THE LEAF: ANATOMY

The leaf can be defined as a flattened part of the shoot system in which the apical growth is terminated early during the development.

The main function of foliage leaves is photosynthesis.

The flattened architecture of the leaf means high surface/volume ratio which in turn mean high light perception and gas exchange through stomata.

These features are essential to maintain efficient photosynthesis.

A typical leaf is composed of a ***petiole*** and a ***blade***.

In addition, a pair of minute structures that develops form the leaf primordium-the ***stipules***-is found at the leaf base

The arrangement of tissues in leaves

The epidermis

The leaf is covered with epidermis on both sides.

The face of the leaf that is usually directed upward and is closer to the internode is the ***adaxial surface.***

The other face is the ***abaxial surface***.

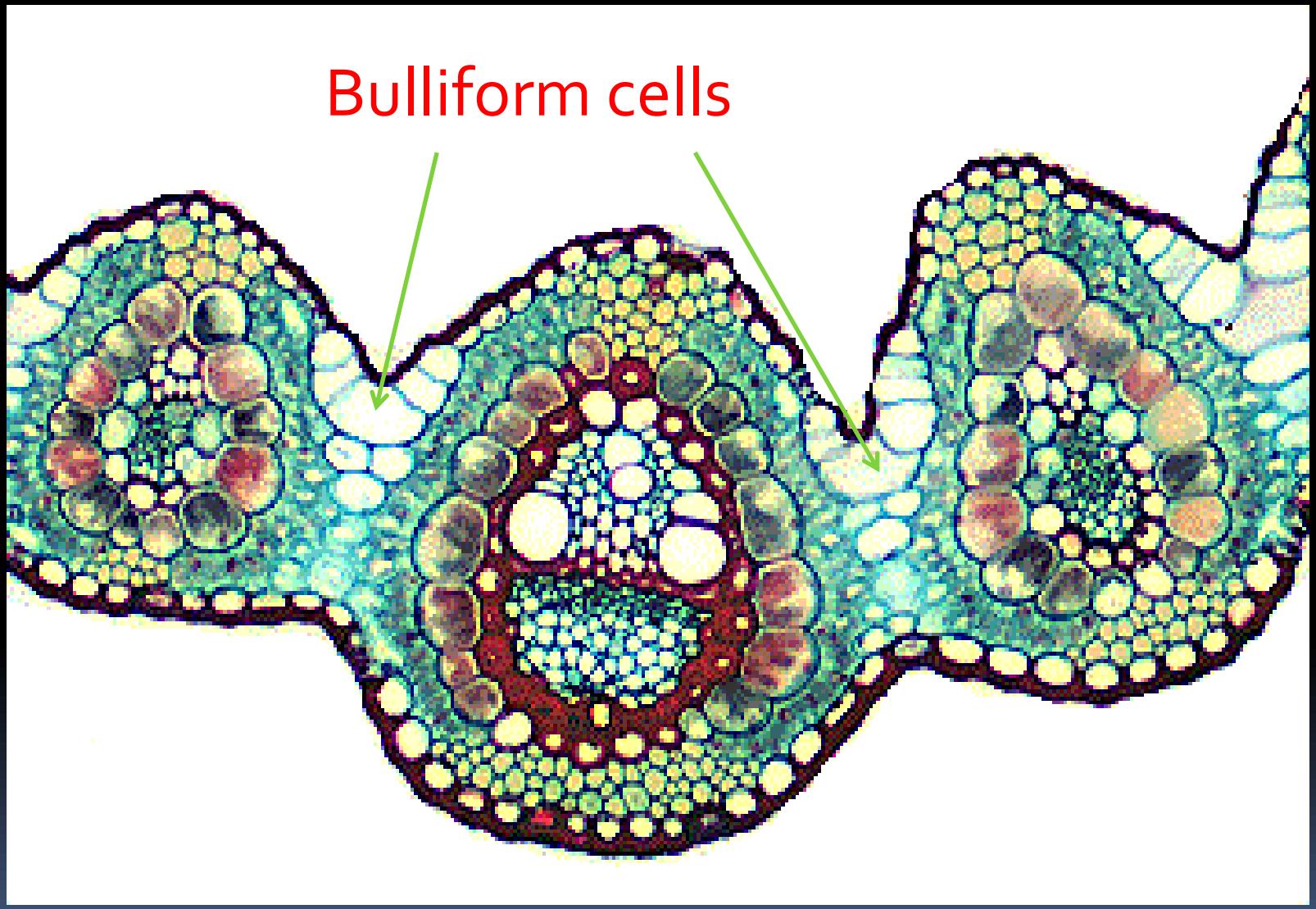
The ***adaxial epidermis*** of some plants such as grasses contains ***bulliform cells*** that are larger in size and different in shape from the basic epidermal cells.

They are thin walled, devoid of chloroplasts, and have large vacuoles.

These cells may constitute the whole epidermis or exist in separate strips.

The function of these cells is **folding** and **unfolding** of the leaf as a result of water loss or uptake.

This feature is important for preventing excessive water loss when the water supply from soil is limited.


Bulliform cells

The mesophyll

The mesophyll comprises the parenchymatous tissue inside the epidermis.

In many plants especially dicotyledons it is differentiated into two types of cells: the ***palisade and the spongy parenchyma.***

But in monocotyledons the mesophyll is usually homogenous.

Also the mesophyll of some plants such as *Eucalyptus* is composed entirely of palisade.

The cells of the ***palisade parenchyma*** are cylindrical and contain three to five times as many chloroplasts as those of the spongy parenchyma.

The cells of the palisade may be arranged in one or more rows.

The palisade tissue is usually found on the adaxial side of the leaf with some exception in which it exists on the abaxial side.

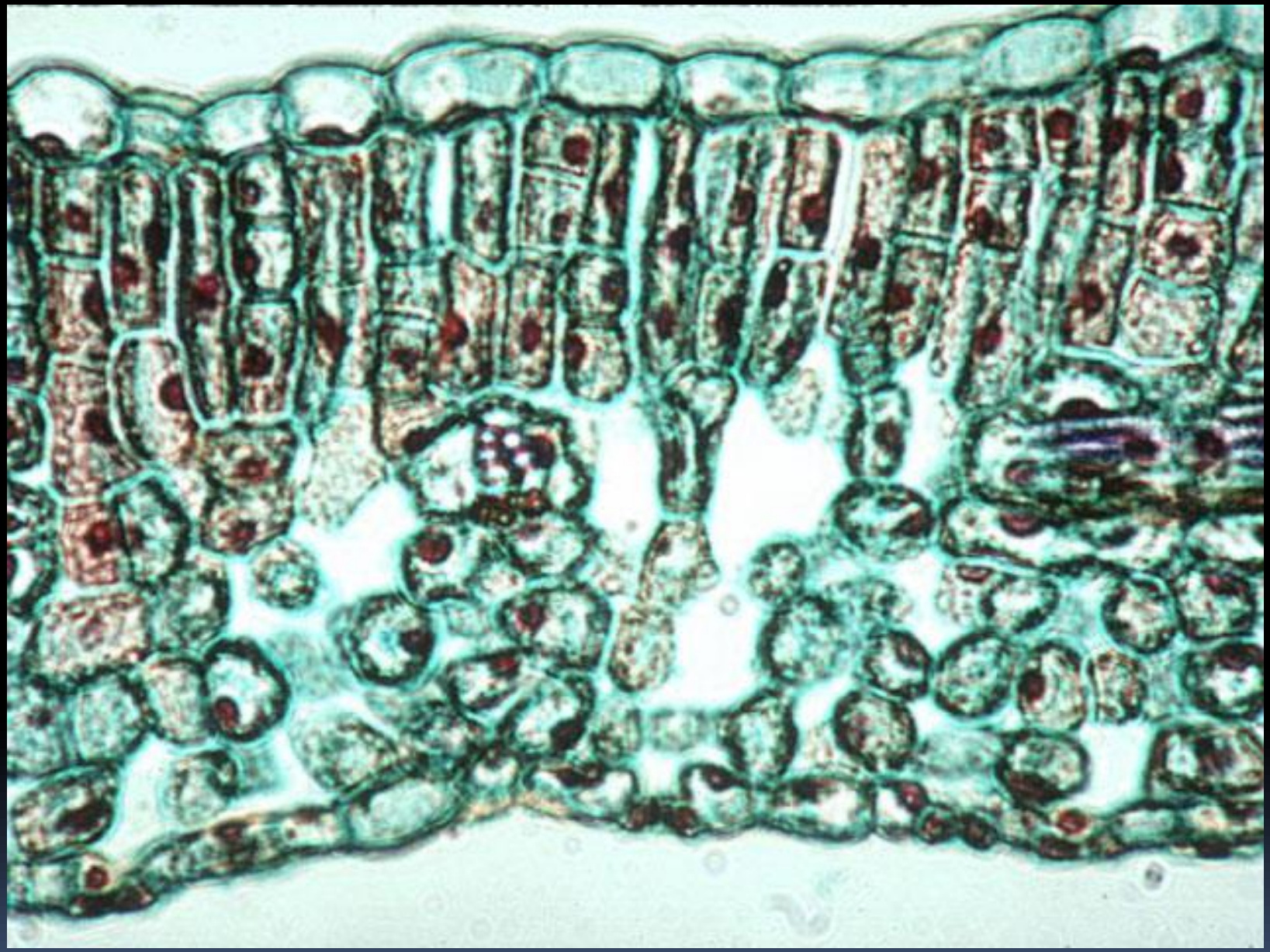
A leaf with palisade on one side and spongy on the other side is termed ***dorsiventral or bifacial*.**

When the palisade exists on both sides the leaf, it is termed ***isolateral or isobilateral***

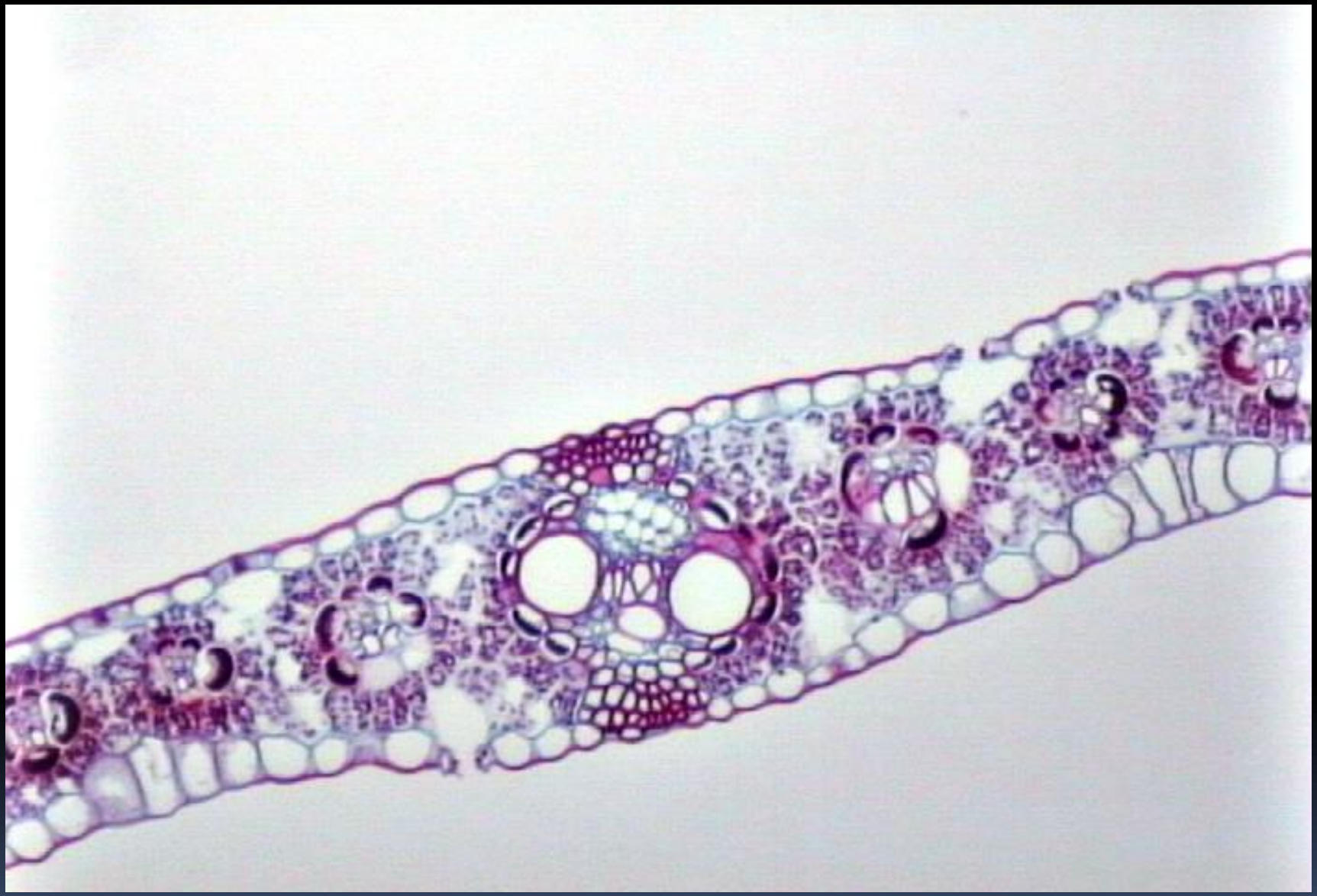
The spongy cells are variously shaped. They are characterized by the presence of lobes by which the cells are interconnected.

