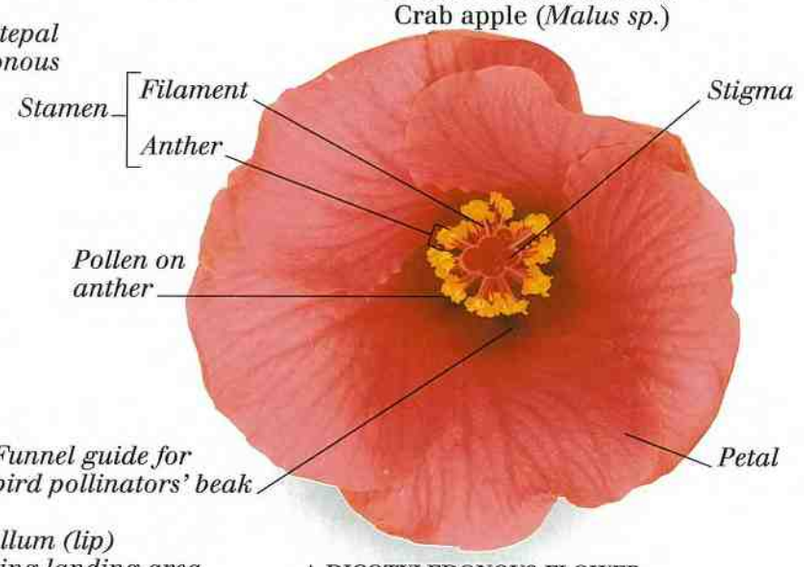
MICROGRAPH OF CROSS SECTION THROUGH A MONOCOTYLEDONOUS LEAF
Yucca (*Yucca sp.*)



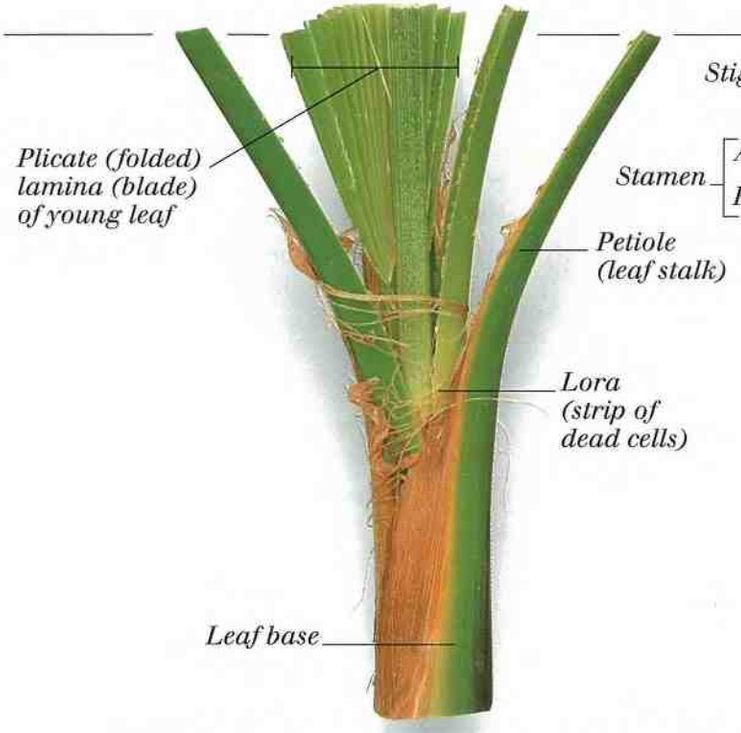
MICROGRAPH OF CROSS SECTION THROUGH A DICOTYLEDONOUS LEAF
Crab apple (*Malus sp.*)



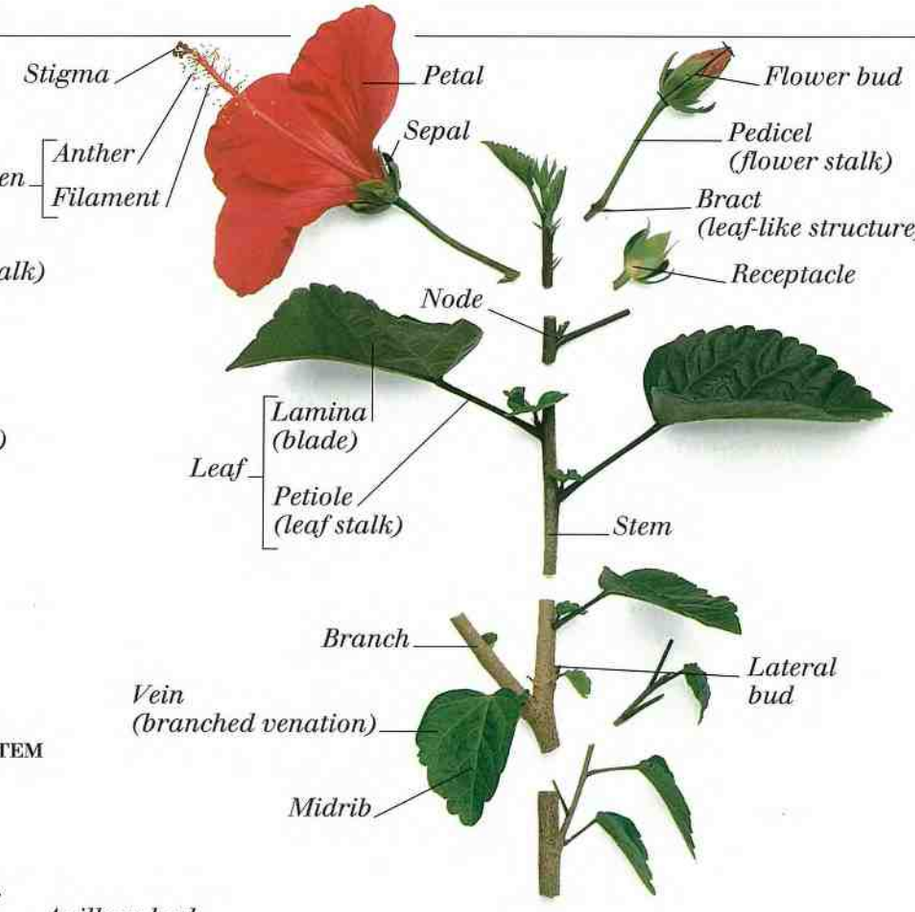
A MONOCOTYLEDONOUS FLOWER
Orchid
(*Phalaenopsis sp.*)

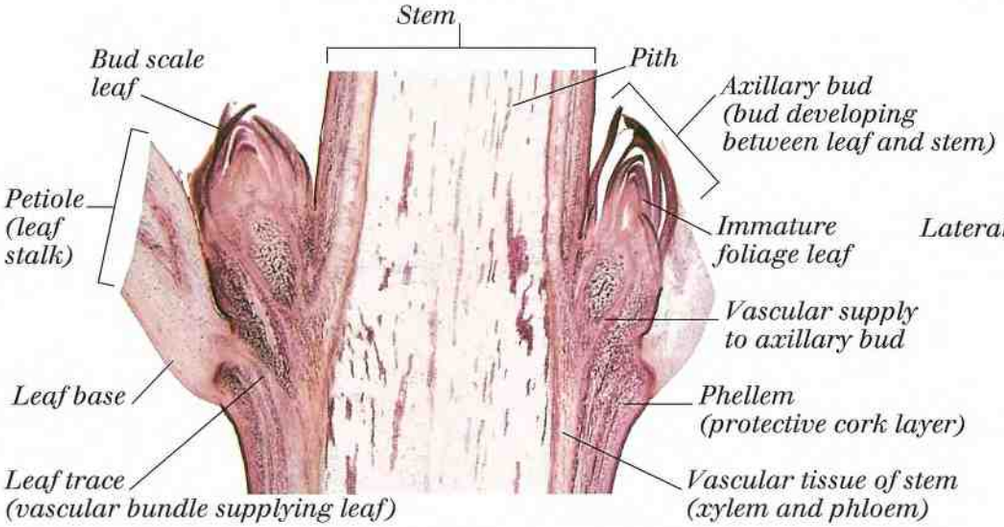


A DICOTYLEDONOUS FLOWER
Hibiscus
(*Hibiscus rosa-sinensis*)

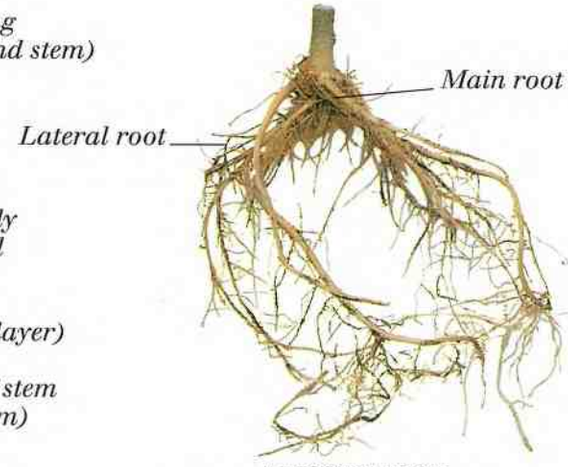


MONOCOTYLEDONOUS LEAF BASES FORMING STEM
Chusan palm
(*Trachycarpus fortunei*)

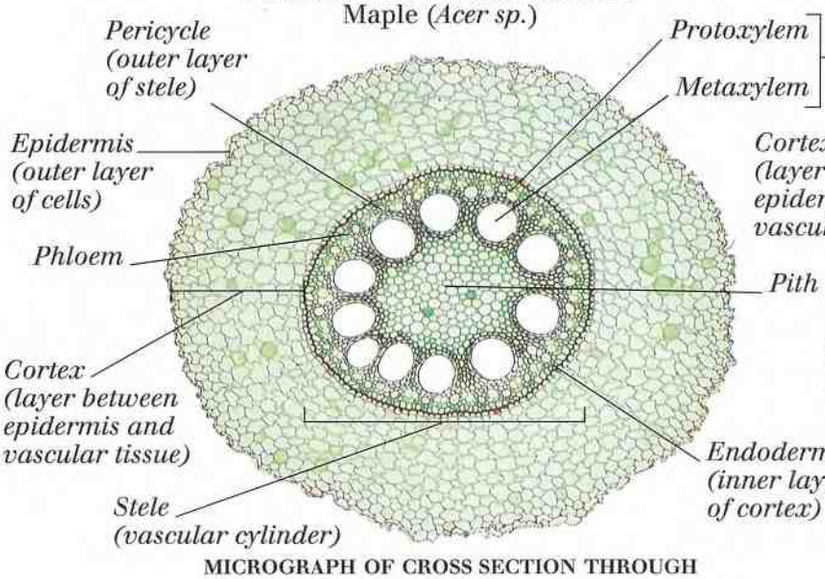




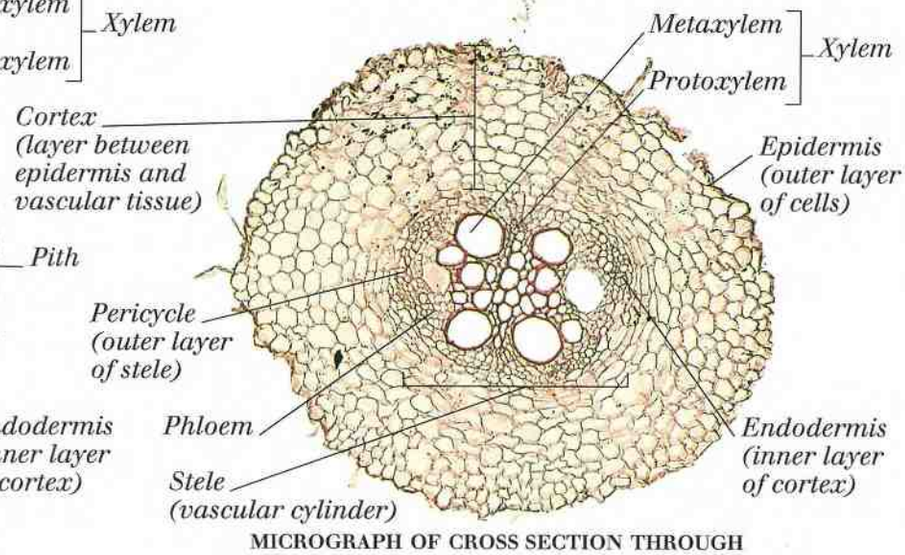
MICROGRAPH OF LONGITUDINAL SECTION THROUGH A WOODY DICOTYLEDONOUS STEM
Maple (*Acer sp.*)



A DICOTYLEDON
Hibiscus (*Hibiscus rosa-sinensis*)



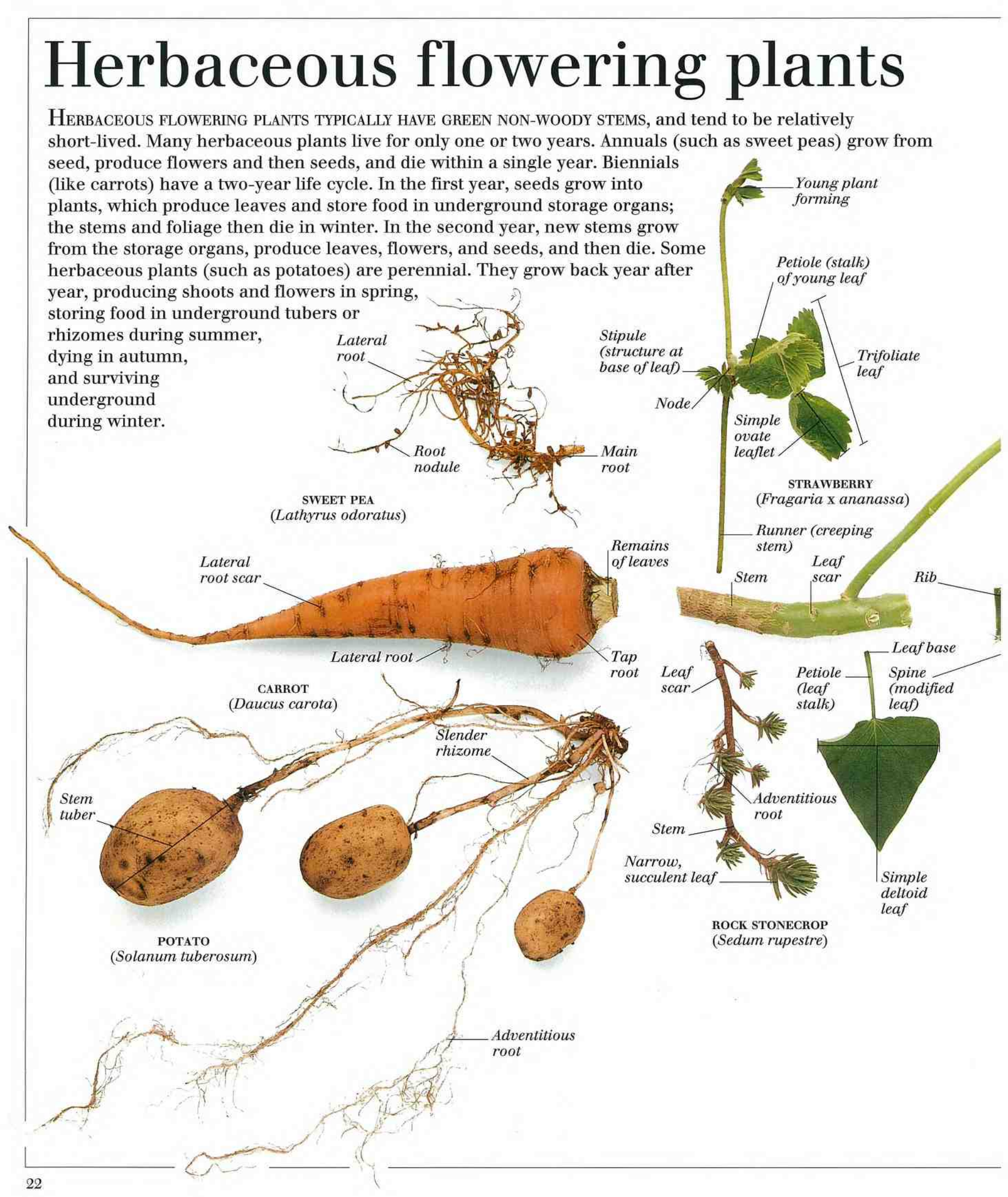
MICROGRAPH OF CROSS SECTION THROUGH A MONOCOTYLEDONOUS ROOT
Corn (*Zea mays*)



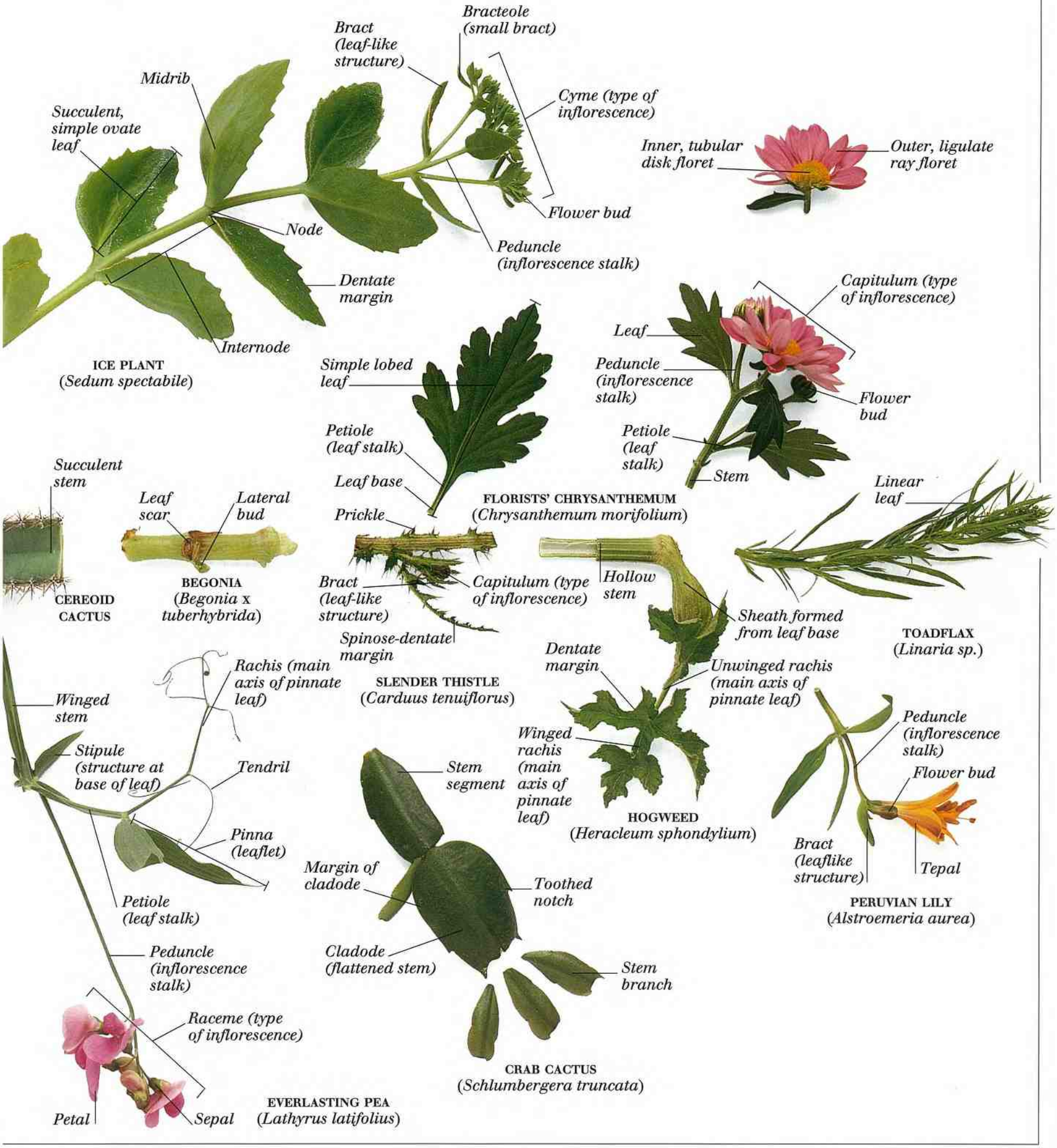
MICROGRAPH OF CROSS SECTION THROUGH A DICOTYLEDONOUS ROOT
Buttercup (*Ranunculus sp.*)

Herbaceous flowering plants

HERBACEOUS FLOWERING PLANTS TYPICALLY HAVE GREEN NON-WOODY STEMS, and tend to be relatively short-lived. Many herbaceous plants live for only one or two years. Annuals (such as sweet peas) grow from seed, produce flowers and then seeds, and die within a single year. Biennials (like carrots) have a two-year life cycle. In the first year, seeds grow into plants, which produce leaves and store food in underground storage organs; the stems and foliage then die in winter. In the second year, new stems grow from the storage organs, produce leaves, flowers, and seeds, and then die. Some herbaceous plants (such as potatoes) are perennial. They grow back year after year, producing shoots and flowers in spring, storing food in underground tubers or rhizomes during summer, dying in autumn, and surviving underground during winter.

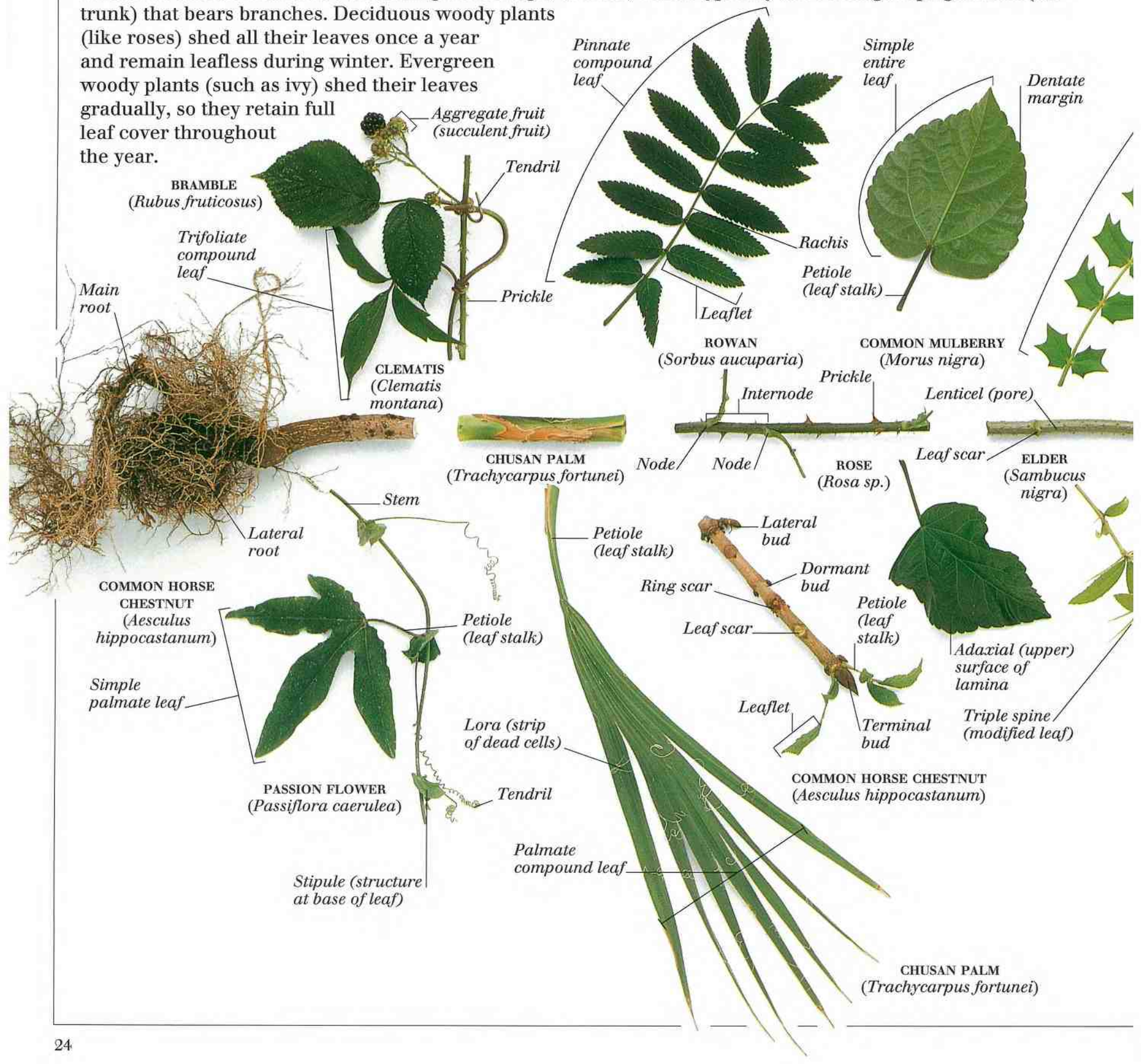


PARTS OF HERBACEOUS FLOWERING PLANTS

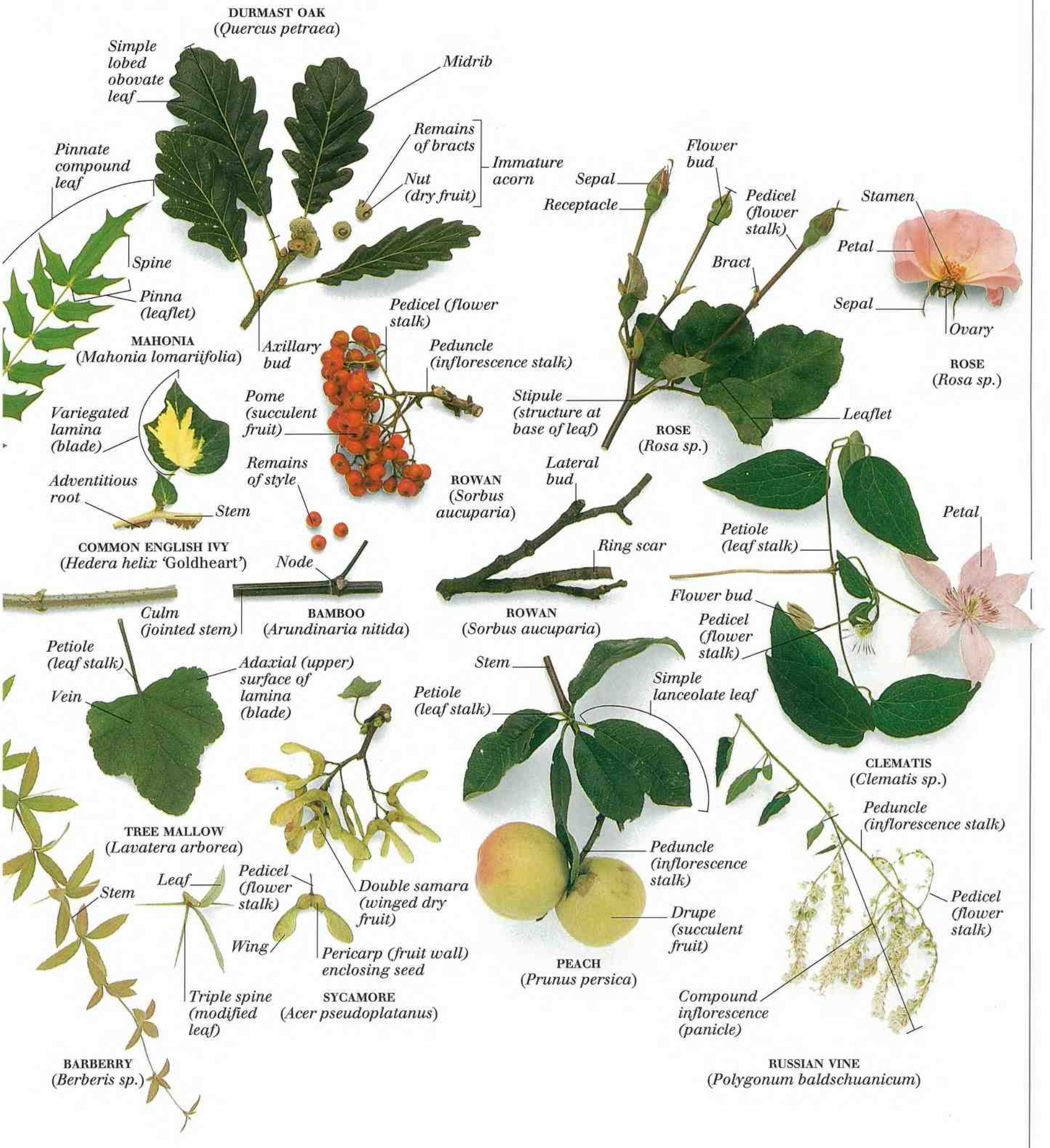


Woody flowering plants

WOODY FLOWERING PLANTS ARE PERENNIAL: They continue to grow and reproduce for many years. They have one or more permanent stems above ground and numerous smaller branches. The stems and branches have a strong woody core that supports the plant and contains vascular tissue for transporting water and nutrients. Outside the woody core is a layer of tough, protective bark, which has lenticels (tiny pores) to allow gases to pass through. Woody flowering plants may be shrubs, which have several stems rising from the soil; bushes, which are shrubs with dense branching and foliage; or trees, which typically have a single upright stem (the trunk) that bears branches. Deciduous woody plants (like roses) shed all their leaves once a year and remain leafless during winter. Evergreen woody plants (such as ivy) shed their leaves gradually, so they retain full leaf cover throughout the year.

