82
BASIC FLOWER STRUCTURE

Color the pedicel (A)/peduncle (A[1]) and receptacle (B) on the three large longitudinal section diagrams of flowers. Color the sepals (C) and petals (D) of the flowers on the upper half of the plate and the tepals (E) on the flower at the bottom of the plate.

The flower is a specialized branch, or shoot, consisting of a short stem with four kinds of parts. The individual flower parts are derived from highly specialized leaves. In flowering plants that produce an inflorescence (clusters of two or more flowers, such as some roses, geramiums, lilies, etc.), each flower is supported by a stalklike stem called the *pedicel.* In flowering plants that produce solitary flowers (such as some roses, poppies, and magnolia, for example), the stalklike stem is called a *peduncle.* In addition, the stem supporting an inflorescence is called a *peduncle* (see Plate 91). In any case, the flower-bearing stem is terminated by an enlarged end, the *receptacle,* to which the individual flower parts are attached. The tight clustering of flower parts is due to little or no elongation of the *receptacle.* In most flowers, all parts of one kind are arranged in a distinct group, called a floral series. For example, the *calyx,* one floral series, is made up of one kind of flower part, the *sepals.* Since each flower has four kinds of parts, each has four distinct floral series.

The lower two floral series, the *calyx* and the *corolla,* are referred to as the two sterile series because they do not function directly in sexual reproduction. The first, or lowermost, floral series, is the *calyx.* While the flower is in the bud stage, the *calyx* functions to protect the other, more delicate, flower parts. The *sepals* are usually green, somewhat leaflike, and relatively tough, such as the *sepals* of roses, but in some flowers, such as most lilies, the *sepals* are delicate and colorful at maturity and closely resemble the *petals* of the second floral series.

The second floral series, called the *corolla,* consists of individual flower parts called *petals.* A major function of the *corolla* in most flowers is attracting specific animals, mostly insects, that will efficiently transfer pollen from flower to flower, a process called pollination. The shape, background color, color patterns, and other features of the *petals* are usually adaptations to facilitate efficient pollination. In most flowers, the *petals* are usually larger and more colorful than the *sepals* when the flower is open.

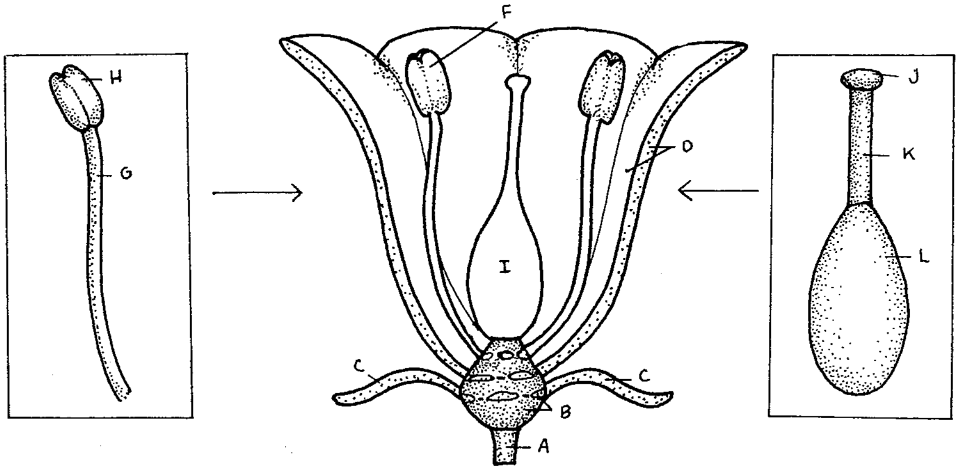
The first two floral series, the *calyx* and the *corolla,* are collectively called the perianth. If the *sepals* and *petals* are similar in size, shape, and color and grade into one another, such as in magnolias, the individual flower parts of the perianth are called *tepals.*

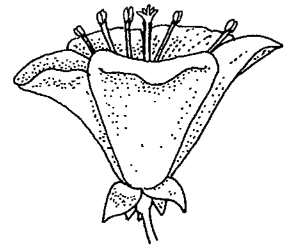
Color the stamens (F) on all flower diagrams and the filament (G) and anther (H) of the single boxed stamen. Also color the pistils (I) on all flower diagrams and the stigma (J), style (K), and ovary (L) of the single boxed pistil.

The upper two floral series, the androecium and the gynoecium, are referred to as the two fertile series because they function directly in sexual reproduction. The third floral series, called the androecium, which means "male home," consists of individual flower parts called *stamens.* In most flowers, each *stamen* consists of a thin, stalklike *filament* and an enlarged end, the *anther,* consisting of one to four chambers within which pollen is produced. Pollen, which is released by rupture of the mature *anther,* contains the male gametes.

