



**TRACHEIDS  
&  
VESSEL MEMBERS**

# ROOT

# TRUE ROOT

YOUNG SPOROPOPHYTE FROND

GAMETOPHYTE

FOOT

SHOOT APEX

RHIZOIDS

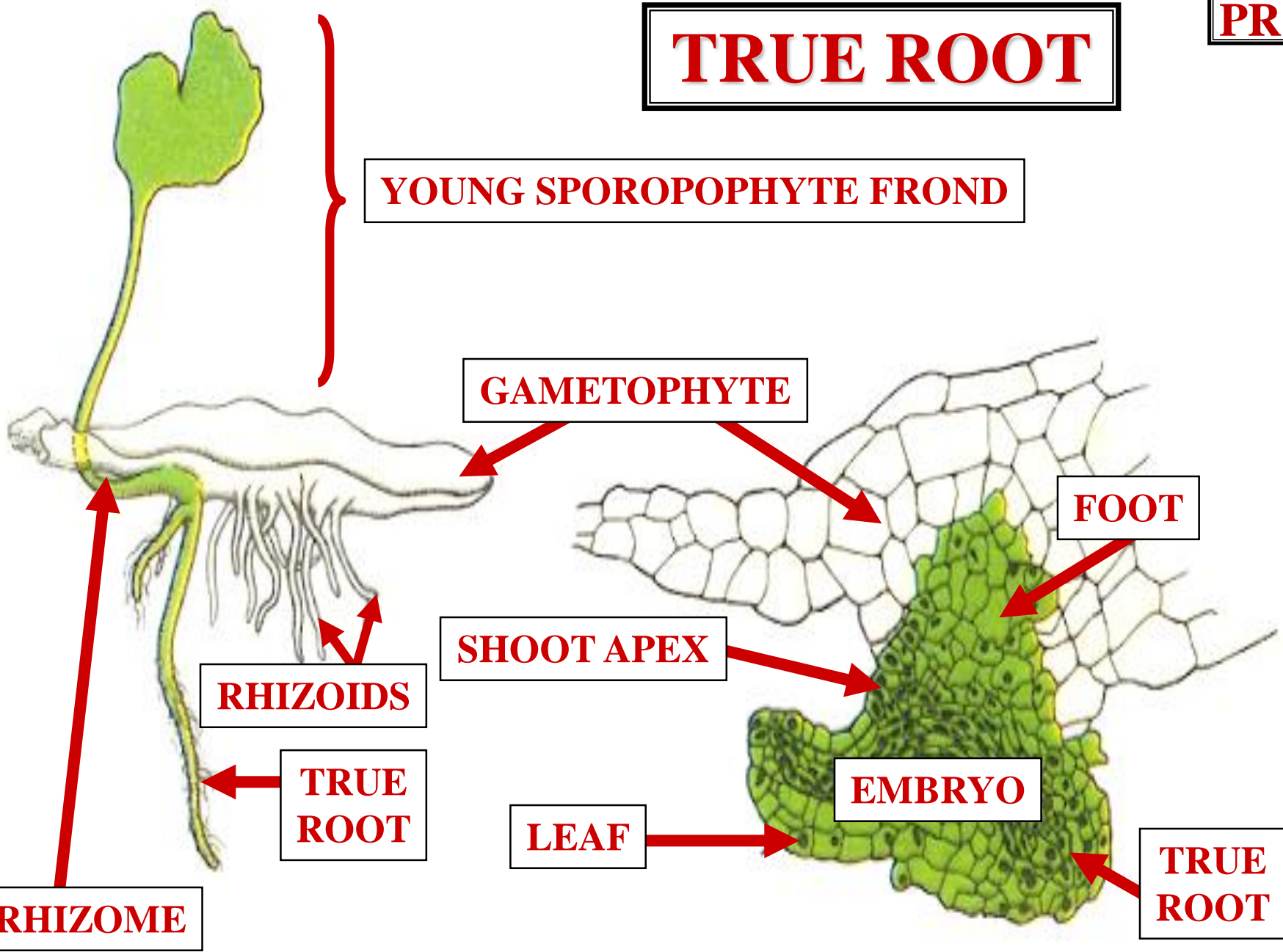
TRUE ROOT

LEAF

EMBRYO

TRUE ROOT

RHIZOME



# TRUE ROOT PRESENT

AB

YOUNG SPOROPOHYTE FROND

GAMETOPHYTE

FOOT

SHOOT APEX

RHIZOIDS

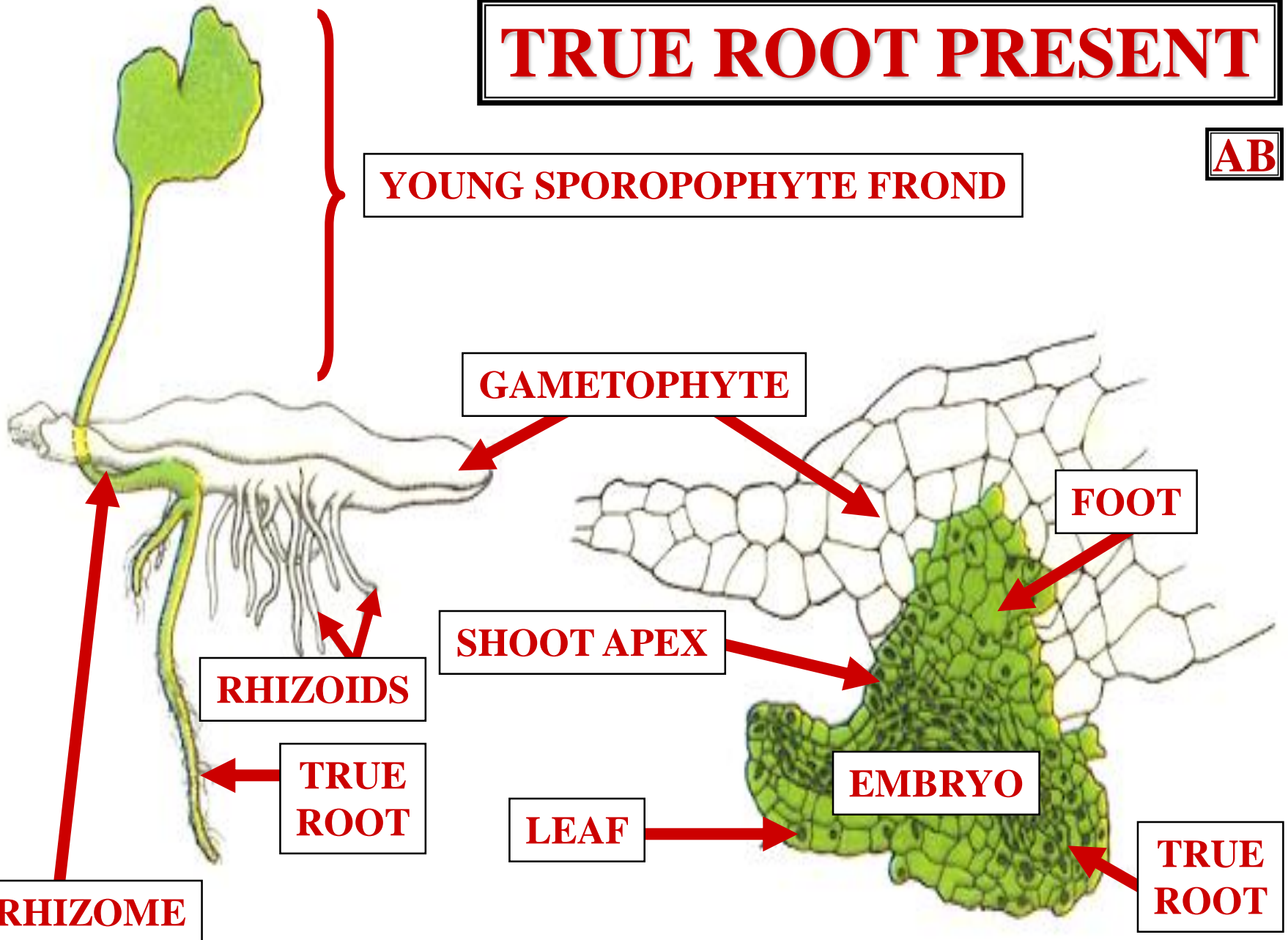
EMBRYO

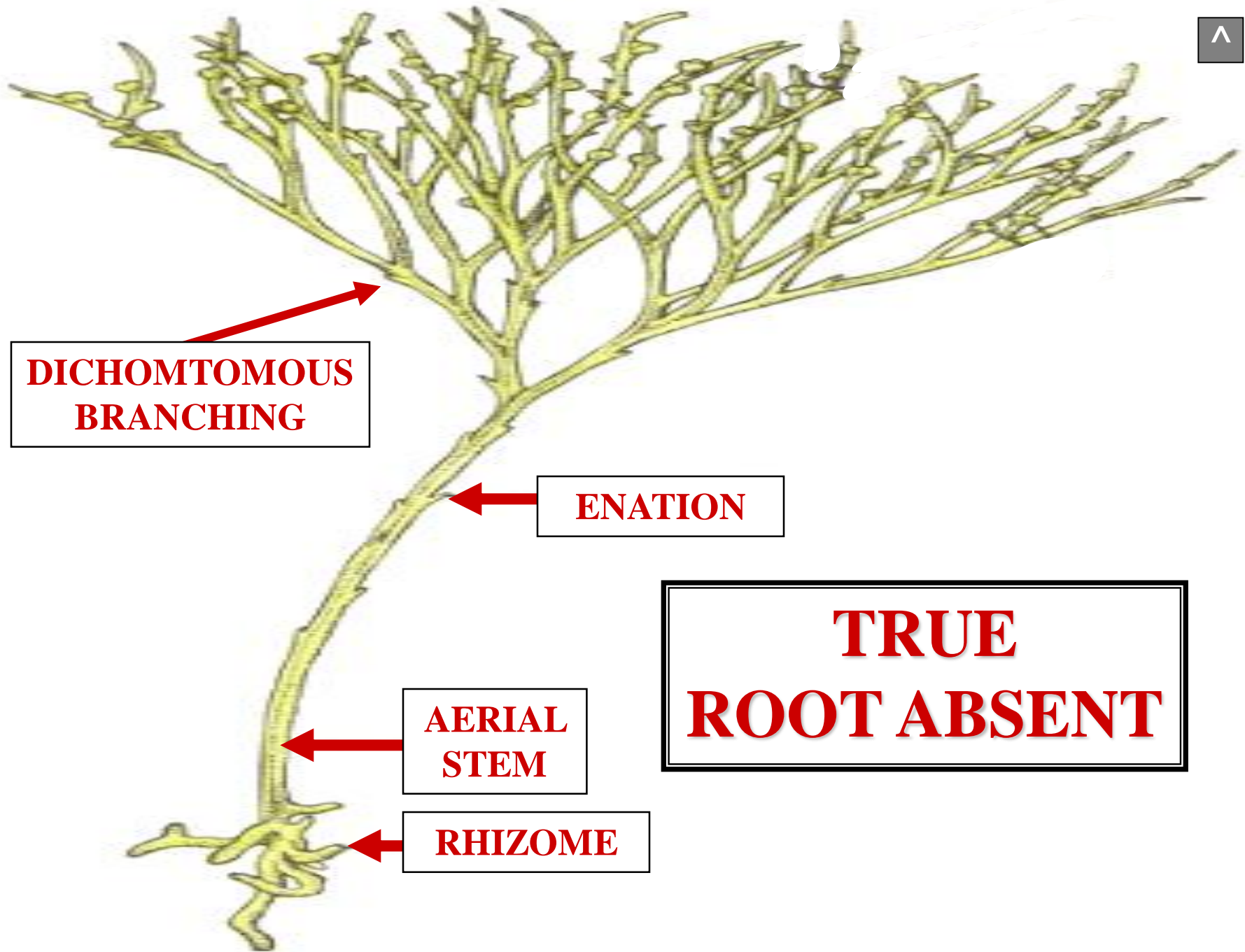
TRUE ROOT

LEAF

TRUE ROOT

RHIZOME





**DICHOTOMOUS  
BRANCHING**

**ENATION**

**AERIAL  
STEM**

**RHIZOME**

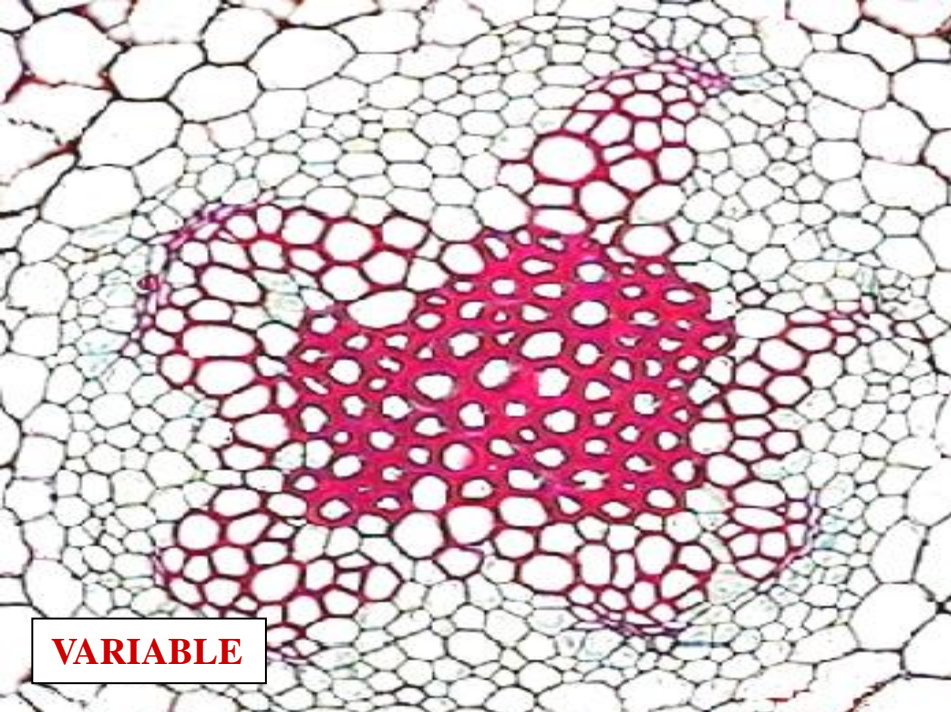
**TRUE  
ROOT ABSENT**



# STEM



# STEM STELE

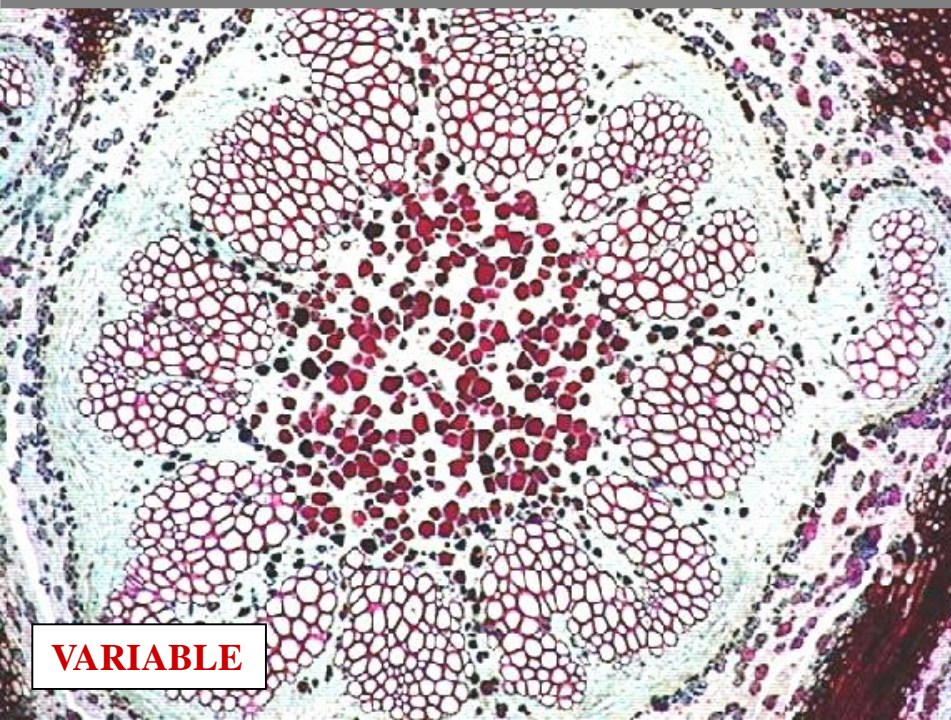


**VARIABLE**



**P**

**VARIABLE**

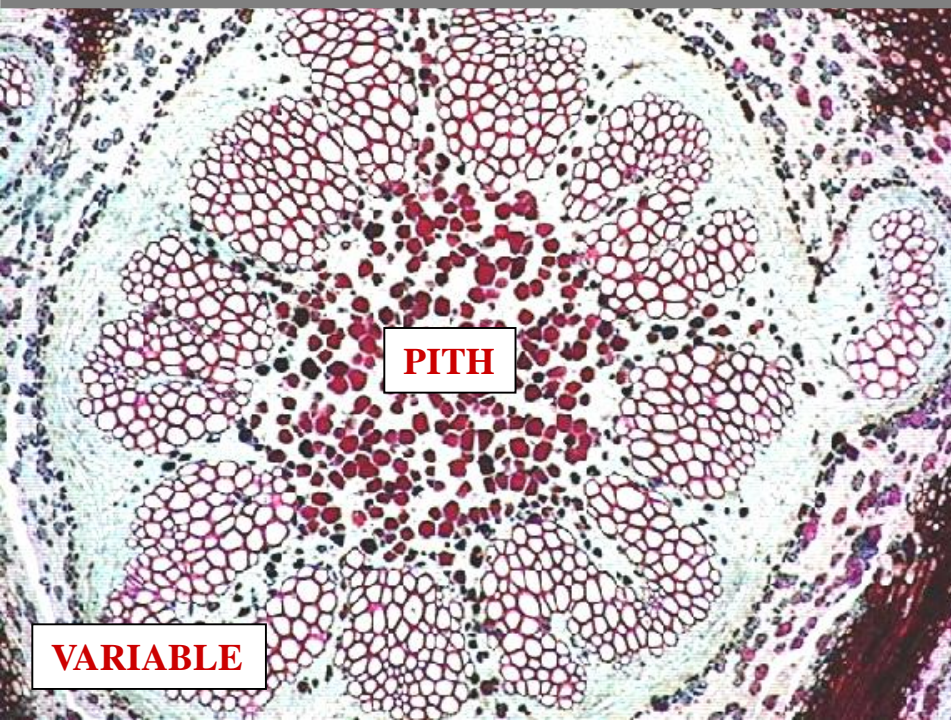
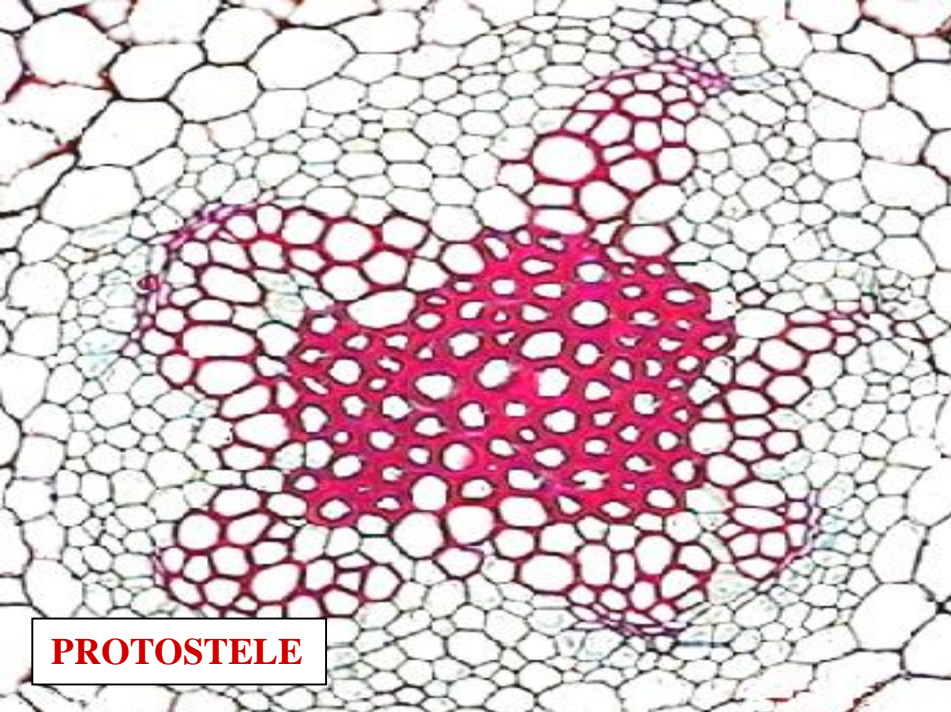