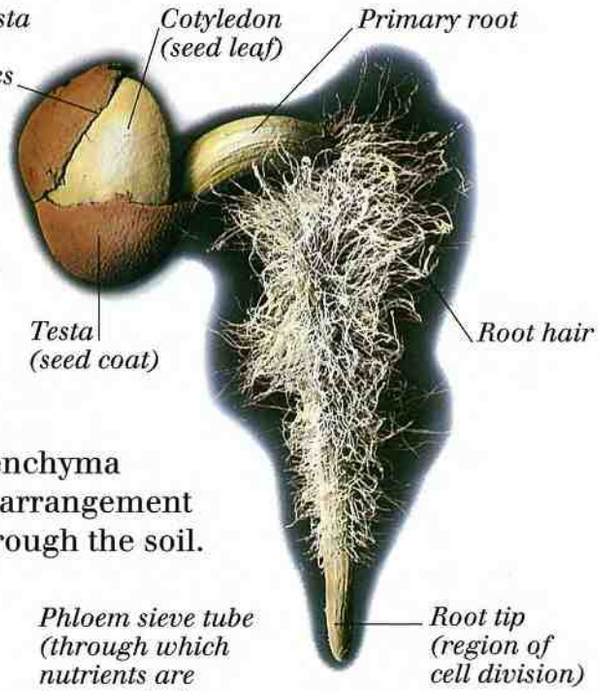


PARTS OF WOODY FLOWERING PLANTS



Roots

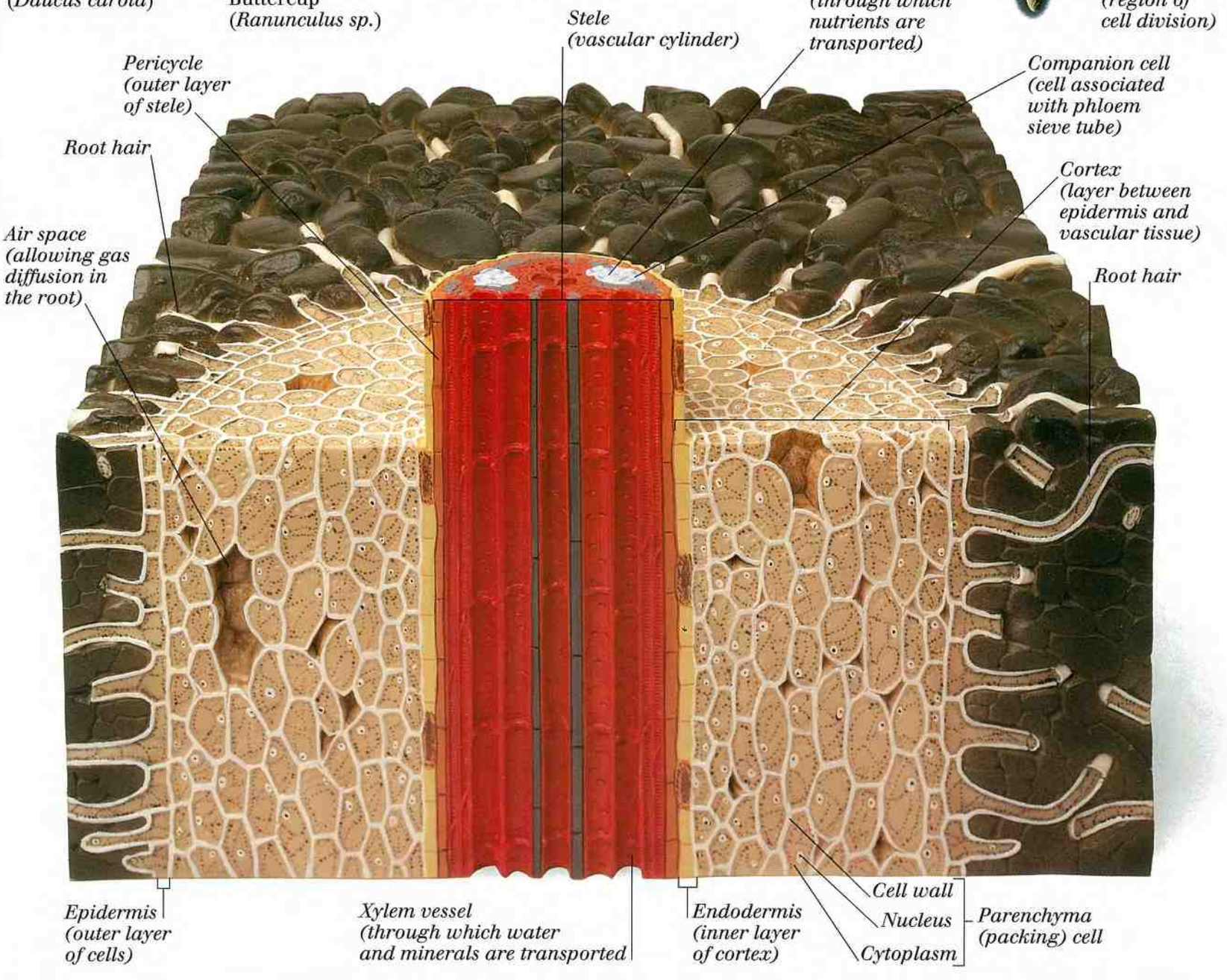
MICROGRAPH OF PRIMARY ROOT DEVELOPMENT
Cabbage (*Brassica sp.*)



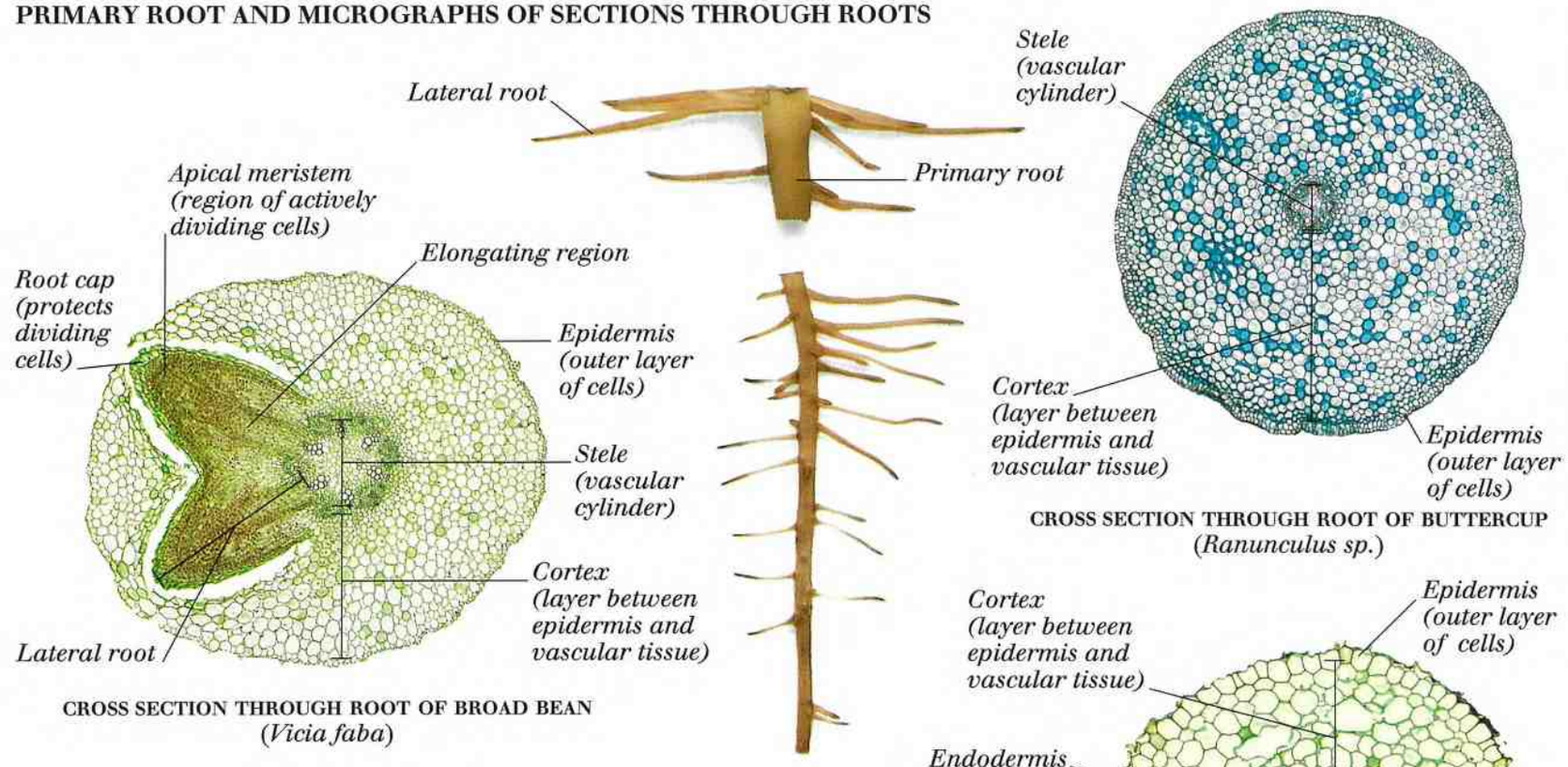
ROOTS ARE THE UNDERGROUND PARTS OF PLANTS. They have three main functions. First, they anchor the plant in the soil. Second, they absorb water and minerals from the spaces between soil particles. The roots' absorptive properties are increased by root hairs, which grow behind the root tip, allowing maximum absorption of vital substances. Third, the root is part of the plant's transport system. Xylem carries water and minerals from the roots to the stem and leaves, and phloem carries nutrients from the leaves to all parts of the root system. In addition, some roots (like carrots) are food stores. Roots have an outer epidermis covering a cortex of parenchyma (packing tissue), and a central cylinder of vascular tissue. This arrangement helps the roots resist the forces of compression as they grow through the soil.

CARROT
(*Daucus carota*)

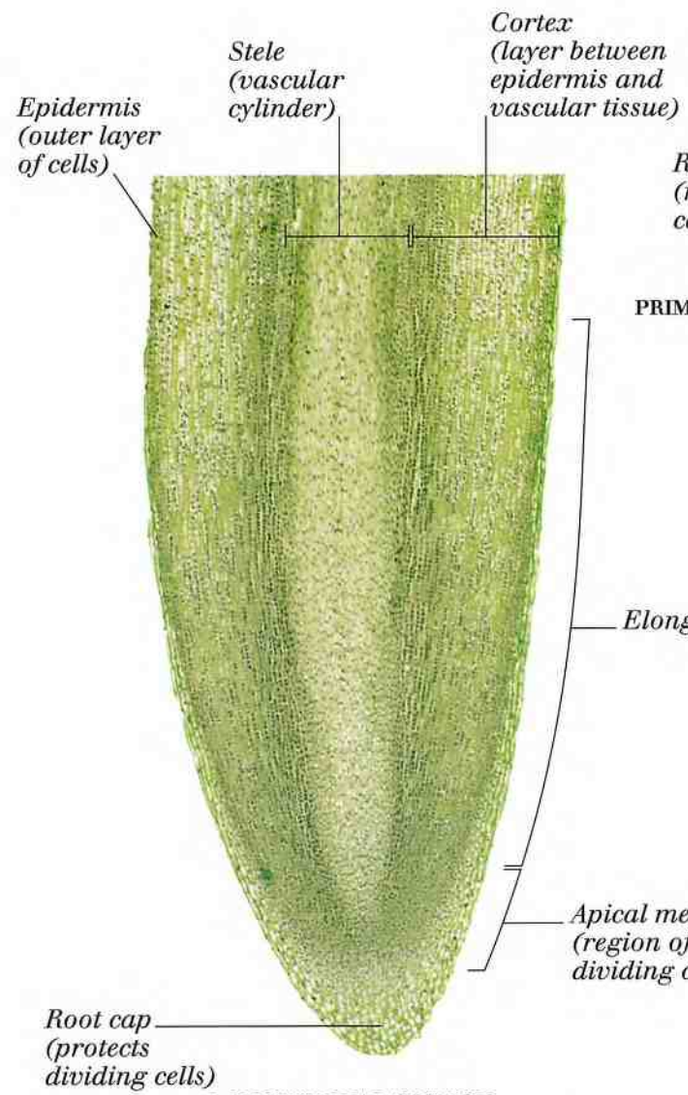
FEATURES OF A TYPICAL ROOT
Buttercup
(*Ranunculus sp.*)



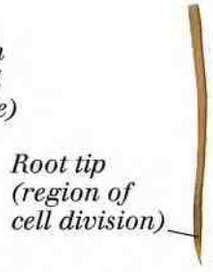
PRIMARY ROOT AND MICROGRAPHS OF SECTIONS THROUGH ROOTS



CROSS SECTION THROUGH ROOT OF BROAD BEAN
(*Vicia faba*)

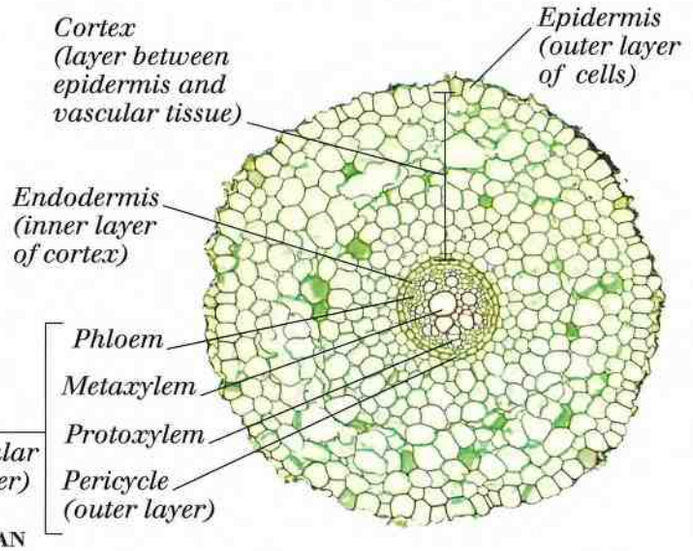


LONGITUDINAL SECTION
THROUGH ROOT TIP OF BROAD BEAN
(*Vicia faba*)

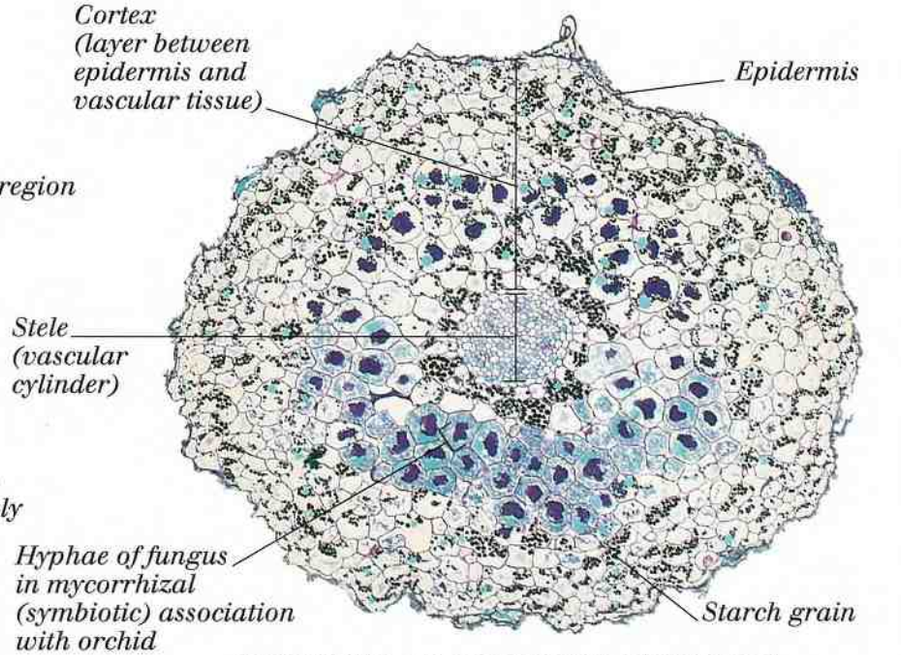


PRIMARY ROOT OF BROAD BEAN
(*Vicia faba*)

CROSS SECTION THROUGH ROOT OF BUTTERCUP
(*Ranunculus sp.*)



CROSS SECTION THROUGH ROOT OF LILY
(*Lilium sp.*)

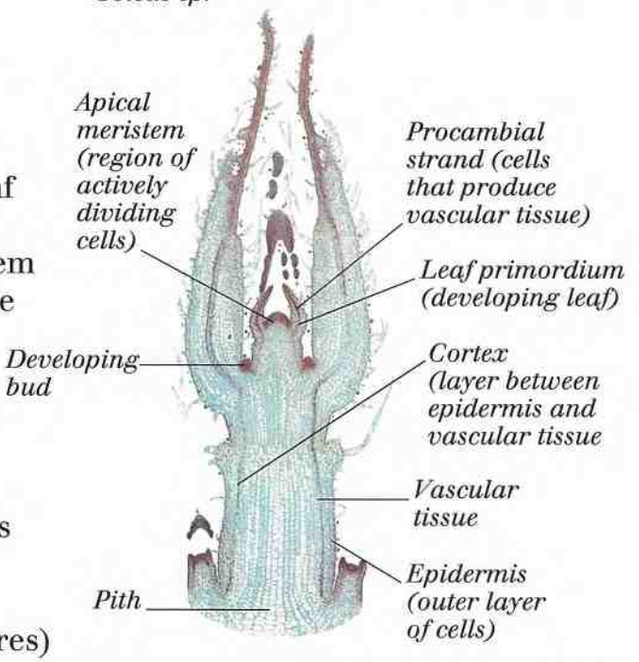


CROSS SECTION THROUGH ROOT OF ORCHID IN
MYCORRHIZAL ASSOCIATION WITH FUNGUS

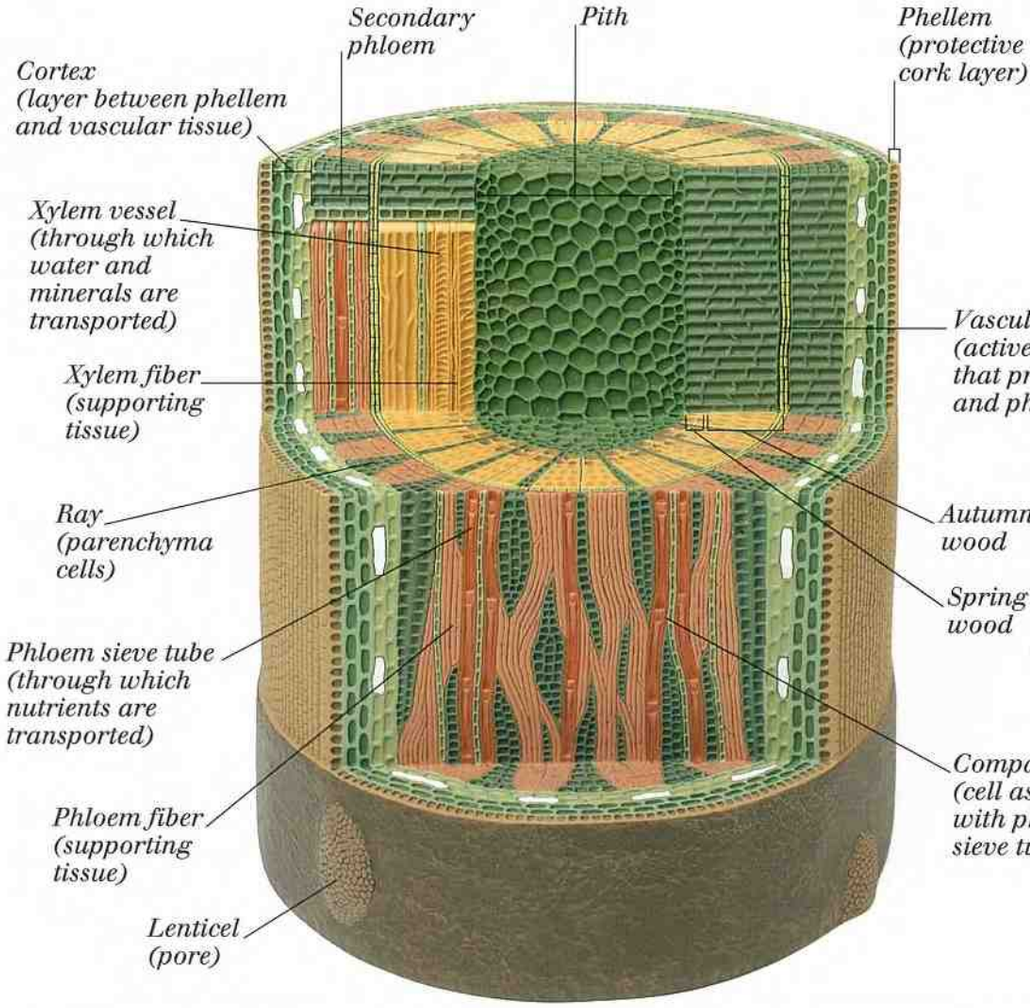
Stems

THE STEM IS THE MAIN SUPPORTIVE PART OF A PLANT that grows above ground. Stems bear leaves (organs of photosynthesis), which grow at nodes; buds (shoots covered by protective scales), which grow at the stem tip (apical or terminal buds) and in the angle between a leaf and the stem (axillary or lateral buds); and flowers (reproductive structures). The stem forms part of the plant's transport system. Xylem tissue in the stem transports water and minerals from the roots to the aerial parts of the plant, and phloem tissue transports nutrients manufactured in the leaves to other parts of the plant. Stem tissues are also used for storing water and food. Herbaceous (nonwoody) stems have an outer protective epidermis covering a cortex that consists mainly of parenchyma (packing tissue) but also has some collenchyma (supporting tissue). The vascular tissue of such stems is arranged in bundles, each of which consists of xylem, phloem, and sclerenchyma (strengthening tissue). Woody stems have an outer protective layer of tough bark, which is perforated with lenticels (pores) to allow gas exchange. Inside the bark is a ring of secondary phloem, which surrounds an inner core of secondary xylem.

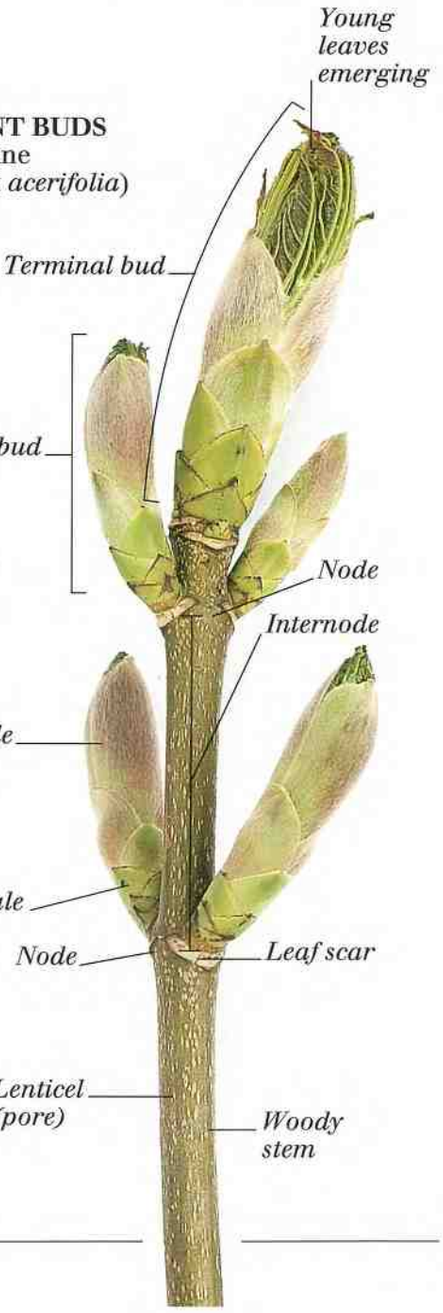
MICROGRAPH OF LONGITUDINAL SECTION THROUGH APEX OF STEM
Coleus sp.



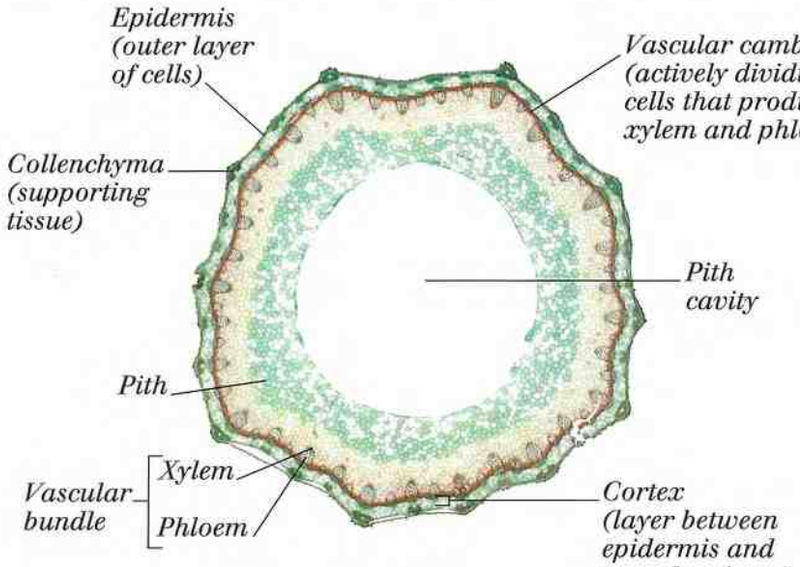
YOUNG WOODY STEM
Lime
(*Tilia sp.*)



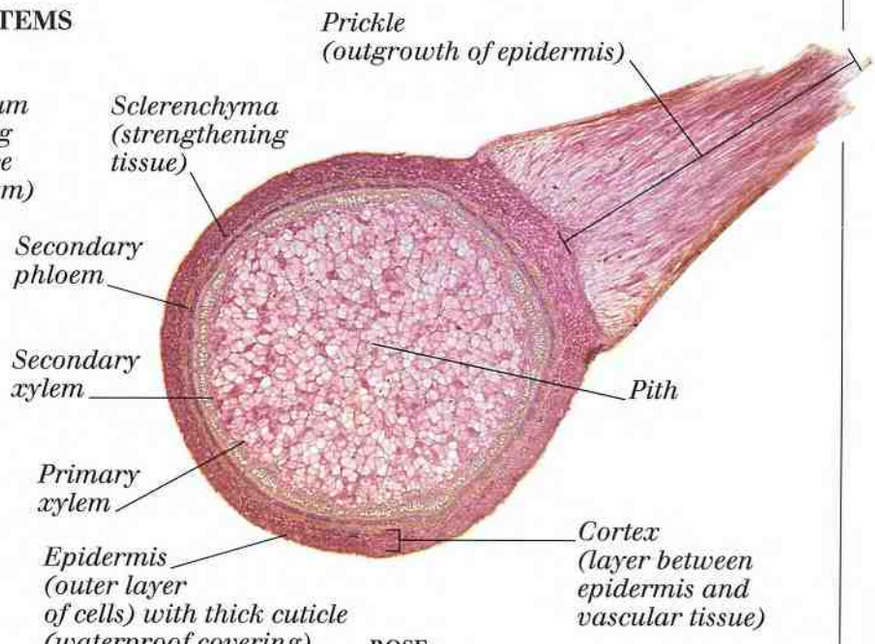
EMERGENT BUDS
London plane
(*Platanus x acerifolia*)



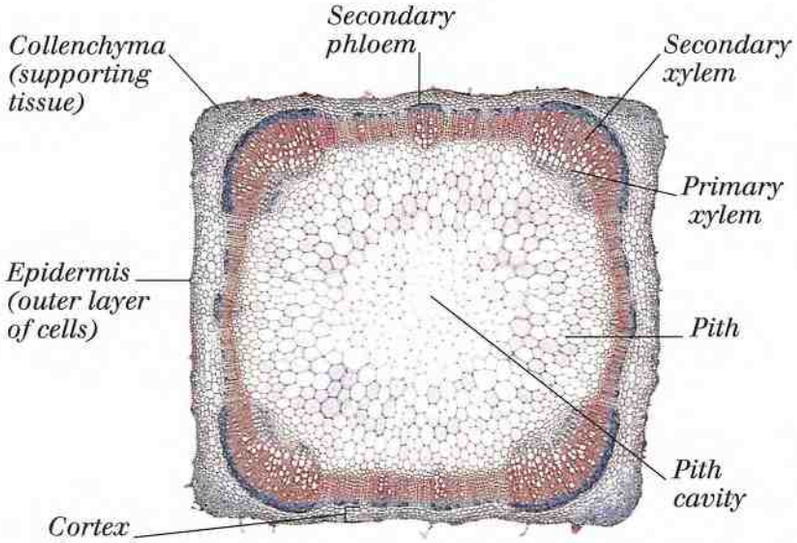
MICROGRAPHS OF CROSS SECTIONS THROUGH VARIOUS STEMS



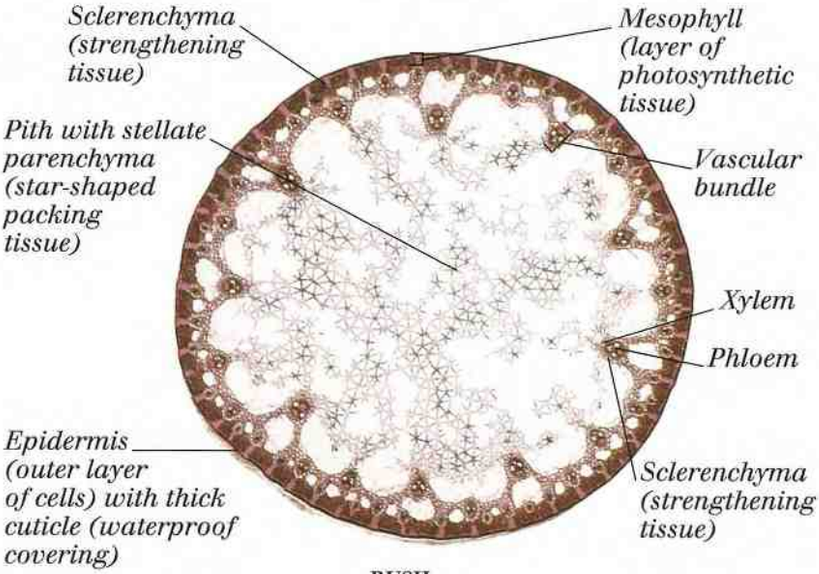
CHERVIL
(Anthriscus sp.)



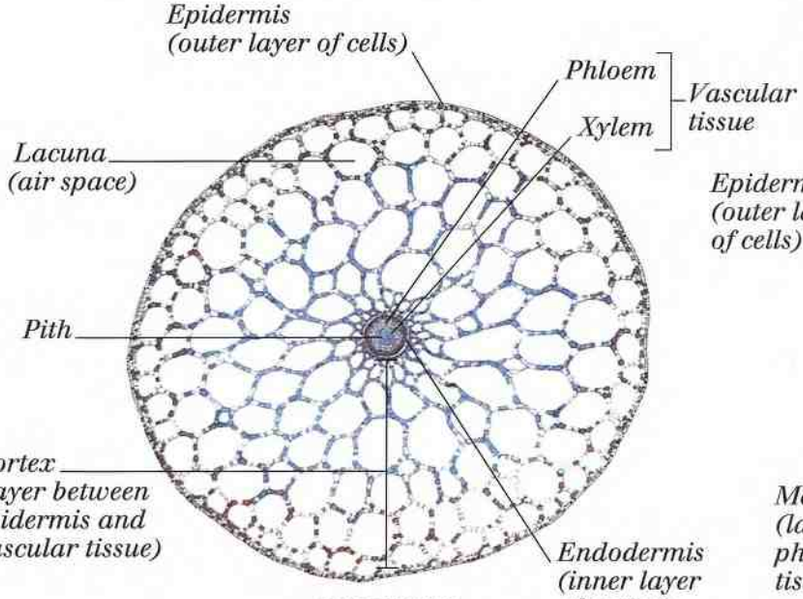
ROSE
(Rosa sp.)



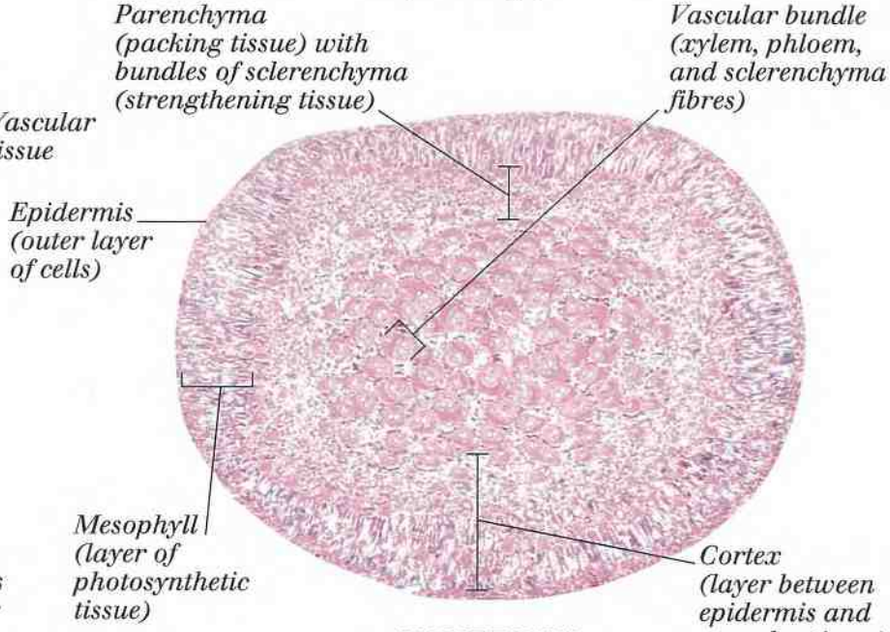
DEADNETTLE
(Lamium sp.)



RUSH
(Juncus sp.)

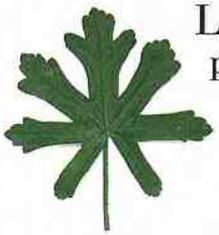


MARE'S TAIL
(Hippuris vulgaris)



COCONUT PALM
(Cocos nucifera)

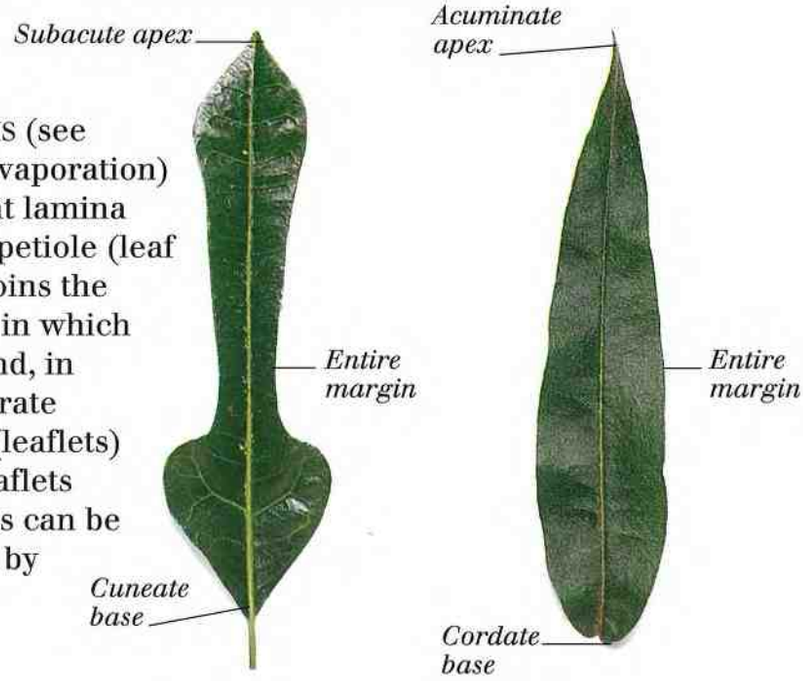
Leaves



CHECKERBLOOM
(*Sidalcea malviflora*)

LEAVES ARE THE MAIN SITES OF PHOTOSYNTHESIS (see pp. 32-33) and transpiration (water loss by evaporation) in plants. A typical leaf consists of a thin, flat lamina (blade) supported by a network of veins; a petiole (leaf stalk); and a leaf base, where the petiole joins the stem. Leaves can be classified as simple, in which the lamina is a single unit, or compound, in which the lamina is divided into separate leaflets. Compound leaves may be pinnate, with pinnae (leaflets) on both sides of a rachis (main axis), or palmate, with leaflets arising from a single point at the tip of the petiole. Leaves can be classified further by the overall shape of the lamina, and by the shape of the lamina's apex, margin, and base.