The fourth floral series, called the gynoecium, which means "female home," consists of individual floral parts called *pistils. Pistils* may be derived from a single specialized leaf or two or more specialized leaves that are fused into one unit. Depending upon plant species, one to numerous *pistils* are found within the gynoecium. Each *pistil* usually has three parts: *stigma, style,* and *ovary.* The apex of the *pistil,* the *stigma,* is often branched or lobed and has a receptive surface that exudes a sticky substance to which pollen adheres. The narrowed, necklike portion of the *pistil* below the *stigma* is the *style,* but in some flowers, it is reduced or lacking. The enlarged base of the *pistil,* the *ovary,* contains one or more chambers in which one to many thousands of female gametes are produced.

BASIC FLOWER STRUCTURE•

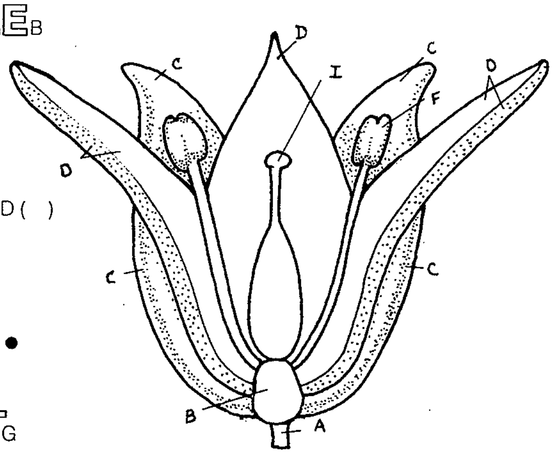


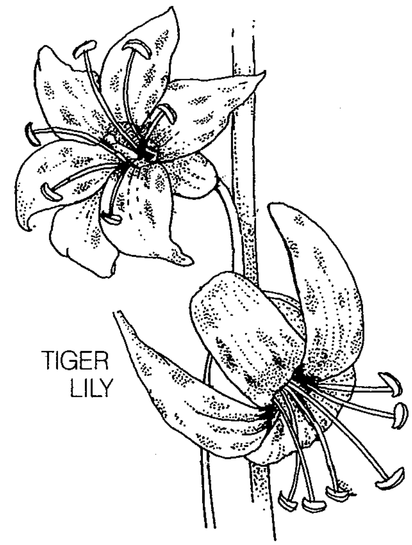


GERANIUM

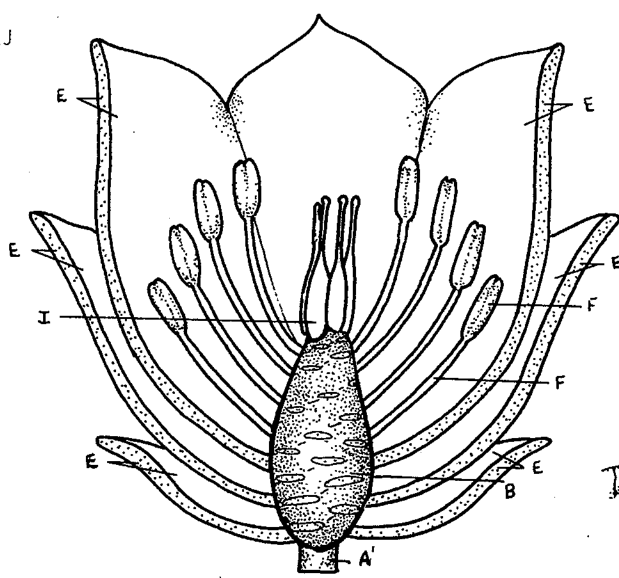
FLOWER PARTS★

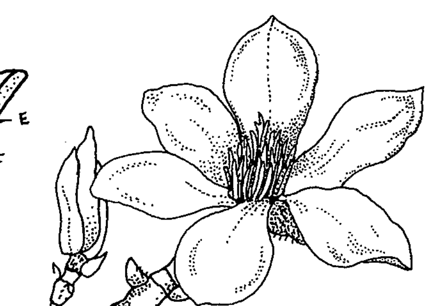
- PEDICEL A / PEDUNCLE A'
- RECEPTACLE B
- PERIANTH•
  - CALYX C ( )
    - SEPAL C
  - COROLLA D ( )
    - PETAL D
  - TEPAL E
- ANDROECIUM•
  - STAMEN F
  - FILAMENT G
  - ANTHER H
- GYNOECIUM•
  - PISTIL I
    - STIGMA J
    - STYLE K
    - OVARY L





TIGER LILY





MAGNOLIA

81
SEED PLANT REPRODUCTION

This plate compares some major reproductive features for the two types of seed plants, the gymnosperms (meaning "naked seeds") and the angiosperms (meaning "covered seeds").