The most important feature of mesophyll cells is the abundant intercellular spaces.

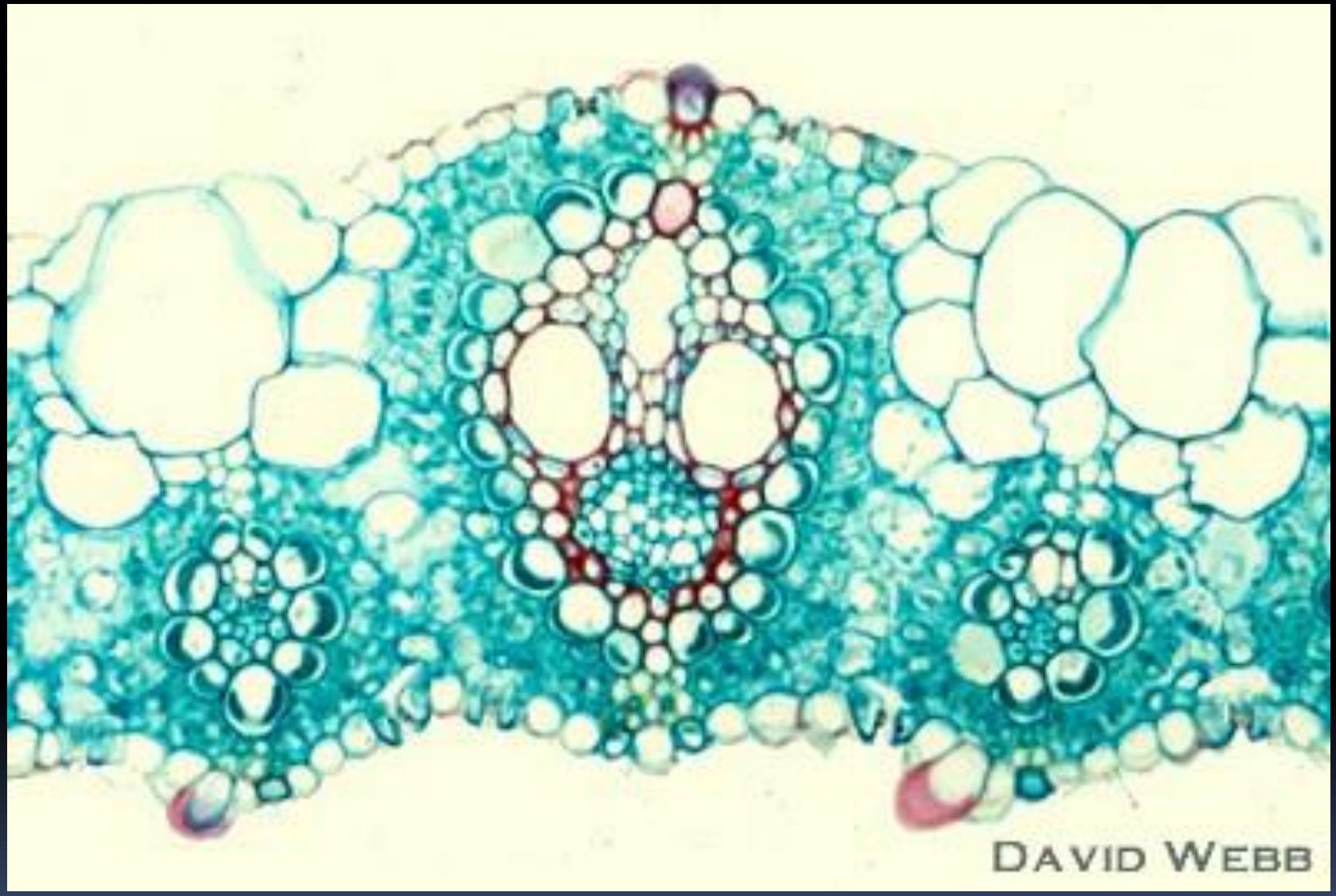
This feature allows the atmospheric CO_2 to diffuse readily into the leaf tissues and thereby ensures adequate supply of CO_2 for photosynthesis.



