

L.S.

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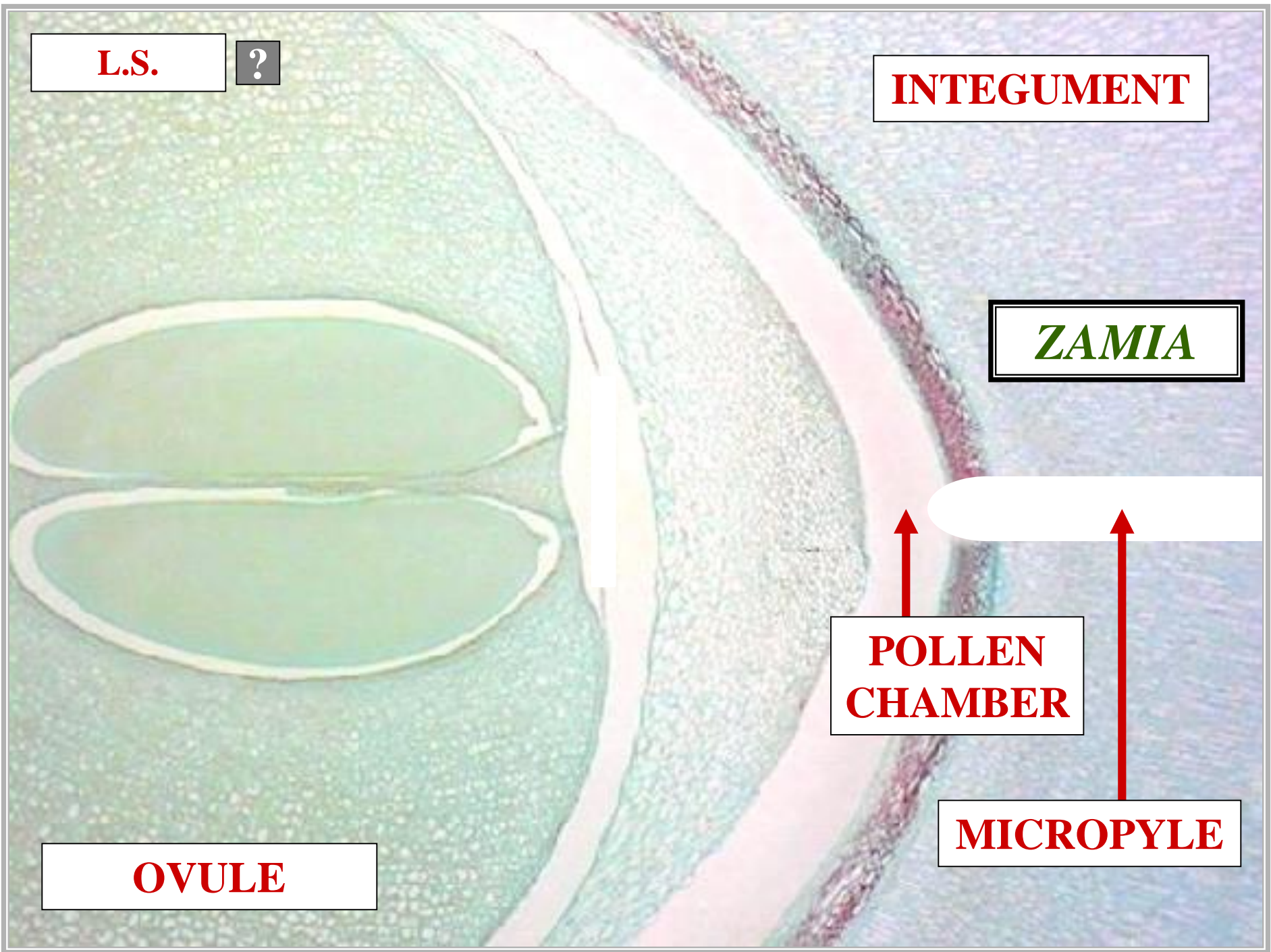
INTEGUMENT

ZAMIA

**POLLEN
CHAMBER**

MICROPYLE

OVULE



L.S.

M

INTEGUMENT

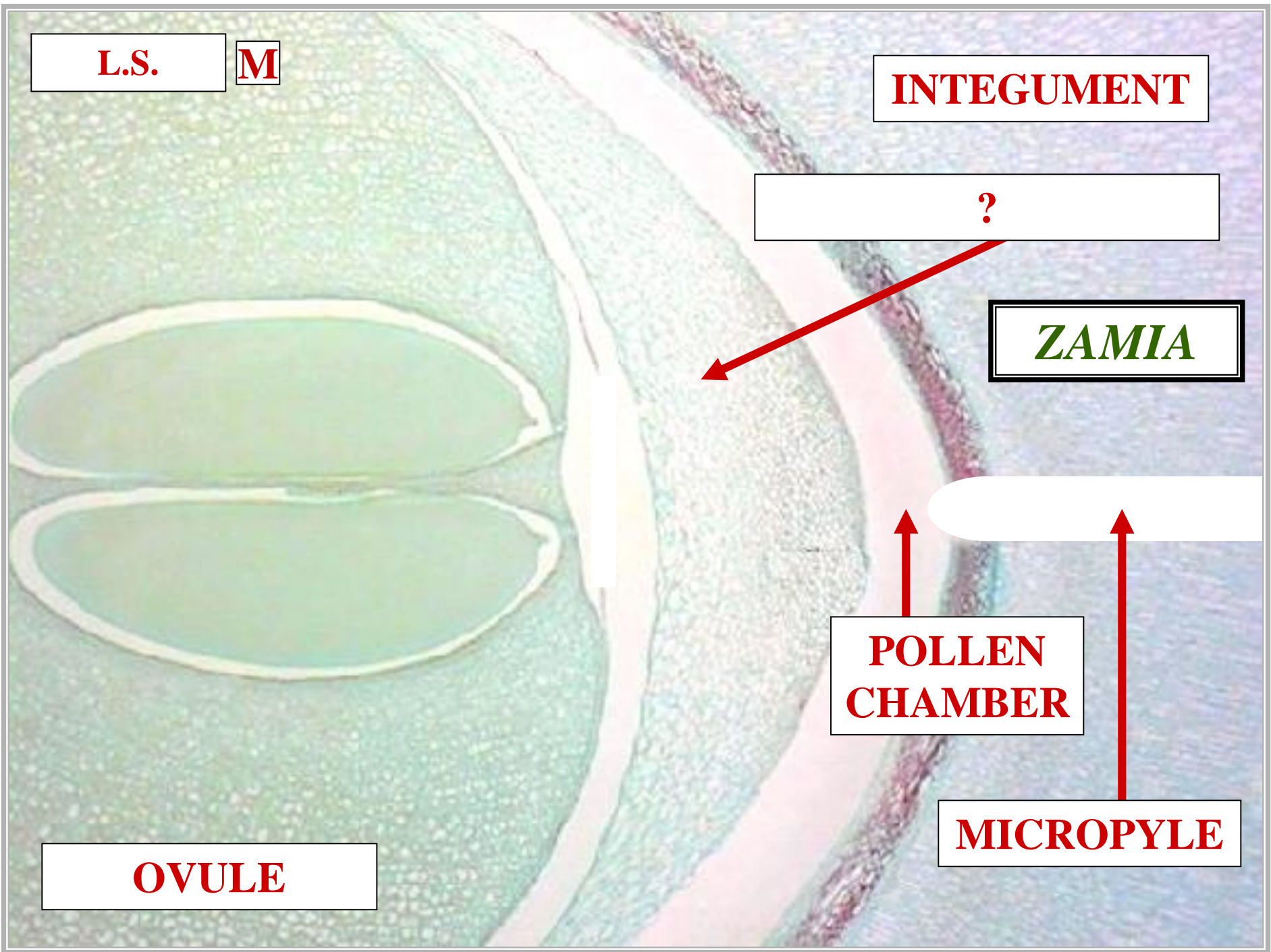
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ZAMIA

**POLLEN
CHAMBER**

MICROPYLE

OVULE



L.S.



