

**HIGHLY  
TAPPED  
END WALL**

**LESS  
TAPPED  
END WALL**

?

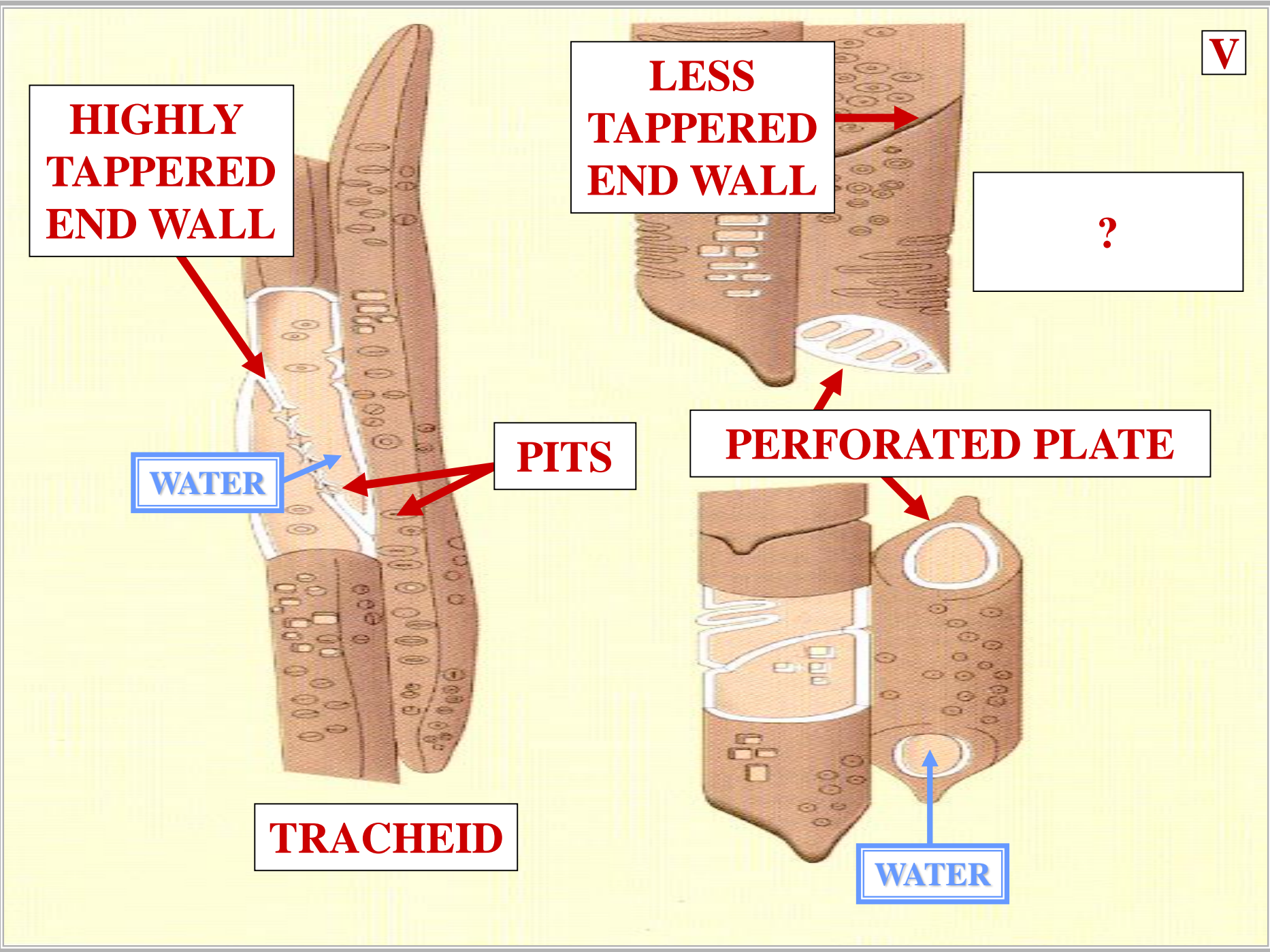
**WATER**

**PITS**

**PERFORATED PLATE**

**TRACHEID**

**WATER**





**HIGHLY  
TAPPED  
END WALL**

**LESS  
TAPPED  
END WALL**

**VESSEL  
MEMBER**

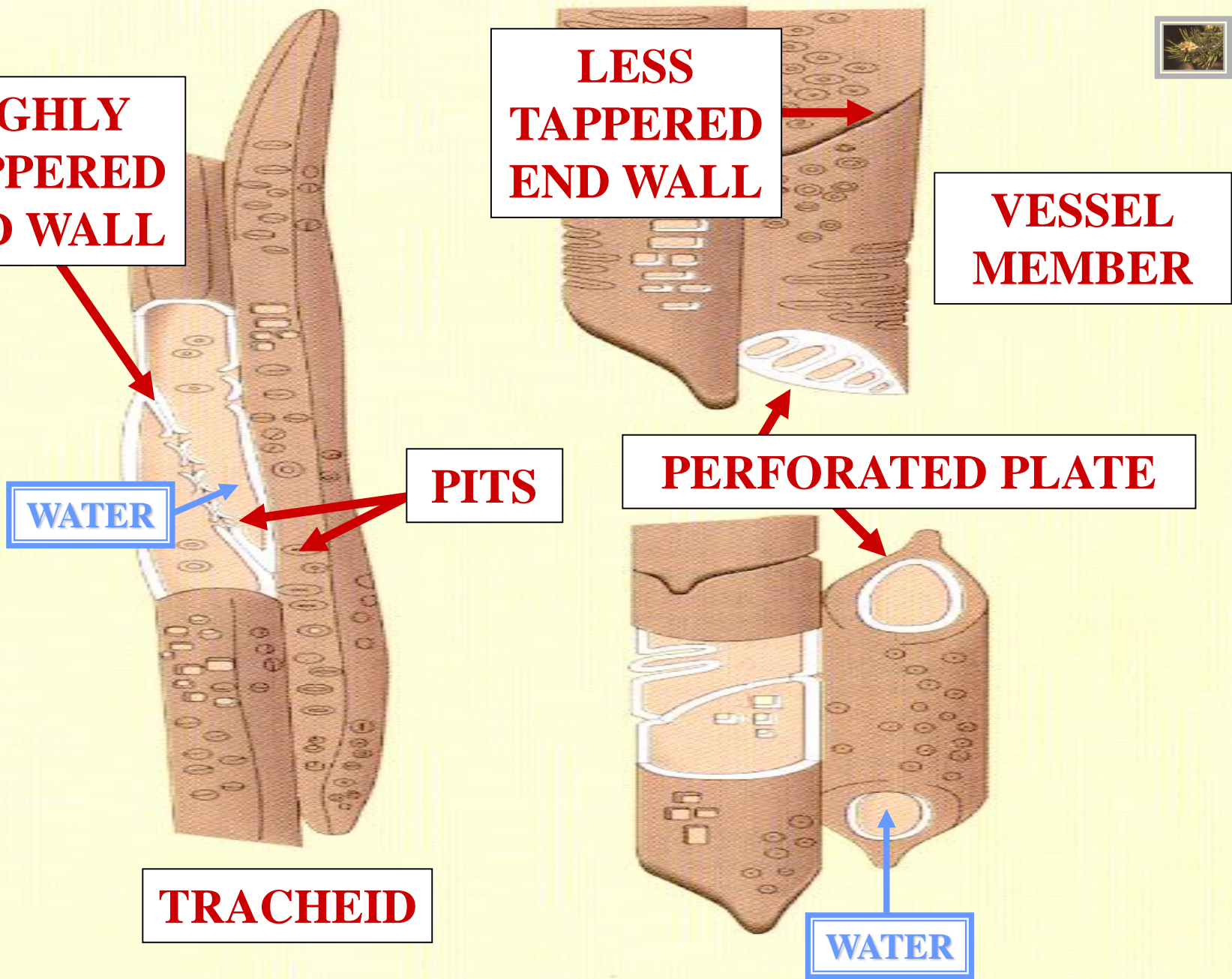
**WATER**

**PITS**

**PERFORATED PLATE**

**TRACHEID**

**WATER**





**GYMNOSPERMS**



**TRACHEIDS**

**GYMNOSPERMS**



# PHLOEM

**NUCLEUS**

**SE**

**SUGAR**

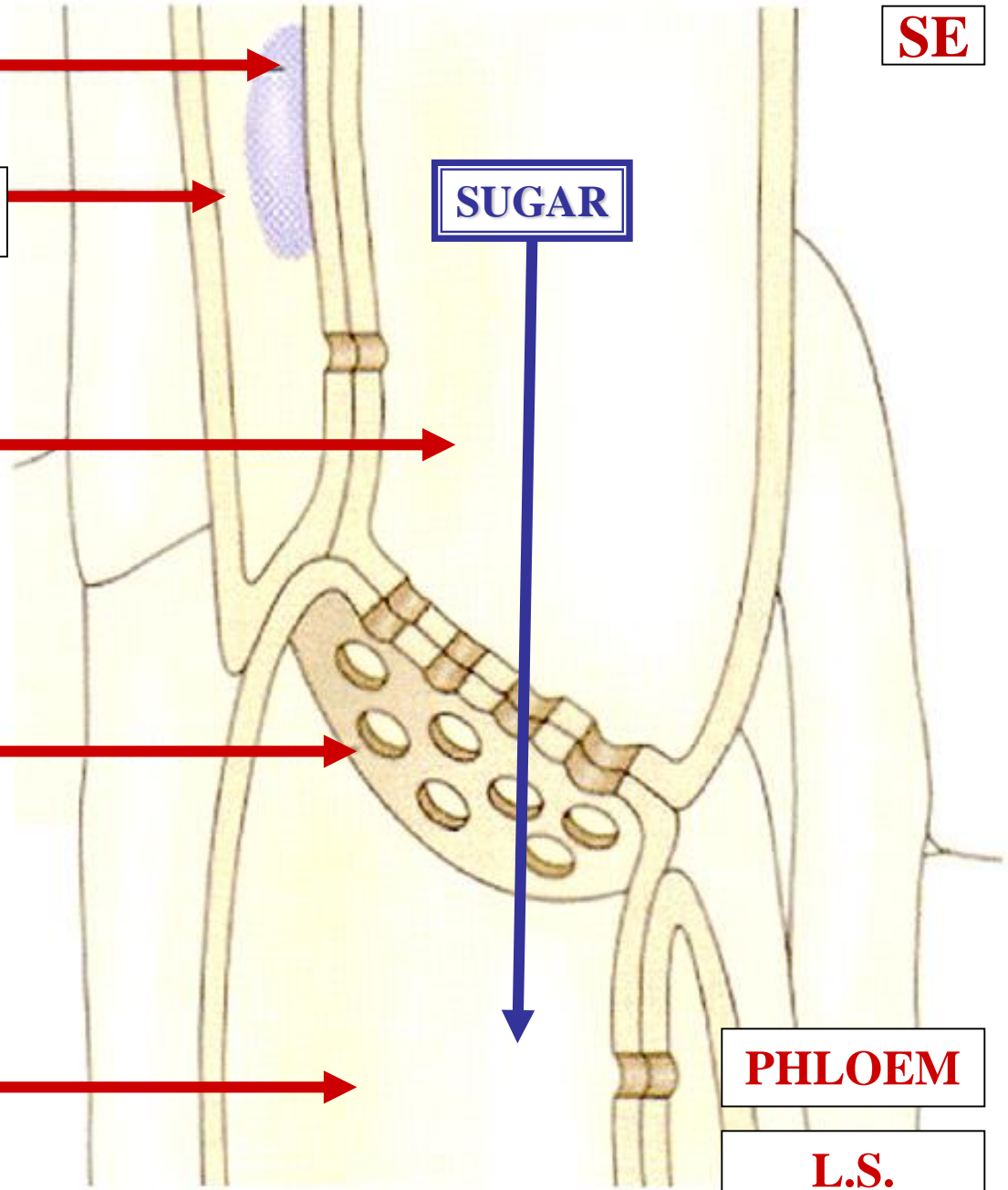
**PHLOEM CELL**

**END WALL**

**PHLOEM CELL**

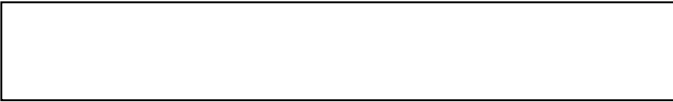
**PHLOEM**

**L.S.**



?