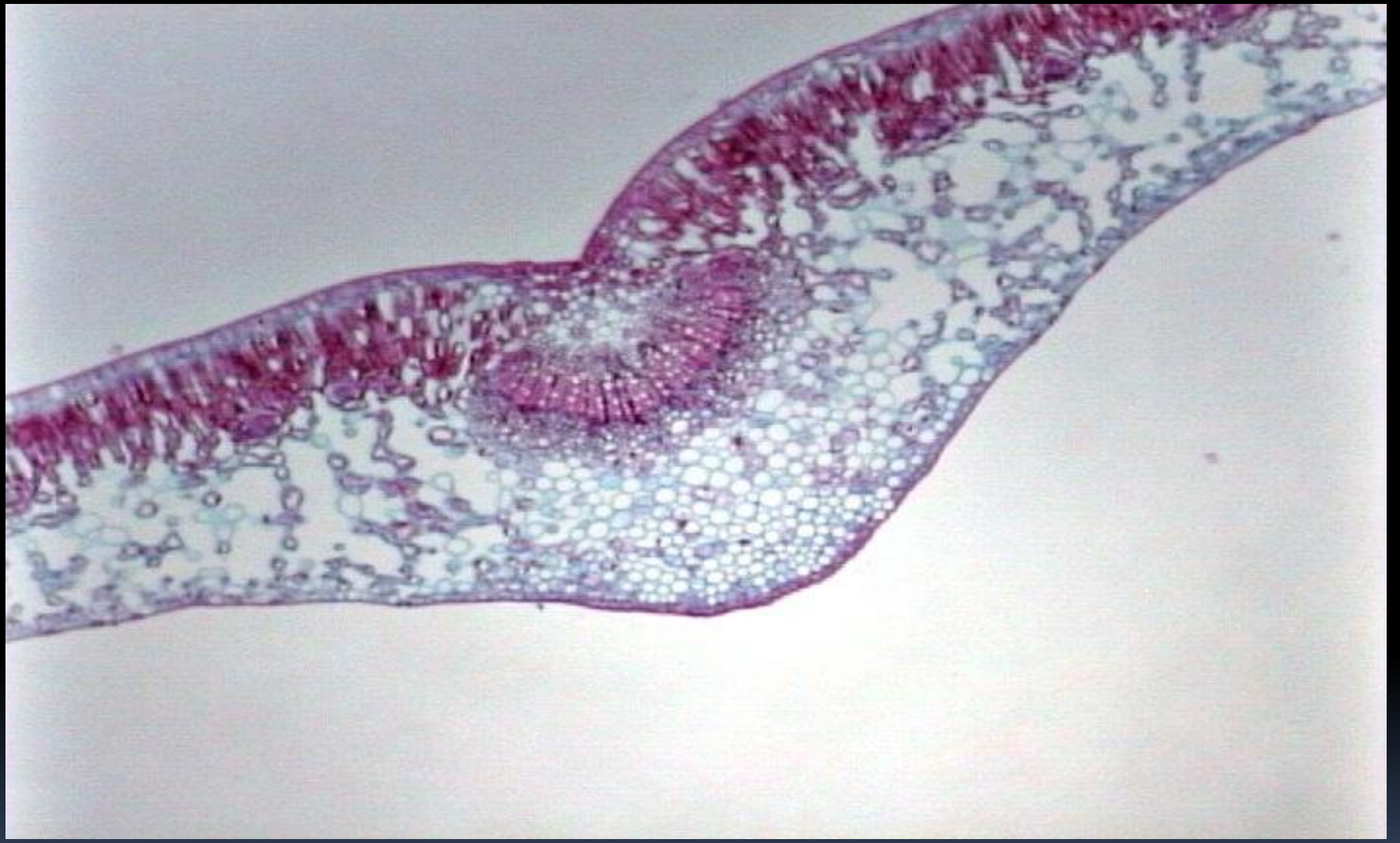
Dicot leaf

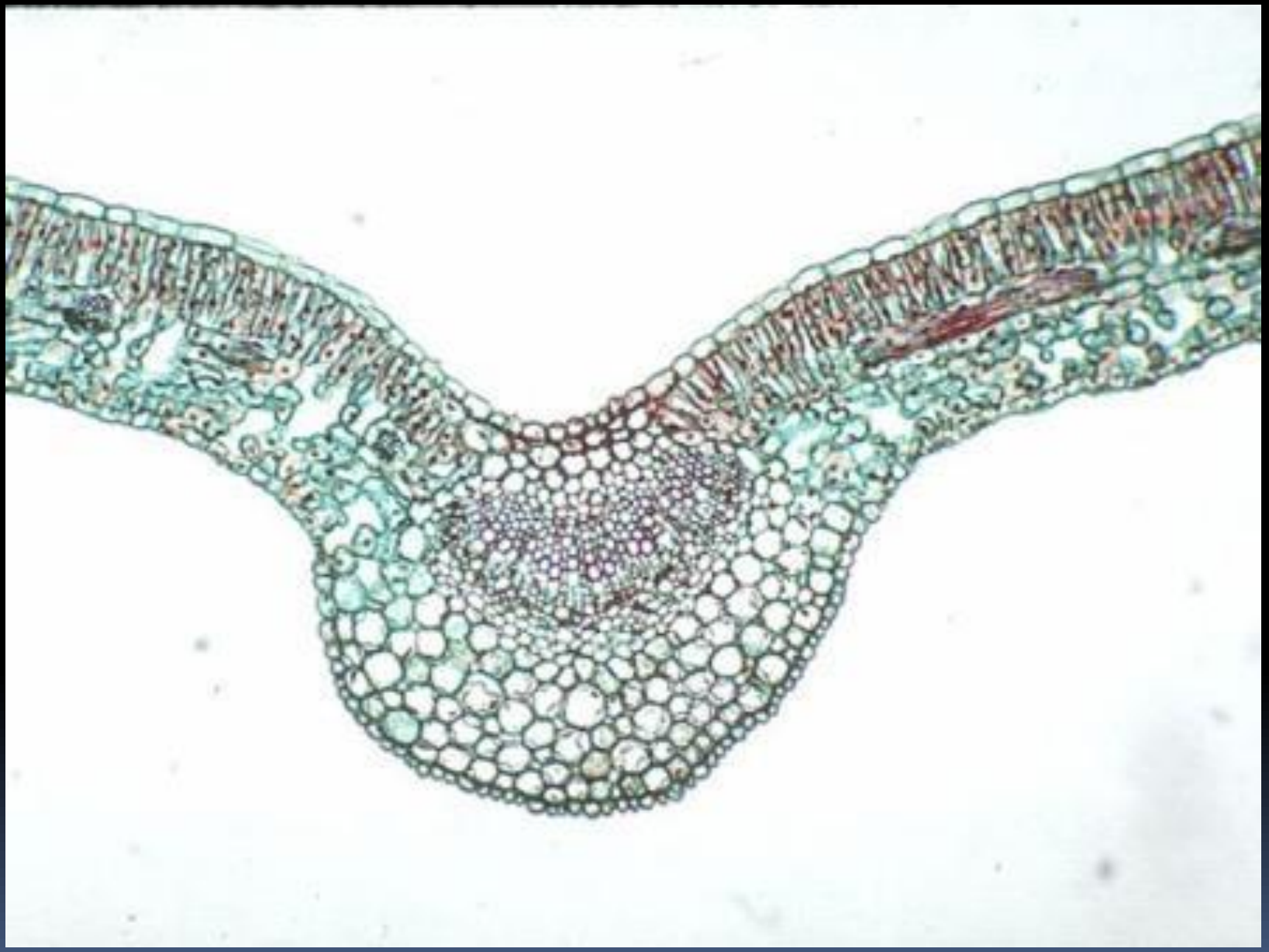


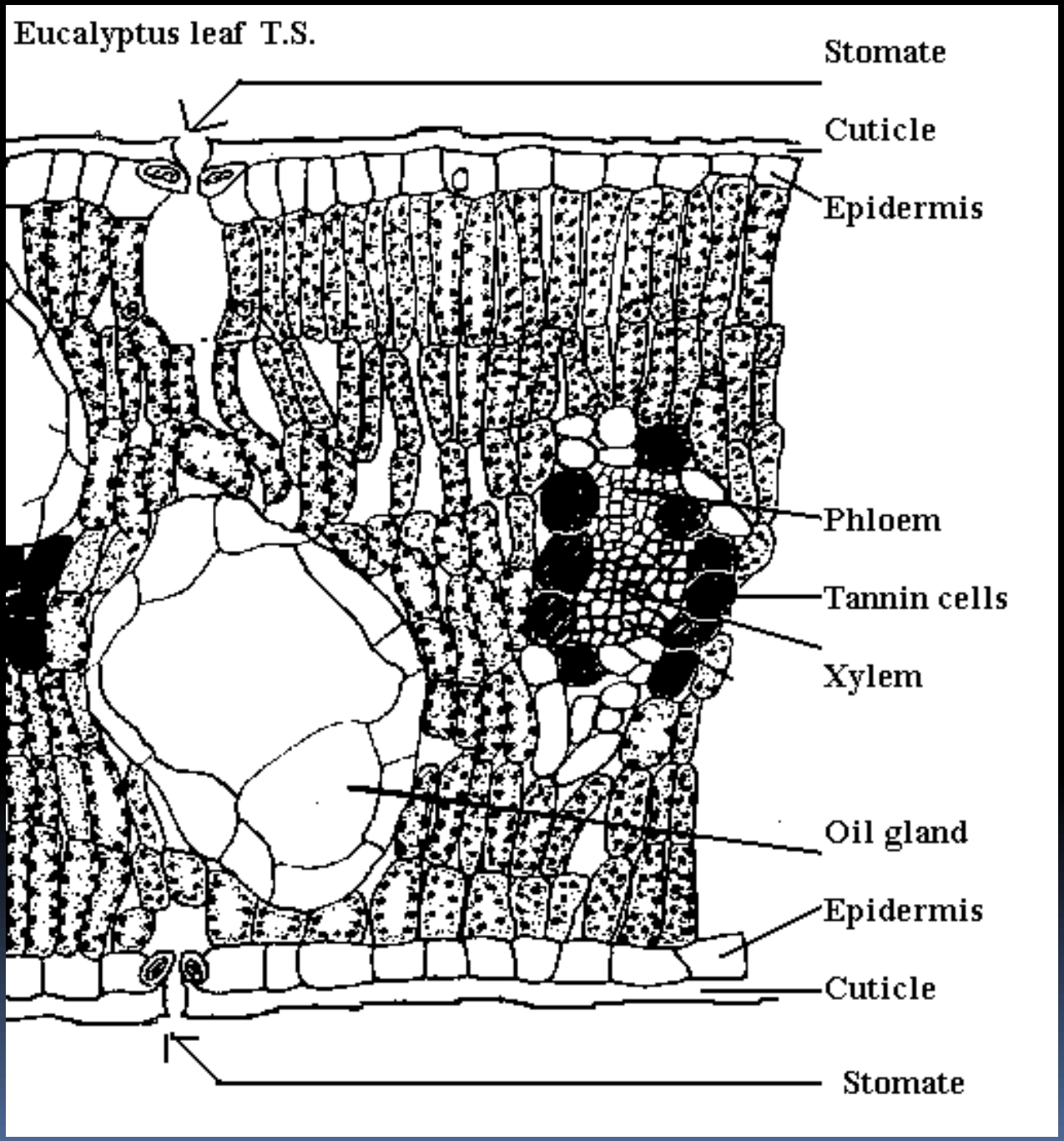
Monocot leaf

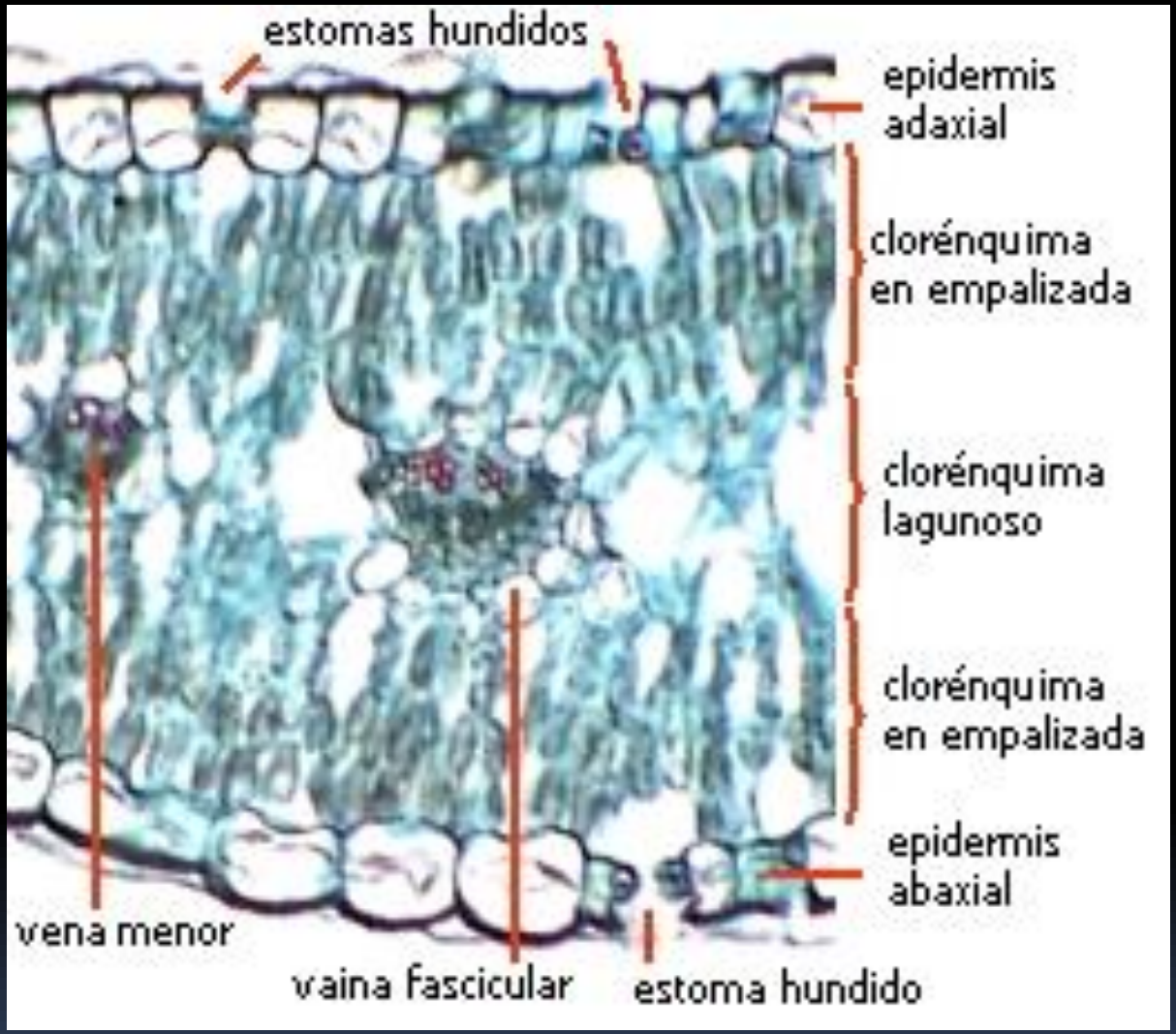


Monocot leaf






Eucalyptus leaf T.S.
Stomate
Cuticle
Epidermis
Phloem
Tannin cells
Xylem
Oil gland
Epidermis
Cuticle
Stomate


estomas hundidos
epidermis adaxial
clorénquima en empalizada
clorénquima lagunoso
clorénquima en empalizada
epidermis abaxial
vena menor
vaina fascicular
estoma hundido

The vascular system of the petiole

arises from that of the stem and is termed the ***leaf trace*.**

As a result of the branching of the vascular tissues of the stem a gap is formed immediately above the leaf trace.

Such a gap is filled with parenchyma and is termed ***leaf gap***.
For each leaf one, two or three leaf gaps may be formed

The vascular bundles of the petiole may be collateral, bicollateral or concentric.

They may appear as continuous or interrupted crescent or ring. If there is a single vascular bundle in the petiole the phloem is found on the **abaxial side** and if there is a ring of vascular bundles the phloem is external to the xylem on the periphery of the ring.

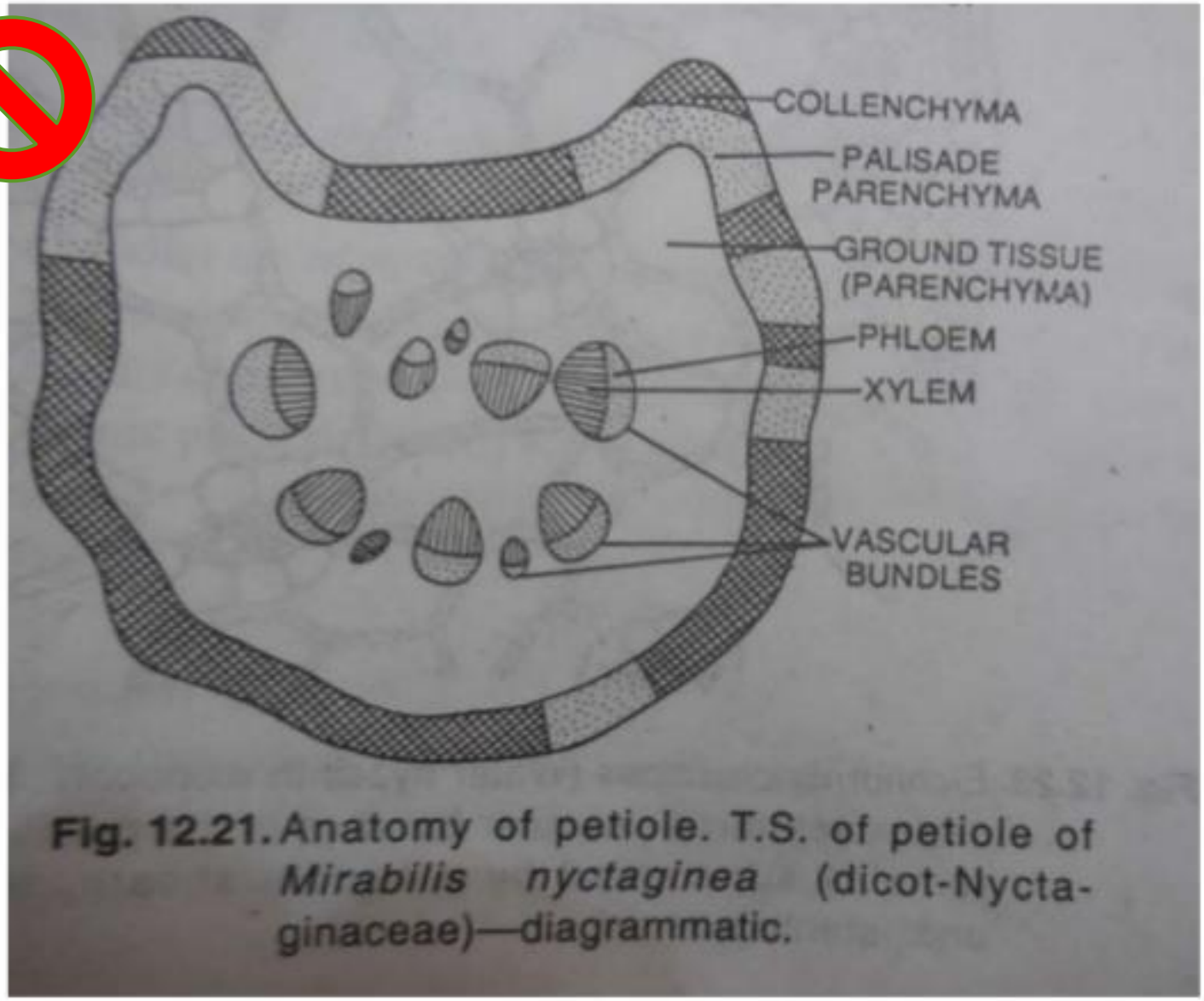
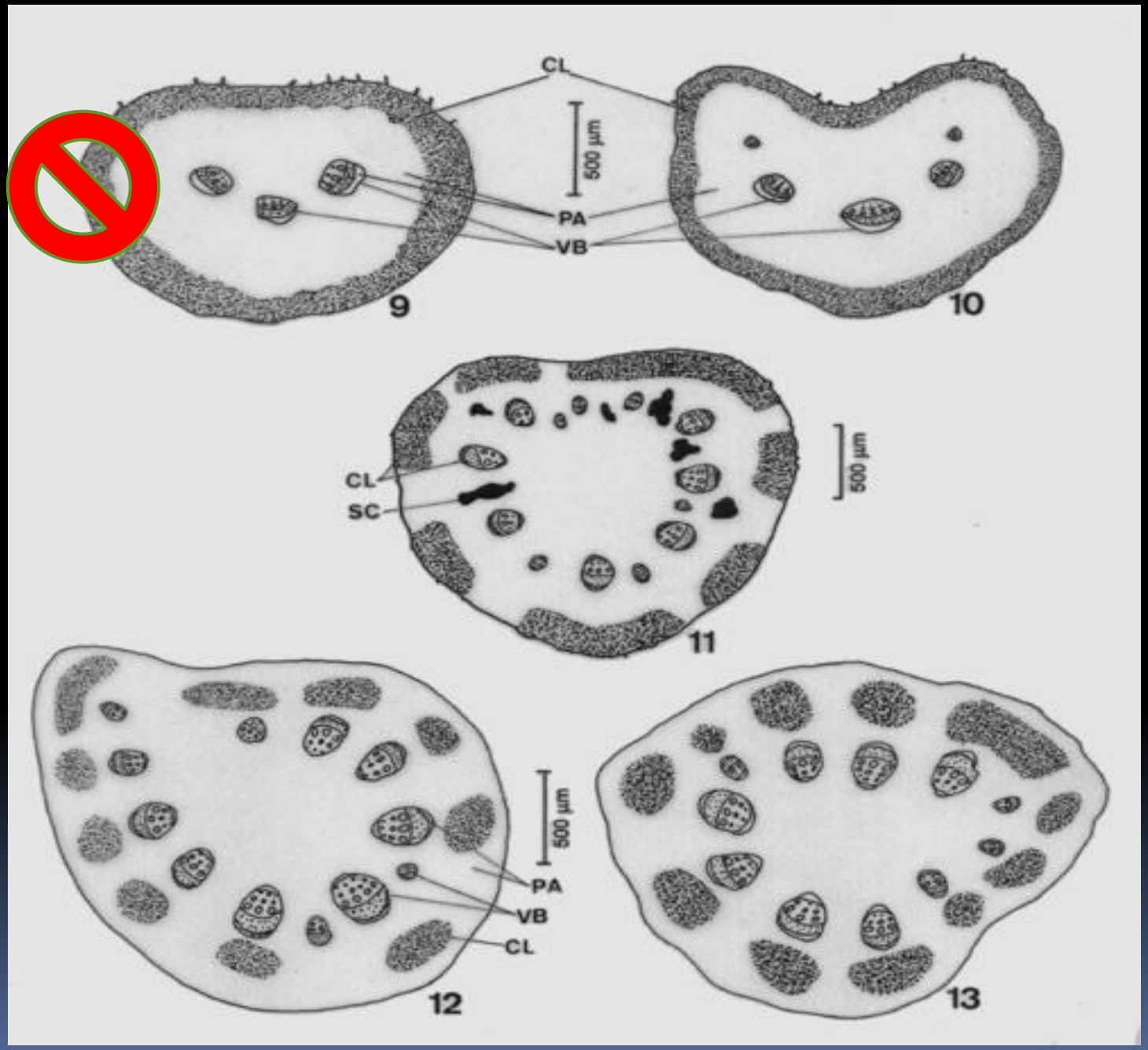
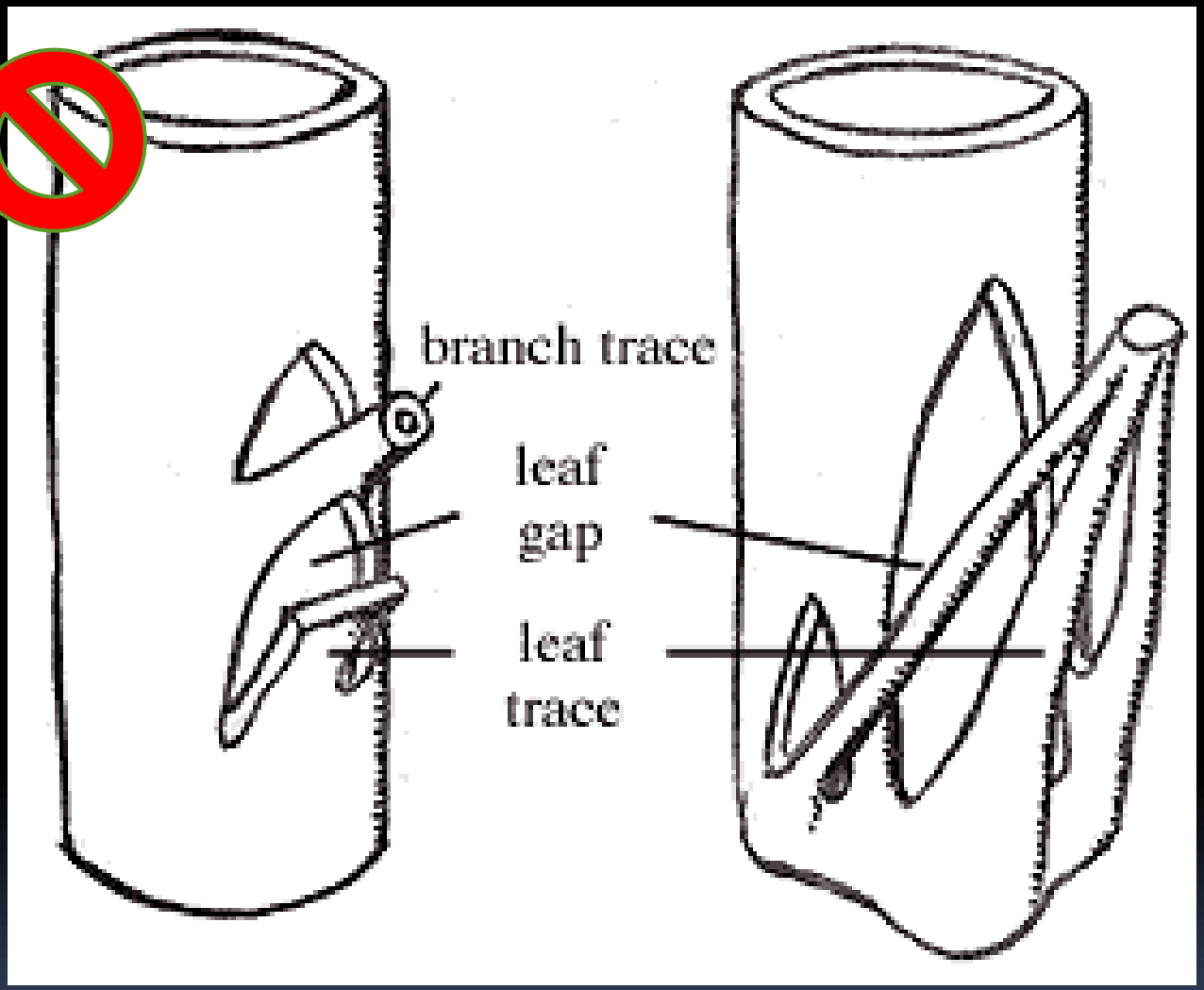