Color the ovules (A), micropyles (B), pollen grains (H), and pistil (L) on the two diagrams at the top of the plate.

The exposed *ovules* of gymnosperms (a pine conifer, Coniferophyta, is illustrated) permit the transfer of *pollen grains* directly to the *micropyle,* where the pollination droplet (not shown), secreted through the *micropyle,* catches them. In flowering plants, Anthophyta, the *ovules* are completely surrounded and enclosed by a specialized sporophytic structure called a *pistil.* One or more *ovules* are located within each chamber, or *locule,* formed by the *pistil.* Angiosperm *pollen grains* are deposited on a specialized, often sticky, surface at the top of the *pistil* and not in the immediate vicinity of the *micropyle* because the *micropyle* is not exposed to permit direct transfer, as in gymnosperms.

Color the integument (C), nucellus (D), and megagametophyte (E) on the two ovule diagrams across the middle of the plate.

The gymnosperm *ovule* has a single-layered *integument,* several cells thick, of sporophytic tissue that completely surrounds, except for the *micropyle,* the megasporangium or *nucellus.* In gymnosperms, the *nucellus* produces from one (in pines) to a few diploid megasporocytes (not shown) that, upon meiosis, each form one functional megaspore and three nonfunctional megaspores (not shown). A functional megaspore undergoes mitotic division to produce a mature multicelluar *megagametophyte* surrounded by the *nucellus.* Between the *nucellus* and the *integument,* in the area of the *micropyle,* is a large chamber called the micropylar chamber (not colored).

In most angiosperms, the *ovules* have a two-layered *integument* and a very small chamber behind the *micropyle.* The *nucellus* produces only one megasporocyte that typically produces one functional megaspore and three nonfunctional megaspores. The *megagametophyte* that develops from the functional megaspore is highly reduced and consists of only seven cells in most angiosperms.

On the third row of diagrams, color the previously listed features and the archegonia (F), eggs (G), microgametophyte (I), tube nucleus (J), and sperm (K).

Though the gymnosperm *megagametophyte* is a single multinucleate cell in its early stages of development (not shown), at maturity, it consists of a multitude of uninucleate haploid cells. Each *megagametophyte* produces two or more *archegonia* completely imbedded within the *megagametophyte* with their neck region oriented toward the micropylar chamber (not shown). Gymnosperms produce typical *archegonia* with a swollen basal chamber that contains a single *egg* and a narrow neck region.

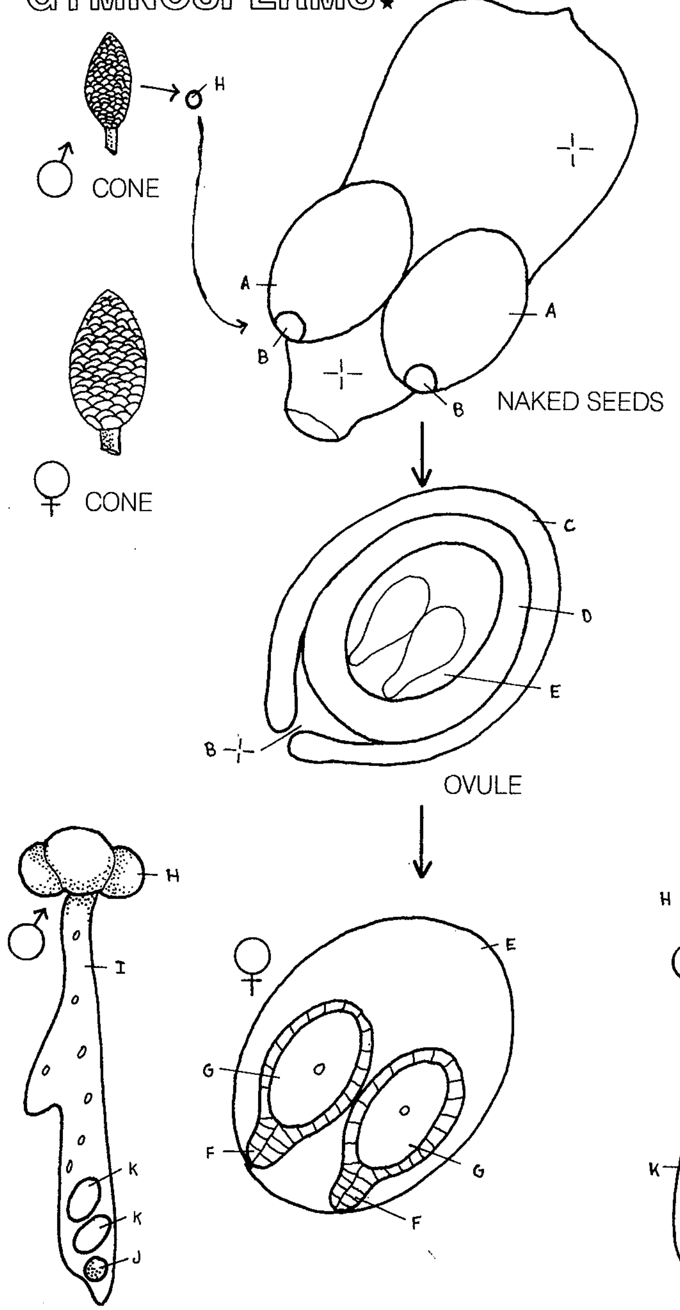
The seven-celled angiosperm *megagametophyte* has six uninucleate haploid cells and a large central cell containing two haploid nuclei called polar nuclei. The single *egg* is flanked by two cells that are thought to be a highly reduced *archegonium.*