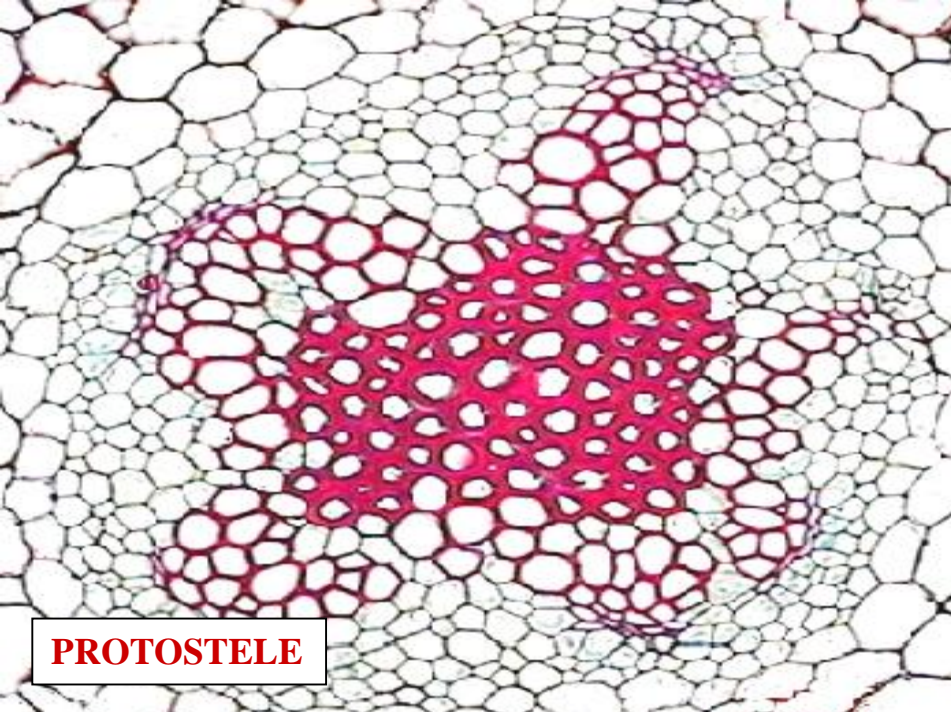
**VARIABLE**



**VARIABLE**



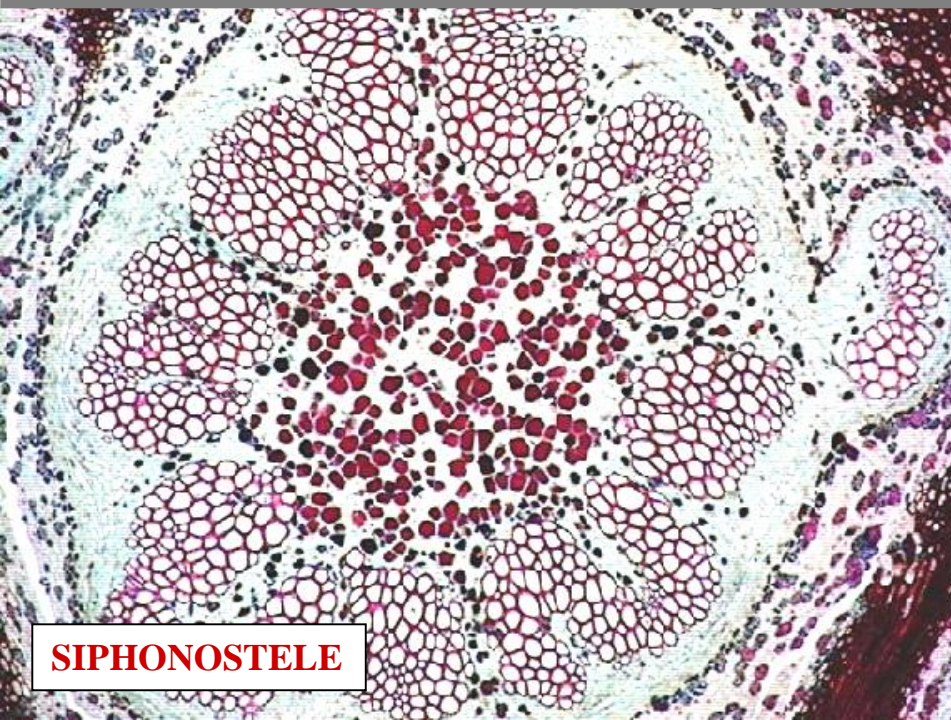




**PROTOSTELE**



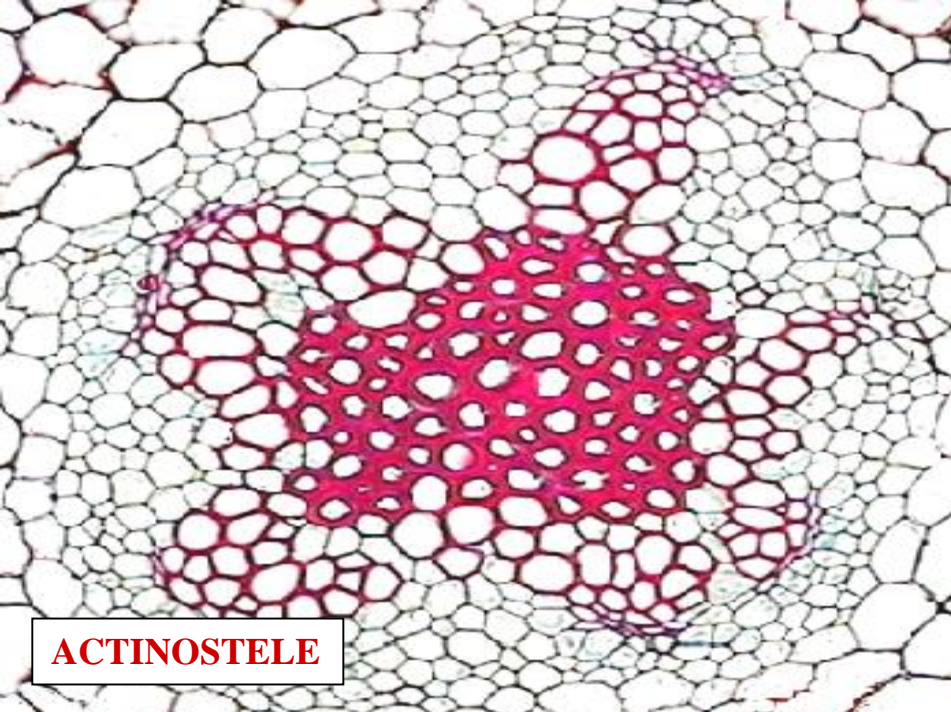
**SIPHONOSTELE**



**SIPHONOSTELE**



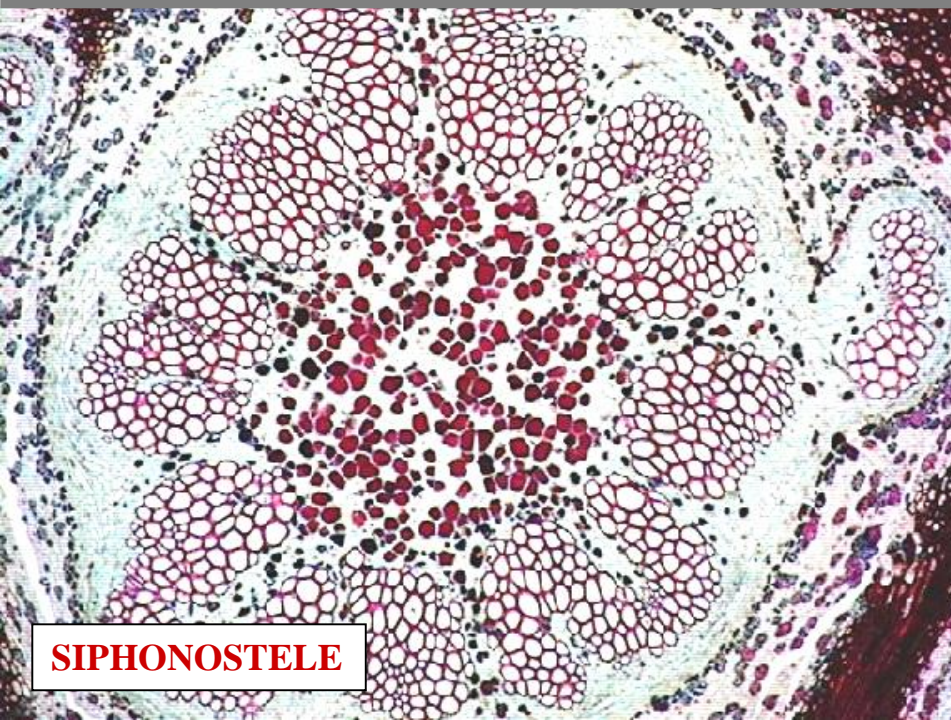
**SIPHONOSTELE**



**ACTINOSTELE**



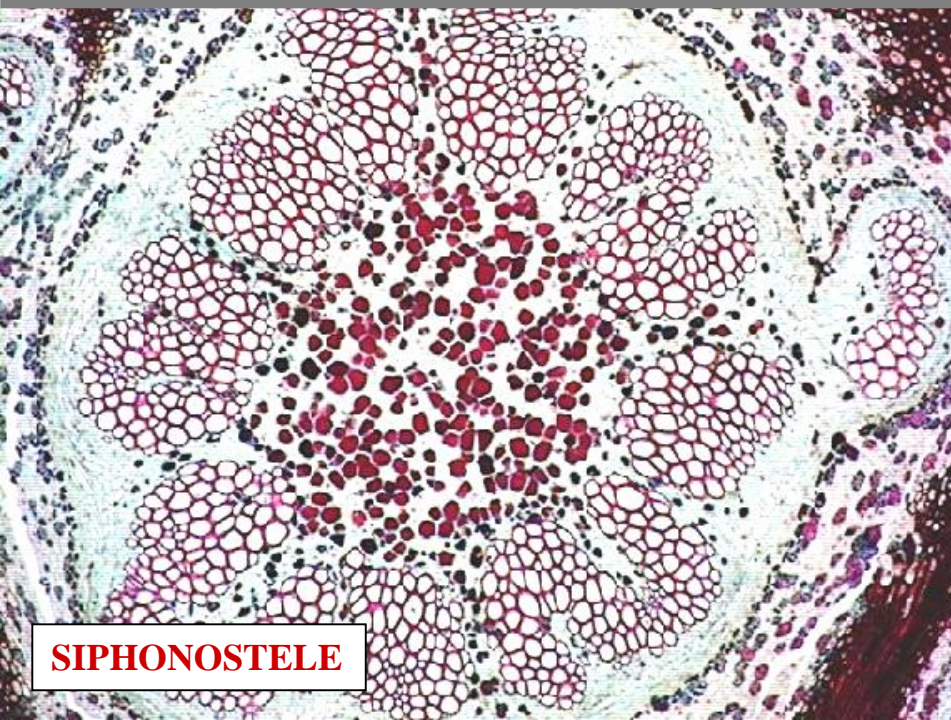
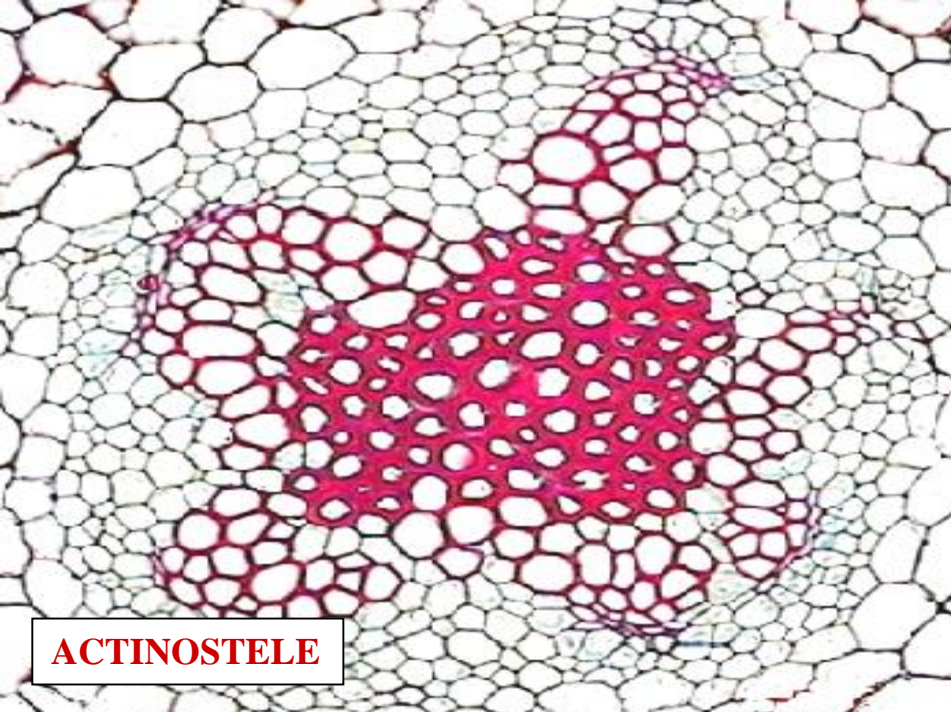
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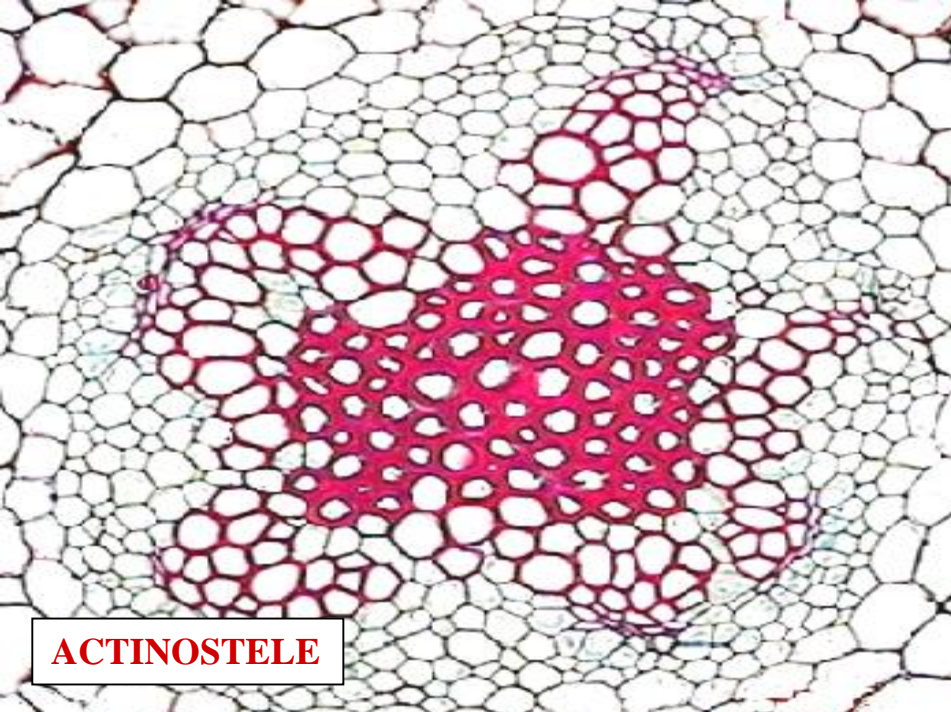