INTEGUMENT

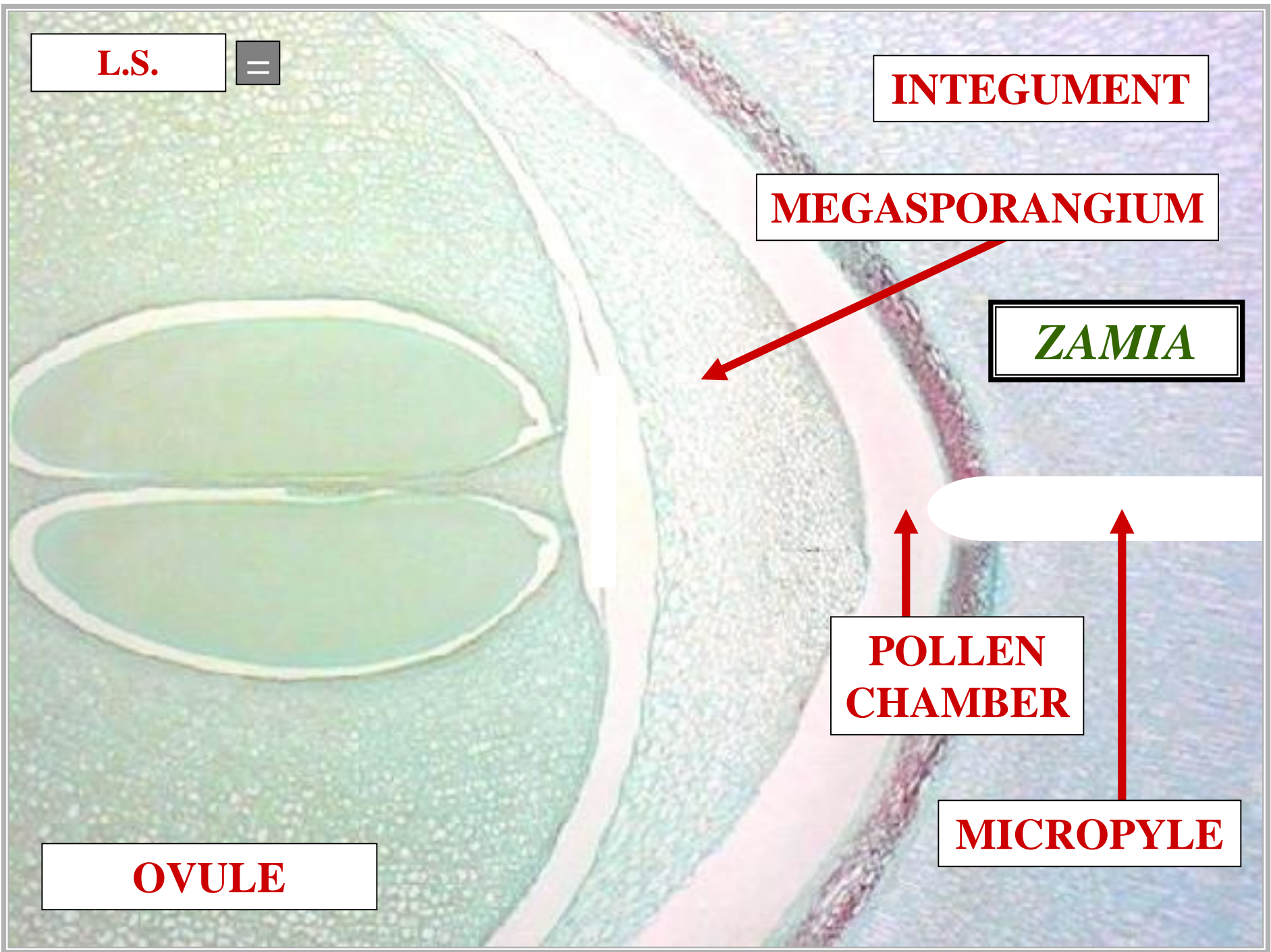
MEGASPORANGIUM

ZAMIA

**POLLEN
CHAMBER**

MICROPYLE

OVULE



L.S.

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INTEGUMENT

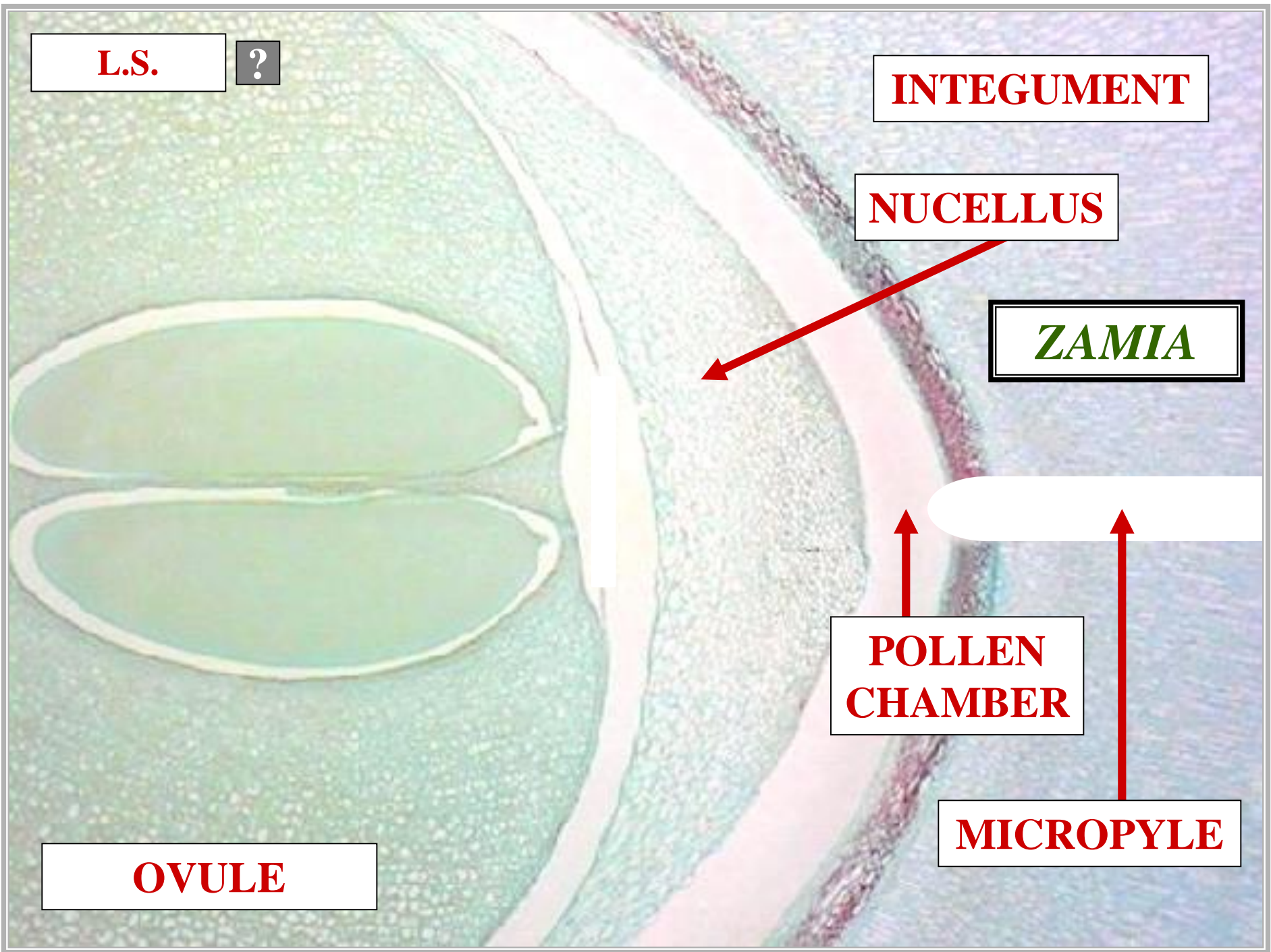
NUCELLUS

ZAMIA

**POLLEN
CHAMBER**

MICROPYLE

OVULE



L.S.

M

INTEGUMENT

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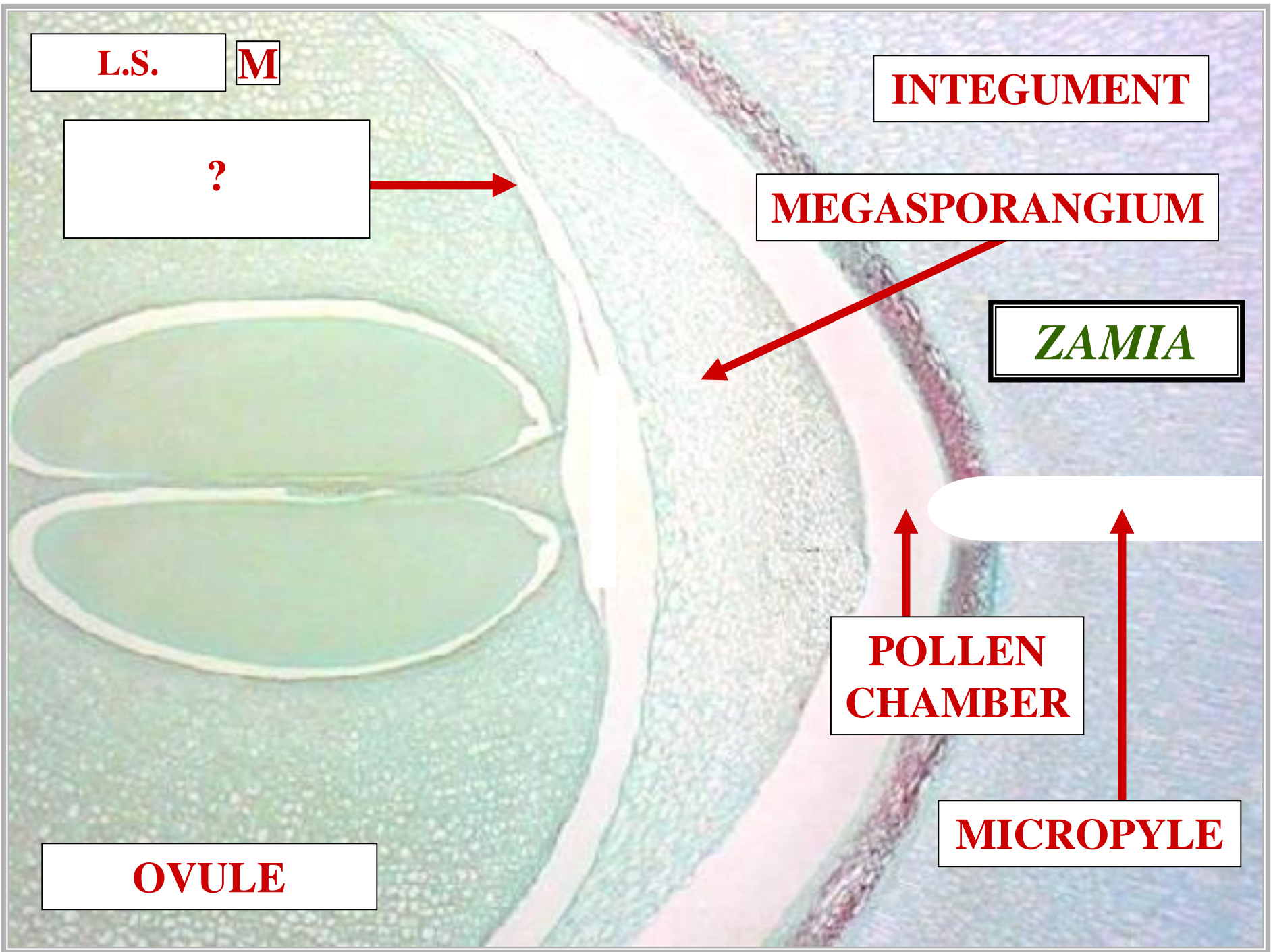
MEGASPORANGIUM