In gymnosperms, dehydration of the pollination droplet pulls attached *pollen grains* through the *micropyle,* into the micropylar chamber, and in direct contact with the *nucellus.* Prior to germination, gymnosperm *microgametophytes* within the *pollen grain* consist of four to several cells (not shown). Upon germination, the *microgametophyte* forms a pollen tube that grows through the *nucellus* toward the *megagametophyte.* Within the pollen tube of the gymnosperm *microgametophyte* just prior to fertilization are several vegetative haploid nuclei (not separately colored), a *tube nucleus* at the apex, and two *sperm* located just behind the *tube nucleus.* Most gymnosperms produce nonmotile *sperm,* but a few, such as cycads and ginkgo, produce *sperm* motile by numerous cilia.

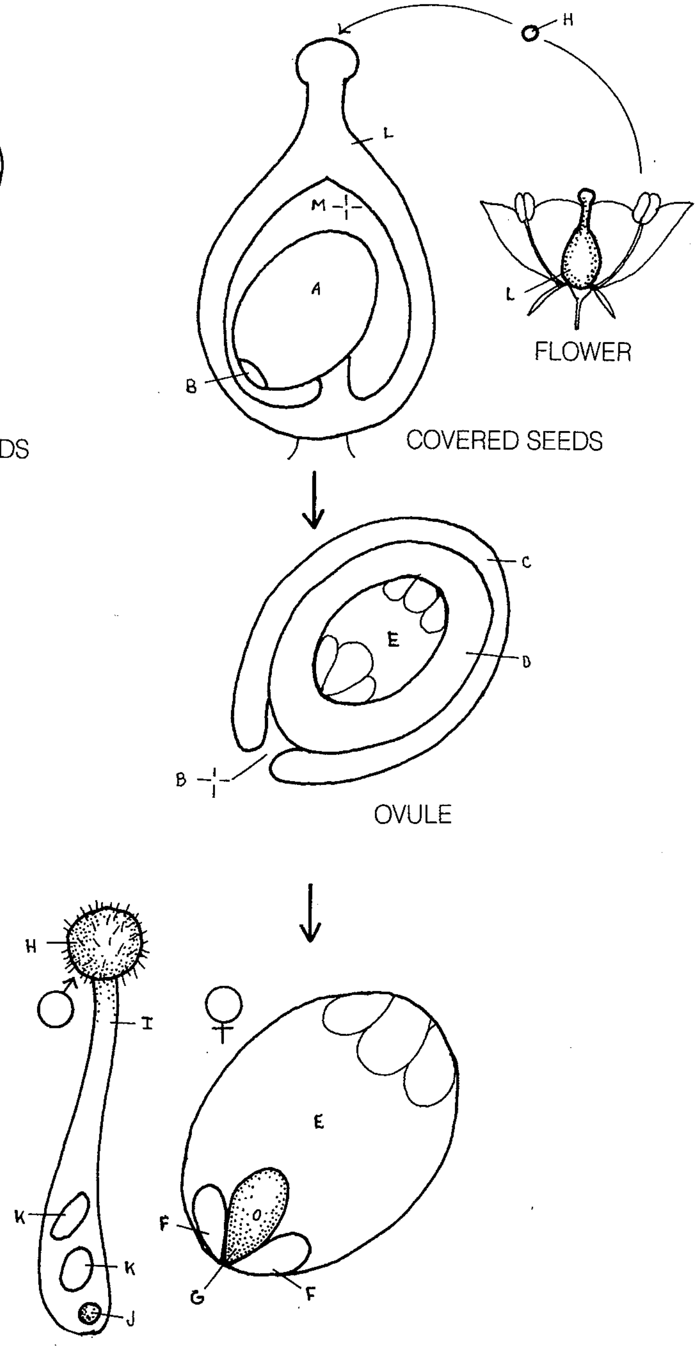
Prior to germination, most angiosperm *microgametophytes* are two celled. Upon germination on the surface of the *pistil,* the *microgametophyte* sends a pollen tube through the tissue of the *pistil,* through the *micropyle,* through the *nucellus,* and to the *megagametophyte.* At maturity, the pollen tube of the angiosperm *microgametophyte* contains only the *tube nucleus* at the growing end of the pollen tube and two nonmotile *sperm.* All angiosperm *sperm* are nonmotile.