**SIPHONOSTELE**



**SIPHONOSTELE**



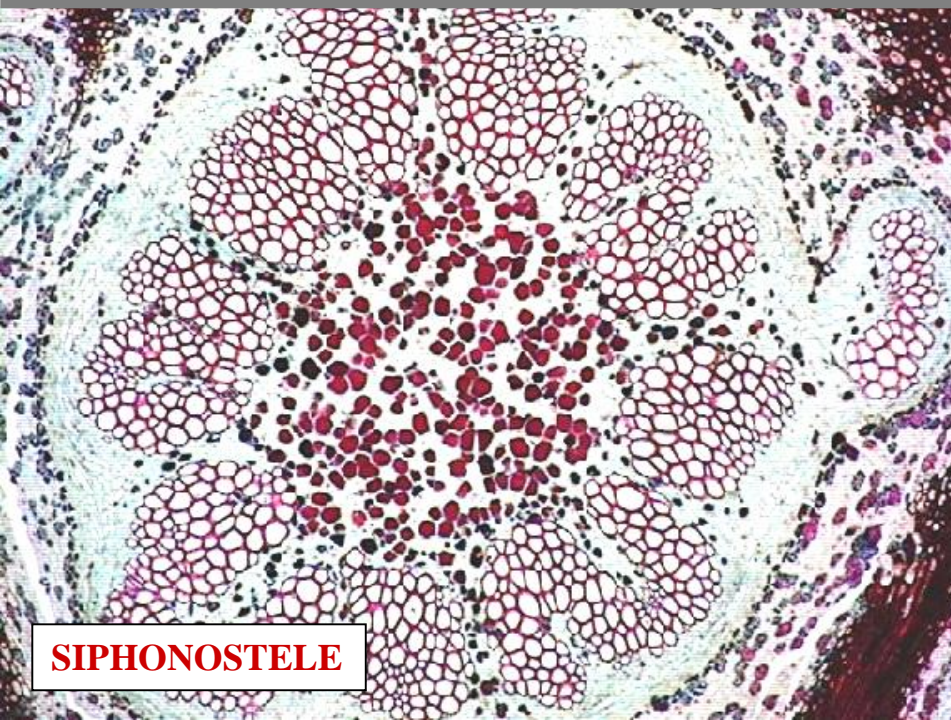


**ACTINOSTELE**



**E**

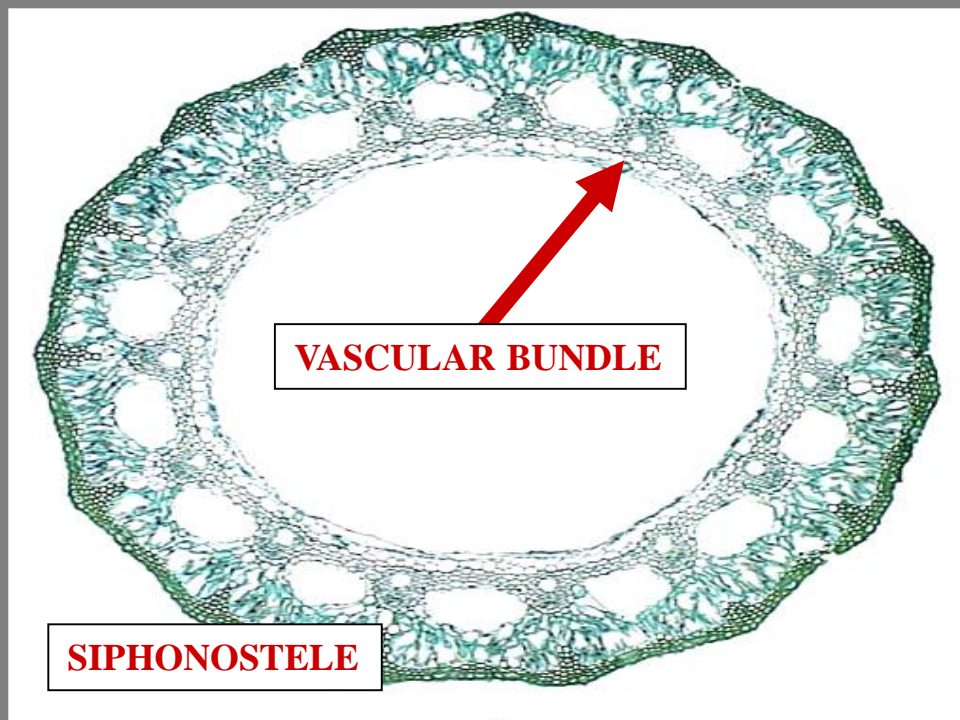
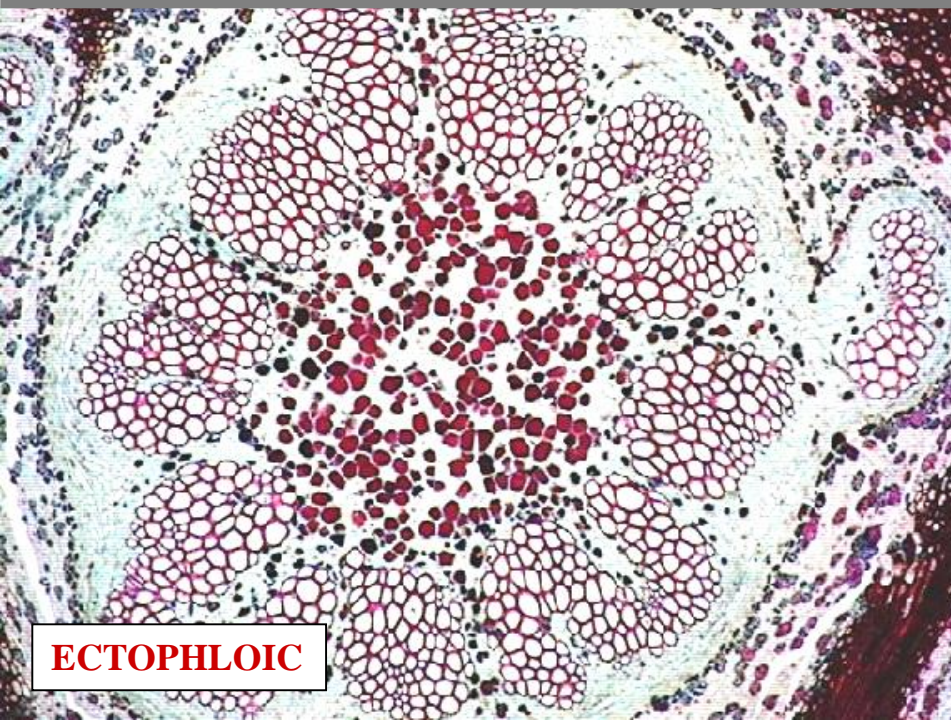
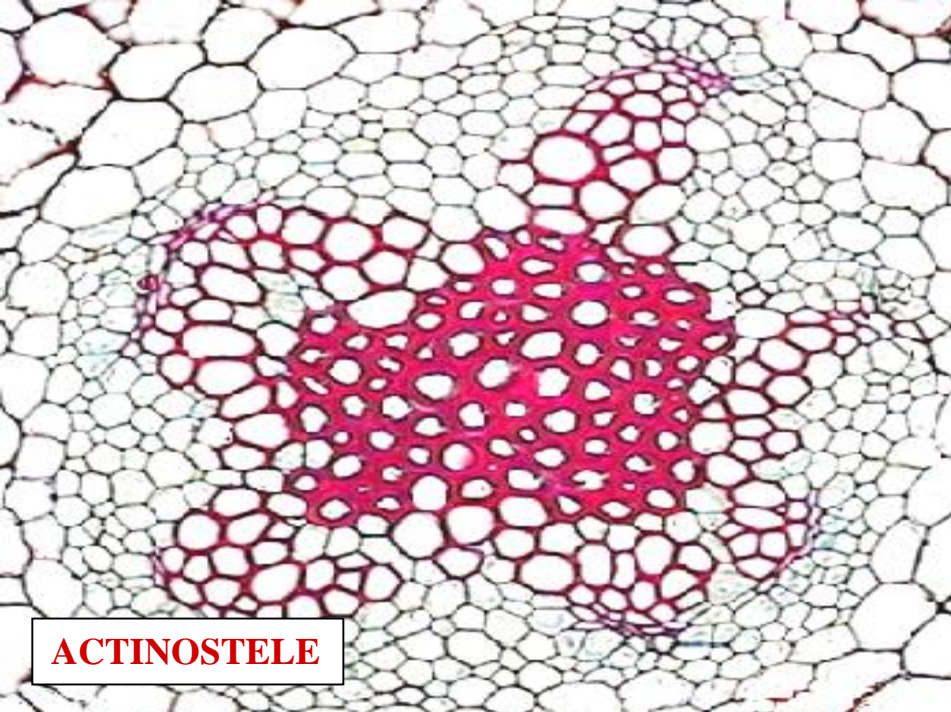
**AMPHIPHLOIC**