ZAMIA

POLLEN
CHAMBER

MICROPYLE

OVULE



L.S.

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INTEGUMENT

MEGASPORE
WALL

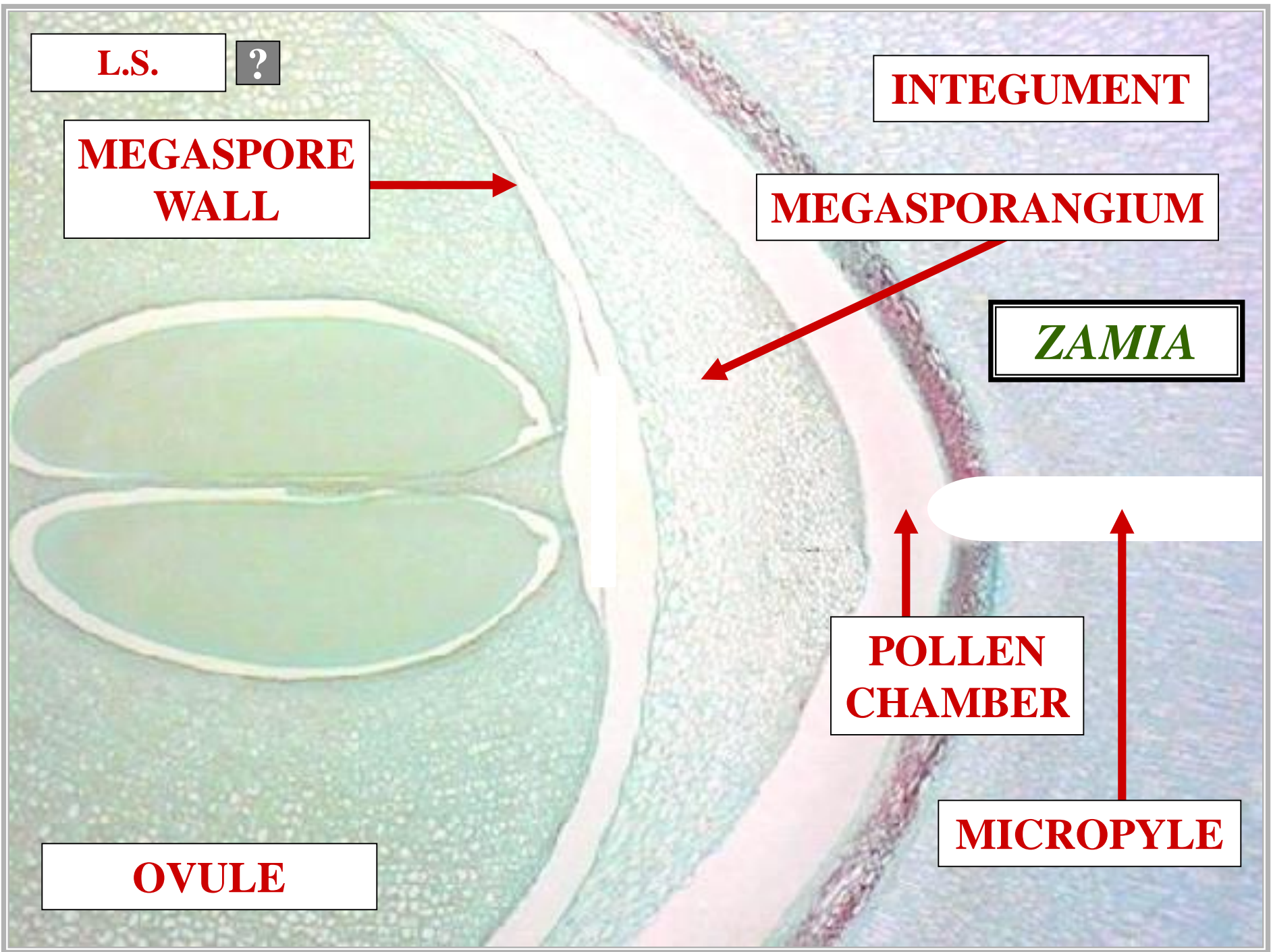
MEGASPORANGIUM

ZAMIA

POLLEN
CHAMBER

MICROPYLE

OVULE



L.S.

M

INTEGUMENT

MEGASPORE
WALL

MEGASPORANGIUM

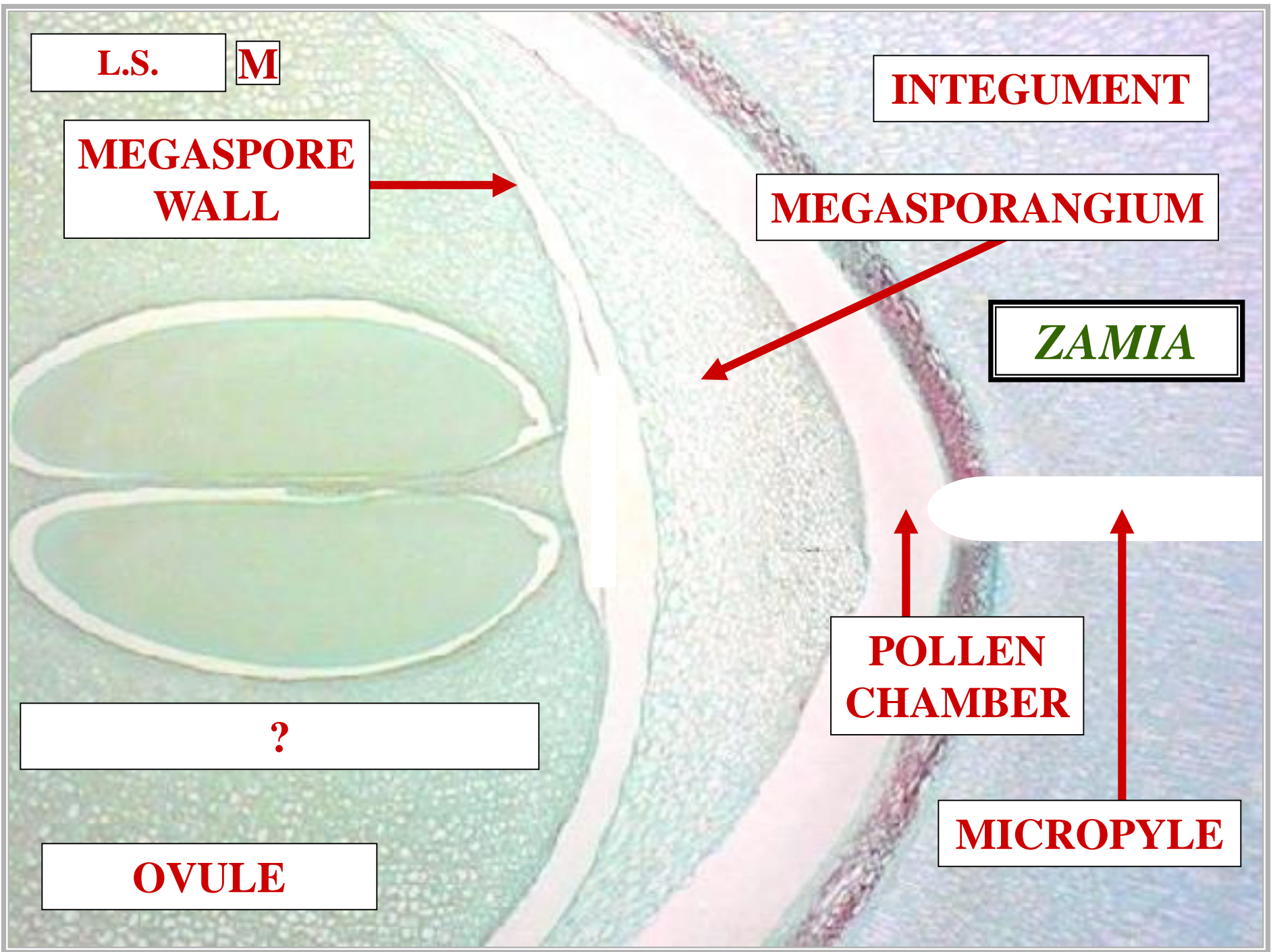
ZAMIA

POLLEN
CHAMBER

?