OVULE AND MICROGAMETOPHYTE STRUCTURE.

GYMNOSPERMS★



ANGIOSPERMS★



OVULEA
MICROPYLE B
INTEGUMENT C
NUCELLUS D
MEGAGAMETOPHYTE E
ARCHEGONIUM F
EGG G

POLLEN GRAIN H
MICROGAMETOPHYTE I
TUBE NUCLEUS J
SPERM K
PISTIL L
LOCULE M-¦-

55
VASCULAR SYSTEM FUNCTION

Color the pith (A), xylem (B), and phloem (D). Also color the arrows indicating the flow of water and minerals (C) into the root and, on the "stem section," up the stem and the arrows indicating the flow of food materials (E) down the leaf and down the stem section. Do not color the cortex and epidermis (F).

In order for land plants to break away from existing solely as small, prostrate plants appressed to a moist substrate, numerous adaptations, both morphological and physiological, evolved. These were necessary to overcome the problems encountered with growth upward into a relatively dry atmosphere without external support. The development of the vascular system fulfilled two major requirements by providing a means for both conduction and support.

In a typical dicot stem, the central portion of the stem is occupied by the *pith,* a storage tissue composed of thin-walled cells. Surrounding the *pith* is a cylinder of *xylem* tissue that functions in conducting *mineral nutrients* and *water* upward and as the major structural plant tissue. A cylinder of a second kind of vascular tissue, *phloem,* which functions in conducting photosynthetic *food materials,* primarily downward, and as a support tissue, surrounds the *xylem* cylinder. Surrounding all this is the *cortex,* which functions in storage and support, and an outer layer, the *epidermis,* which functions in water retention.

In roots, a *pith* is usually lacking and the *xylem* forms a solid central core. The arrangement of the two types of vascular tissues, *xylem* and *phloem,* in the leaf differs from that found in roots and stems. Vascular tissue entering a leaf is arranged with the *xylem* as a continuous layer in the upper half of leaf veins and with the *phloem* in the lower half of the veins as if the leaf vascular tissues were peeled away from the stem.

The arrangement of vascular tissues within different plant groups has many variations, but the commonest arrangements are either a cylinder or core of *xylem* surrounded by a cylinder of *phloem* or strands of vascular tissue with *xylem* toward the inside and *phloem* toward the outside of each strand.

Color the arrows on the leaf indicating the direction of movement of carbon dioxide (G), oxygen (H), and transpiration water (I).