**NUCLEUS**



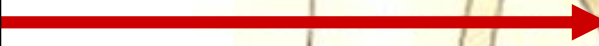
**SUGAR**



**SIEVE ELEMENTS**



**END WALL**

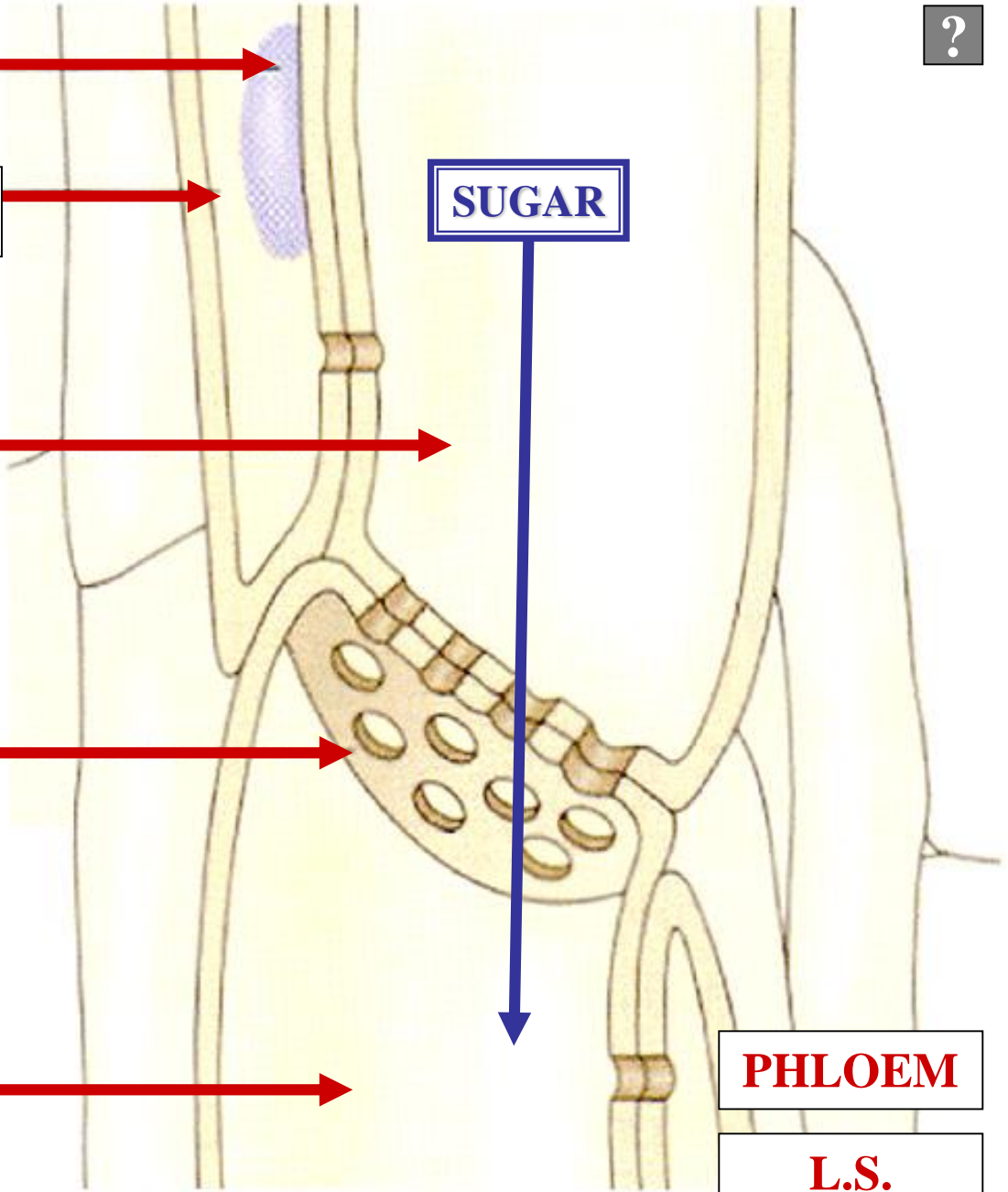


**SIEVE ELEMENTS**



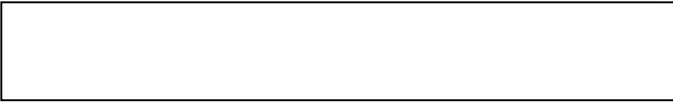
**PHLOEM**

**L.S.**



**S**

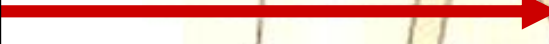
**NUCLEUS**



**SUGAR**

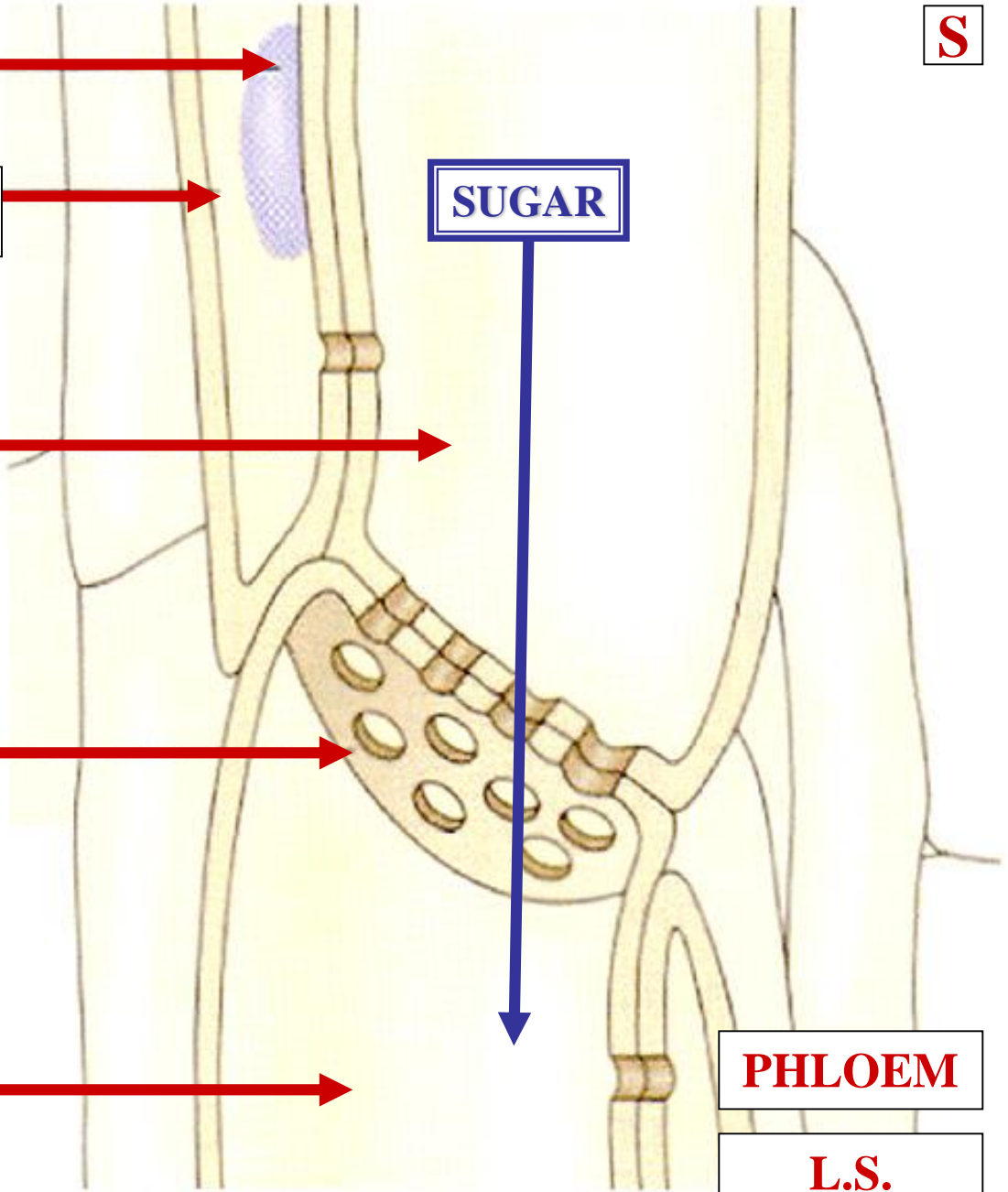


**SIEVE AREA  
SMALL PORES**



**PHLOEM**

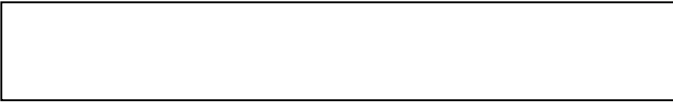
**L.S.**







**NUCLEUS**



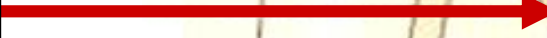
**SUGAR**



**SIEVE CELL**



**SIEVE AREA  
SMALL PORES**

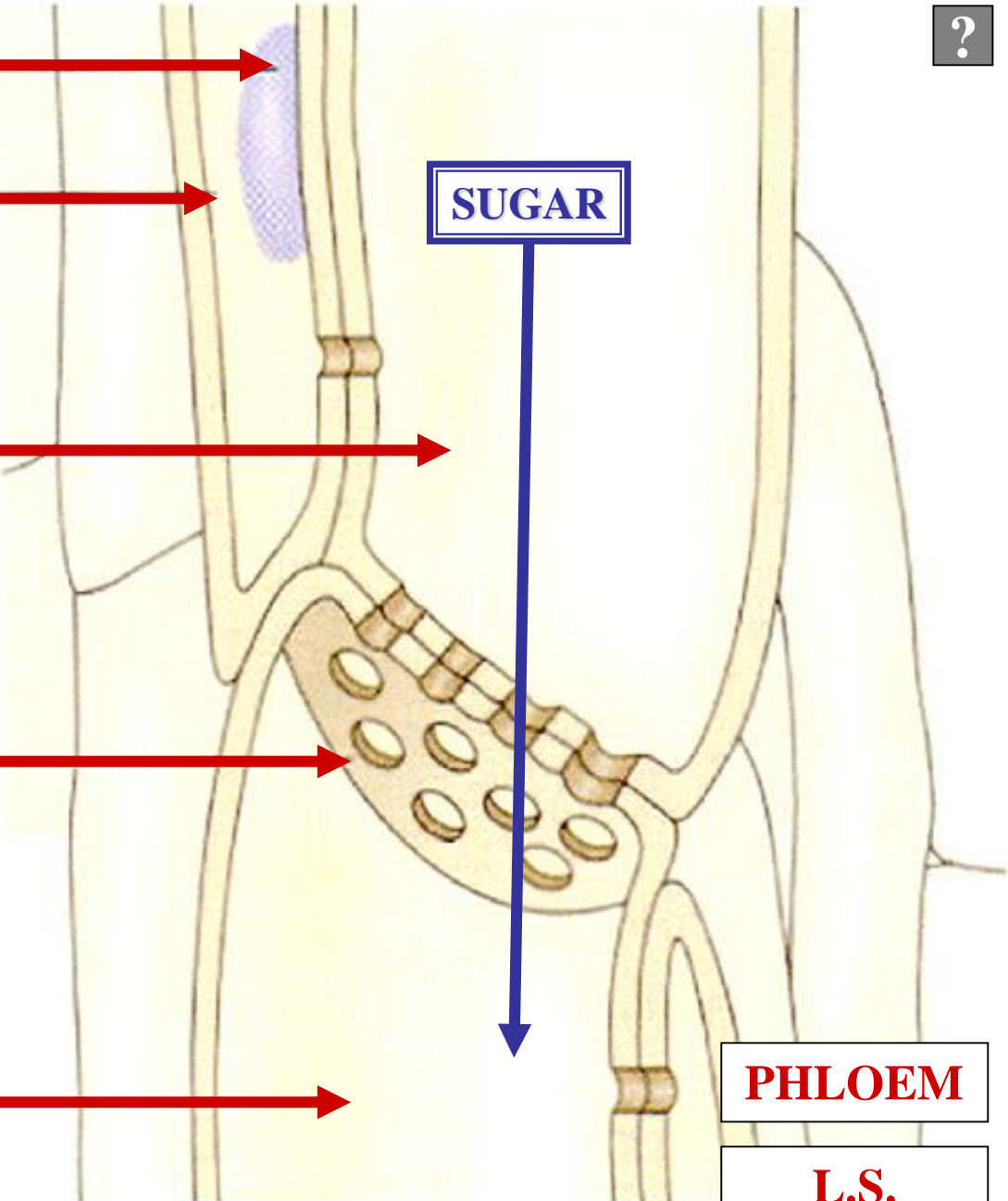


**SIEVE CELL**



**PHLOEM**

**L.S.**

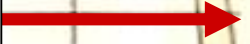


**A**

**NUCLEUS**



**?**



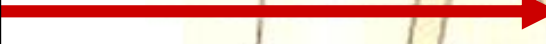
**SUGAR**



**SIEVE CELL**



**SIEVE AREA  
SMALL PORES**

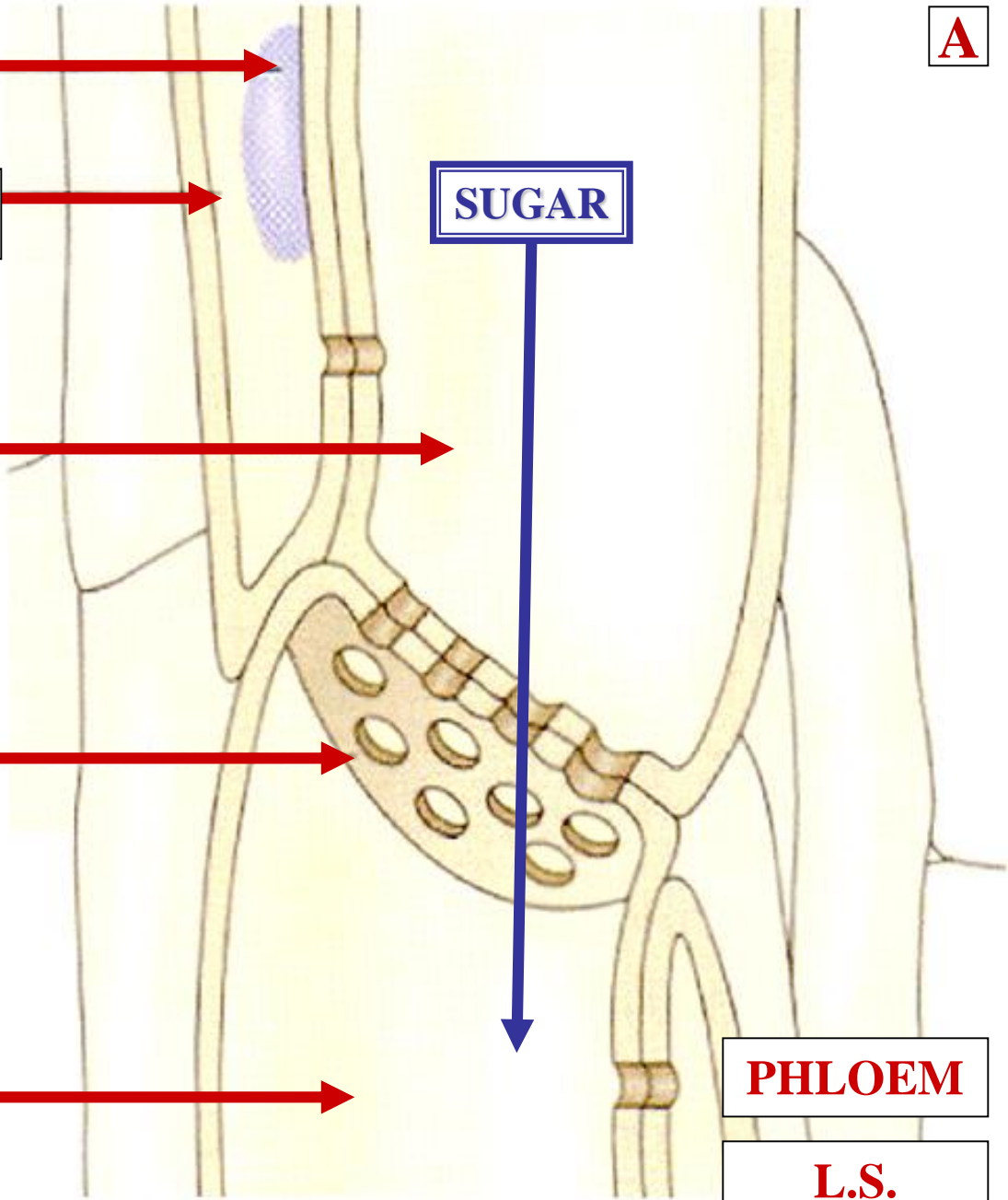


**SIEVE CELL**



**PHLOEM**

**L.S.**





**NUCLEUS**



**ALBUMINOUS CELL**



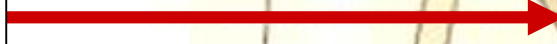
**SUGAR**



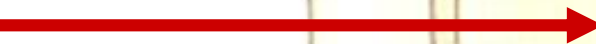
**SIEVE CELL**



**SIEVE AREA  
SMALL PORES**

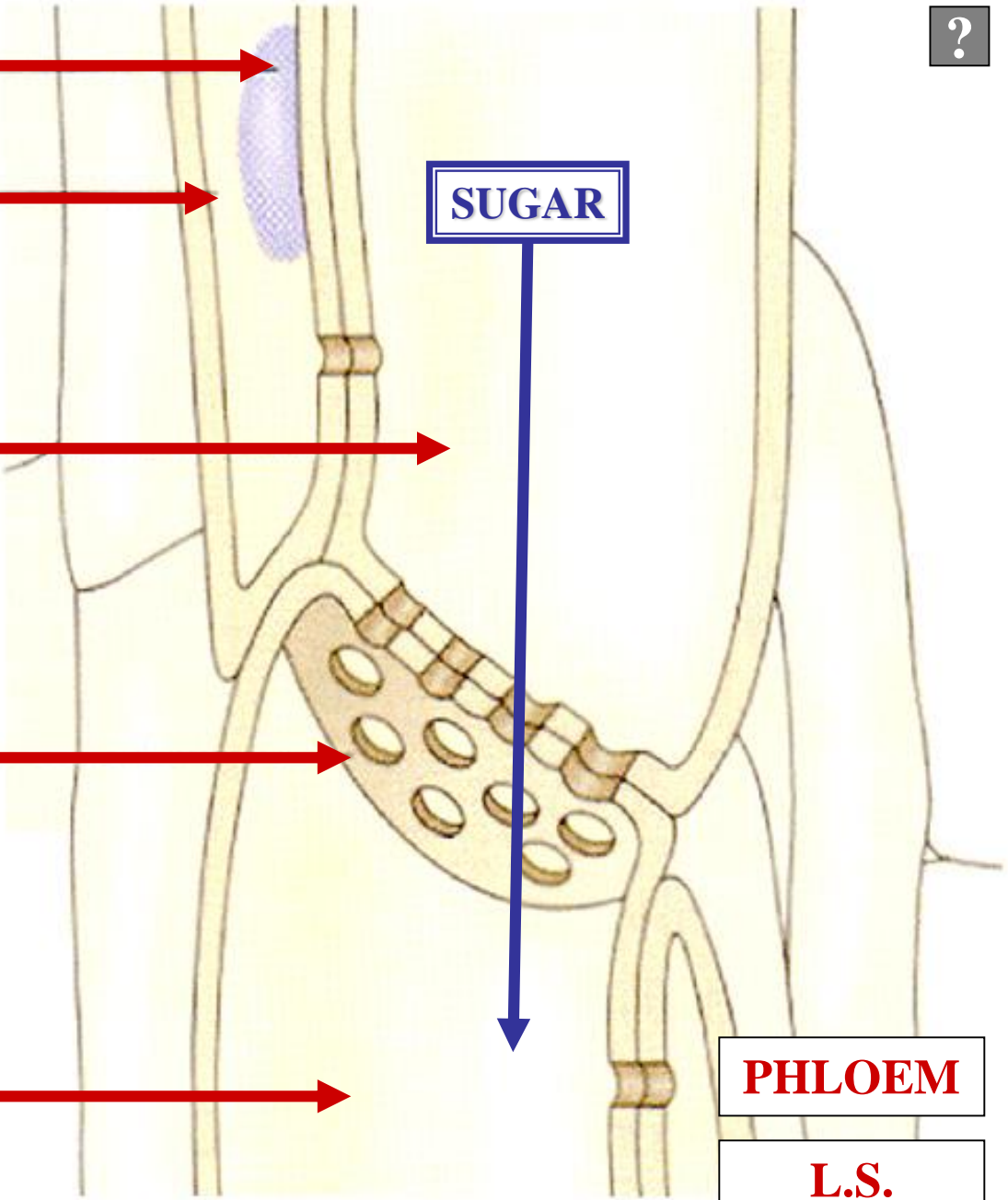


**SIEVE CELL**



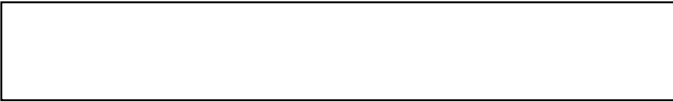
**PHLOEM**

**L.S.**



**S**

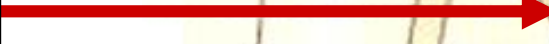
**NUCLEUS**



**SUGAR**

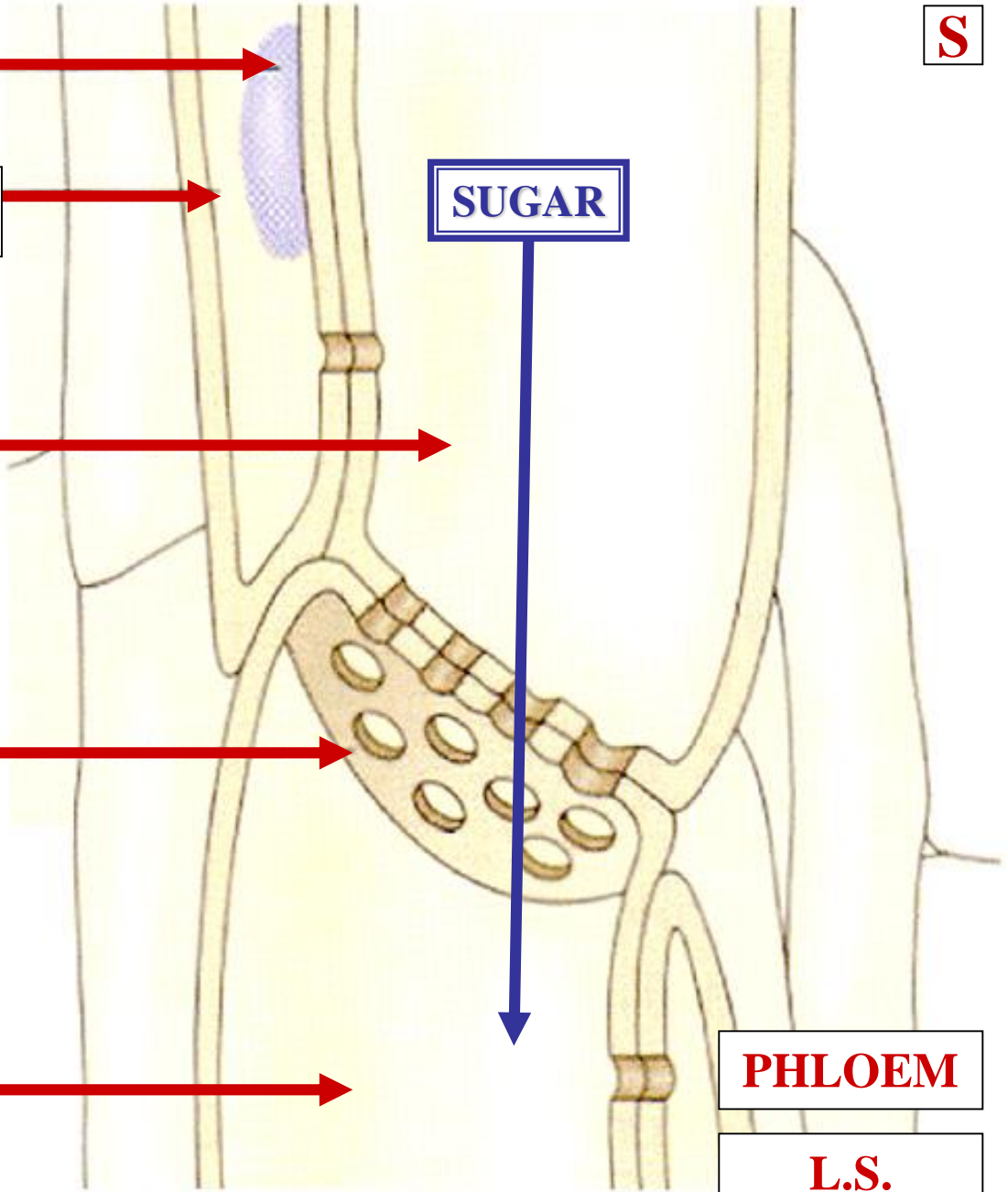


**SIEVE PLATE  
LARGE PORES**



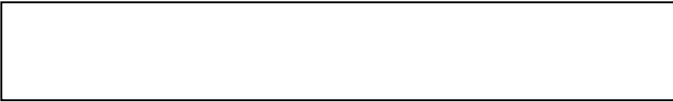
**PHLOEM**

**L.S.**





**NUCLEUS**



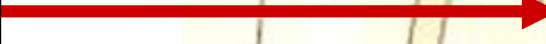
**SUGAR**



**SIEVE MEMBER**



**SIEVE PLATE  
LARGE PORES**

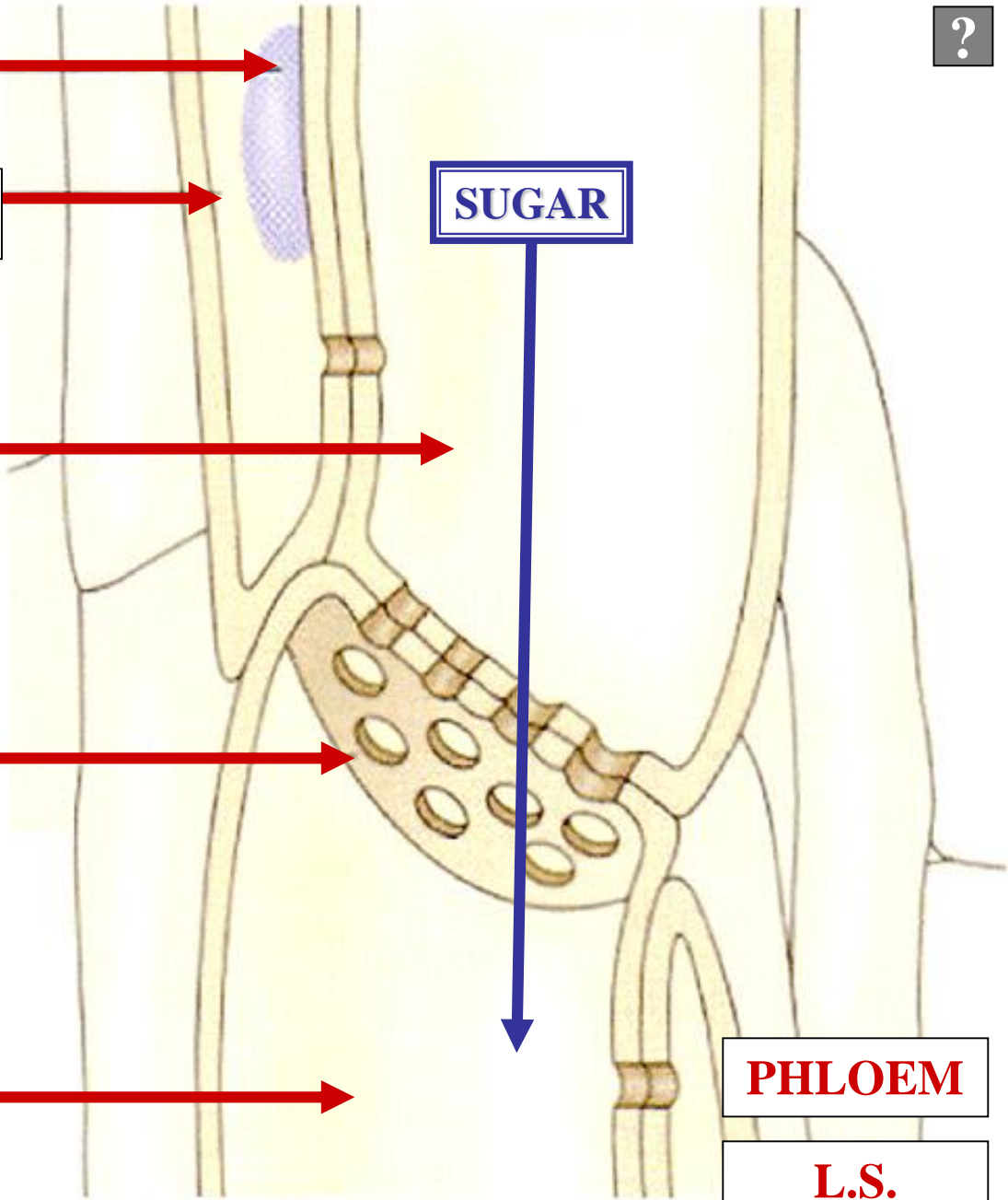


**SIEVE MEMBER**



**PHLOEM**

**L.S.**



C

**NUCLEUS**



?



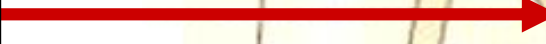
**SUGAR**



**SIEVE MEMBER**



**SIEVE PLATE  
LARGE PORES**

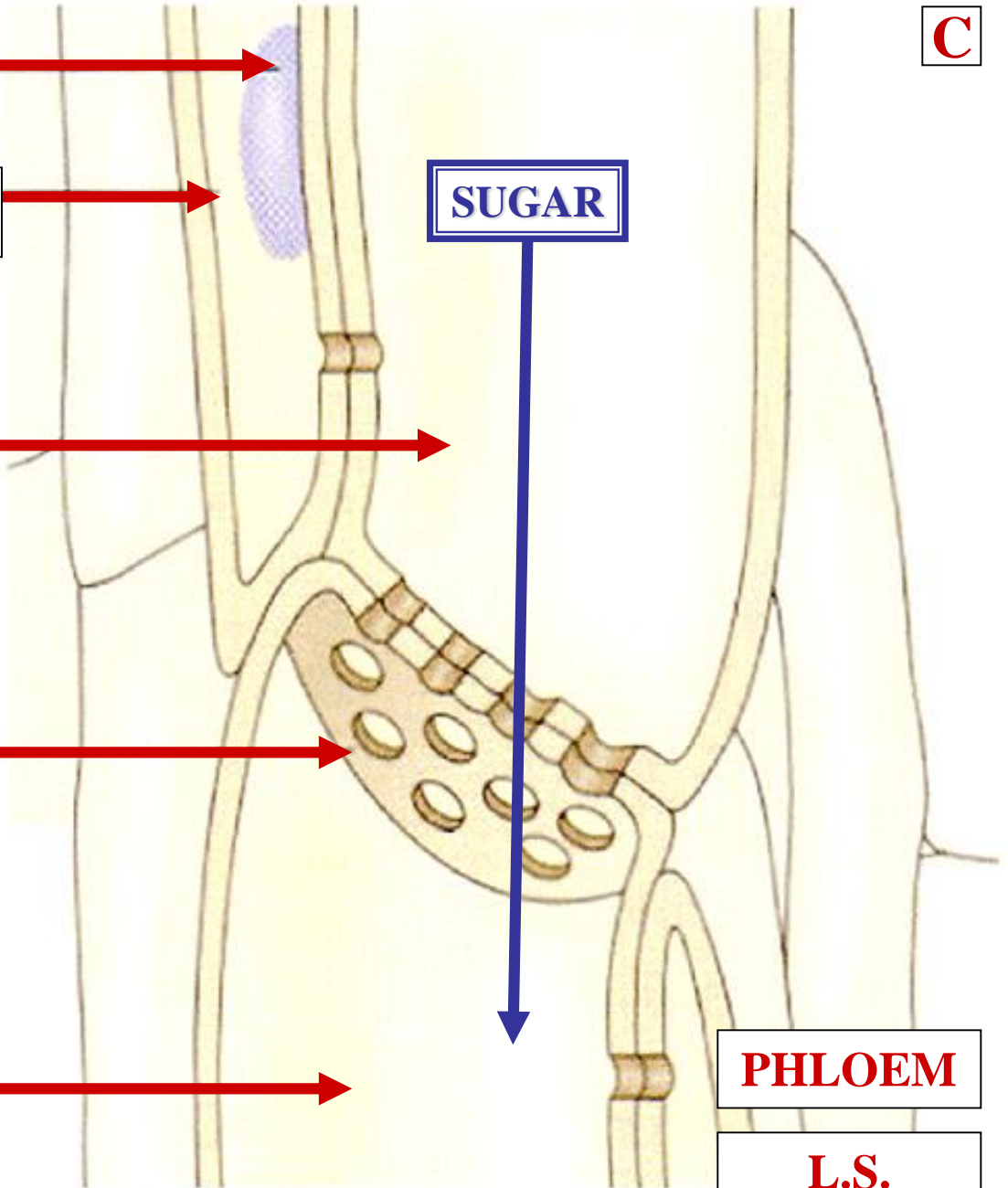


**SIEVE MEMBER**



**PHLOEM**

**L.S.**

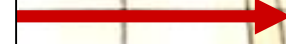




**NUCLEUS**



**CAMPANION CELL**



**SUGAR**



**SIEVE MEMBER**



**SIEVE PLATE  
LARGE PORES**

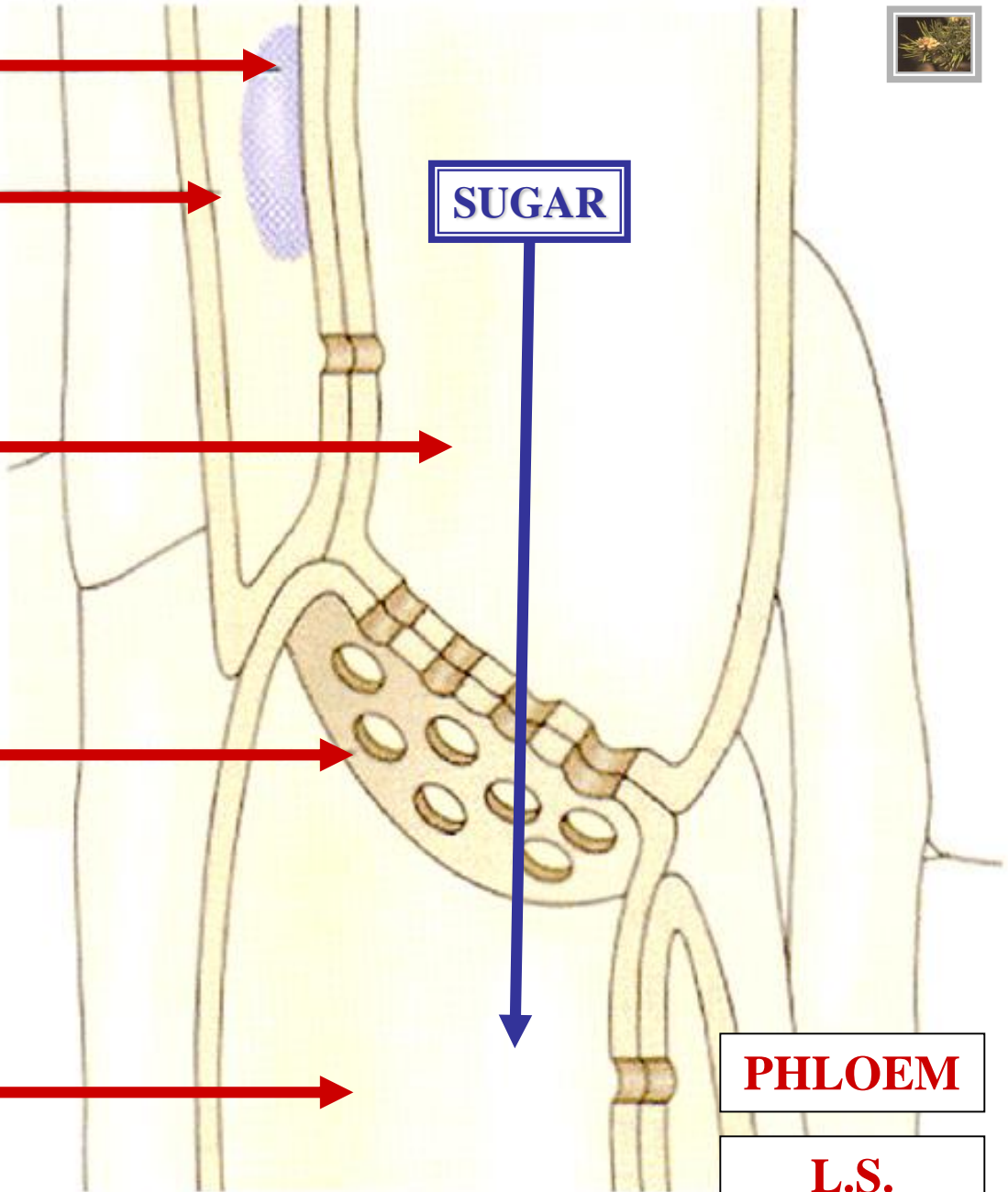


**SIEVE MEMBER**



**PHLOEM**

**L.S.**





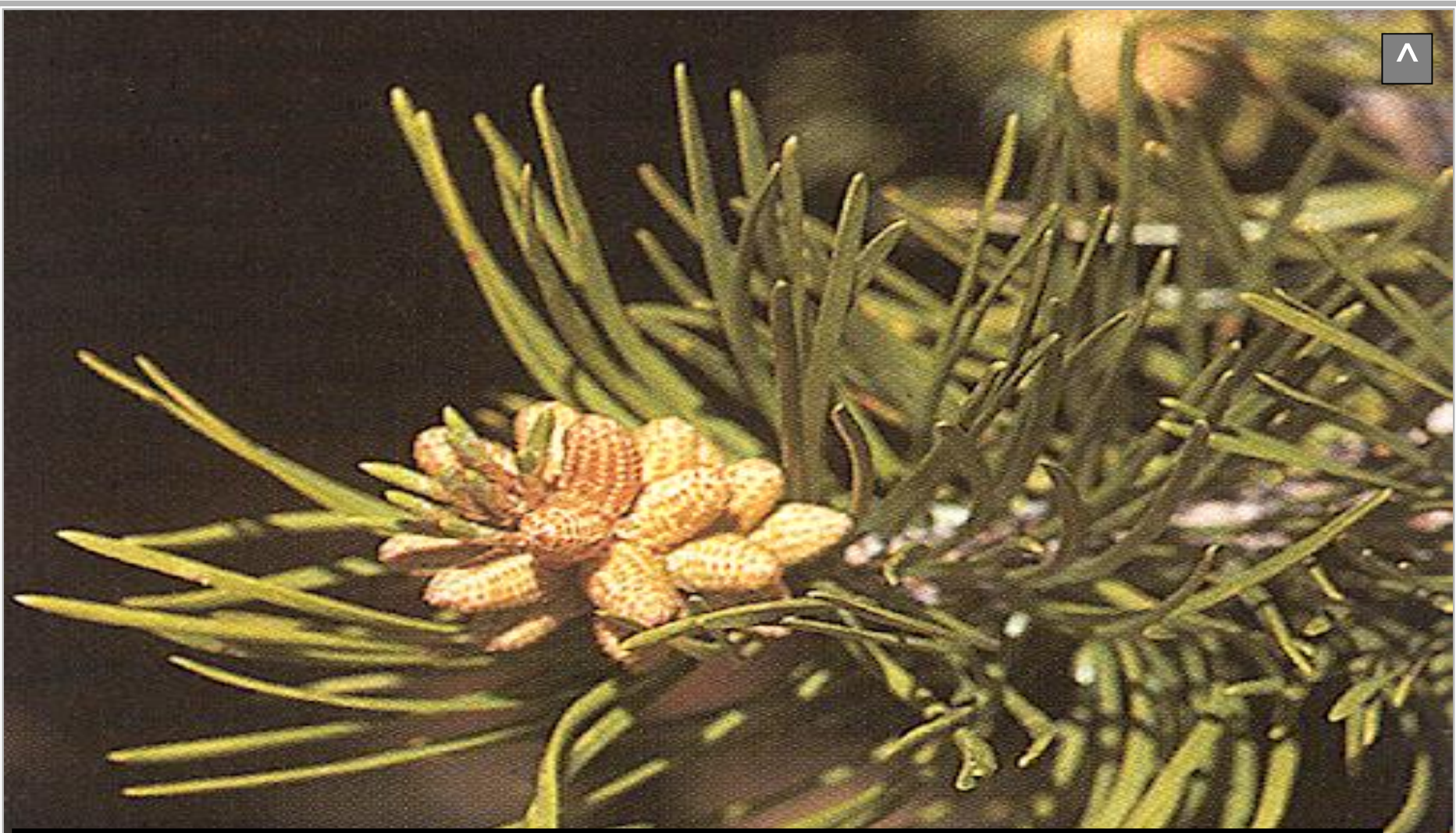
**GYMNOSPERMS**





**SIEVE CELLS**

**GYMNOSPERMS**



**SIEVE CELLS & ALBUMINOUS CELLS**

**GYMNOSPERMS**

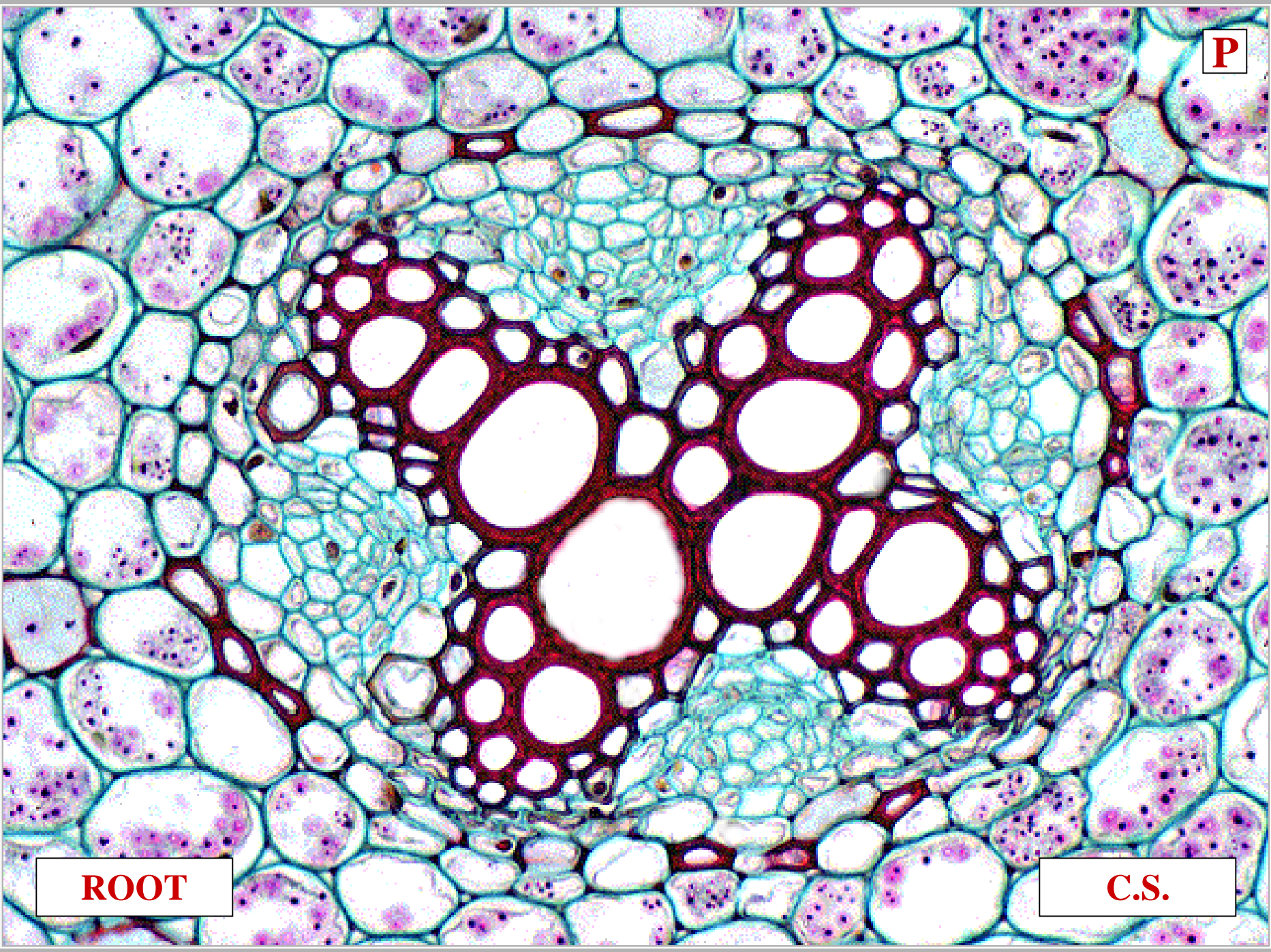


**ROOT**



# ROOT STELE

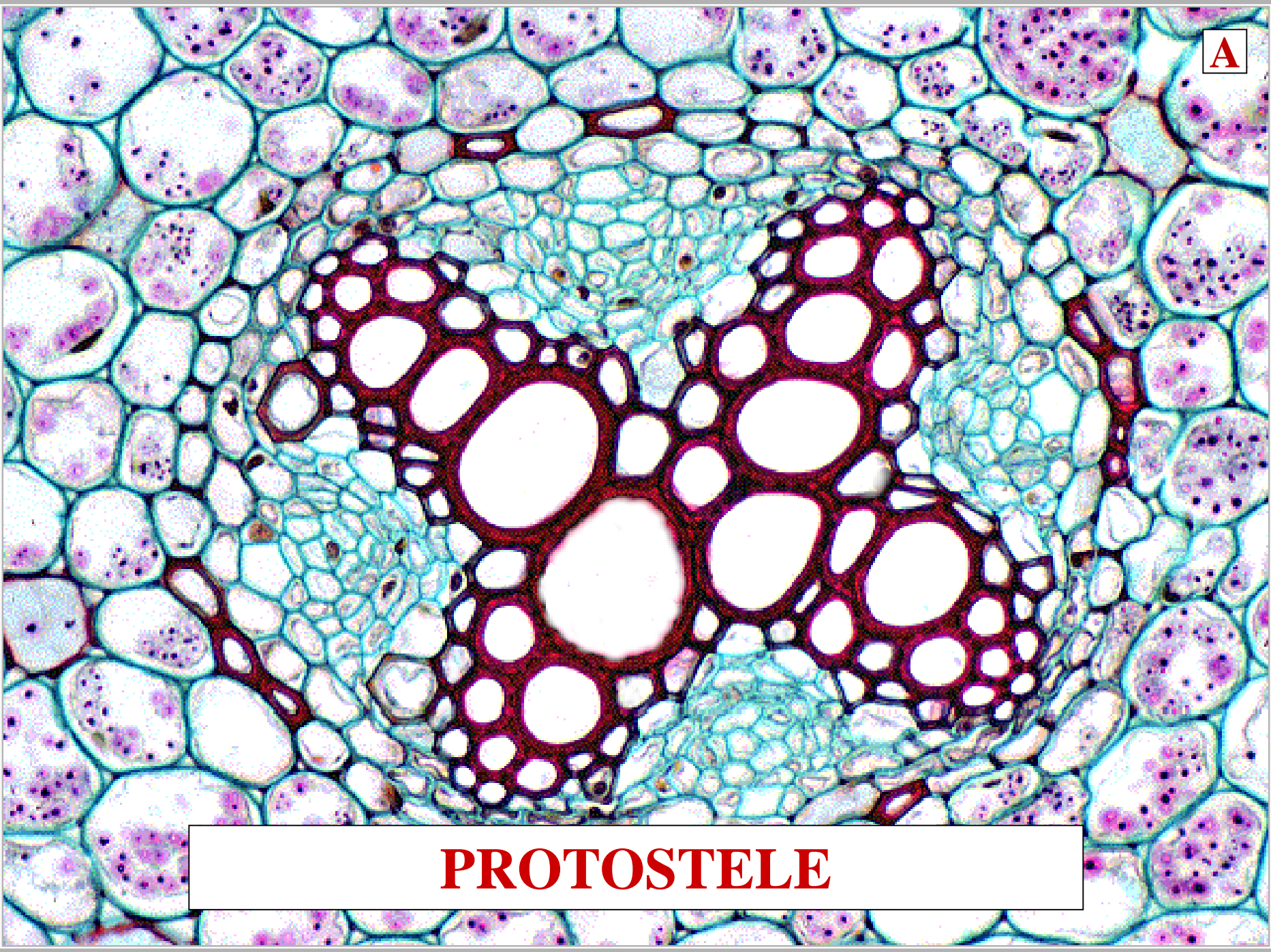
P



ROOT

C.S.