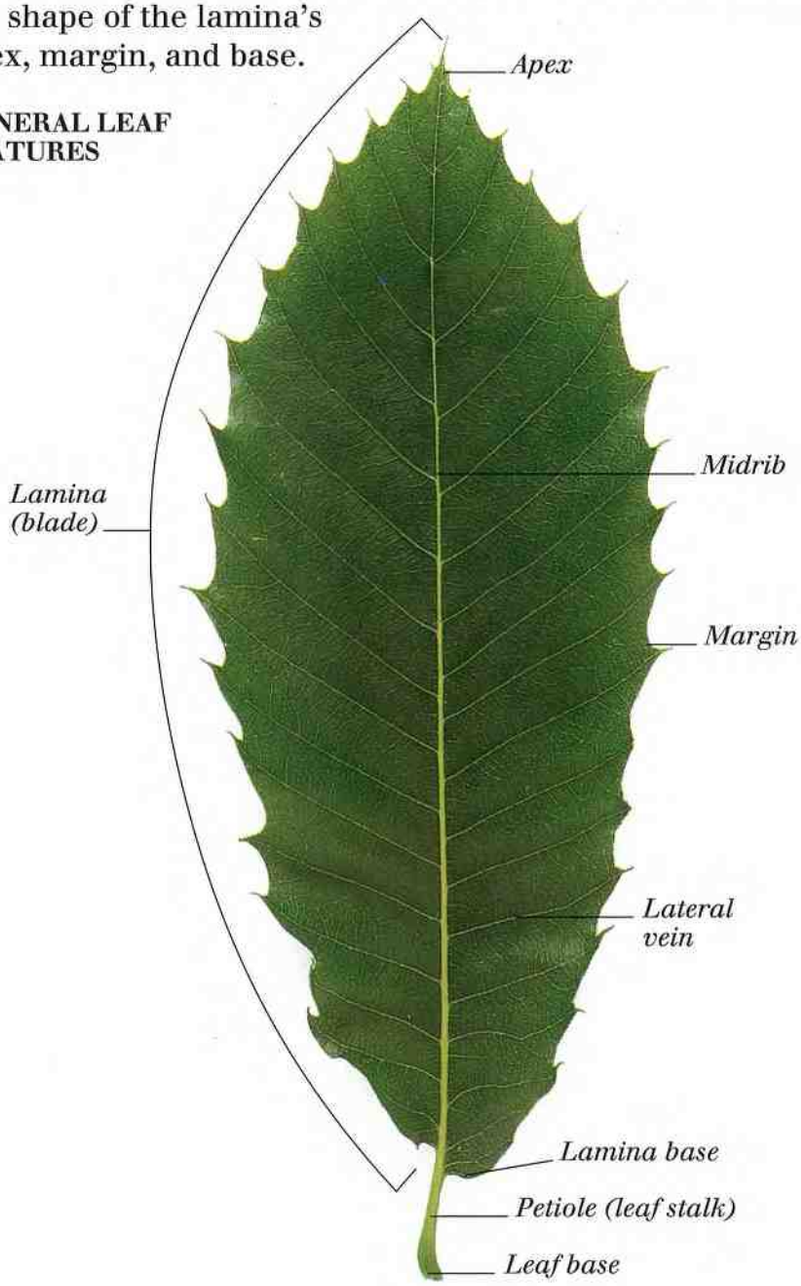
SIMPLE LEAF SHAPES



PANDURIFORM
Croton
(*Codiaeum variegatum*)

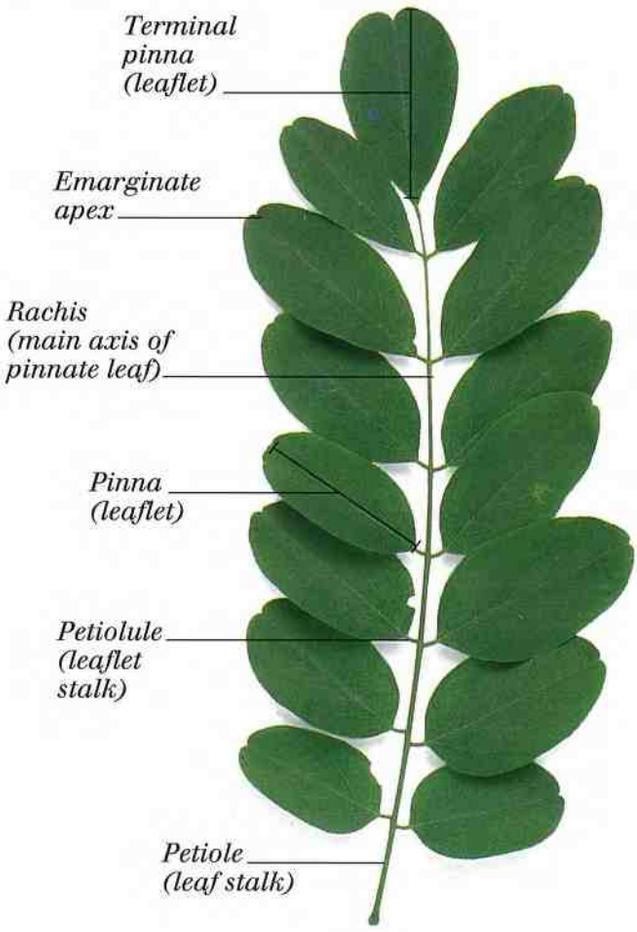
LANCEOLATE
Sea buckthorn
(*Hippophae rhamnoides*)

GENERAL LEAF FEATURES

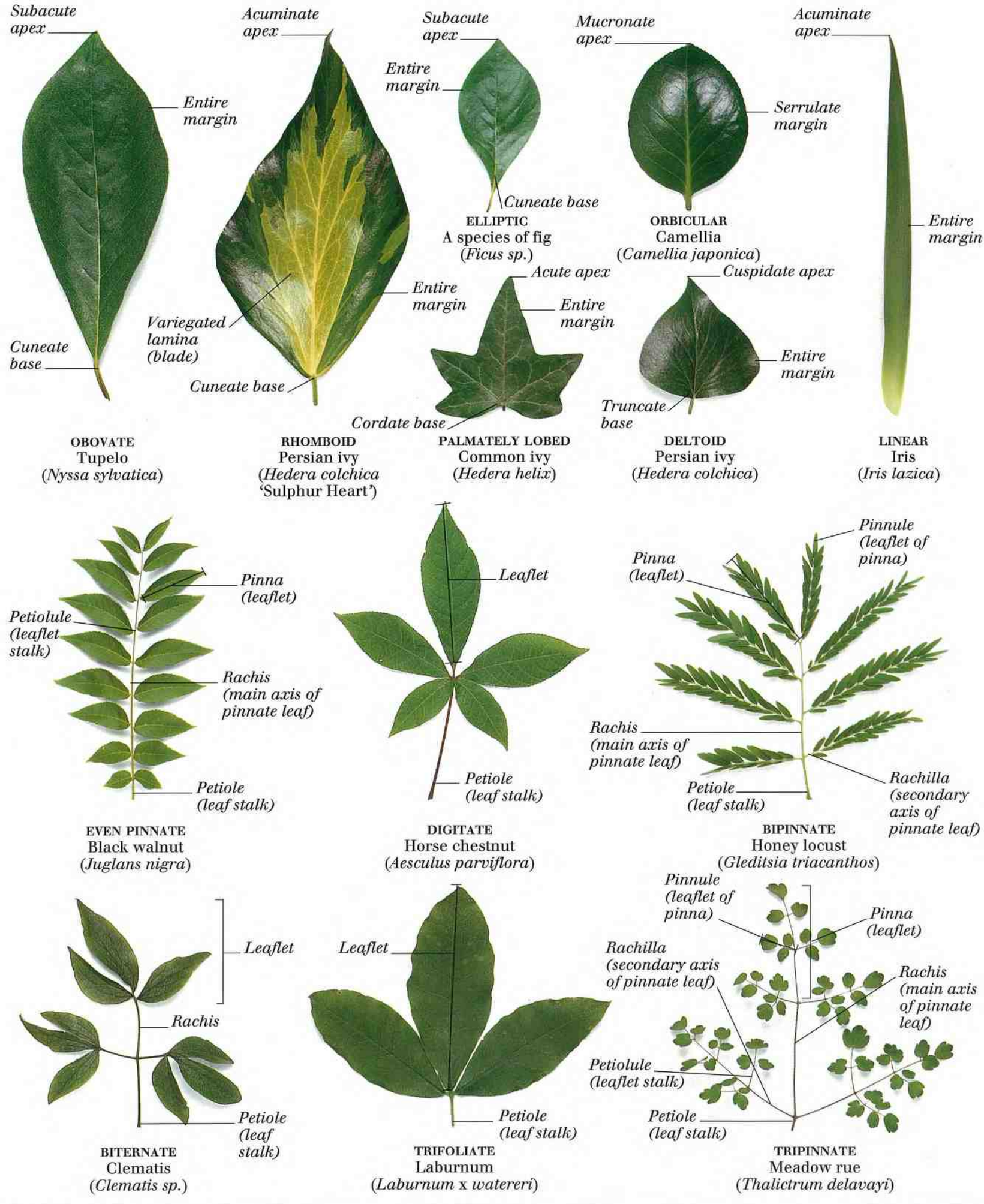


Spanish chestnut
(*Castanea sativa*)

COMPOUND LEAF SHAPES



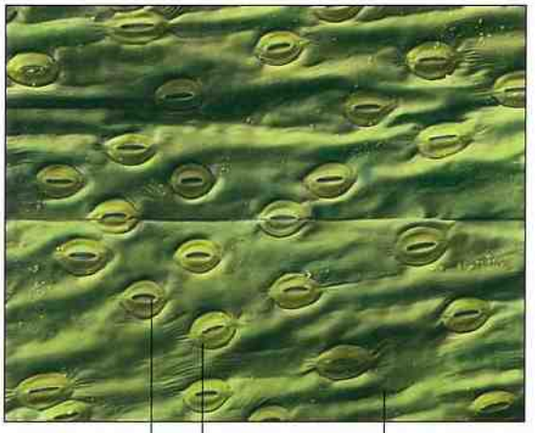
ODD PINNATE
False acacia
(*Robinia pseudoacacia*)


Subacute apex
Entire margin
Cuneate base
OBOVATE
Tupelo
(Nyssa sylvatica)
Acuminate apex
Entire margin
Variegated lamina (blade)
Cuneate base
RHOMBOID
Persian ivy
(Hedera colchica 'Sulphur Heart')
Subacute apex
Entire margin
Cuneate base
ELLIPTIC
A species of fig
(Ficus sp.)
Acute apex
Entire margin
Cordate base
PALMATELY LOBED
Common ivy
(Hedera helix)
Mucronate apex
Serrulate margin
ORBICULAR
Camellia
(Camellia japonica)
Cuspidate apex
Entire margin
Truncate base
DELTOID
Persian ivy
(Hedera colchica)
Acuminate apex
Entire margin
LINEAR
Iris
(Iris lazica)
Pinna (leaflet)
Petiolule (leaflet stalk)
Rachis (main axis of pinnate leaf)
Petiole (leaf stalk)
EVEN PINNATE
Black walnut
(Juglans nigra)
Leaflet
Petiole (leaf stalk)
DIGITATE
Horse chestnut
(Aesculus parviflora)
Pinnule (leaflet of pinna)
Pinna (leaflet)
Rachis (main axis of pinnate leaf)
Petiole (leaf stalk)
Rachilla (secondary axis of pinnate leaf)
BIPINNATE
Honey locust
(Gleditsia triacanthos)
Leaflet
Rachis
Petiole (leaf stalk)
BITERNATE
Clematis
(Clematis sp.)
Leaflet
Petiole (leaf stalk)
TRIFOLIATE
Laburnum
(Laburnum x watereri)
Pinnule (leaflet of pinna)
Pinna (leaflet)
Rachilla (secondary axis of pinnate leaf)
Rachis (main axis of pinnate leaf)
Petiolule (leaflet stalk)
Petiole (leaf stalk)
TRIPINNATE
Meadow rue
(Thalictrum delavayi)

Photosynthesis

PHOTOSYNTHESIS IS THE PROCESS by which plants make their food using sunlight, water, and carbon dioxide. It takes place inside special structures in leaf cells called chloroplasts. The chloroplasts contain chlorophyll, a green pigment that absorbs energy from sunlight. During photosynthesis, the absorbed energy is used to join together carbon dioxide and water to form the sugar glucose, which is the energy source for the whole plant. Oxygen, a waste product, is released into the air. Leaves are the main sites of photosynthesis and have various adaptations for that purpose. Flat laminae (blades) provide a large surface for absorbing sunlight; stomata (pores) in the lower surface of the laminae allow gases (carbon dioxide and oxygen) to pass into and out of the leaves; and an extensive network of veins brings water into the leaves and transports the glucose produced by photosynthesis to the rest of the plant.

MICROGRAPH OF LEAF
Lily (*Lilium sp.*)



Stoma (pore)

Guard cell (controls opening and closing of stoma)

Lower surface of lamina (blade)

THE PROCESS OF PHOTOSYNTHESIS

Glucose molecule

Oxygen atom

Carbon atom

Hydrogen atom

Glucose is a high-energy product of photosynthesis. It travels to all parts of the plant through the phloem

Sunlight, which is absorbed by chloroplasts in the leaf, provides the energy for photosynthesis

The leaf is the main site of photosynthesis. Its broad, thin lamina (blade) is an adaptation for this process

Hydrogen atom

Oxygen atom

Hydrogen atom

Water molecule

Oxygen atom

Carbon atom

Oxygen atom

Carbon dioxide molecule

Oxygen atom

Oxygen atom

Oxygen molecule

Water, a raw material in the soil, travels to the leaf from the roots via the xylem

Carbon dioxide, a raw material in the air, enters the leaf through stomata on the lower surface of the lamina (blade)

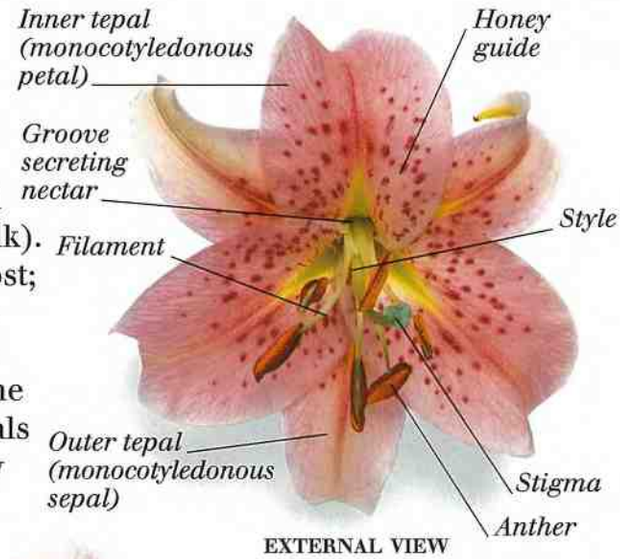
Oxygen, a waste product of photosynthesis, leaves the leaf through stomata on the lower surface of the lamina (blade)

CROSS SECTION THROUGH LEAF
Christmas rose
(Helleborus niger)

INTERNAL VIEW OF CHLOROPLAST

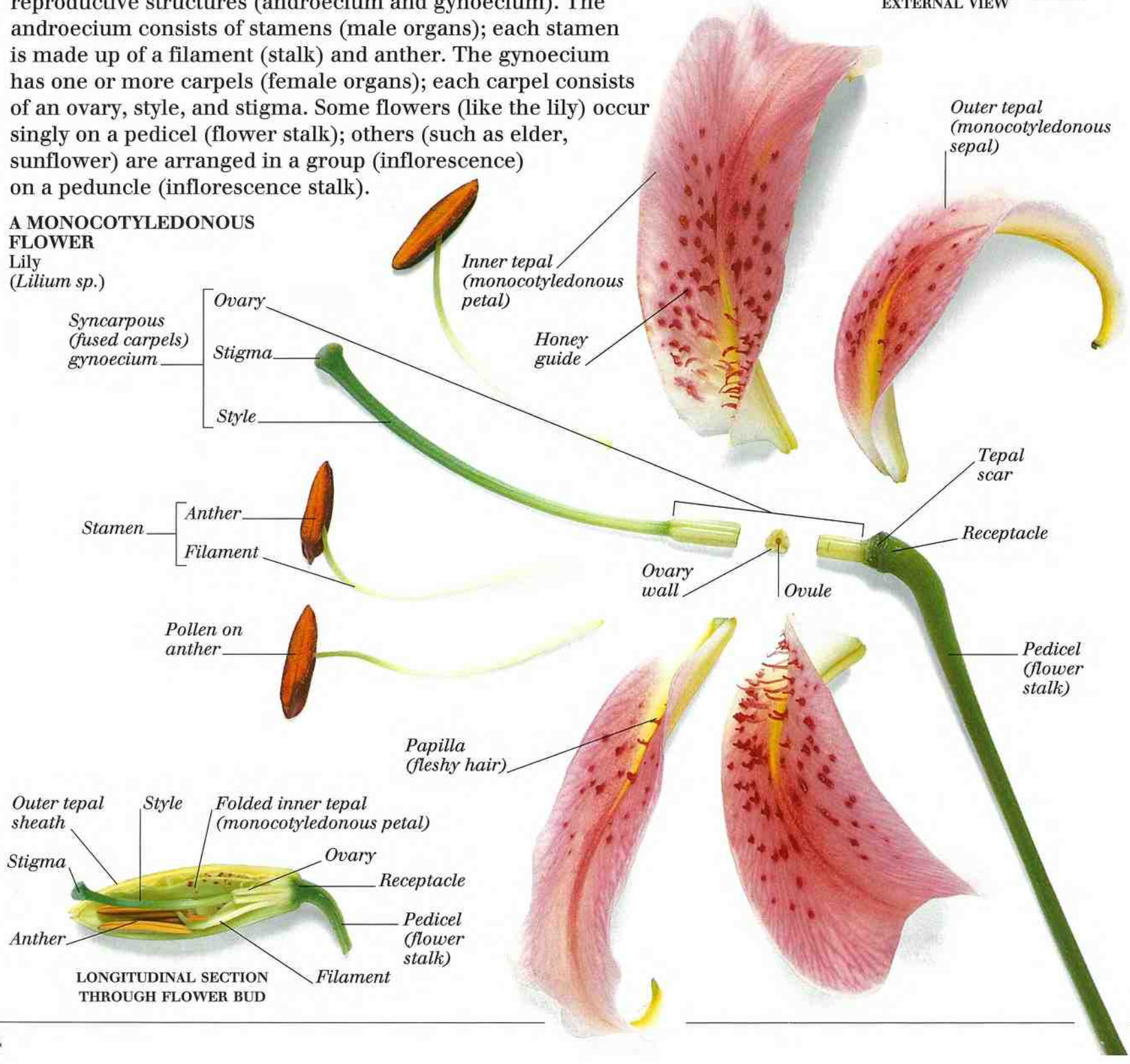
Flowers 1

FLOWERS ARE THE SITES OF SEXUAL REPRODUCTION in flowering plants. Their component parts are arranged in whorls around the receptacle (tip of the flower stalk). The sepals (collectively called the calyx) are outermost; typically small and green, they protect the developing flower. The petals (collectively called the corolla) are typically large and brightly colored; they are found inside the sepals. In monocotyledonous flowers (see pp. 20-21), sepals and petals are indistinguishable; individually they are called tepals (collectively called the perianth). The petals surround the male and female reproductive structures (androecium and gynoecium). The androecium consists of stamens (male organs); each stamen is made up of a filament (stalk) and anther. The gynoecium has one or more carpels (female organs); each carpel consists of an ovary, style, and stigma. Some flowers (like the lily) occur singly on a pedicel (flower stalk); others (such as elder, sunflower) are arranged in a group (inflorescence) on a peduncle (inflorescence stalk).

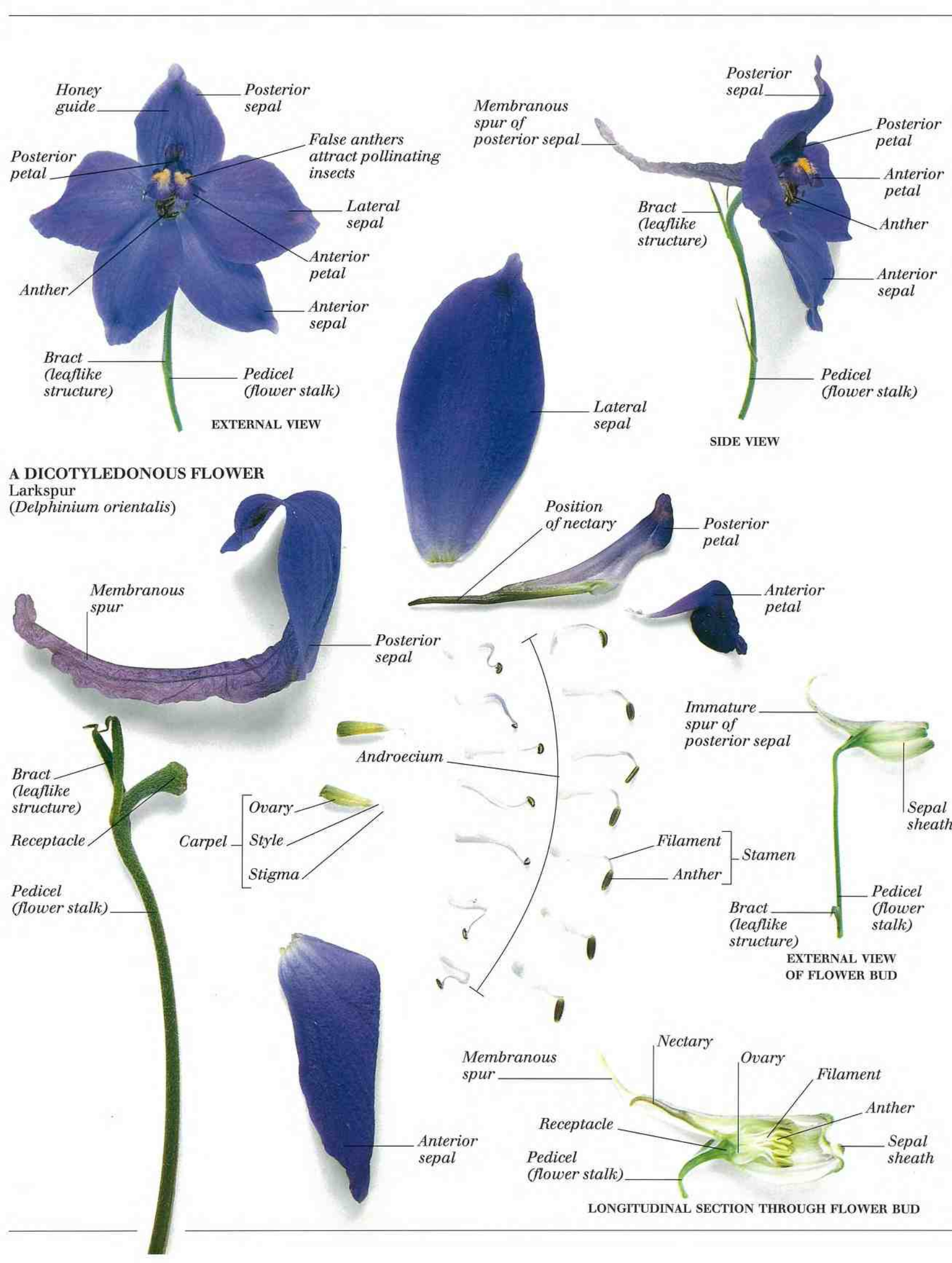


EXTERNAL VIEW

A MONOCOTYLEDONOUS FLOWER
Lily
(*Lilium sp.*)

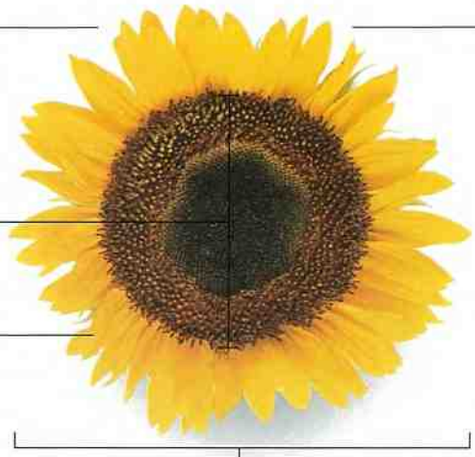


LONGITUDINAL SECTION THROUGH FLOWER BUD

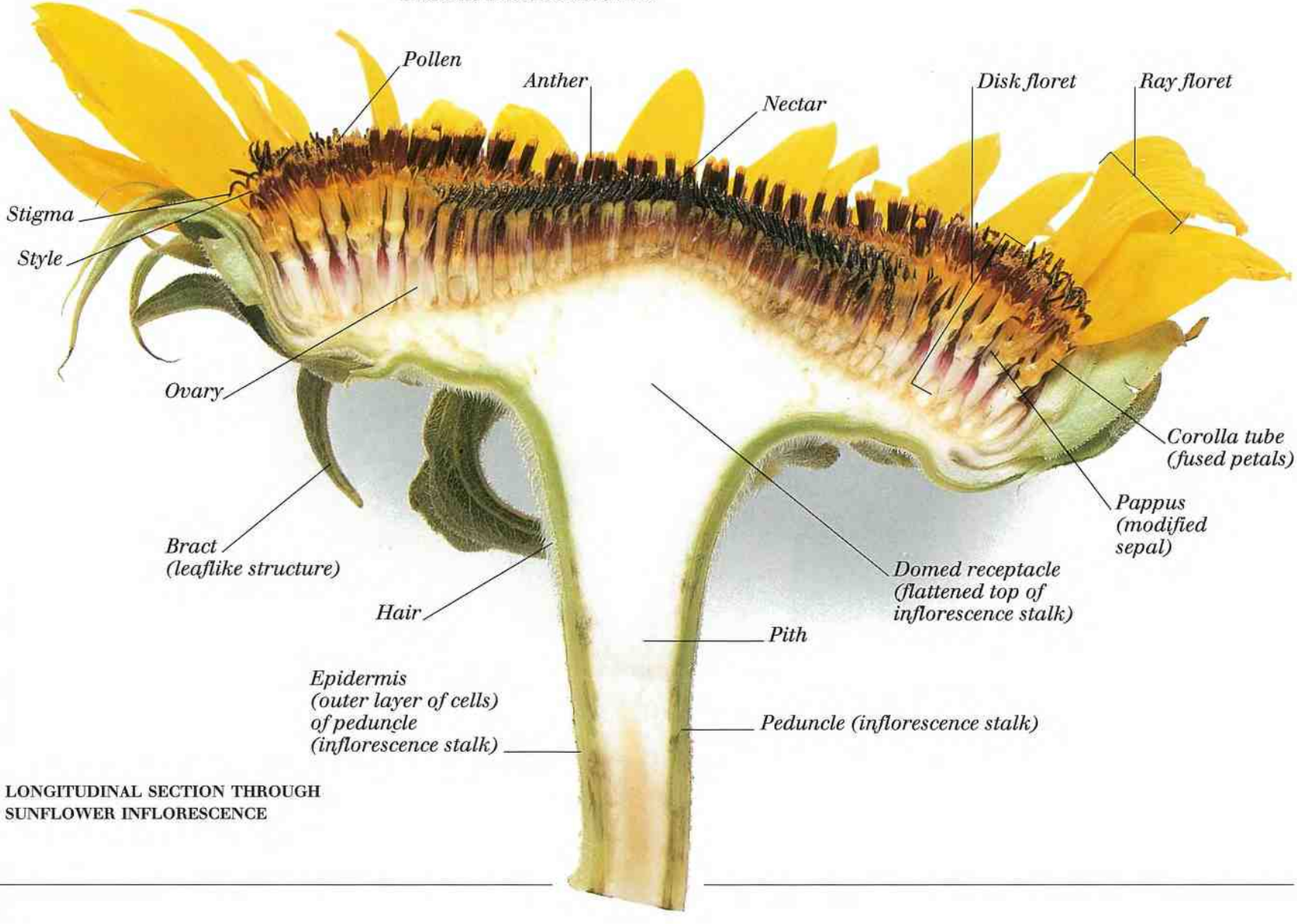

Honey guide
Posterior sepal
False anthers attract pollinating insects
Posterior petal
Lateral sepal
Anterior petal
Anther
Anterior sepal
Bract (leaflike structure)
Pedicel (flower stalk)
EXTERNAL VIEW
Membranous spur of posterior sepal
Posterior sepal
Posterior petal
Anterior petal
Anther
Bract (leaflike structure)
Anterior sepal
Pedicel (flower stalk)
SIDE VIEW
Lateral sepal
A DICOTYLEDONOUS FLOWER
Larkspur
(Delphinium orientalis)
Position of nectary
Posterior petal
Anterior petal
Membranous spur
Posterior sepal
Androecium
Immature spur of posterior sepal
Sepal sheath
Bract (leaflike structure)
Receptacle
Pedicel (flower stalk)
Carpel
Ovary
Style
Stigma
Filament
Anther
Stamen
Pedicel (flower stalk)
Bract (leaflike structure)
EXTERNAL VIEW OF FLOWER BUD
Anterior sepal
Membranous spur
Nectary
Ovary
Filament
Anther
Receptacle
Sepal sheath
Pedicel (flower stalk)
LONGITUDINAL SECTION THROUGH FLOWER BUD

Flowers 2

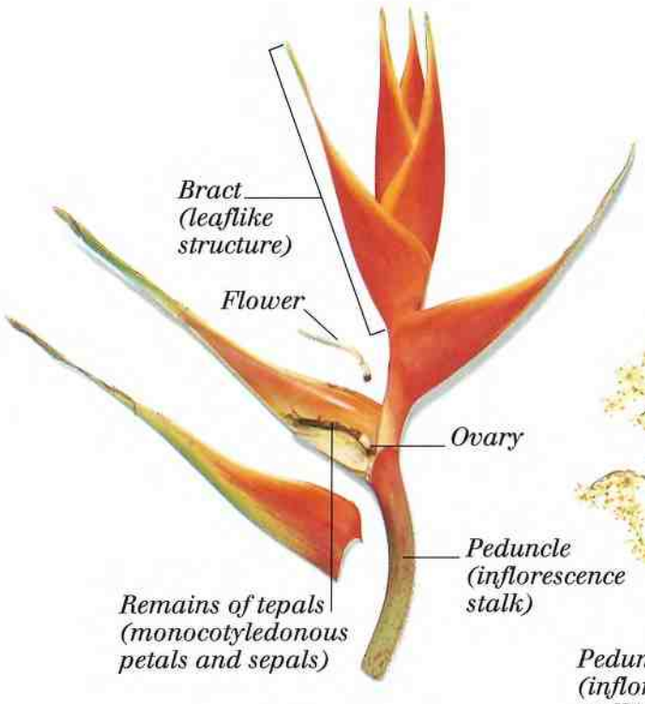
COMPOUND INFLORESCENCE (CAPITULUM)
Sunflower
(*Helianthus annulus*)