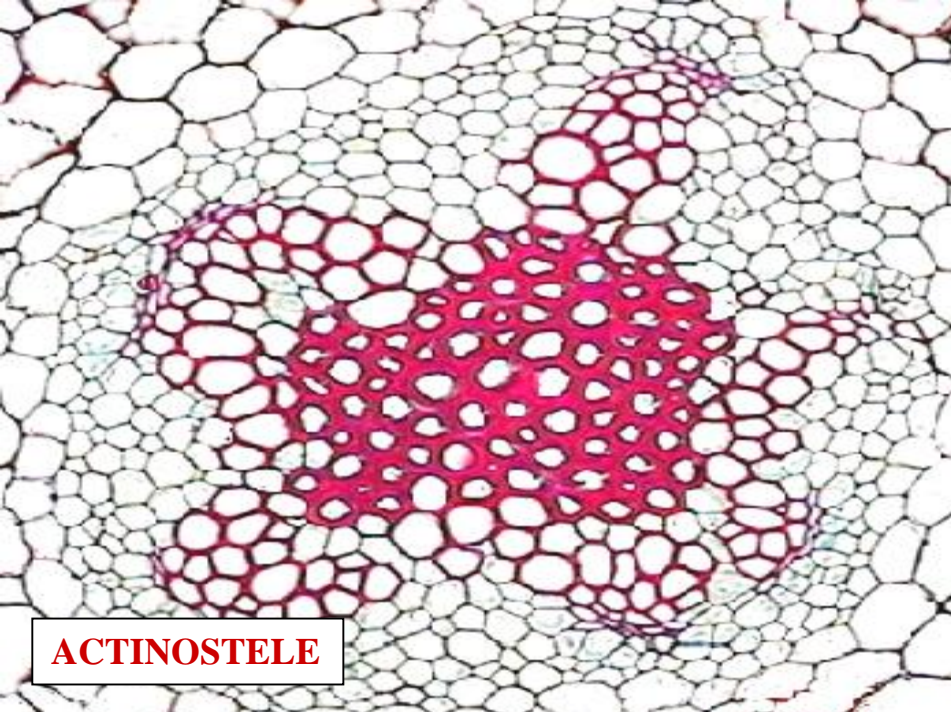


**SIPHONOSTELE**



**SIPHONOSTELE**

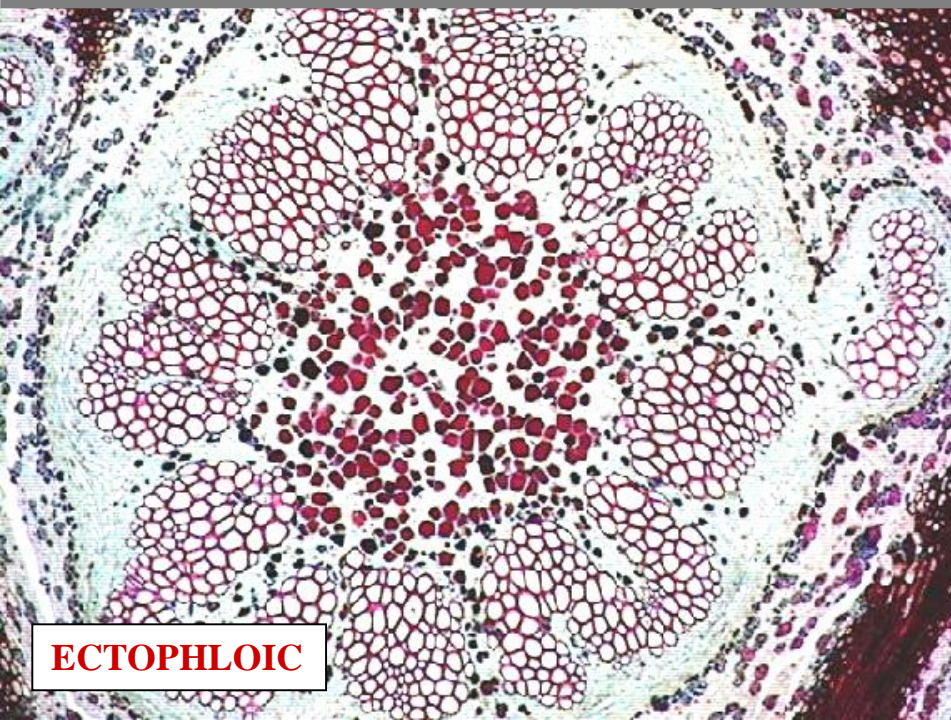




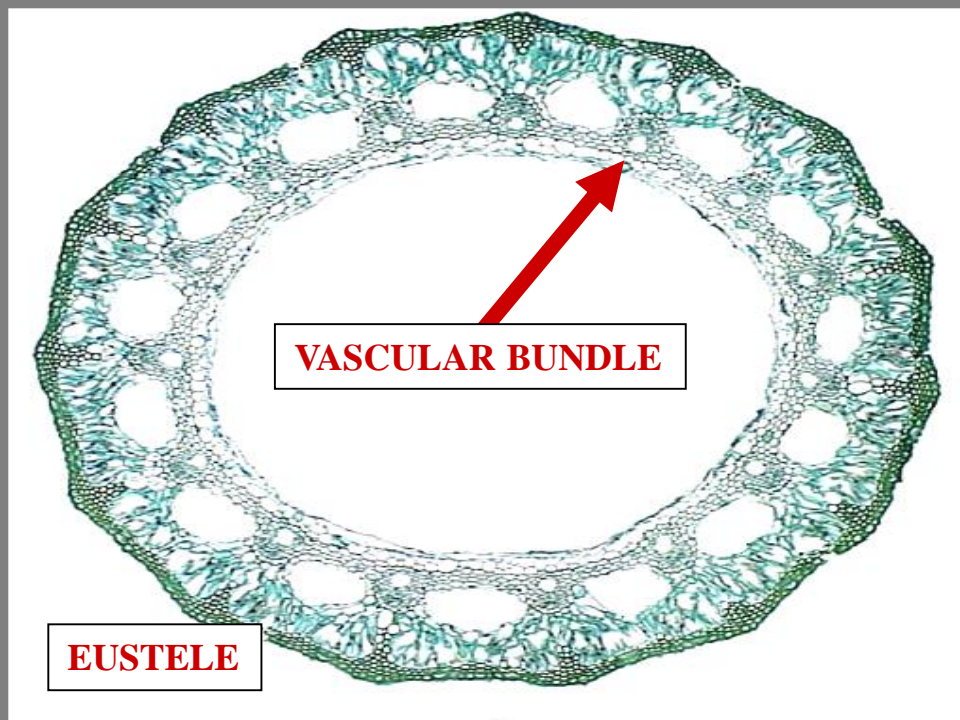
**ACTINOSTELE**



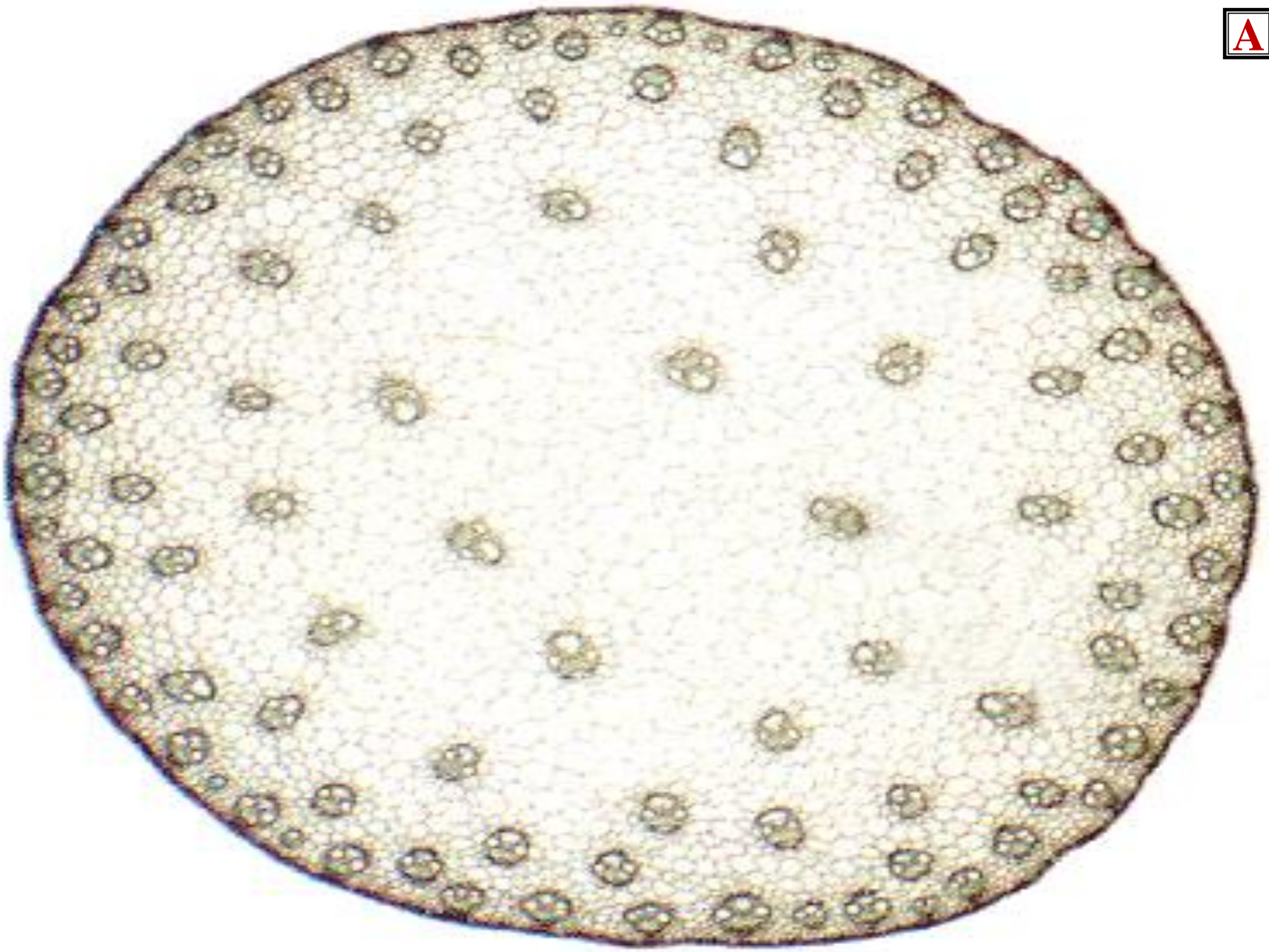
**AMPHIPHLOIC**



**ECTOPHLOIC**



**EUSTELE**







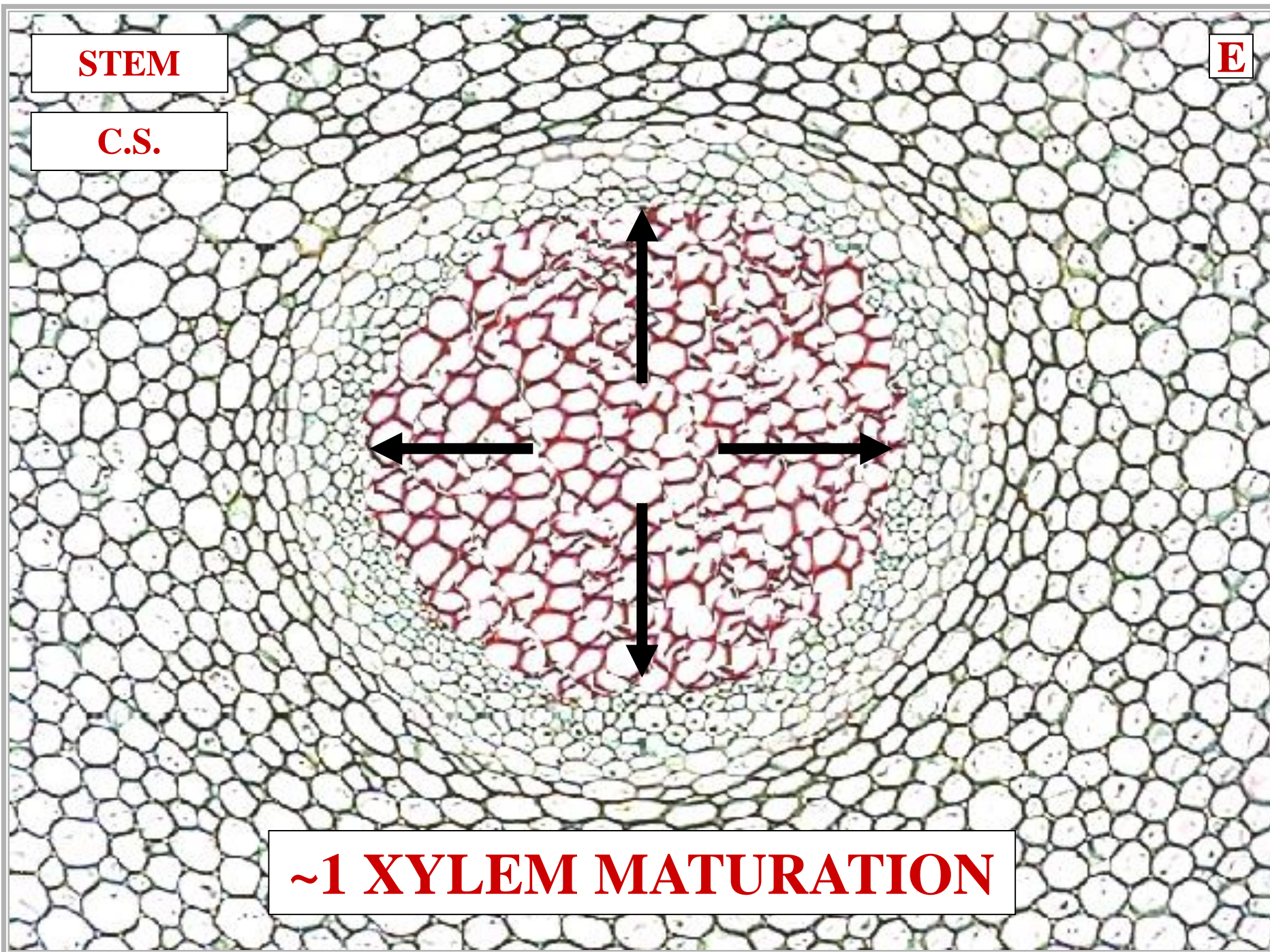
**ATACTOSTELE: ABSENT**

**STEM**

**C.S.**

**E**

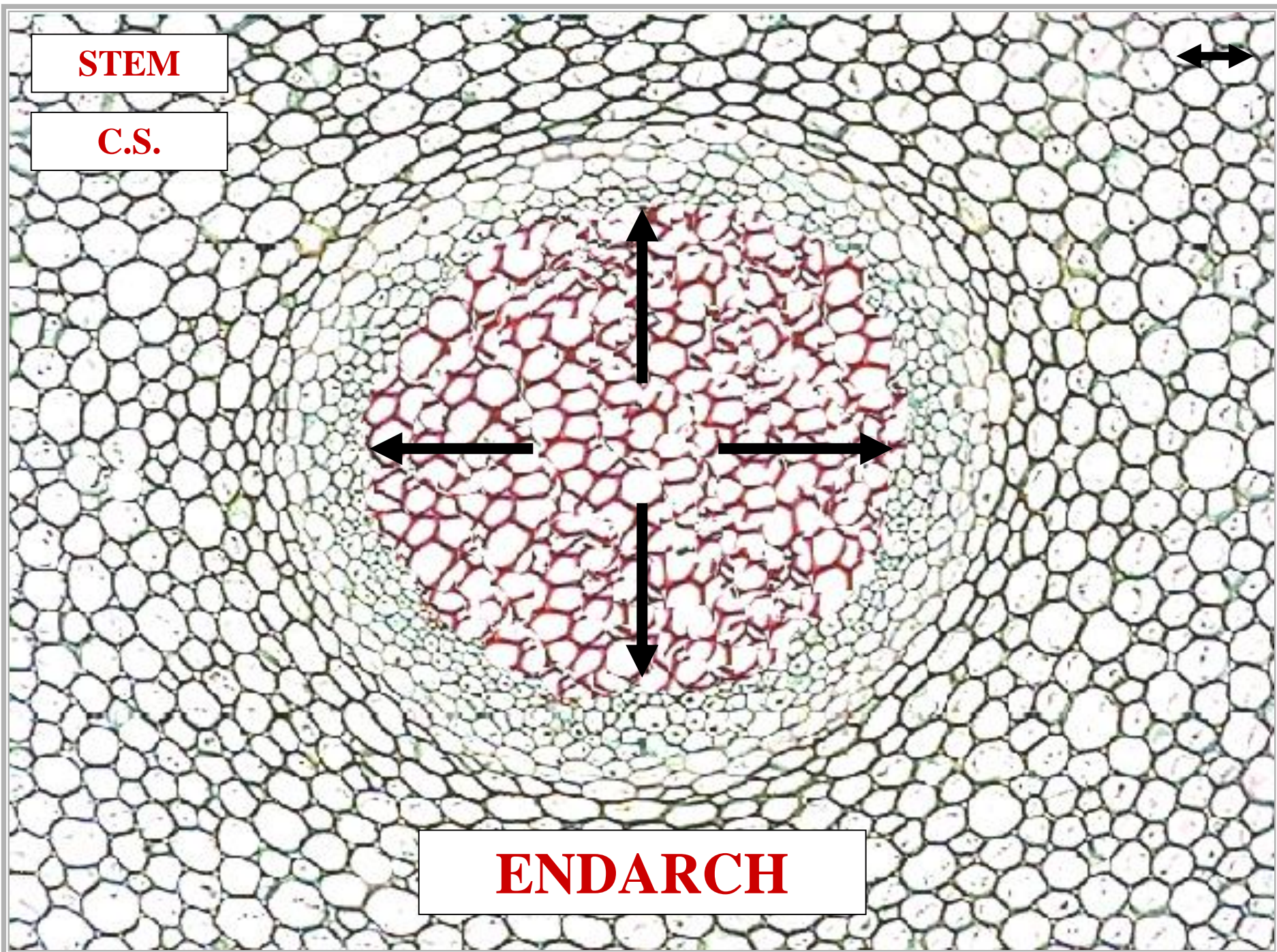
**~1 XYLEM MATURATION**



**STEM**

**C.S.**

**ENDARCH**

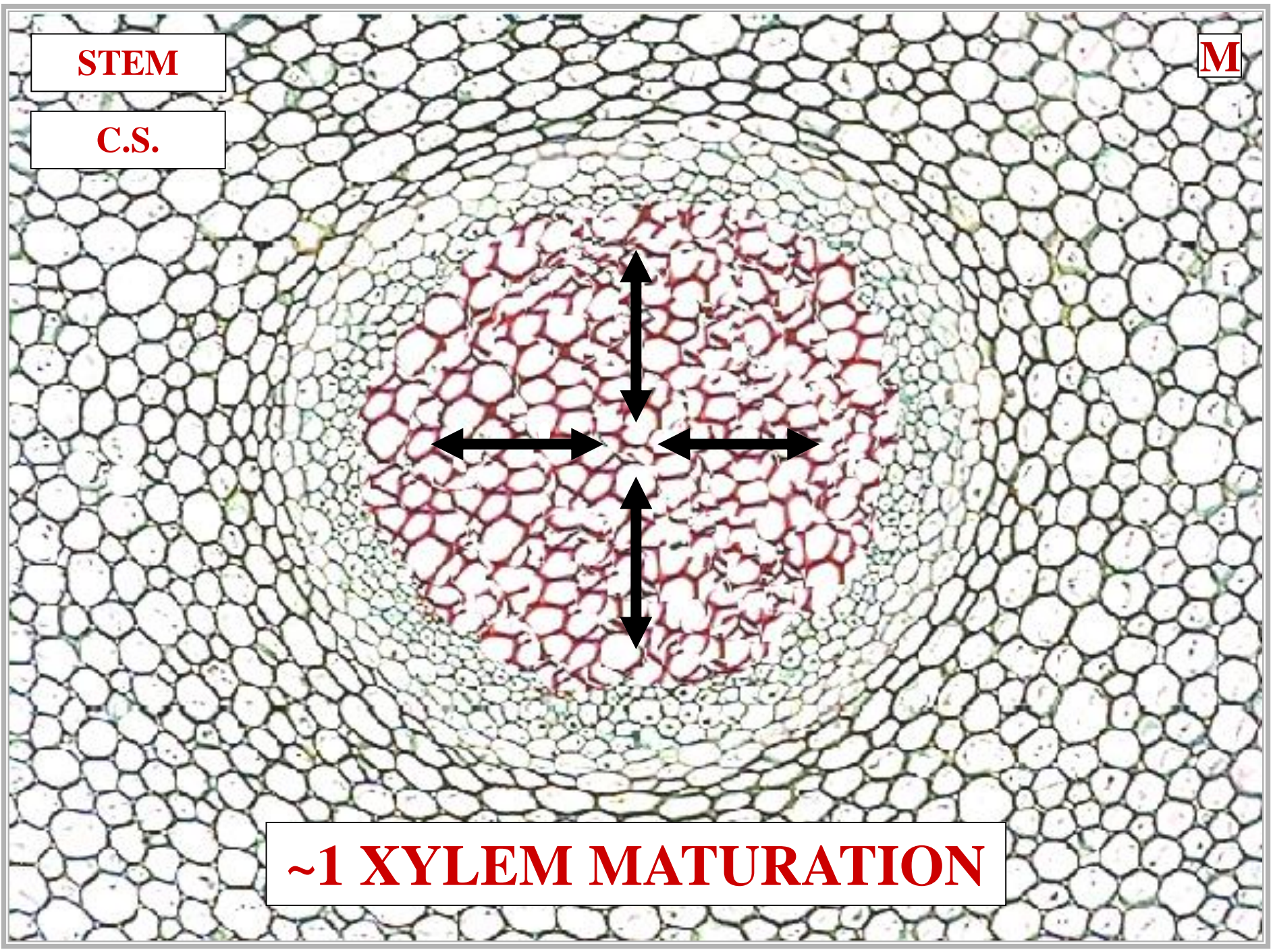


**STEM**

**C.S.**

**M**

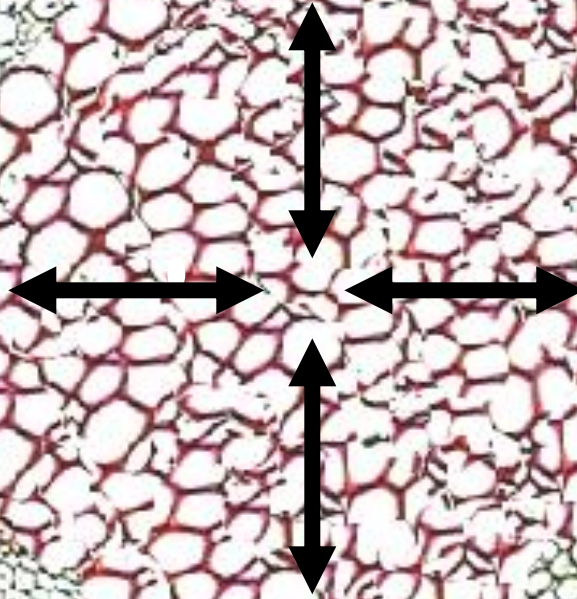
**~1 XYLEM MATURATION**



**STEM**

**C.S.**

**MESARCH**





# RHIZOME

**NON-FERTILE  
FRONDS**

**LATERAL  
RHIZOME**

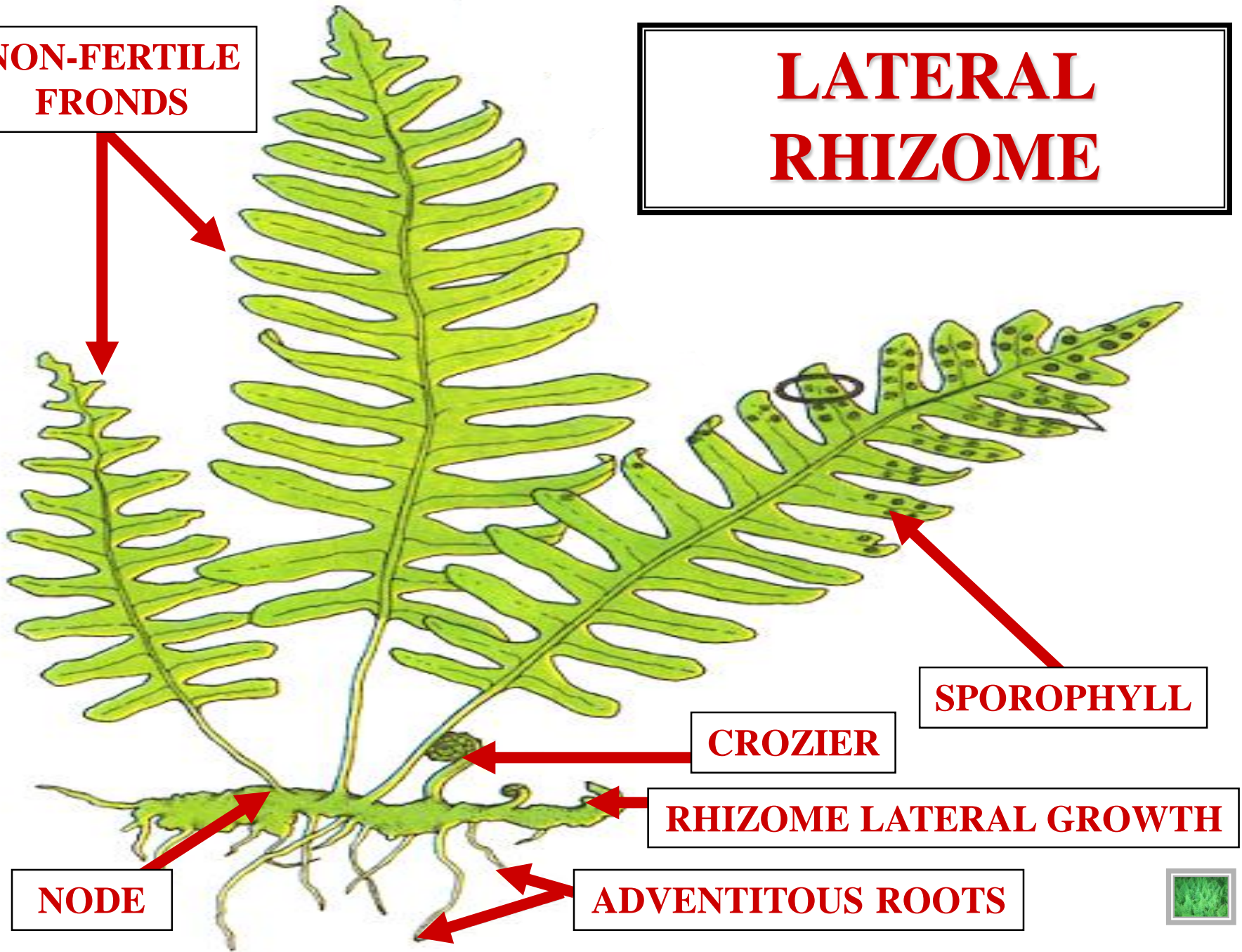
**CROZIER**

**SPOROPHYLL**

**RHIZOME LATERAL GROWTH**

**NODE**

**ADVENTITIOUS ROOTS**





**EXTENSIVE LATERAL GROWTH**





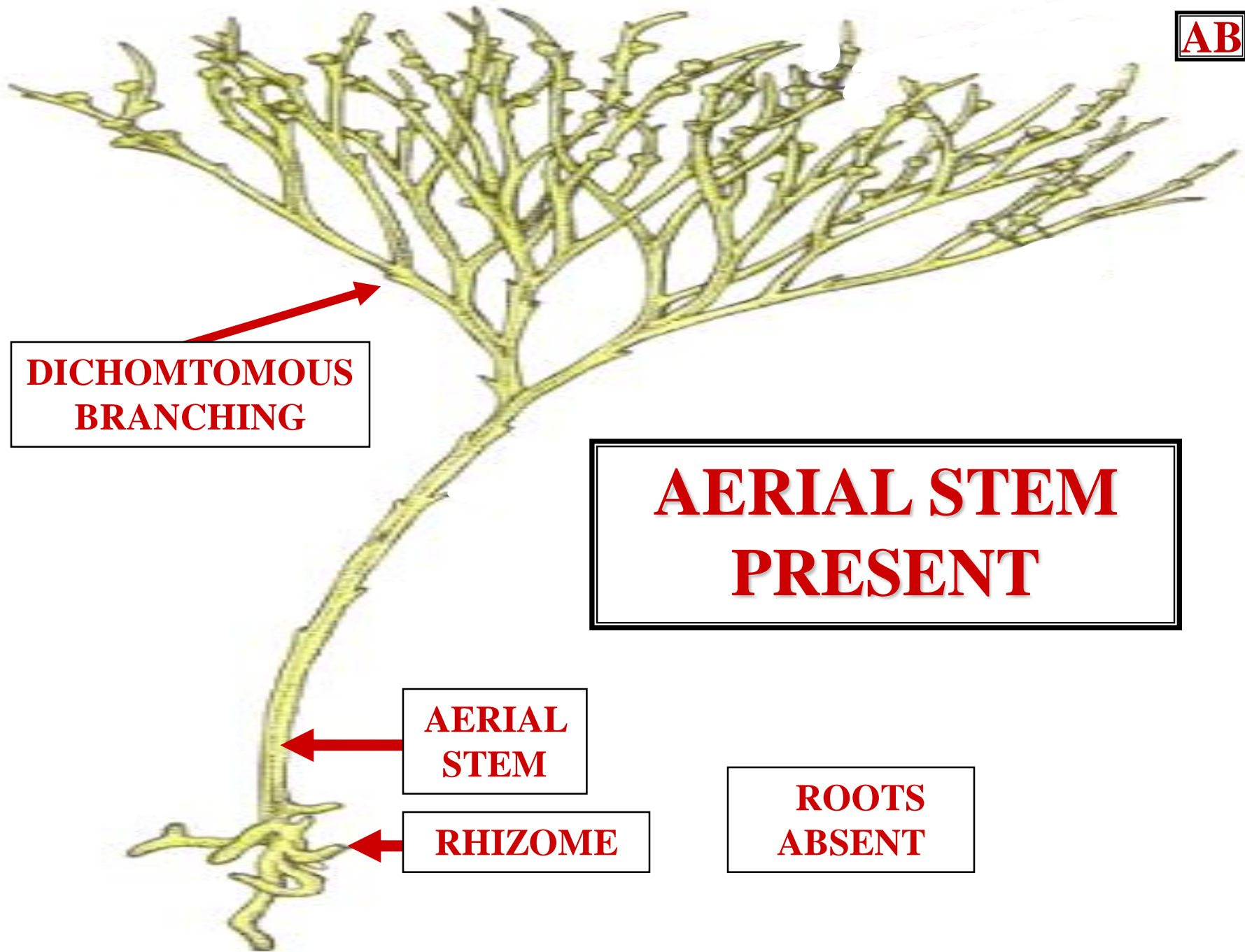
# VERTICAL RHIZOME



**ADVENTITIOUS  
ROOTS**

**RHIZOME  
VERTICAL GROWTH**

# AERIAL STEM



**DICHOTOMOUS  
BRANCHING**

**AERIAL STEM  
PRESENT**

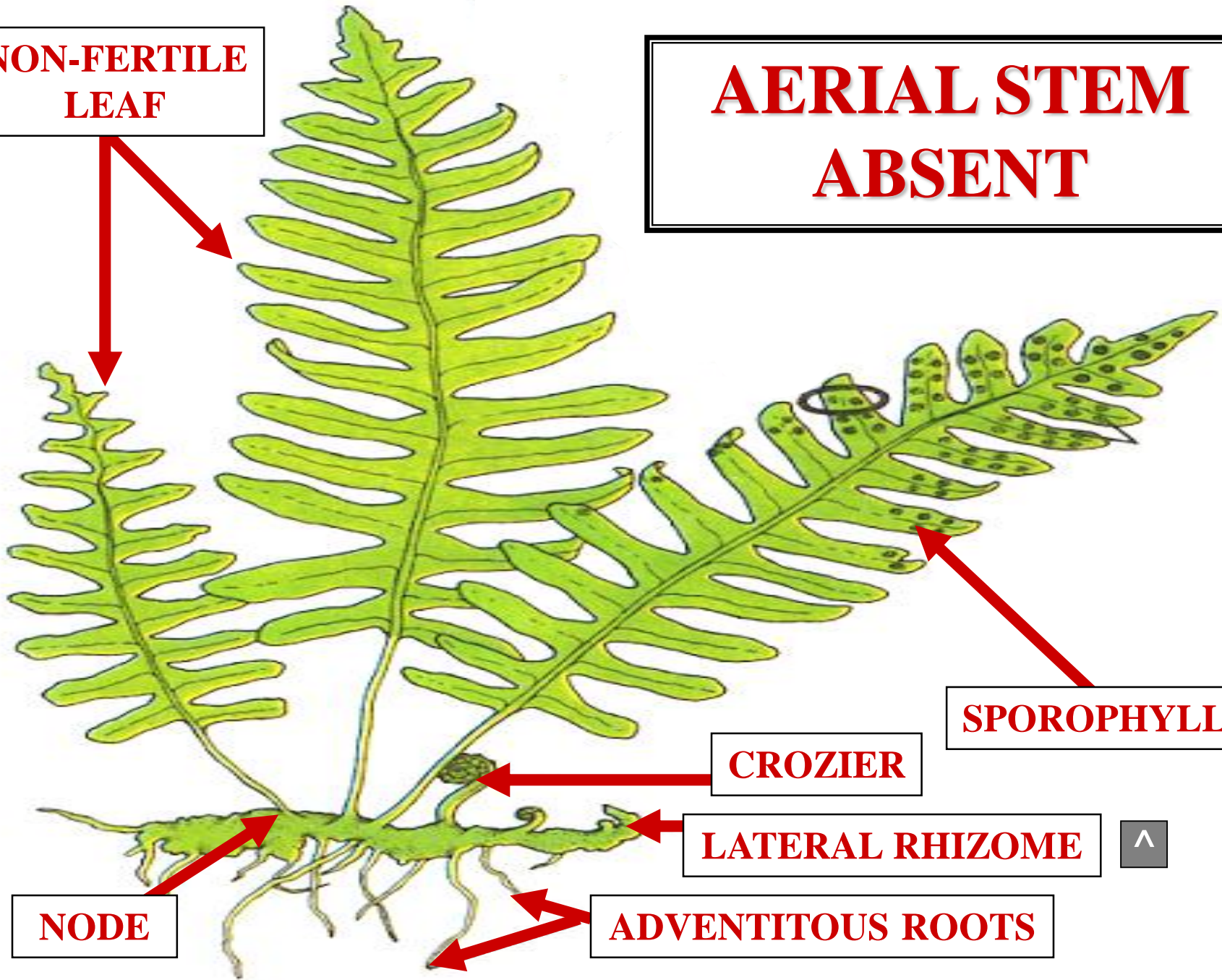
**AERIAL  
STEM**

**RHIZOME**

**ROOTS  
ABSENT**

**NON-FERTILE  
LEAF**

**AERIAL STEM  
ABSENT**



**SPOROPHYLL**

**CROZIER**

**LATERAL RHIZOME**

**NODE**

**ADVENTITIOUS ROOTS**





**LEAF**

# FERN LEAF

?