MICROPYLE

OVULE



L.S.

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INTEGUMENT

**MEGASPORE
WALL**

MEGASPORANGIUM

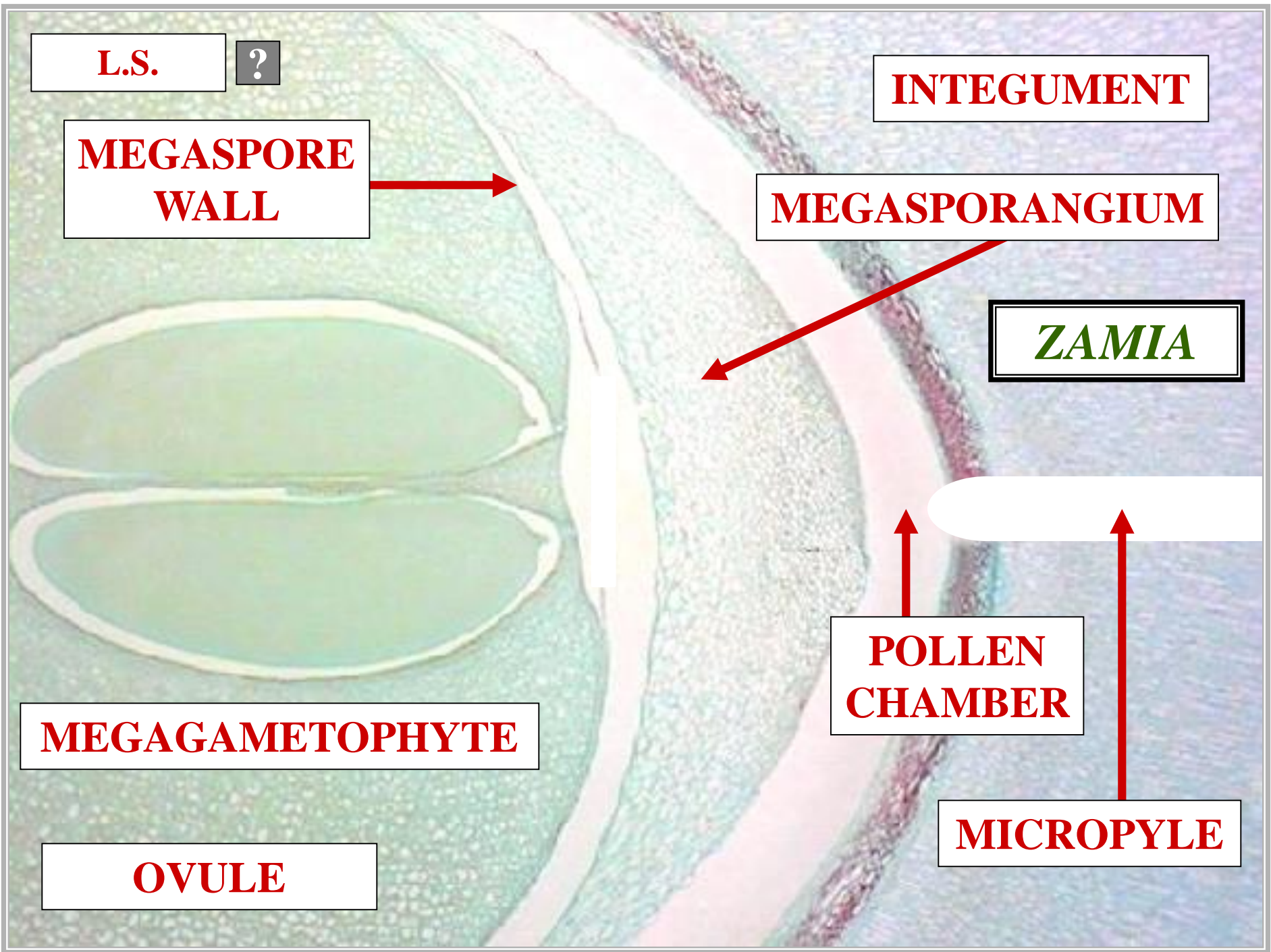
ZAMIA

MEGAGAMETOPHYTE

**POLLEN
CHAMBER**

OVULE

MICROPYLE



L.S.

A

INTEGUMENT

MEGASPORE
WALL

MEGASPORANGIUM

ZAMIA

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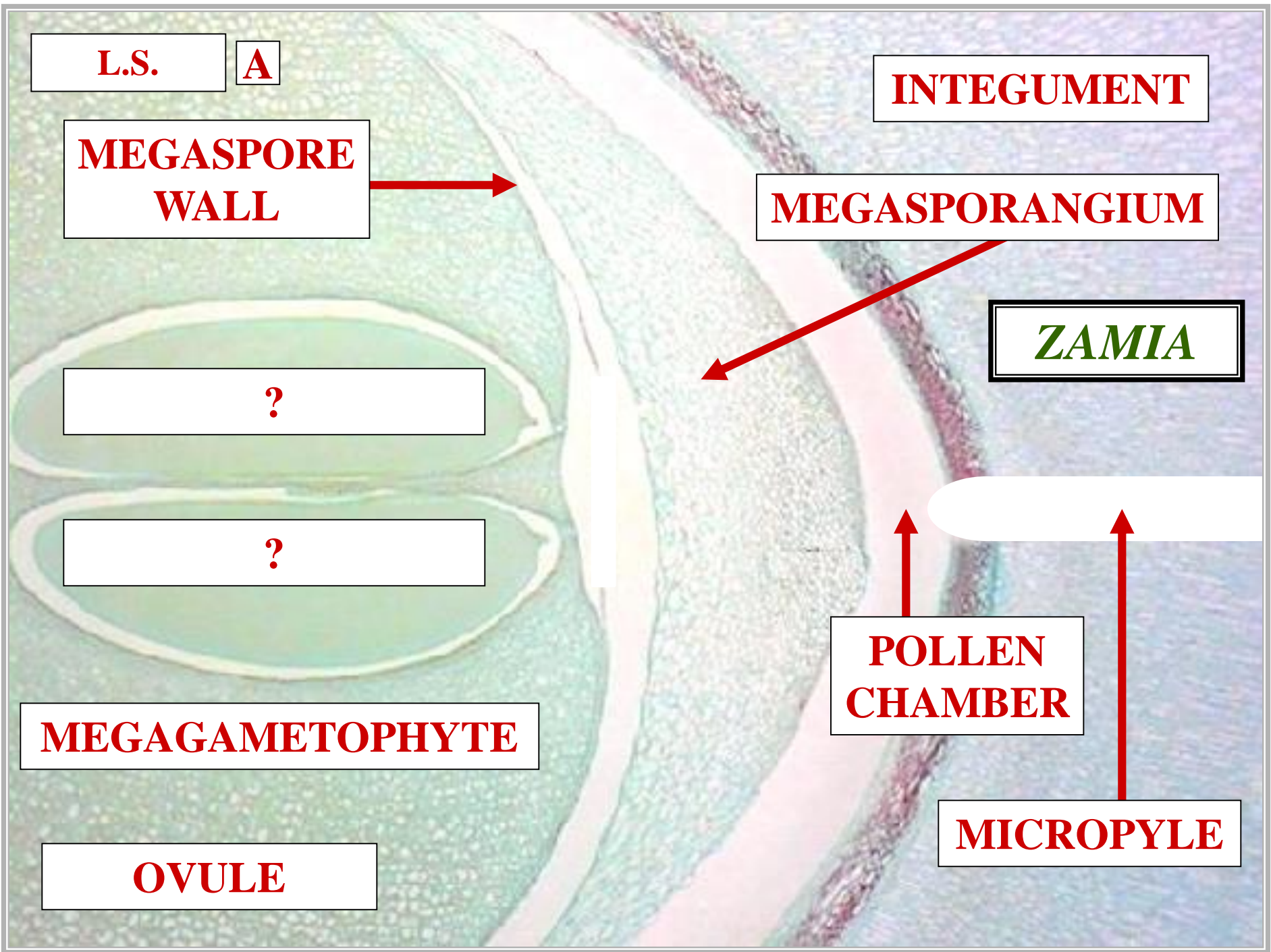
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POLLEN
CHAMBER

MEGAGAMETOPHYTE

MICROPYLE

OVULE



L.S.