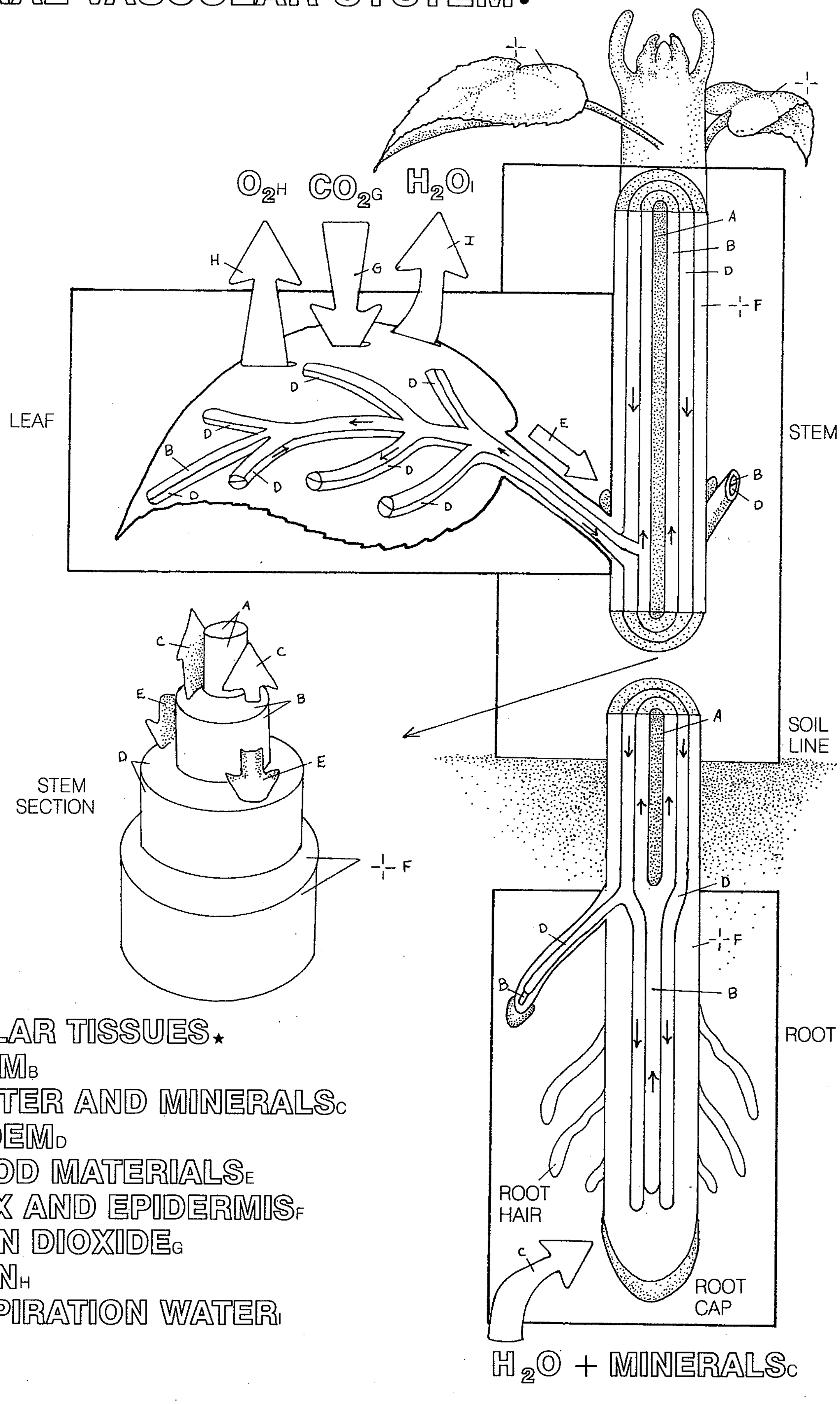
In vascular plants, *mineral nutrients* and *water,* taken into young roots near their tips, enter the *xylem* tissue, which consists primarily of nonliving conductive and supportive cells, and are carried upward through the root and stem systems to all plant parts. In *xylem* tissue, the net direction of material flow is upward, and the primary materials transported are *mineral nutrients* and *water.* The photosynthetic process that occurs in all green portions of a plant requires *water* and *carbon dioxide* for the production of photosynthetic *food materials,* mostly sugars, and the liberation of *oxygen.* The synthesis of many organic compounds requires the *mineral nutrients* carried in the *water.* All living cells require an energy source, and this is provided by the photosynthetic *food materials,* which are carried downward from the elevated sites of photosynthesis through the *phloem* tissue to nonphotosynthetic cells in the stem and roots.

In *phloem* tissue, the primary materials transported are photosynthetic *food materials.* The net direction of flow is from areas of high *food materials* concentration, or sources, to areas of low *food materials* concentration, or sinks (for example, from the photosynthetic cells of leaves to the nonphotosynthetic cells of roots).

Photosynthesis requires a large amount of water, but most of the water taken into a plant is lost through *transpiration* (the evaporation of water from plant surfaces) directly through the *epidermis* and through pores called stomates (not shown). The loss of water through *transpiration* is one factor of the mechanism for the movement of water upward in the *xylem,* to over two hundred fifty feet in some trees, and also is required for normal plant growth.

In small, nonvascular plants in contact with a moist substrate, simple diffusion is a sufficient means of transporting *mineral nutrients, water,* and photosynthetic *food materials* to all living cells, but diffusion is a slow process and could not support the requirements of a large plant. The plants that are best adapted to the land habitat, the vascular plants, have evolved an efficient conduction and support system that permits them to be successful in even the most arid habitats, to become elevated above the surface to expand their photosynthetic surface area and to reach for the light.

GENERAL VASCULAR SYSTEM.



PITH A
VASCULAR TISSUES ★
XYLEM B
WATER AND MINERALS C
PHLOEM D
FOOD MATERIALS E
CORTEX AND EPIDERMIS F
CARBON DIOXIDE G
OXYGEN H
TRANSPIRATION WATER I

67
LEAF STRUCTURE

Color the epidermis (A) on the diagrams of the whole leaf, leaf section, and enlargement of a portion of the leaf section. Note that the cuticle (B) is separately colored only on the enlarged portion. Also color the guard cells (C) on the leaf section and the enlarged portion and on the diagrams illustrating their function at the lower right. The stoma (D), which is the pore formed by the guard cells, is not colored. Note that the fundamental system and vascular system features remain uncolored for now.