F



# FERN LEAF FROND

F



**FROND**





**FROND**

**FERN LEAF**

**FROND**

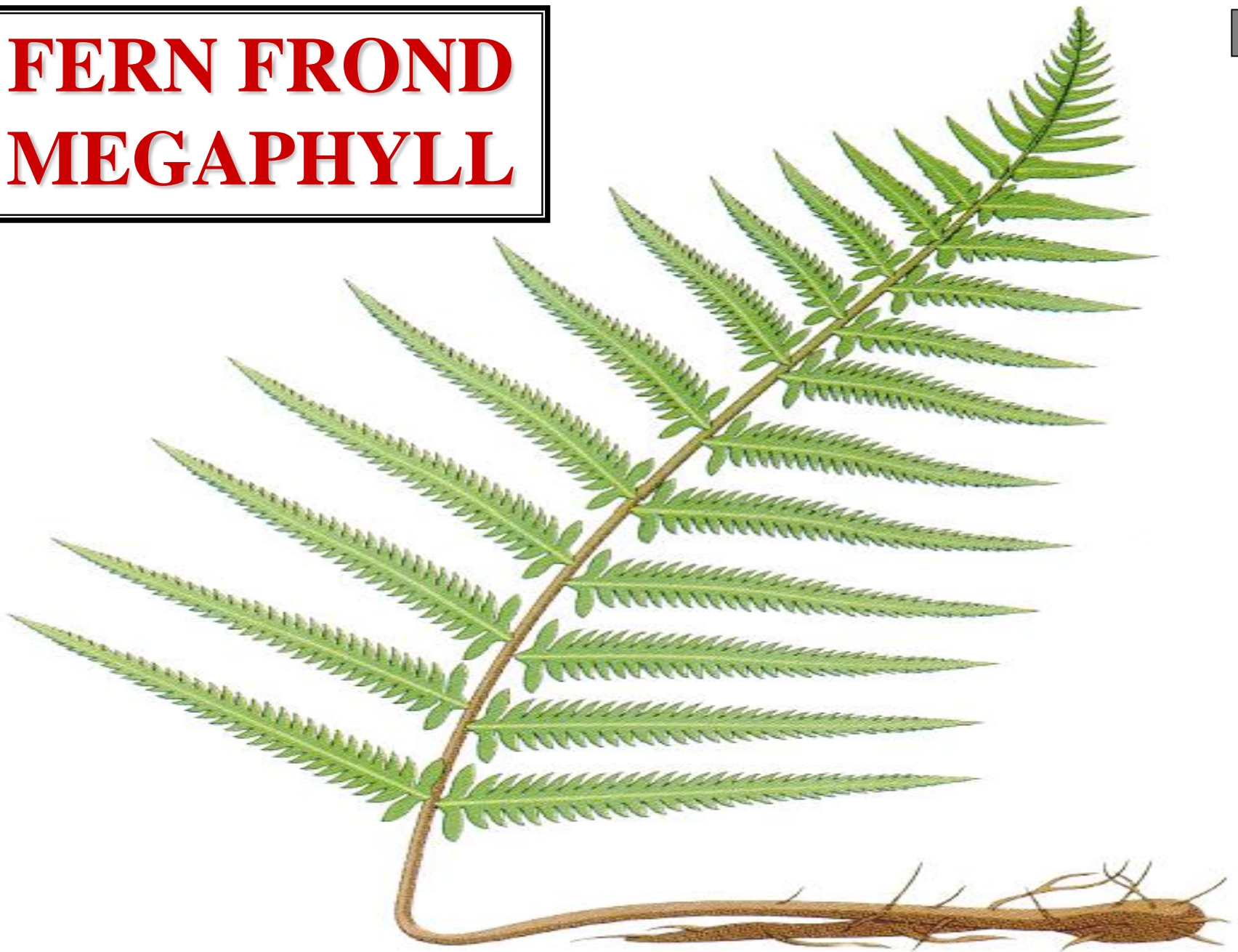
# FERN FROND

?

M



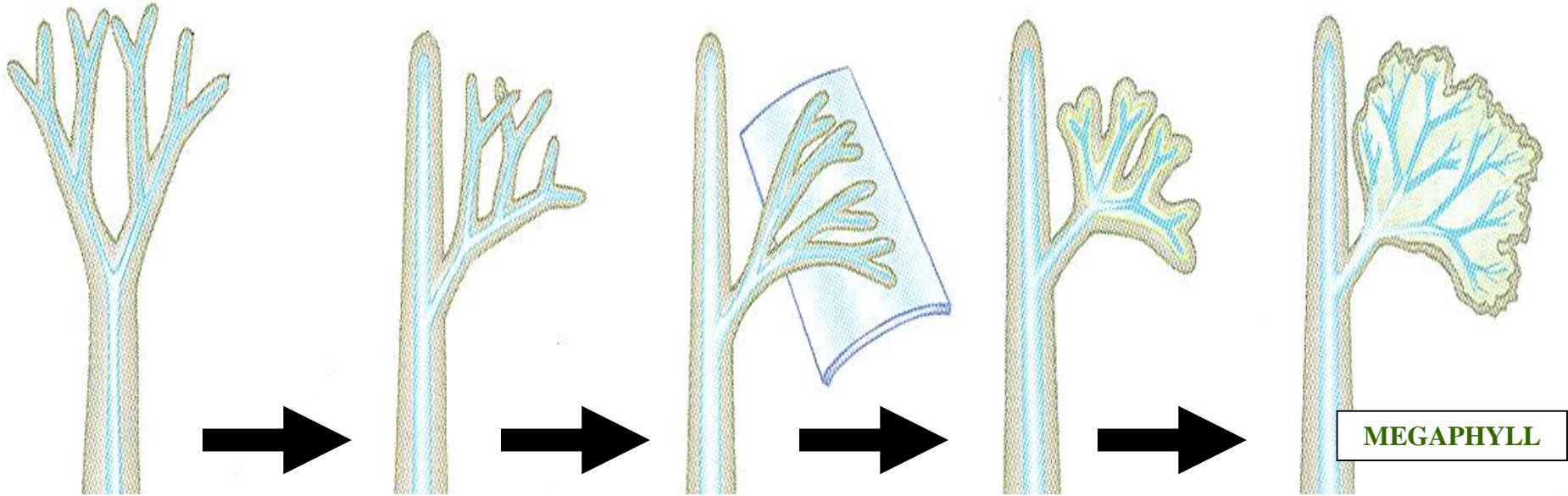
# FERN FROND MEGAPHYLL





# LEAF EVOLUTION

# THEORY



**A**

**B**

**C**

**D**

**E**

DICHOTOMOUS  
TELOME

OVERTOPPING  
TELOME

PLANATION  
TELOME

WEBBING  
TELOME

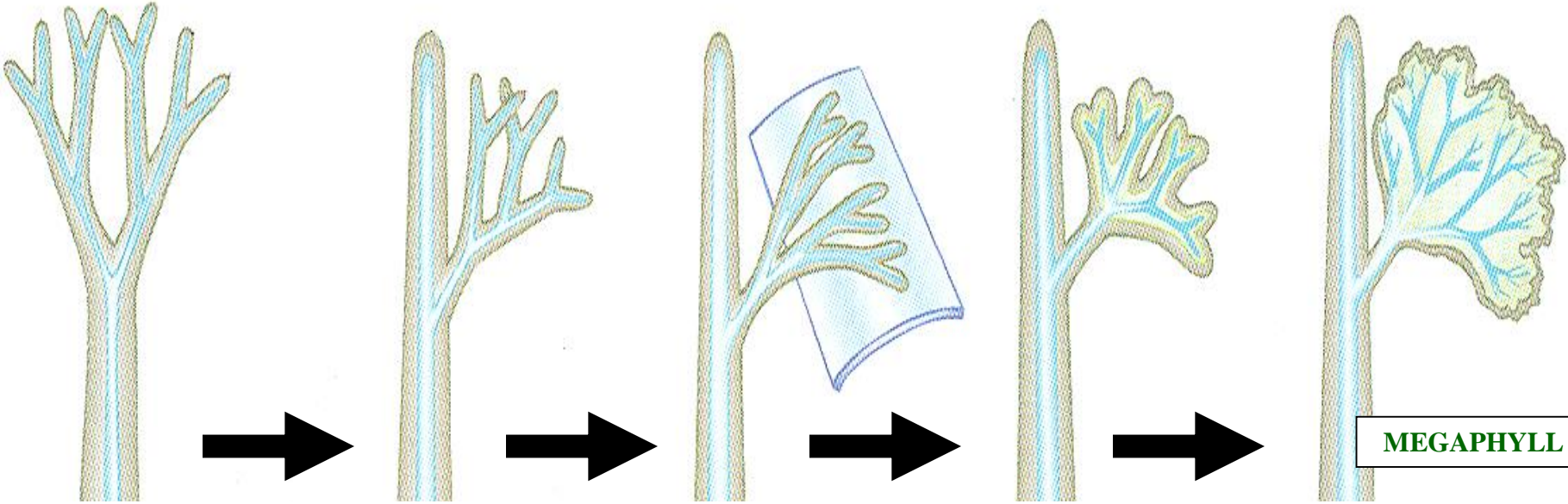
FUSION  
TELOME

➔ = TIME

**MEGAPHYLL**



# TELOME THEORY



**A**

**B**

**C**

**D**

**E**

DICHOTOMOUS  
TELOME

OVERTOPPING  
TELOME

PLANATION  
TELOME

WEBBING  
TELOME

FUSION  
TELOME

MEGAPHYLL

➔ = TIME

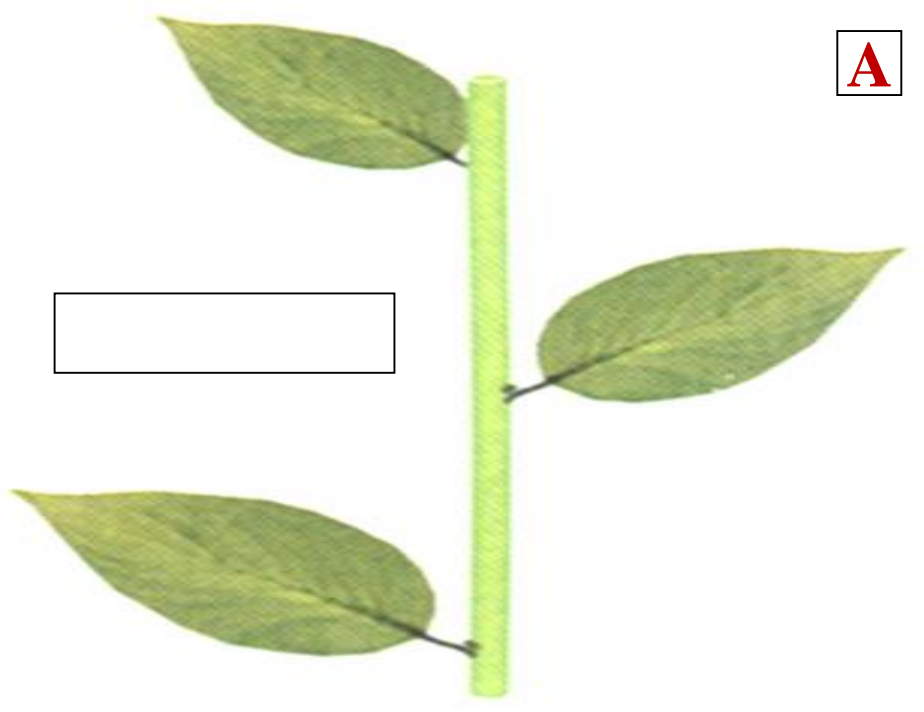
# MEGAPHYLL

# PHYLLLOTAXY

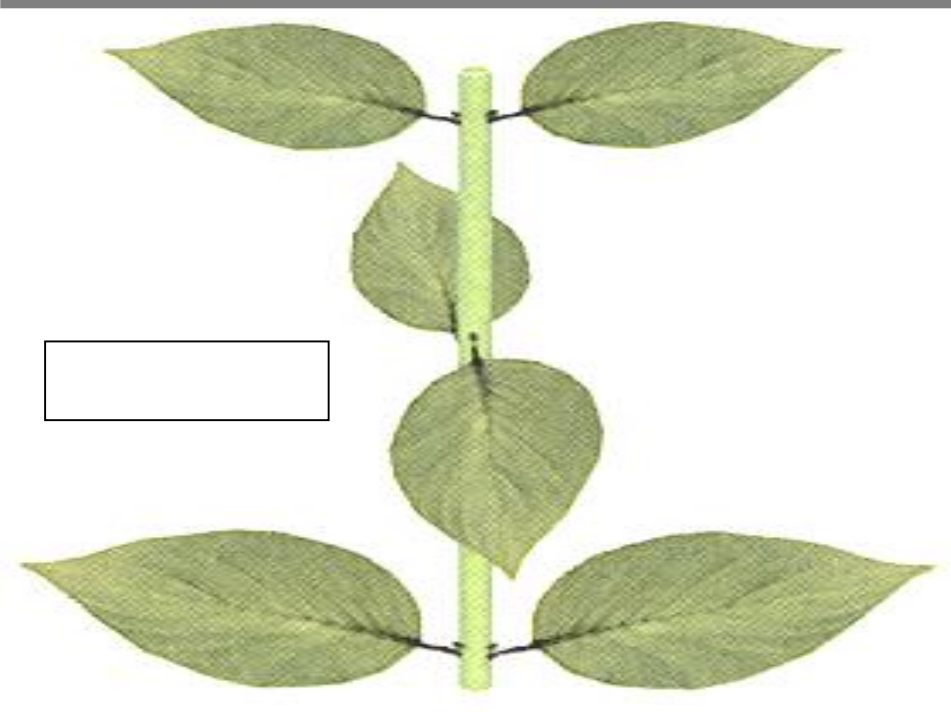


**FERN FROND**

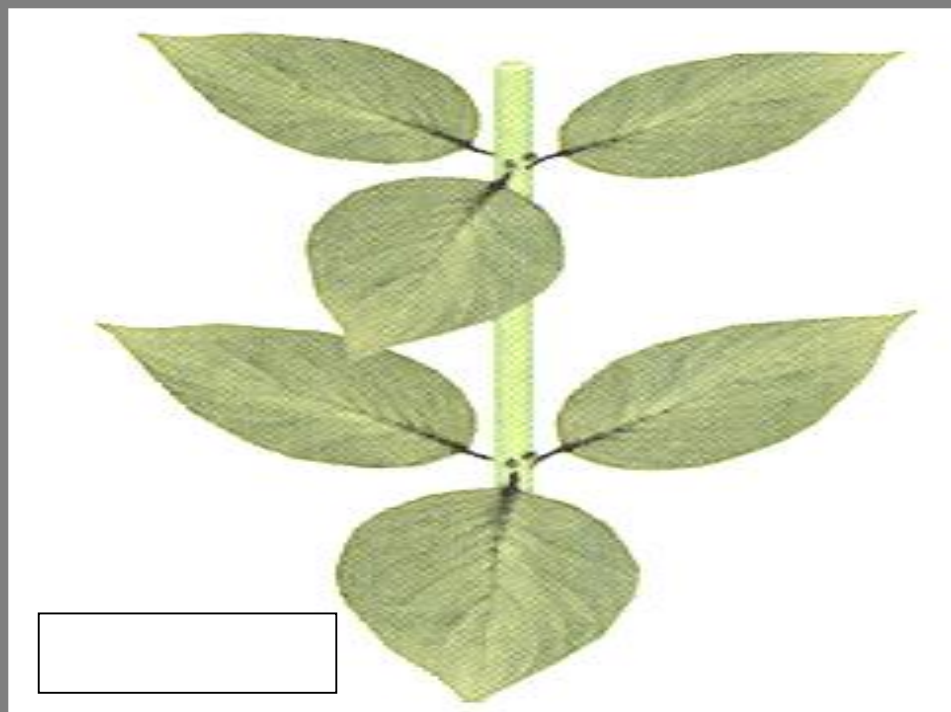
**A**



[ ]



[ ]