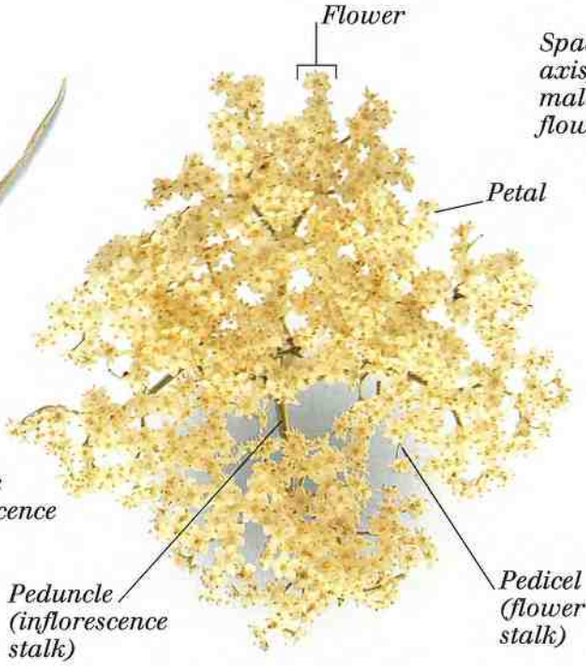
FLORETS FROM SUNFLOWER



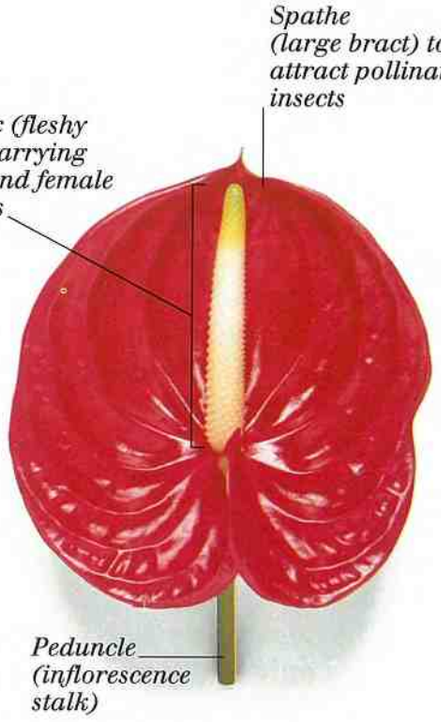
LONGITUDINAL SECTION THROUGH SUNFLOWER INFLORESCENCE



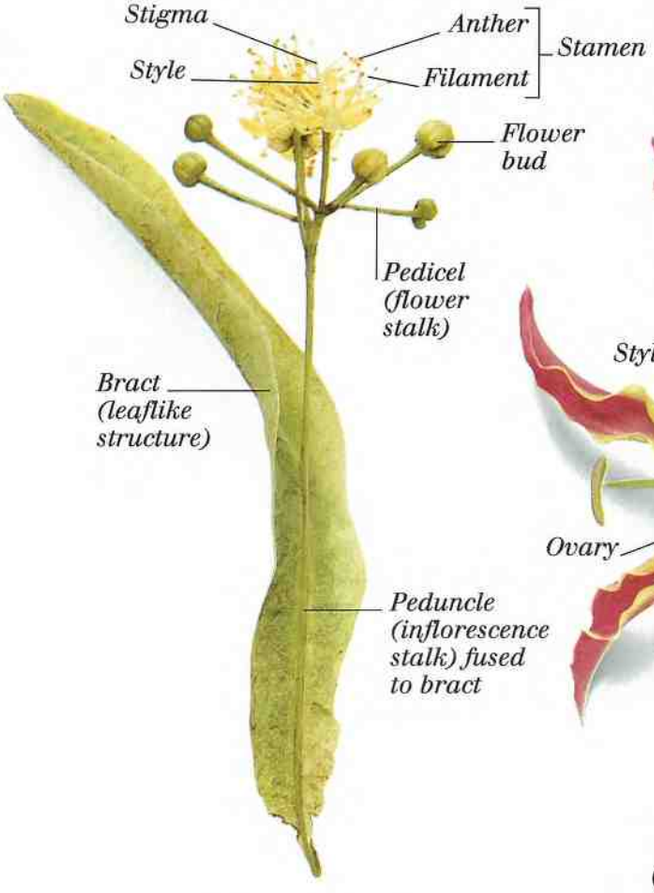
INFLORESCENCE (SPIKE)
Heliconia peruviana



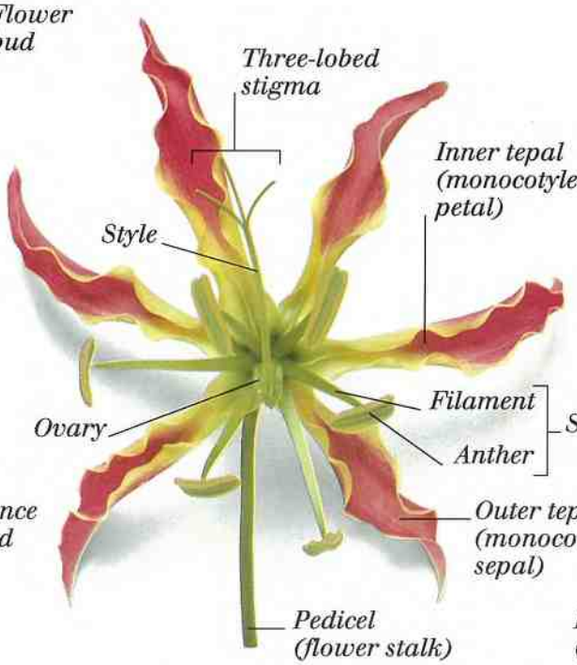
INFLORESCENCE (COMPOUND UMBEL)
European elder
(*Sambucus nigra*)



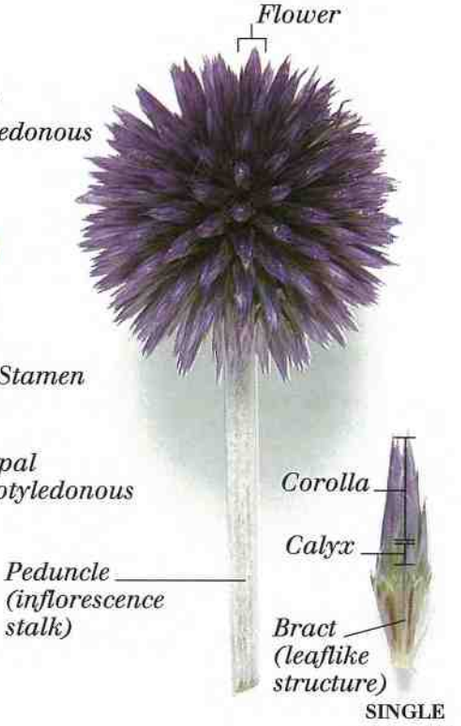
INFLORESCENCE (SPADIX)
Painter's palette
(*Anthurium andreanum*)



INFLORESCENCE (DICHASIAL CYME)
Common lime
(*Tilia* x *europaea*)



SINGLE FLOWER
Glory lily
(*Gloriosa superba*)



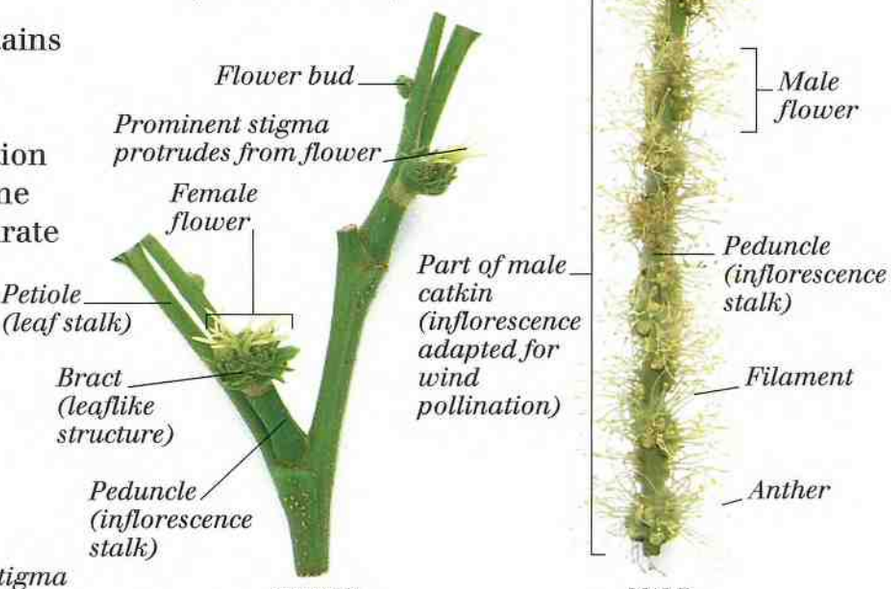
SINGLE FLOWER

INFLORESCENCE (SPHERICAL UMBEL)
Allium sp.

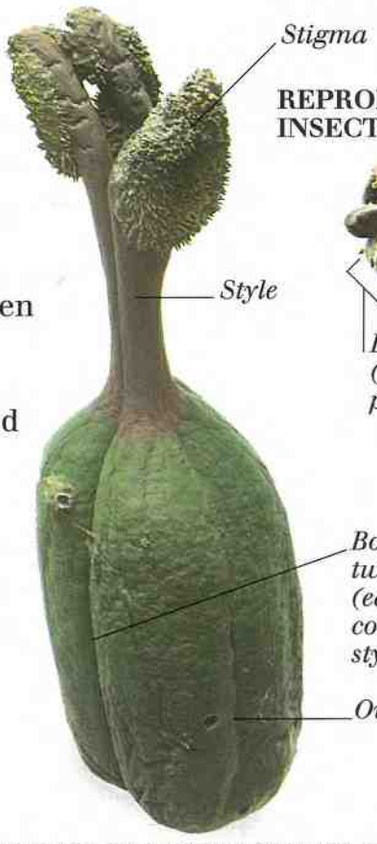
Pollination

POLLINATION IS THE TRANSFER OF POLLEN (which contains the male sex cells) from an anther (part of the male reproductive organ) to a stigma (part of the female reproductive organ). This process precedes fertilization (see pp. 40-41). Pollination may occur within the same flower (self-pollination), or between flowers on separate plants of the same species (cross-pollination). In most plants, pollination is carried out either by insects (entomophilous pollination) or by the wind (anemophilous pollination). Less commonly, birds, bats, or water are the agents of pollination. Insect-pollinated flowers are typically scented and brightly colored. They also produce nectar, on which insects feed. Such flowers also tend to have patterns that are visible only in ultraviolet light, which many insects can see but which is invisible to humans. These features attract insects, which become covered with the sticky pollen grains when they visit one flower, and then transfer the pollen to the next flower they visit. Wind-pollinated flowers are generally small, relatively inconspicuous, and unscented. They produce large quantities of light pollen grains that are easily blown by the wind to other flowers.

REPRODUCTIVE STRUCTURES IN WIND-POLLINATED PLANT
Sweet chestnut
(*Castanea sativa*)

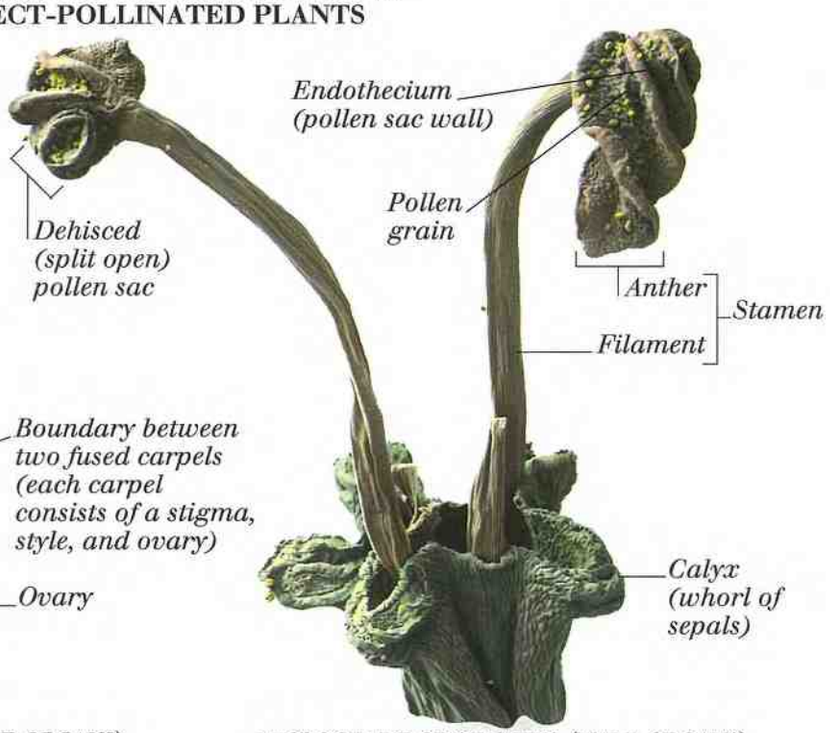


FEMALE MALE



MICROGRAPH OF CARPELS (FEMALE ORGANS)
Yellow-wort
(*Blackstonia perfoliata*)

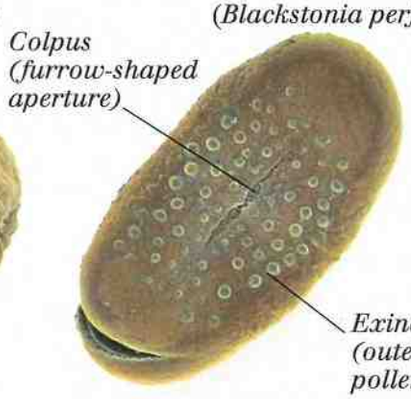
REPRODUCTIVE STRUCTURES IN INSECT-POLLINATED PLANTS



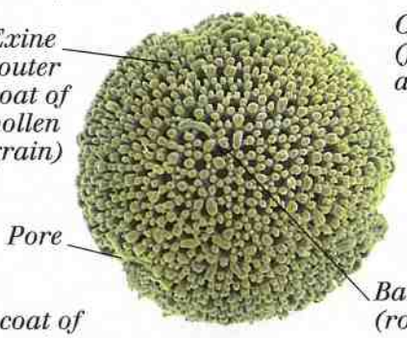
MICROGRAPH OF STAMENS (MALE ORGANS)
Common centaury
(*Centaurium erythraea*)

MICROGRAPHS OF POLLEN GRAINS

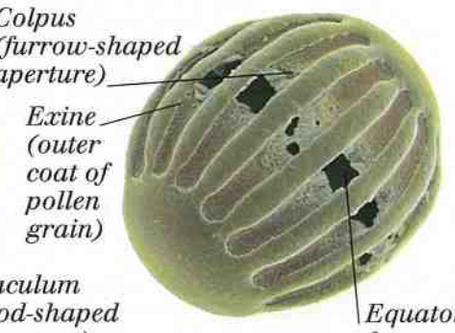
EUROPEAN FIELD ELM
(*Ulmus minor*)



JUSTICIA AUREA

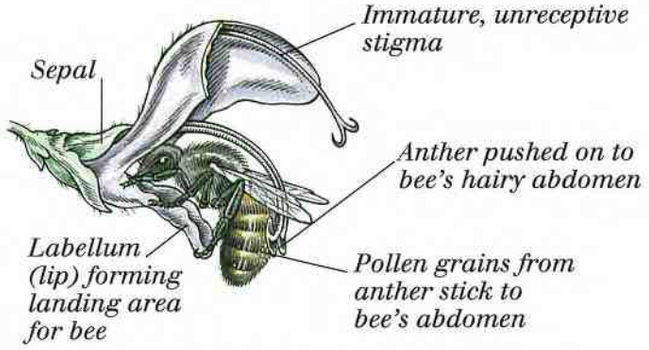


MEADOW CRANESBILL
(*Geranium pratense*)



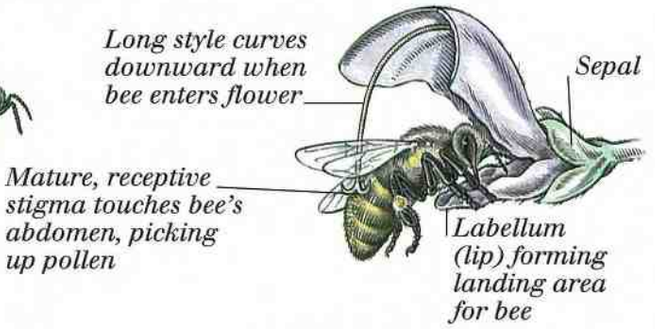
BOX-LEAVED MILKWORT
(*Polygala chamaebuxus*)

INSECT POLLINATION OF MEADOW SAGE



1. BEE VISITS FLOWER WITH MATURE ANTHERS BUT IMMATURE STIGMA

2. BEE FLIES TO OTHER FLOWERS



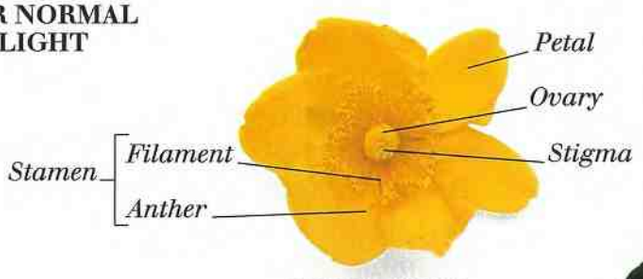
3. BEE VISITS FLOWER WHERE THE ANTHERS HAVE WITHERED AND THE STIGMA IS MATURE

SUNFLOWER UNDER NORMAL AND ULTRAVIOLET LIGHT

NORMAL LIGHT

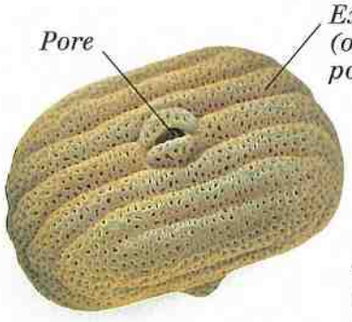
ULTRAVIOLET LIGHT

ST JOHN'S WORT UNDER NORMAL AND ULTRAVIOLET LIGHT

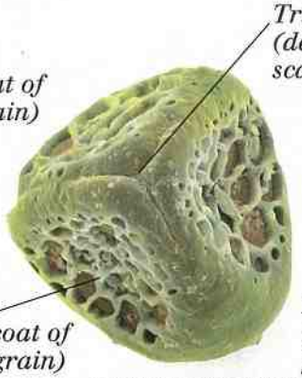


NORMAL LIGHT

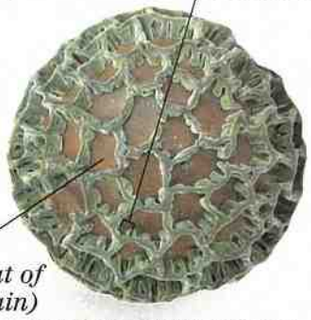
ULTRAVIOLET LIGHT



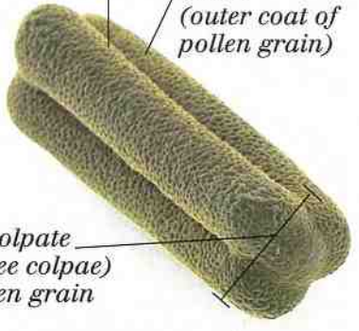
MIMULOPSIS SOLMSII



THESIUM ALPINIUM

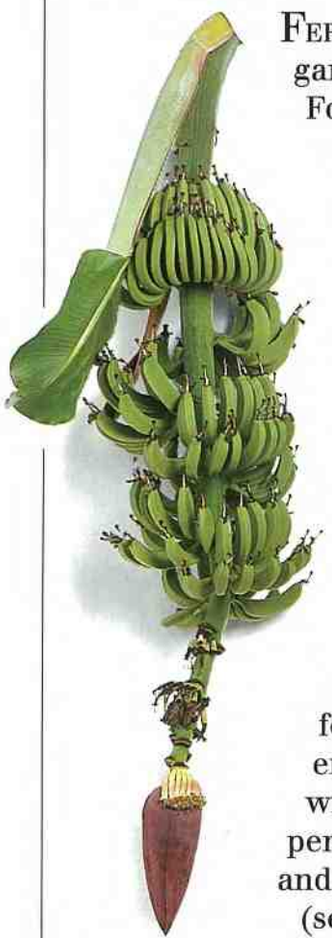


RUELLIA GRANDIFLORA



CROSSANDRA NILOTICA

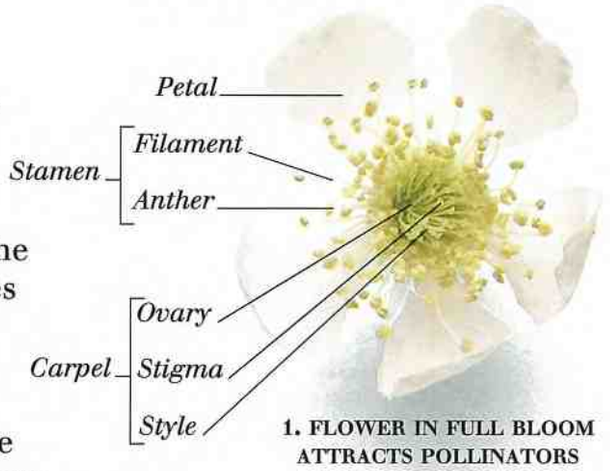
Fertilization



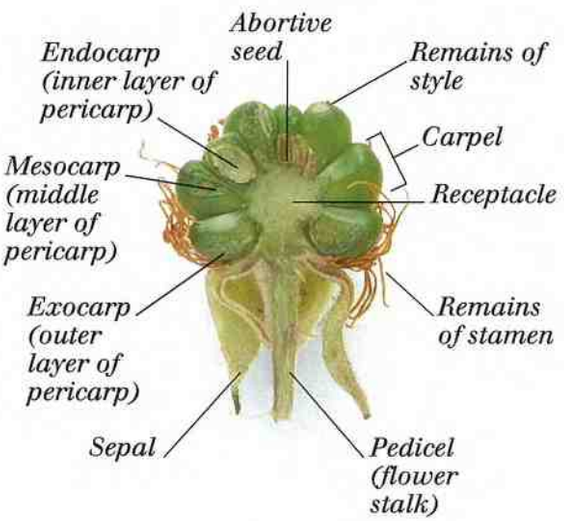
BANANA
(*Musa 'lacatan'*)

FERTILIZATION IS THE FUSION of male and female gametes (sex cells) to produce a zygote (embryo). Following pollination (see pp. 38-39), the pollen grains that contain the male gametes are on the stigma, some distance from the female gamete (ovum) inside the ovule. To enable the gametes to meet, the pollen grain germinates and produces a pollen tube, which grows down and enters the embryo sac (the inner part of the ovule that contains the ovum). Two male gametes, traveling at the tip of the pollen tube, enter the embryo sac. One gamete fuses with the ovum to produce a zygote that will develop into an embryo plant. The other male gamete fuses with two polar nuclei to produce the endosperm, which acts as a food supply for the developing embryo. Fertilization also initiates other changes: the integument (outer part of ovule) forms a testa (seed coat) around the embryo and endosperm; the petals fall off; the stigma and style wither; and the ovary wall forms a layer (called the pericarp) around the seed. Together, the pericarp and seed form the fruit, which may be succulent (see pp. 42-43) or dry (see pp. 44-45). In some species (such as blackberry), apomixis can occur: The seed develops without fertilization of the ovum by a male gamete, but endosperm formation and fruit development take place as in other species.

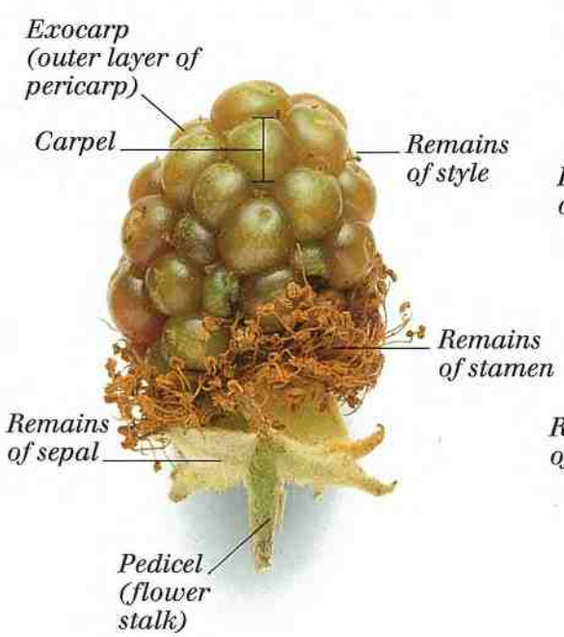
DEVELOPMENT OF A SUCCULENT FRUIT
Blackberry
(*Rubus fruticosus*)



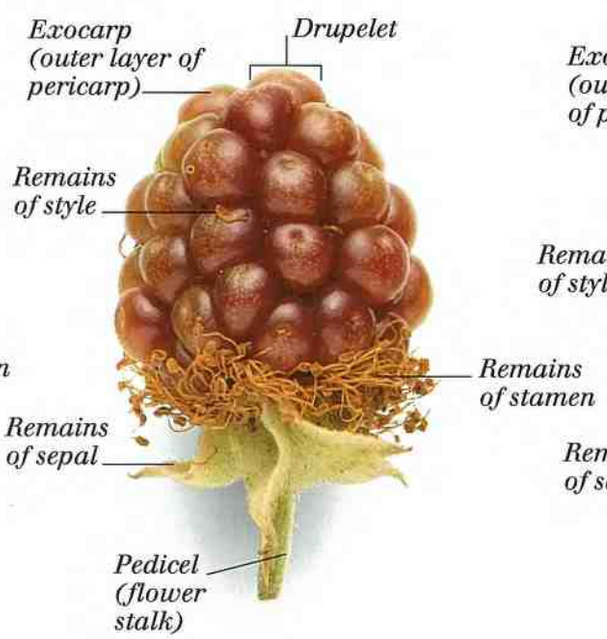
1. FLOWER IN FULL BLOOM ATTRACTS POLLINATORS



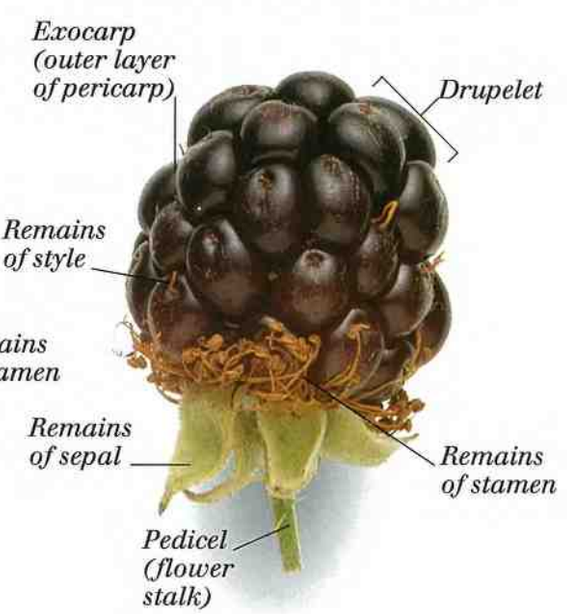
4. PERICARP FORMS FLESH, SKIN, AND A HARD INNER LAYER (SHOWN IN CROSS SECTION)



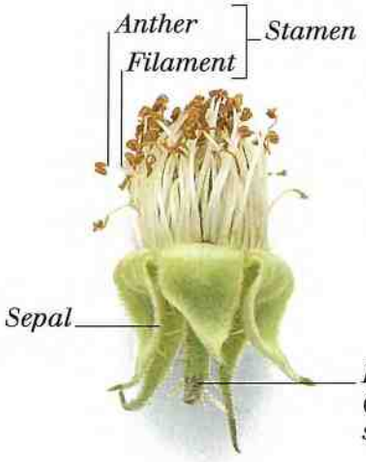
7. MESOCARP (FLESHY PART OF PERICARP) OF EACH CARPEL STARTS TO CHANGE COLOR



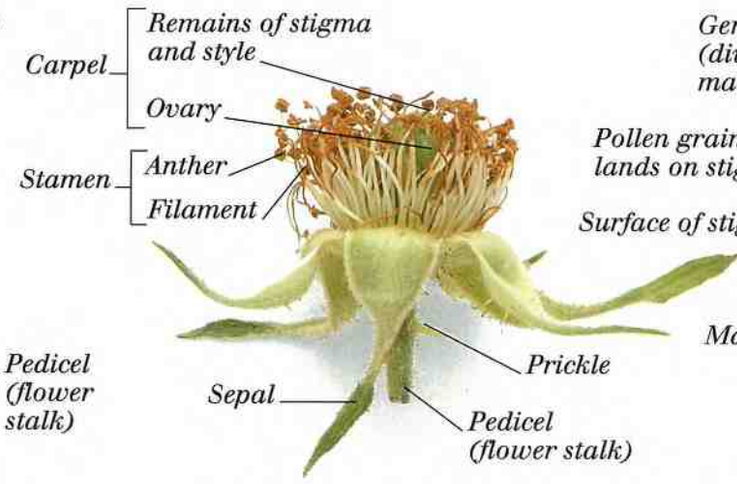
8. CARPELS MATURE INTO DRUPELETS (SMALL FLESHY FRUITS WITH SINGLE SEEDS SURROUNDED BY HARD ENDOCARP)