Fig. 12.21. Anatomy of petiole. T.S. of petiole of *Mirabilis nyctaginea* (dicot-Nyctaginaceae)—diagrammatic.


CL
500 µm
PA
VB
9
10
CL
SC
500 µm
11
500 µm
PA
VB
CL
12
13


branch trace
leaf gap
leaf trace

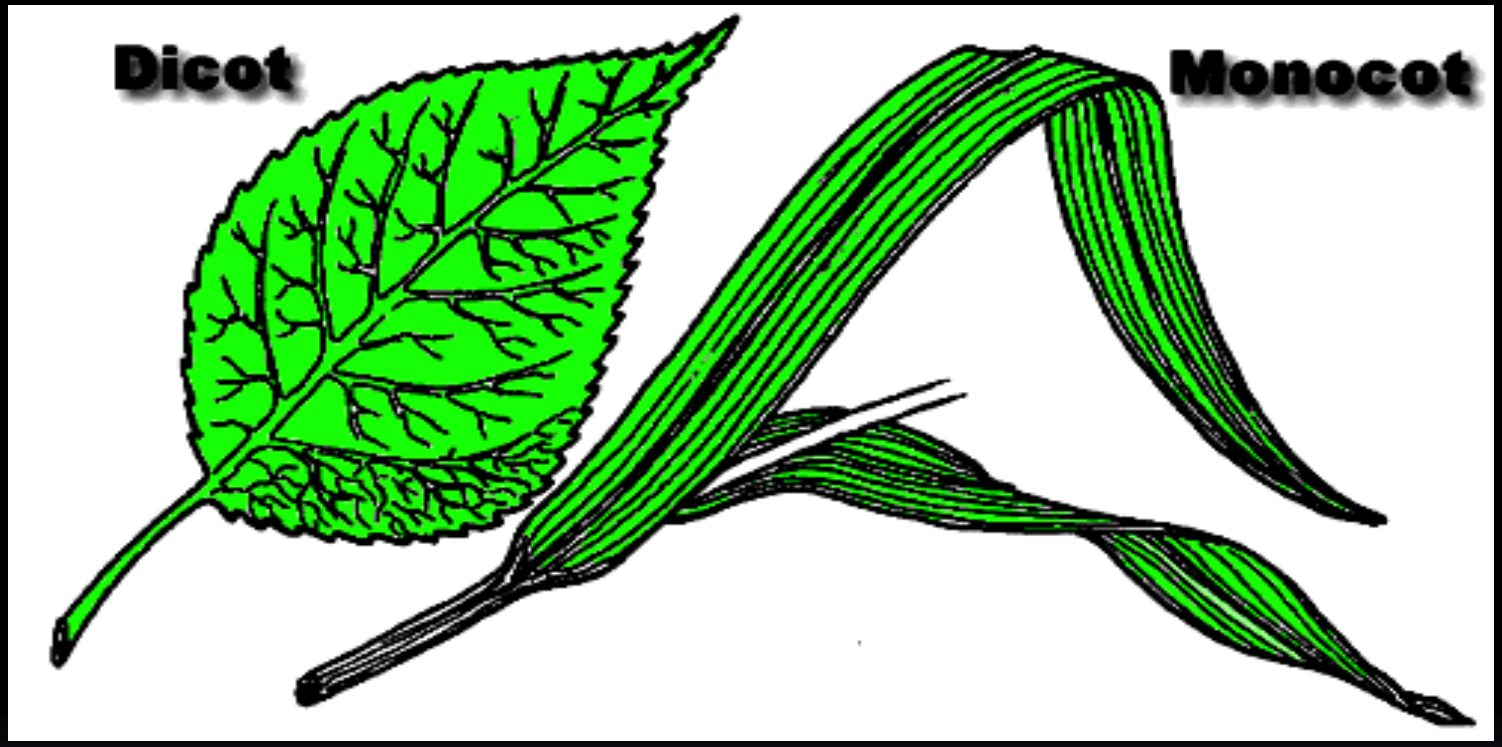
Leaf trace and gap

Vascular system of the leaf

In the leaf blade, the leaf traces may continue in the same number throughout the entire length of the leaf or they may divide, fuse and branch again later.

Single or several closely associated vascular bundles are termed a ***vein***. The arrangement of veins in the leaf is termed ***venation .***

In all cases, the large veins are surrounded by chloroplast free parenchyma that forms projections known as ***ribs*** on the abaxial side. The largest vein is located at the middle of the blade forming the ***midrib***.