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INTEGUMENT

MEGASPORE
WALL

MEGASPORANGIUM

ZAMIA

ARCHEGONIUM

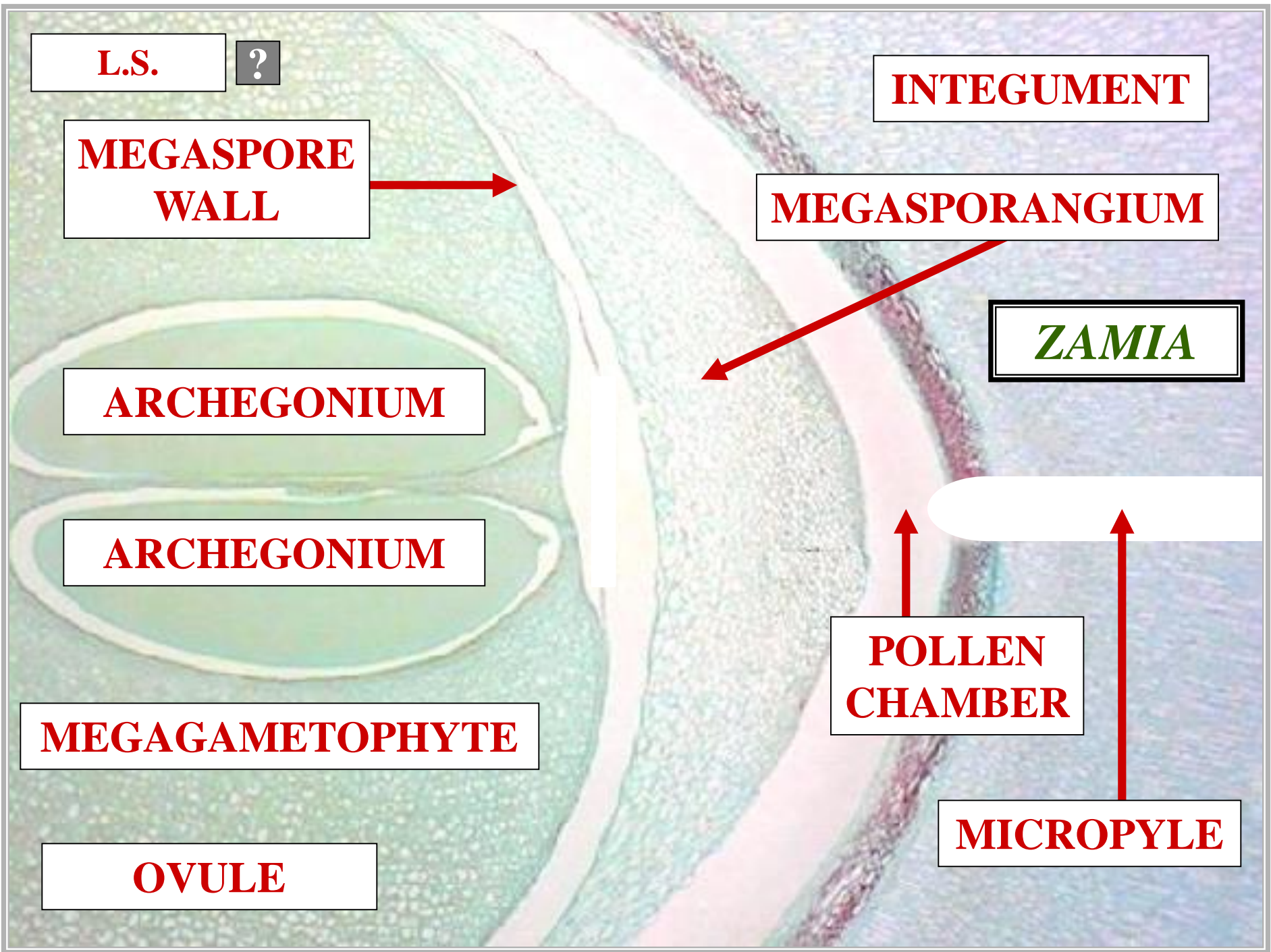
ARCHEGONIUM

MEGAGAMETOPHYTE

POLLEN
CHAMBER

OVULE

MICROPYLE



L.S.

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INTEGUMENT

MEGASPORE
WALL

MEGASPORANGIUM

ZAMIA

ARCHEGONIUM

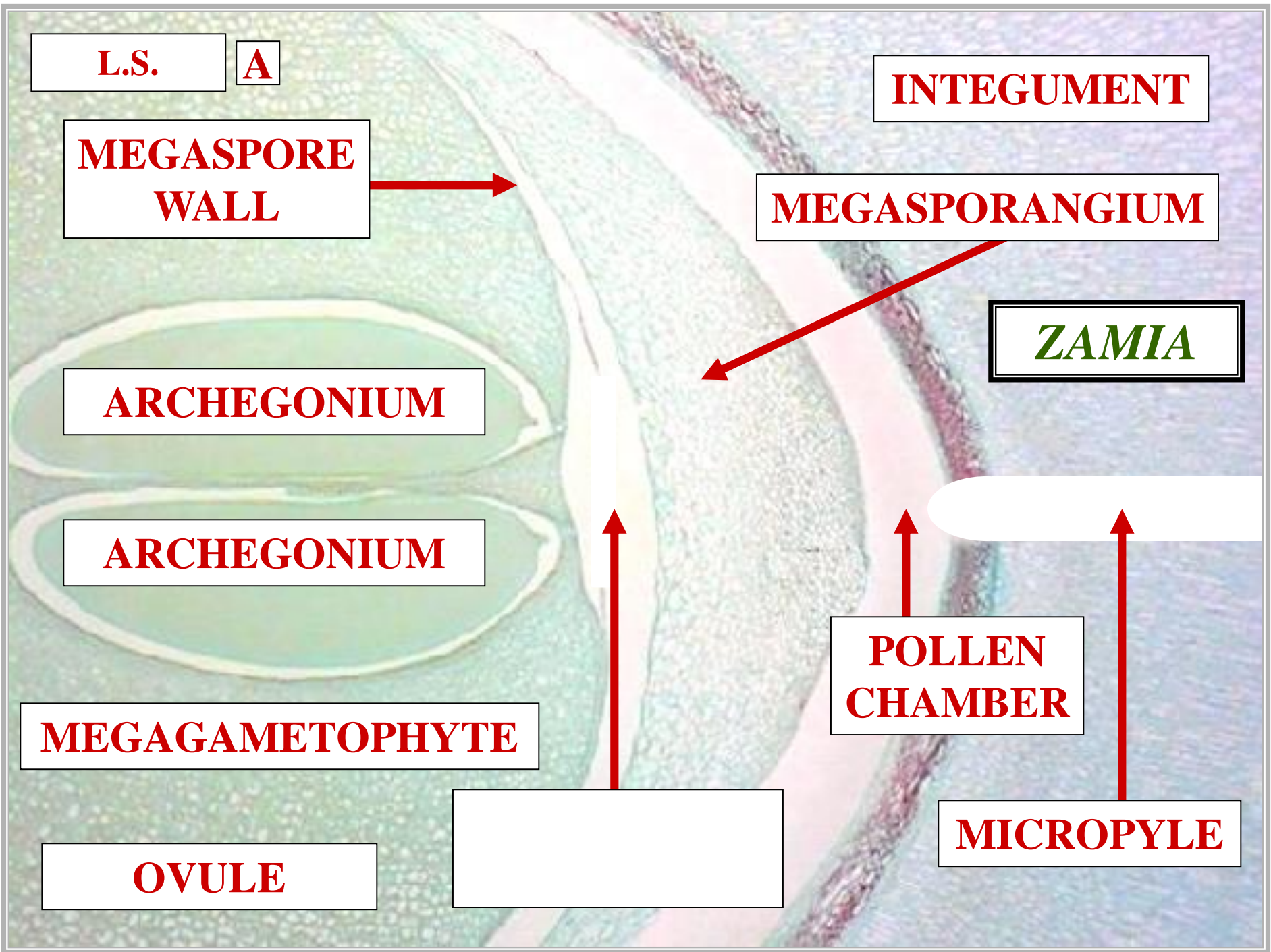
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MEGAGAMETOPHYTE