9. MESOCARP OF DRUPELET BECOMES DARKER AND SWEETER

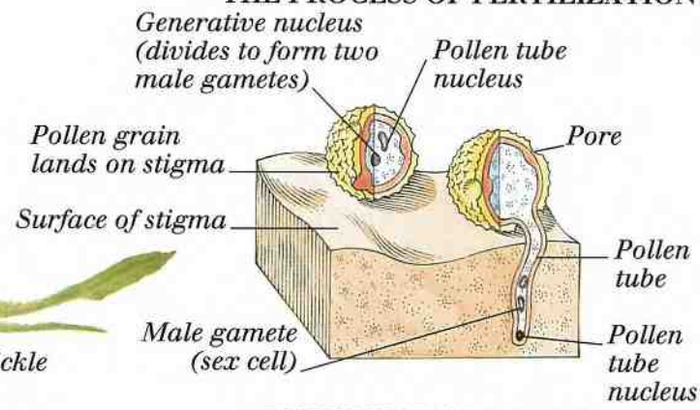


2. FERTILIZATION HAS TAKEN PLACE; PETALS FALL OFF

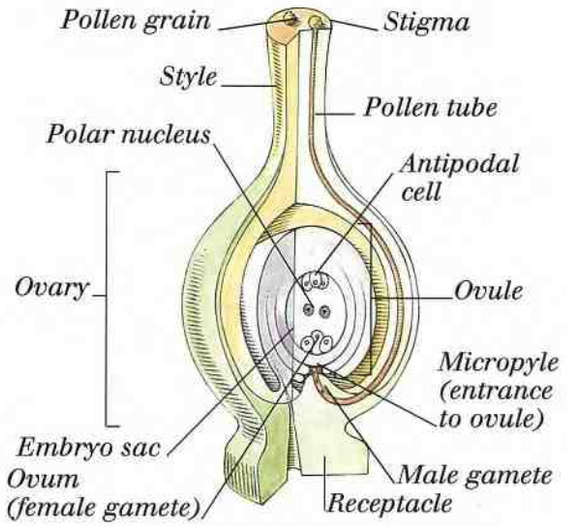


3. OVARIES BEGIN TO SWELL; STAMENS WITHER AND DIE

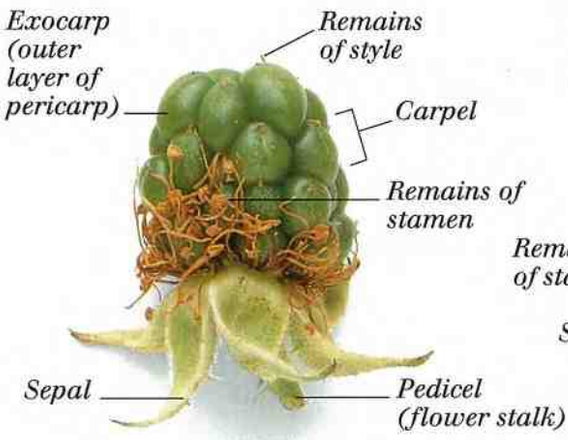
THE PROCESS OF FERTILIZATION



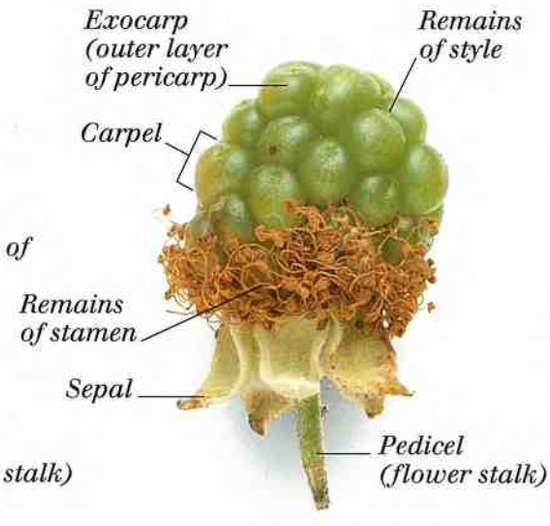
POLLEN GRAIN GERMINATES



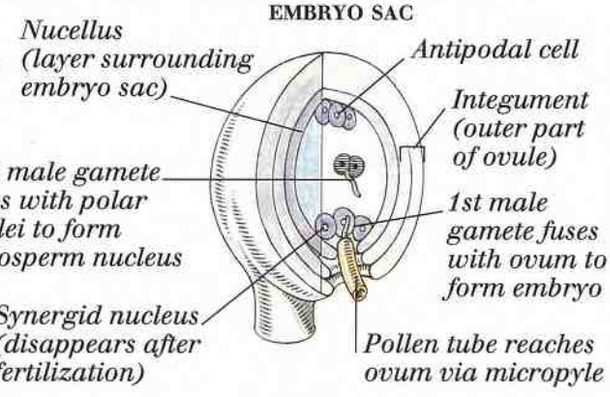
MALE GAMETES TRAVEL TO EMBRYO SAC



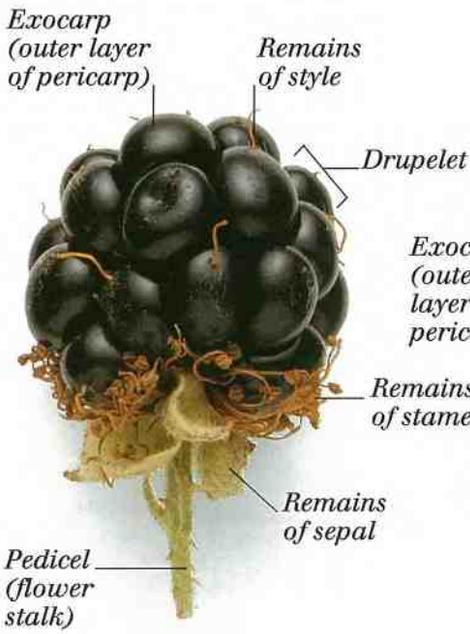
5. CARPELS EXPAND AND BECOME MORE FLESHY



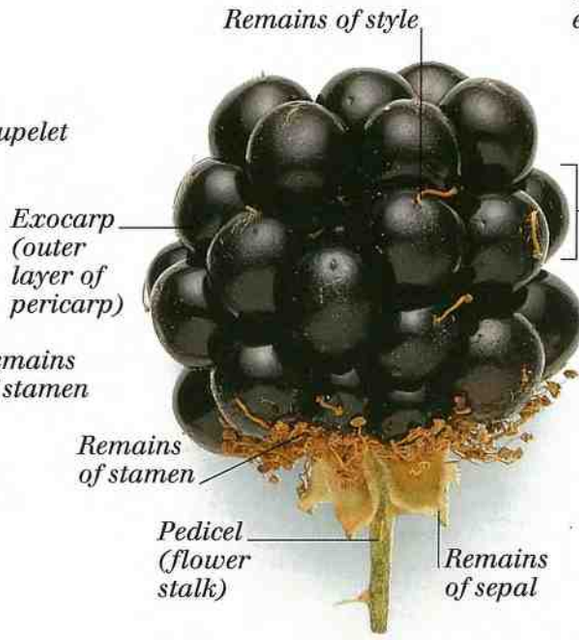
6. CARPELS EXPAND FURTHER



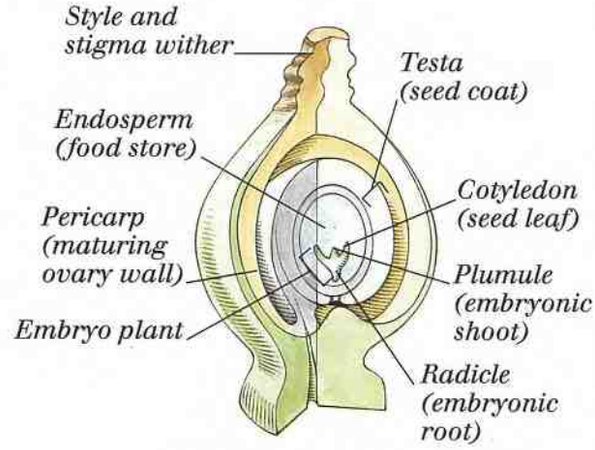
FERTILIZATION



10. DRUPELETS (COLLECTIVELY AN AGGREGATE FRUIT) EXPAND



11. DRUPELETS RIPEN FULLY



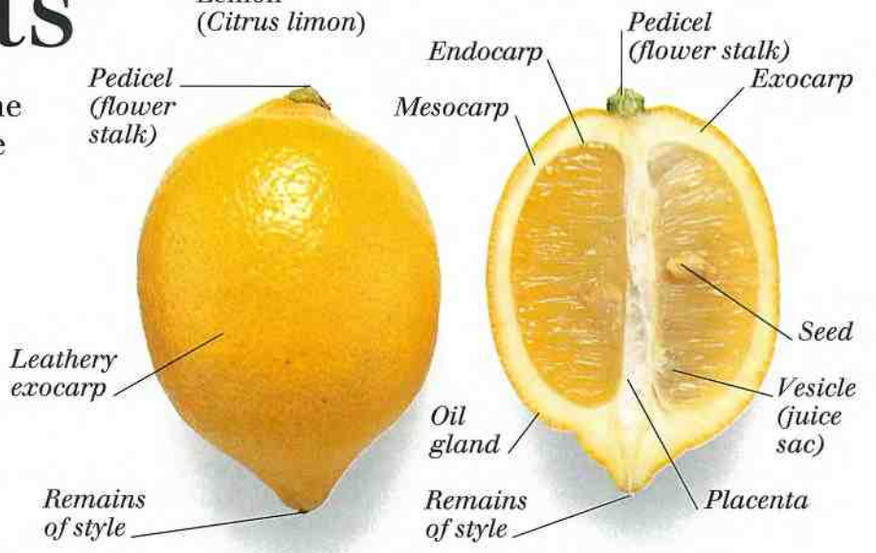
DEVELOPMENT OF EMBRYO

Succulent fruits

A FRUIT IS A FULLY DEVELOPED and ripened ovary—the seed-producing part of a plant's female reproductive organs. Fruits may be succulent or dry (see pp. 44-45). Succulent fruits are fleshy and brightly colored, making them attractive to animals, which eat them and disperse the seeds away from the parent plant. The wall (pericarp) of a succulent fruit has three layers: an outer exocarp, a middle mesocarp, and an inner endocarp. These three layers vary in thickness and texture in different types of fruits and may blend into each other. Succulent fruits can be classed as simple (derived from one ovary) or compound (derived from several ovaries). Simple succulent fruits include berries, which typically have many seeds, and drupes, which typically have a single stone or pit (such as cherry and peach). Compound succulent fruits include aggregate fruits, which are formed from many ovaries in one flower, and multiple fruits, which develop from the ovaries of many flowers. Some fruits, known as false fruits or pseudocarps, develop from parts of the flower in addition to the ovaries. For example, the flesh of the apple is formed from the receptacle (the upper end of the flower stalk).

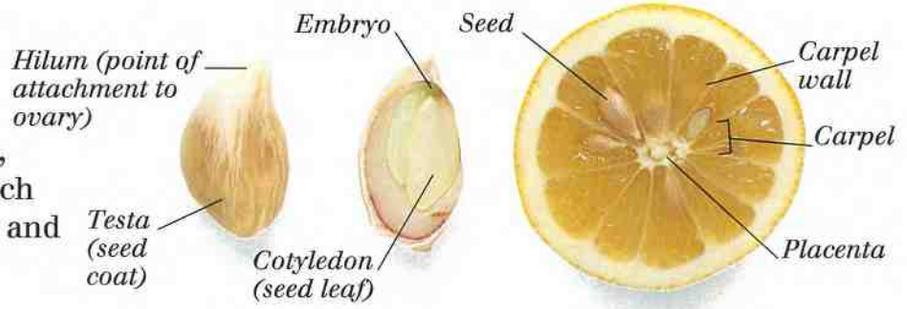
BERRY
Cocoa
(*Theobroma cacao*)

HESPERIDIUM (A TYPE OF BERRY)
Lemon
(*Citrus limon*)



EXTERNAL VIEW OF FRUIT

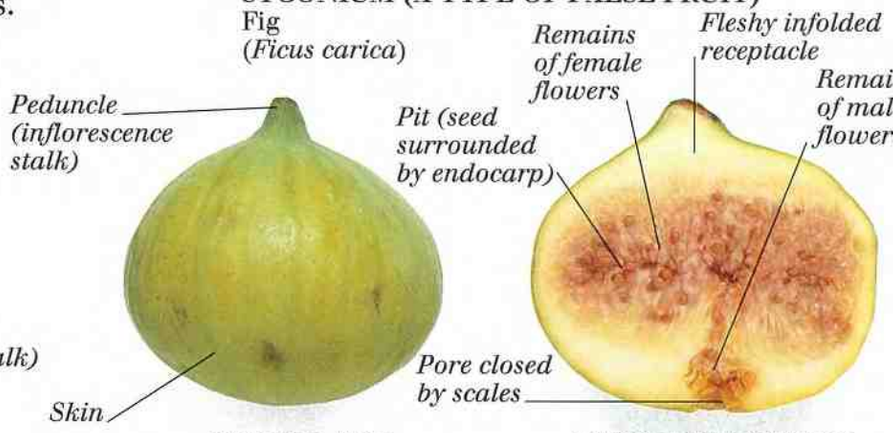
LONGITUDINAL SECTION THROUGH FRUIT



EXTERNAL VIEW AND SECTION THROUGH SEED

CROSS SECTION THROUGH FRUIT

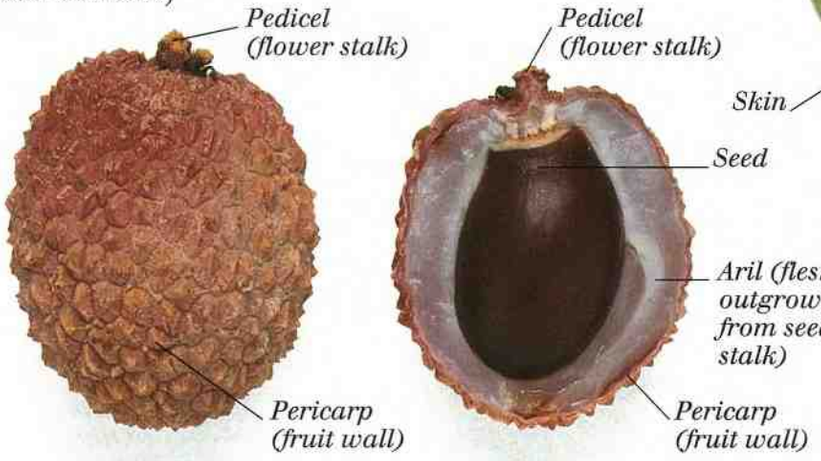
SYCONIUM (A TYPE OF FALSE FRUIT)
Fig
(*Ficus carica*)



EXTERNAL VIEW OF FRUIT

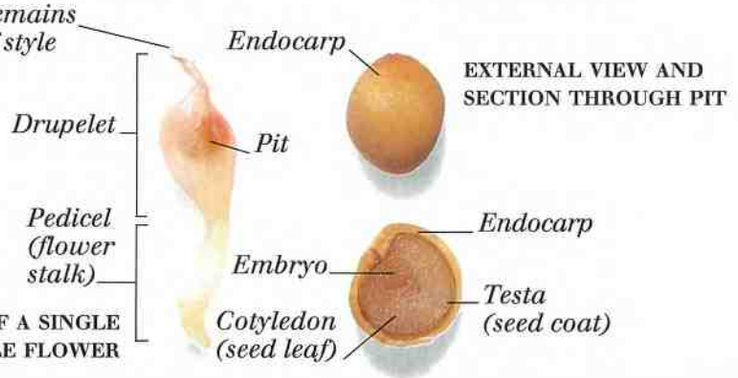
LONGITUDINAL SECTION THROUGH FRUIT

FRUIT WITH FLESHY ARIL
Lychee
(*Litchi chinensis*)



EXTERNAL VIEW OF FRUIT

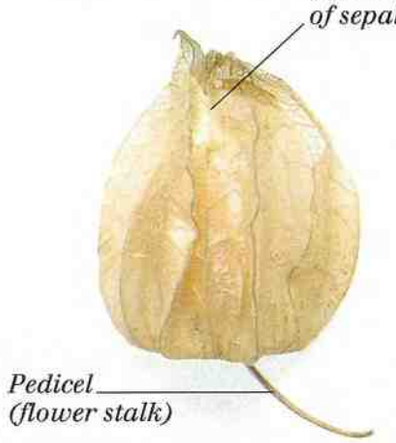
LONGITUDINAL SECTION THROUGH FRUIT



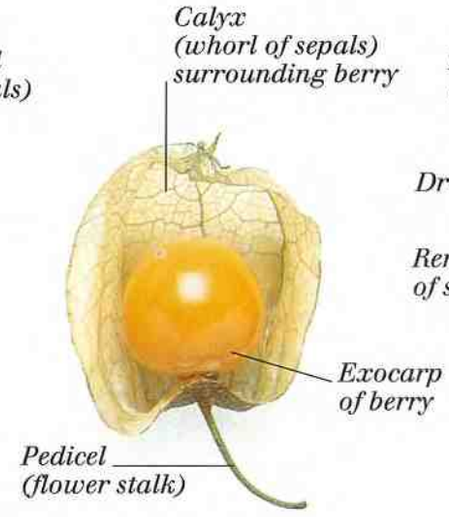
REMAINS OF A SINGLE FEMALE FLOWER

EXTERNAL VIEW AND SECTION THROUGH PIT

BERRY
Cape gooseberry
(*Physalis peruviana*)

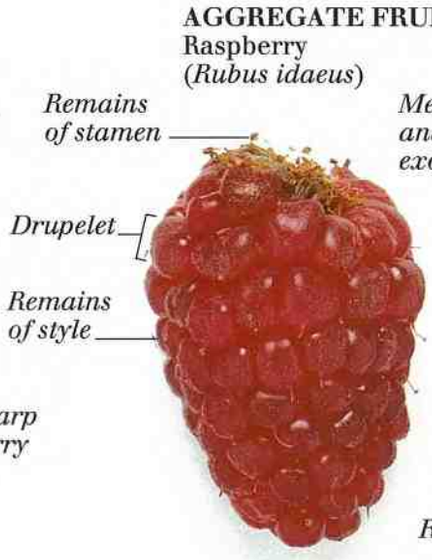


EXTERNAL VIEW OF FRUIT

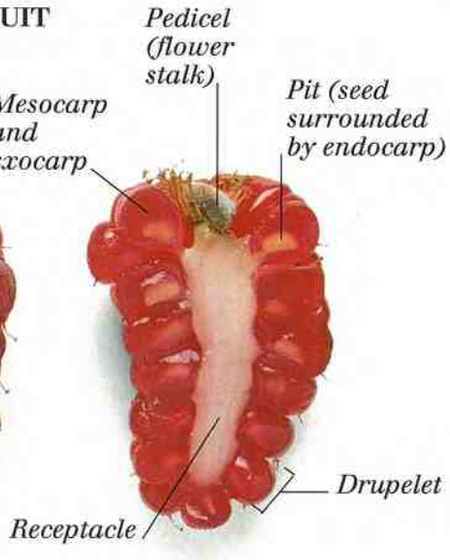


INTERNAL VIEW OF FRUIT

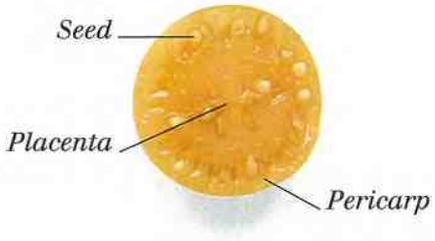
AGGREGATE FRUIT
Raspberry
(*Rubus idaeus*)



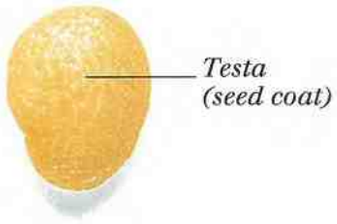
EXTERNAL VIEW OF FRUIT



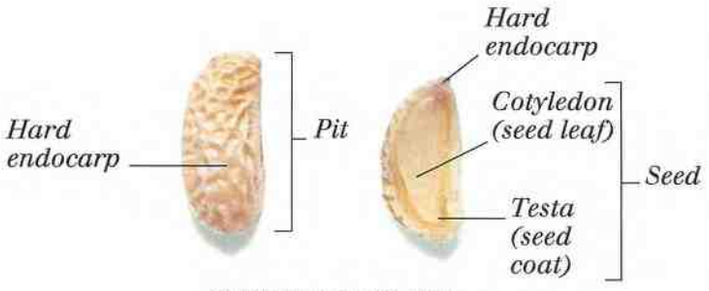
LONGITUDINAL SECTION THROUGH FRUIT



CROSS SECTION THROUGH FRUIT

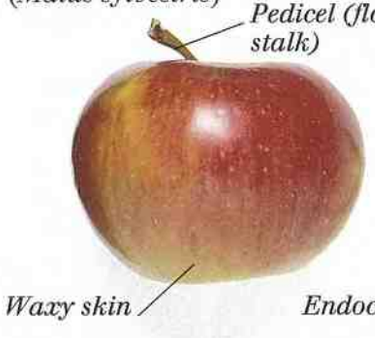


EXTERNAL VIEW OF SEED

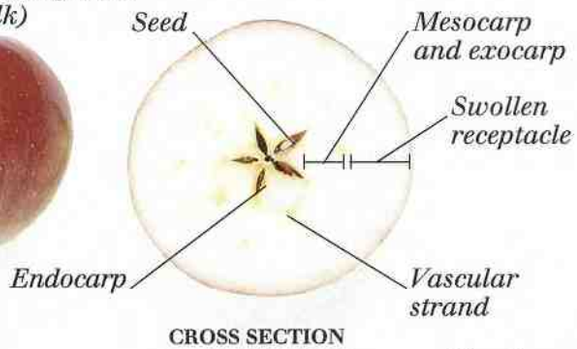


EXTERNAL VIEW AND SECTION THROUGH PIT

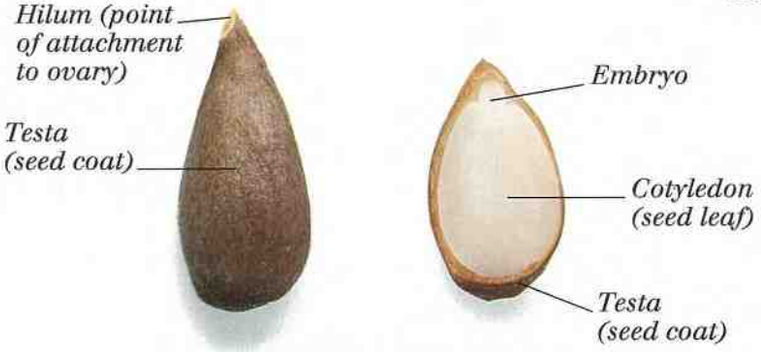
POME (A TYPE OF FALSE FRUIT)
Apple
(*Malus sylvestris*)



EXTERNAL VIEW OF FRUIT



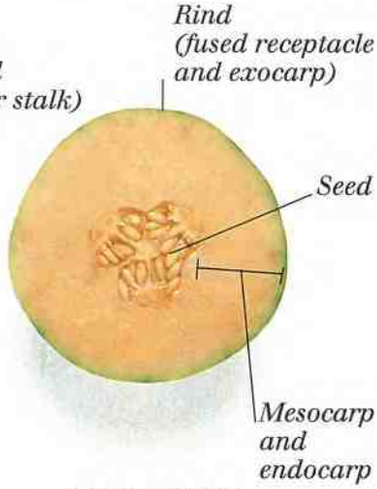
CROSS SECTION THROUGH FRUIT



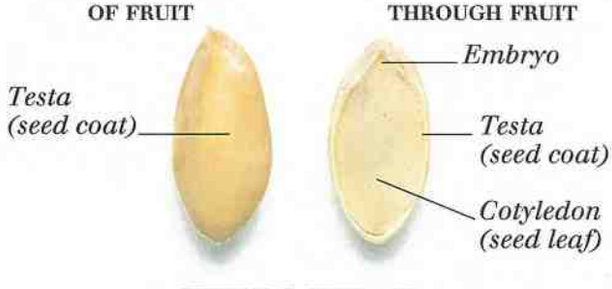
EXTERNAL VIEW AND SECTION THROUGH SEED

PEPO (A TYPE OF BERRY)
Charentais melon
(*Cucumis melo*)

EXTERNAL VIEW OF FRUIT



CROSS SECTION THROUGH FRUIT



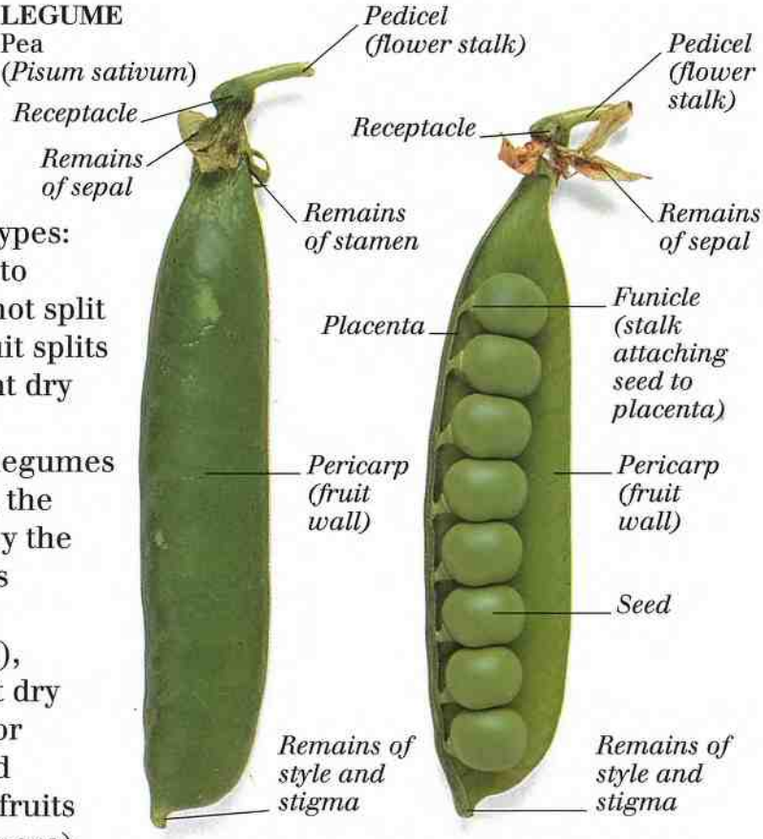
EXTERNAL VIEW AND SECTION THROUGH SEED

Dry fruits

DRY FRUITS HAVE A HARD, DRY PERICARP (fruit wall) around their seeds, unlike succulent fruits, which have fleshy pericarps (see pp. 42-43). Dry fruits are divided into three types: dehiscent, in which the pericarp splits open to release the seeds; indehiscent, which do not split open; and schizocarpic, in which the fruit splits but the seeds are not exposed. Dehiscent dry fruits include capsules (for example, love-in-a-mist), follicles (delphinium), legumes (pea), and siliquas (honesty). Typically, the seeds of dehiscent fruits are dispersed by the wind. Indehiscent dry fruits include nuts (sweet chestnut), nutlets (goose grass), achenes (strawberry), caryopses (wheat), samaras (elm), and cypselas (dandelion). Some indehiscent dry fruits are dispersed by the wind, assisted by "wings" (elm) or "parachutes" (dandelion); others (goose grass) have hooked pericarps to aid dispersal on animals' fur. Schizocarpic dry fruits include cremocarps (hogweed), and double samaras (sycamore); these are dispersed by the wind.

NUTLET
Goose grass
(*Galium aparine*)

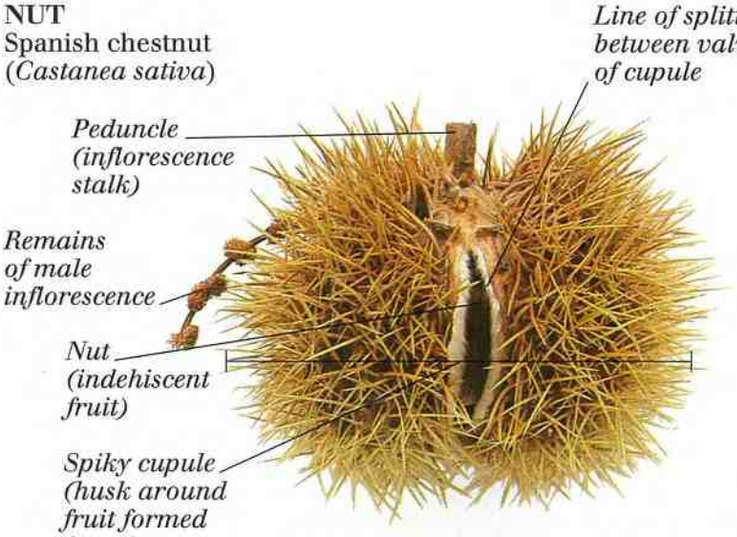
LEGUME
Pea
(*Pisum sativum*)



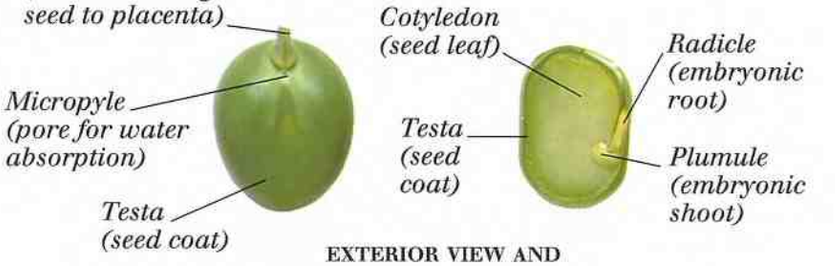
EXTERNAL VIEW OF FRUIT

INTERNAL VIEW OF FRUIT

NUT
Spanish chestnut
(*Castanea sativa*)

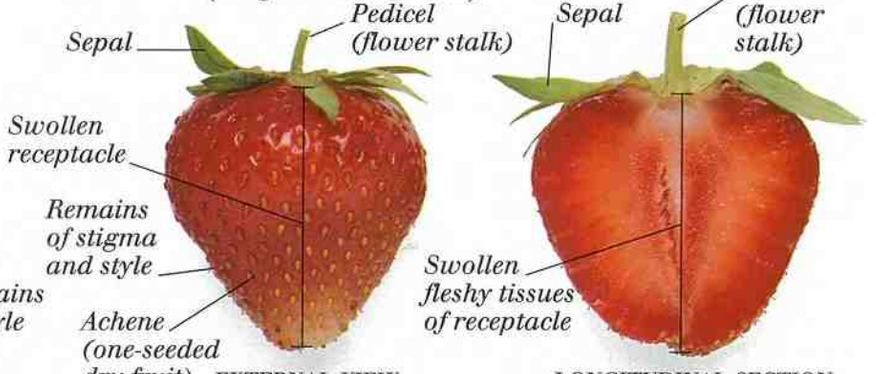


EXTERNAL VIEW OF FRUIT WITH SURROUNDING CUPULE



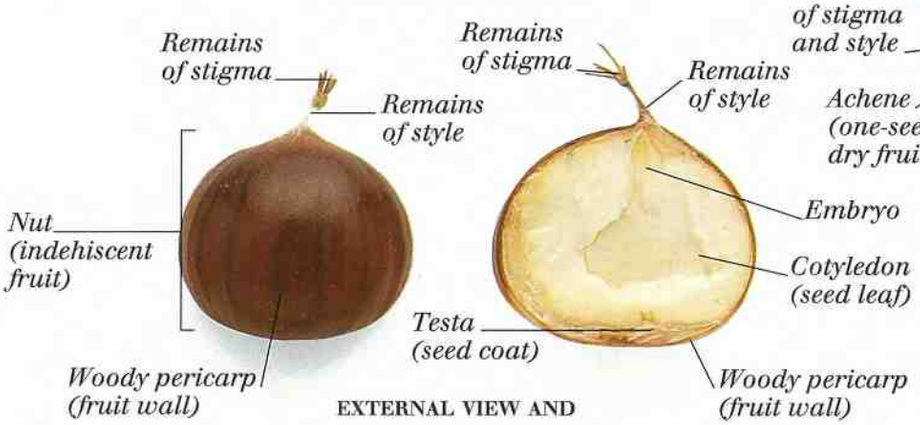
EXTERIOR VIEW AND SECTION THROUGH SEED

ACHENE
Strawberry
(*Fragaria x ananassa*)

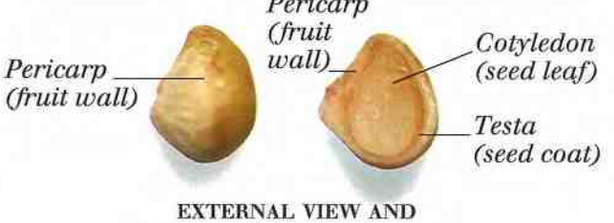


EXTERNAL VIEW OF FRUIT

LONGITUDINAL SECTION THROUGH FRUIT

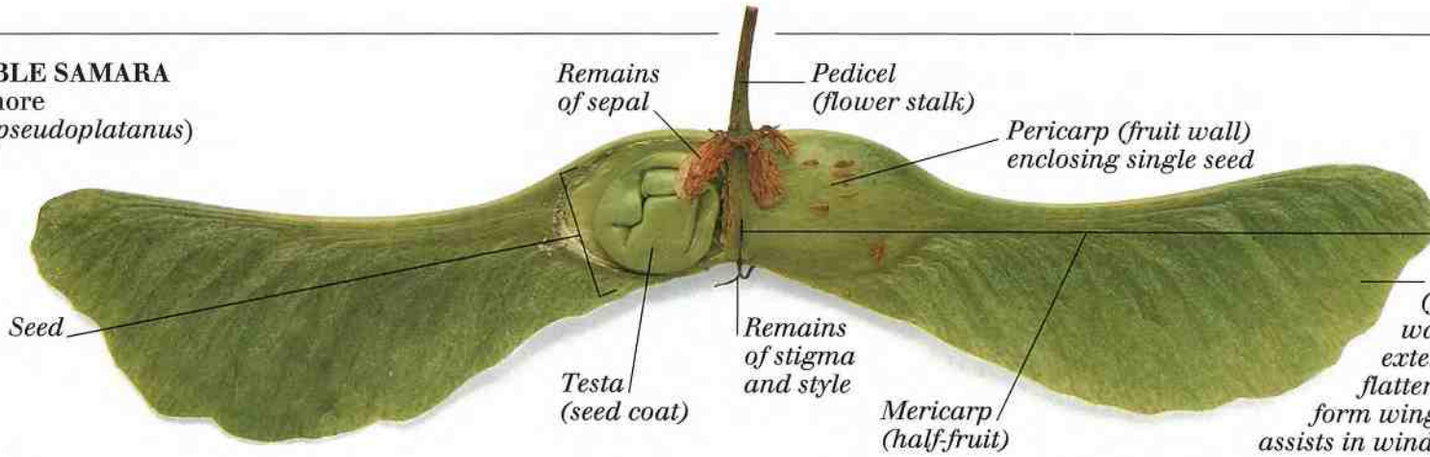


EXTERNAL VIEW AND SECTION THROUGH FRUIT

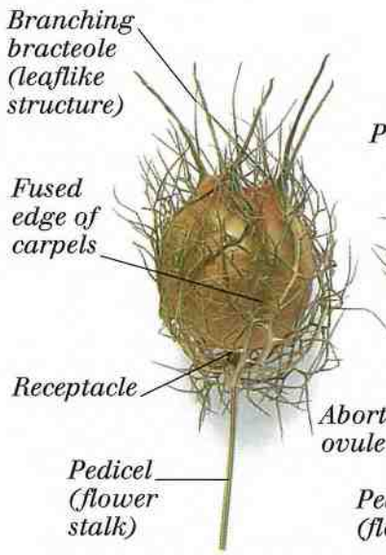


EXTERNAL VIEW AND SECTION THROUGH SEED

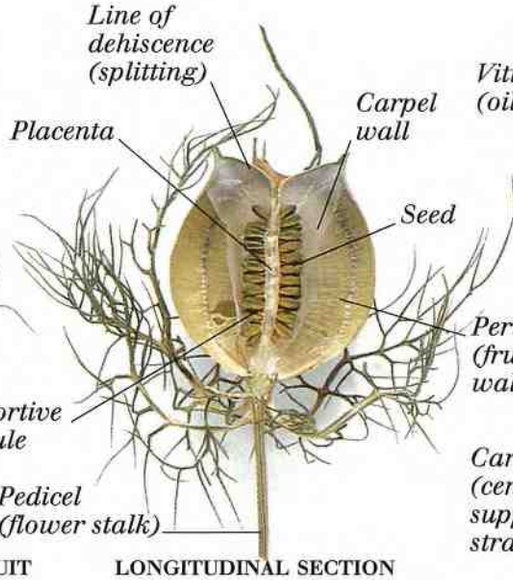
DOUBLE SAMARA
Sycamore
(*Acer pseudoplatanus*)