A



**PROTOSTELE**





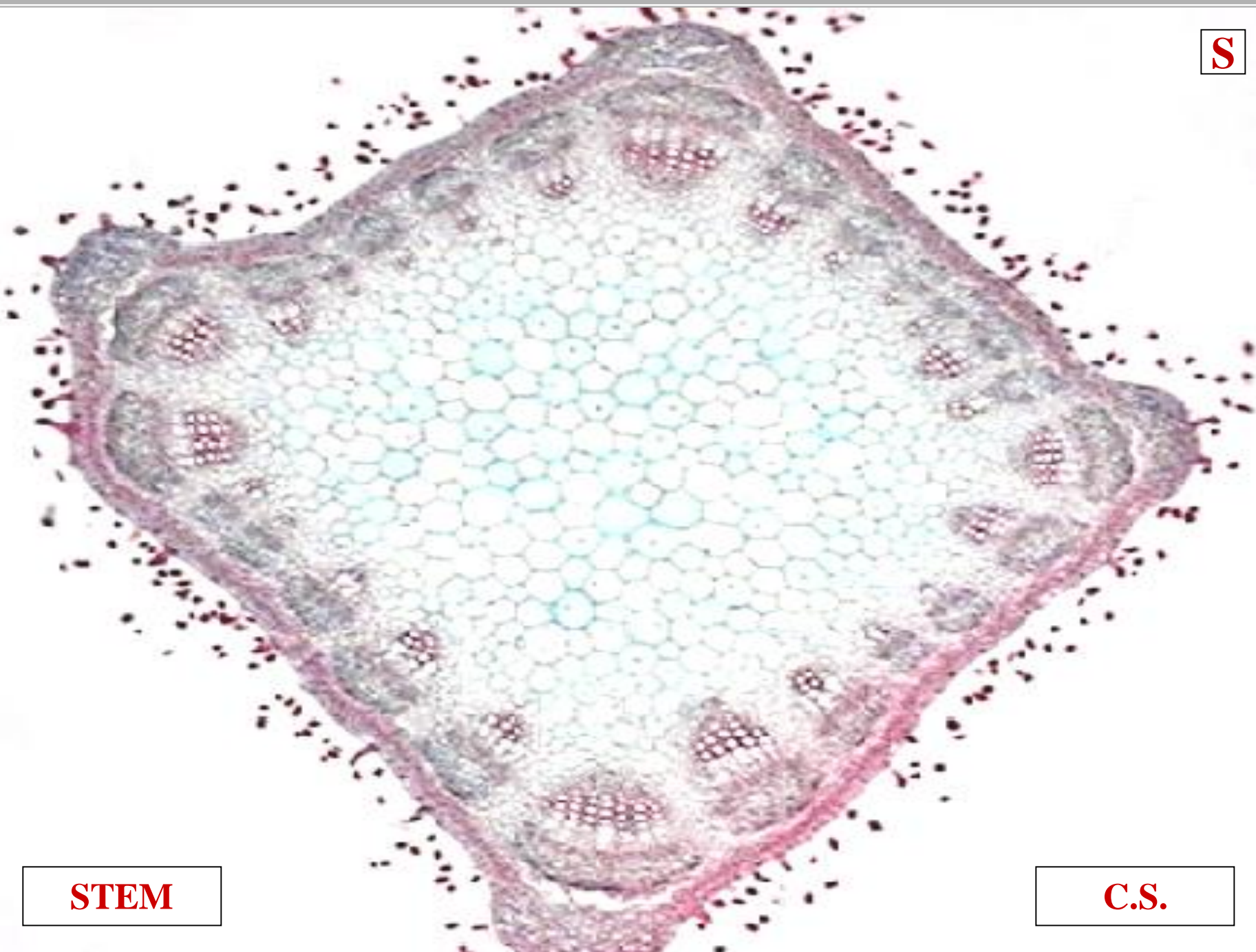
**STEM**





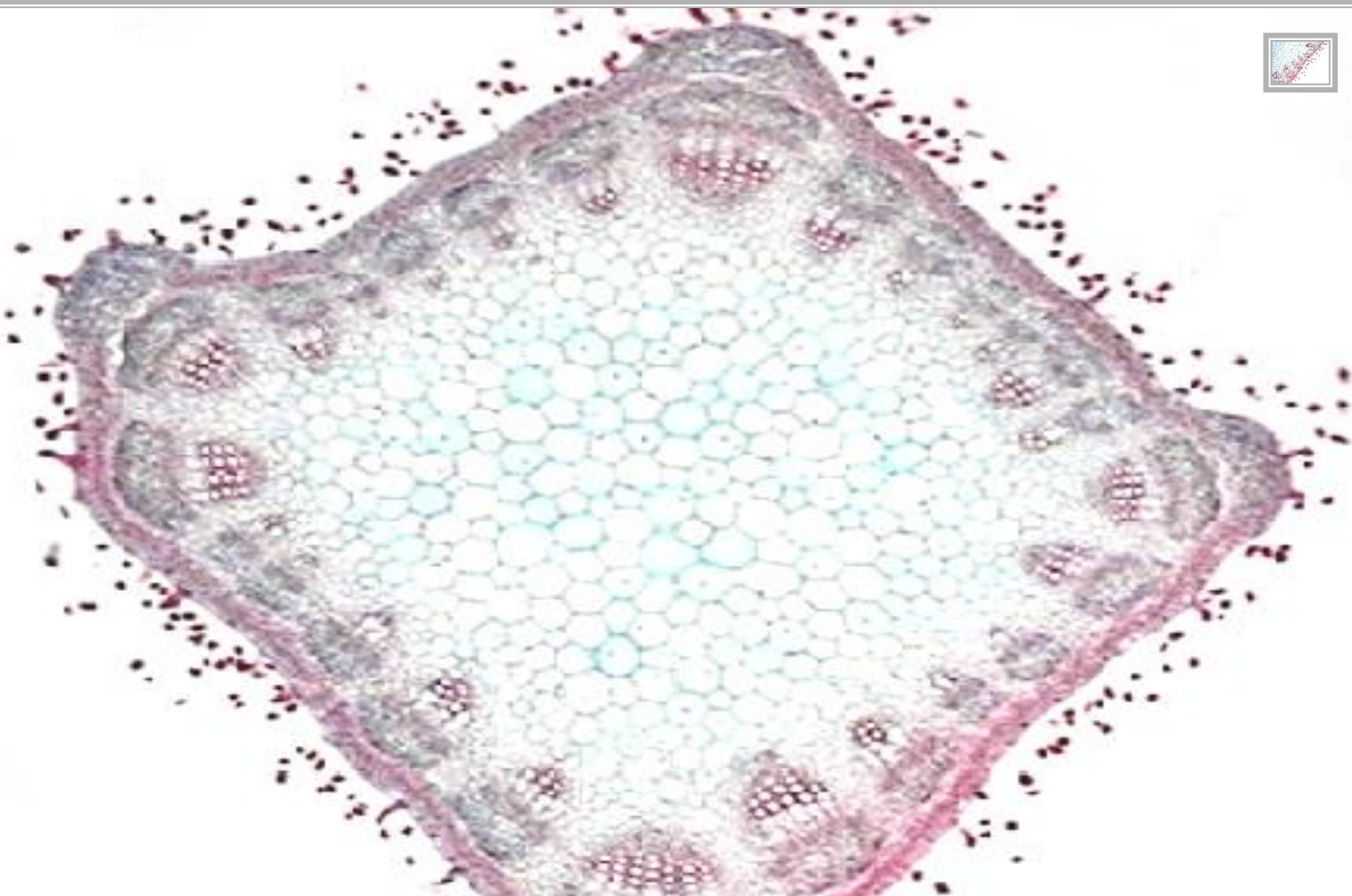
# STEM STELE

**S**



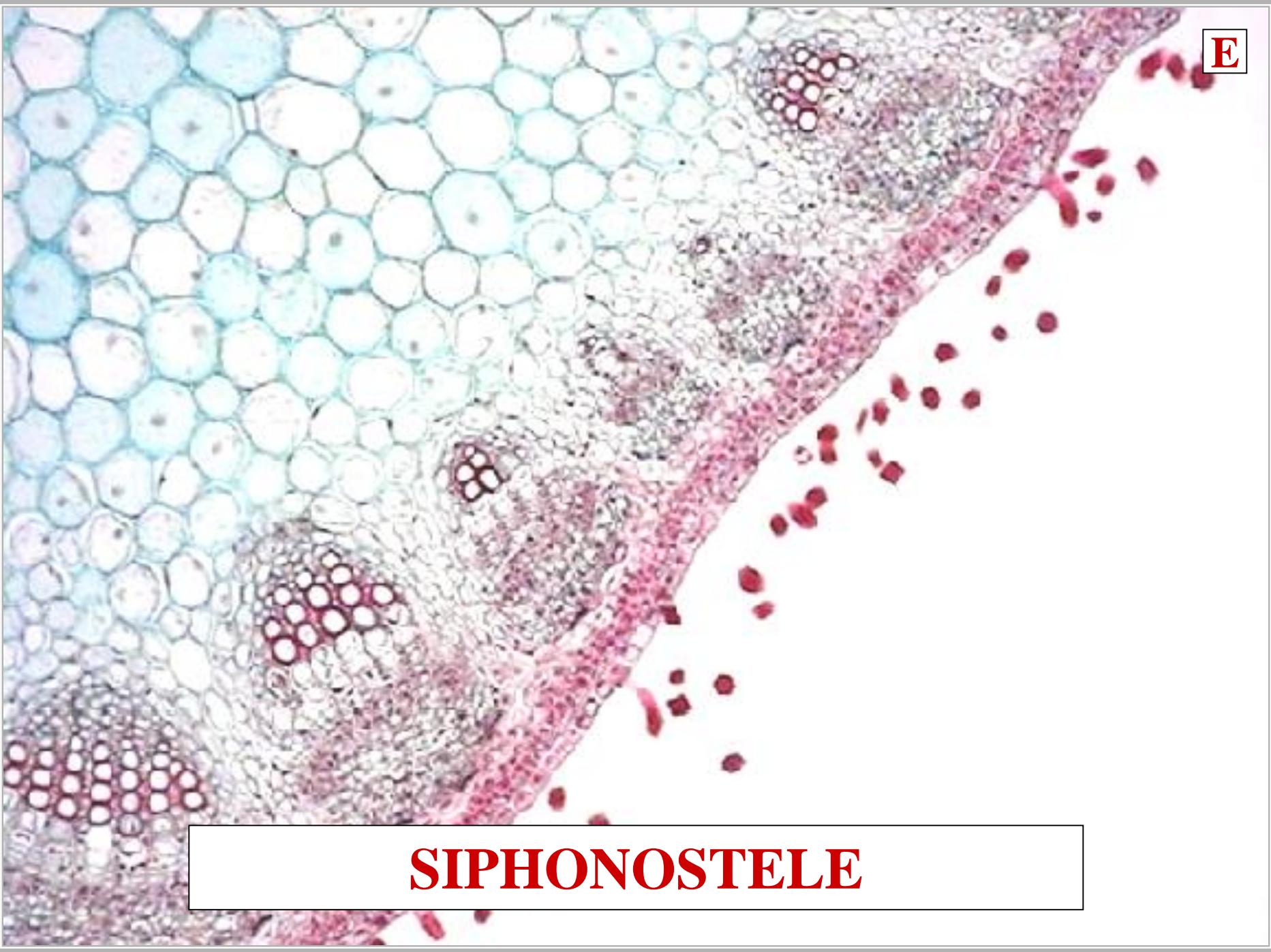
**STEM**

**C.S.**



**SIPHONOSTELE**

E



**SIPHONOSTELE**



?

VC

+

**SIPHONOSTELE / EUSTELE**

*PINUS*

RESIN DUCT

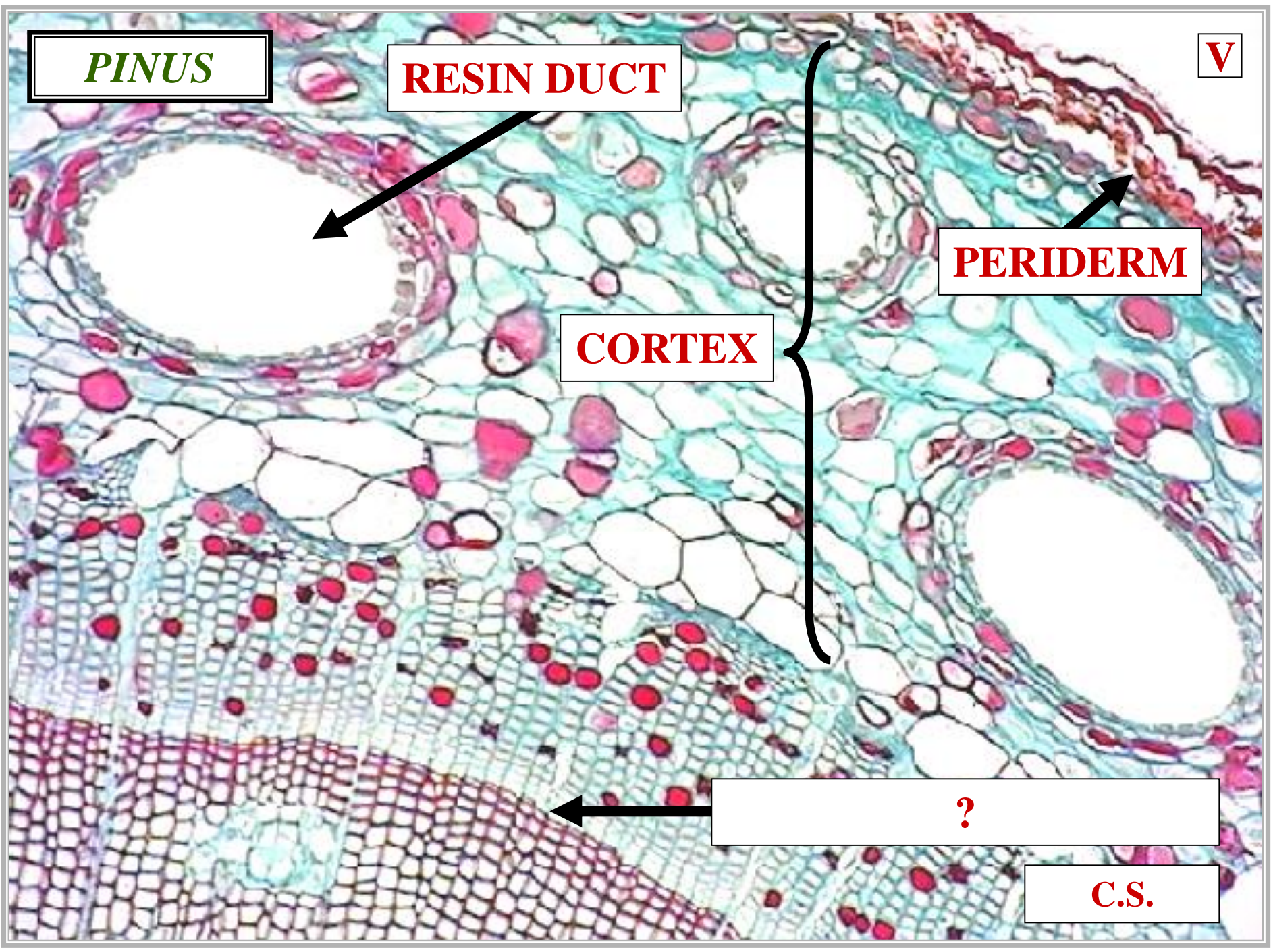
V

PERIDERM

CORTEX

?

C.S.



*PINUS*

**RESIN DUCT**

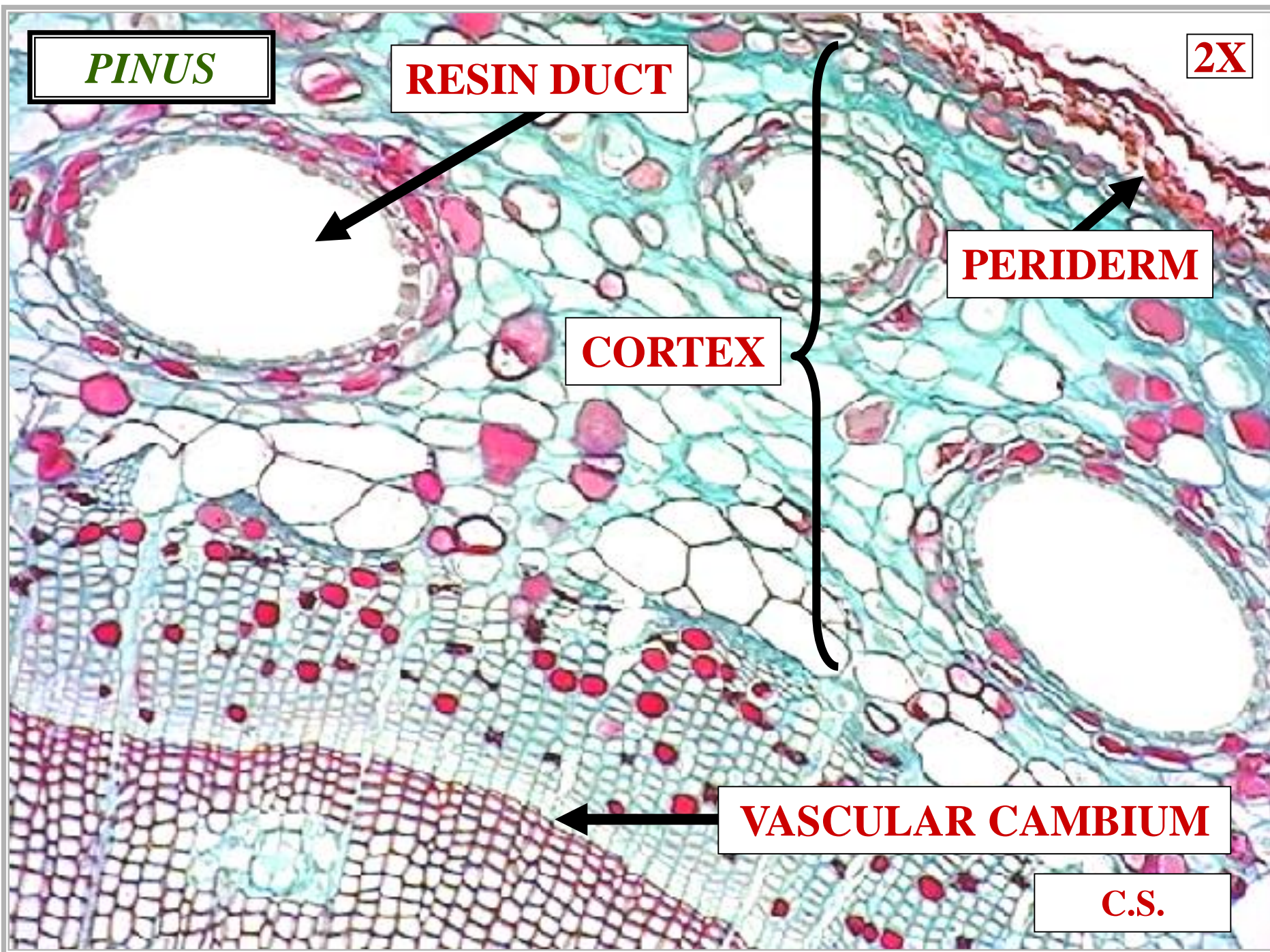
**2X**

**PERIDERM**

**CORTEX**

**VASCULAR CAMBIUM**

**C.S.**



*PINUS*

RESIN DUCT

2P

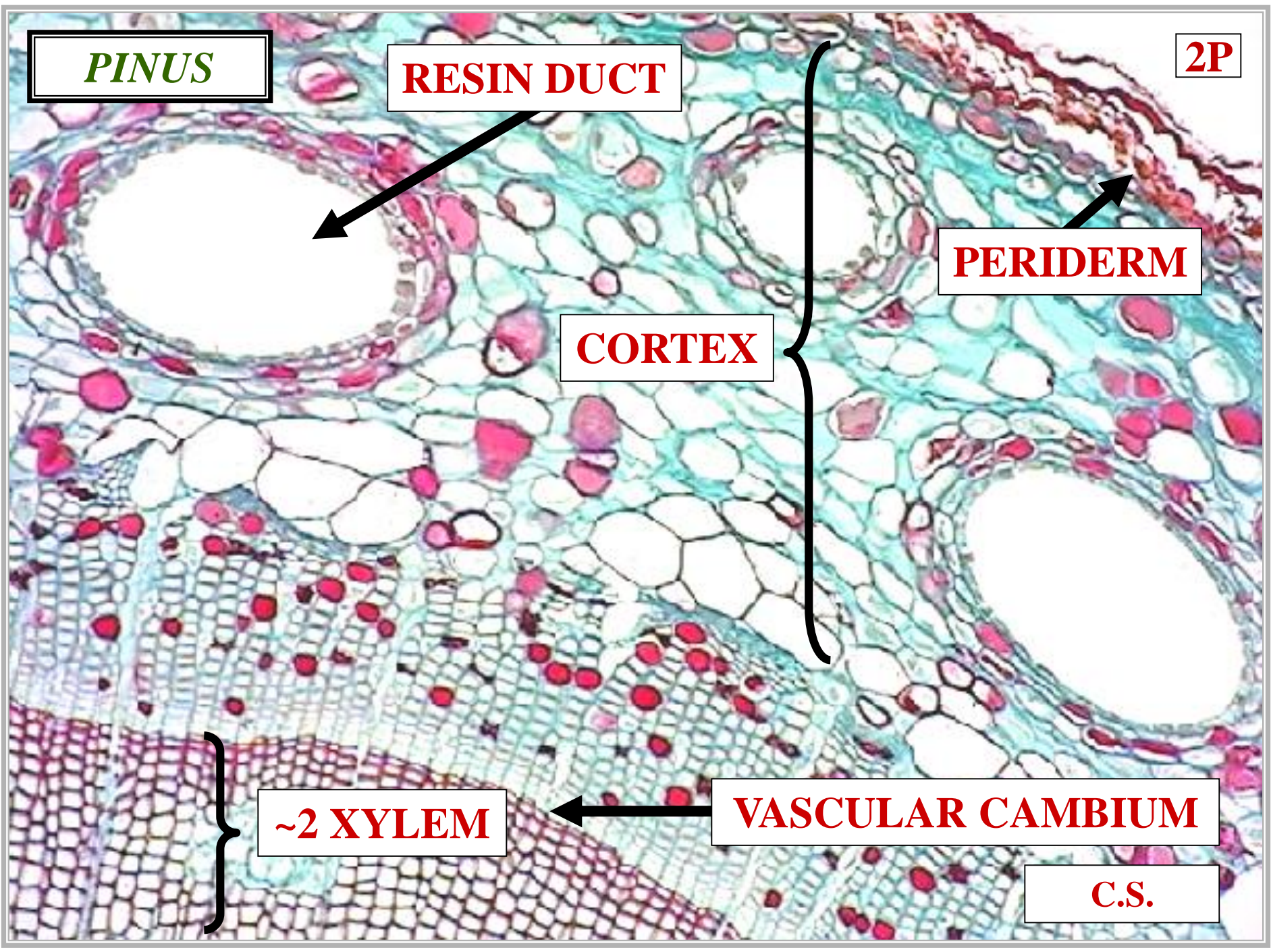
PERIDERM

CORTEX

~2 XYLEM

VASCULAR CAMBIUM

C.S.





*PINUS*

RESIN DUCT

2G

PERIDERM

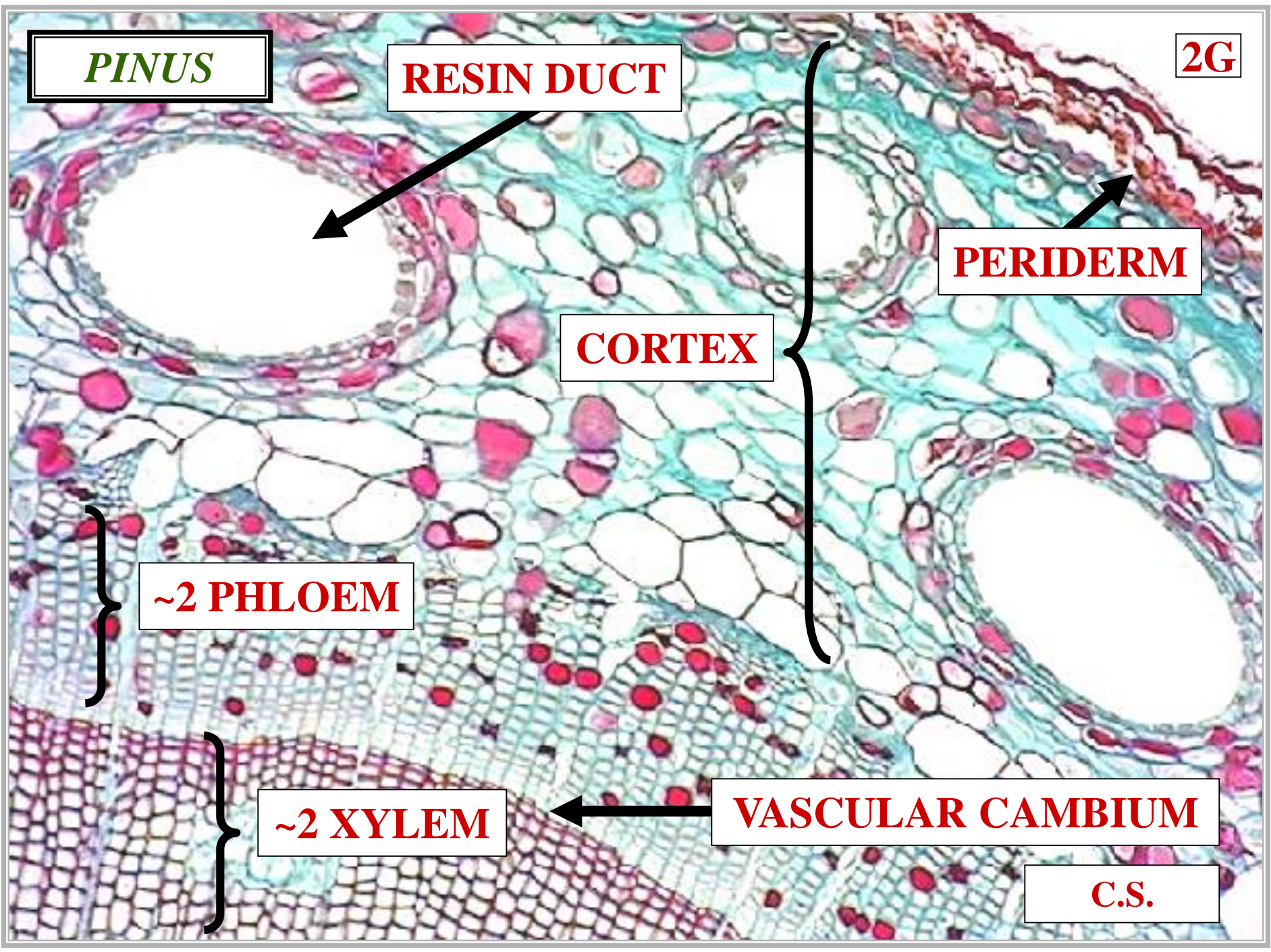
CORTEX

~2 PHLOEM

~2 XYLEM

VASCULAR CAMBIUM

C.S.