In most higher plants, the leaf is the primary photosynthentic structure (organ). A generalized dicot leaf is illustrated. Though the dermal, fundamental (ground), and vascular systems are found in most leaves, their arrangement and structure vary. The dermal system consists of a single cell layer, the *epidermis,* and a waxy layer, the *cuticle,* which is secreted by the *epidermis.* The dermal system covers the entire leaf surface to provide protection against desiccation. The epidermal cells are usually cuboidal in cross section, with the outer cell walls thicker than the inner walls. The *cuticle* varies in thickness, depending on plant species and aridity of the environment. *Cuticle* thickness is usually greatest in an arid environment.

Since the *epidermis* and *cuticle* effectively inhibit the movement of water and gases through the leaf surface and since gas exchange is necessary for photosynthesis, a means of allowing gases to pass into and out of a leaf is required. Numerous stomates, which are found only in the lower leaf *epidermis* in most plants, permit gas exchange and also regulate water loss. A stomate consists of two *guard cells* that function as gatelike valves that open the stomate by forming an opening, called a *stoma,* or that close the stomate by coming together. In most plants, stomates open during the day, for gas exchange while photosynthesis is occurring, and close at night to prevent water loss. Stomates may close during hot days to reduce water loss. Stomate function is controlled by internal hydrostatic (water) pressure, called turgor pressure (represented by the small arrows on the open stomate), within the *guard cells.*

Each *guard cell,* unlike the other cells of the *epidermis,* contains several chloroplasts. During the day, photosynthesis within the chloroplasts in the *guard cells* produces sugars. This causes an influx of water and therefore an increase in the turgor pressure within the *guard cells.* As a result, the *guard cells* swell. Since the outer, thin-walled areas (those away from the *stoma*) of the *guard cells* distend more readily than the inner, thick-walled areas (those adjacent to the *stoma*), the *guard cells* swell outward and pull the thick walls outward. This creates the opening, the *stoma,* of the stomate. At night, the sugars are used; the excess water leaves the *guard cells;* the turgor pressure drops; the *guard cells* shrink; and the *stoma* is closed.

Color the palisade parenchyma (E) and spongy parenchyma (F) cells of the mesophyll on the large leaf section diagram in the middle of the plate and on the enlarged section of leaf in the lower left corner. Do not color the air spaces (G).

The mesophyll, or middle leaf, is the fundamental tissue system of the leaf. Two regions of mesophyll, the *palisade parenchyma* and the *spongy parenchyma,* can be recognized. The *palisade parenchyma* consists of cylindrical, thin-walled parenchyma cells that contain numerous chloroplasts. This is the primary photosynthetic tissue of the leaf. *Palisade parenchyma* cells are closely packed, with only a very small air space between cells.

The thin-walled cells of the *spongy parenchyma* are irregularly shaped and loosely packed, forming large air spaces that create a continuous *air space* within the mesophyll. Most gas exchange, O_2 and CO_2, occurs in this area.

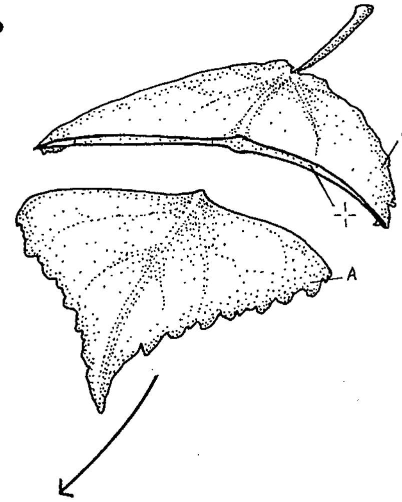
Color the bundle sheath (H) and bundle sheath extension (H^1) and the complex tissues of the vascular system, the xylem (I) and phloem (J), in the two large diagrams that are partially colored.