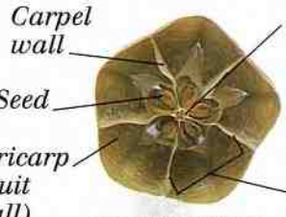
CAPSULE
Love-in-a-mist
(*Nigella damascena*)



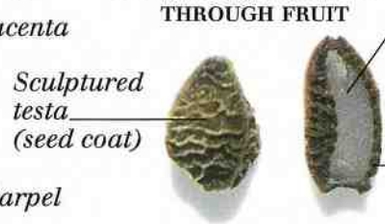
EXTERNAL VIEW OF FRUIT



LONGITUDINAL SECTION THROUGH FRUIT

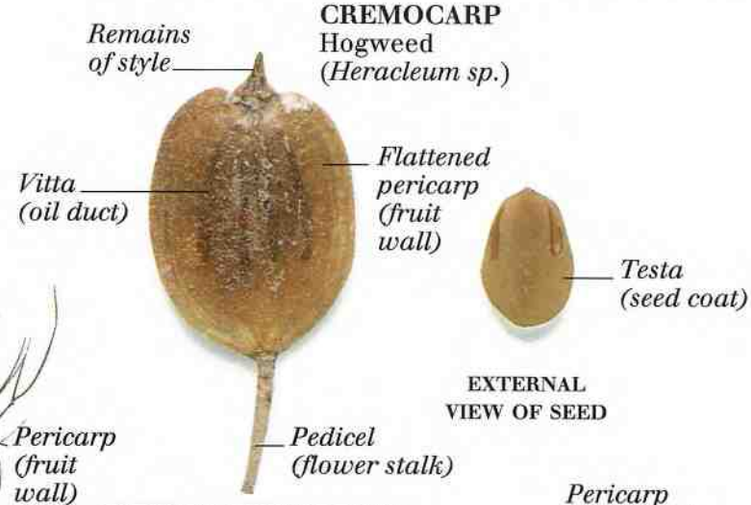


CROSS SECTION THROUGH FRUIT

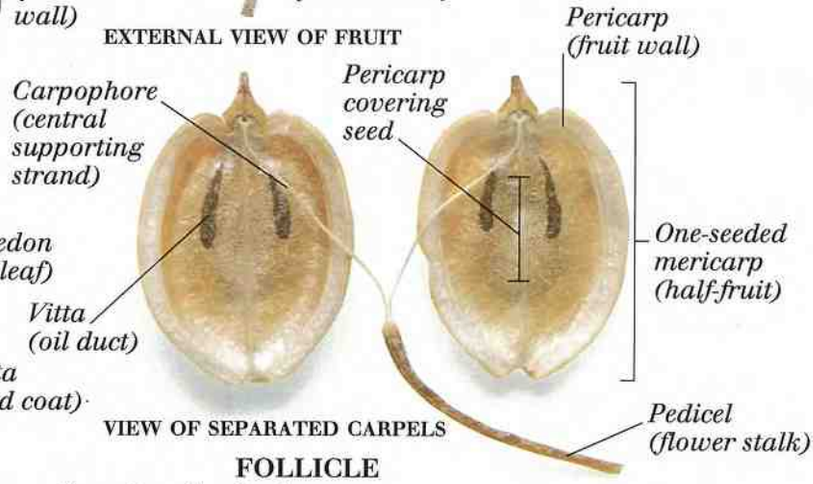


EXTERIOR VIEW AND SECTION THROUGH SEED

CREMOCARP
Hogweed
(*Heracleum sp.*)

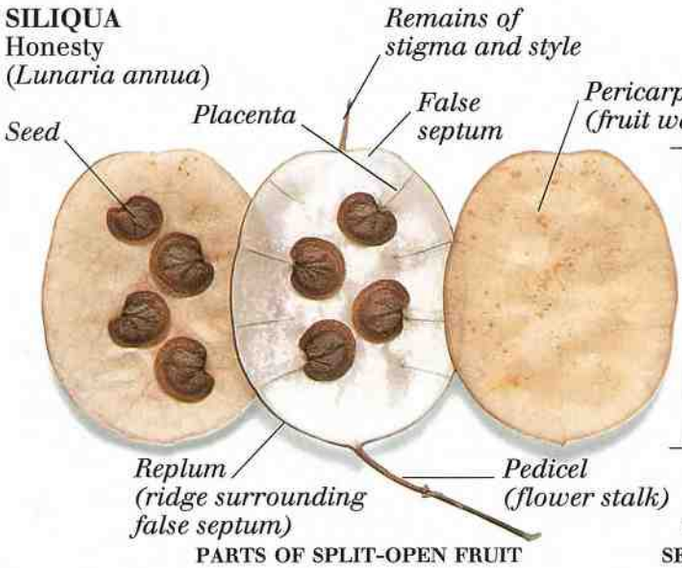


EXTERNAL VIEW OF FRUIT

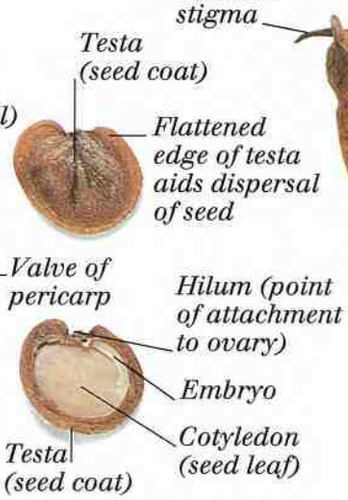


VIEW OF SEPARATED CARPELS

SILIQUA
Honesty
(*Lunaria annua*)



PARTS OF SPLIT-OPEN FRUIT

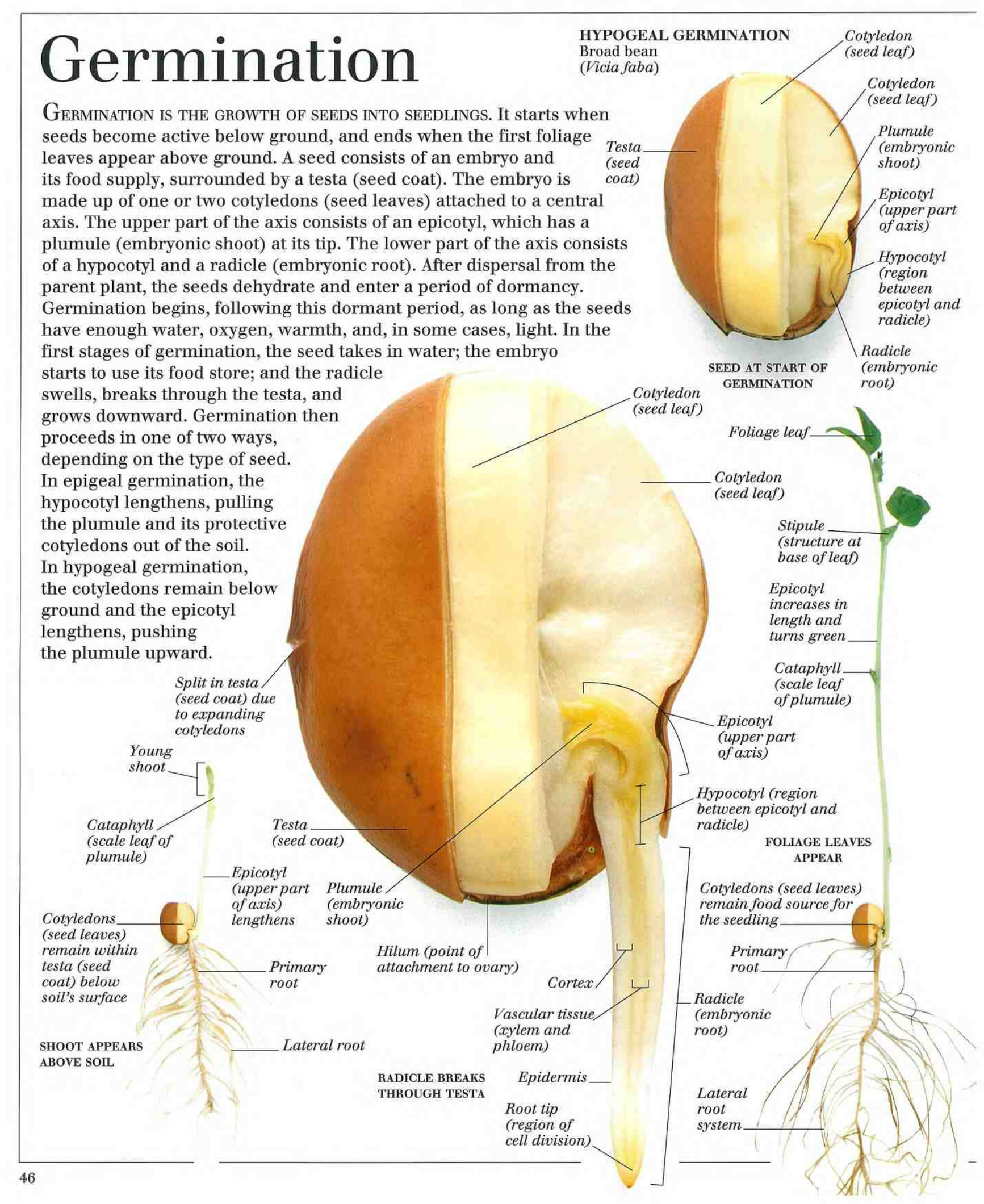


EXTERNAL VIEW AND SECTION THROUGH SEED

FOLLICLE
Larkspur
(*Delphinium sp.*)

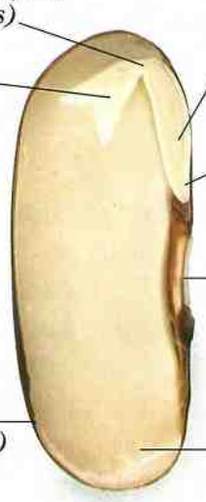
Germination

GERMINATION IS THE GROWTH OF SEEDS INTO SEEDLINGS. It starts when seeds become active below ground, and ends when the first foliage leaves appear above ground. A seed consists of an embryo and its food supply, surrounded by a testa (seed coat). The embryo is made up of one or two cotyledons (seed leaves) attached to a central axis. The upper part of the axis consists of an epicotyl, which has a plumule (embryonic shoot) at its tip. The lower part of the axis consists of a hypocotyl and a radicle (embryonic root). After dispersal from the parent plant, the seeds dehydrate and enter a period of dormancy. Germination begins, following this dormant period, as long as the seeds have enough water, oxygen, warmth, and, in some cases, light. In the first stages of germination, the seed takes in water; the embryo starts to use its food store; and the radicle swells, breaks through the testa, and grows downward. Germination then proceeds in one of two ways, depending on the type of seed. In epigeal germination, the hypocotyl lengthens, pulling the plumule and its protective cotyledons out of the soil. In hypogeal germination, the cotyledons remain below ground and the epicotyl lengthens, pushing the plumule upward.

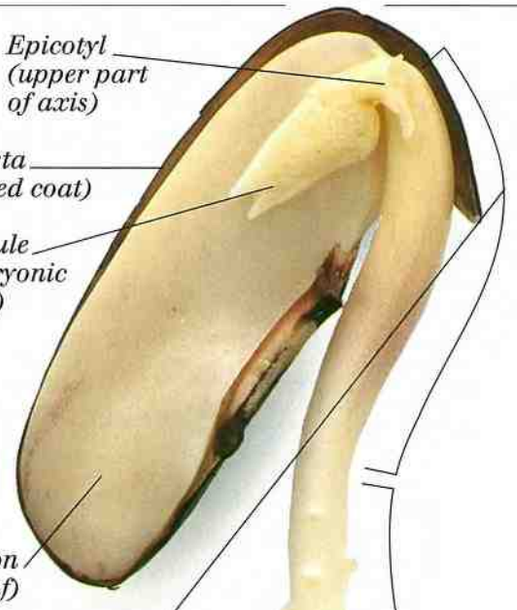


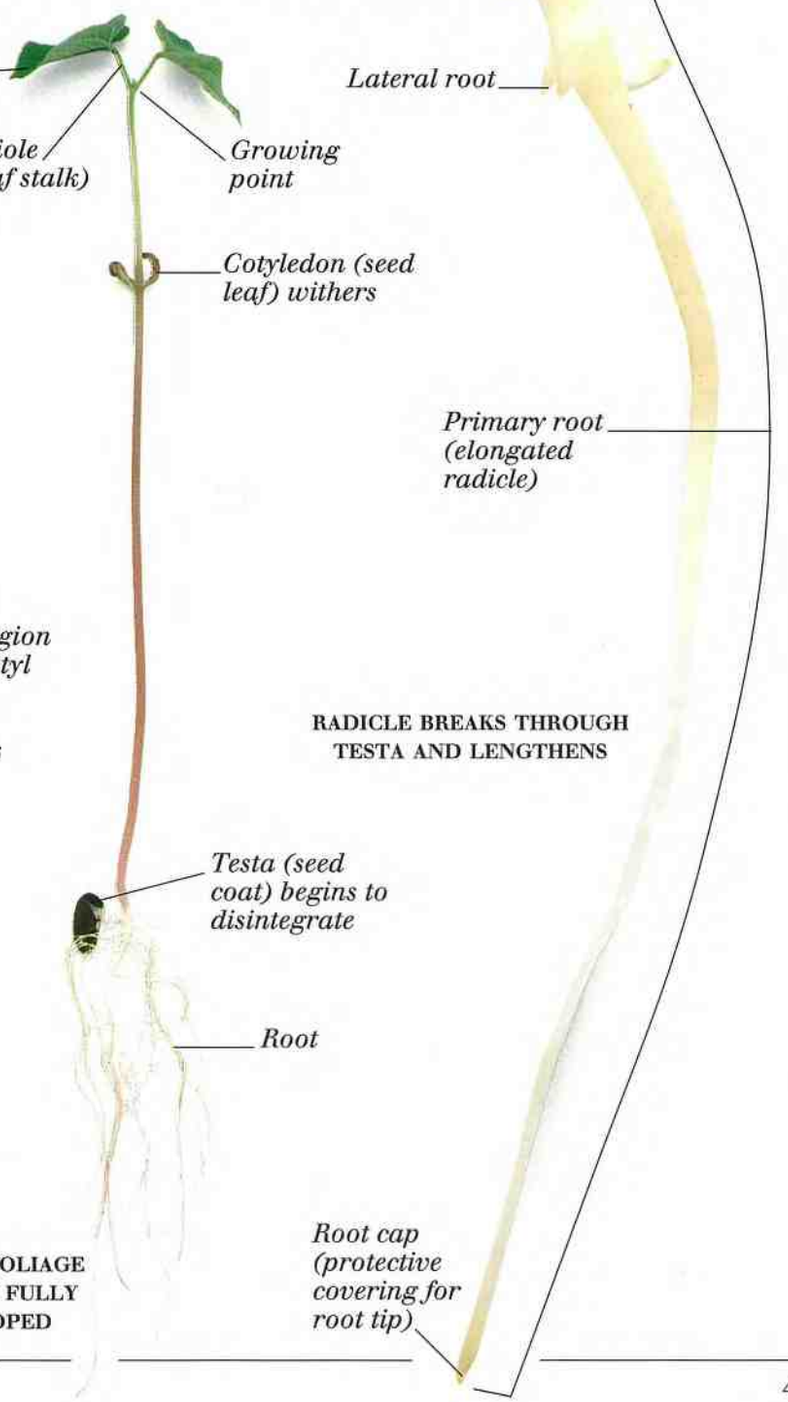
EPIGEAL GERMINATION
Black bean
(*Phaseolus sp.*)

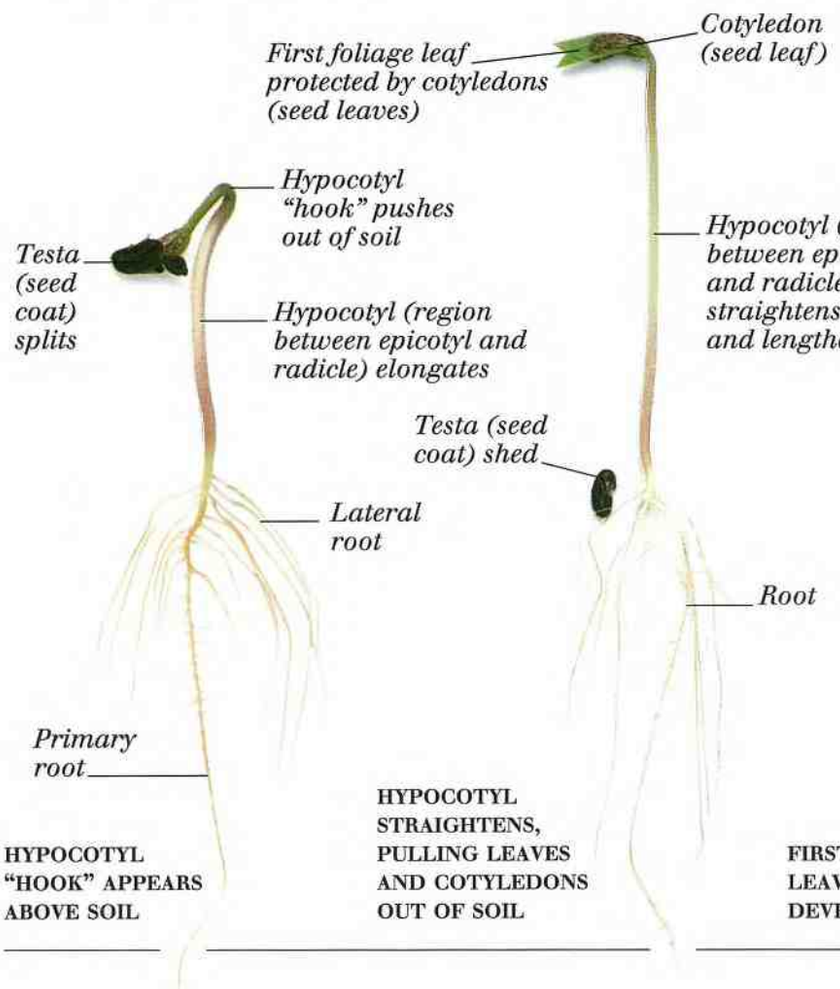
EXTERNAL VIEW OF SEED AT START OF GERMINATION



LONGITUDINAL SECTION THROUGH SEED AT START OF GERMINATION





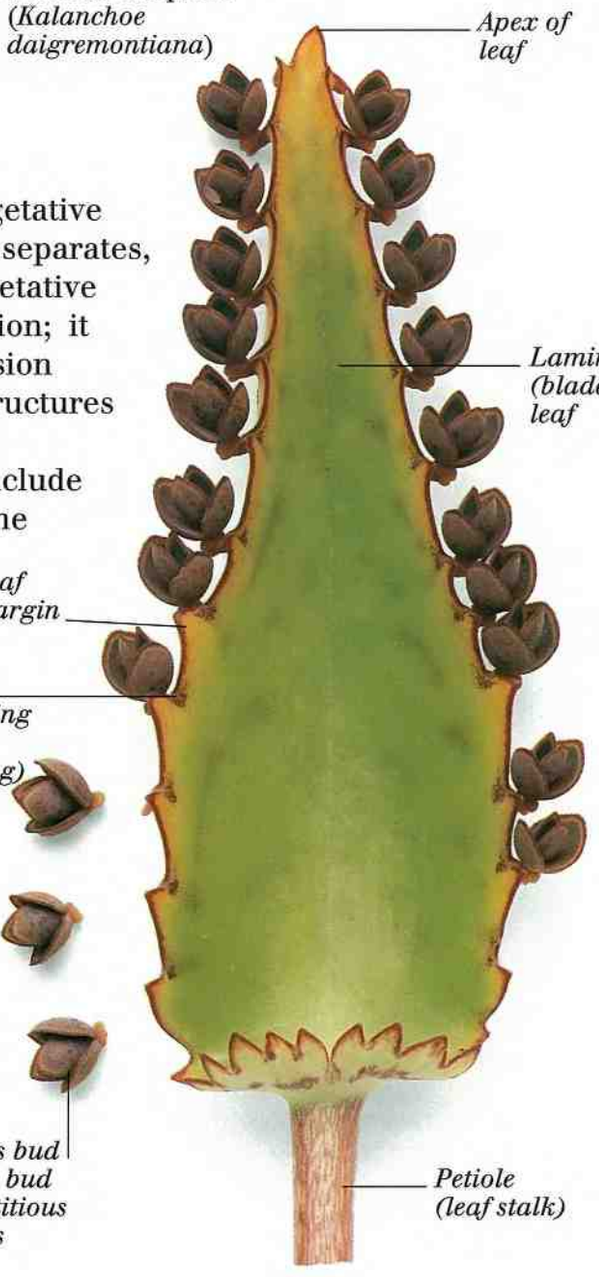


Vegetative reproduction

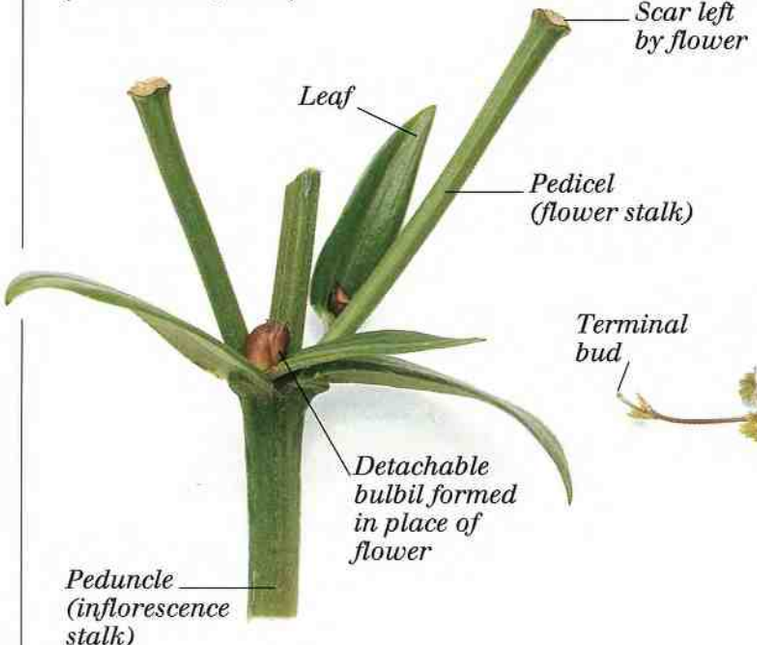
MANY PLANTS CAN PROPAGATE THEMSELVES by vegetative reproduction. In this process, part of a plant separates, takes root, and grows into a new plant. Vegetative reproduction is a type of asexual reproduction; it involves only one parent and there is no fusion of gametes (sex cells). Plants use various structures to reproduce vegetatively. Some plants use underground storage organs. Such organs include rhizomes (horizontal, underground stems), the branches of which produce new plants; bulbs (swollen leaf bases) and corms (swollen stems), which produce daughter bulbs or corms that separate from the parent; and stem tubers (thickened underground stems) and root tubers (swollen adventitious roots), which also separate from the parent. Other propagative structures include runners and stolons, creeping horizontal stems that take root and produce new plants; bulbils, small bulbs that develop on the stem or in the place of flowers, and then drop off and grow into new plants; and adventitious buds, miniature plants that form on leaf margins before dropping to the ground and growing into mature plants.

CORM
Gladiolus
(*Gladiolus sp.*)

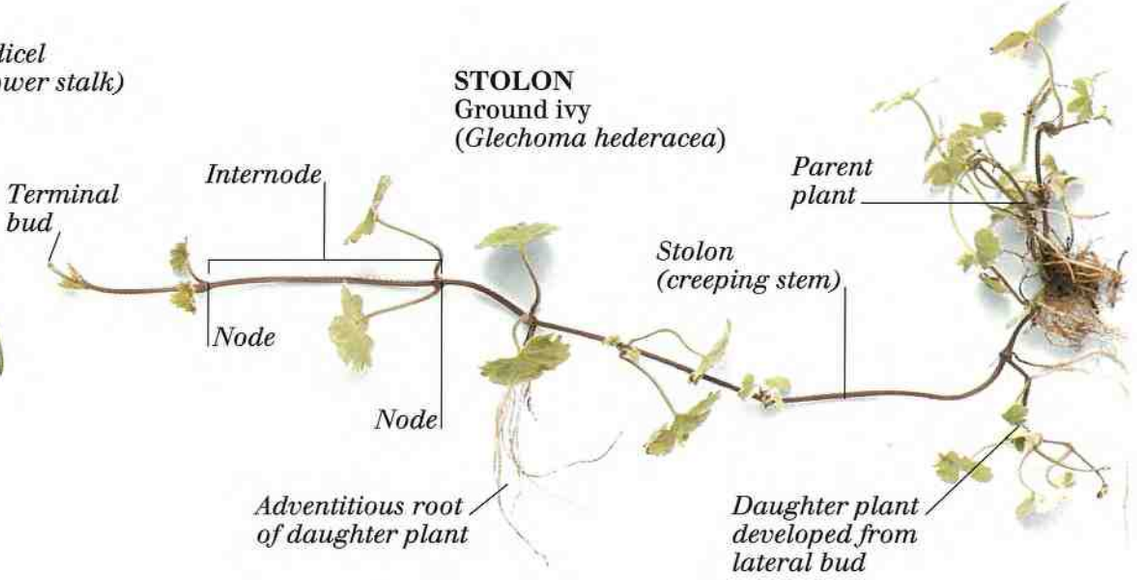
ADVENTITIOUS BUD
Mexican hat plant
(*Kalanchoe daigremontiana*)



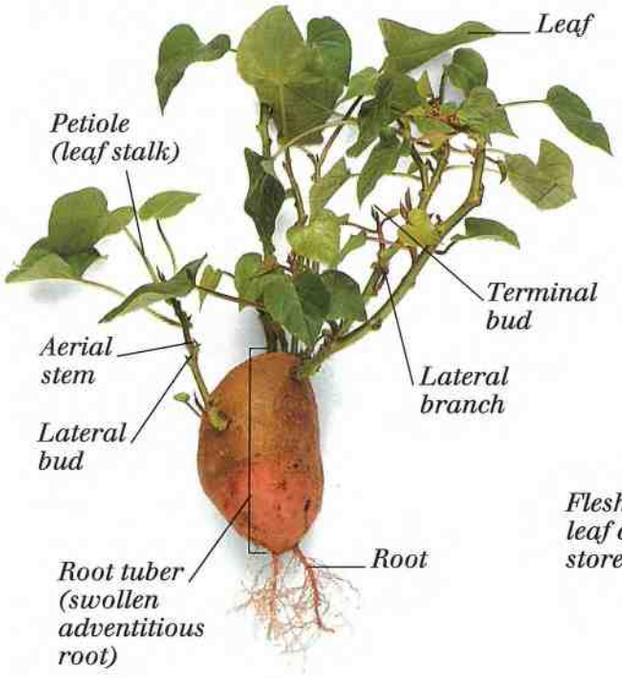
BULBIL IN PLACE OF FLOWER
Orange lily
(*Lilium bulbiferum*)



STOLON
Ground ivy
(*Glechoma hederacea*)

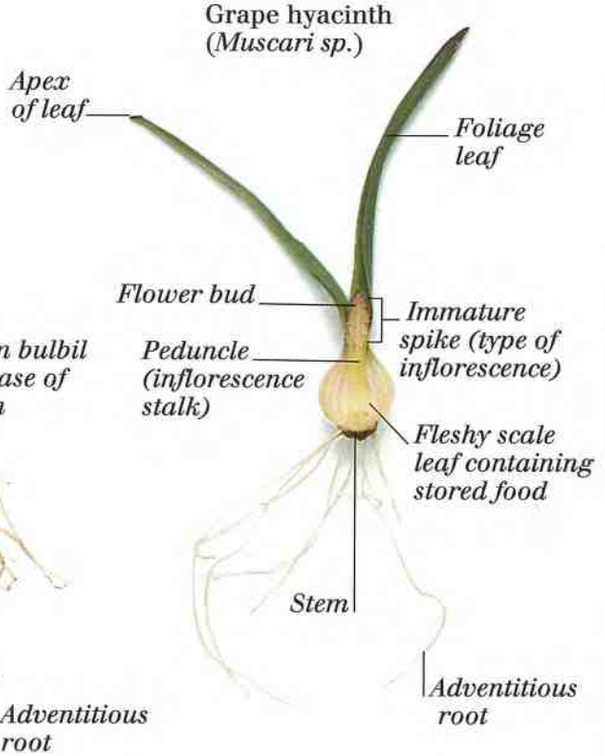


ROOT TUBER
Sweet potato
(*Ipomoea batatas*)

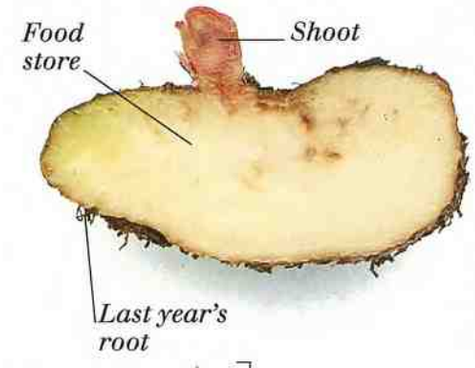


STEM BULBIL
Lily
(*Lilium sp.*)

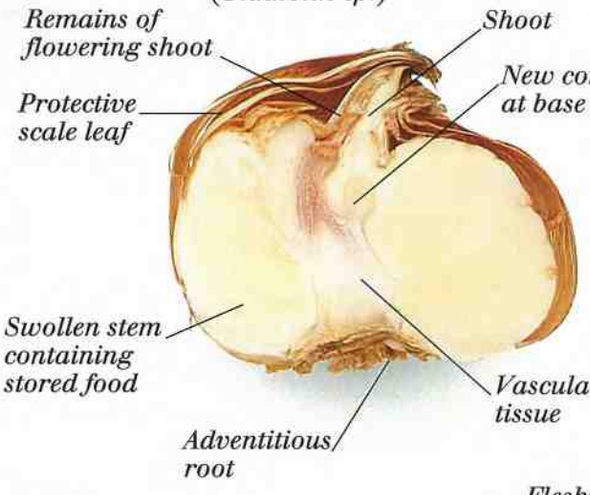
GROWING BULB
Grape hyacinth
(*Muscari sp.*)



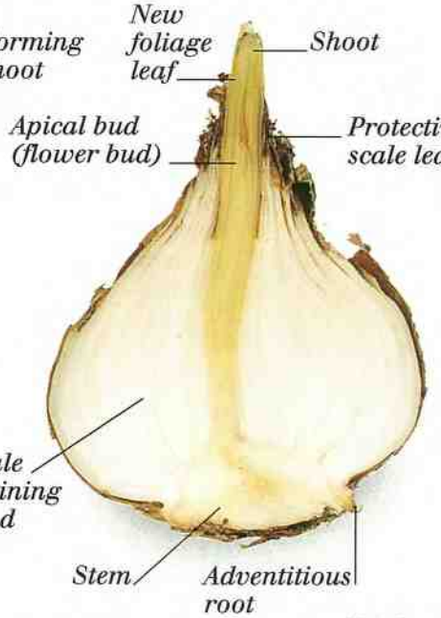
ROOT TUBER
Begonia
(*Begonia* x *tuberhybrida*)

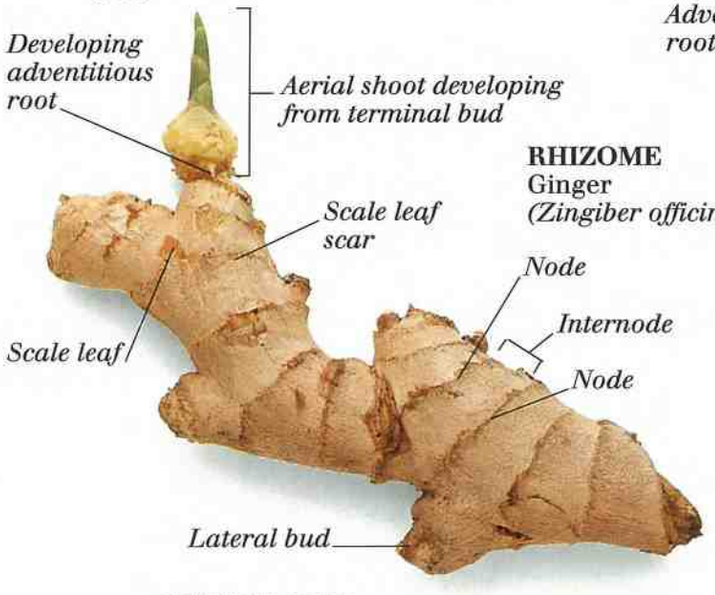


CORM
Gladiolus
(*Gladiolus sp.*)



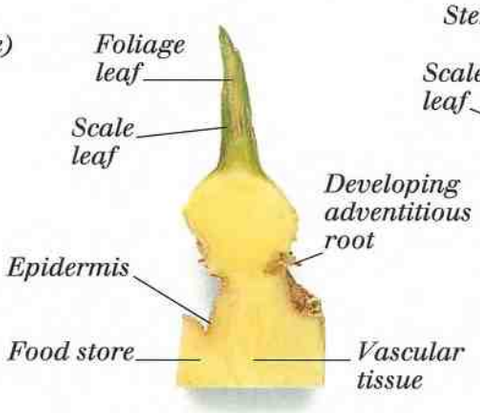
BULB WITH SHOOT
Amaryllis
(*Hippeastrum sp.*)



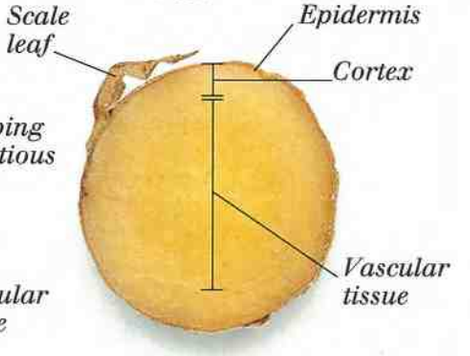


EXTERNAL VIEW

RHIZOME
Ginger
(*Zingiber officinale*)



LONGITUDINAL SECTION THROUGH AERIAL SHOOT



CROSS SECTION THROUGH RHIZOME

Dryland plants

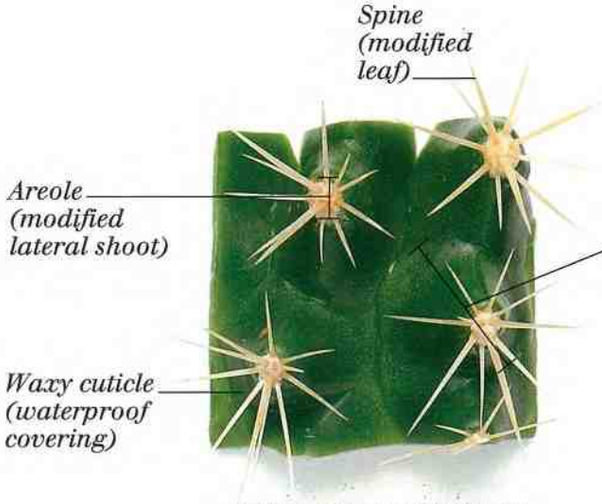
LEAF SUCCULENT
Lithops sp.