**PINUS**

**RESIN DUCT**

**PERIDERM**

**CORTEX**

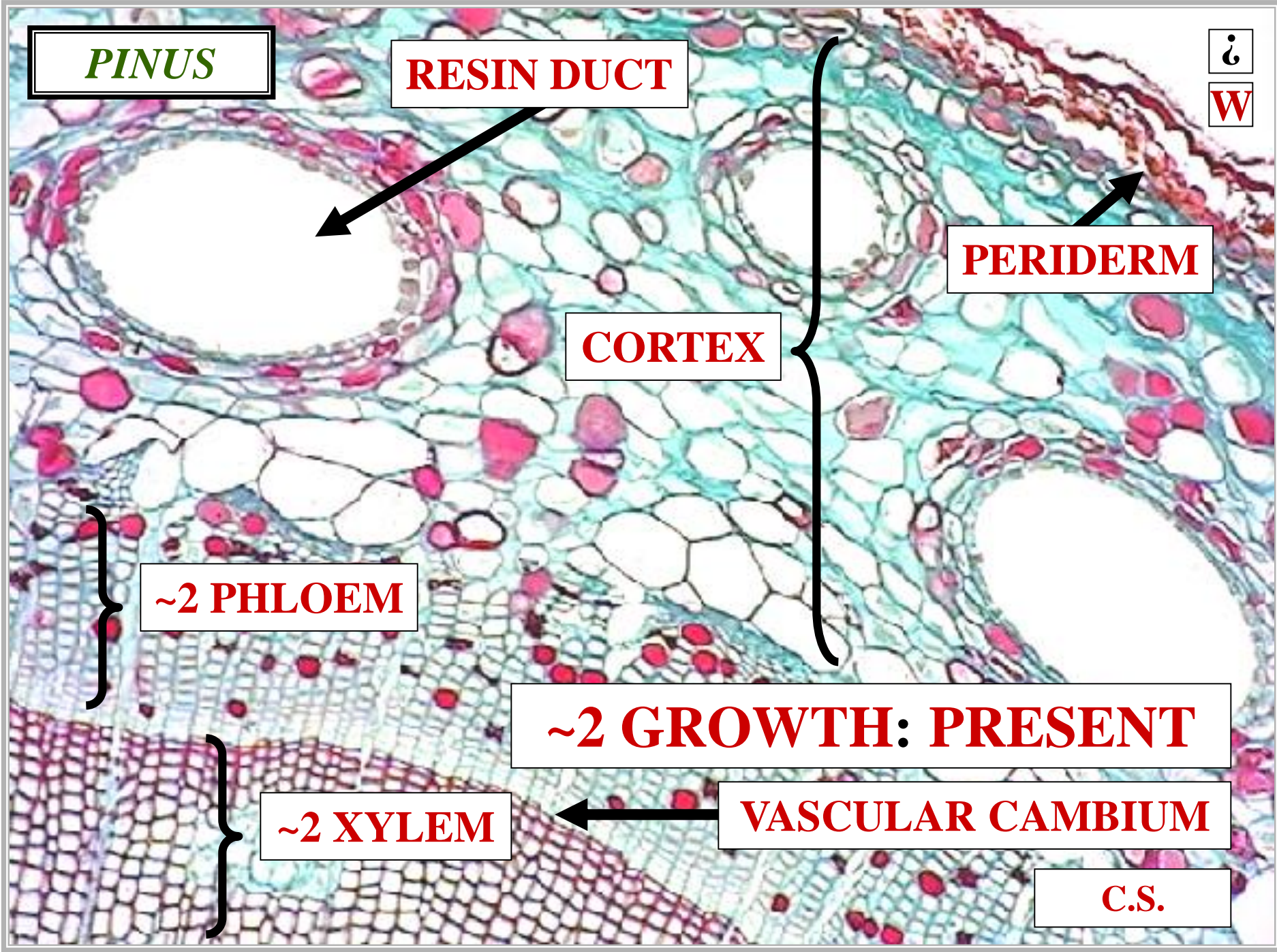
**~2 PHLOEM**

**~2 GROWTH: PRESENT**

**~2 XYLEM**

**VASCULAR CAMBIUM**

**C.S.**





***PINUS***

**RESIN DUCT**



**PERIDERM**



**CORTEX**



**~2 PHLOEM**



**~2 GROWTH: PRESENT**

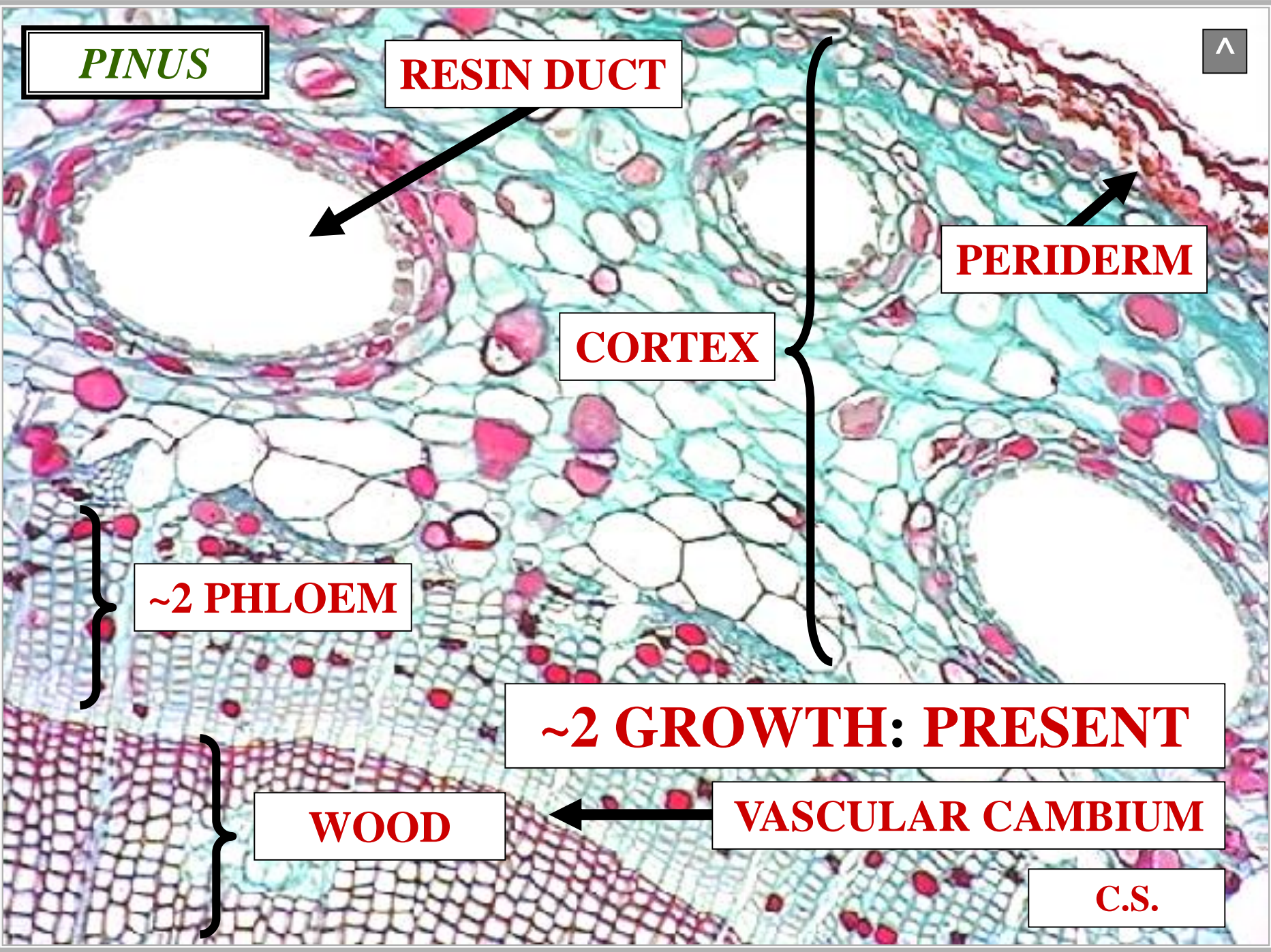
**WOOD**



**VASCULAR CAMBIUM**



**C.S.**





# **GYMNOSPERM WOOD ANATOMY**



**MANOXYLIC  
WOOD  
VS  
PYCNOXYLIC  
WOOD**



# MANOXYLIC WOOD ANATOMY

EG



*CYCAS*

# MANOXYLIC

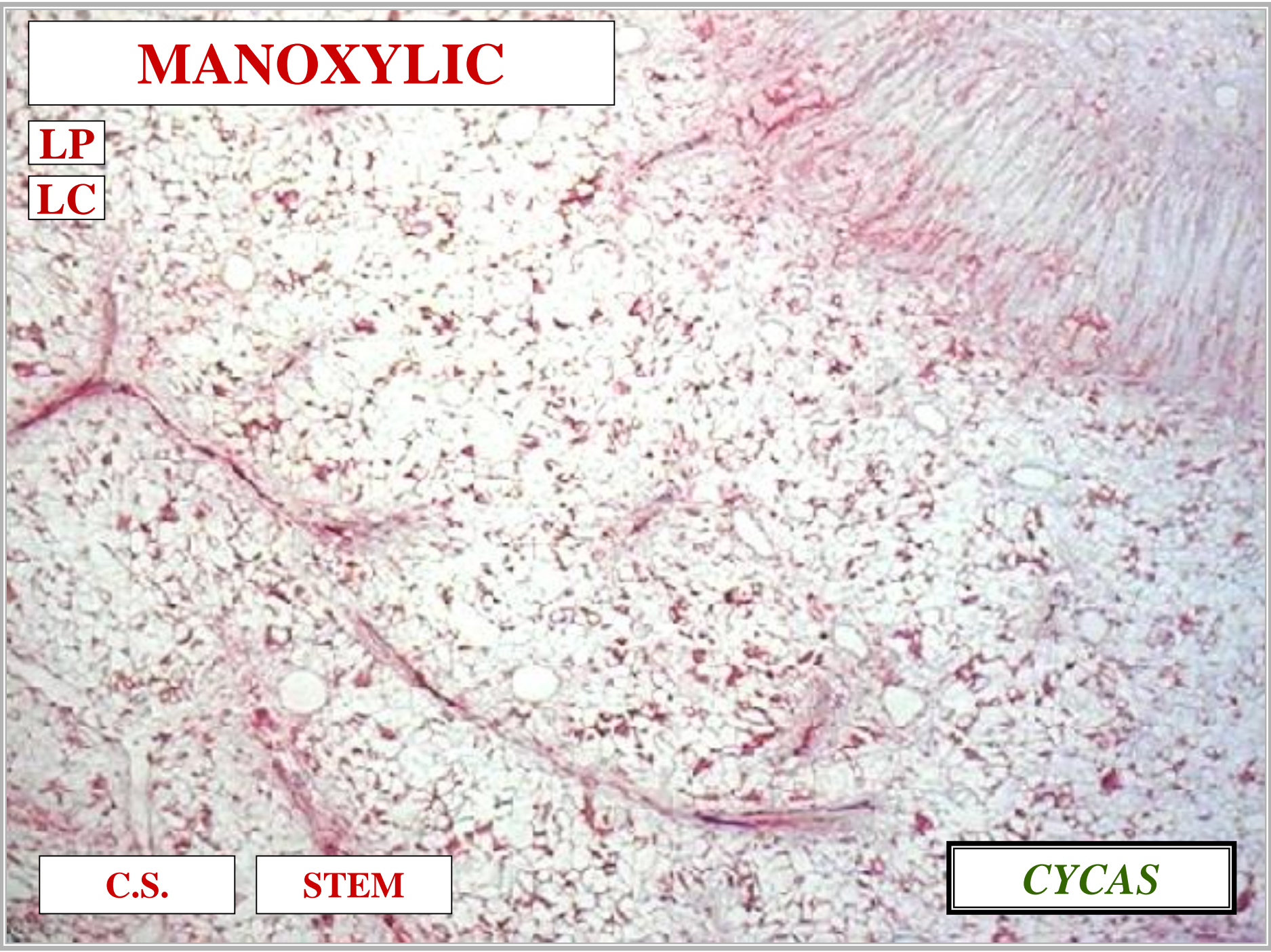
LP

LC

C.S.