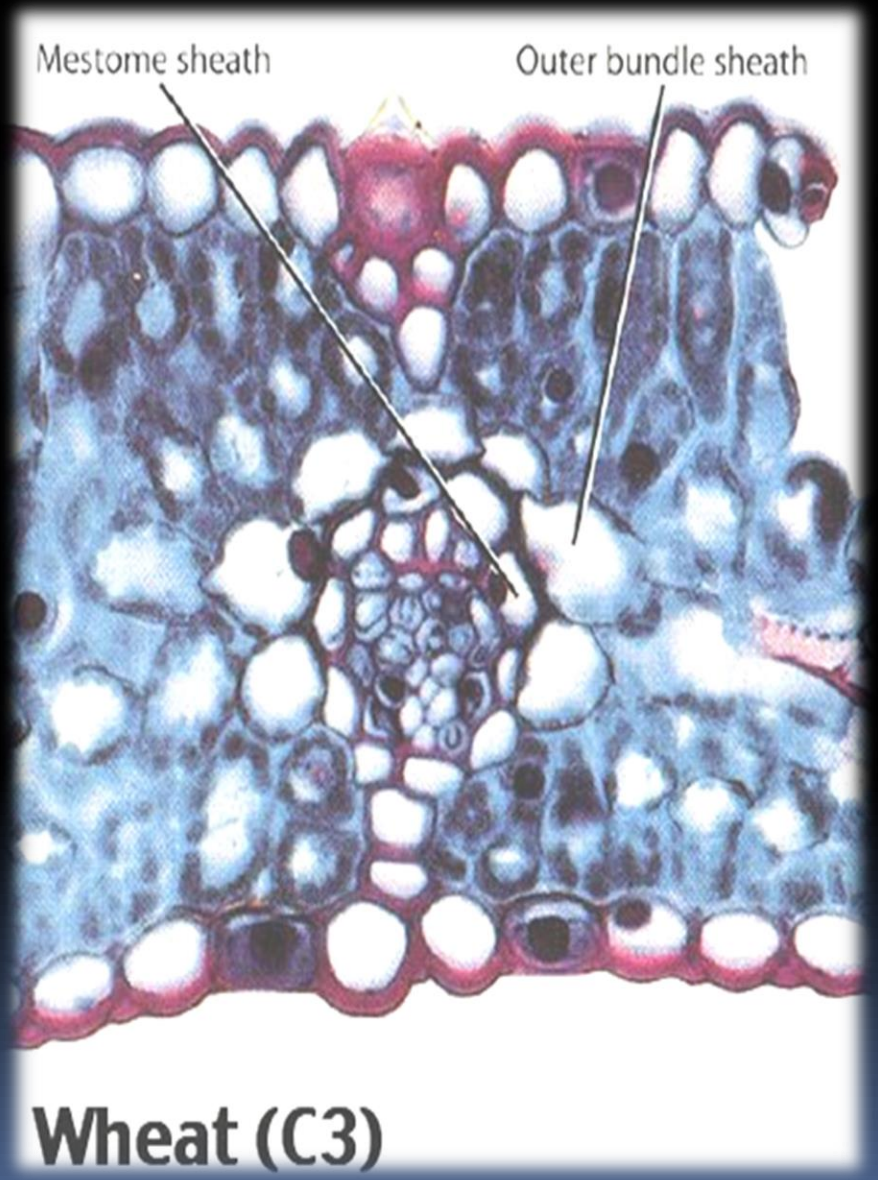

Dicot
Monocot

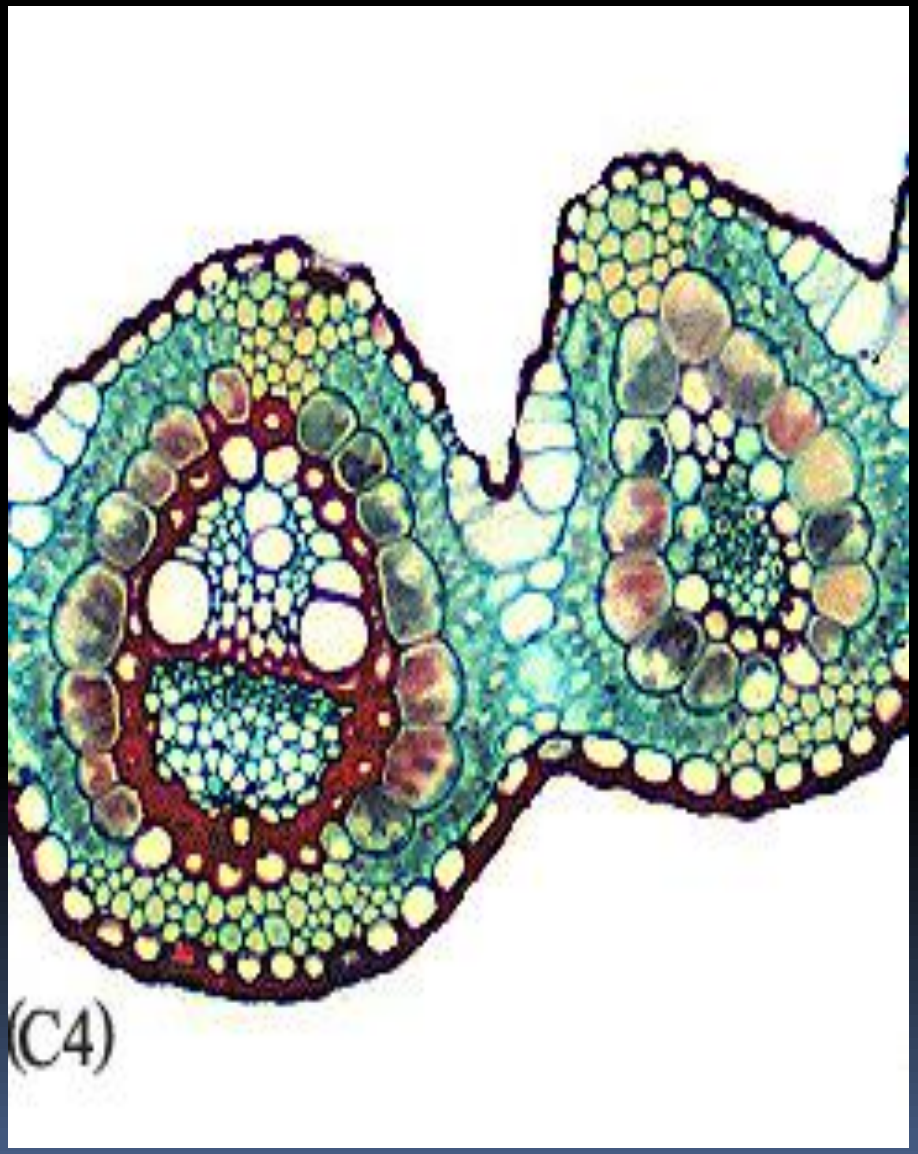
The arrangement of vascular tissues in the **main veins** usually resembles that **in the petiole**.

The large veins of dicotyledons contain primary and secondary tissues, whereas the small veins contain only primary tissues.

The large veins contain **vessels and sieve tubes**.

In the smallest veins the tracheary elements are **tracheids** and the phloem close to the veins ending consists of **parenchyma only**.


Mestome sheath
Outer bundle sheath
Wheat (C3)


(C4)


Fibers

The bundle sheath and kranz anatomy of the leaf.

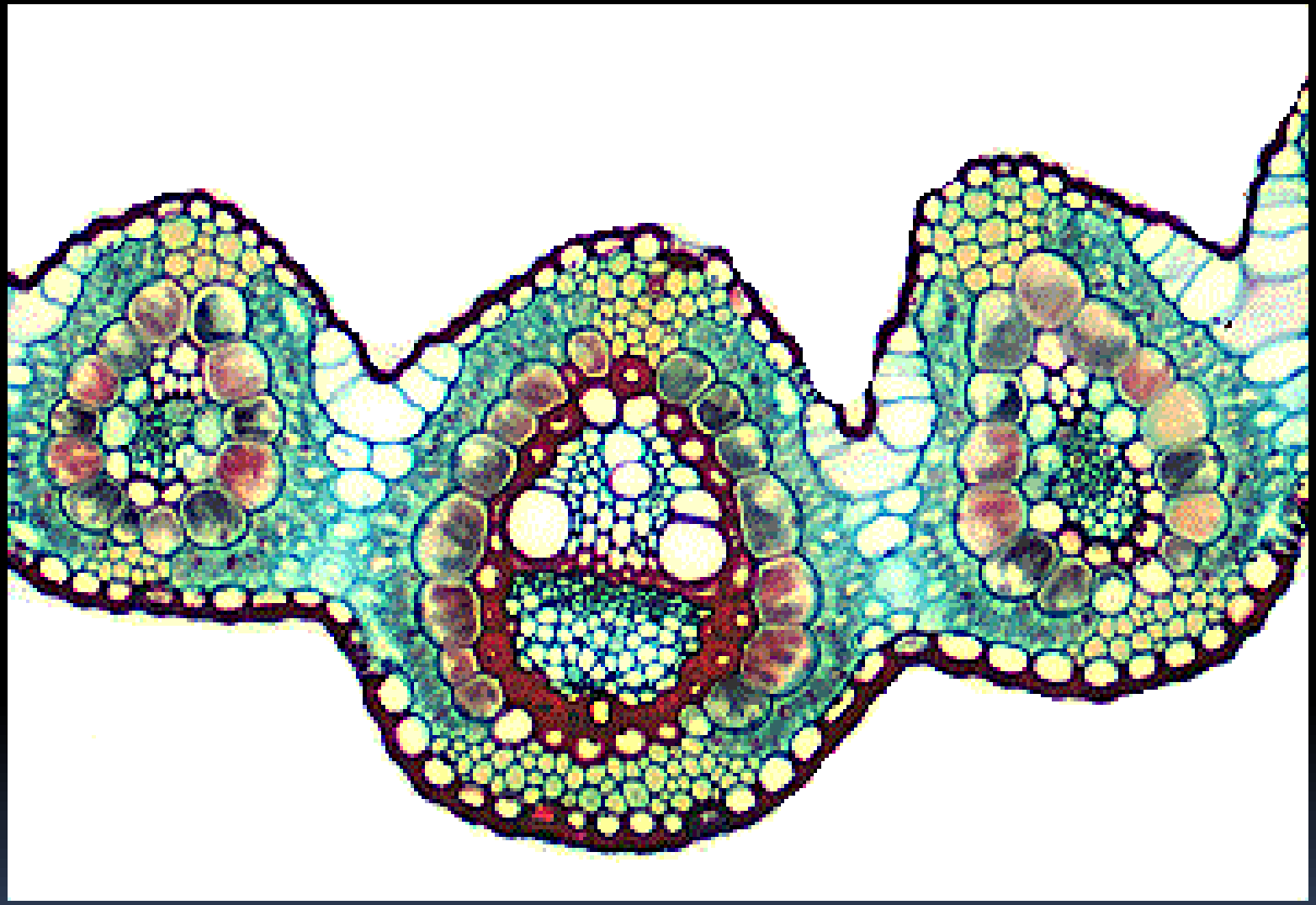
In some plants such as corn (*Zea mays*), sugarcane (*Saccharum*) and *Flavaria* the bundle sheath consists of large parenchymatous cells that are packed with chloroplasts.
This structure resembles a wreath and therefore is called ***kranz anatomy***.

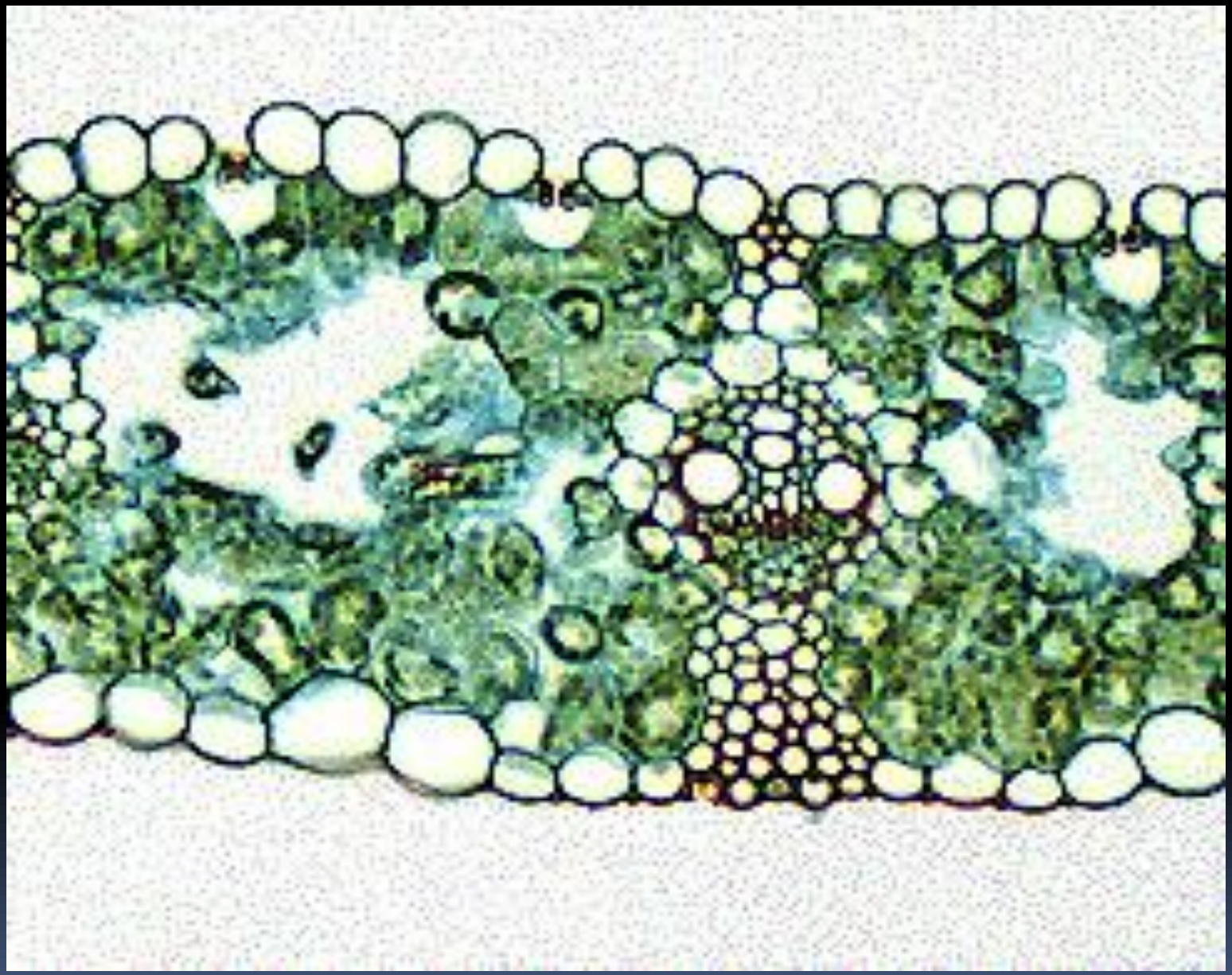
The bundle sheath in leaves with kranz anatomy is surrounded by chloroplast rich mesophyll cells and the stomata are arranged in such a way that allows efficient gas exchange by the mesophyll.

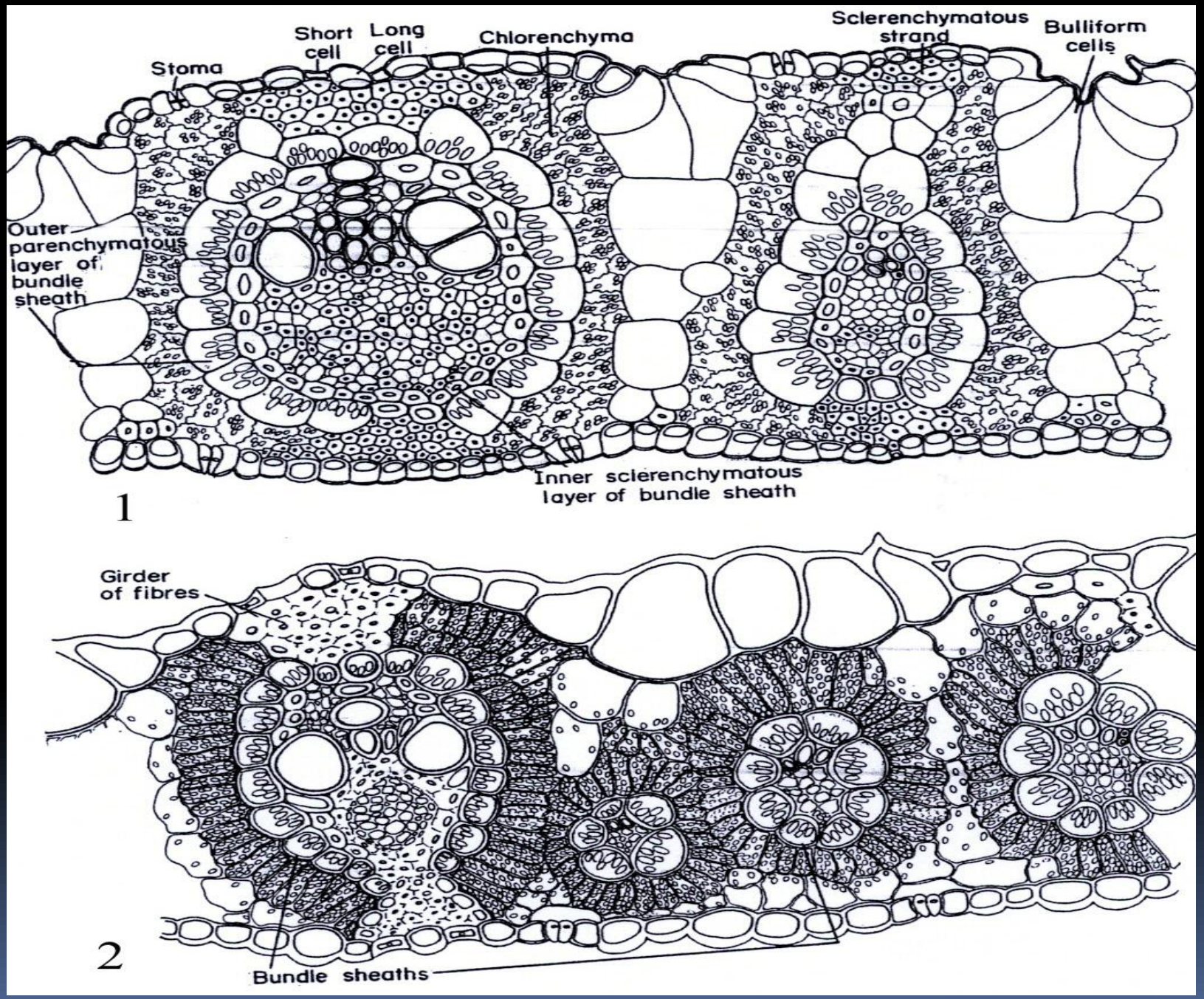
The bundle sheath in plants that lack kranz anatomy is **devoid of chloroplasts** and is surrounded by homogenous mesophyll cells.