POLLEN
CHAMBER

OVULE

MICROPYLE

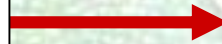


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INTEGUMENT

MEGASPORE WALL



MEGASPORANGIUM



ZAMIA

ARCHEGONIUM

ARCHEGONIUM

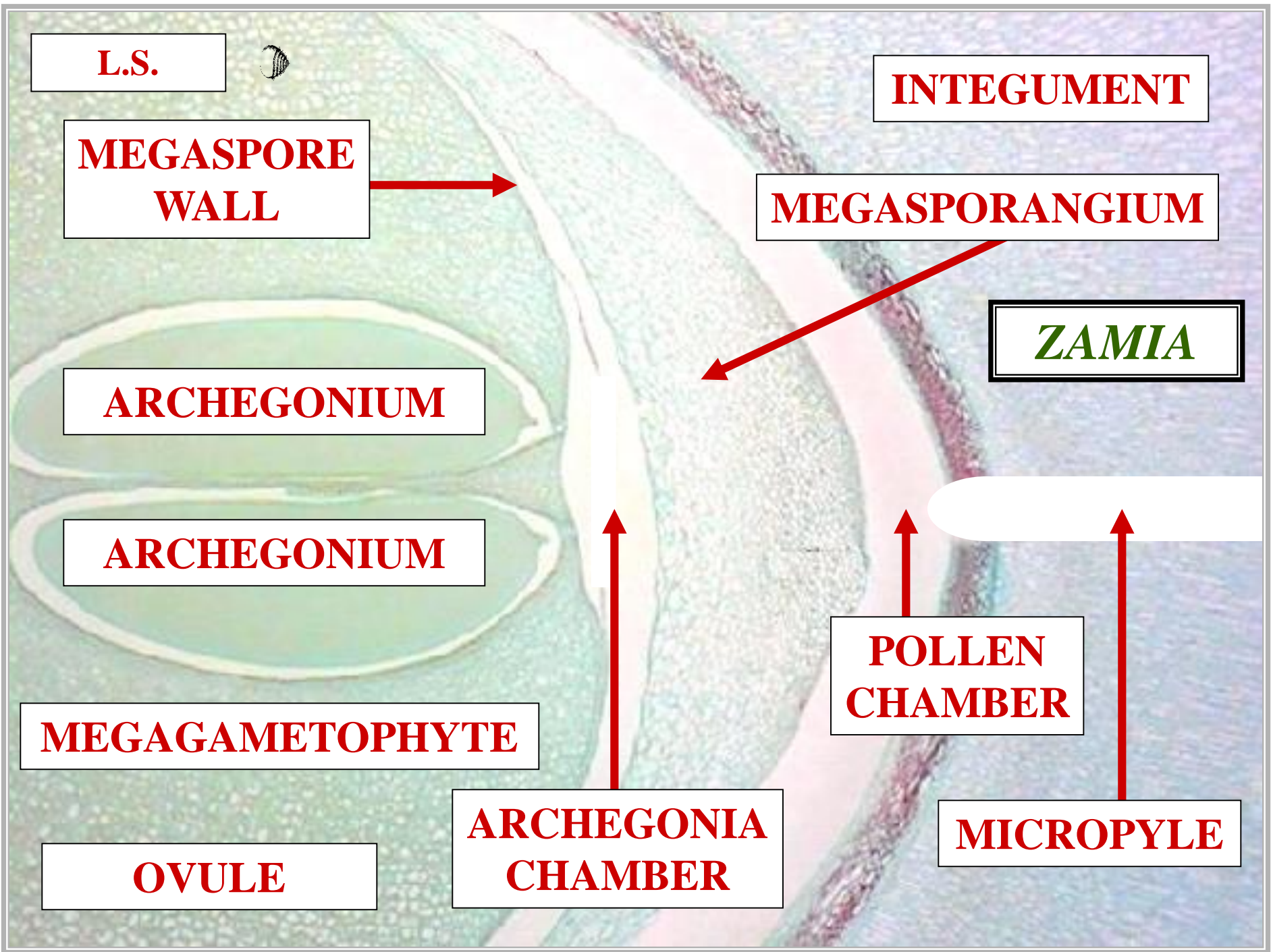
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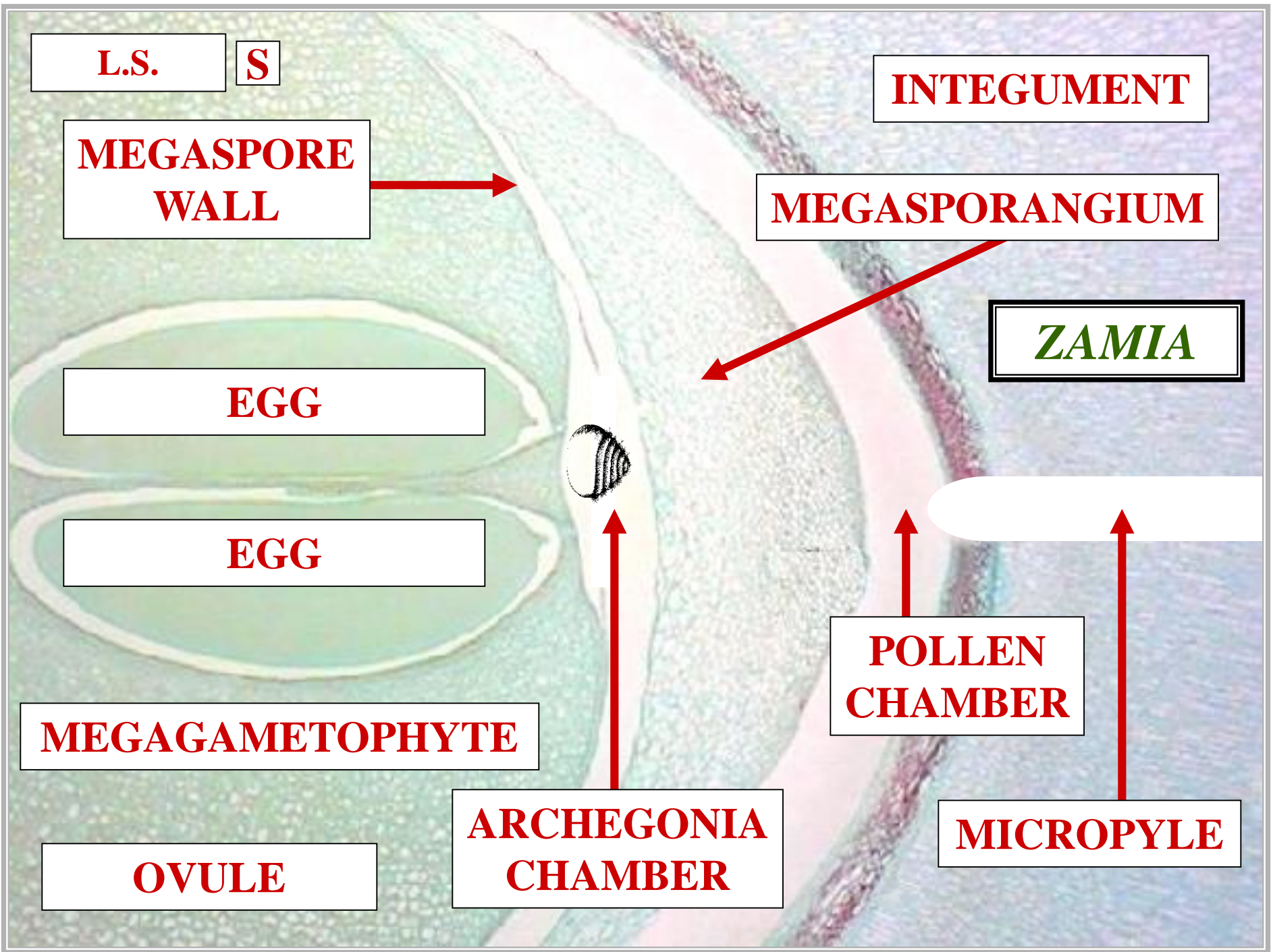
POLLEN CHAMBER

ARCHEGONIA CHAMBER

MICROPYLE

OVULE





L.S.

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INTEGUMENT

MEGASPORE WALL

MEGASPORANGIUM

ZAMIA

EGG

EGG

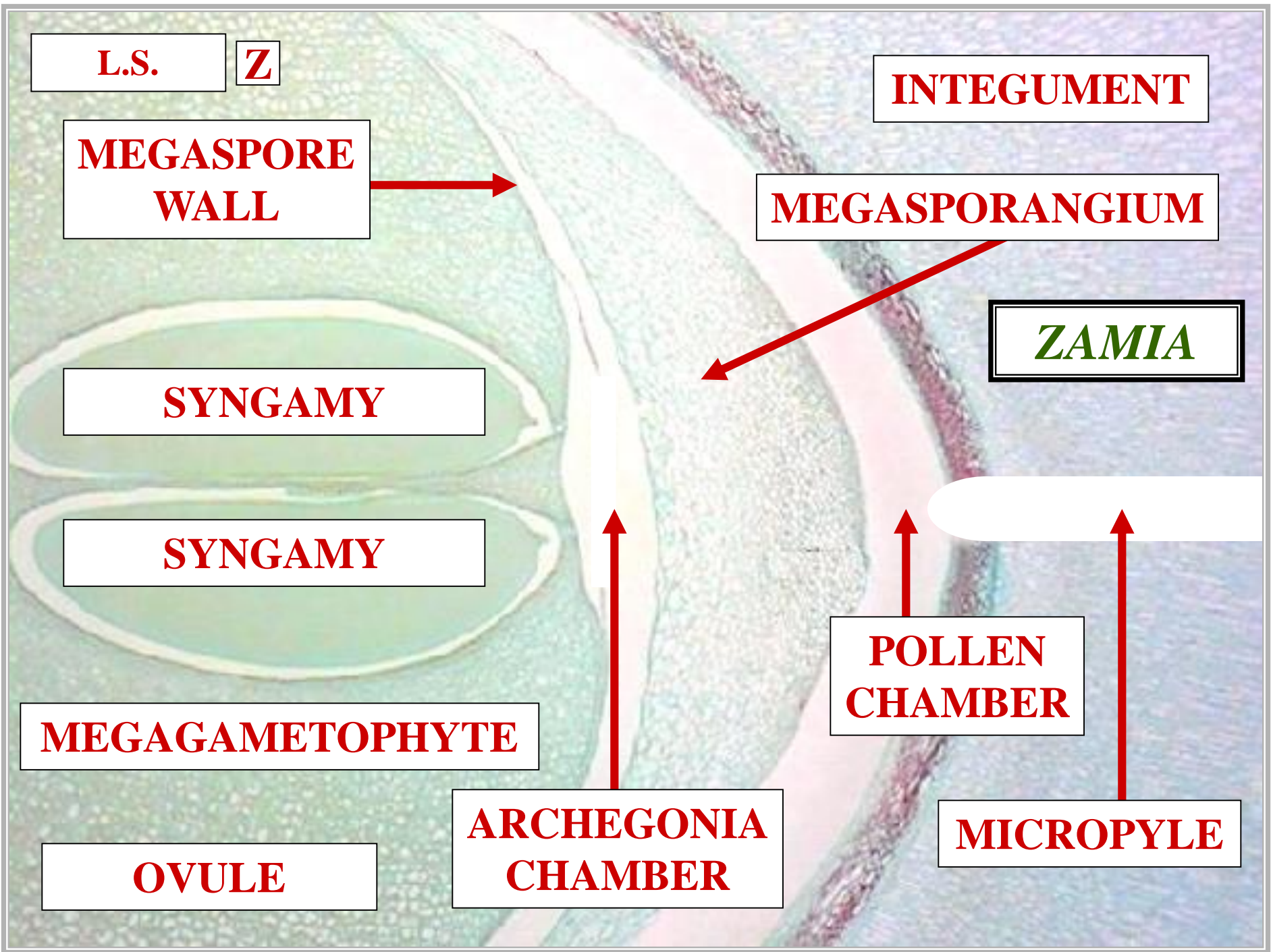
MEGAGAMETOPHYTE

POLLEN CHAMBER

OVULE

ARCHEGONIA CHAMBER

MICROPYLE



L.S.