DRYLAND PLANTS (XEROPHYTES) are able to survive in unfavorable habitats. All are found in places where little water is available; some live in high temperatures that cause excessive loss of water from the leaves. Xerophytes show a number of adaptations to dry conditions. These include reduced leaf area, rolled leaves, sunken stomata, hairs, spines, and thick cuticles. One group, succulent plants, stores water in specially enlarged spongy tissues found in leaves, roots, or stems. Leaf succulents have enlarged, fleshy, water-storing leaves. Root succulents have a large underground water-storage organ with short-lived stems and leaves above ground. Stem succulents are represented by the cacti (family Cactaceae). Cacti stems are fleshy, green, and photosynthetic. They are typically ribbed or covered by tubercles in rows, with leaves being reduced to spines or entirely absent.

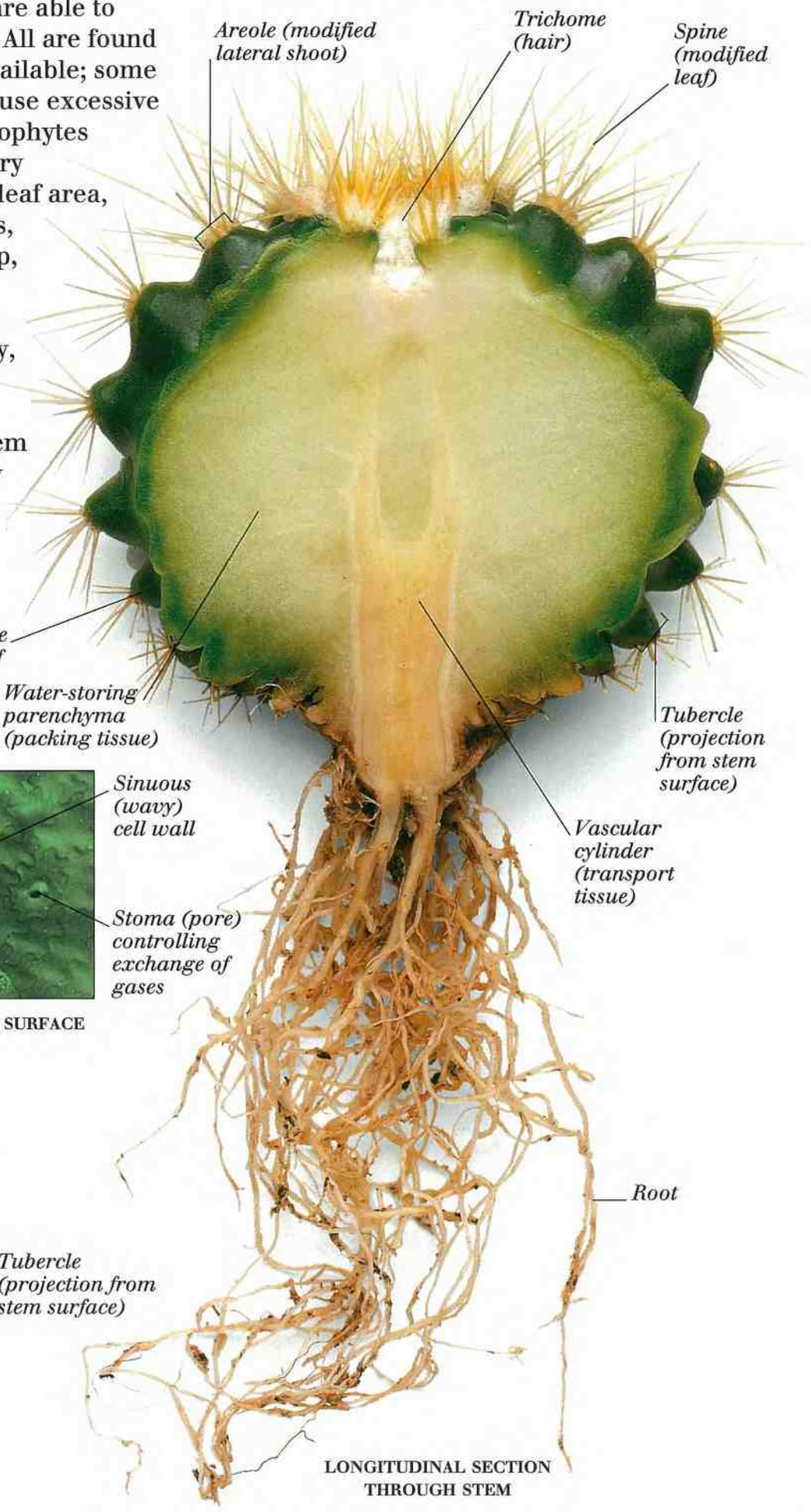
STEM SUCCULENT
Golden barrel cactus
(*Echinocactus grusonii*)

EXTERNAL VIEW

MICROGRAPH OF STEM SURFACE

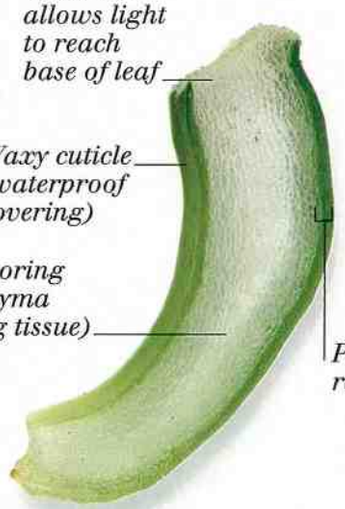


DETAIL OF STEM SURFACE

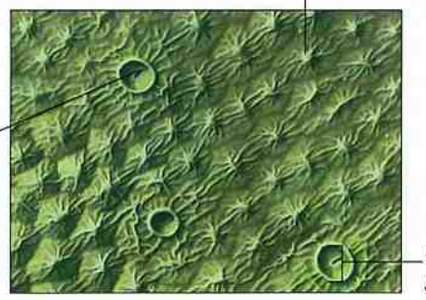


LONGITUDINAL SECTION THROUGH STEM

LEAF SUCCULENT
Haworthia truncata

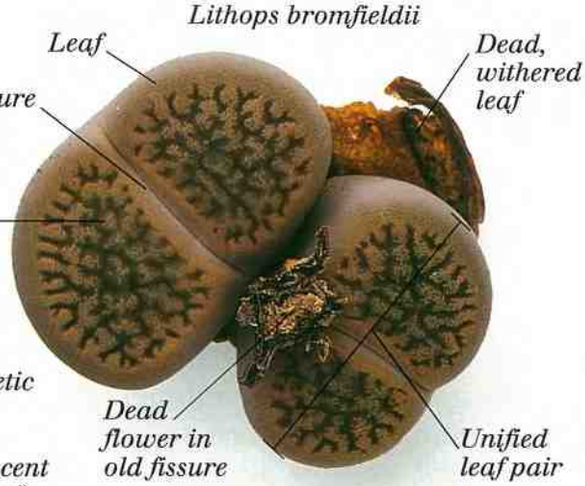


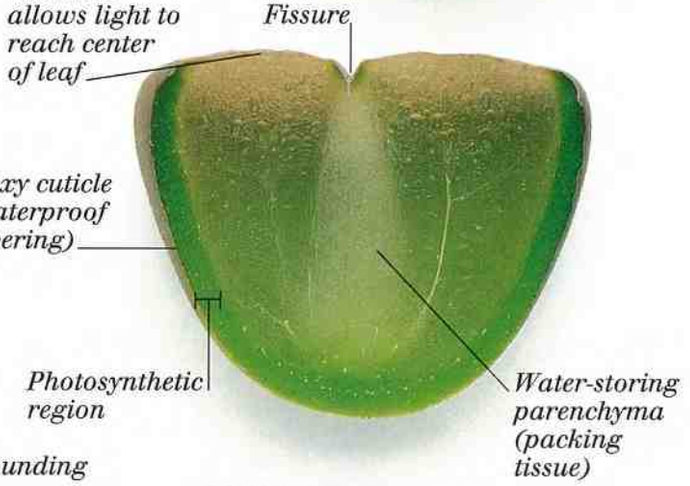
LONGITUDINAL SECTION THROUGH LEAF



MICROGRAPH OF LEAF SURFACE

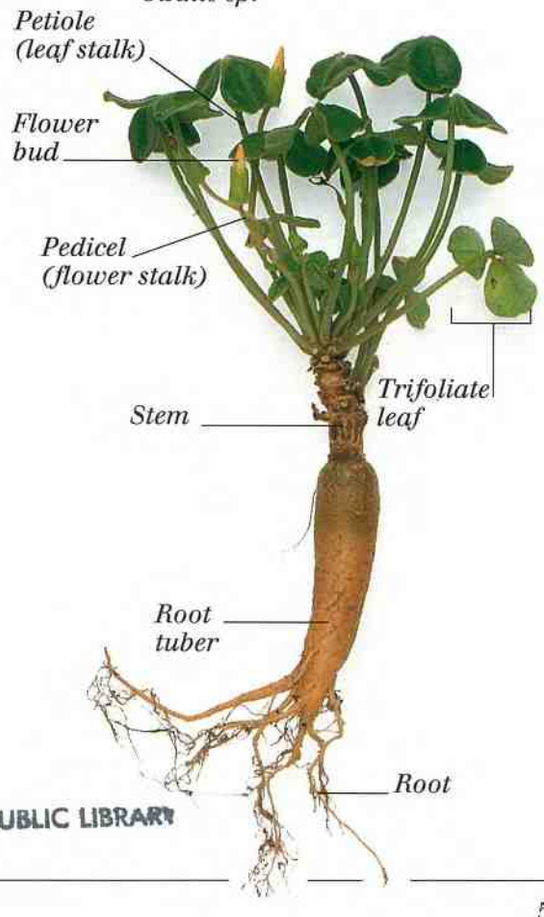
LEAF SUCCULENT
Lithops bromfieldii



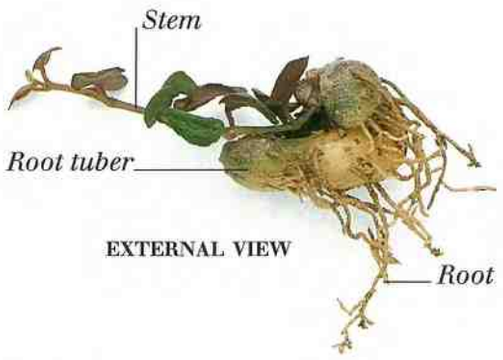


LONGITUDINAL SECTION THROUGH LEAF PAIR

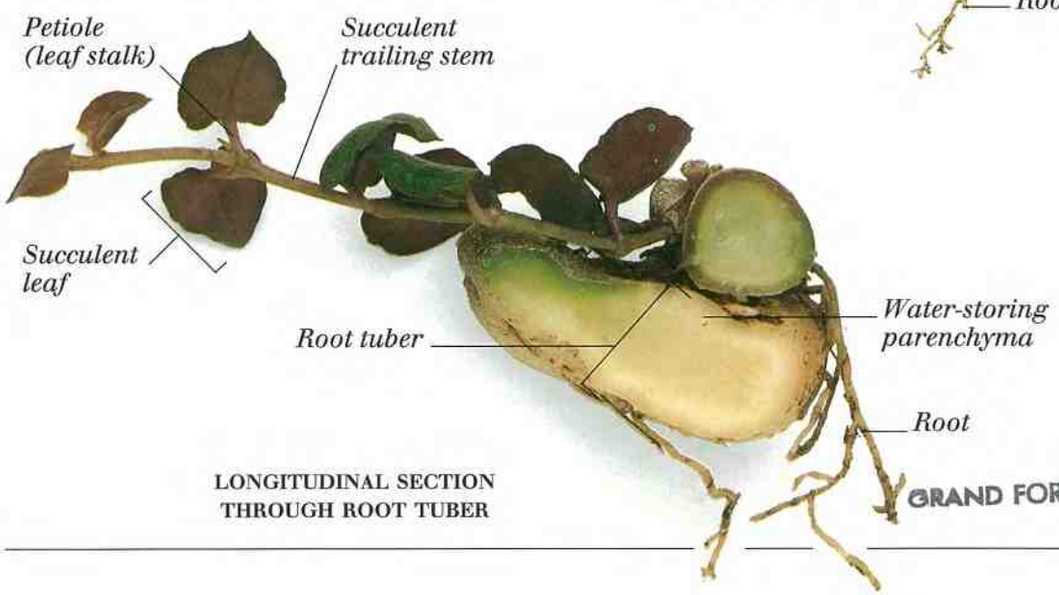
ROOT SUCCULENT
Oxalis sp.



STEM AND ROOT SUCCULENT
String of hearts
(*Ceropegia woodii*)



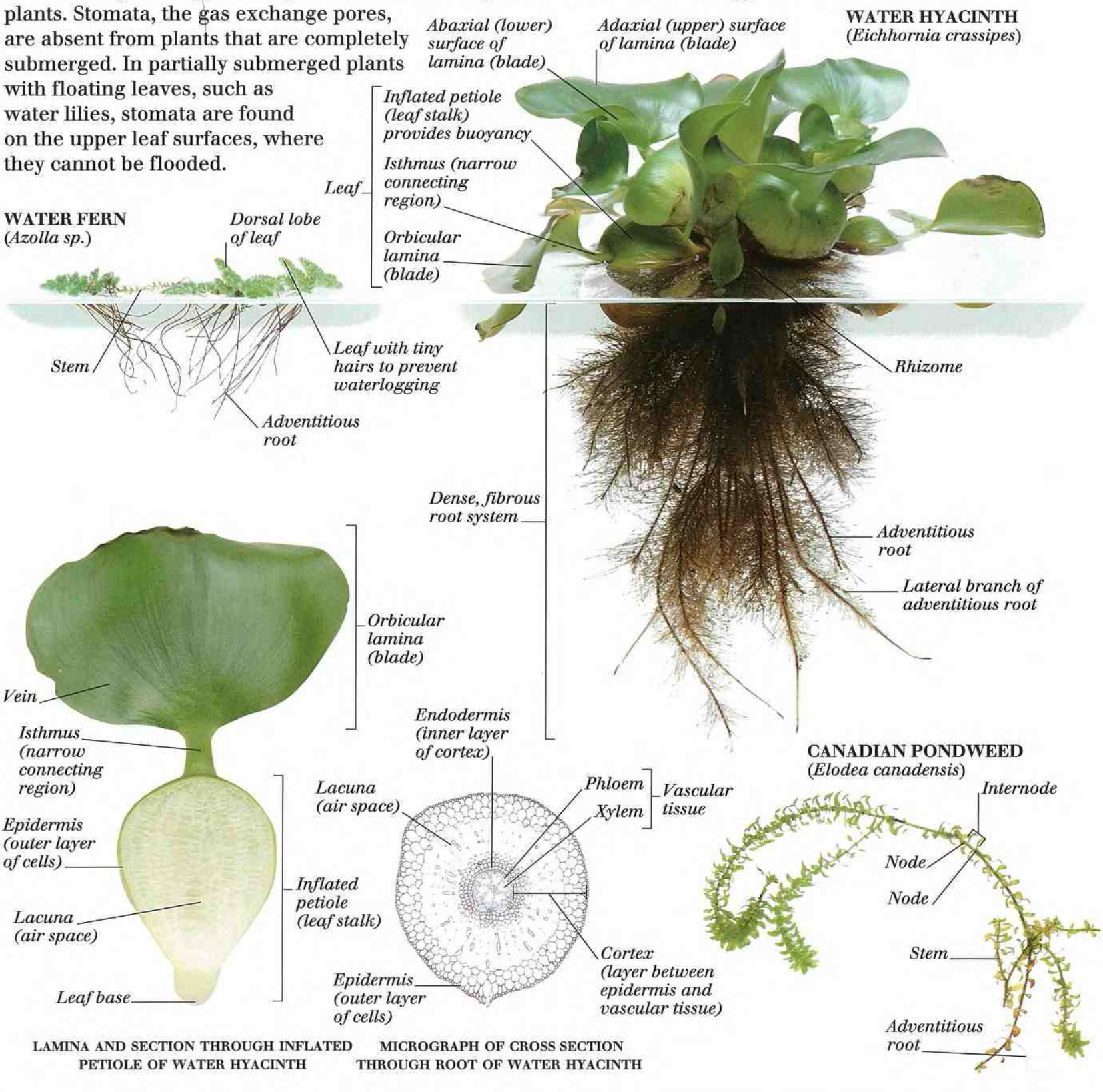
EXTERNAL VIEW



LONGITUDINAL SECTION THROUGH ROOT TUBER

Wetland plants

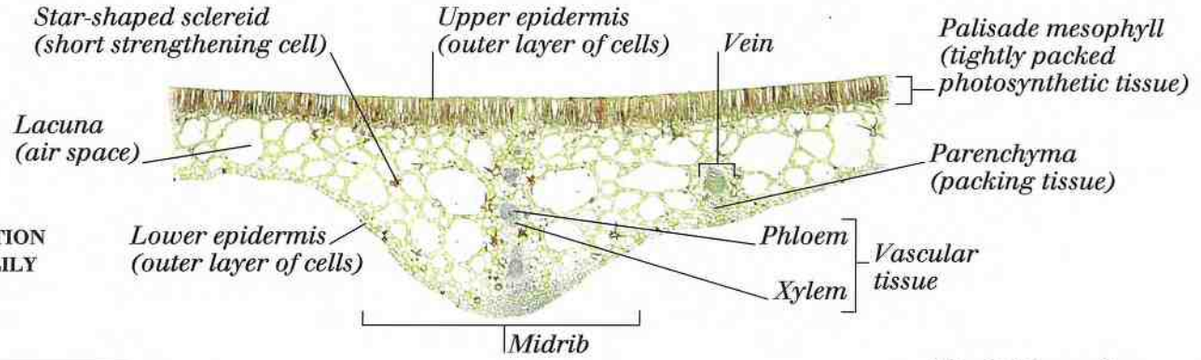
WETLAND PLANTS GROW SUBMERGED IN WATER, either partially, like the water hyacinth, or completely, like the pondweeds, and show various adaptations to this habitat. Typically, there are numerous air spaces inside the stems, leaves, and roots; these aid gas exchange and buoyancy. Submerged parts generally have no cuticle (waterproof covering), allowing the plants to absorb minerals and gases directly from the water. Also, because they are supported by the water, wetland plants need little of the supportive tissue found in land plants. Stomata, the gas exchange pores, are absent from plants that are completely submerged. In partially submerged plants with floating leaves, such as water lilies, stomata are found on the upper leaf surfaces, where they cannot be flooded.



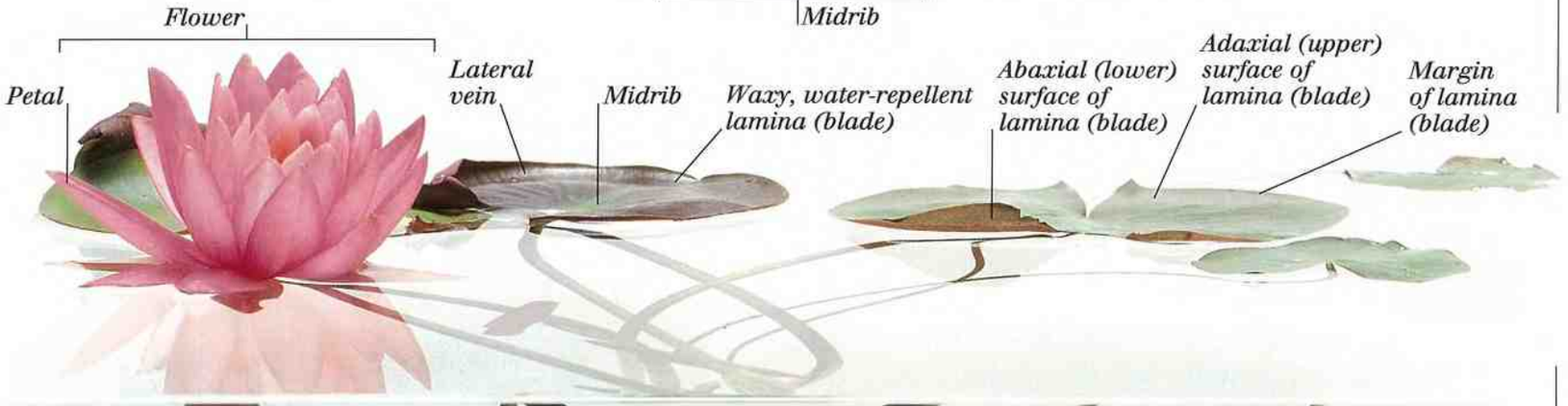
LAMINA AND SECTION THROUGH INFLATED PETIOLE OF WATER HYACINTH

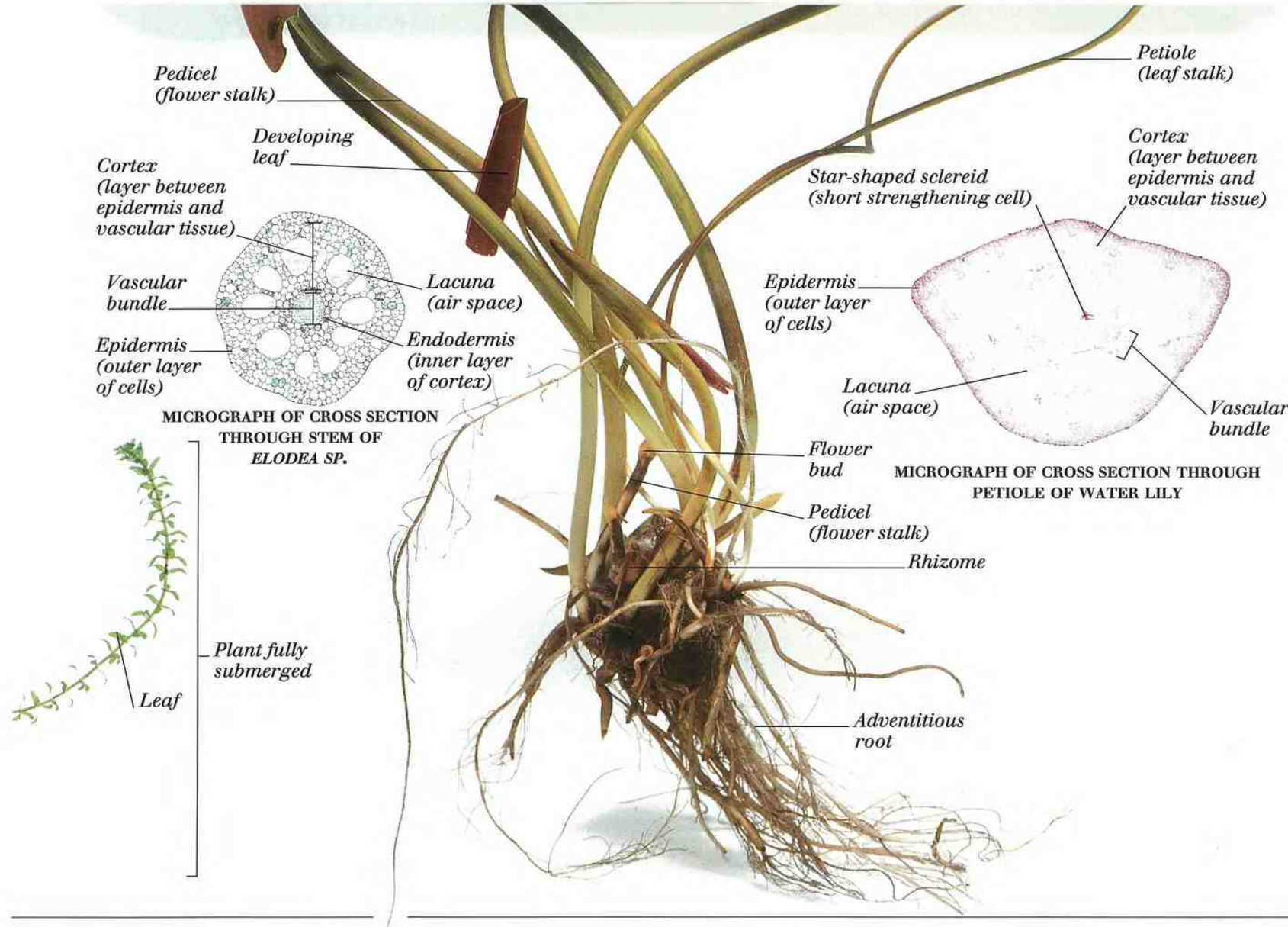
MICROGRAPH OF CROSS SECTION THROUGH ROOT OF WATER HYACINTH

WATER LILY
(Nymphaea sp.)



MICROGRAPH OF CROSS SECTION THROUGH LEAF OF WATER LILY





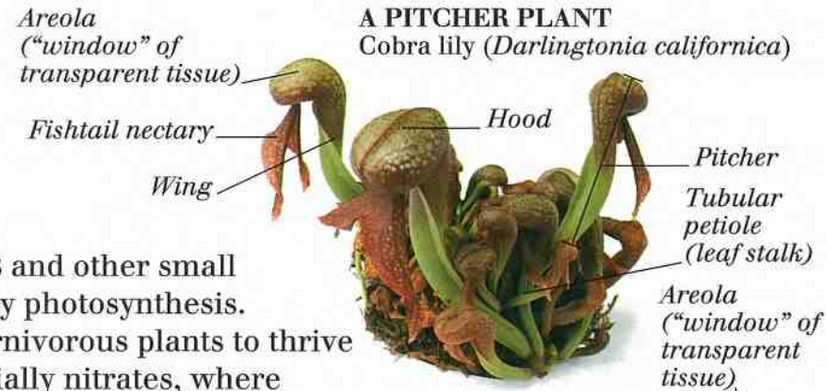
MICROGRAPH OF CROSS SECTION THROUGH STEM OF *ELODEA SP.*

MICROGRAPH OF CROSS SECTION THROUGH PETIOLE OF WATER LILY

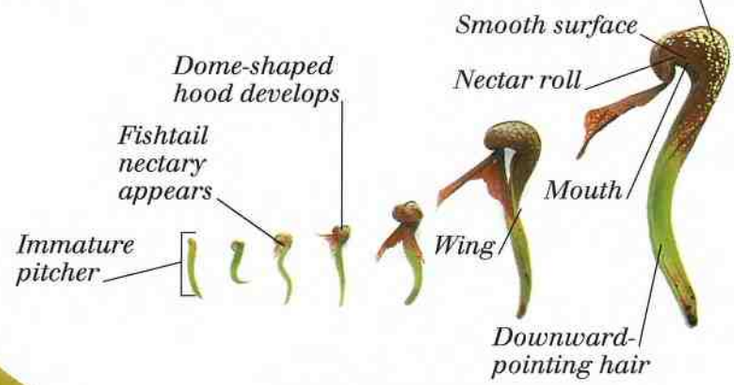
Carnivorous plants

CARNIVOROUS (INSECTIVOROUS) PLANTS FEED ON INSECTS and other small animals in addition to producing food in their leaves by photosynthesis. The nutrients absorbed from trapped insects allow carnivorous plants to thrive in acid, boggy soils that lack essential minerals, especially nitrates, where most other plants could not survive.

All carnivorous plants have some leaves modified as traps. Many use bright colors and scented nectar to attract prey, and most use enzymes to digest the prey. There are three types of traps. Pitcher plants, such as the monkey cup and cobra lily, have leaves modified as pitcher-shaped pitfall traps, half-filled with water. Once lured inside the mouth of the trap, insects lose their footing on the slippery surface, fall into the liquid, and either decompose or are digested. Venus flytraps use a spring-trap mechanism; when an insect touches trigger hairs on the inner surfaces of the leaves, the two lobes of the trap snap shut. Butterworts and sundews entangle prey by sticky droplets on the leaf surface, while the edges of the leaves slowly curl over to envelop and digest the prey.