STEM

*CYCAS*





**MANOXYLIC**

**LARGE PITH** →

**VC**

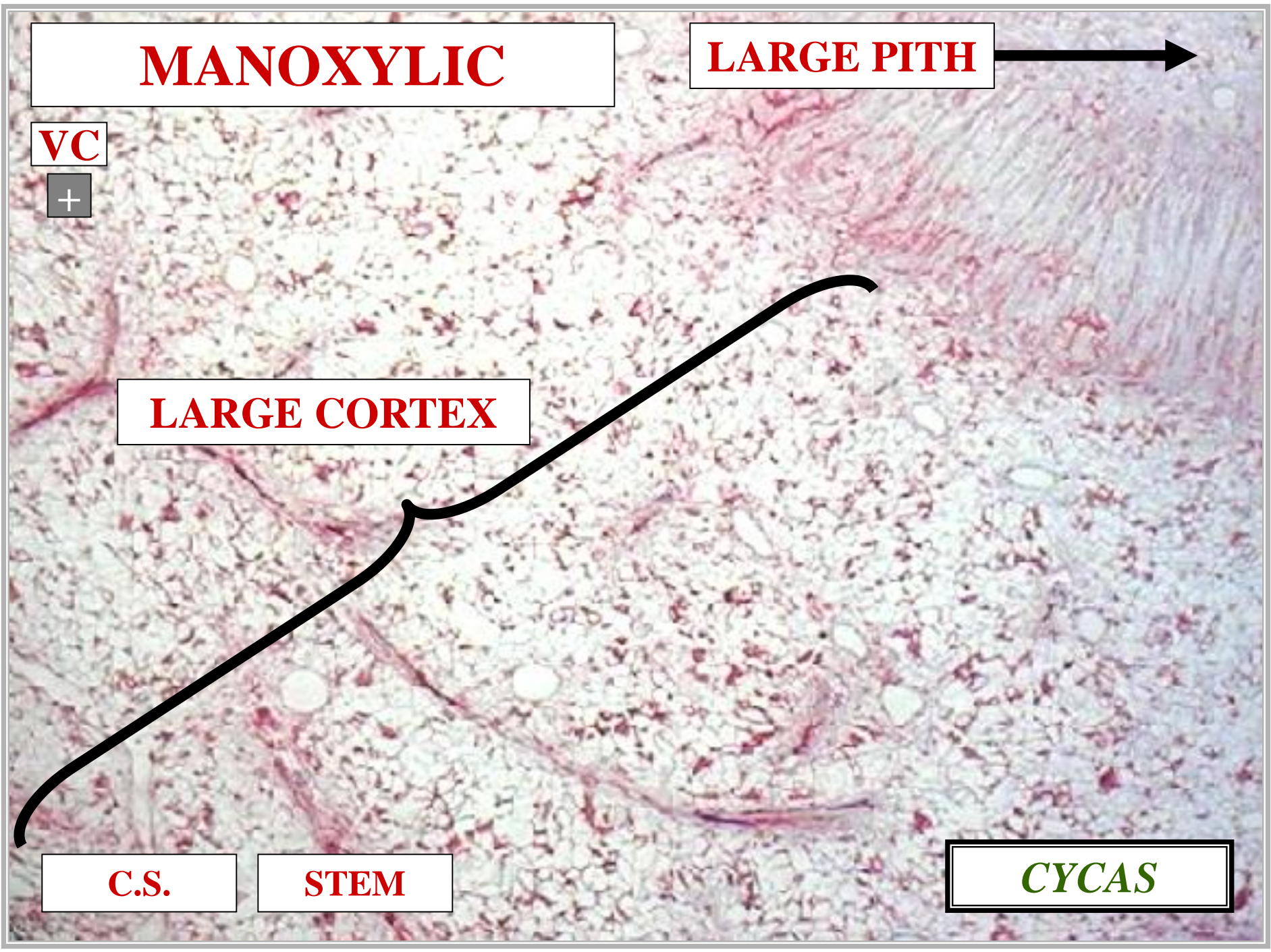
+

**LARGE CORTEX**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH** →

**2**

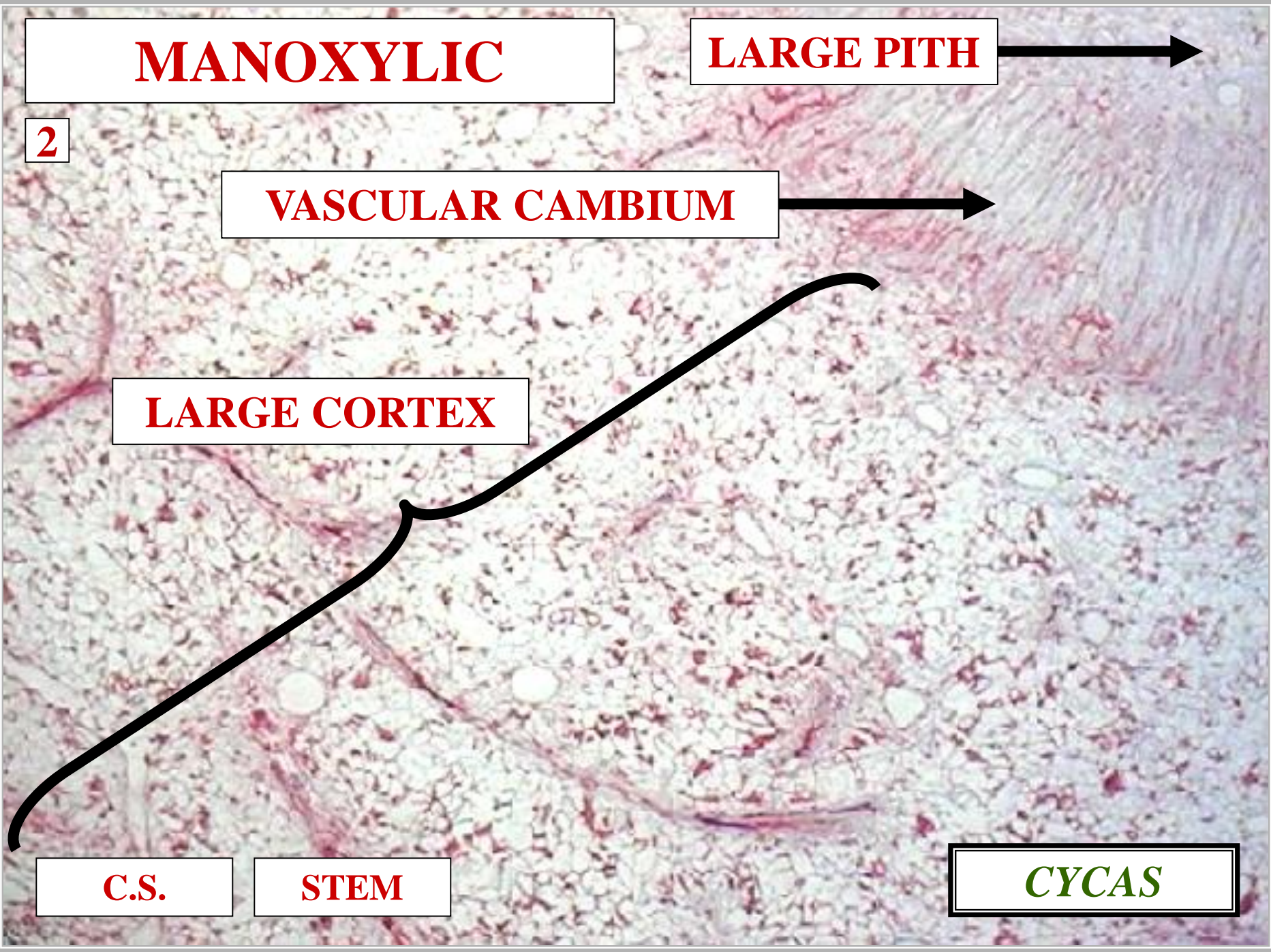
**VASCULAR CAMBIUM** →

**LARGE CORTEX**

**C.S.**

**STEM**

***CYCAS***



**MANOXYLIC**

**LARGE PITH**

**SG**

**VASCULAR CAMBIUM**

**LARGE CORTEX**

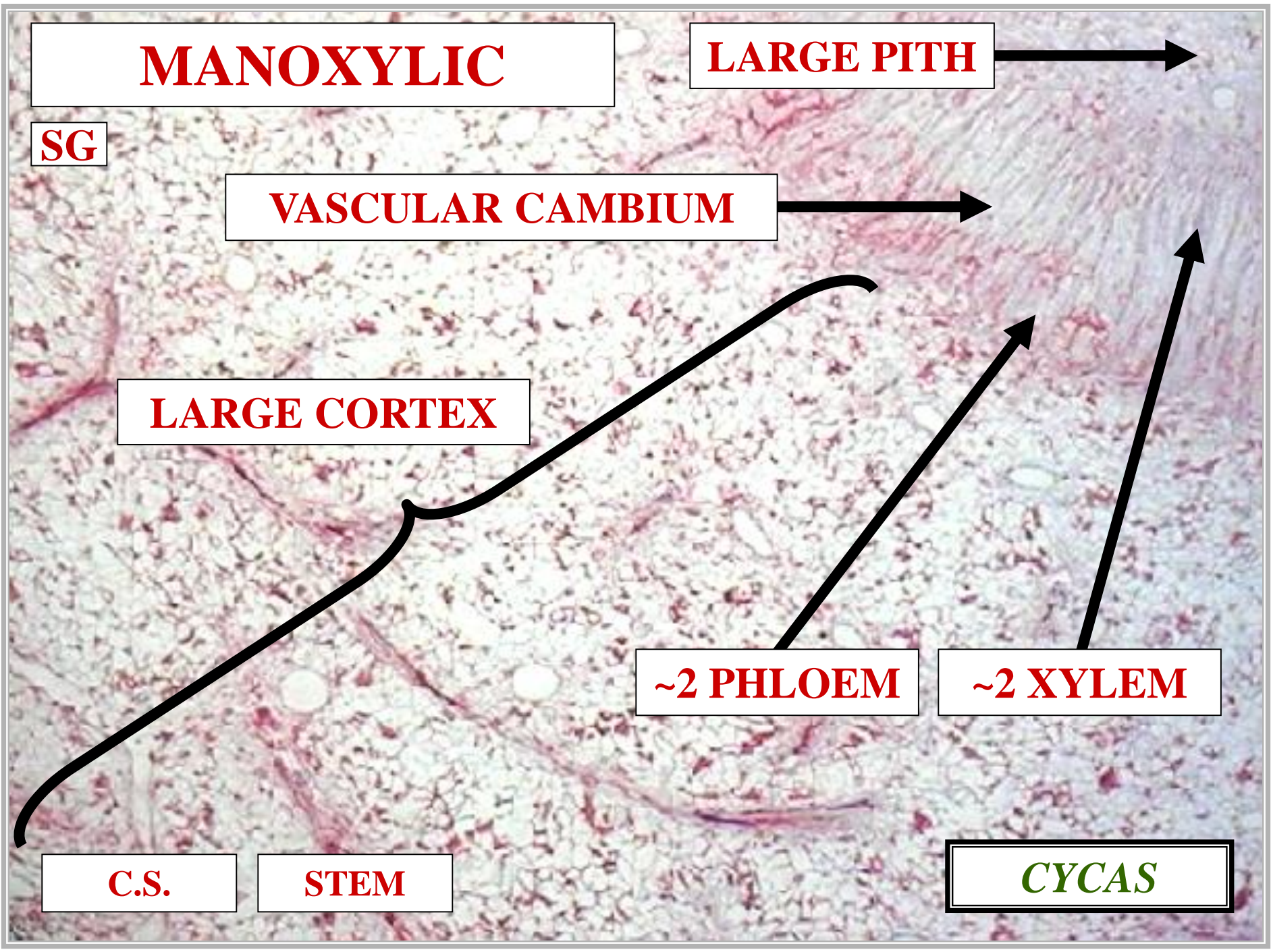
**~2 PHLOEM**

**~2 XYLEM**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH** →

**LX**

**VASCULAR CAMBIUM** →

**LARGE CORTEX**

**~2 PHLOEM**

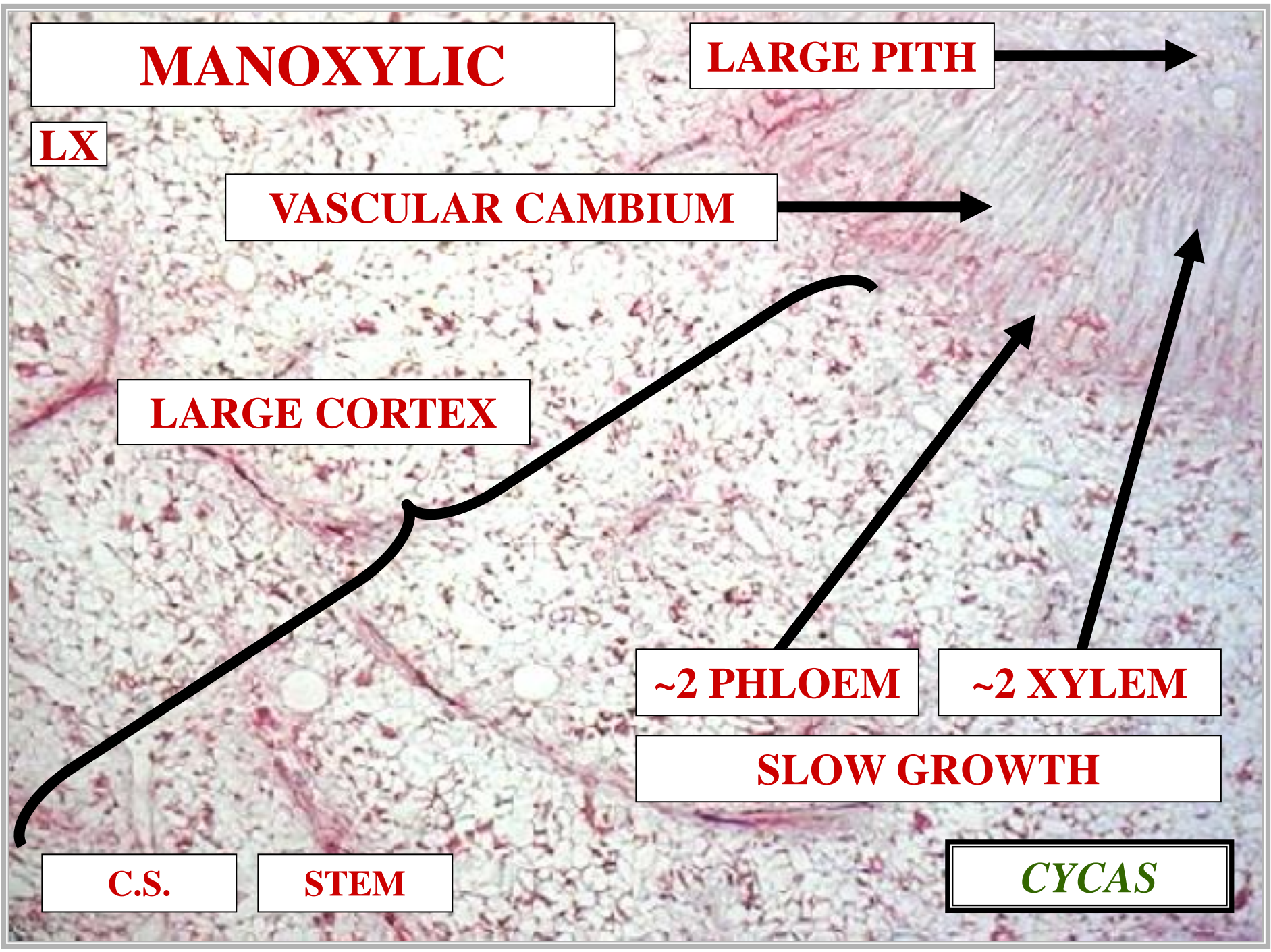
**~2 XYLEM**

**SLOW GROWTH**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH**

**A**

**VASCULAR CAMBIUM**

**LARGE CORTEX**

**~2 PHLOEM**

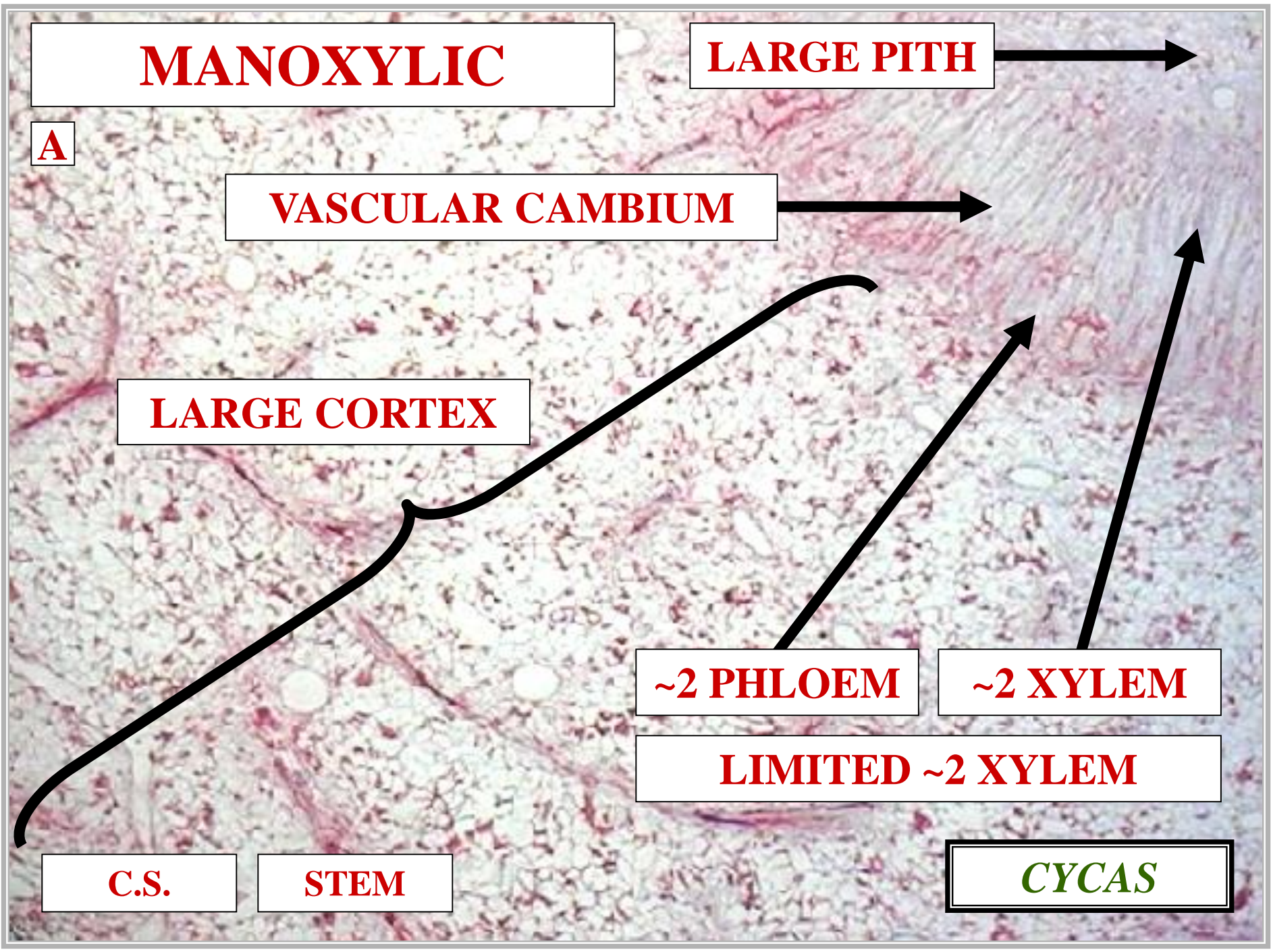
**~2 XYLEM**

**LIMITED ~2 XYLEM**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH**

**P**

**VASCULAR CAMBIUM**

**LARGE CORTEX**

**~2 PHLOEM**

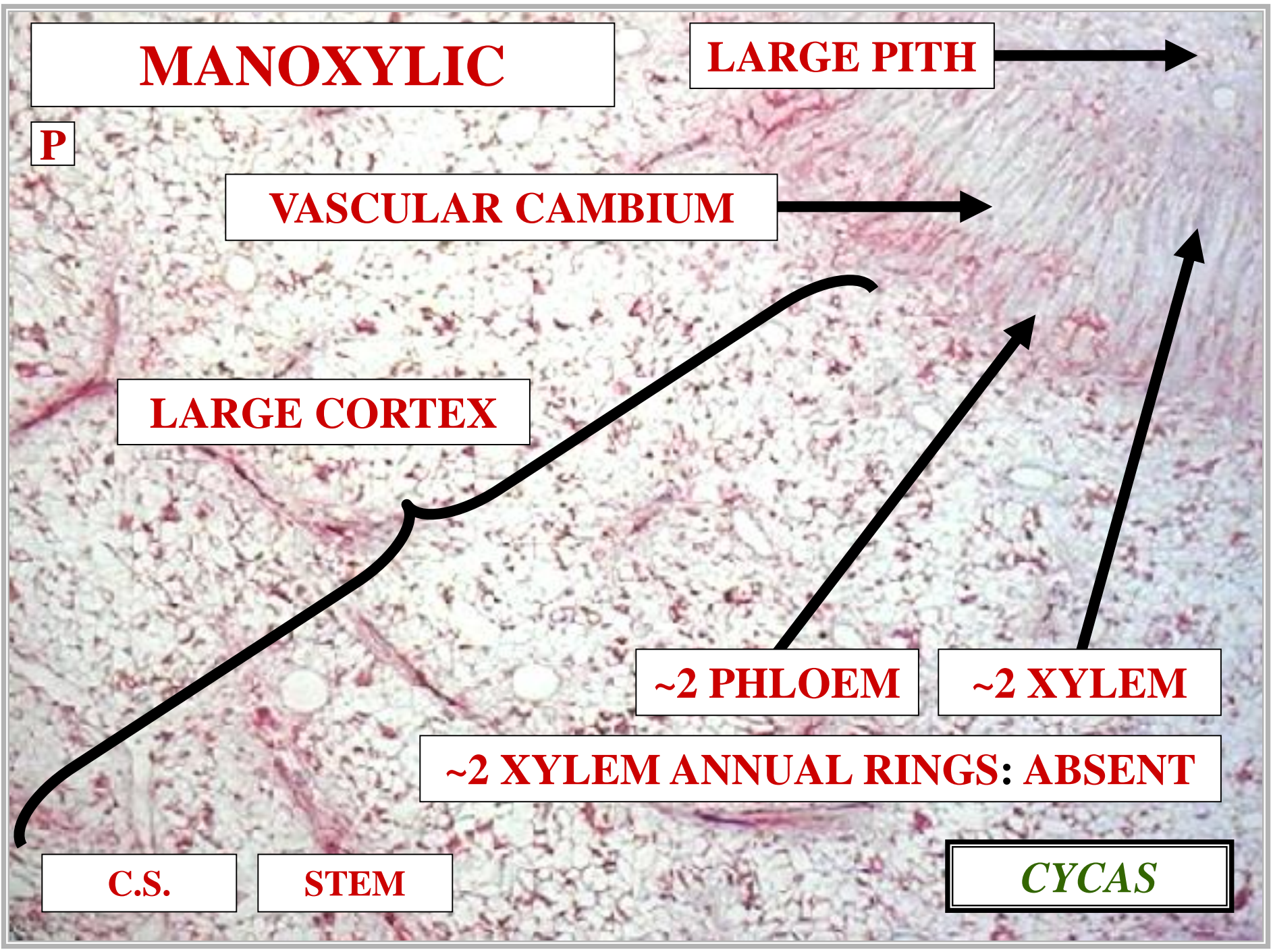
**~2 XYLEM**

**~2 XYLEM ANNUAL RINGS: ABSENT**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH** →

**PL**

**VASCULAR CAMBIUM** →

**LARGE CORTEX**

**~2 PHLOEM**

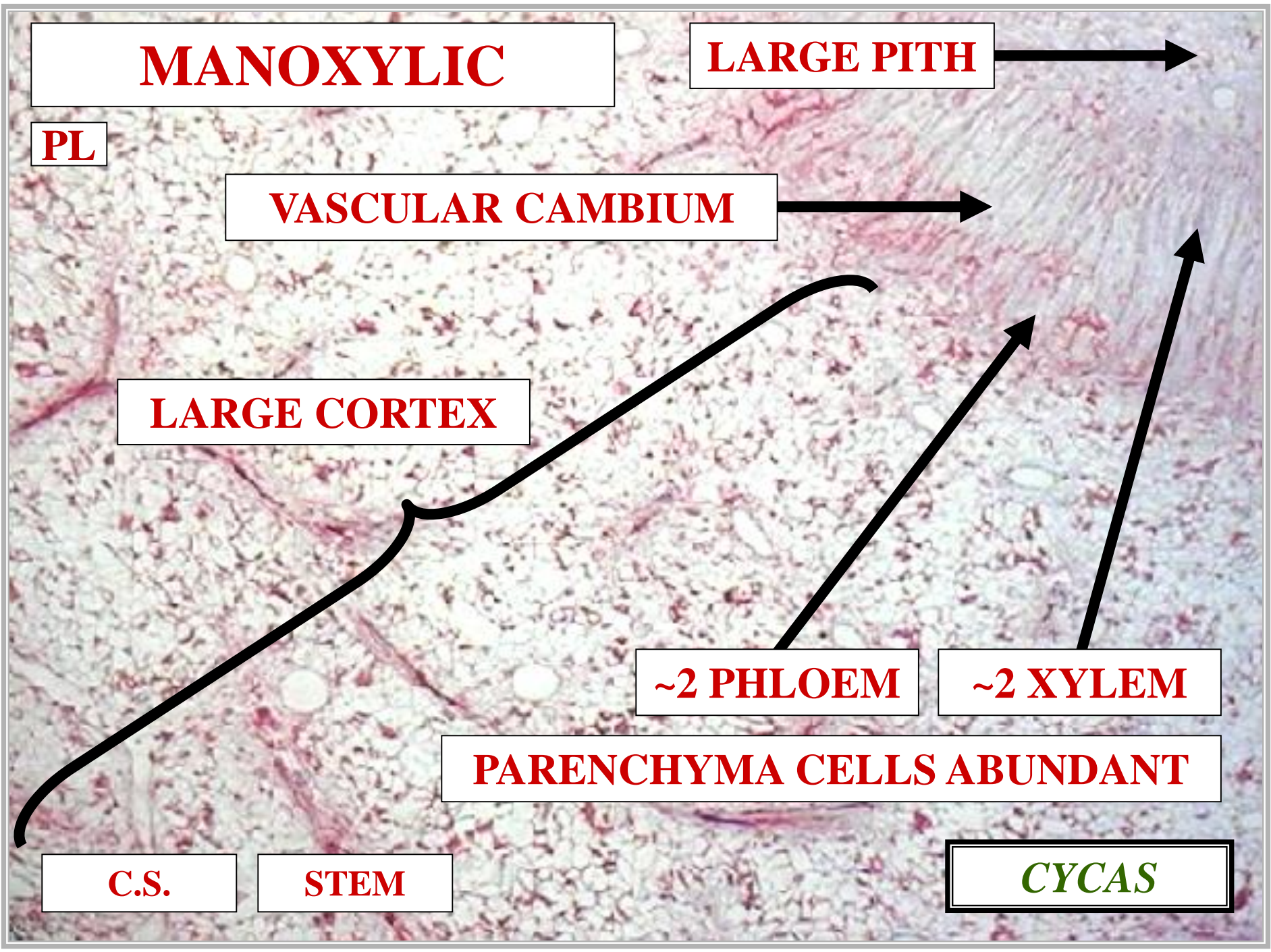
**~2 XYLEM**

**PARENCHYMA CELLS ABUNDANT**

**C.S.**

**STEM**

**CYCAS**



**MANOXYLIC**

**LARGE PITH**

**VASCULAR CAMBIUM**

**LARGE CORTEX**

**~2 PHLOEM**

**~2 XYLEM**

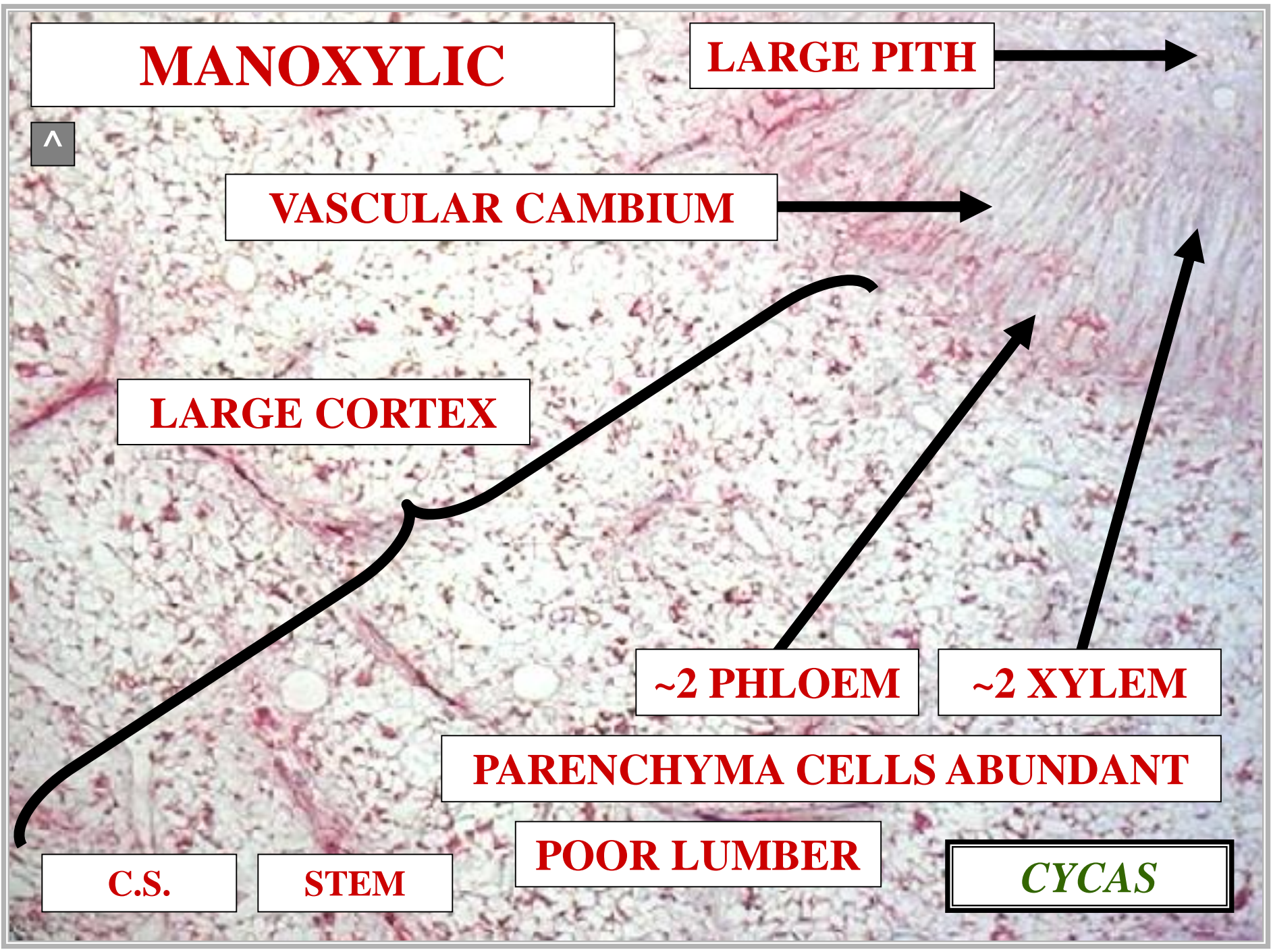
**PARENCHYMA CELLS ABUNDANT**

**C.S.**

**STEM**

**POOR LUMBER**

**CYCAS**







# PYCNOXYLIC WOOD ANATOMY

*PINUS*



# PYCNOXYLIC

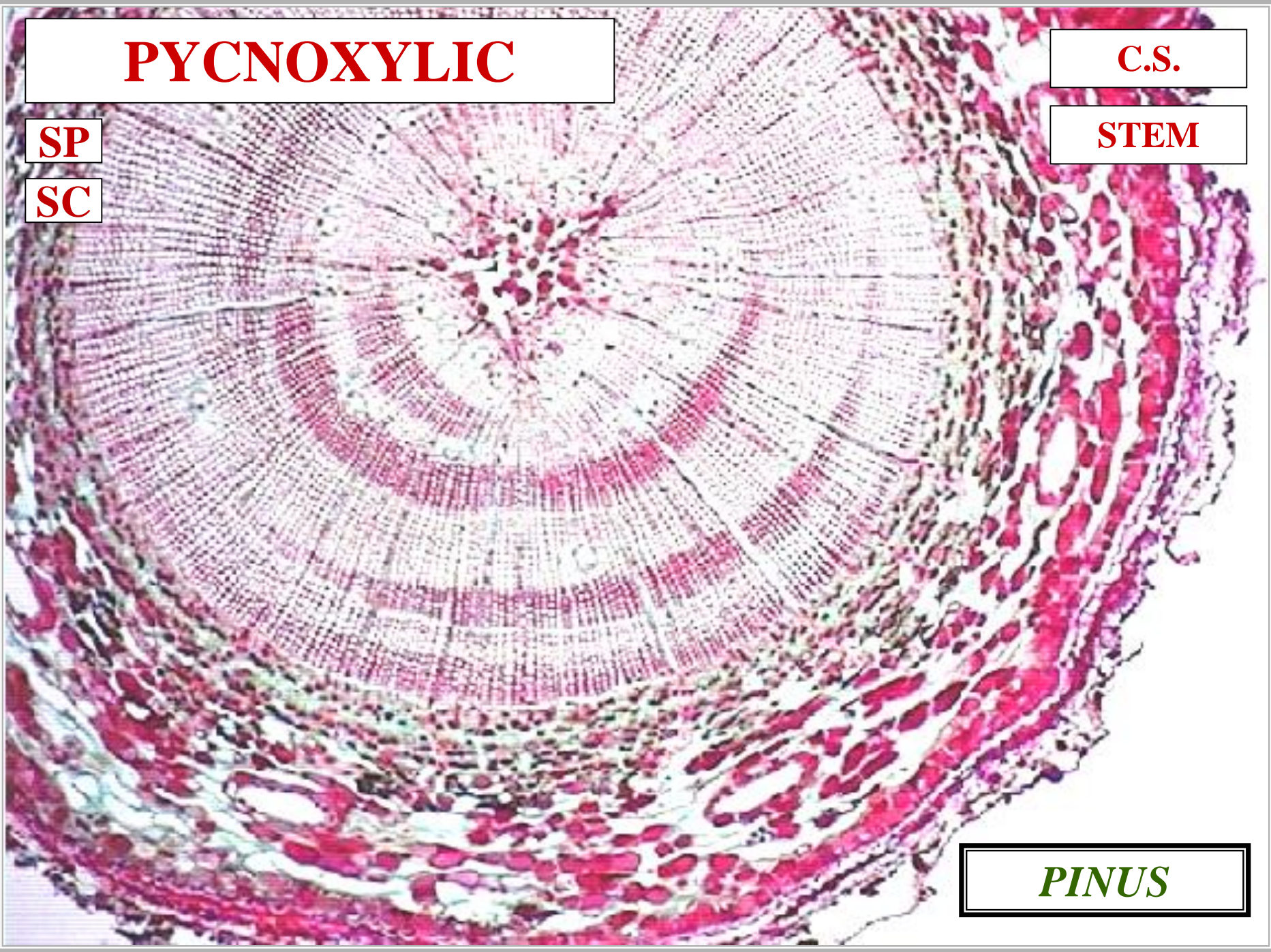
SP

SC

C.S.