Z

INTEGUMENT

MEGASPORE WALL

MEGASPORANGIUM

ZAMIA

SYNGAMY

SYNGAMY

MEGAGAMETOPHYTE

POLLEN CHAMBER

OVULE

ARCHEGONIA CHAMBER

MICROPYLE

L.S.

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E

INTEGUMENT

MEGASPORE
WALL

MEGASPORANGIUM

ZAMIA

ZYGOTE

ZYGOTE

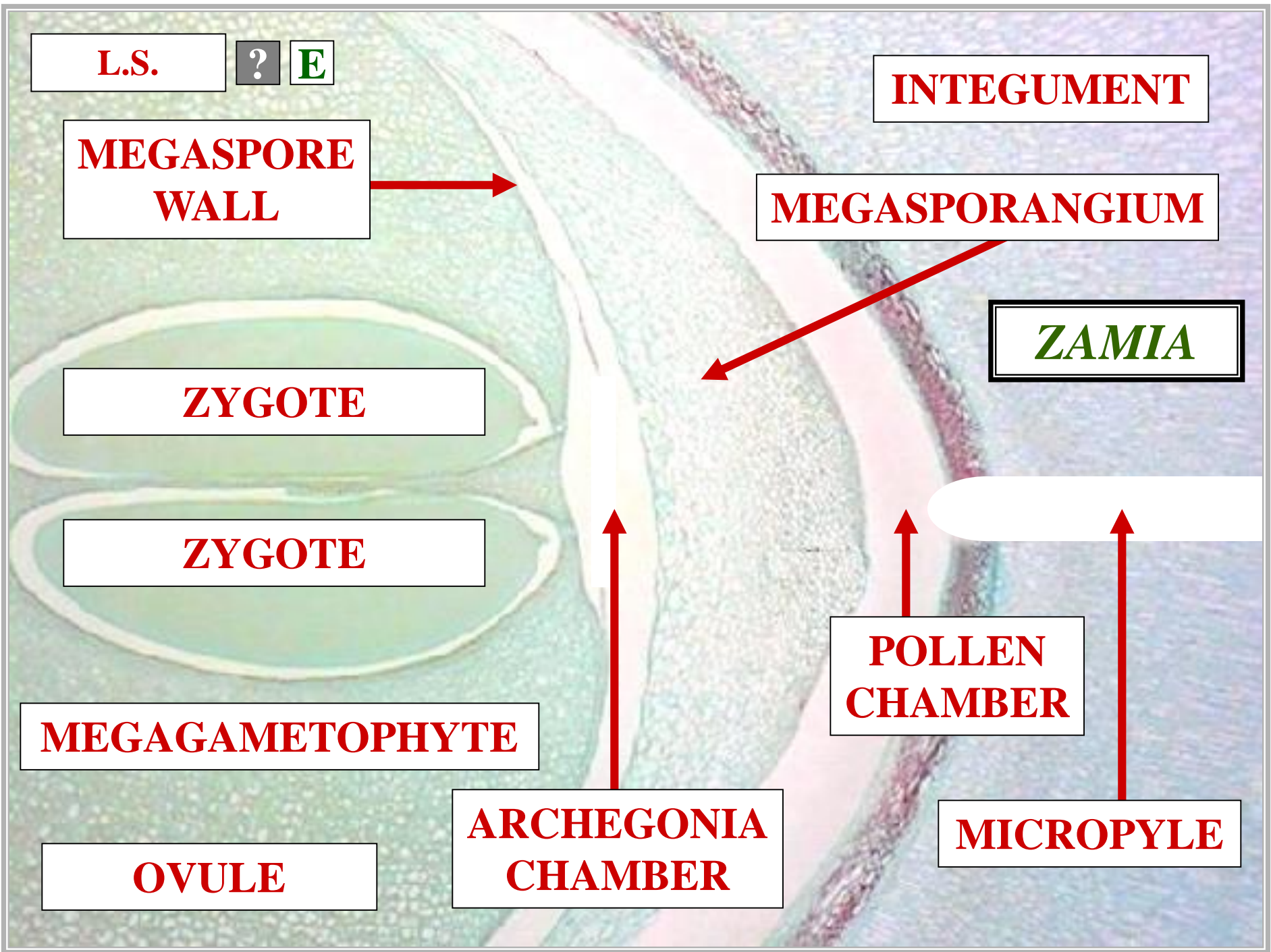
MEGAGAMETOPHYTE

POLLEN
CHAMBER

OVULE

ARCHEGONIA
CHAMBER

MICROPYLE



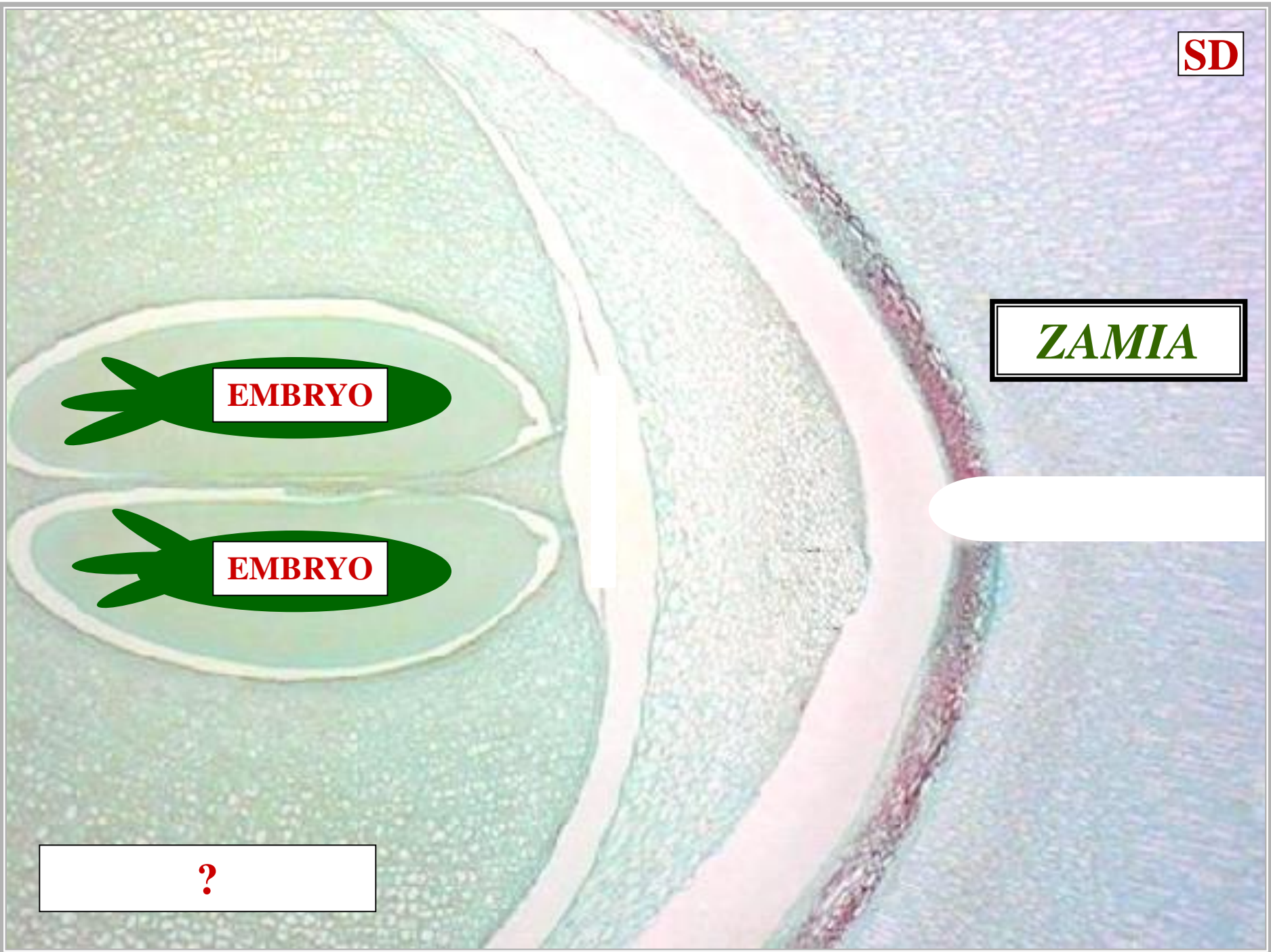