The vascular system forms a diversely branching network of conductive veins within the mesophyll. In the veins, the *xylem,* which conducts water and minerals, lies above the *phloem,* which conducts food materials. Each vein, or vascular bundle, is surrounded by a sheath of parenchyma cells called the *bundle sheath.* On major veins, ***bundle sheath extensions*** connect the vein with the upper and lower *epidermis.*

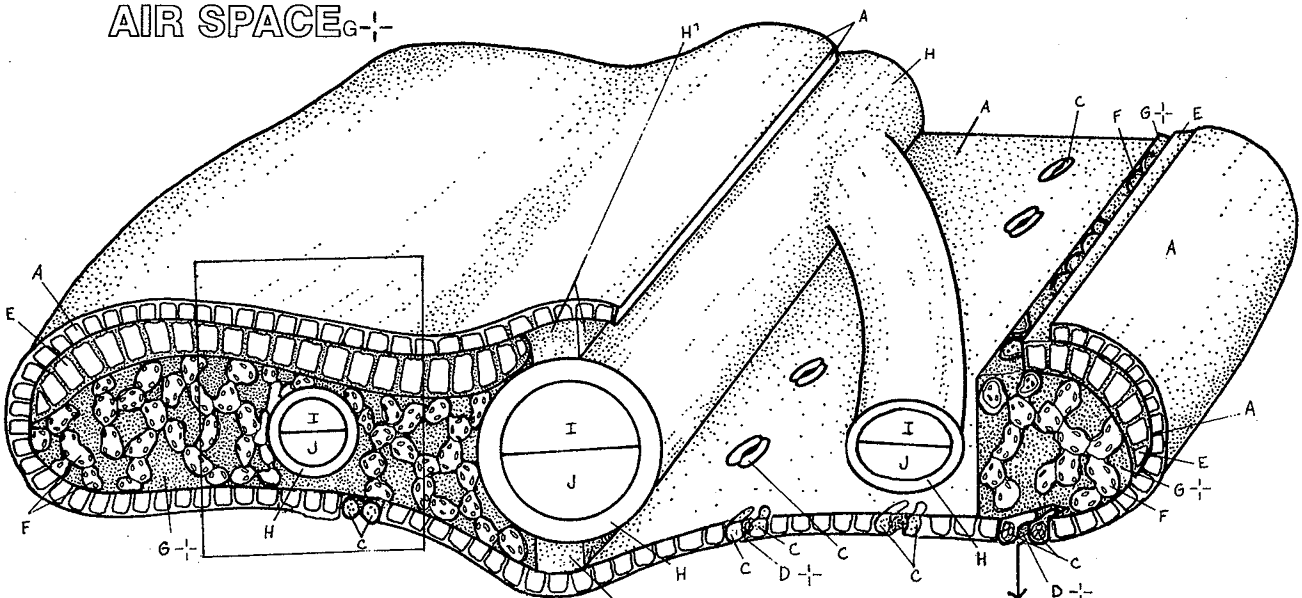
GENERAL LEAF ANATOMY•

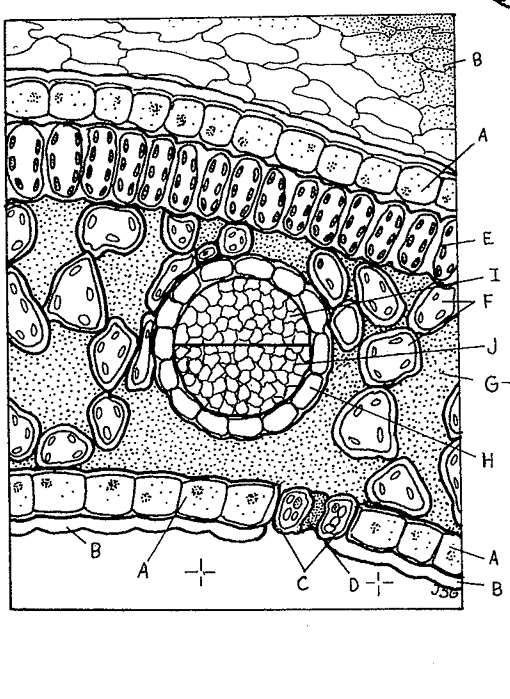
DERMAL SYSTEM★
- EPIDERMIS A
- CUTICLE B

STOMATE★
- GUARD CELL C
- STOMA D -¦-

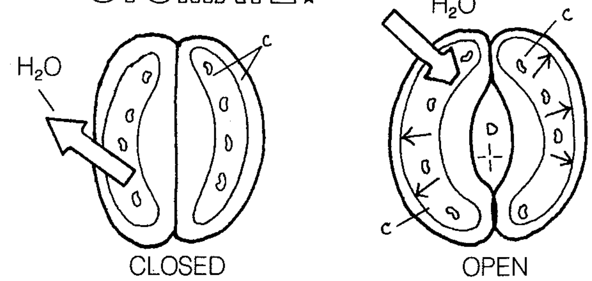


FUNDAMENTAL SYSTEM★
- MESOPHYLL★
- PALISADE PARENCHYMA E
- SPONGY PARENCHYMA F
- AIR SPACE G -¦-





STOMATE★



BUNDLE SHEATH H

BUNDLE SHEATH EXTENSION H¹

VASCULAR SYSTEM★
- XYLEM I
- PHLOEM J