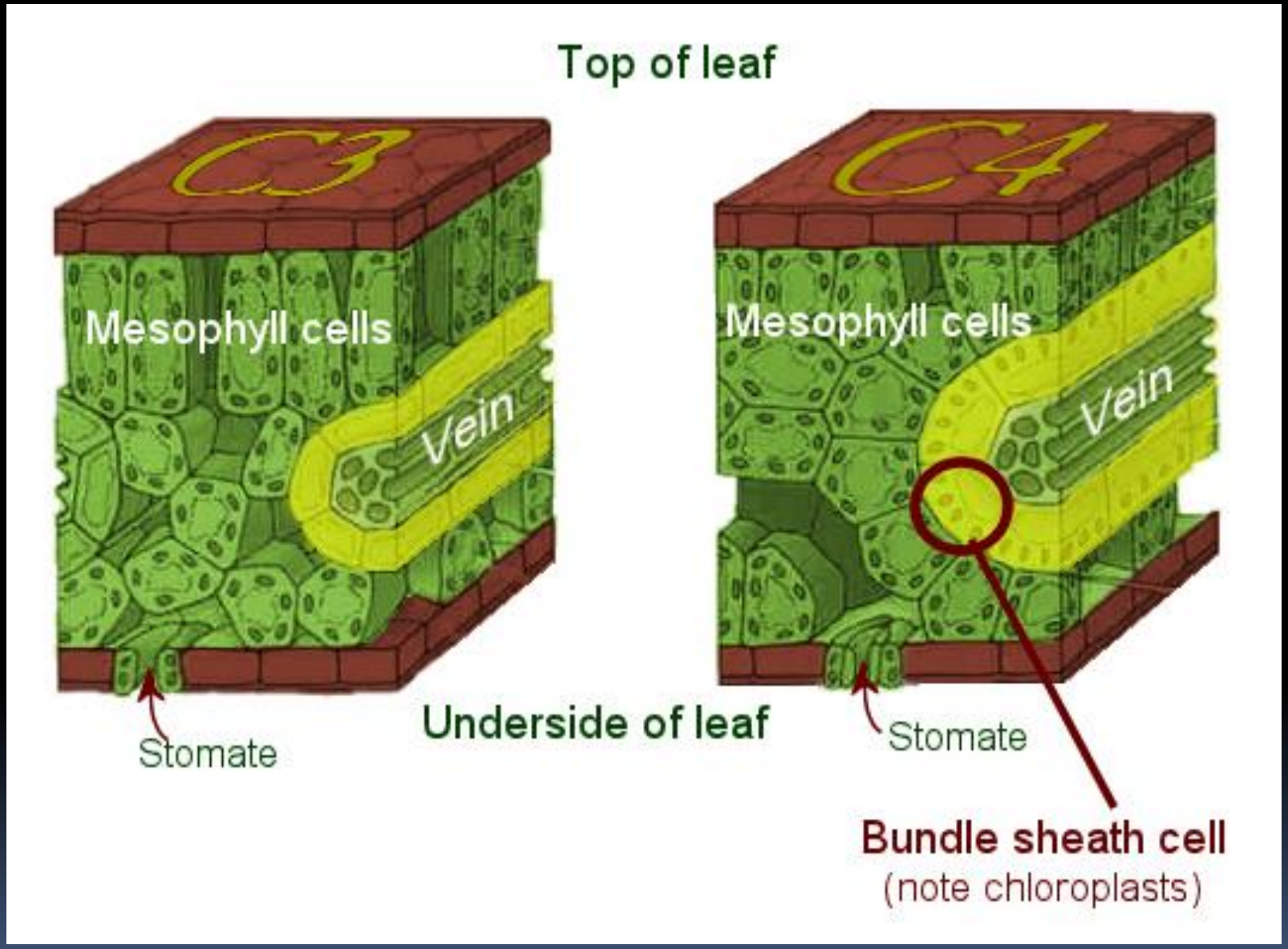
Kranz anatomy occurs in monocotyledons as well as dicotyledons.

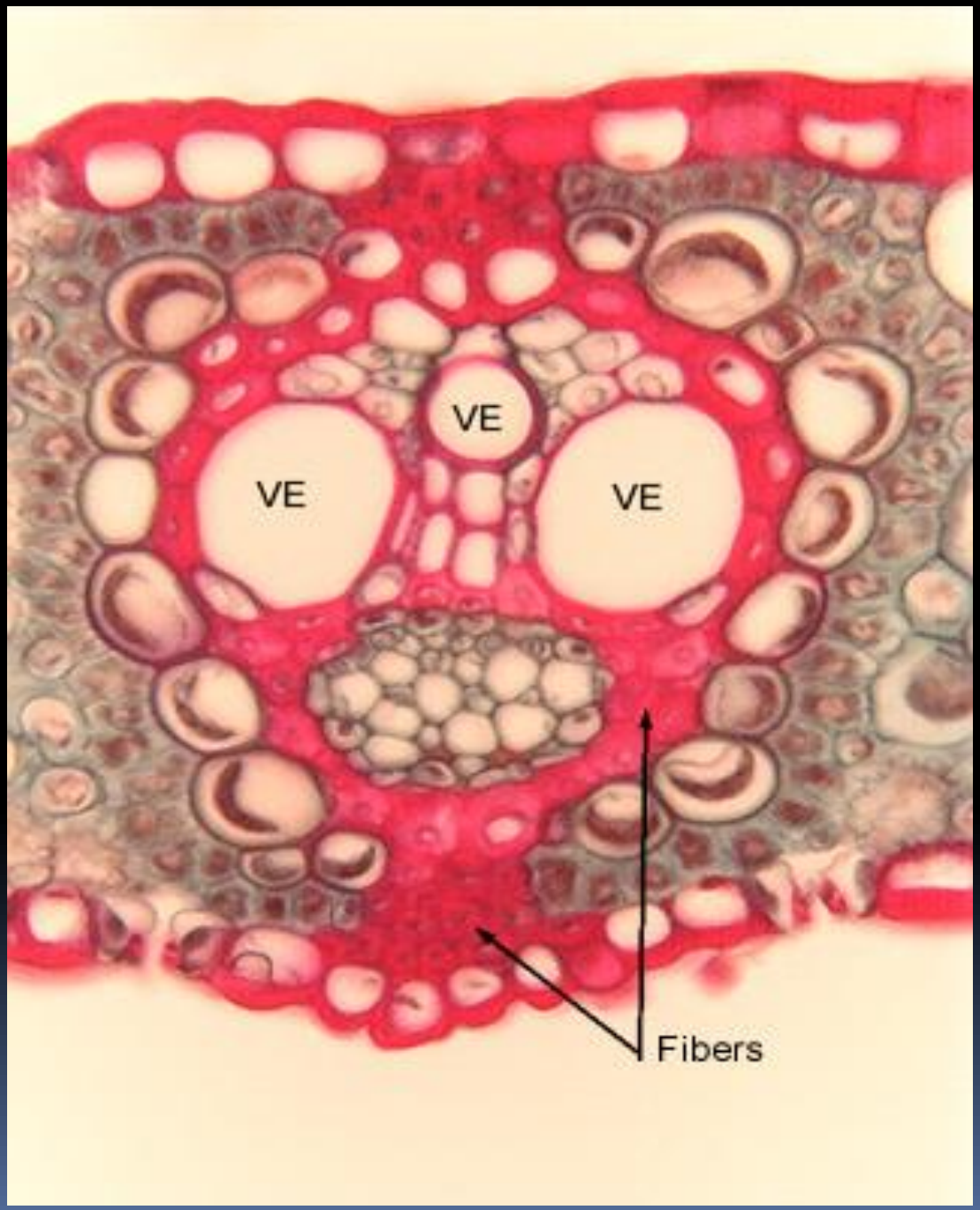
Plants with kranz anatomy usually have C_4 type photosynthesis, while those lacking kranz anatomy have C_3 photosynthesis.