STEM

*PINUS*



**PYCNOXYLIC**

**C.S.**

**VC**

**STEM**

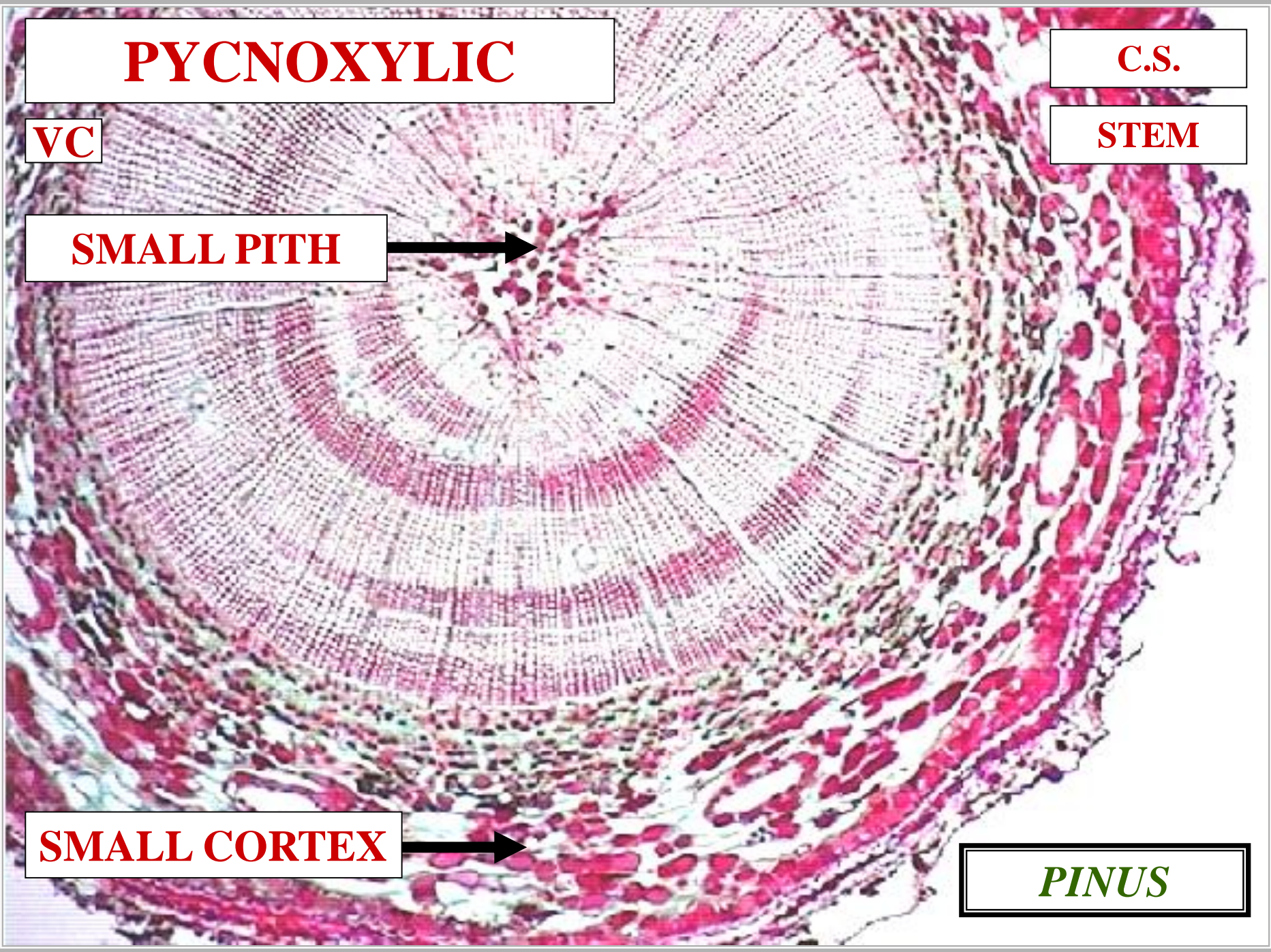
**SMALL PITH**



**SMALL CORTEX**



***PINUS***



**PYCNOXYLIC**

**C.S.**

**2**

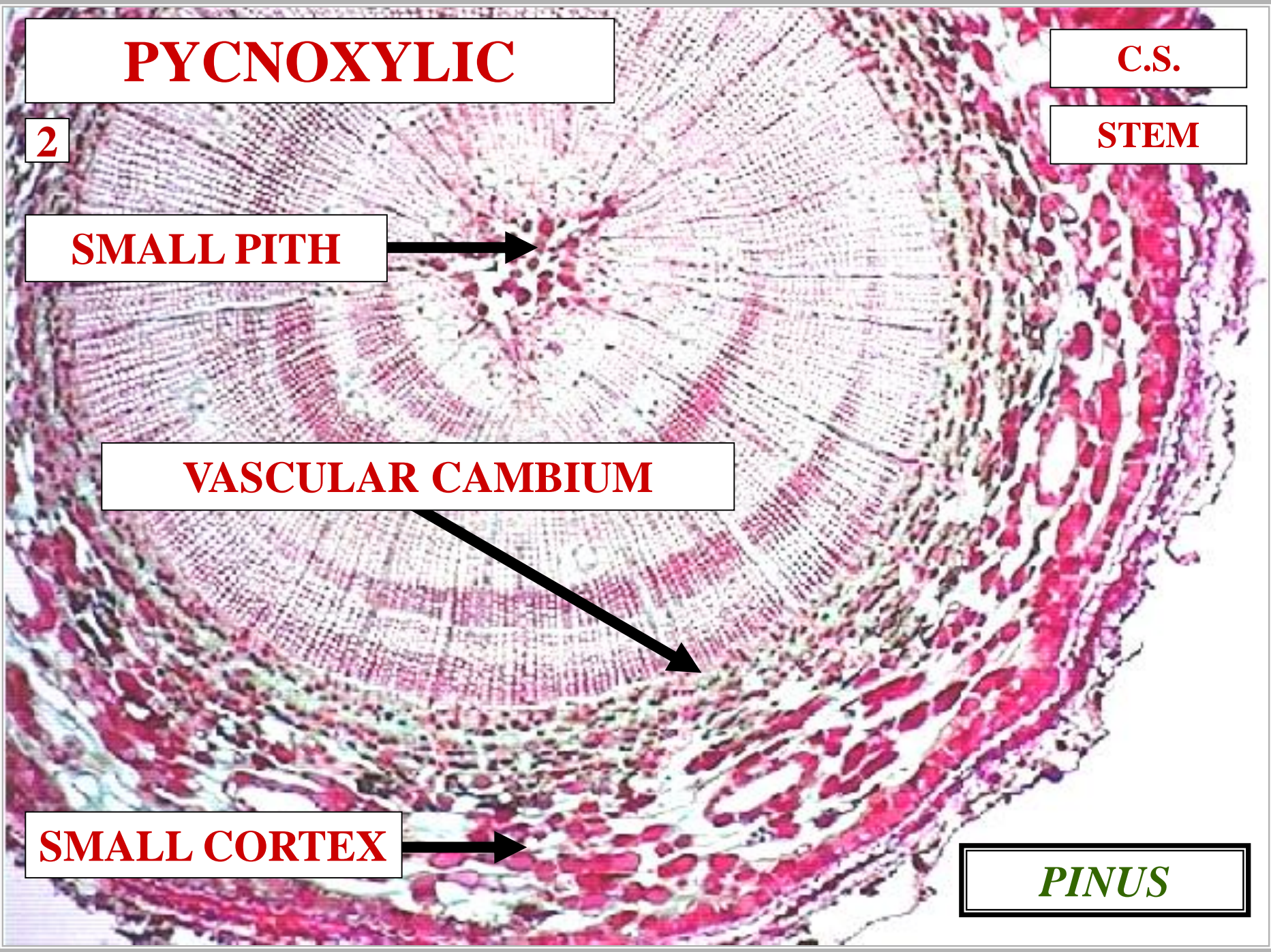
**STEM**

**SMALL PITH**

**VASCULAR CAMBIUM**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**RG**

**STEM**

**SMALL PITH**

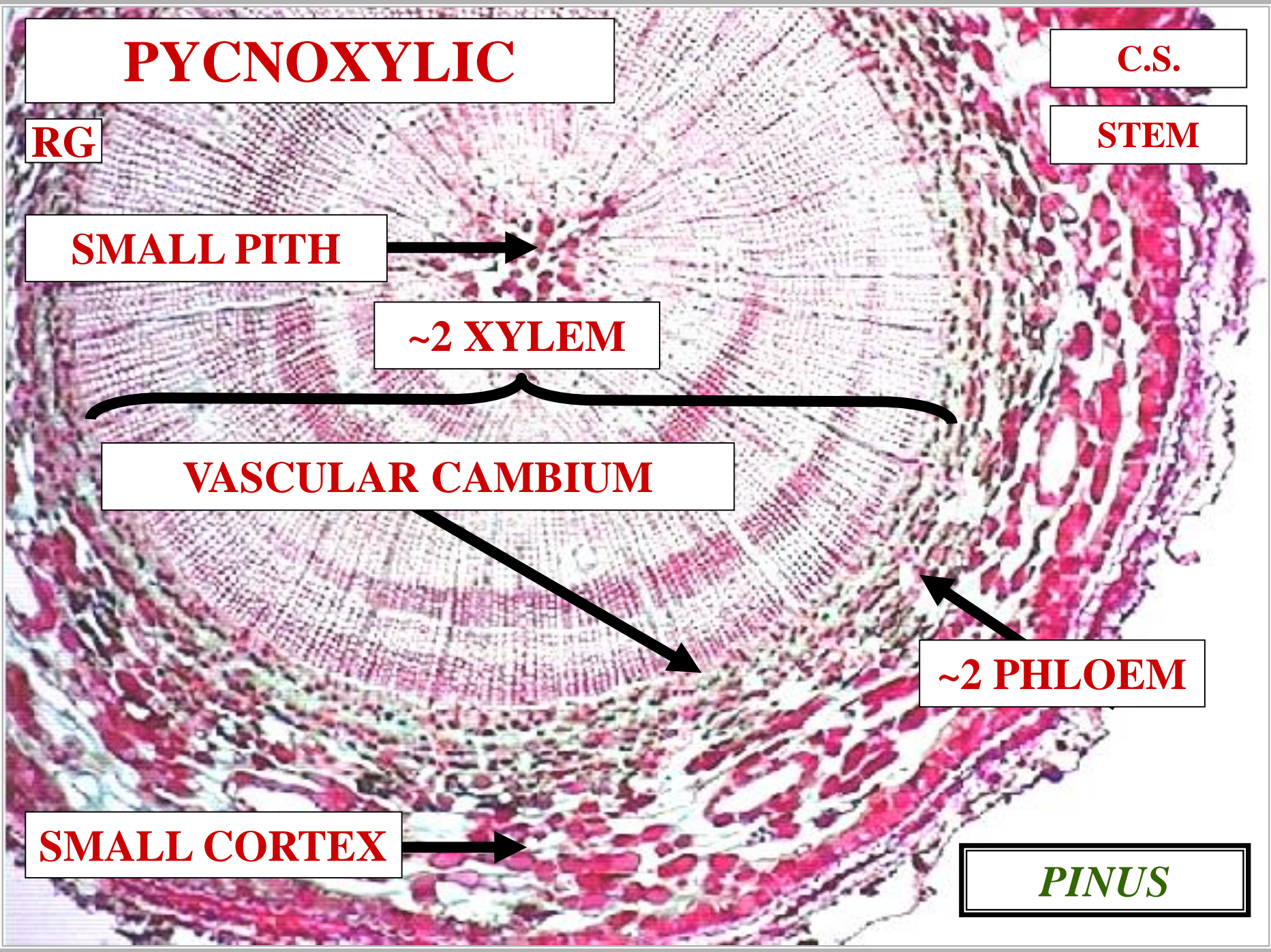
**~2 XYLEM**

**VASCULAR CAMBIUM**

**~2 PHLOEM**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**EX**

**STEM**

**SMALL PITH**

**~2 XYLEM**

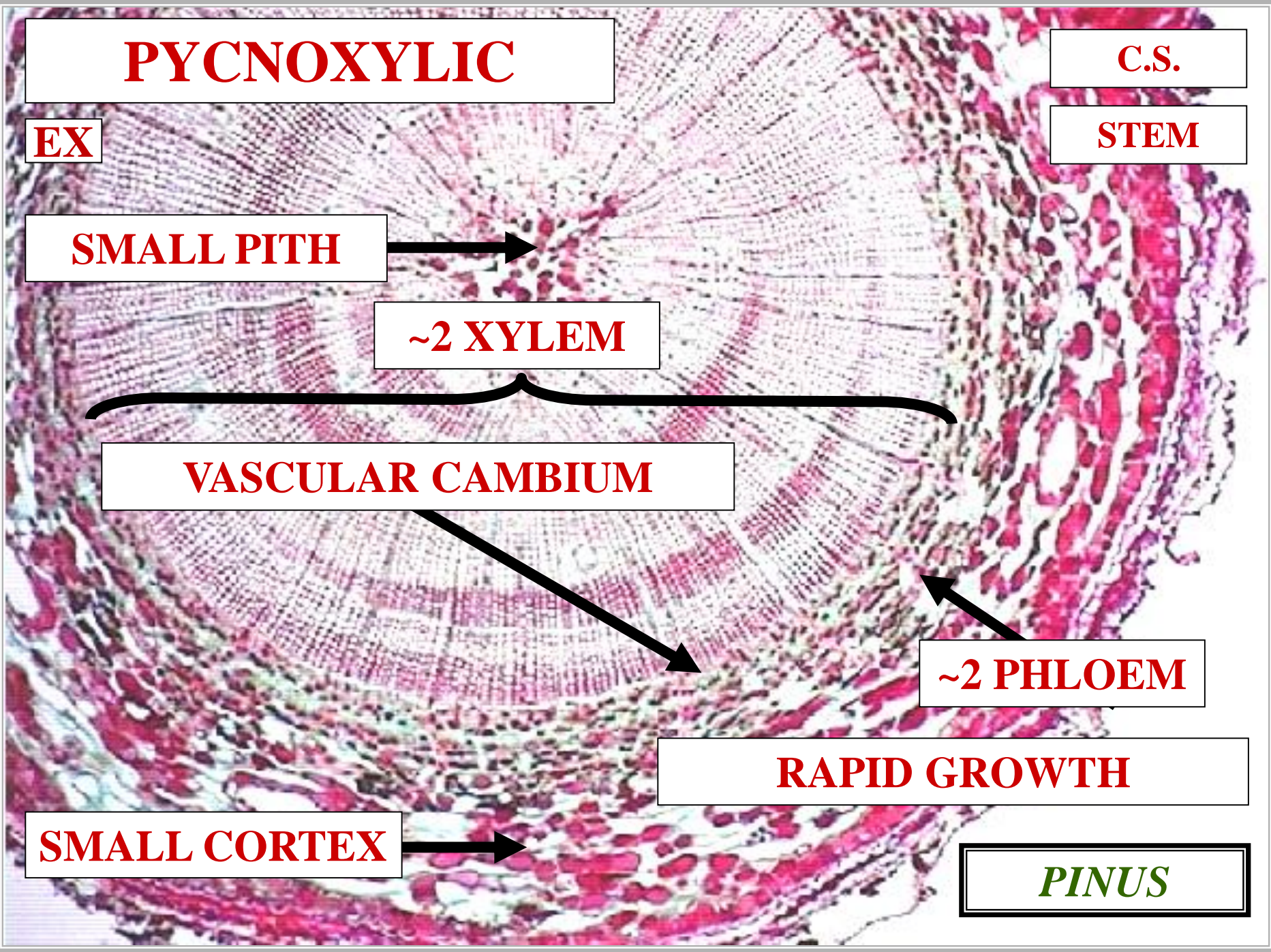
**VASCULAR CAMBIUM**

**~2 PHLOEM**

**RAPID GROWTH**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**STEM**

**?**

**SMALL PITH**

**~2 XYLEM**

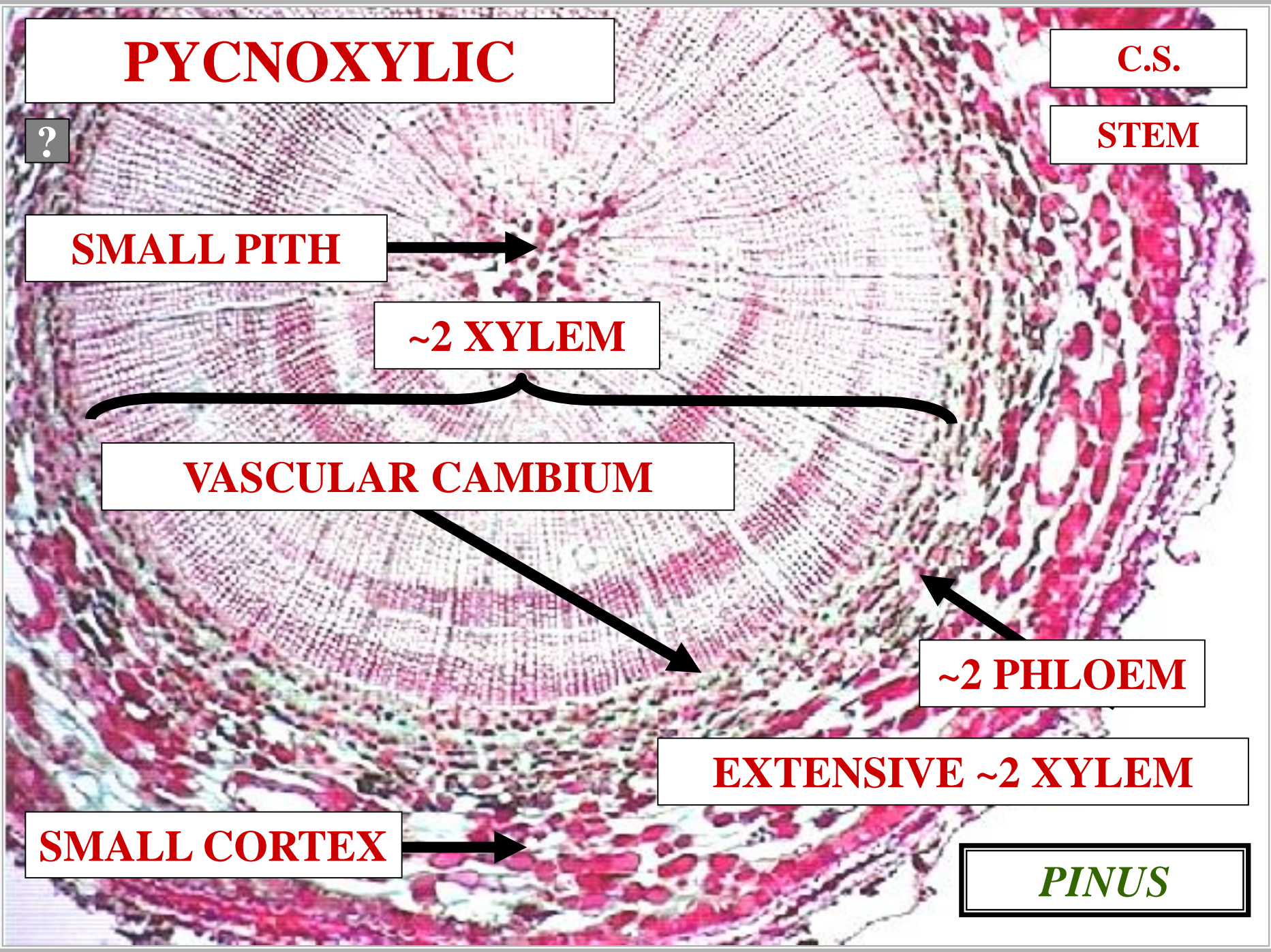
**VASCULAR CAMBIUM**

**~2 PHLOEM**

**EXTENSIVE ~2 XYLEM**

**SMALL CORTEX**

***PINUS***





**PYCNOXYLIC**

**C.S.**

**AR**

**STEM**

**SMALL PITH**

**?**

**~2 XYLEM**

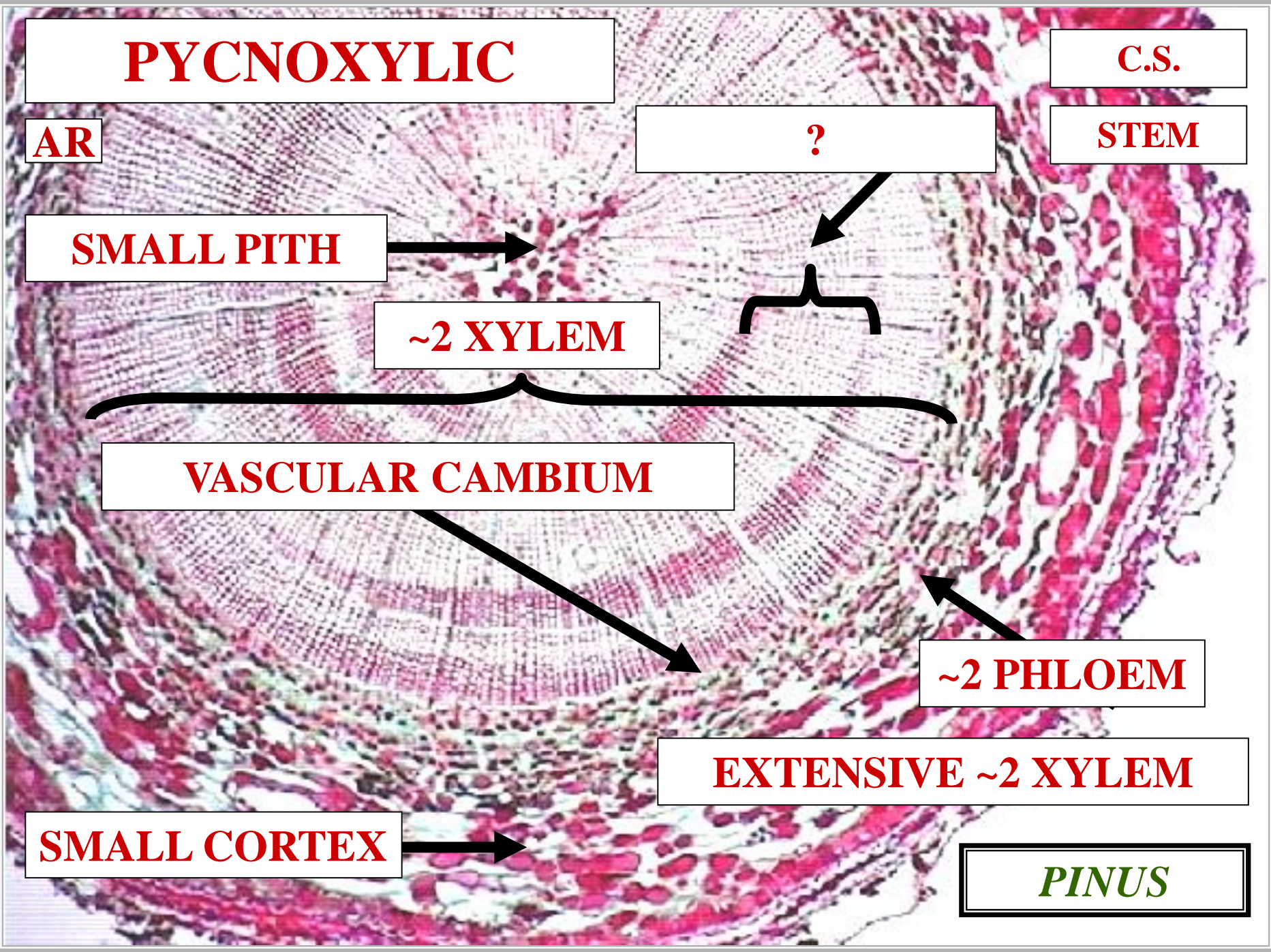
**VASCULAR CAMBIUM**

**~2 PHLOEM**

**EXTENSIVE ~2 XYLEM**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**P**

**ANNUAL RING**

**STEM**

**SMALL PITH**

**~2 XYLEM**

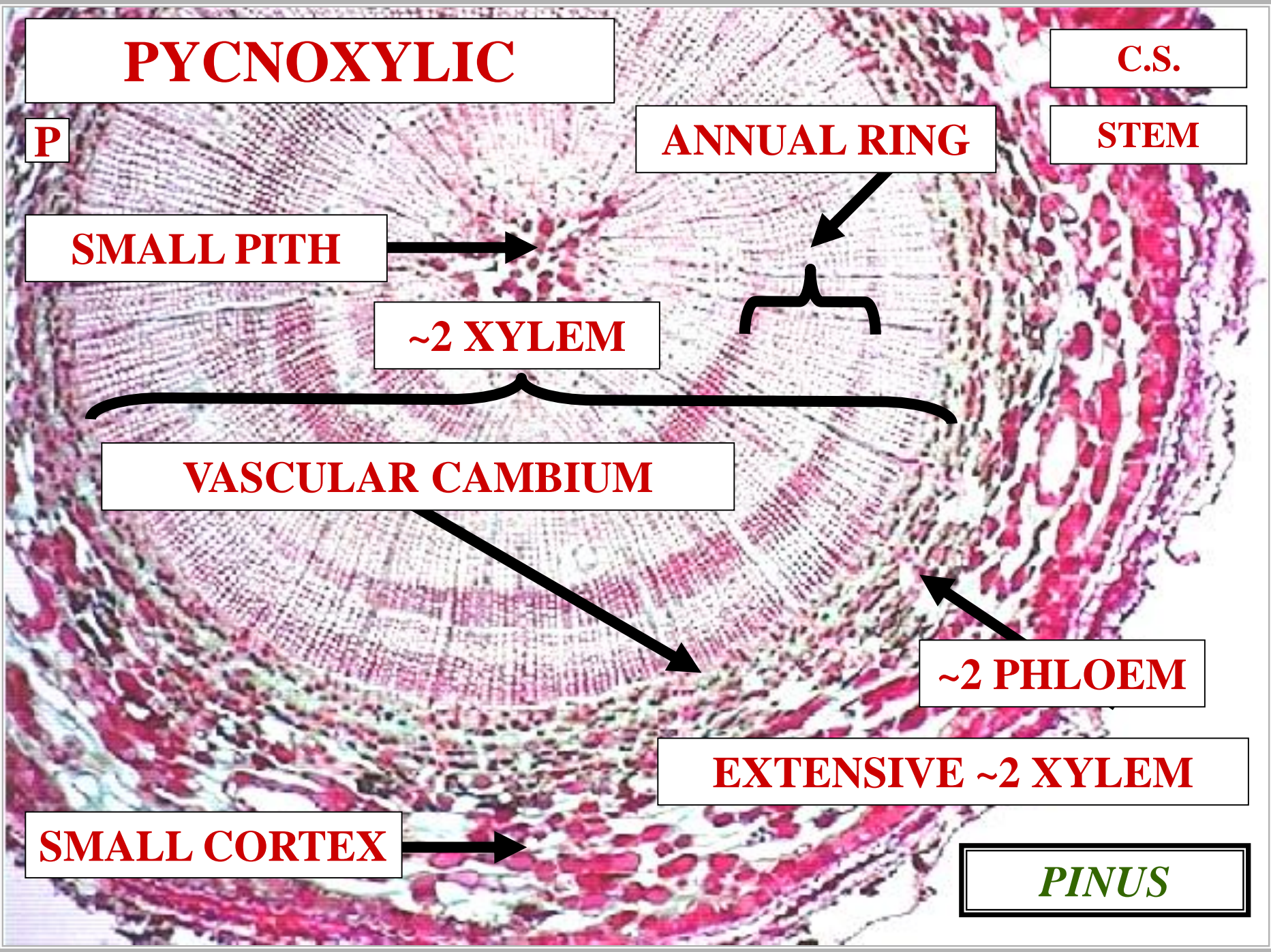
**VASCULAR CAMBIUM**

**~2 PHLOEM**

**EXTENSIVE ~2 XYLEM**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**GL**

**ANNUAL RING**

**STEM**

**SMALL PITH**

**~2 XYLEM**

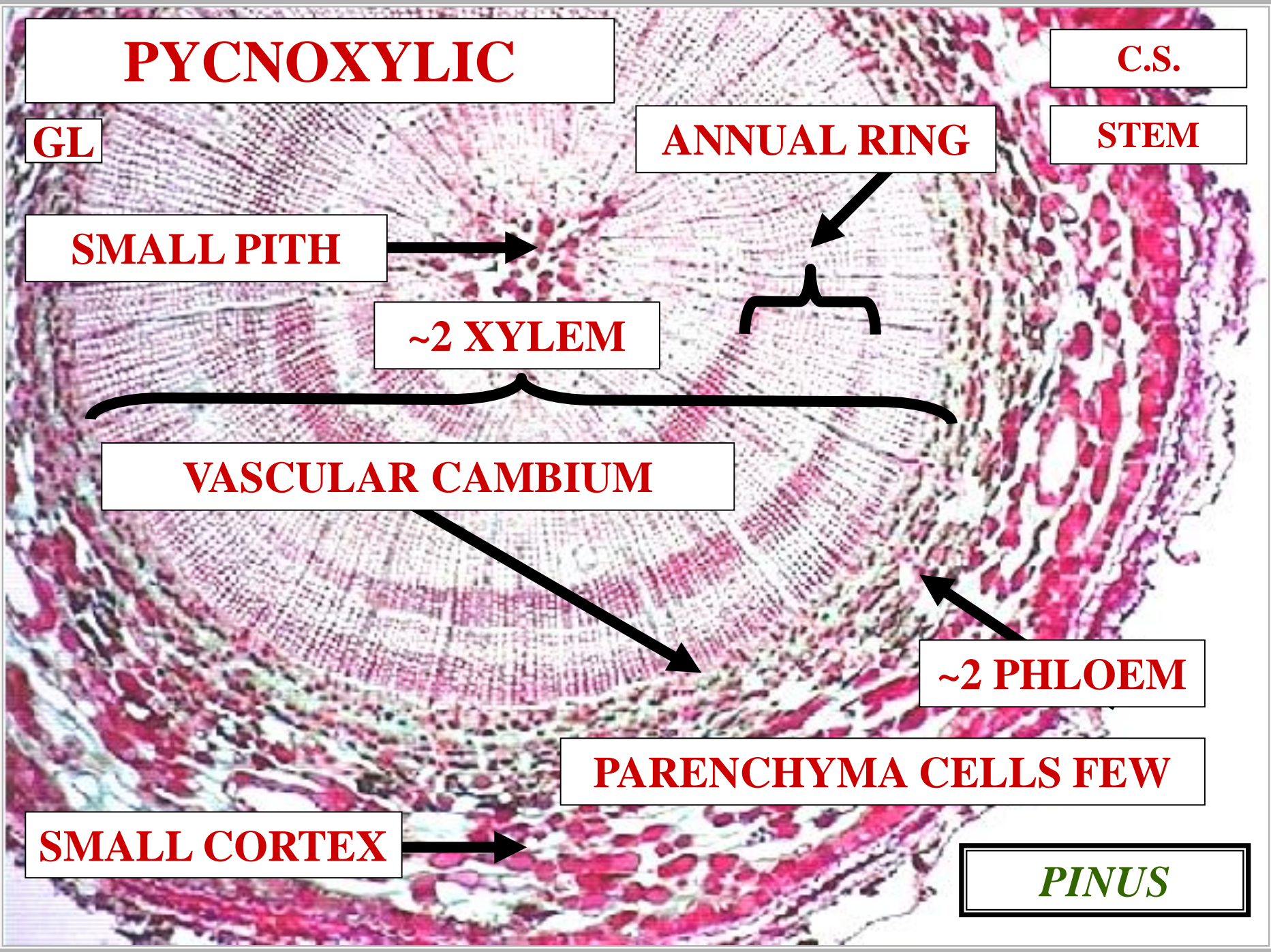
**VASCULAR CAMBIUM**

**~2 PHLOEM**

**PARENCHYMA CELLS FEW**

**SMALL CORTEX**

***PINUS***



**PYCNOXYLIC**

**C.S.**

**STEM**

**ANNUAL RING**

**SMALL PITH**

**~2 XYLEM**

**VASCULAR CAMBIUM**

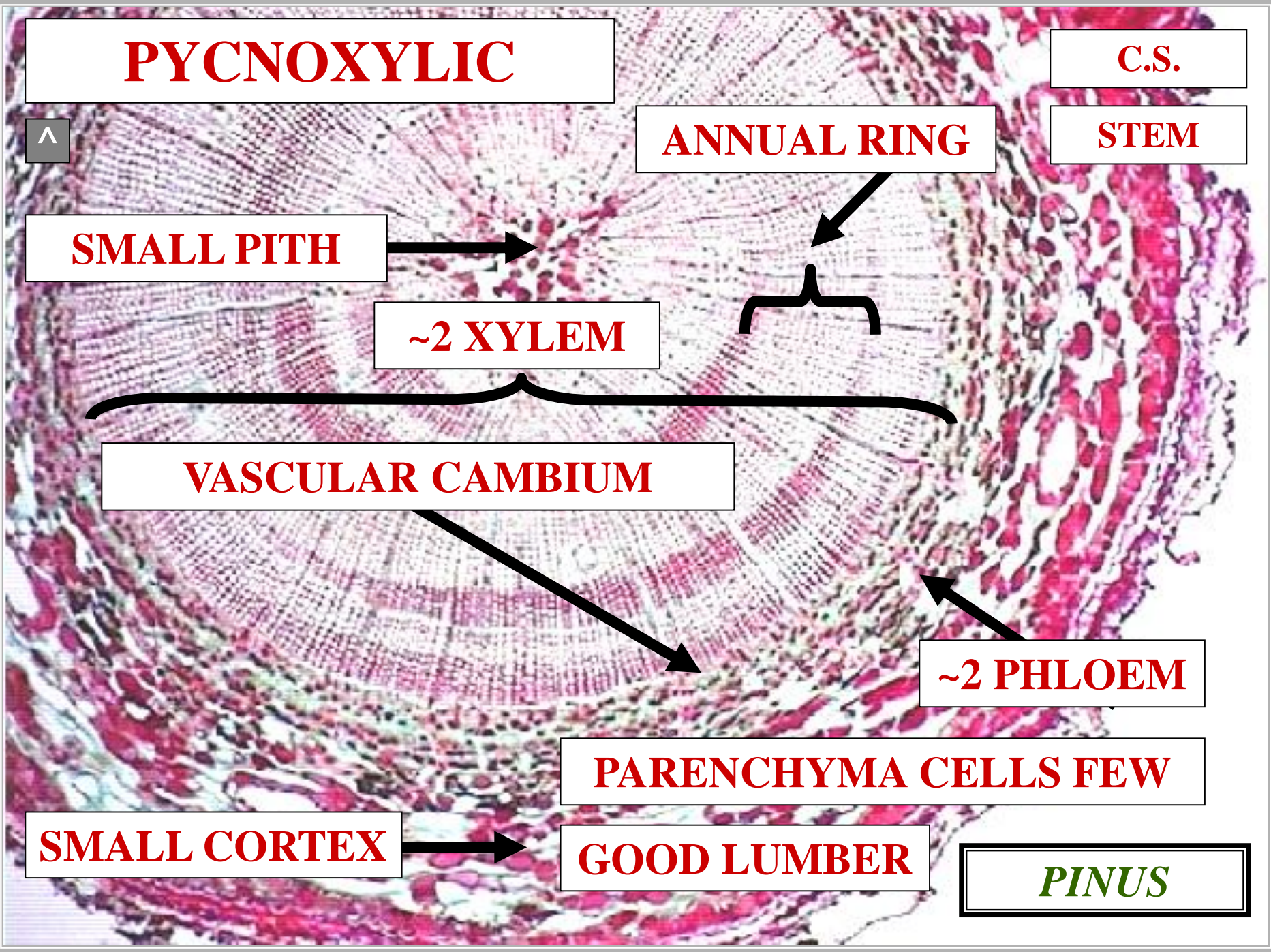
**~2 PHLOEM**

**PARENCHYMA CELLS FEW**

**SMALL CORTEX**

**GOOD LUMBER**

***PINUS***





**LEAF**



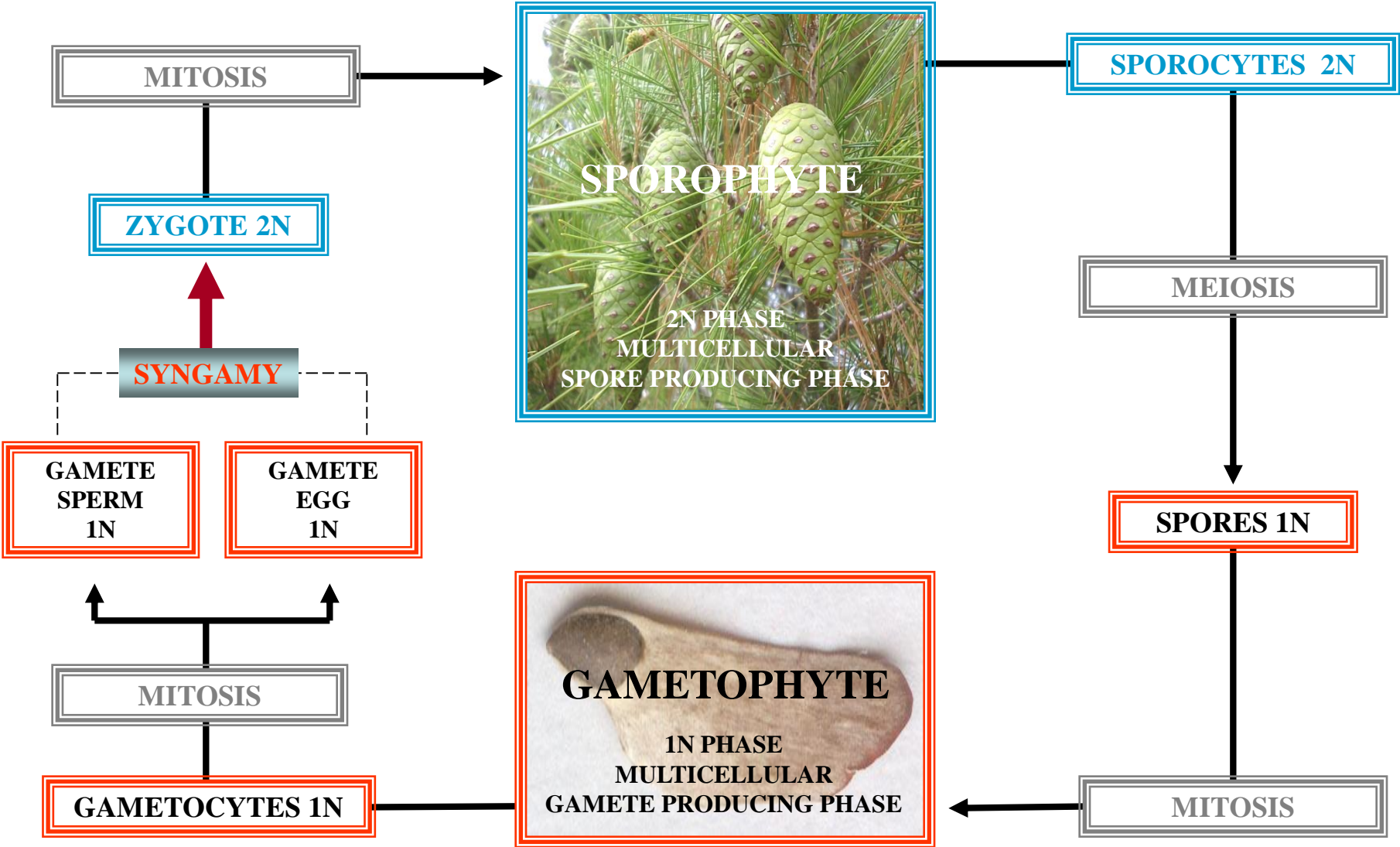
# PHYLLOTAXY



# PHYLLOTAXY ALTERNATE

**GYMNOSPERMS**

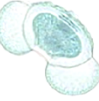
# GYMNOSPERM LIFE CYCLE







# GAMETOPHYTE CHARACTERS



# MICROGAMETOPHYTE

# MICROGAMETOPHYTE



*PINUS*

?

# MICROGAMETOPHYTE

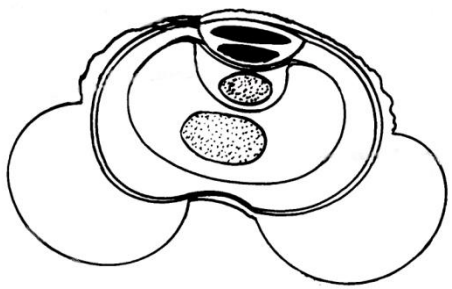


*PINUS*

# POLLEN GRAIN

# MICROGAMETOPHYTE

?

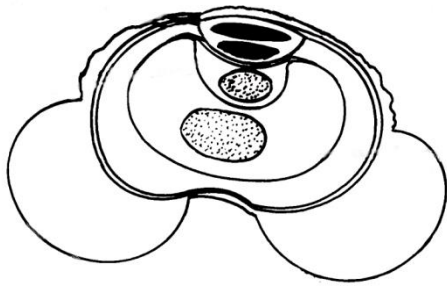


*PINUS*

# POLLEN GRAIN

# MICROGAMETOPHYTE

**PROTHALLIAL CELLS**



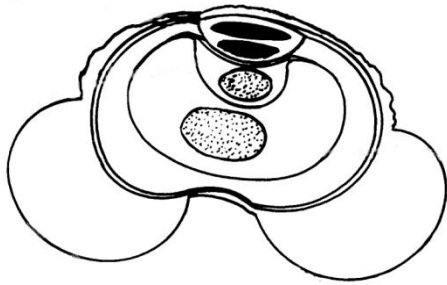
*PINUS*

**POLLEN GRAIN**

# MICROGAMETOPHYTE

?

PROTHALLIAL CELLS



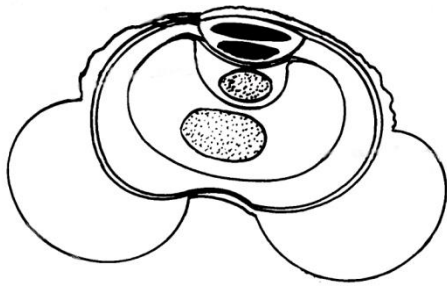
*PINUS*

# POLLEN GRAIN

# MICROGAMETOPHYTE

**GENERATIVE CELL**

**PROTHALLIAL CELLS**



*PINUS*

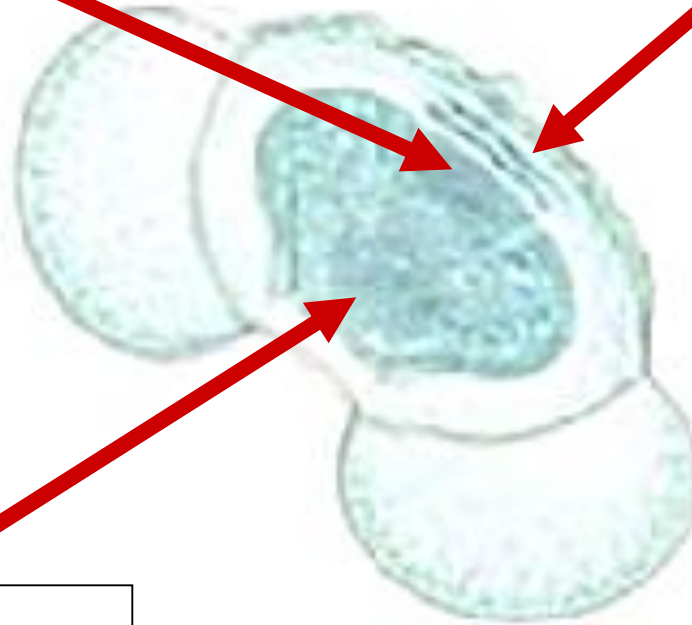
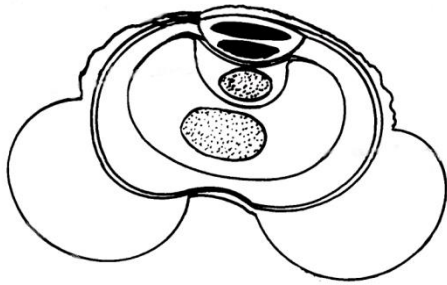
**POLLEN GRAIN**



# MICROGAMETOPHYTE

**GENERATIVE CELL**

**PROTHALLIAL CELLS**



*PINUS*

?