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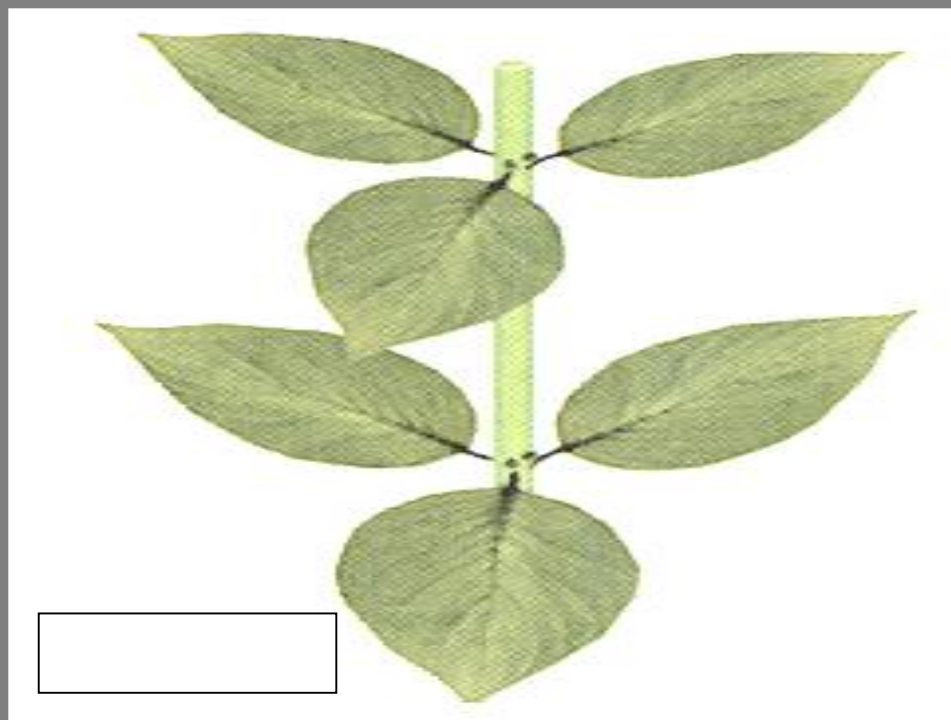
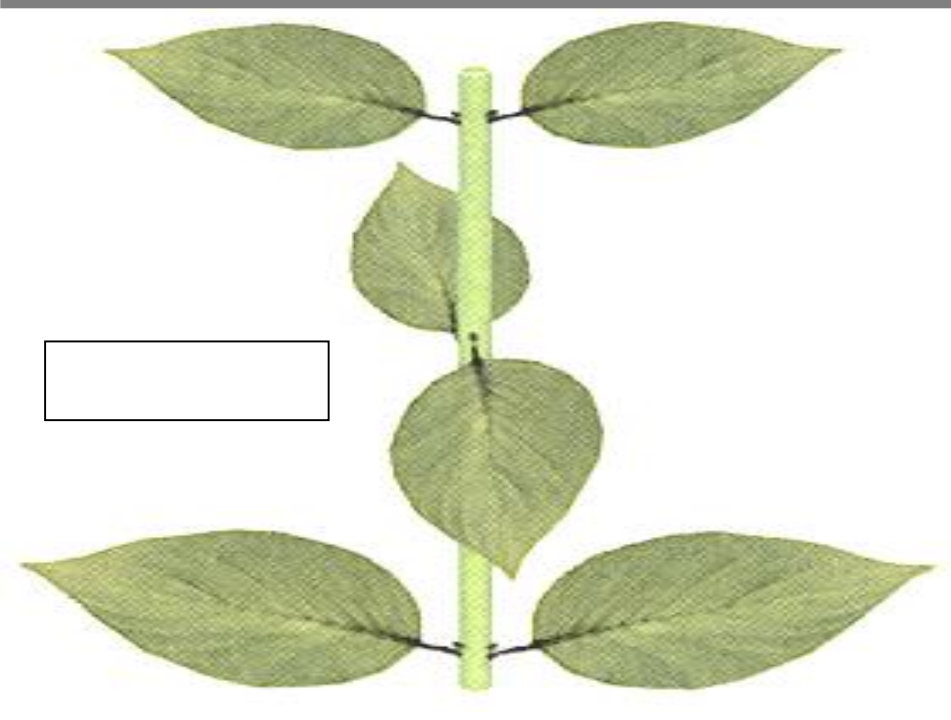