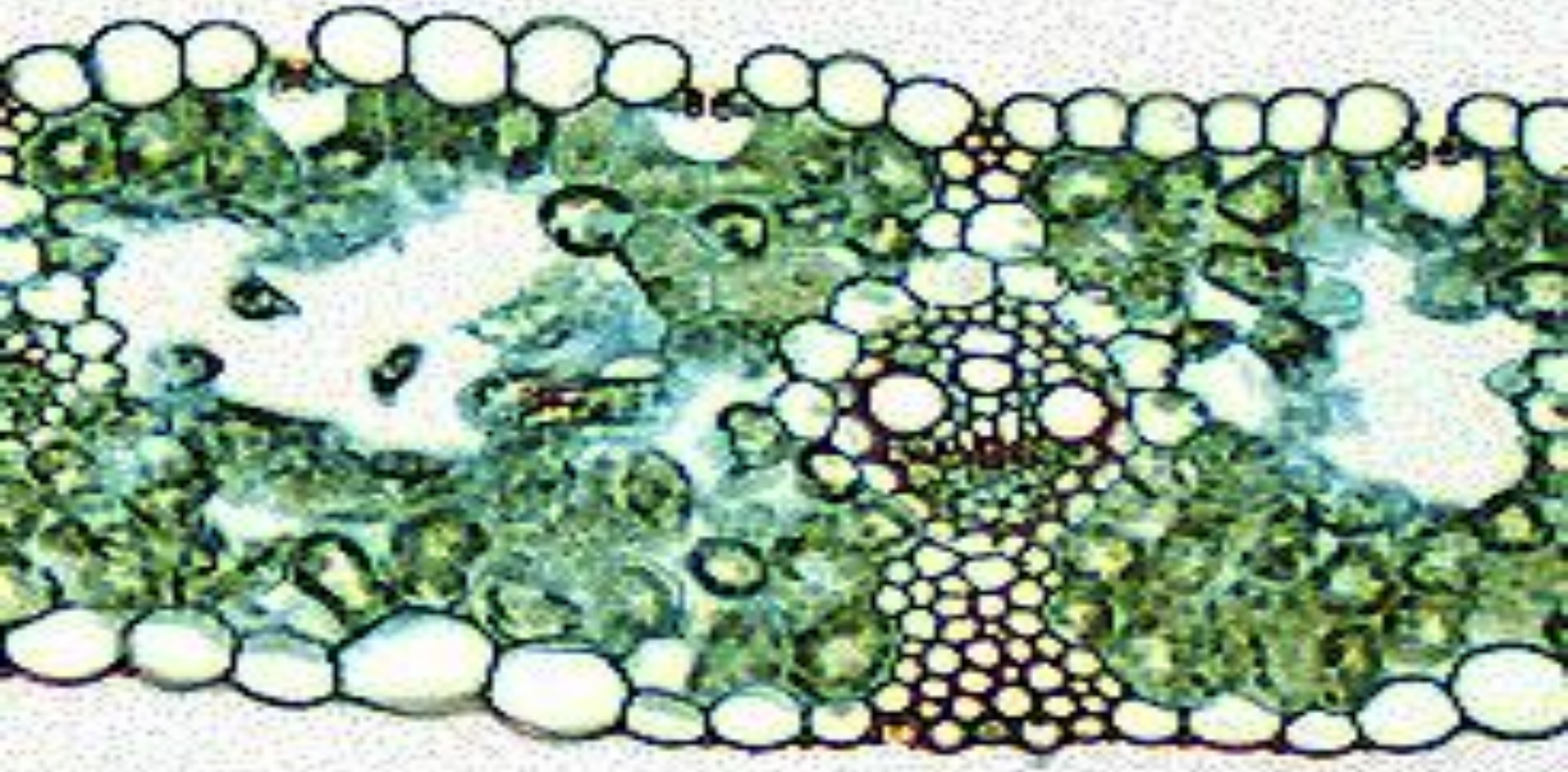




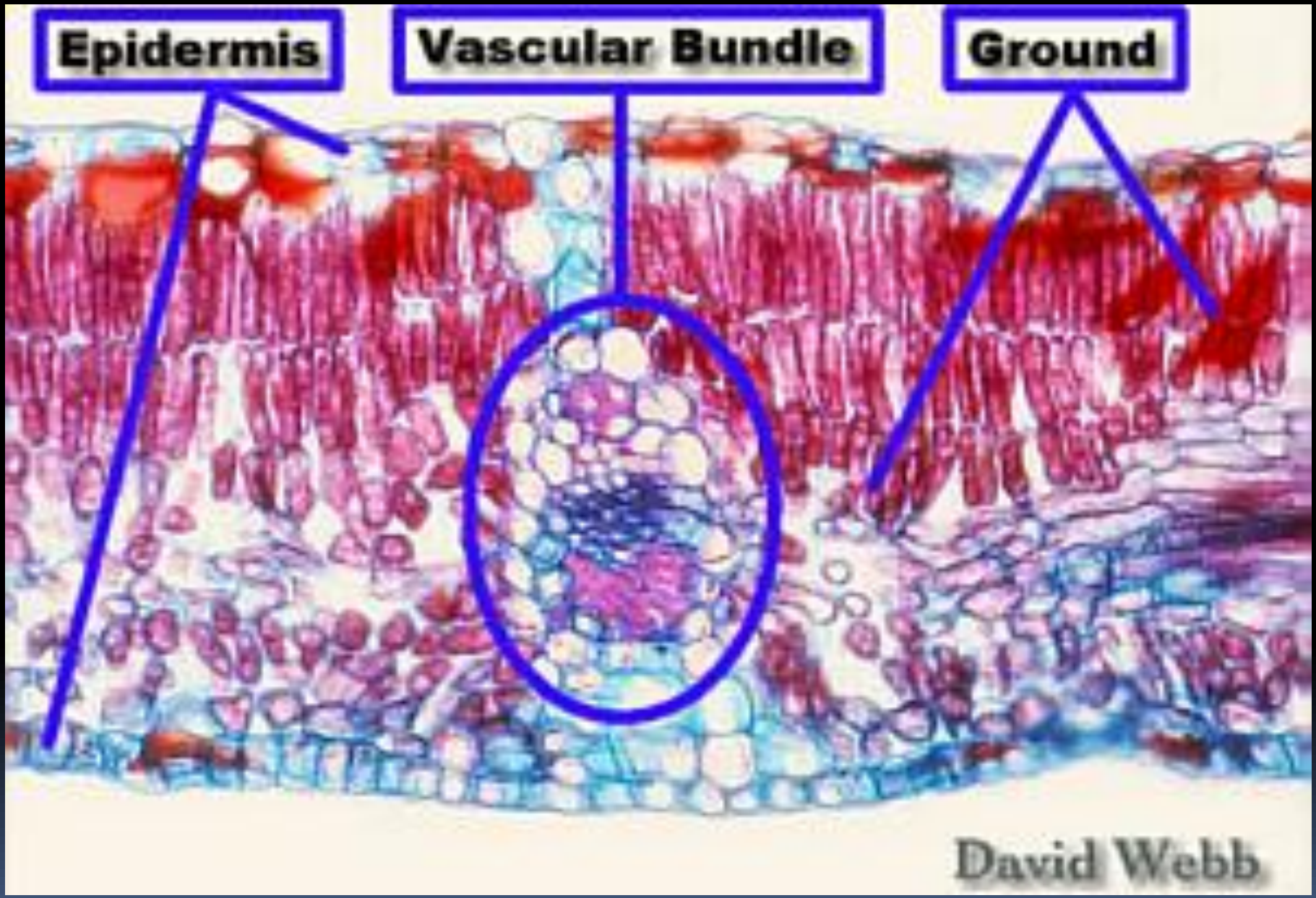

Short cell
Long cell
Chlorenchyma
Sclerenchymatous strand
Bulliform cells
Stoma
Outer parenchymatous layer of bundle sheath
Inner sclerenchymatous layer of bundle sheath
1
Girder of fibres
Bundle sheaths
2

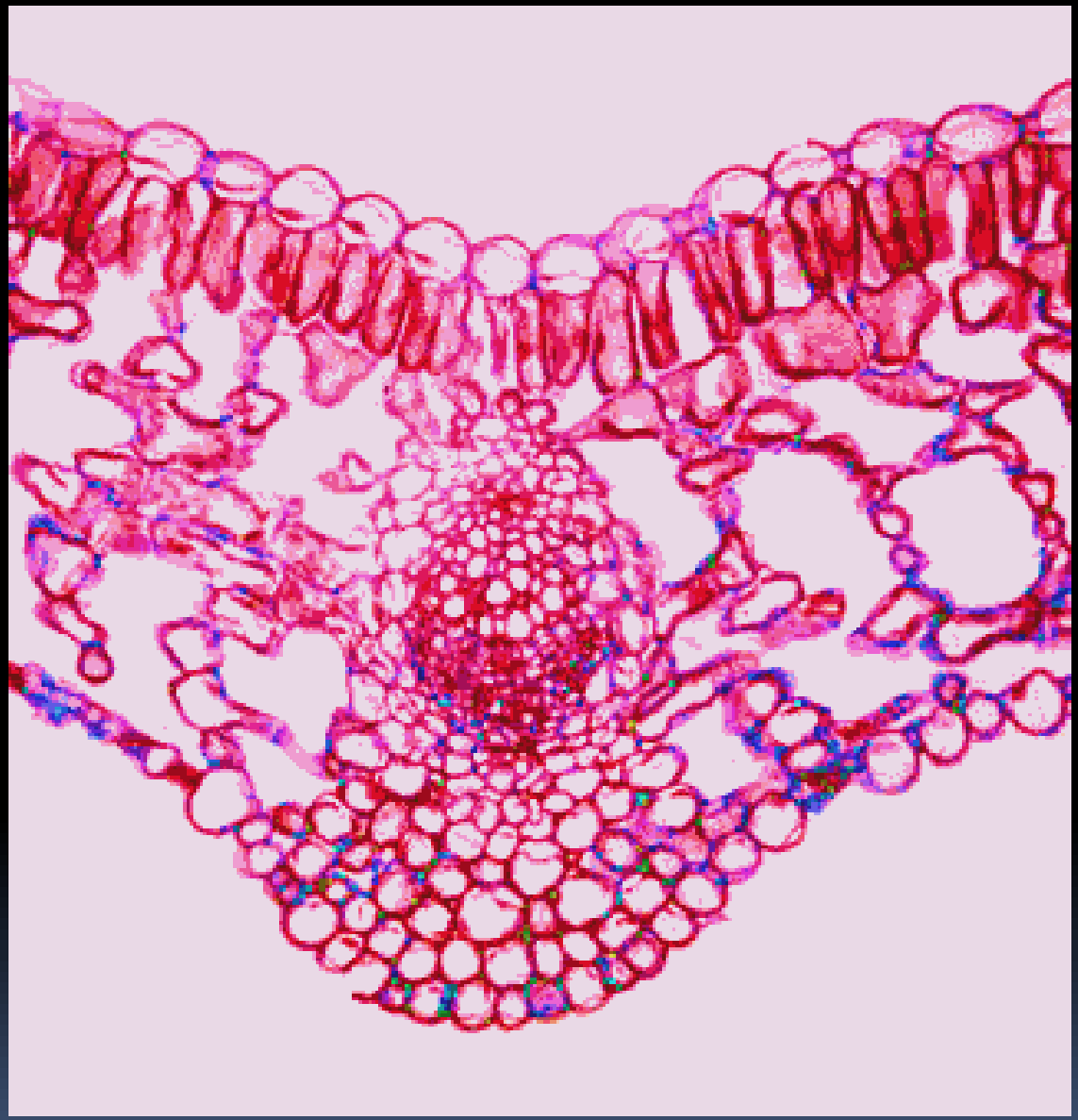

Top of leaf
C3
Mesophyll cells
Vein
Stomate
Underside of leaf
C4
Mesophyll cells
Vein
Stomate
Bundle sheath cell
(note chloroplasts)


VE
VE
VE
Fibers



John Curtis & Nels Lersten
Botanical Society of America


Epidermis
Vascular Bundle
Ground
David Webb



Supporting tissues of the leaf

Because of its compact structure, the epidermis constitutes a supporting tissue in the leaf.

Collenchyma is found in the large veins of dicotyledons such as *Nerium*.

In monocotyledons the vascular bundles are accompanied by sclerenchyma in addition to strips of fibres inner to the epidermis.

Some modifications in leaf anatomy

Stomata

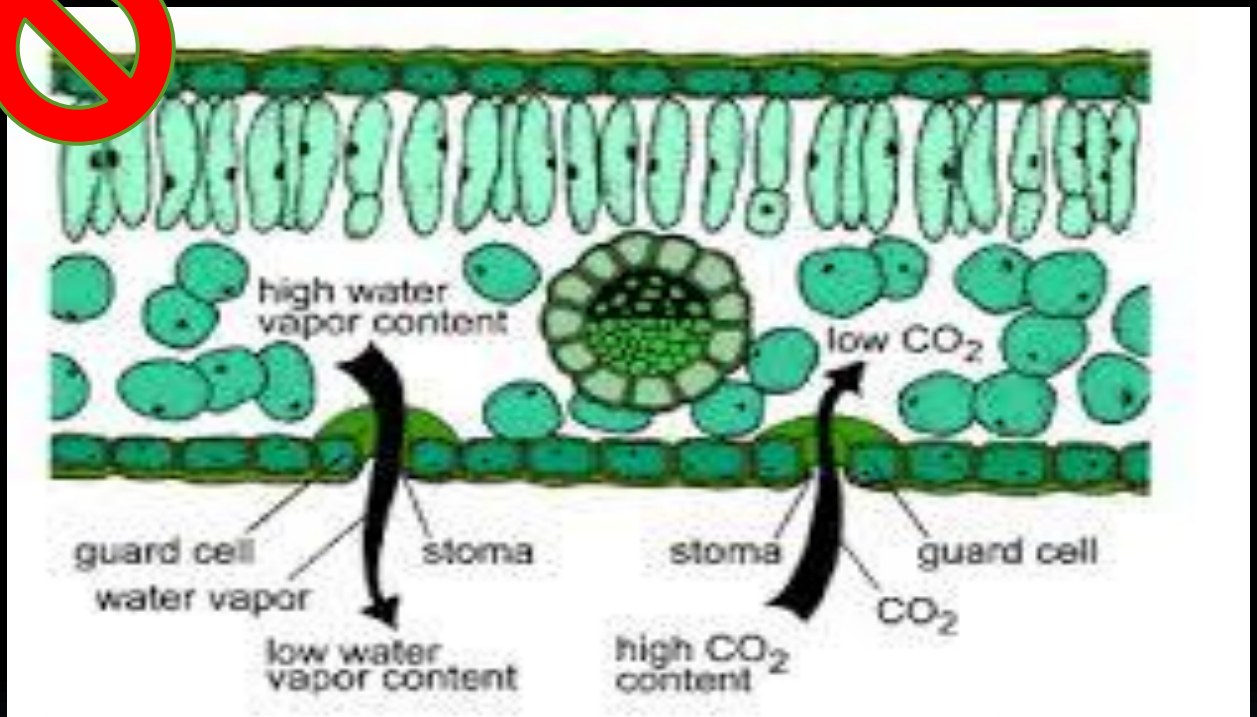
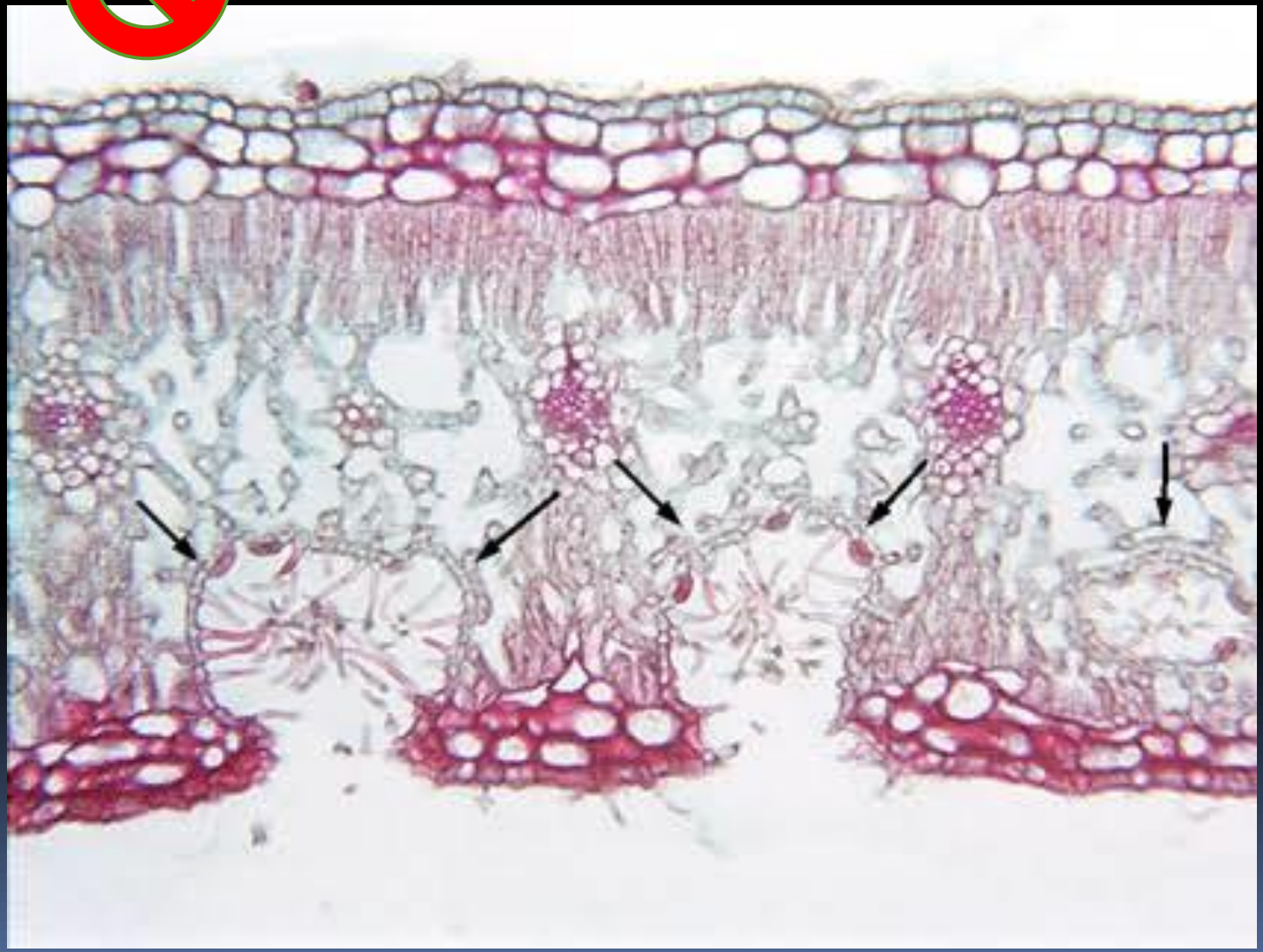


Figure 25. Stomata open to allow carbon dioxide (CO_2) to enter a leaf and water vapor to leave.