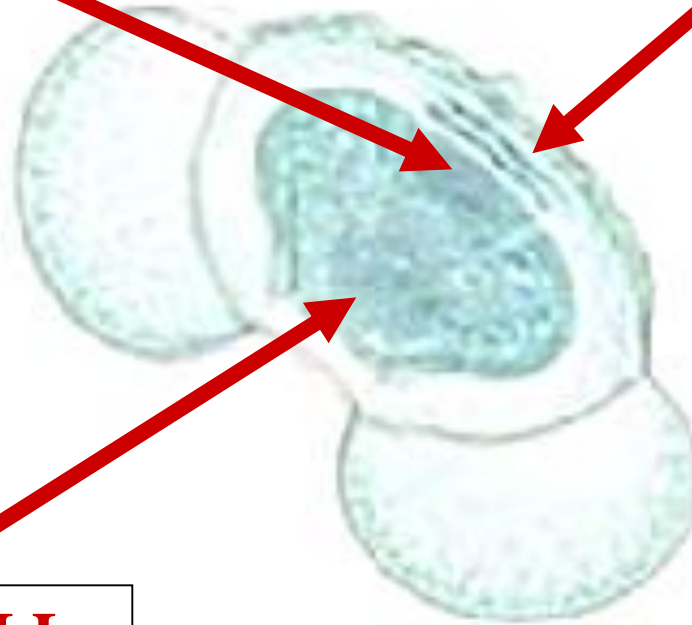
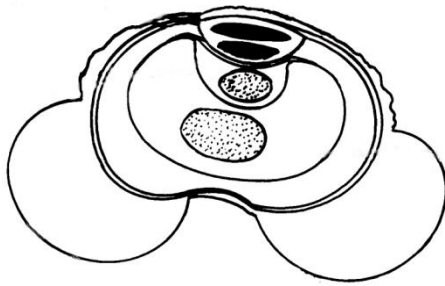
**POLLEN GRAIN**



# MICROGAMETOPHYTE

**GENERATIVE CELL**

**PROTHALLIAL CELLS**



*PINUS*

**TUBE CELL**

**POLLEN GRAIN**



# MICROGAMETOPHYTE

**GYMNOSPERM  
MICROGAMETOPHYTE  
HIGHLY REDUCED**

**POLLEN GRAIN**



# MEGAGAMETOPHYTE

A

# OVULE

MEGAGAMETOPHYTE

MICROPYLE

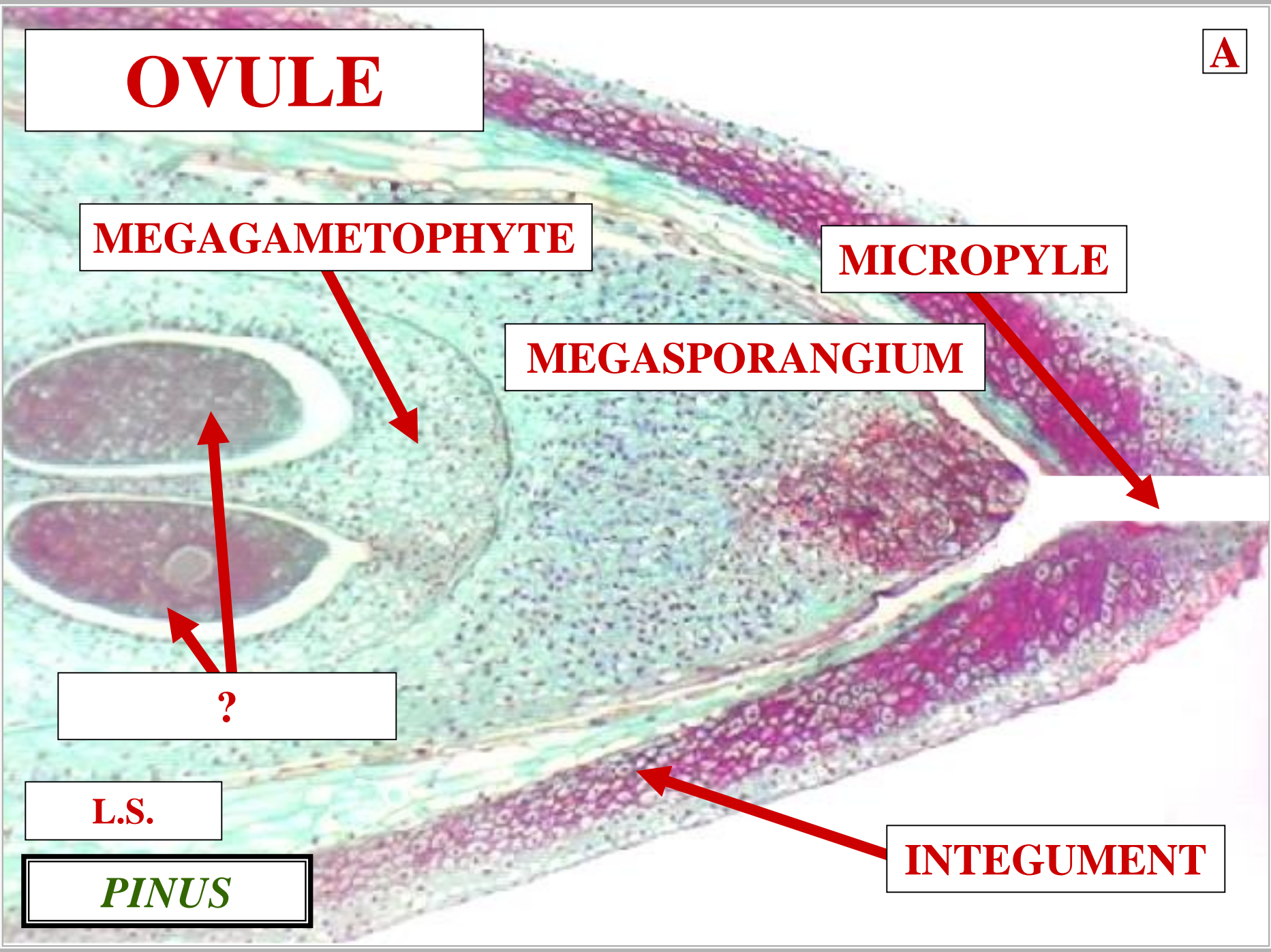
MEGASPORANGIUM

?

L.S.

*PINUS*

INTEGUMENT



# OVULE

MEGAGAMETOPHYTE

MICROPYLE

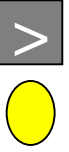
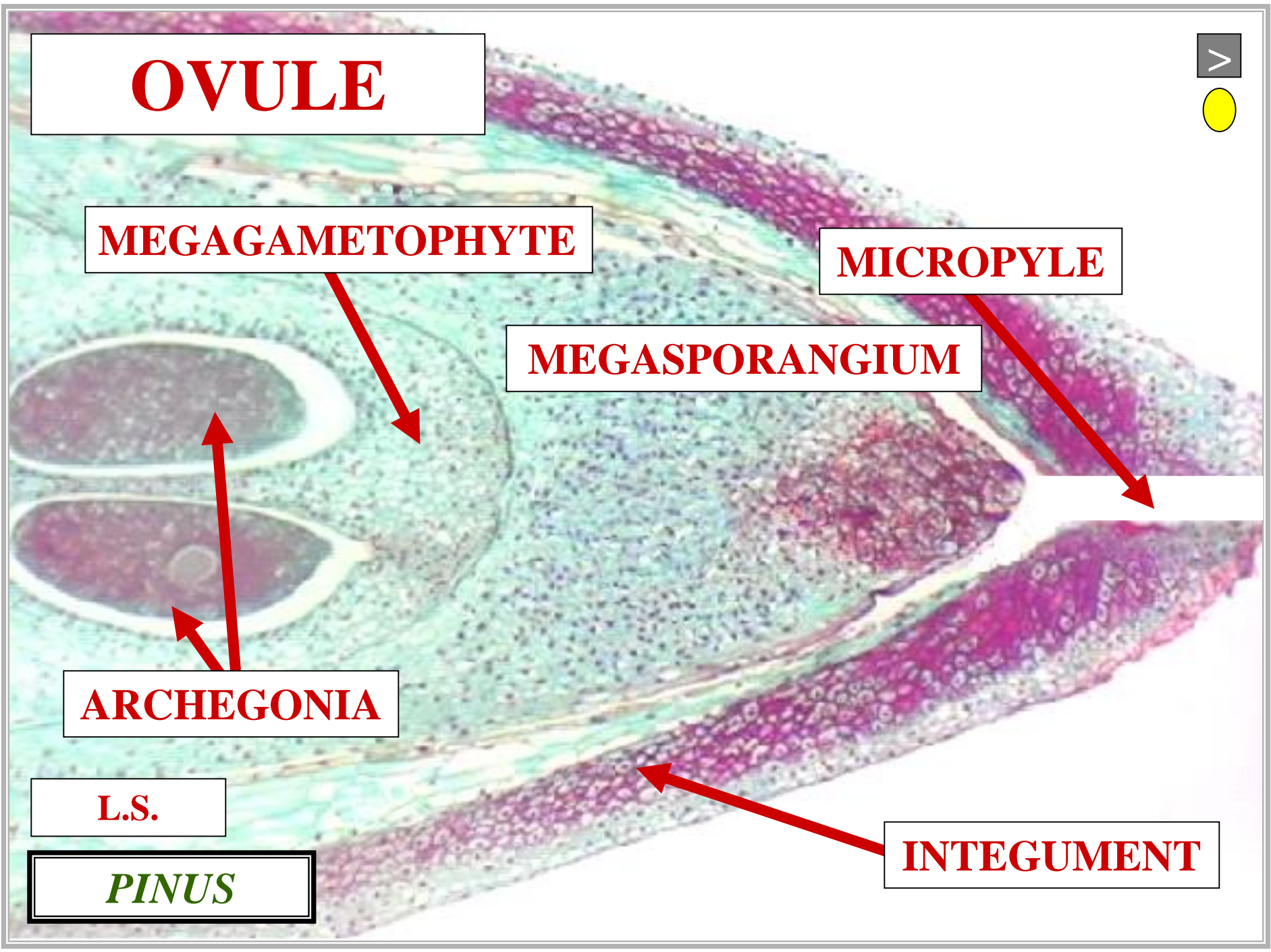
MEGASPORANGIUM

ARCHEGONIA

L.S.

*PINUS*

INTEGUMENT



# OVULE

PT

MEGAGAMETOPHYTE

POLLINATION

MEGASPORANGIUM

1N

1N

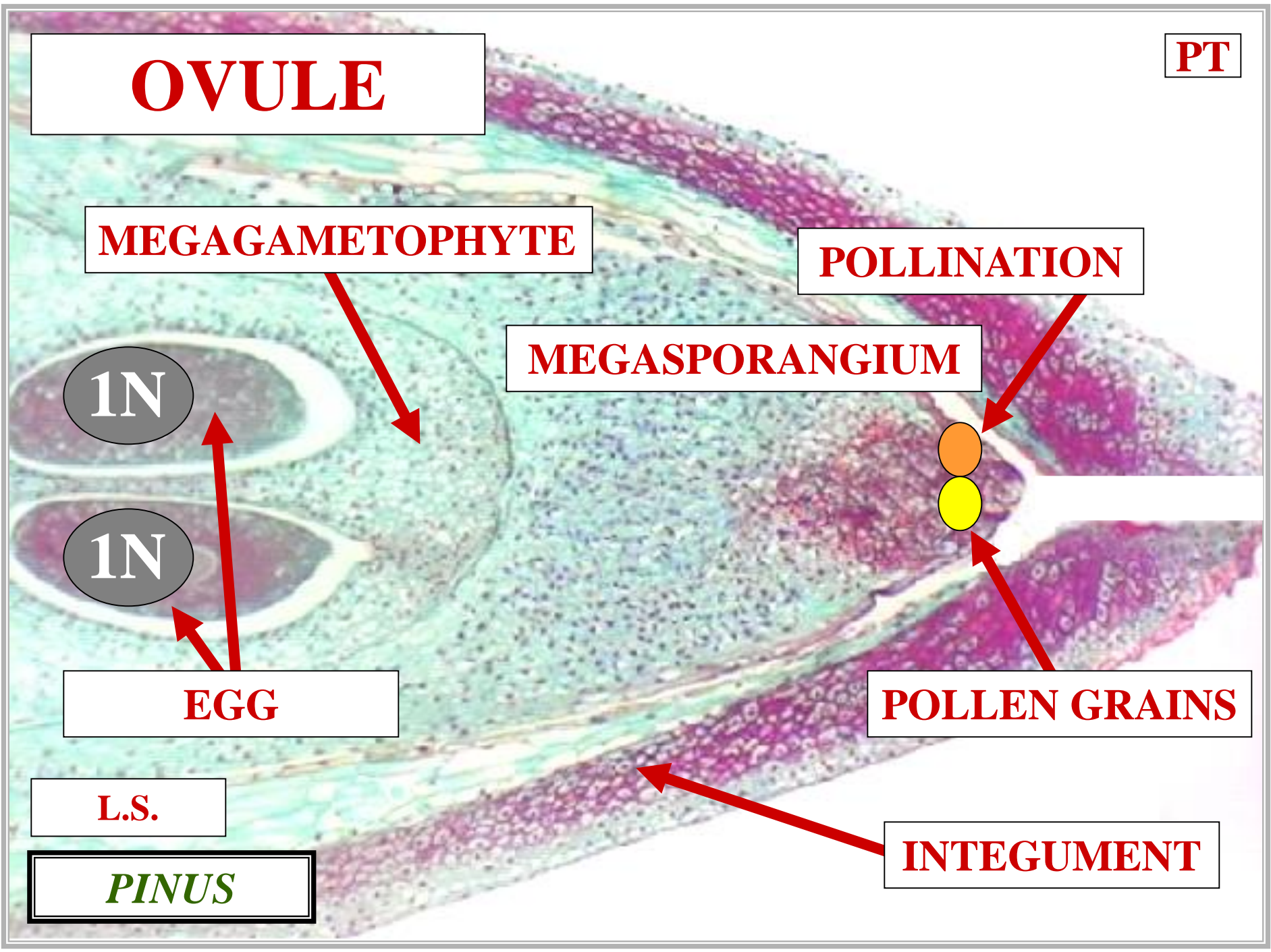
EGG

POLLEN GRAINS

L.S.

INTEGUMENT

*PINUS*



# OVULE

MEGAGAMETOPHYTE

MICROPYLE

MEGASPORANGIUM

1N

1N

EGG

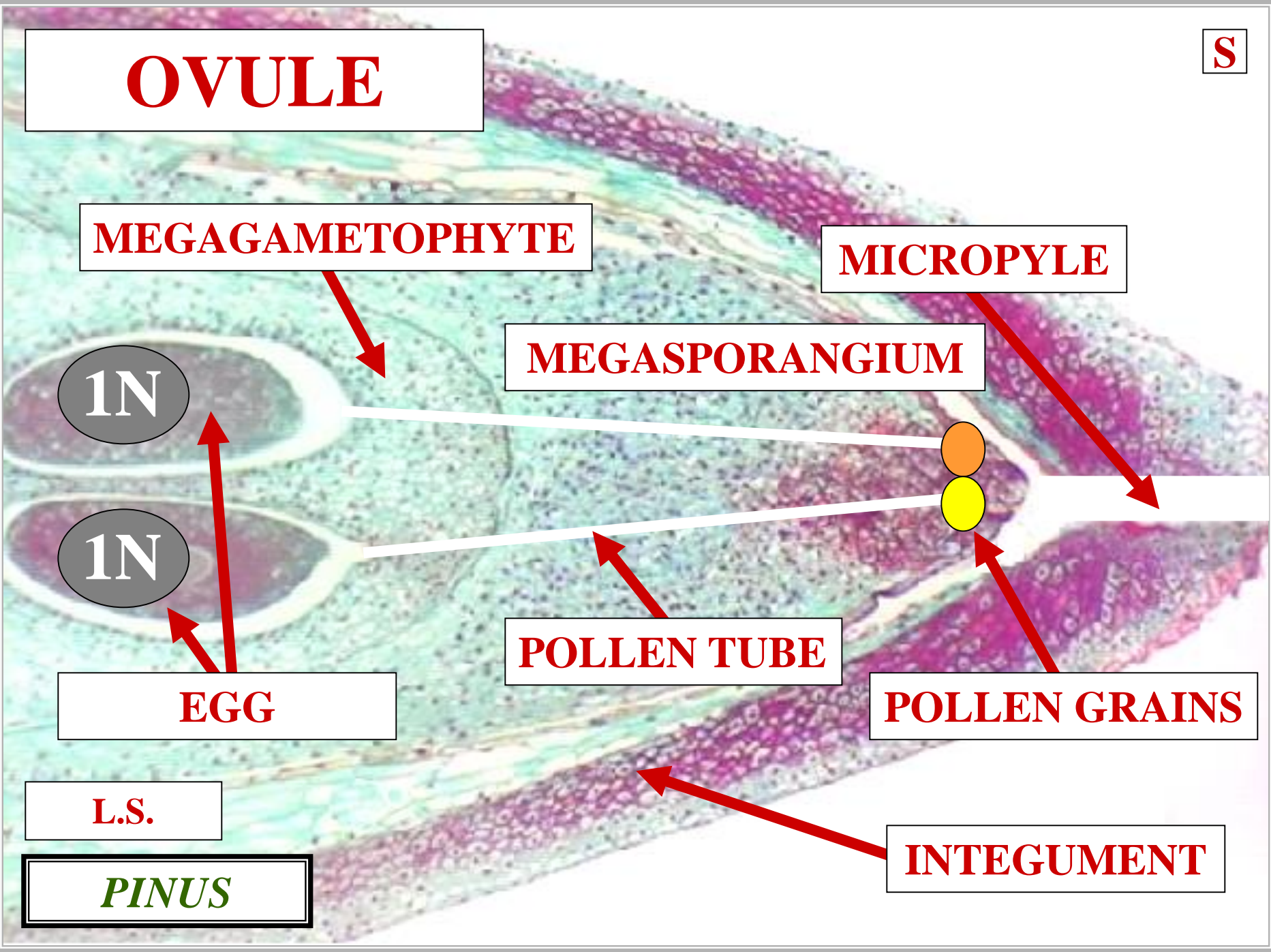
POLLEN TUBE

POLLEN GRAINS

L.S.

*PINUS*

INTEGUMENT





# OVULE

MEGAGAMETOPHYTE

MICROPYLE

MEGASPORANGIUM

1N

1N

EGG

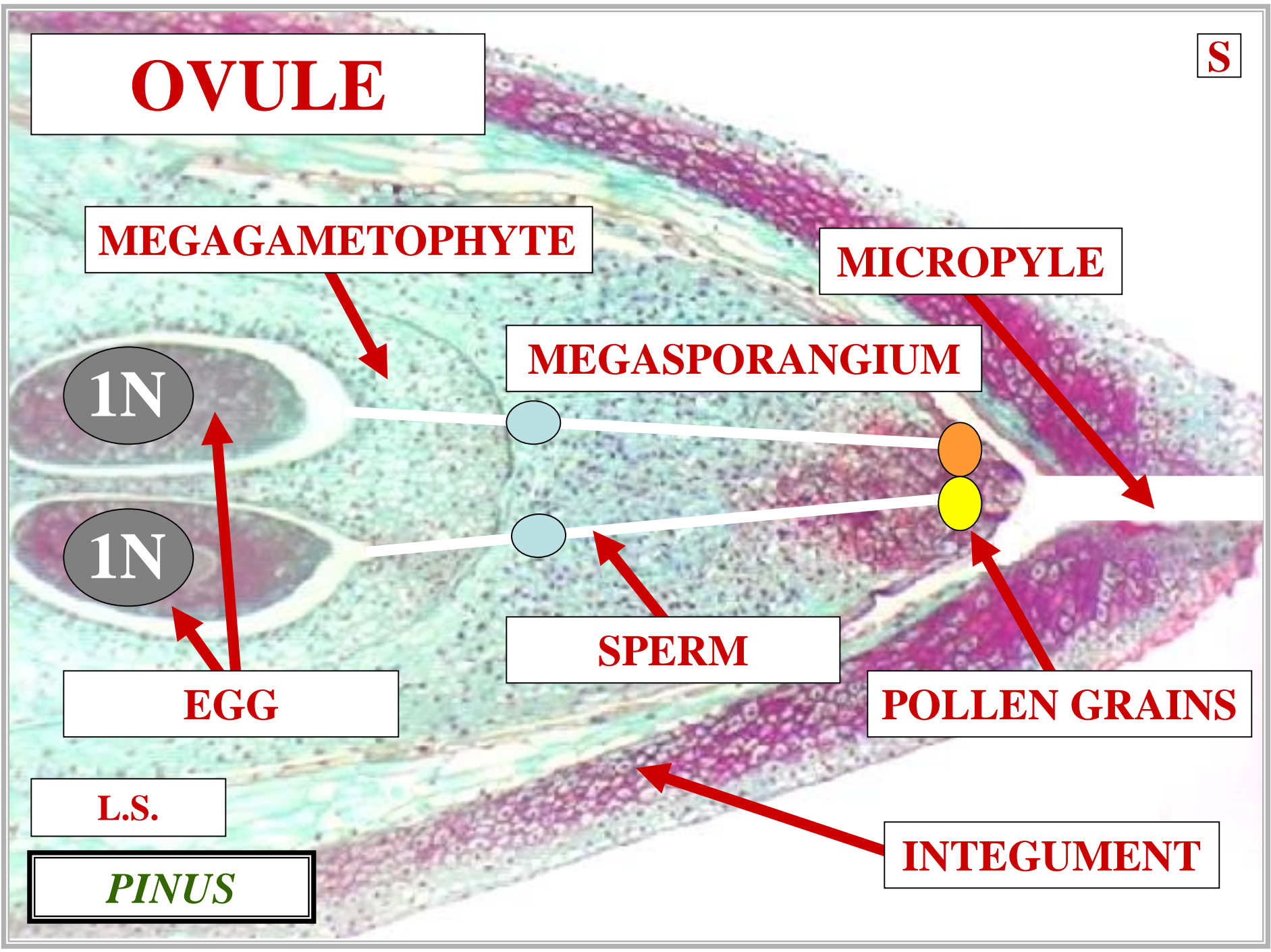
SPERM

POLLEN GRAINS

L.S.

*PINUS*

INTEGUMENT



# OVULE

MEGAGAMETOPHYTE

MICROPYLE

MEGASPORANGIUM

2N

2N

POLLEN TUBE

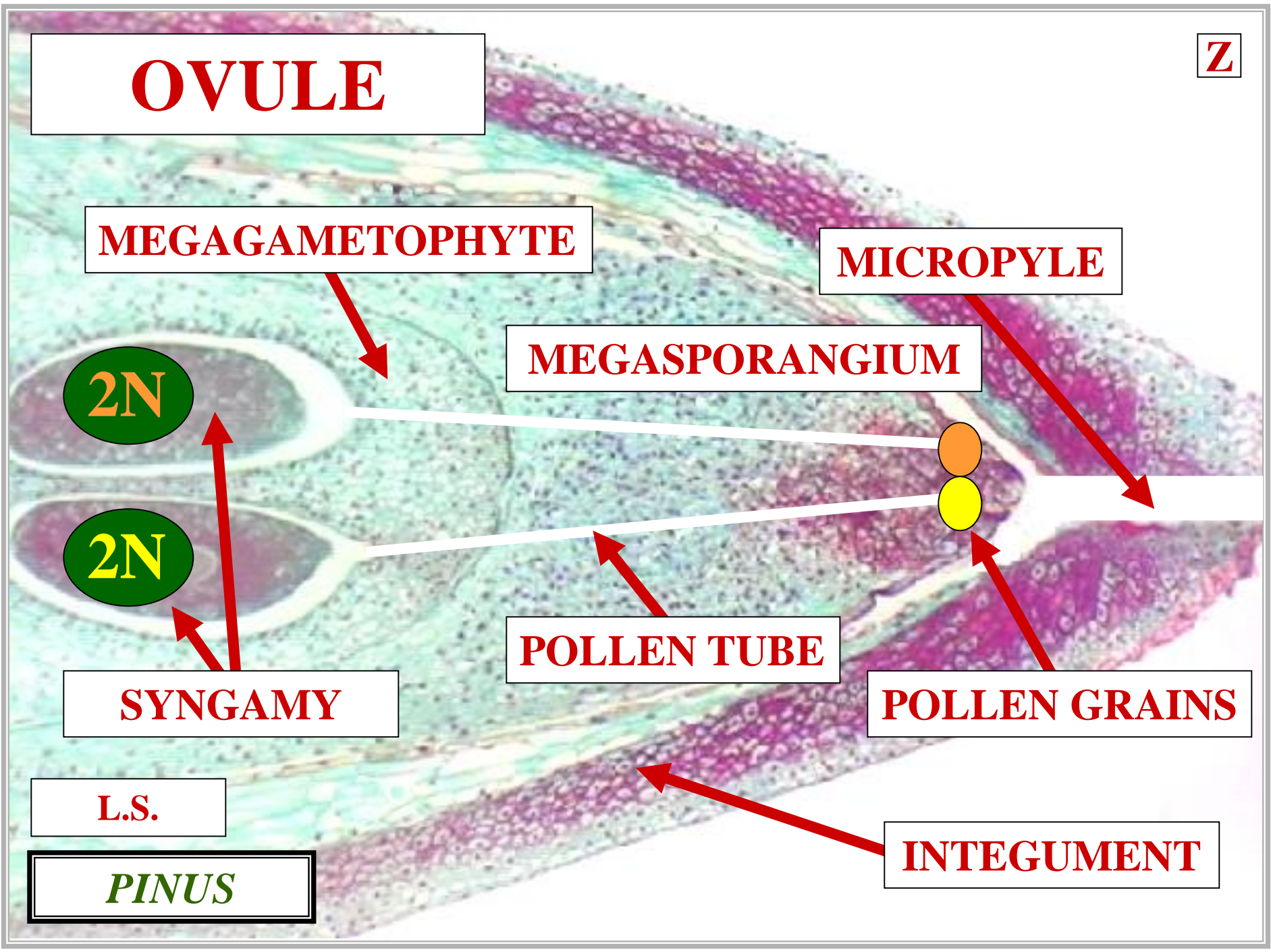
SYNGAMY

POLLEN GRAINS

L.S.

INTEGUMENT

*PINUS*



# OVULE

MEGAGAMETOPHYTE

MICROPYLE

MEGASPORANGIUM

2N

2N

POLLEN TUBE

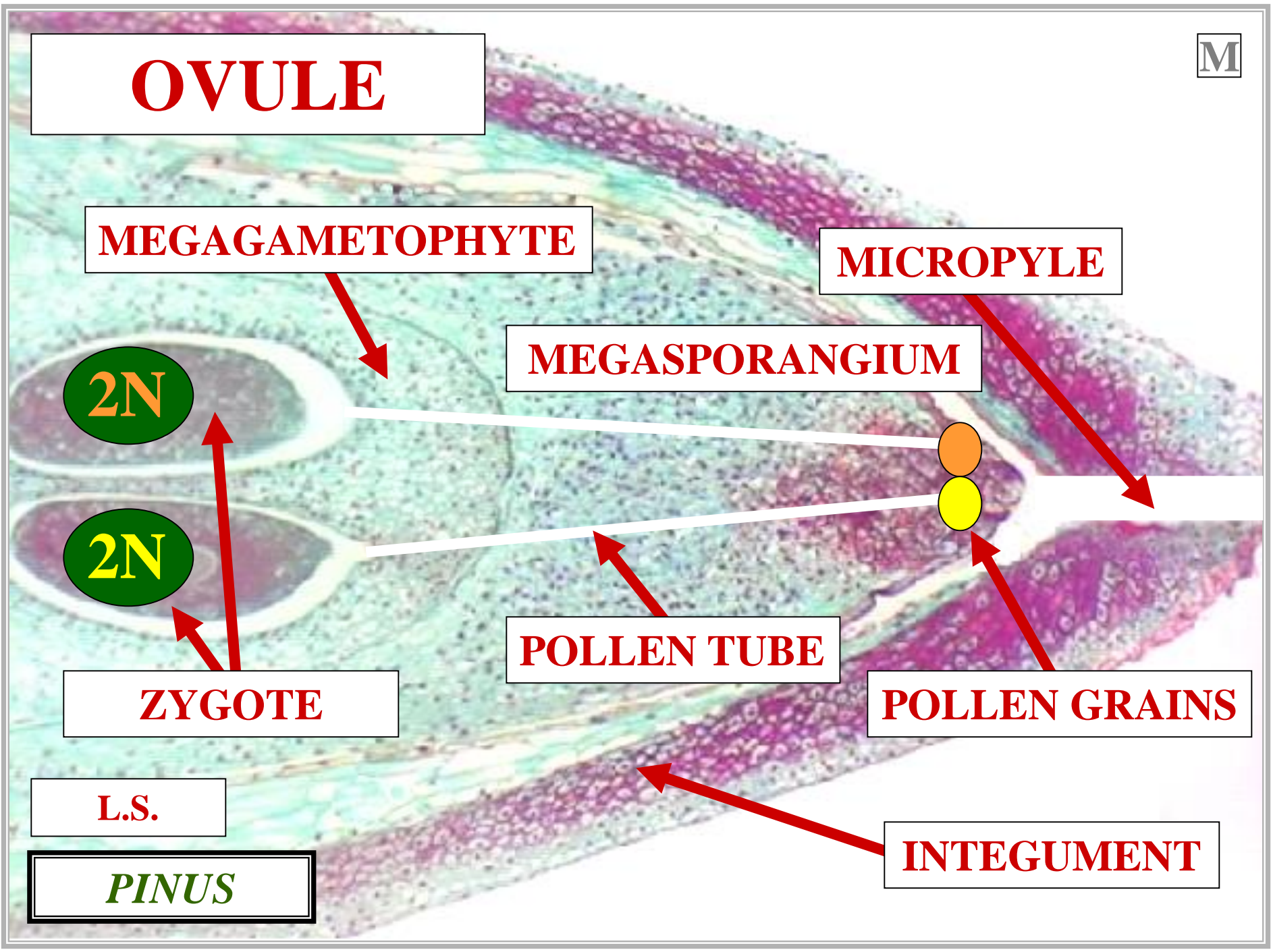
ZYGOTE

POLLEN GRAINS

L.S.