A PITCHER PLANT
Cobra lily (*Darlingtonia californica*)

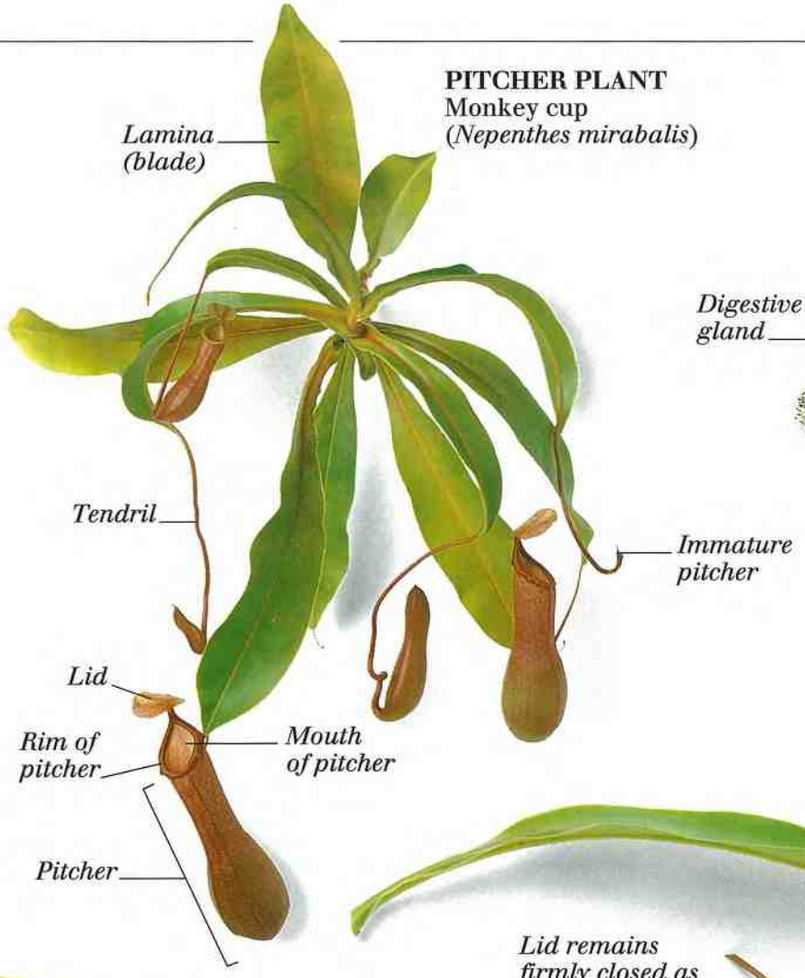


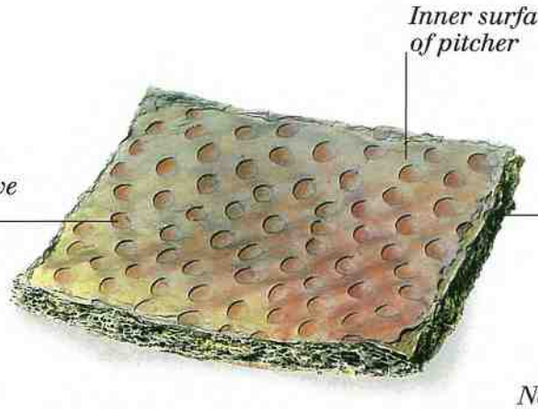
DEVELOPMENT OF MODIFIED LEAF IN COBRA LILY

VENUS FLYTRAP
(*Dionaea muscipula*)

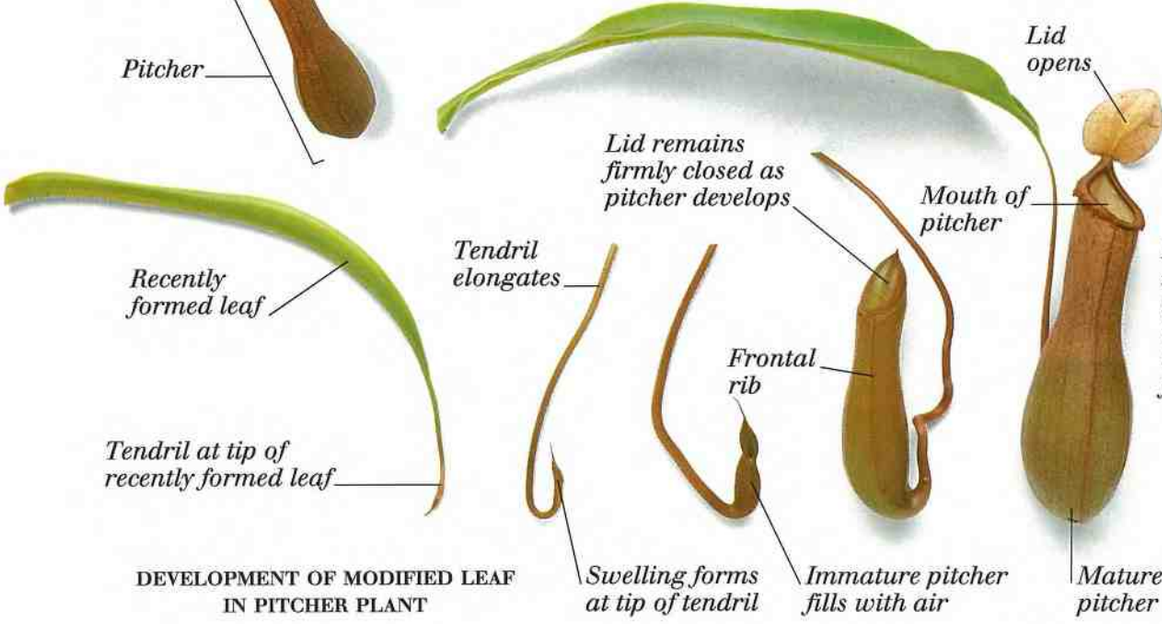
MICROGRAPH OF LOBE OF VENUS FLYTRAP

PITCHER PLANT
Monkey cup
(*Nepenthes mirabalis*)

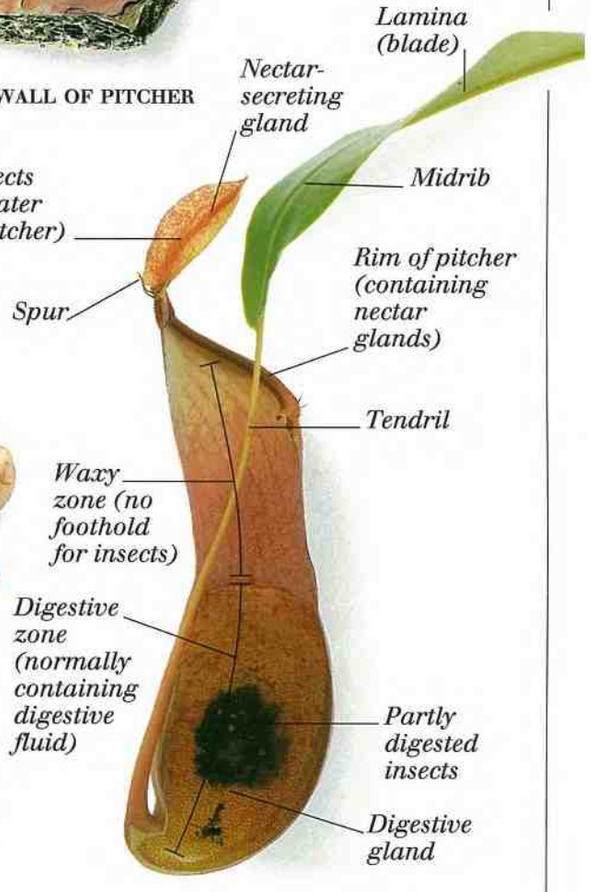




MICROGRAPH OF WALL OF PITCHER

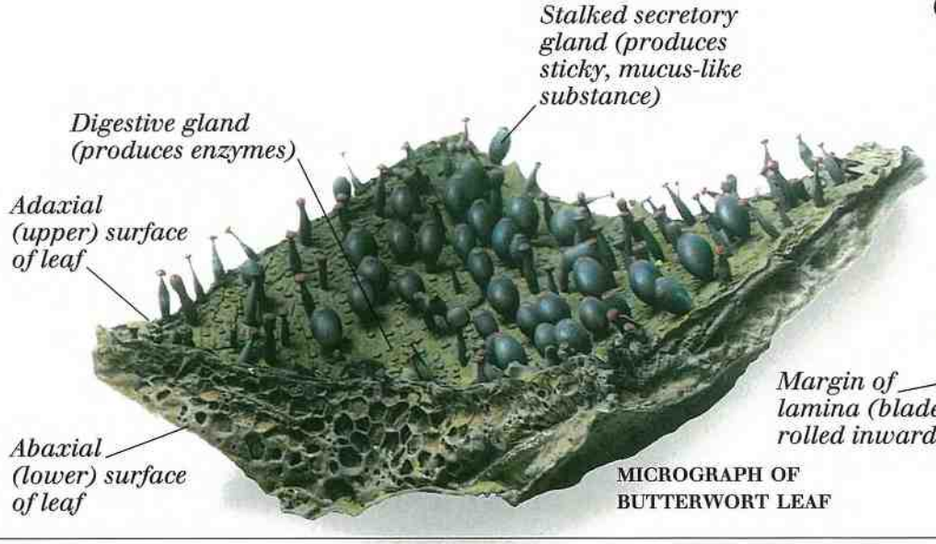


DEVELOPMENT OF MODIFIED LEAF IN PITCHER PLANT

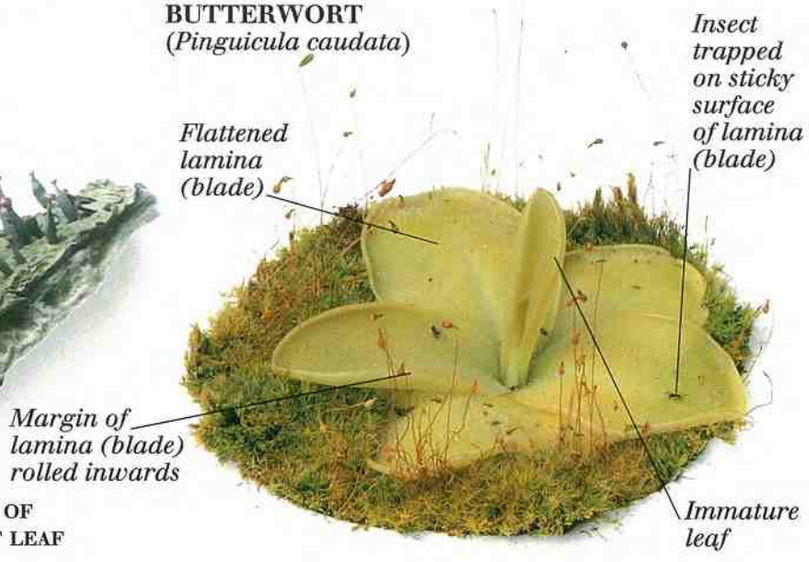


SECTION THROUGH PITCHER

BUTTERWORT
(*Pinguicula caudata*)



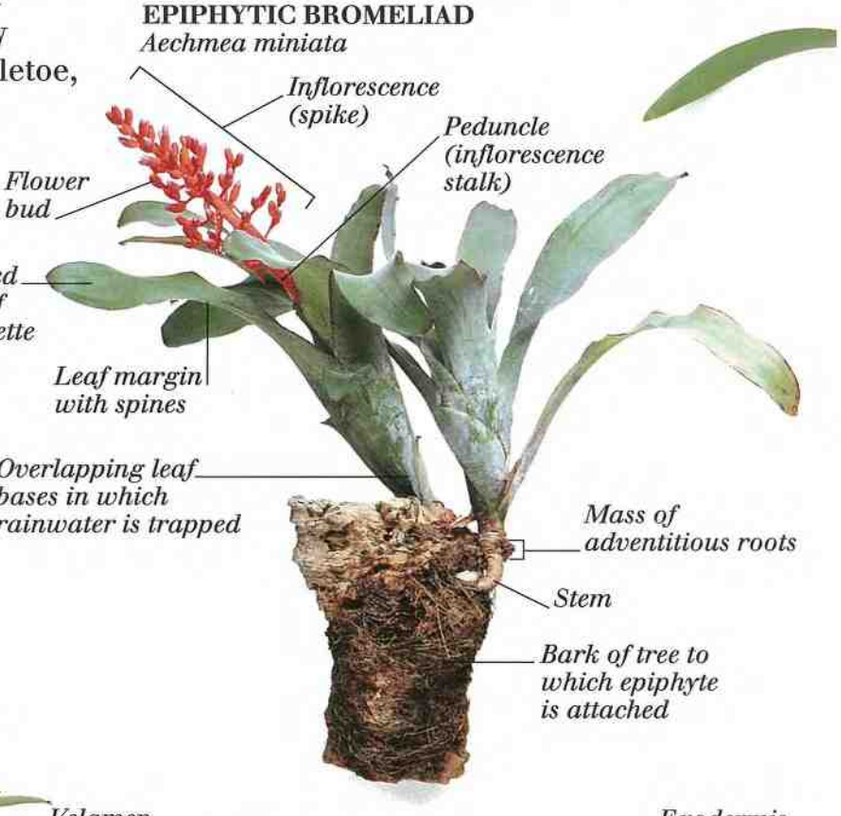
MICROGRAPH OF BUTTERWORT LEAF



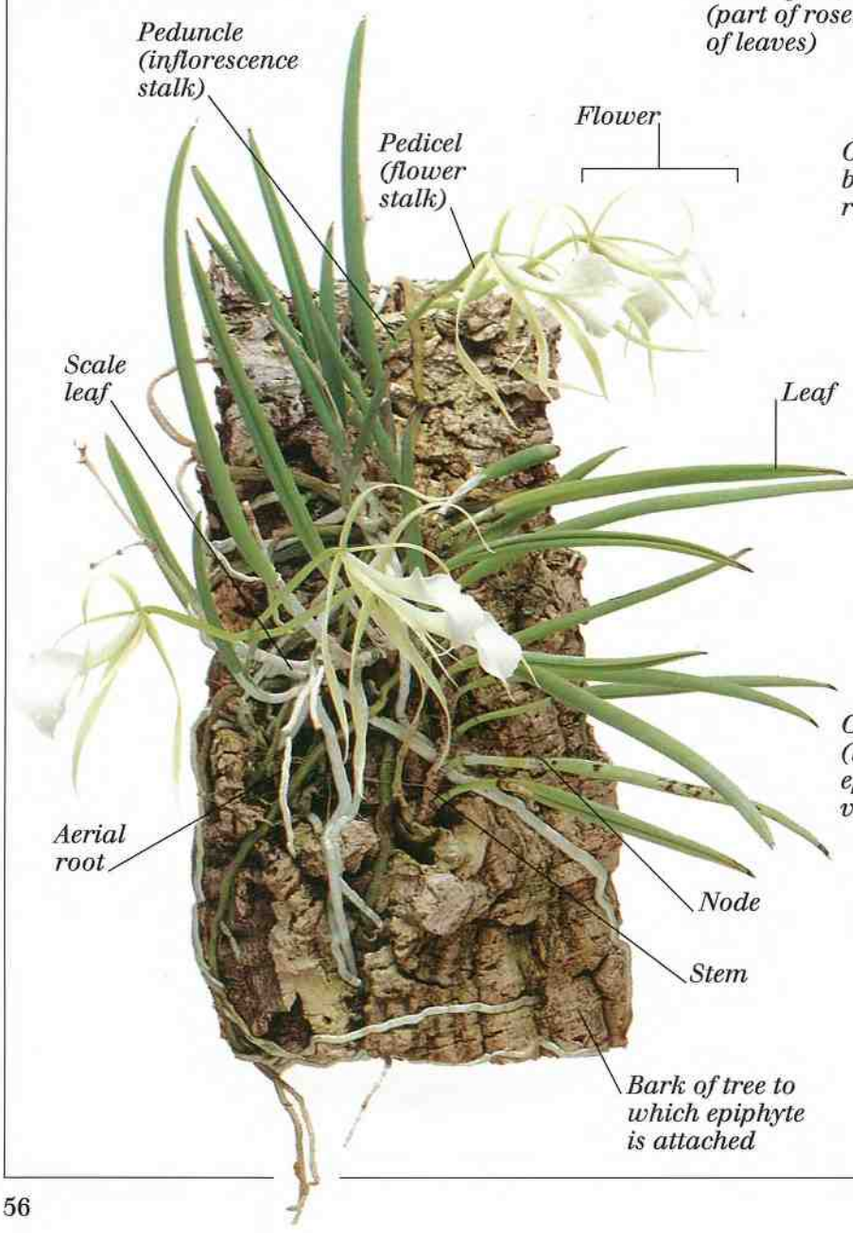
Epiphytic and parasitic plants

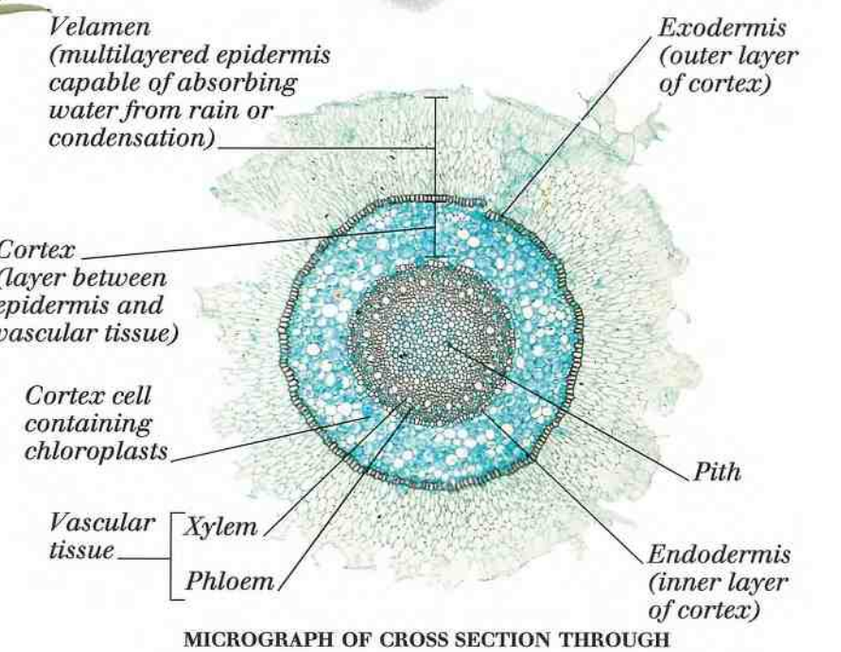
EPIPHYTIC AND PARASITIC PLANTS GROW ON OTHER LIVING PLANTS. Typically, epiphytic plants are not rooted in the soil. Instead, they live above ground level on the stems and branches of other plants. Epiphytes obtain water from trapped rainwater and from moisture in the air. They obtain minerals from organic matter that has accumulated on the surface of the plant on which they are growing. Like other green plants, epiphytes produce their food by photosynthesis. Epiphytes include tropical orchids and bromeliads (air plants) and some mosses that live in temperate regions. Parasitic plants obtain all their nutrient requirements from the host plants on which they grow. The parasites produce haustoria, root-like organs that penetrate the stem or roots of the host and grow inward to merge with the host's vascular tissue. These extract water, minerals, and manufactured nutrients. Because they have no need to produce their own food, parasitic plants lack chlorophyll, the green photosynthetic pigment, and they have no foliage leaves. Partial parasitic plants, like mistletoe, obtain water and minerals from the host plant but have green leaves and stems and are therefore able to produce their own food by photosynthesis.

EPIPHYTIC BROMELIAD
Aechmea miniata



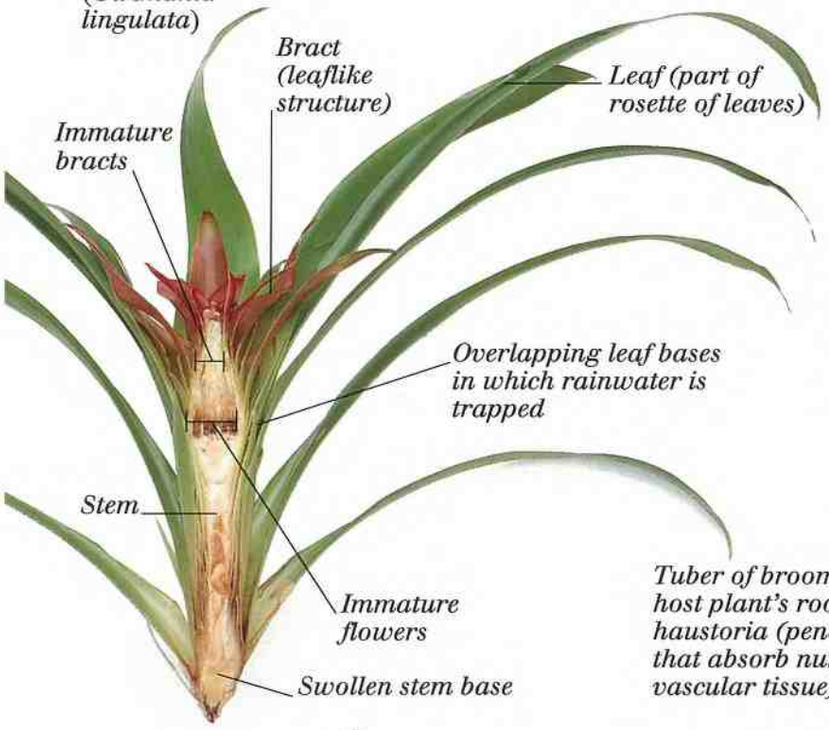
EPIPHYTIC ORCHID
Brassavola nodosa



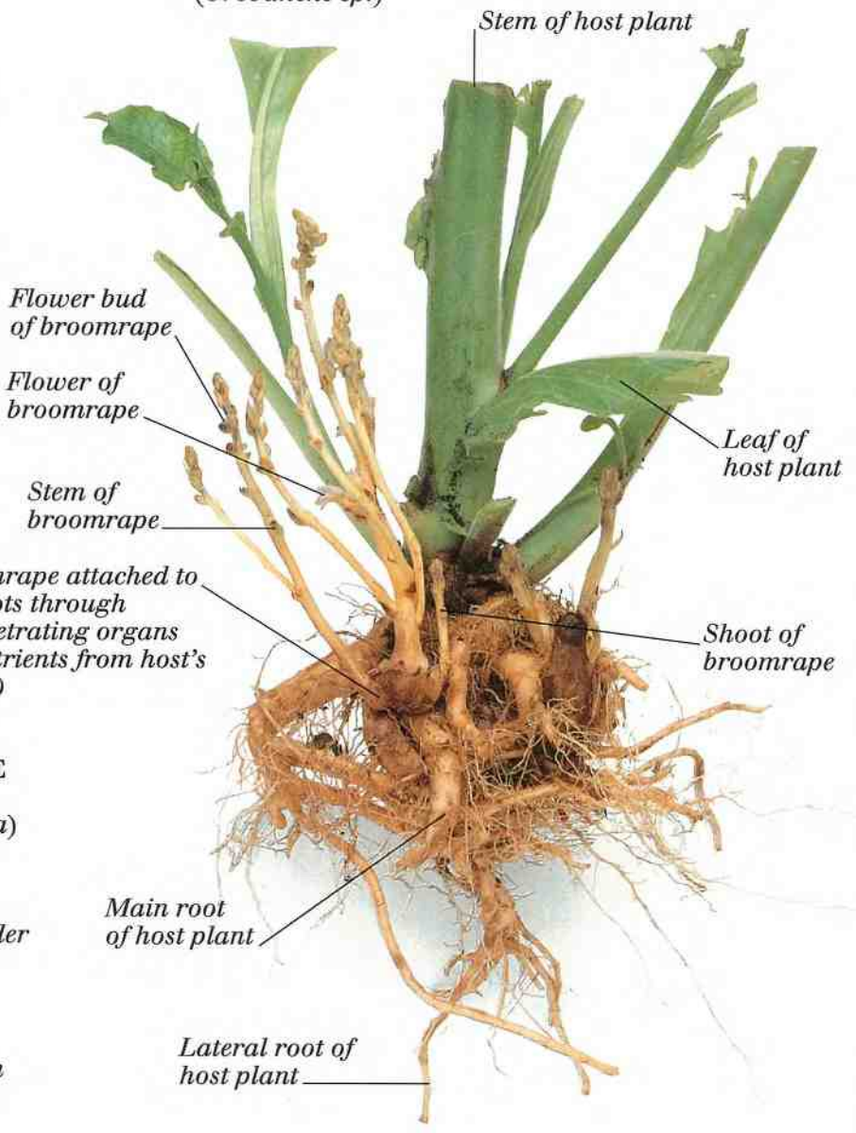


MICROGRAPH OF CROSS SECTION THROUGH AERIAL ROOT OF EPIPHYTIC ORCHID

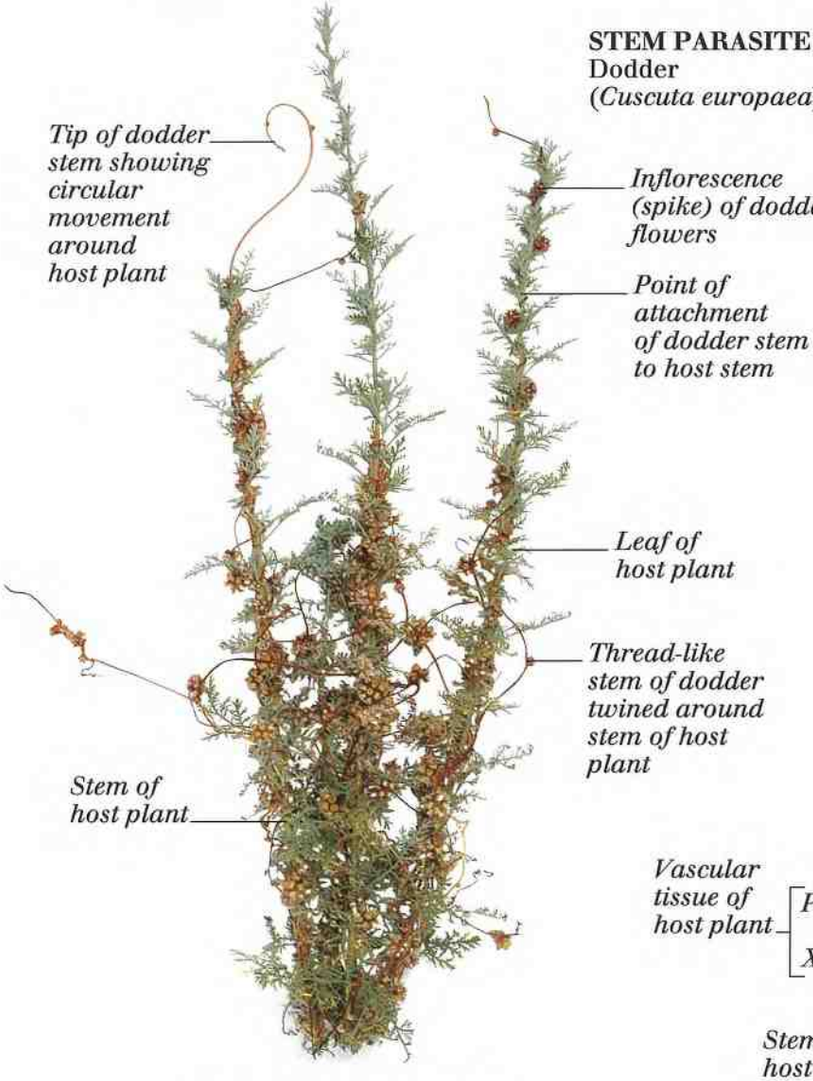
LONGITUDINAL SECTION THROUGH EPIPHYTIC BROMELIAD
Scarlet star
(*Guzmania lingulata*)



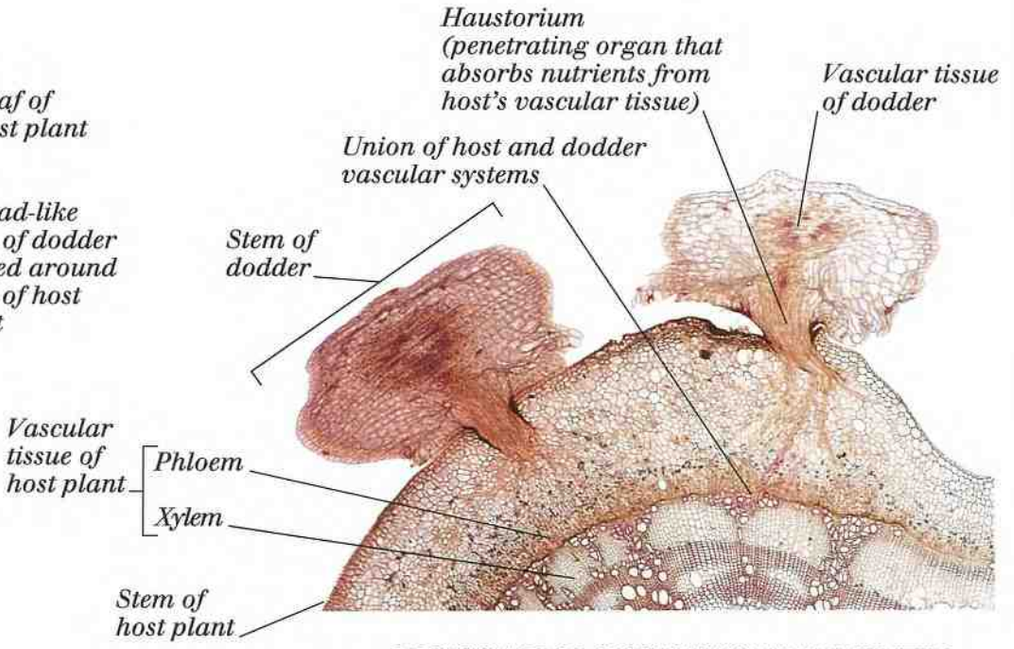
ROOT PARASITE
Broomrape
(*Orobanche sp.*)



STEM PARASITE
Dodder
(*Cuscuta europaea*)



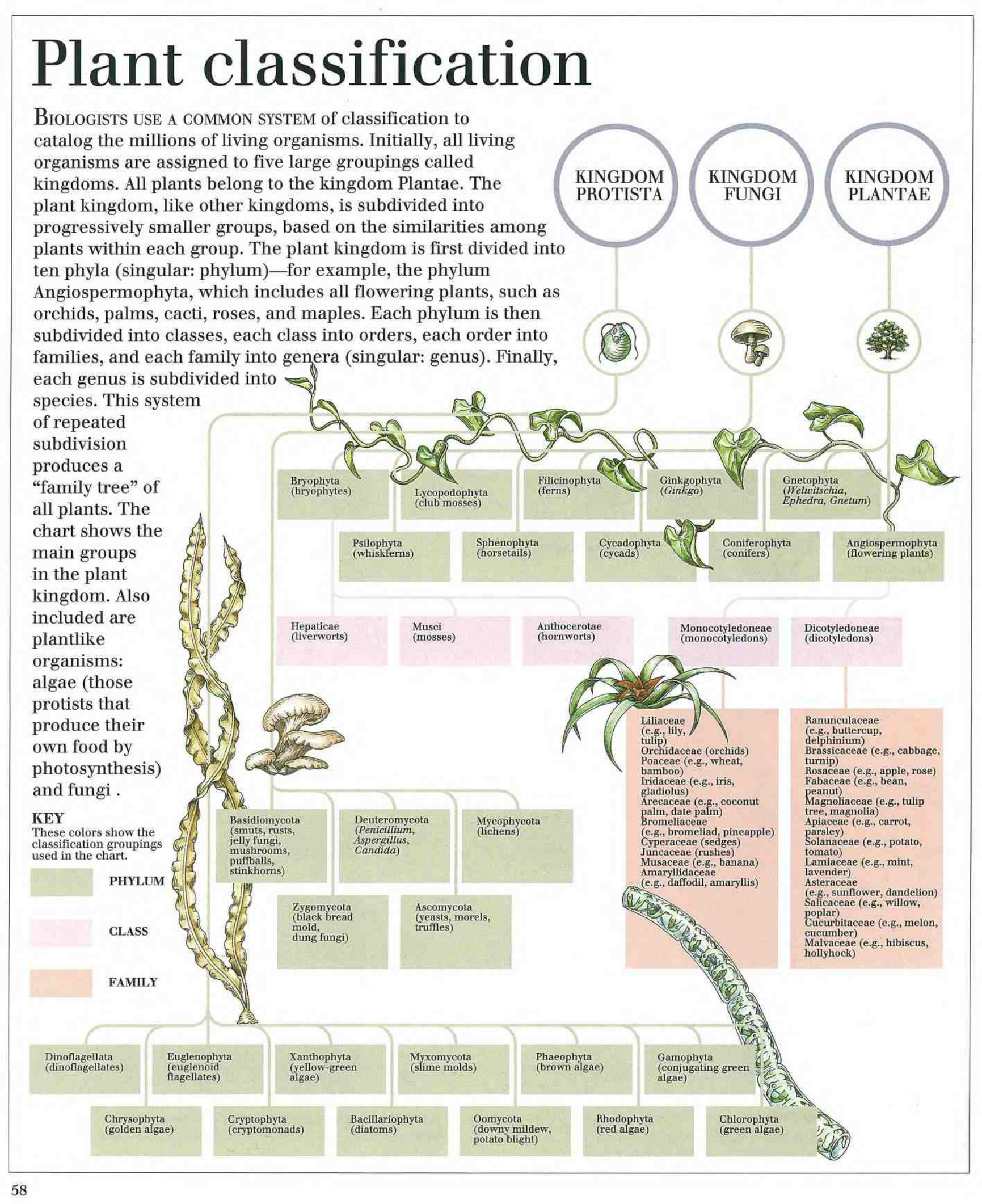
EXTERNAL VIEW OF PLANT PARASITIZED BY DODDER



MICROGRAPH OF CROSS SECTION THROUGH STEM OF PLANT PARASITIZED BY DODDER

Plant classification

BIOLOGISTS USE A COMMON SYSTEM of classification to catalog the millions of living organisms. Initially, all living organisms are assigned to five large groupings called kingdoms. All plants belong to the kingdom Plantae. The plant kingdom, like other kingdoms, is subdivided into progressively smaller groups, based on the similarities among plants within each group. The plant kingdom is first divided into ten phyla (singular: phylum)—for example, the phylum Angiospermophyta, which includes all flowering plants, such as orchids, palms, cacti, roses, and maples. Each phylum is then subdivided into classes, each class into orders, each order into families, and each family into genera (singular: genus). Finally, each genus is subdivided into species. This system of repeated subdivision produces a "family tree" of all plants. The chart shows the main groups in the plant kingdom. Also included are plantlike organisms: algae (those protists that produce their own food by photosynthesis) and fungi .



KEY
These colors show the classification groupings used in the chart.

PHYLUM

CLASS

FAMILY

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