Sunken stoma in pine needle

Also note that epidermal cells are sclerified and fibers occur beneath the epidermis

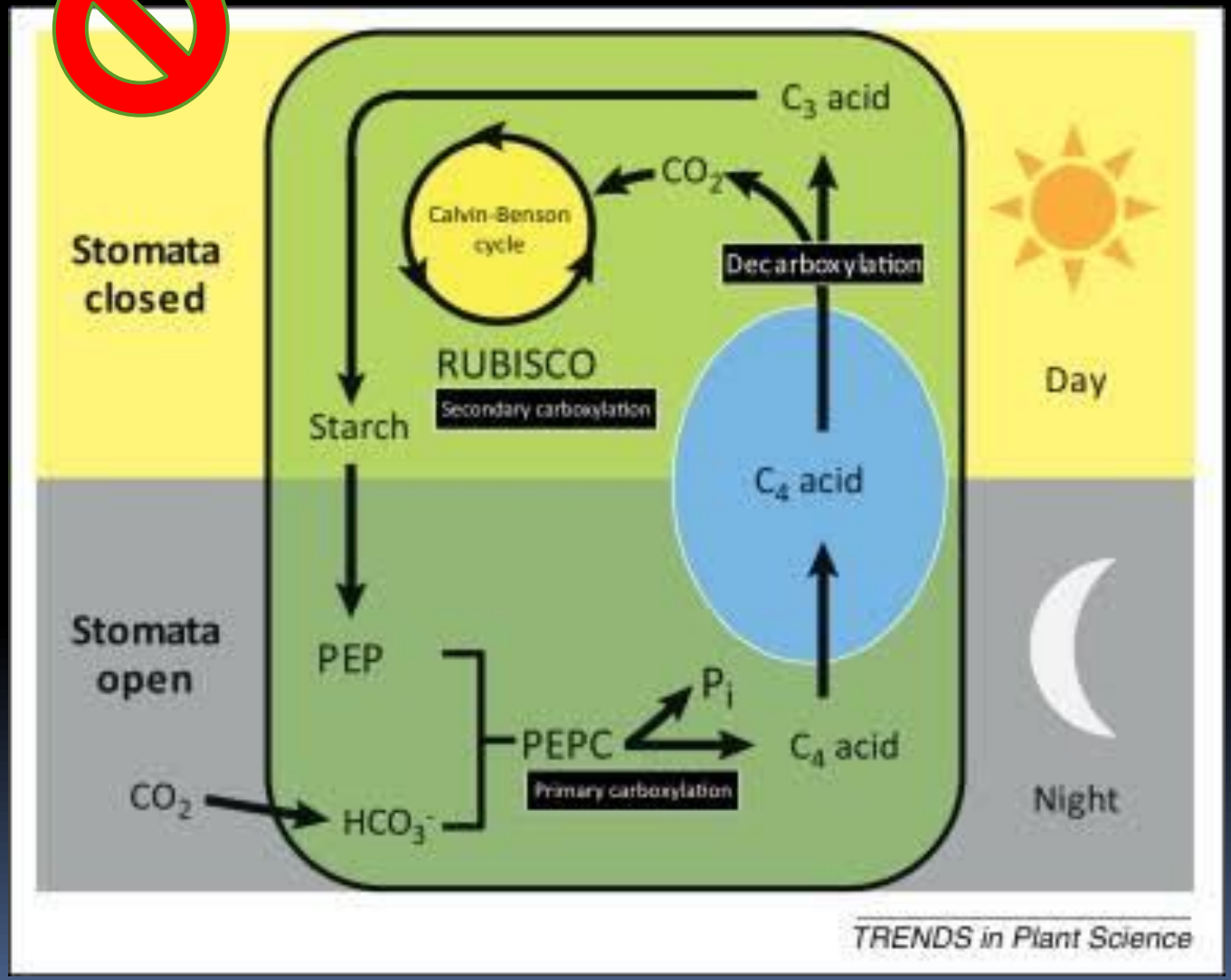
Crypt



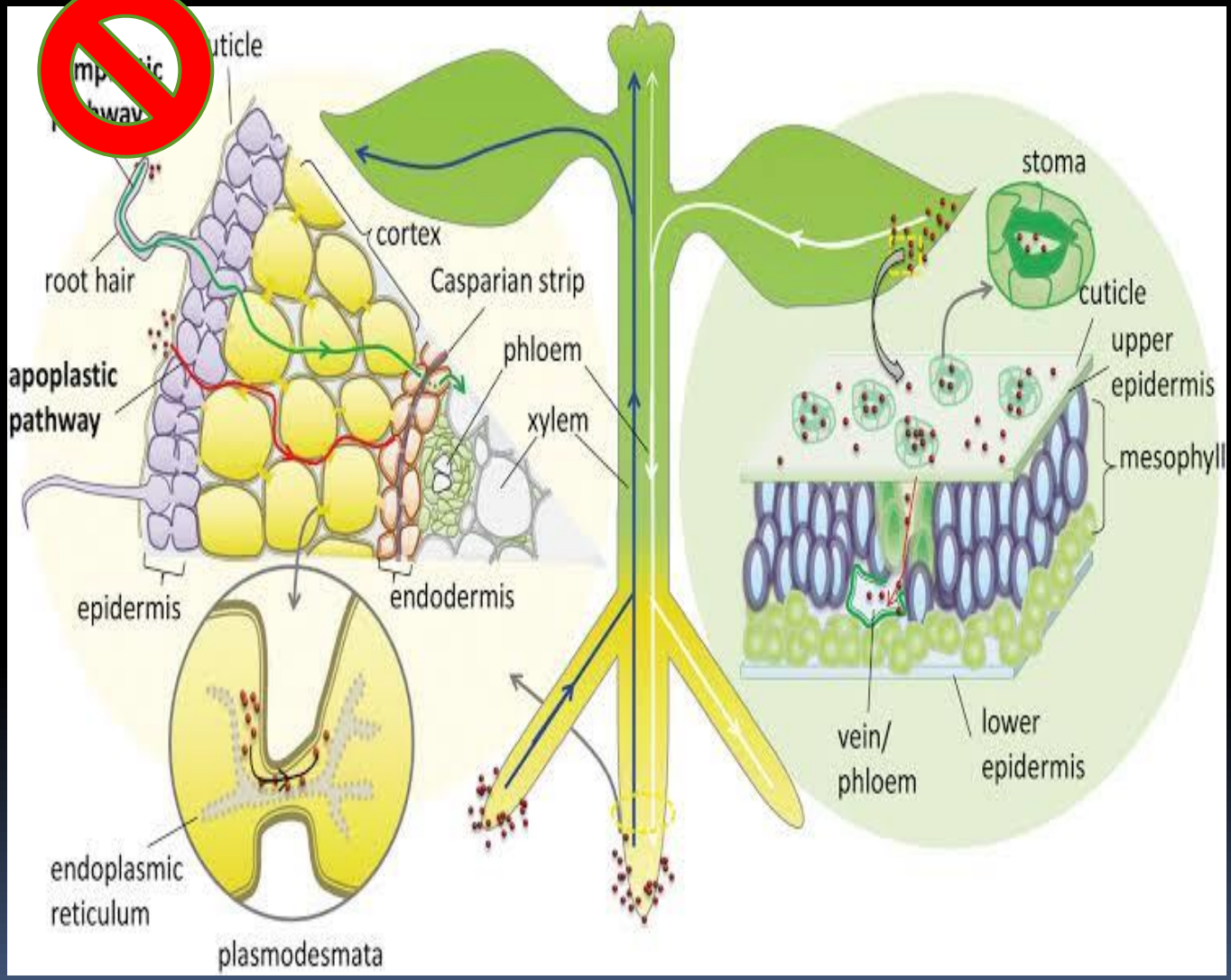
Modification in stomatal regulation

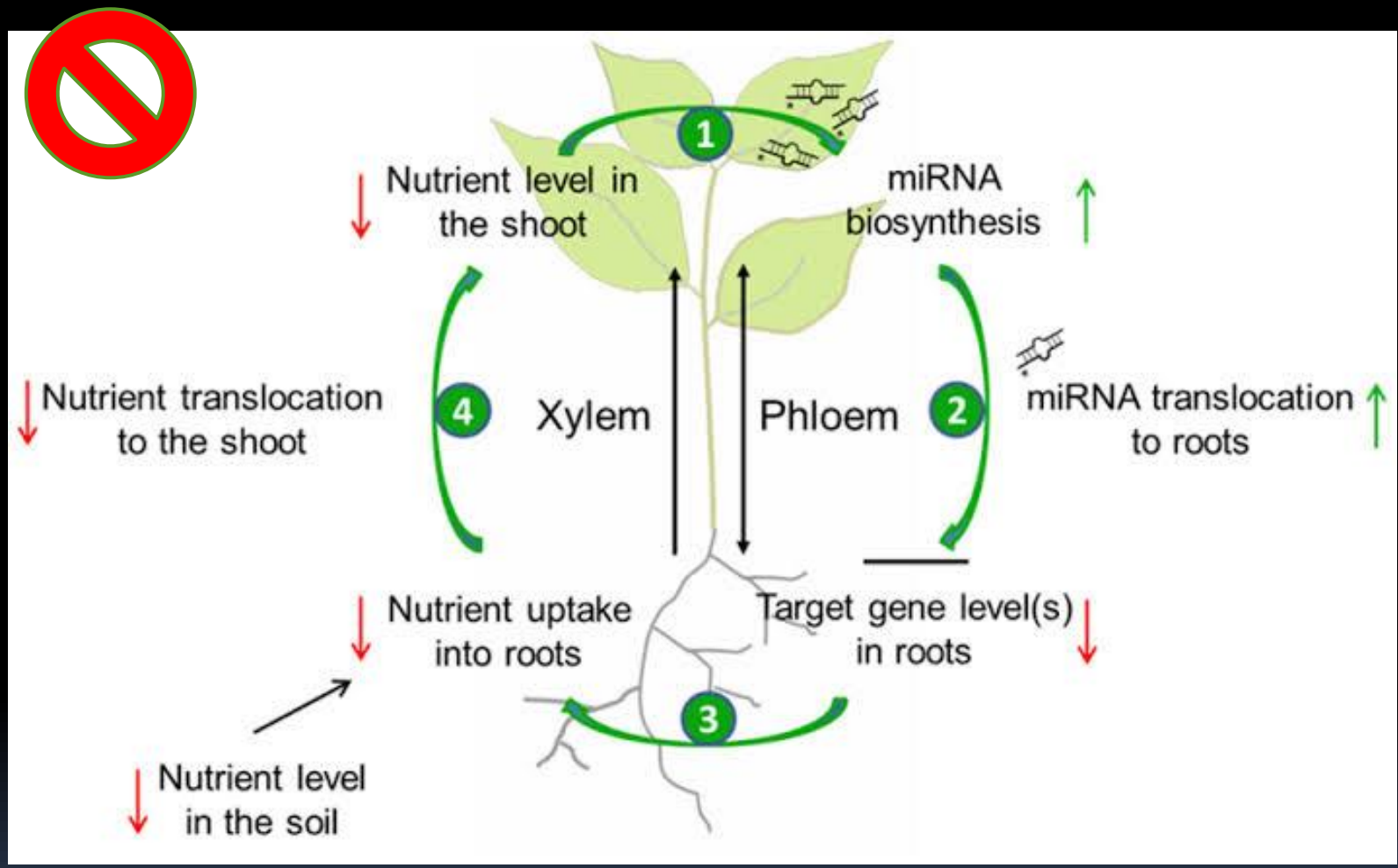
C4 plants

CAM Plants


Stomata closed
Stomata open
Day
Night
C_3 acid
CO_2
Calvin-Benson cycle
Decarboxylation
RUBISCO
Secondary carboxylation
Starch
C_4 acid
PEP
P_i
PEPC
C_4 acid
Primary carboxylation
CO_2
HCO_3^-
TRENDS in Plant Science

Sum-up the interaction between plant organs




1
Nutrient level in the shoot
miRNA biosynthesis
Nutrient translocation to the shoot
4
Xylem
Phloem
2
miRNA translocation to roots
Nutrient uptake into roots
Target gene level(s) in roots
3
Nutrient level in the soil