*PINUS*

INTEGUMENT



# OVULE



MEGAGAMETOPHYTE

MICROPYLE

MEGASPORANGIUM

2N

2N

POLLEN TUBE

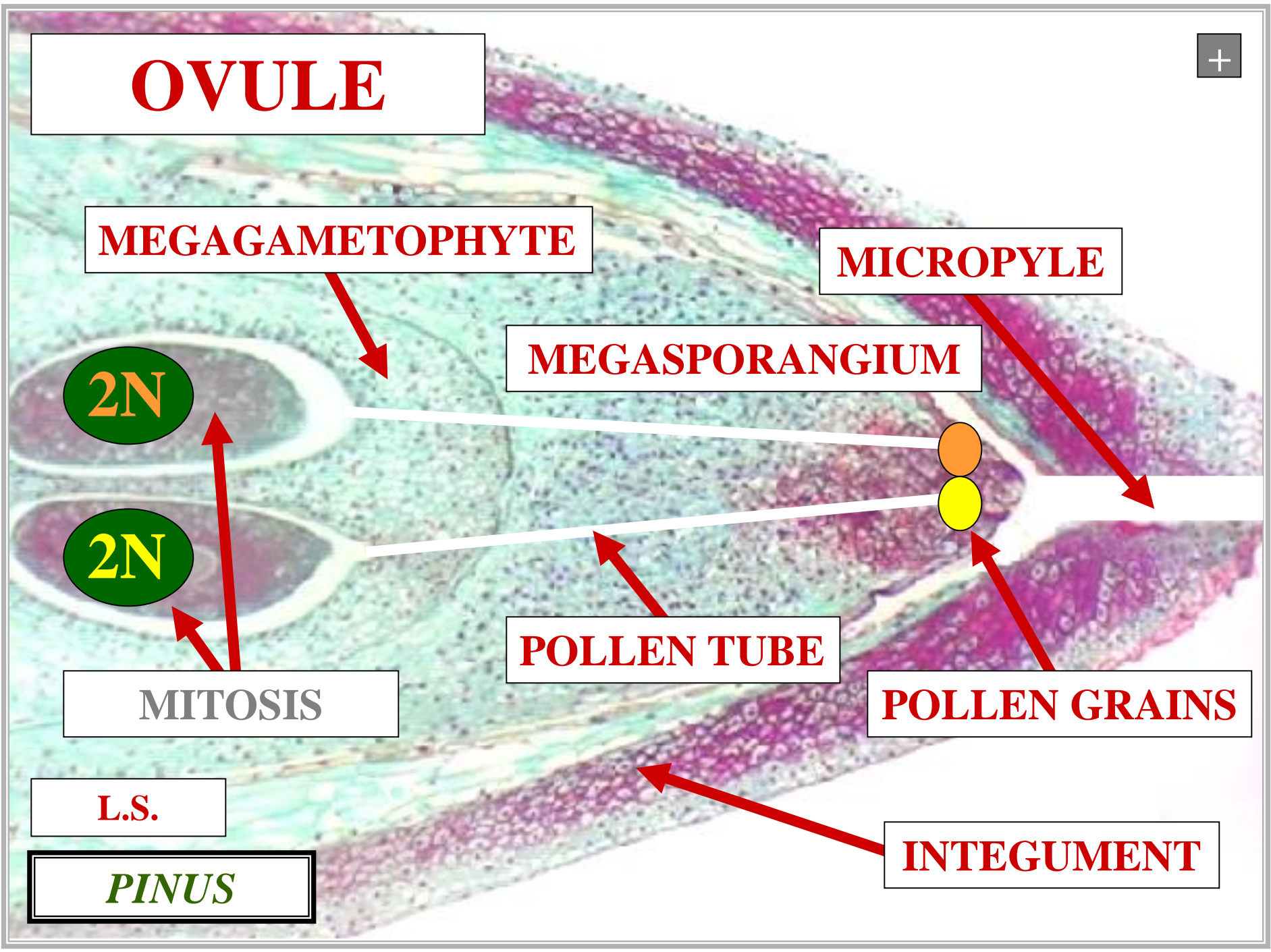
MITOSIS

POLLEN GRAINS

L.S.

*PINUS*

INTEGUMENT



**SEED**

**MEGAGAMETOPHYTE**

**MICROPYLE**



2N

**MEGASPORANGIUM**



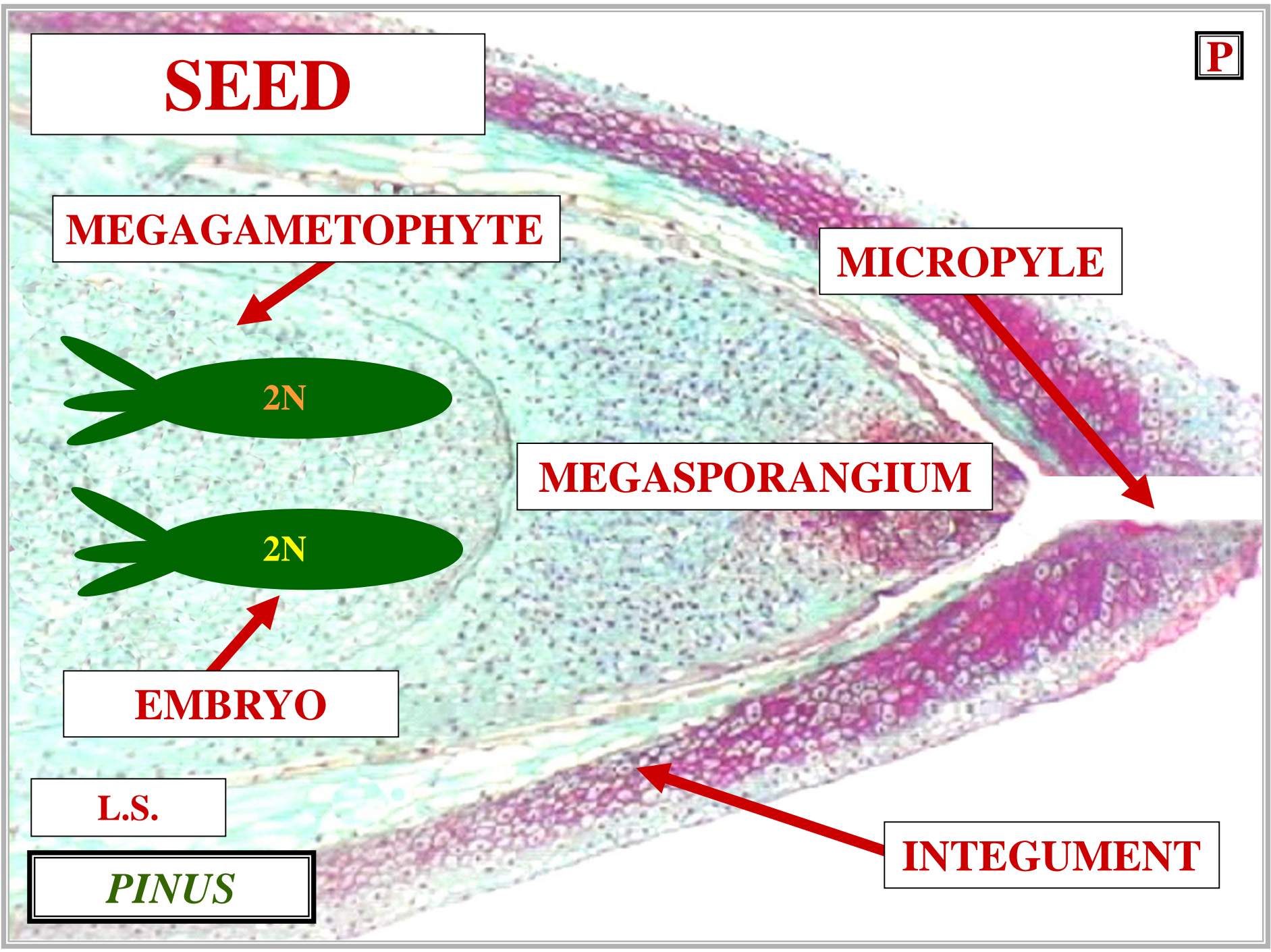
2N

**EMBRYO**

**L.S.**

***PINUS***

**INTEGUMENT**



**SEED**

**POLYEMBRYONY**

**P**

**MEGAGAMETOPHYTE**

**MICROPYLE**



**2N**



**2N**

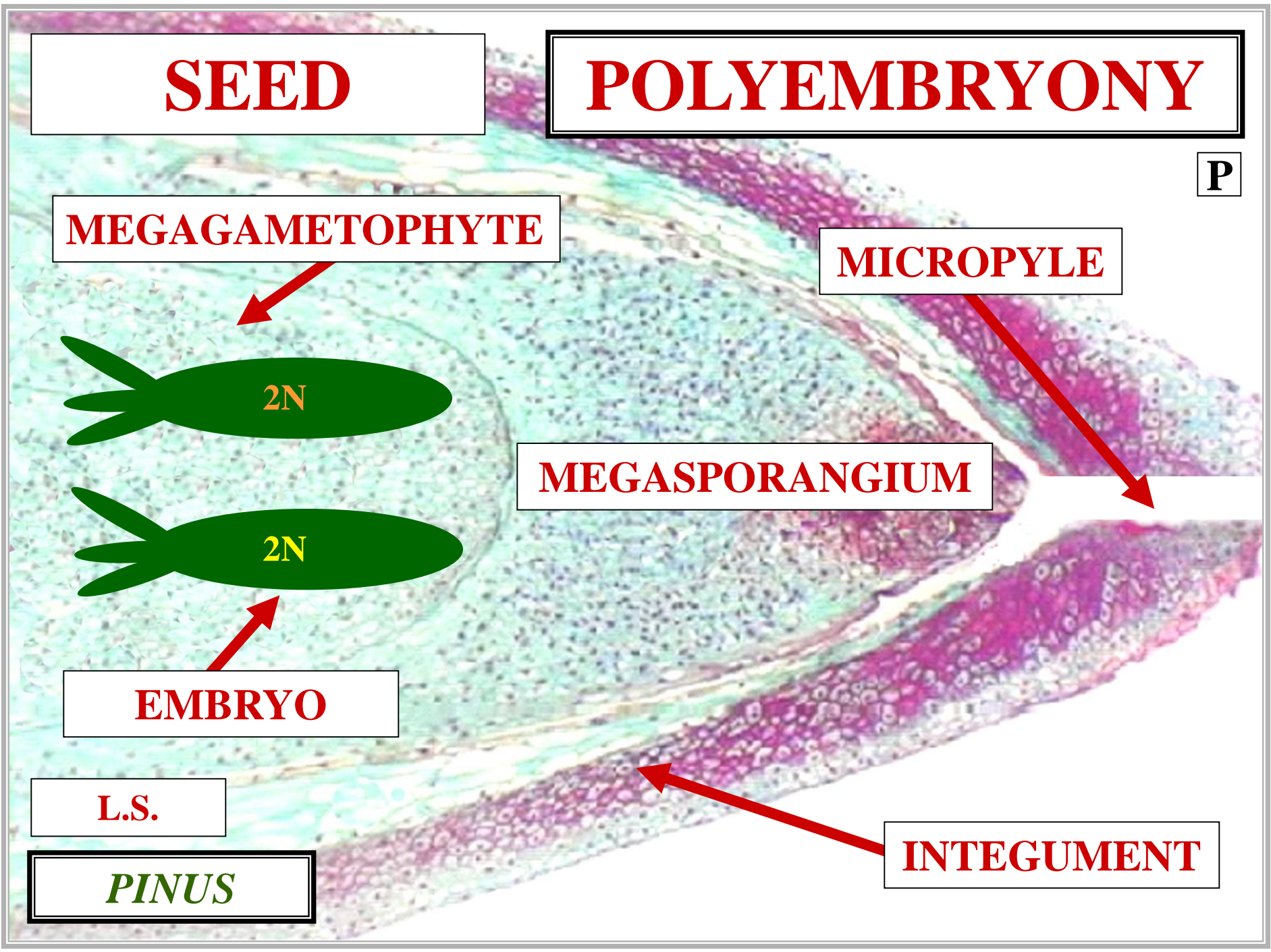
**MEGASPORANGIUM**

**EMBRYO**

**L.S.**

***PINUS***

**INTEGUMENT**



**POLYEMBRYONY**



# **GYMNOSPERM POLYEMBRYONY**

**1+ EMBRYO/SEED**

**GYMNOSPERM  
POLYEMBRYONY**



**SEED**

**POLYEMBRYONY**

**1**

**MEGAGAMETOPHYTE**

**MICROPYLE**



**2N**



**2N**

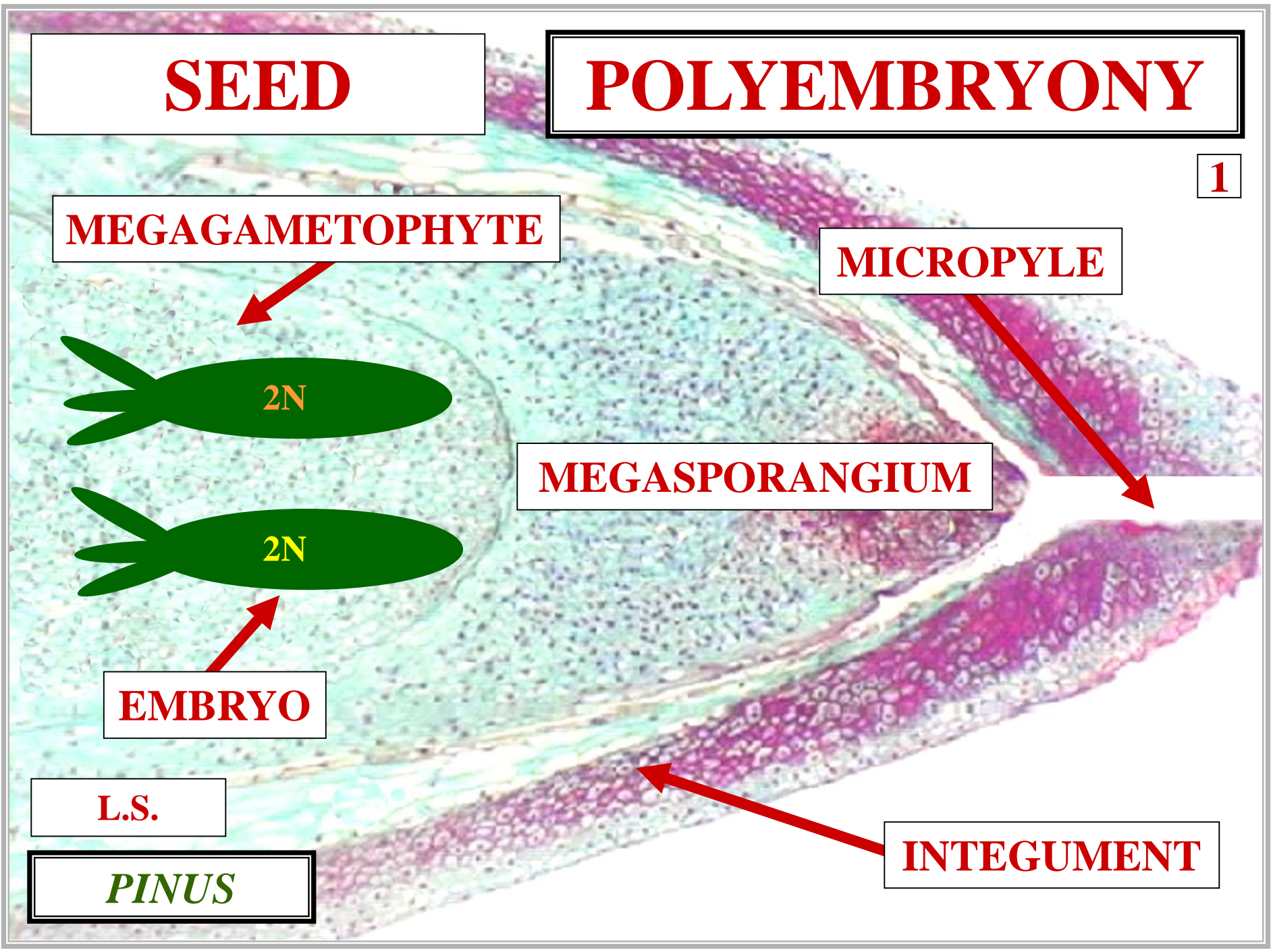
**MEGASPORANGIUM**

**EMBRYO**

**L.S.**

***PINUS***

**INTEGUMENT**



**SEED**

**POLYEMBRYONY**

**MEGAGAMETOPHYTE**

**MICROPYLE**

?

N



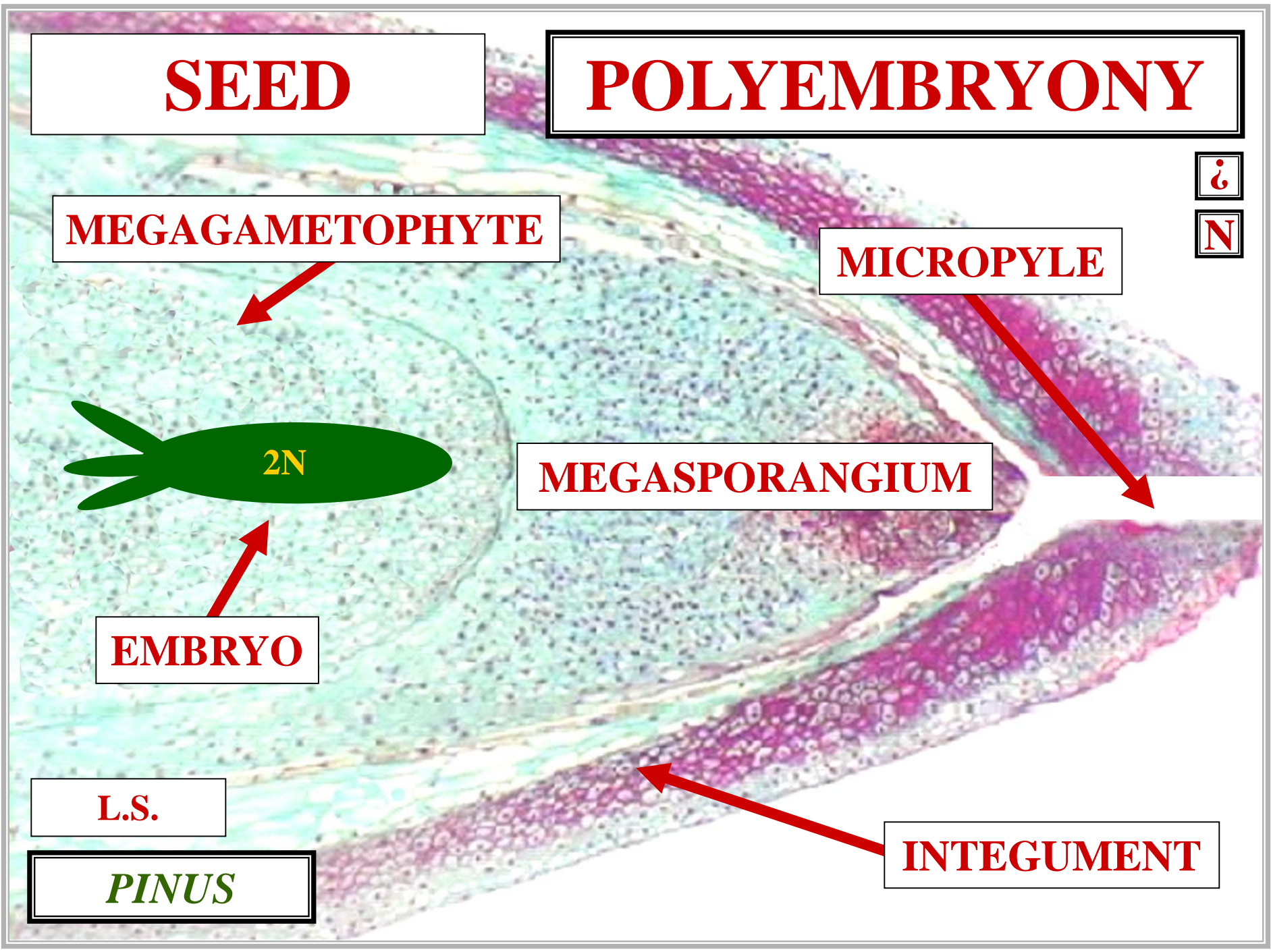
**MEGASPORANGIUM**

**EMBRYO**

**L.S.**

***PINUS***

**INTEGUMENT**



# NATURAL SELECTION



MEGAGAMETOPHYTE

MICROPYLE



2N

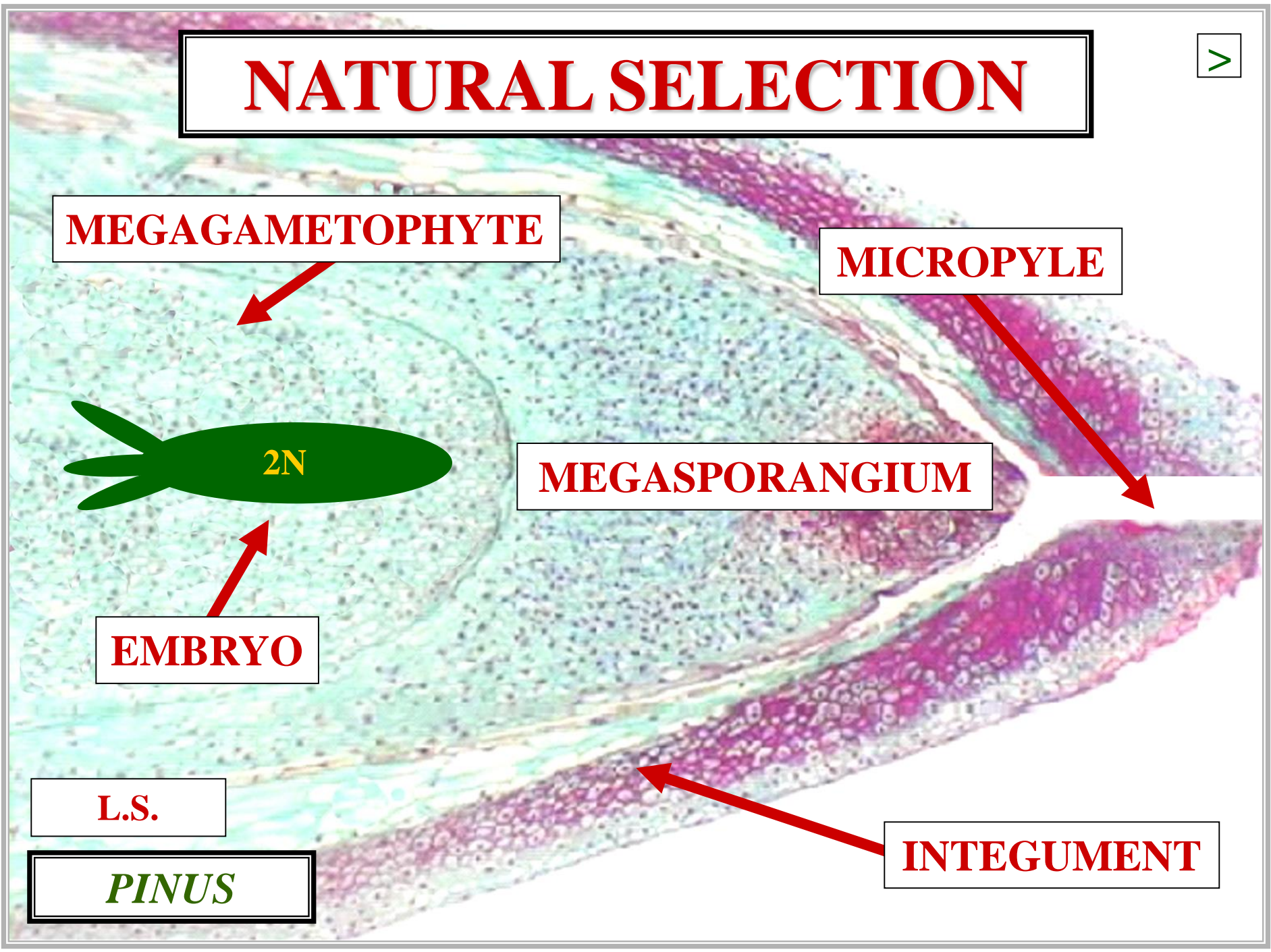
MEGASPORANGIUM

EMBRYO

L.S.

*PINUS*

INTEGUMENT





**GYMNOSPERMS  
EMBRYO  
UNDERGOES  
NATURAL SELECTION  
PRIOR TO SEED  
GERMINATION**



M

**SPERM**



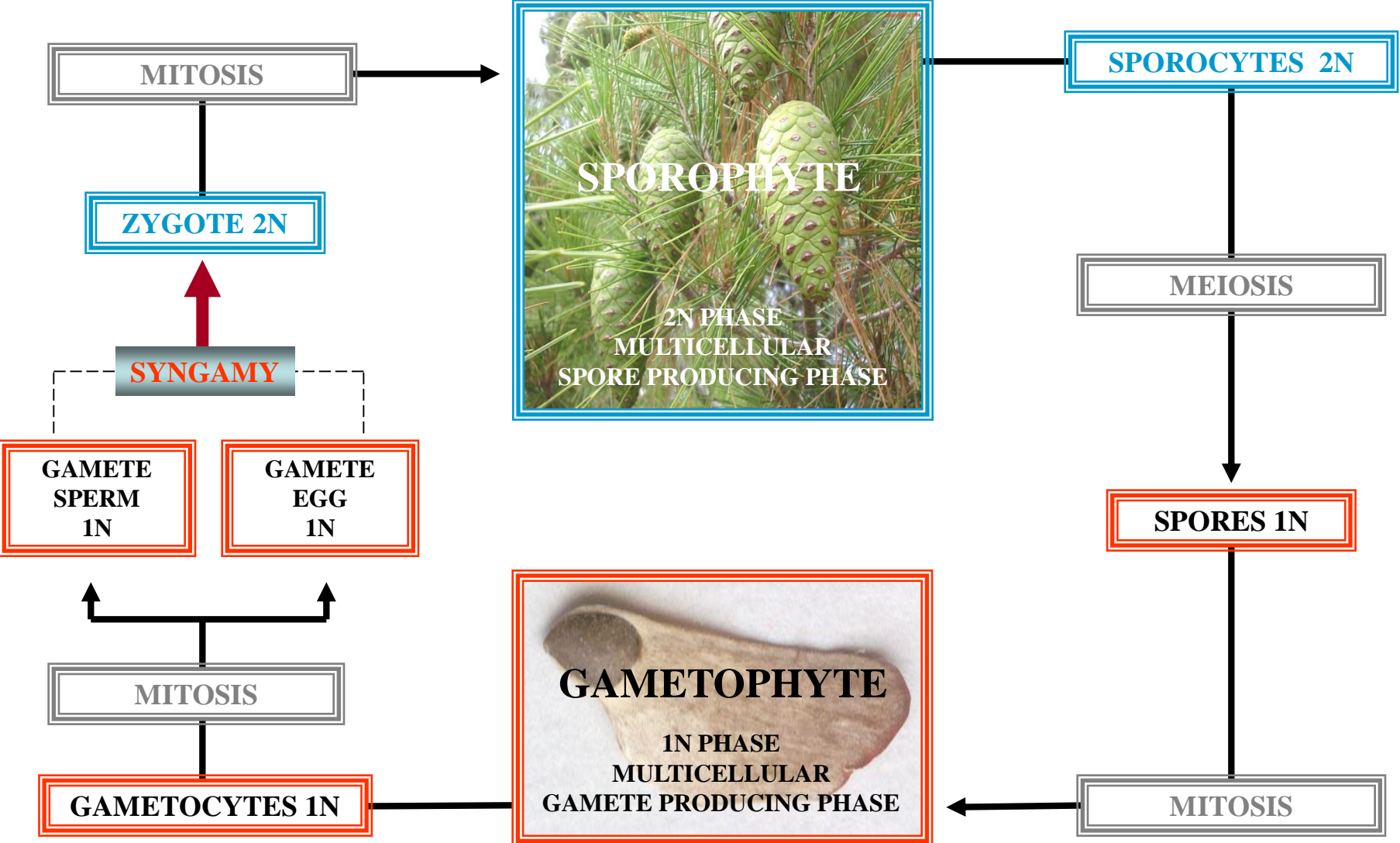
N

**GYMNOSPERMS**  
**SPERM**  
**MULTIFLAGELLATED**



**GYMNOSPERMS**  
**SPERM**  
**MULTIFLAGELLATED**  
**OR**  
**NON-FLAGELLATED**

# GYMNOSPERM LIFE CYCLE







# REPRODUCTION

**MONOECIOUS  
GYMNOSPERM  
VS  
DIOECIOUS  
GYMNOSPERM**

**MONOECIOUS  
GYMNOSPERM**

**GYMNOSPERM  
MONOECIOUS**

**MICROSPORANGIA  
AND  
MEGASPORANGIA  
SAME PLANT**

**GYMNOSPERM  
MONOECIOUS**