**FERN FROND**

**O**



**ALTERNATE**

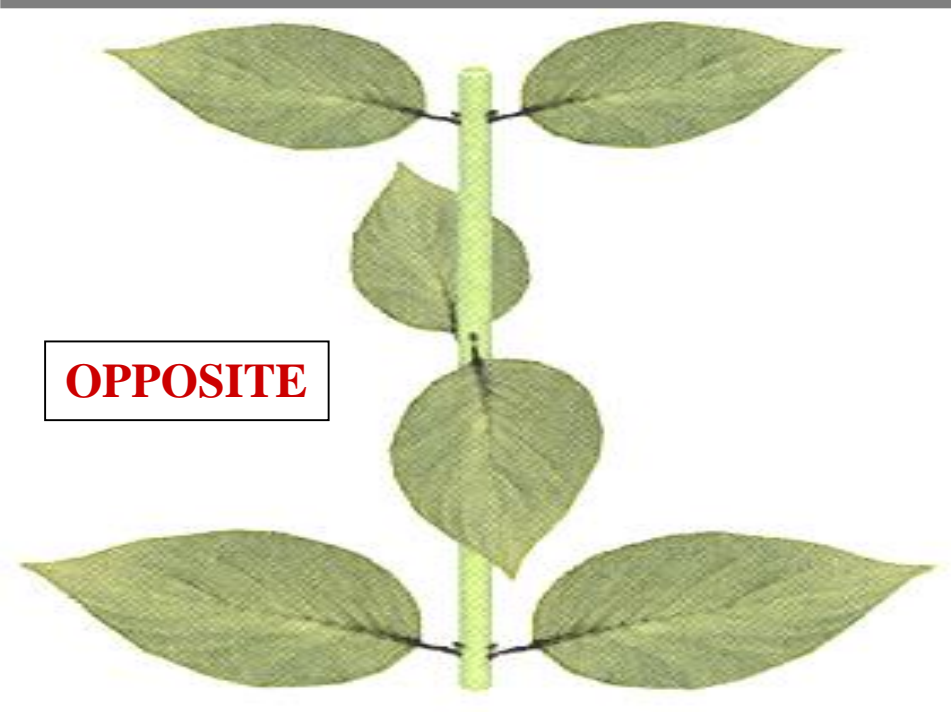




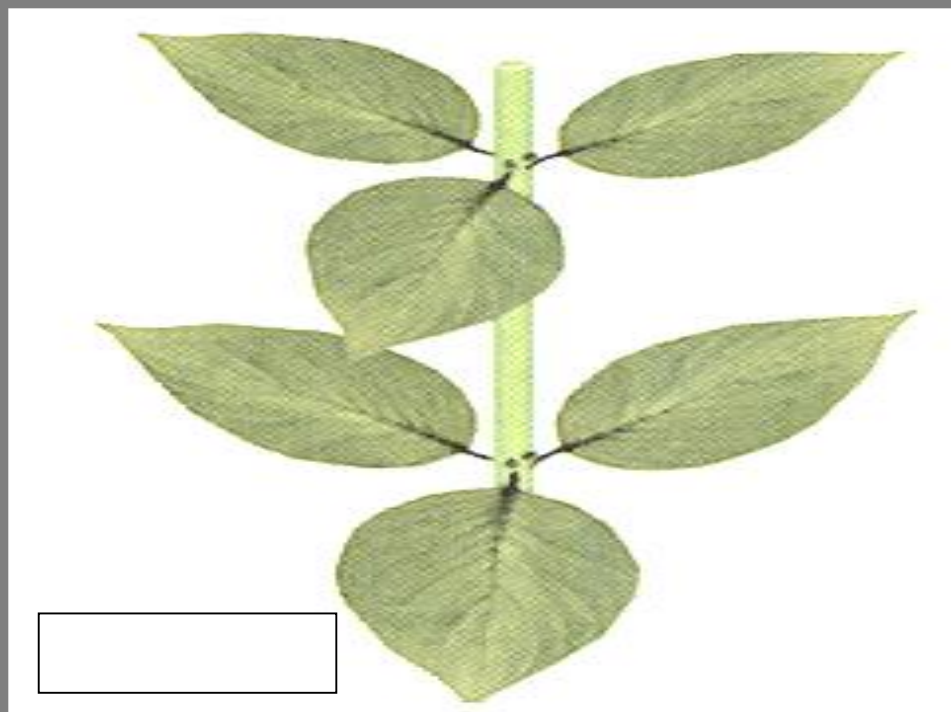
**FERN FROND**



**ALTERNATE**



**OPPOSITE**



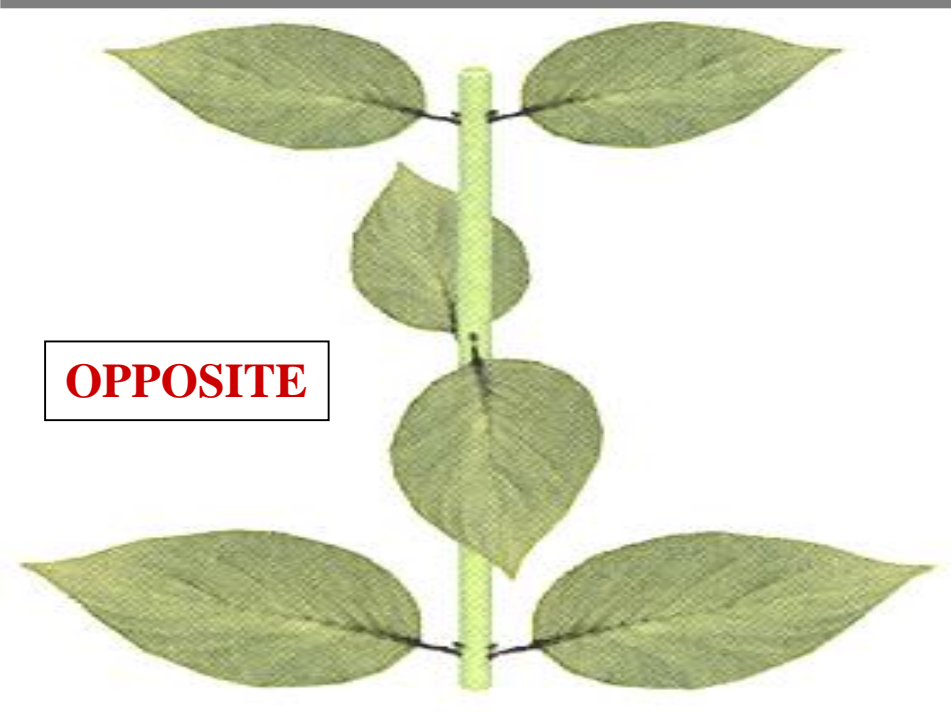


**FERN FROND**

**A**



**ALTERNATE**



**OPPOSITE**



**WHORLED**

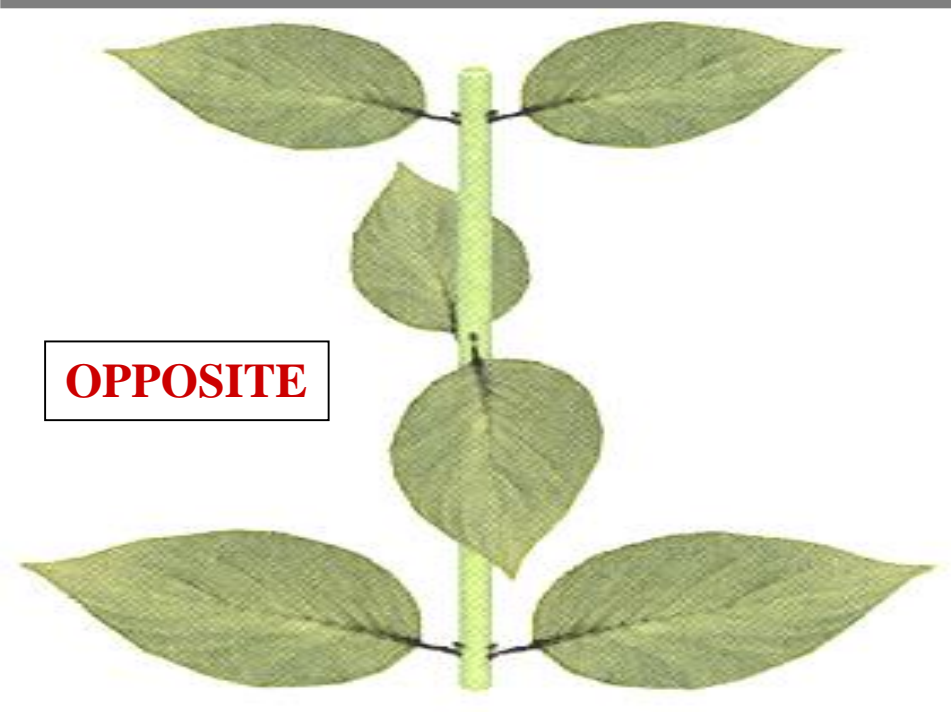


**ALTERNATE**

**FERN FROND**



**ALTERNATE**



**OPPOSITE**



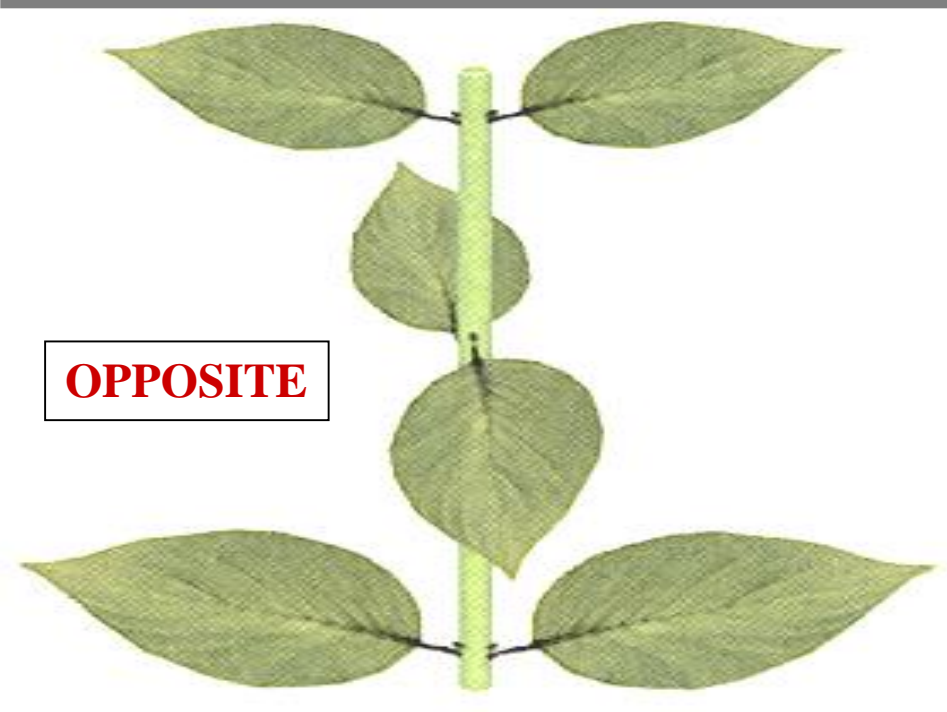
**WHORLED**



**FERN FROND**



**ALTERNATE**



**OPPOSITE**



**WHORLED**

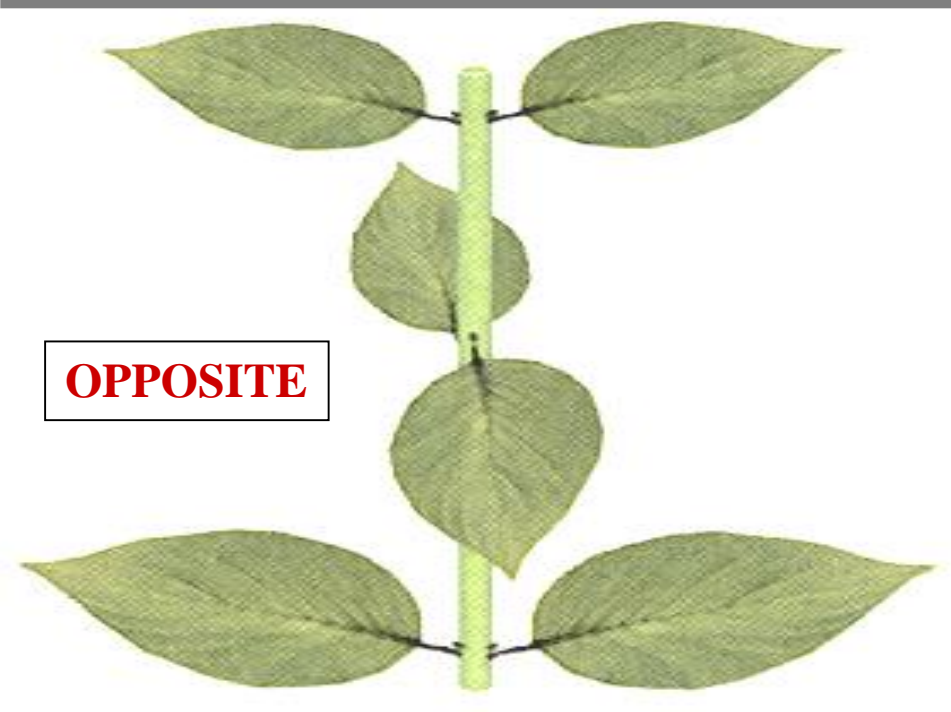


**WHORLED**

**FERN FROND**



**ALTERNATE**



**OPPOSITE**



**WHORLED**



# FROND VERNATION

**VERNATION**





**VERNATION**

**LEAF**

**BUD EMERGENCE**

**PATTERN**

**VERNATION**

# FROND VERNATION TYPES

# **VERNATION TYPES**

**CONDUPLICATE**

**VERNATION  
TYPED**

# VERNATION TYPES

C

CONDUPLICATE  
CIRCINATE

VERNATION  
TYPED

**CONDUPLICATE  
LEAF  
VERNATION**

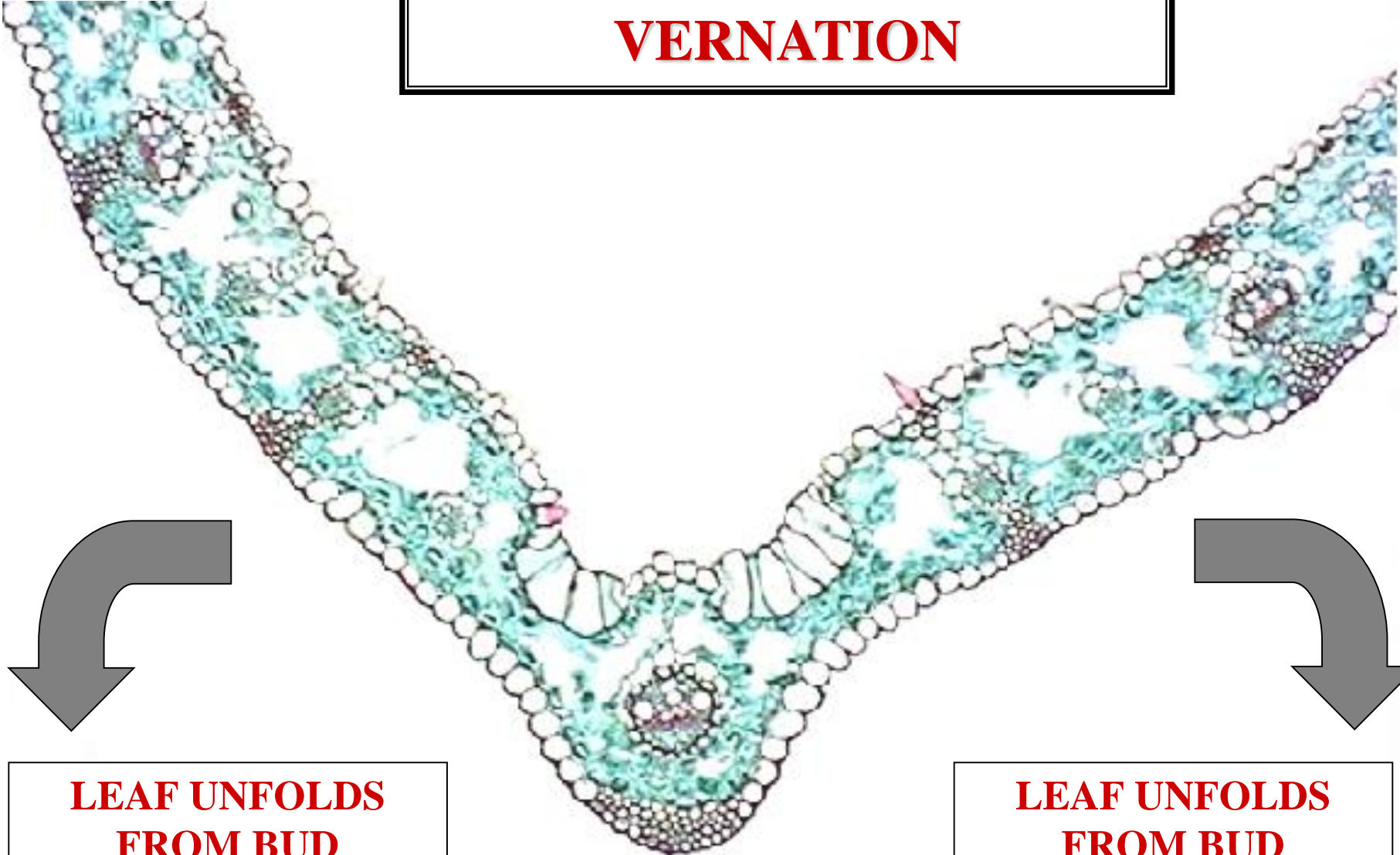
# CONDUPLICATE VERNATION



LEAF UNFOLDS  
FROM BUD

CONDUPLICATE  
VERNATION

**CONDUPPLICATE  
VERNATION**



**LEAF UNFOLDS  
FROM BUD**

**LEAF UNFOLDS  
FROM BUD**

**CIRCINATE  
LEAF  
VERNATION**



**CIRCINATE  
VERNATION**



**LEAF UNROLLS  
FROM BUD**

**CIRCINATE  
VERNATION**



**CIRCINATE VERNATION**

**LEAF UNROLLS  
FROM BUD**

**CROZIER**

**CIRCINATE VERNATION  
CROZIER**



**IMMATURE  
FERN FROND  
“FIDDLEHEAD”**

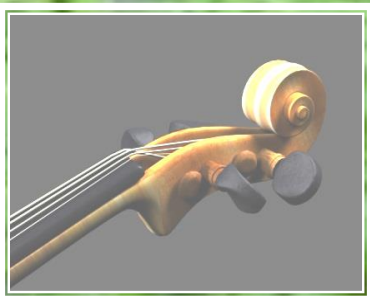
**CIRCINATE VERNATION  
CROZIER**



**CIRCINATE VERNATION**

**CROZIER**

**“FIDDLEHEAD”**



# MATURE FERN FROND





# FROND MORPHOLOGY

# FROND MORPHOLOGY TYPES



# **FROND MORPHOLOGY TYPES**

**COMPOUND FROND**

# **FROND MORPHOLOGY TYPES**

# FROND MORPHOLOGY TYPES



COMPOUND FROND  
SIMPLE FROND

FROND MORPHOLOGY  
TYPES

# COMPOUND FROND

**COMPOUND  
FROND**

# FROND MORPHOLOGY

## COMPOUND FROND



PINNAE PRESENT

# FROND MORPHOLOGY

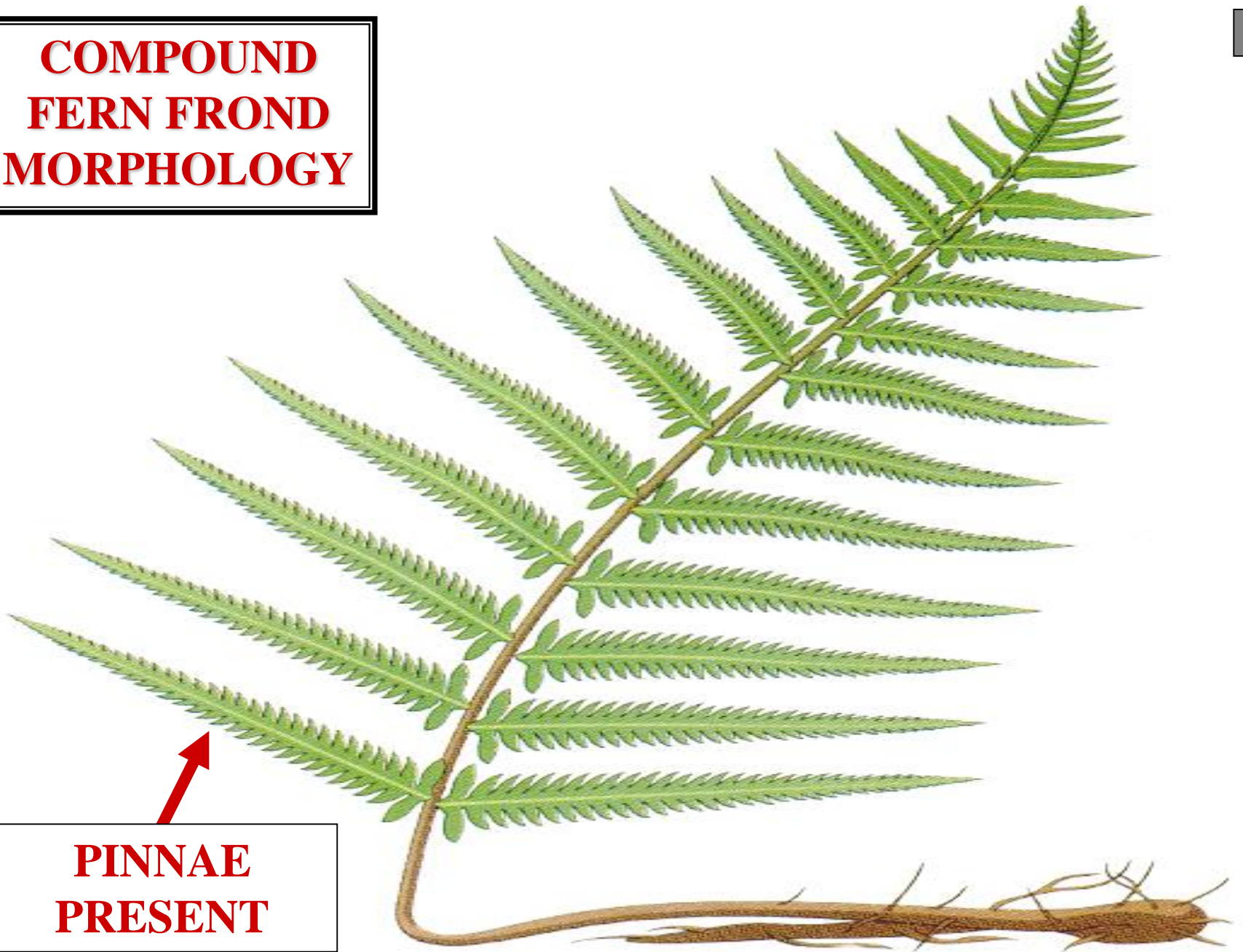
## COMPOUND FROND

**COMPOUND  
FERN FROND  
MORPHOLOGY**

**PP**



**COMPOUND  
FERN FROND  
MORPHOLOGY**



**PINNAE  
PRESENT**



# COMPOUND FROND MORPHOLOGY



**COMPOUND  
FERN FROND  
MORPHOLOGY**

**S**



**STIPE**

# COMPOUND FROND STIPE

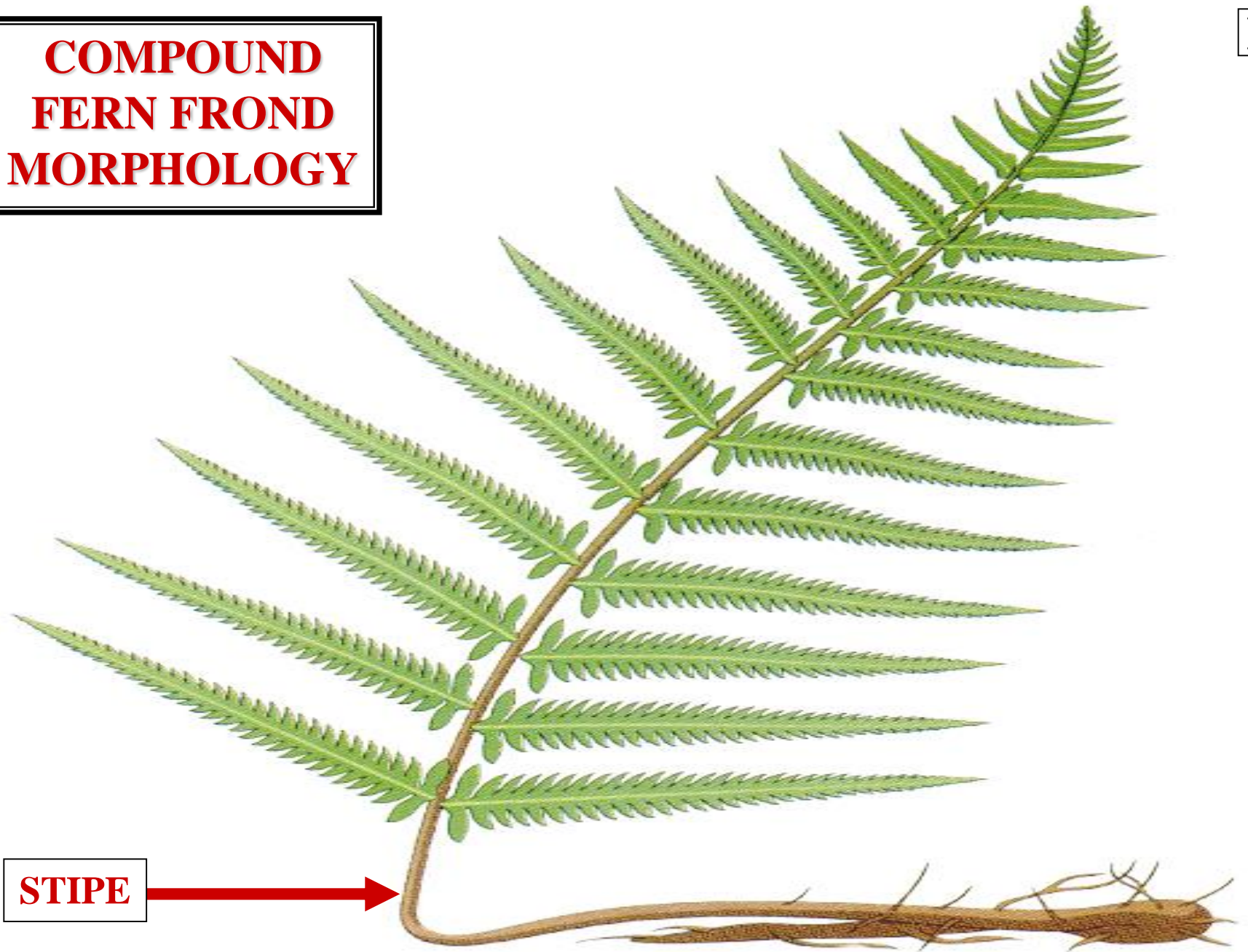


FROND STALK

# COMPOUND FROND STIPE

**COMPOUND  
FERN FROND  
MORPHOLOGY**

**L**



**STIPE**

**LAMINA**

**COMPOUND FROND  
LAMINA**

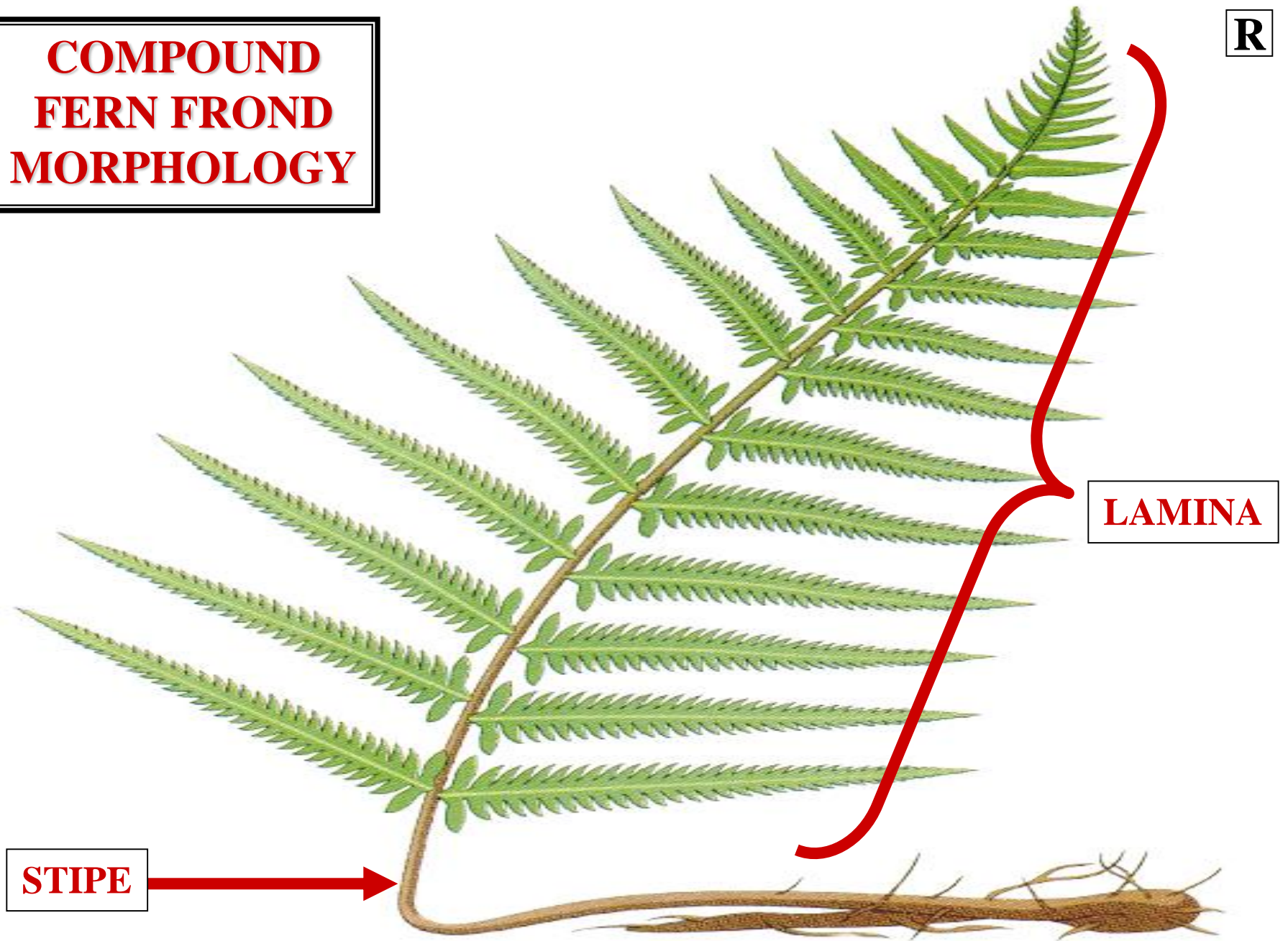


**PHOTOSYNTHETIC  
BLADE**

**COMPOUND FROND  
LAMINA**

**COMPOUND  
FERN FROND  
MORPHOLOGY**

**R**



**RACHIS**



# COMPOUND FROND RACHIS



BEARS PINNAE

# COMPOUND FROND RACHIS

# COMPOUND FERN FROND MORPHOLOGY

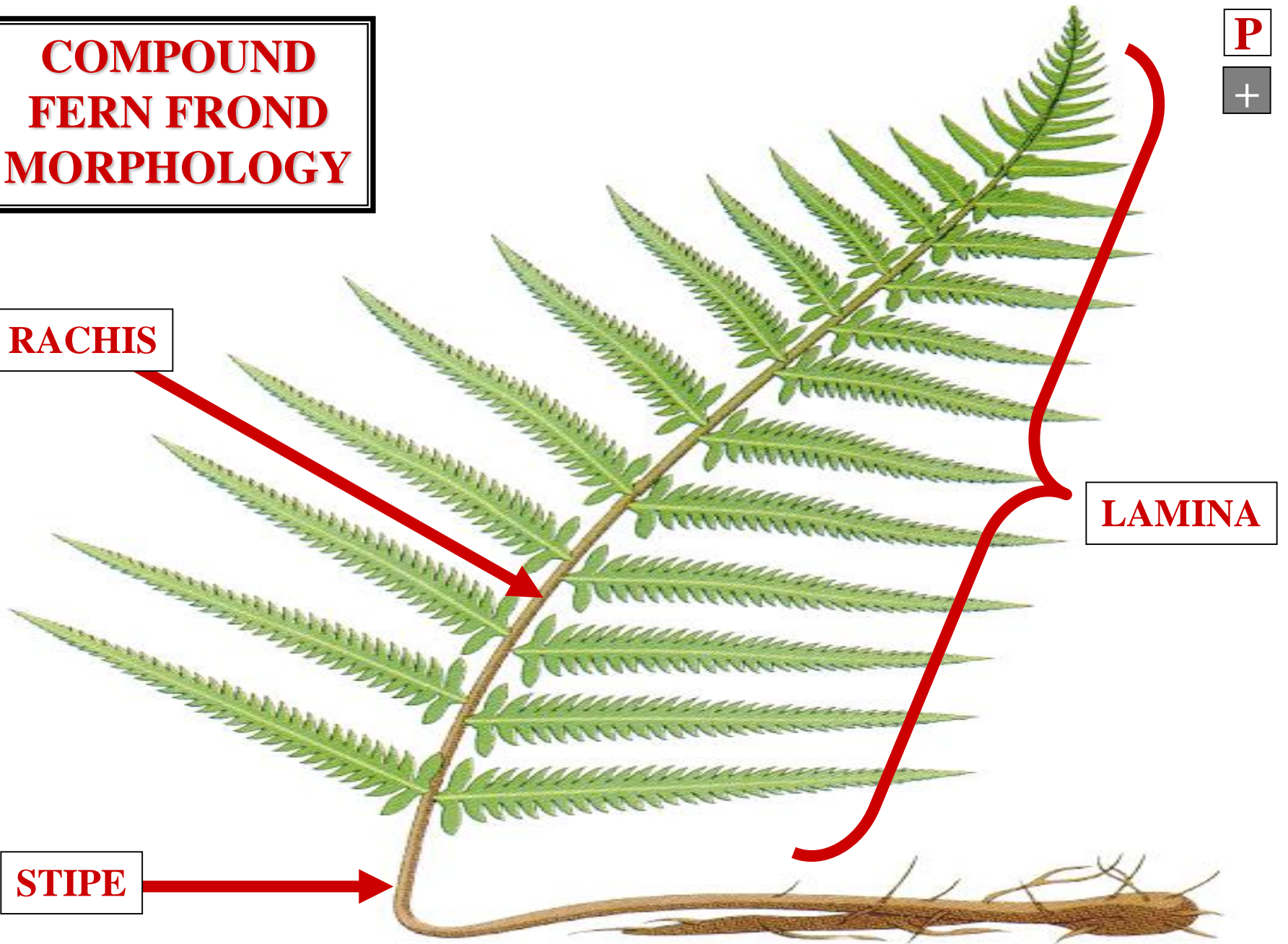
P

+

RACHIS

LAMINA

STIPE



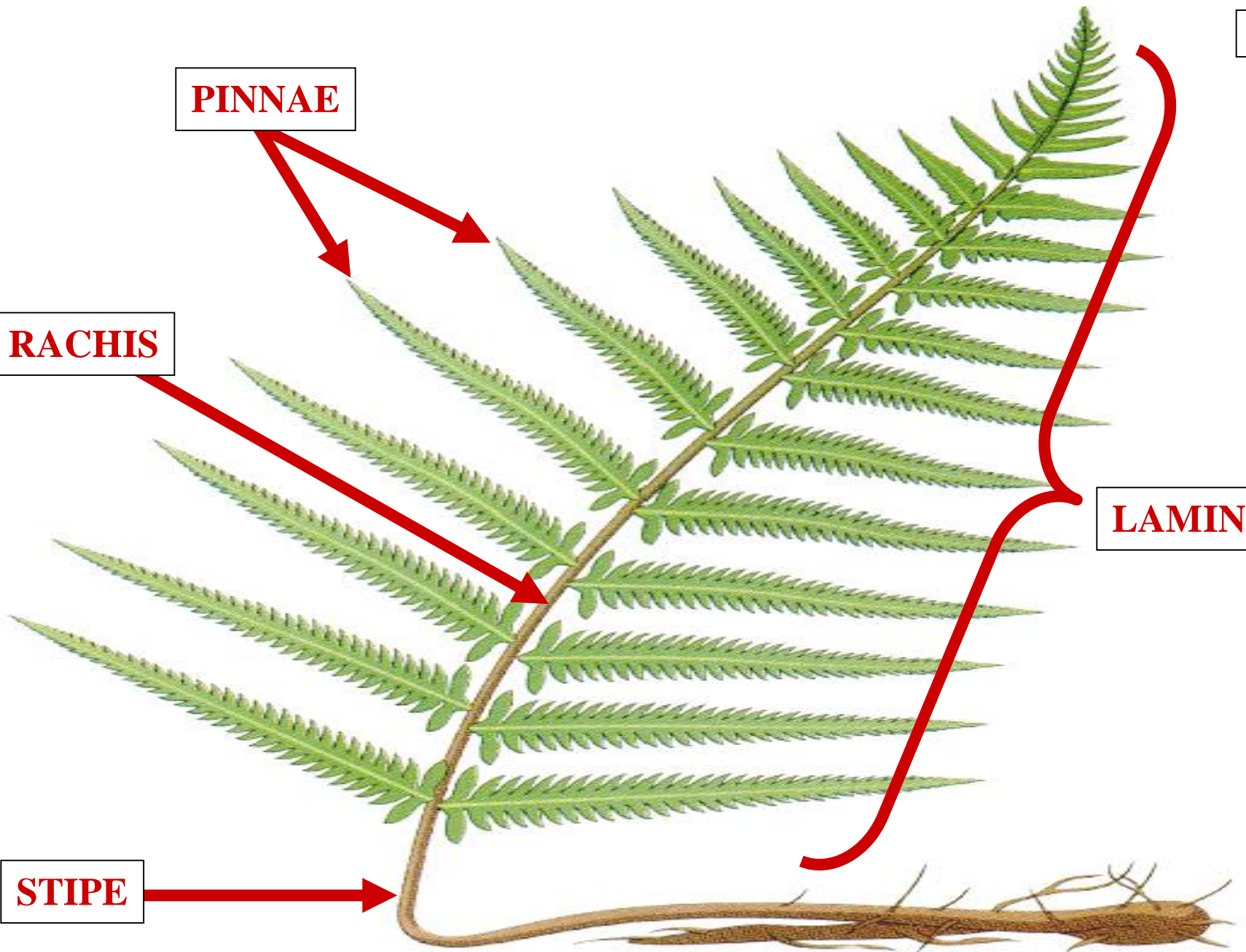
**P**

**PINNAE**

**RACHIS**

**LAMINA**

**STIPE**



**PINNAE**

# COMPOUND FROND PINNAE



FROND  
LEAFLETS

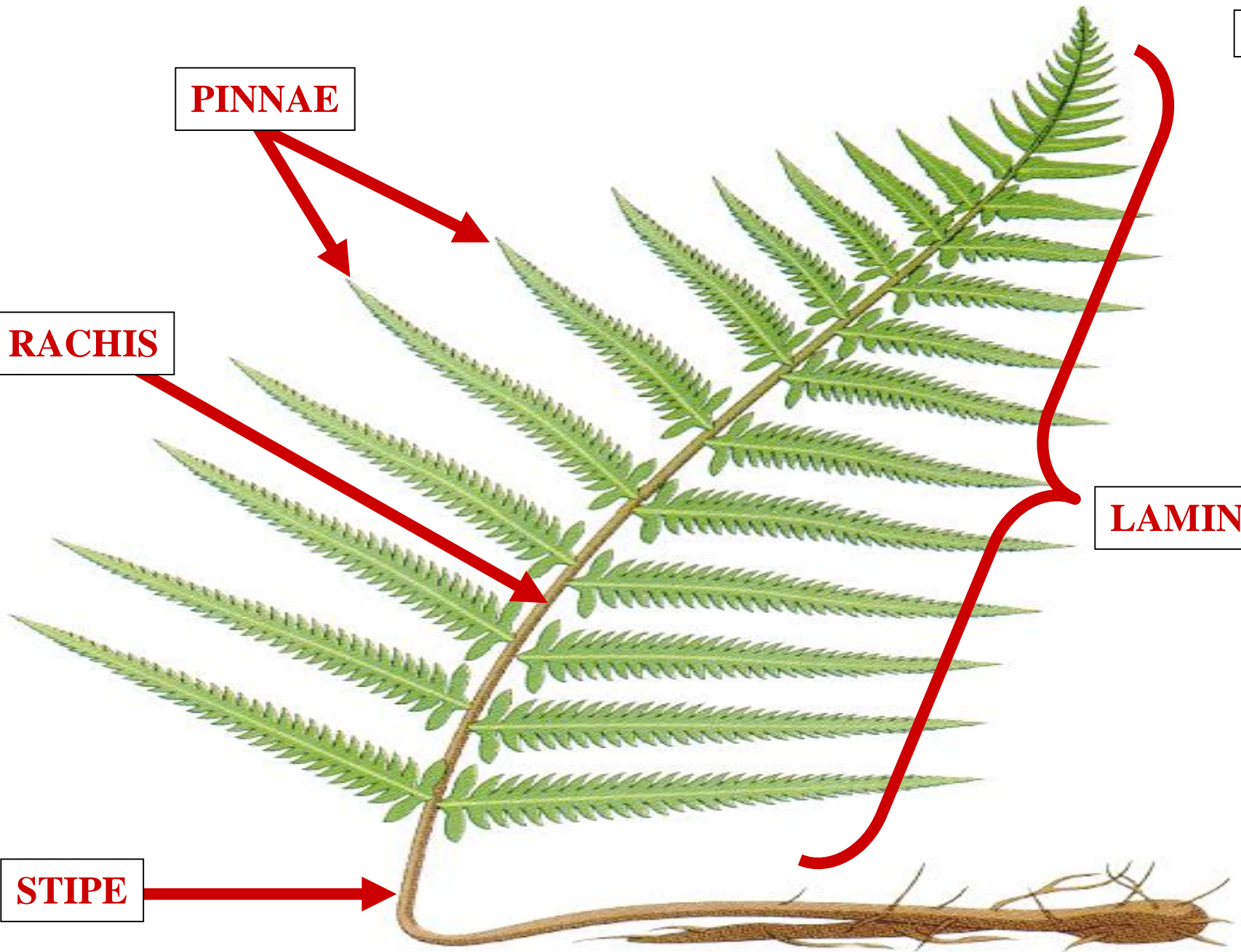
COMPOUND FROND  
PINNAE

**PINNAE**

**RACHIS**

**LAMINA**

**STIPE**



**SUBRACHNIS**

# COMPOUND FROND SUBRACHIS

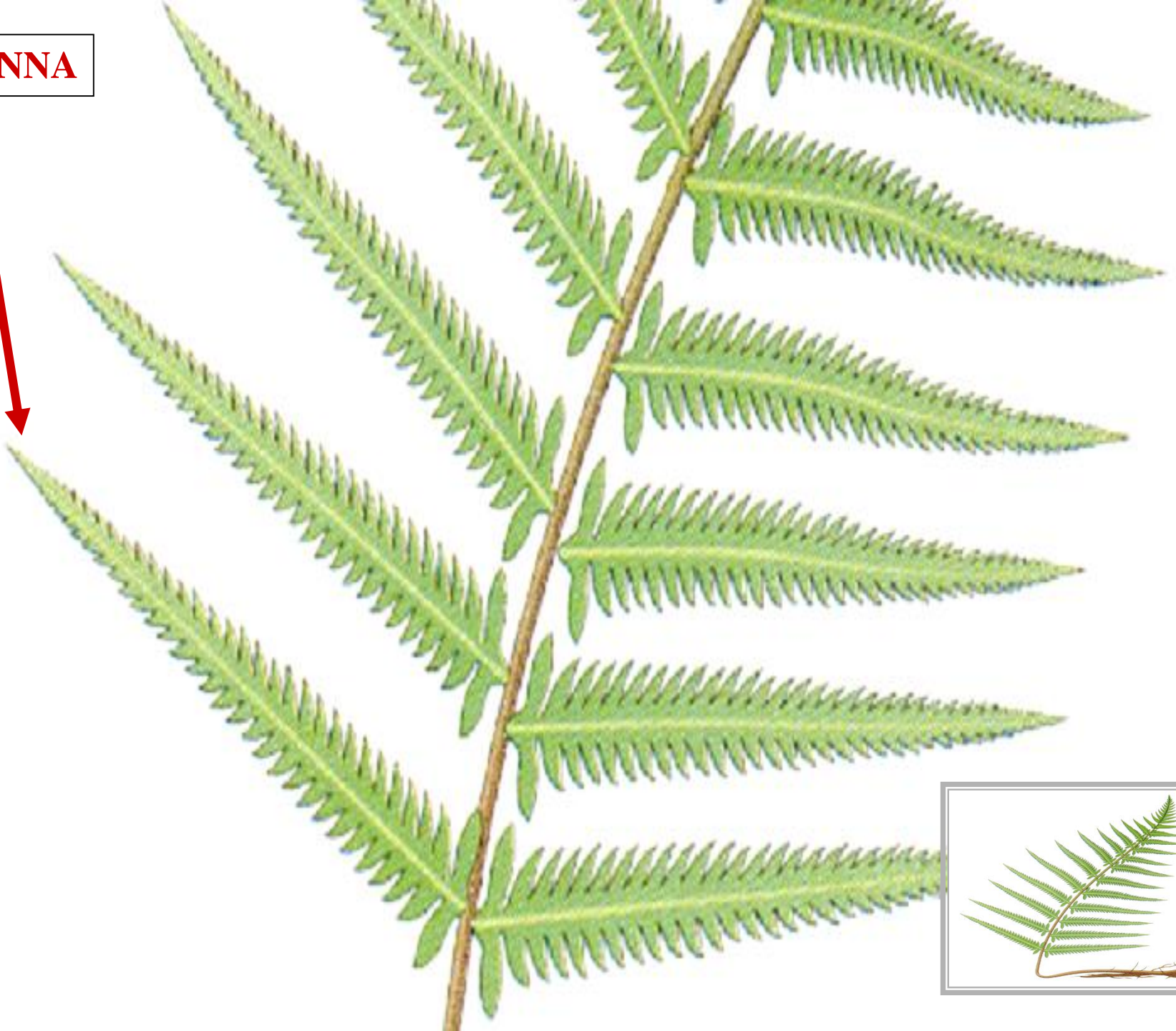


BEARS PINNULES

# COMPOUND FROND SUBRACHIS



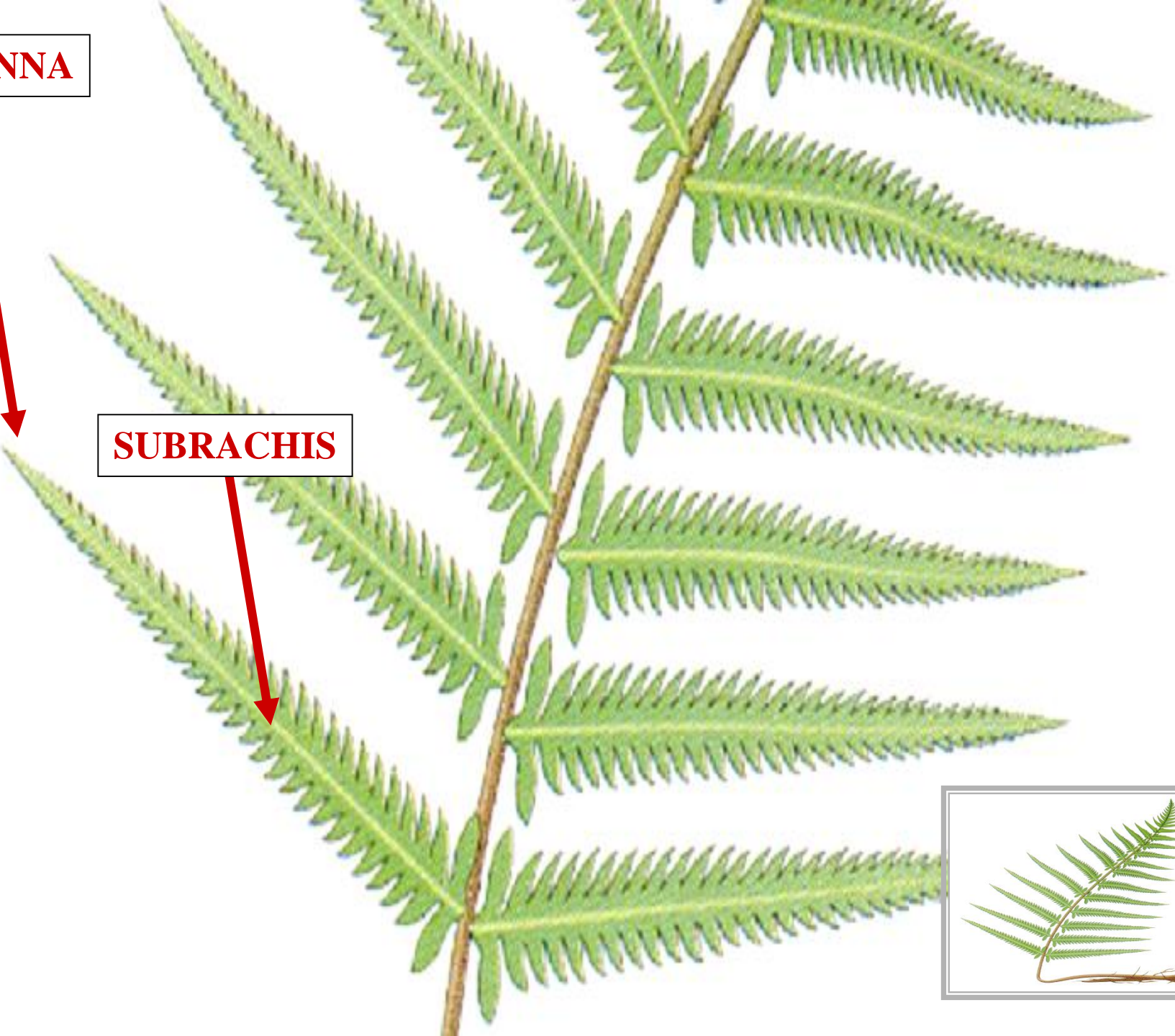
**PINNA**



**PINNA**



**SUBRACHIS**



**PINNA**



**SUBRACHIS**



**PINNULES**



**PINNULES**

# COMPOUND FROND PINNULES



FROND  
SUBLEAFLETS

COMPOUND FROND  
PINNULES



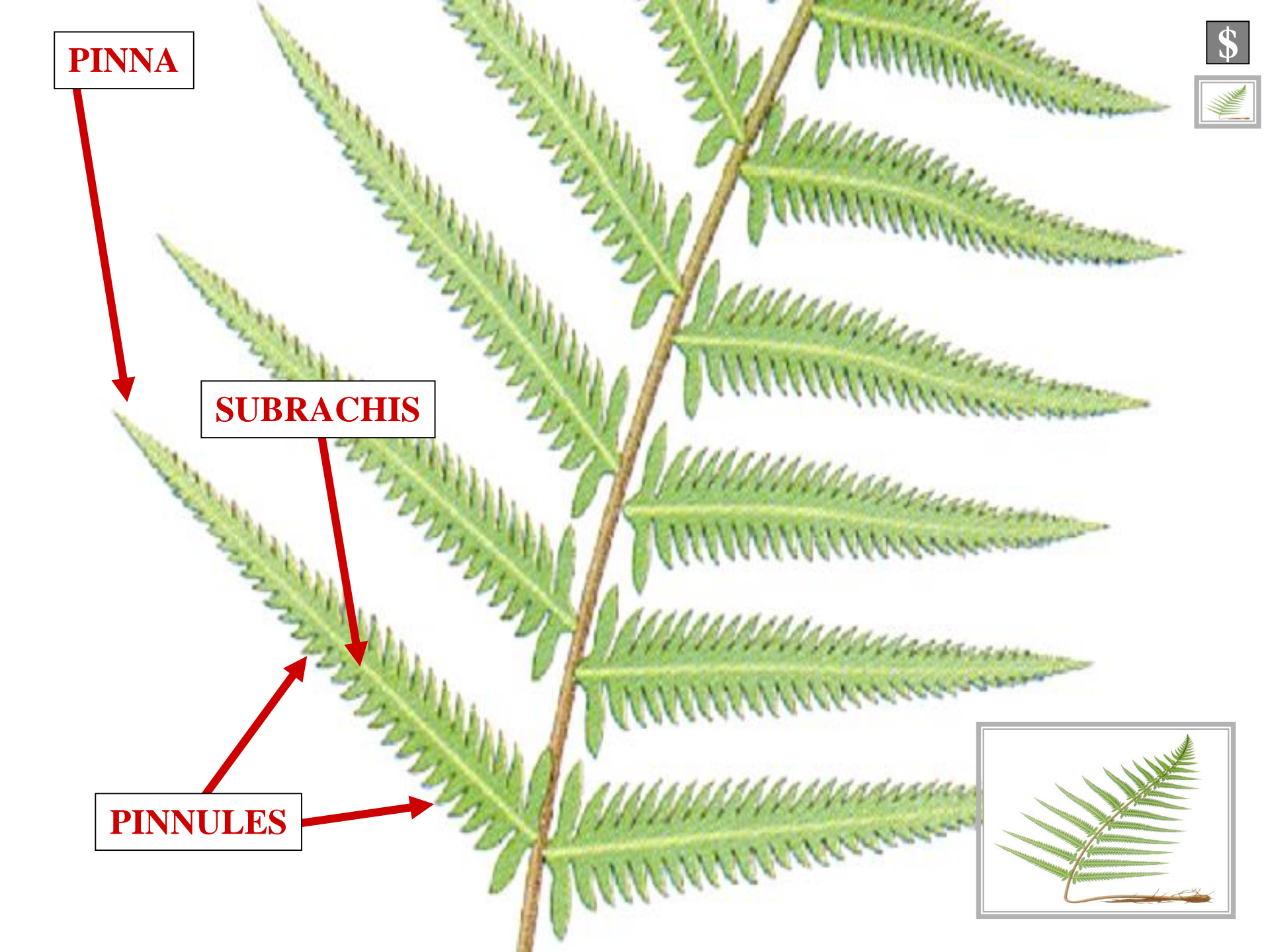
**PINNA**



**SUBRACHIS**



**PINNULES**



**COMPOUND  
FERN FROND  
MORPHOLOGY**



# COMPOUND FROND TYPES



# COMPOUND FROND TYPES

ONCE PINNATE

# COMPOUND FROND TYPES

# COMPOUND FROND TYPES

0

ONCE PINNATE  
TWICE PINNATE

COMPOUND FROND  
TYPES

**ONCE PINNATE  
COMPOUND  
FROND**

**COMPOUND FROND  
ONCE PINNATE**



**COMPOUND FROND  
BEARS  
PINNAE ONLY**

**COMPOUND FROND  
ONCE PINNATE**