SD

ZAMIA

EMBRYO

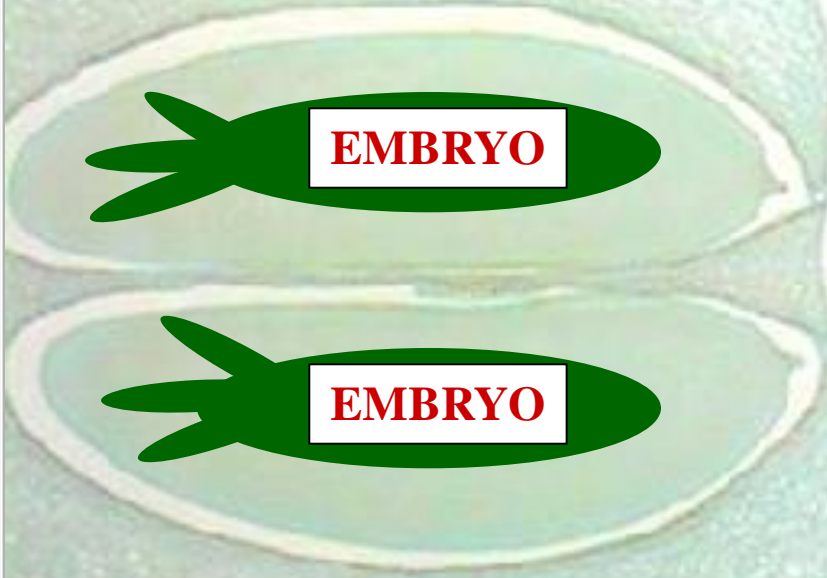
EMBRYO

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ZAMIA



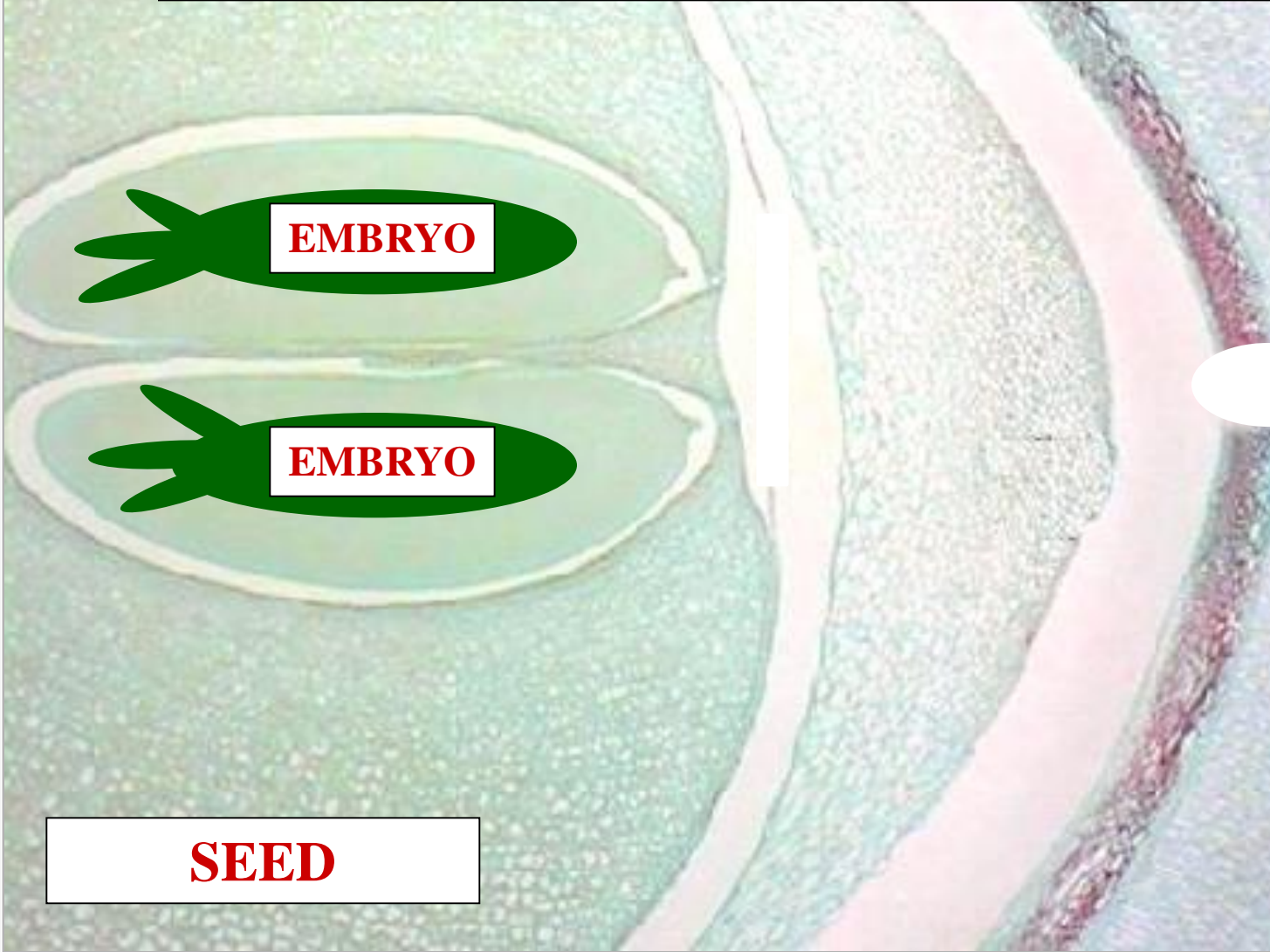
EMBRYO

EMBRYO

SEED

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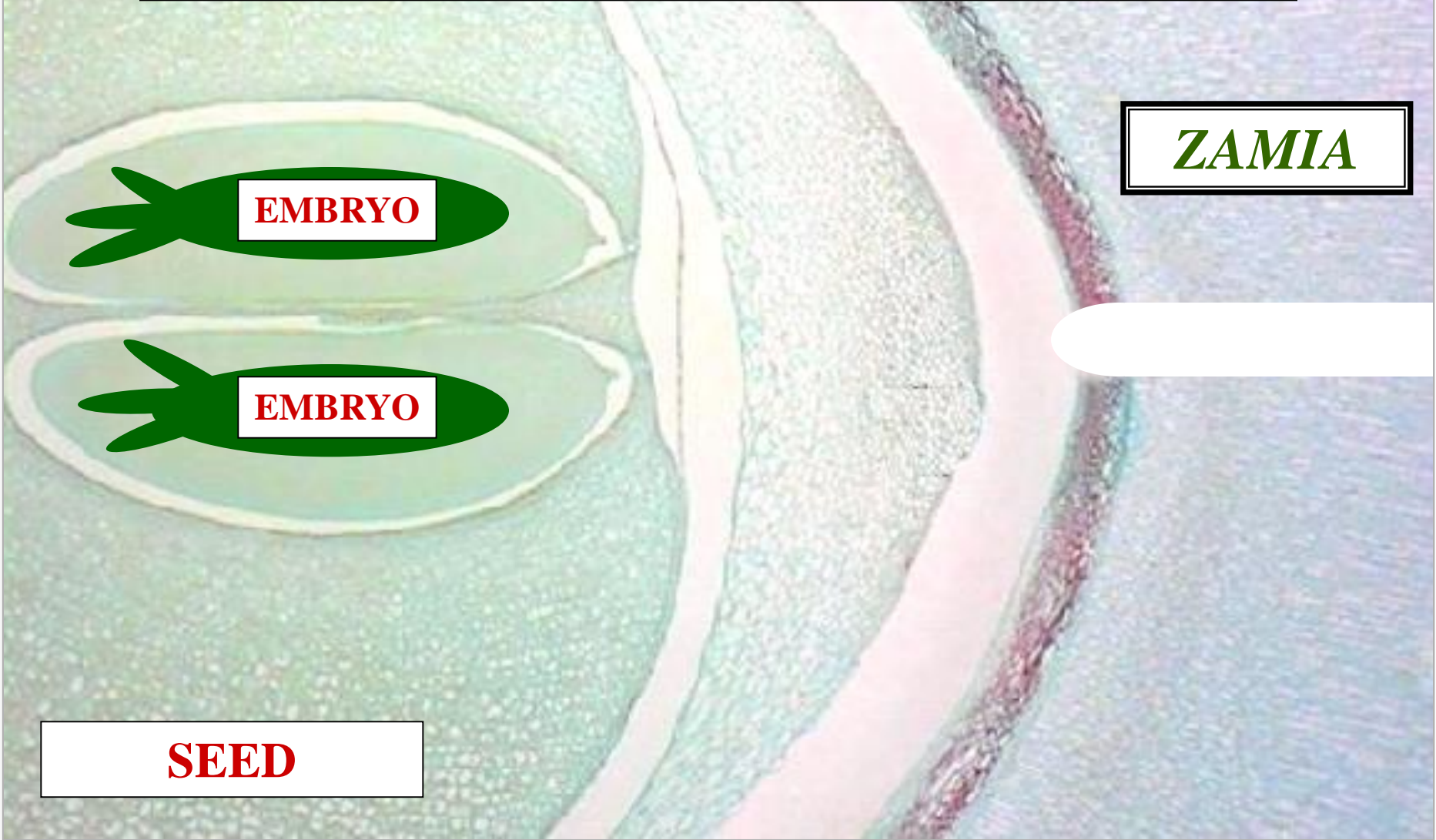
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SEED

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POLYEMBRYONY

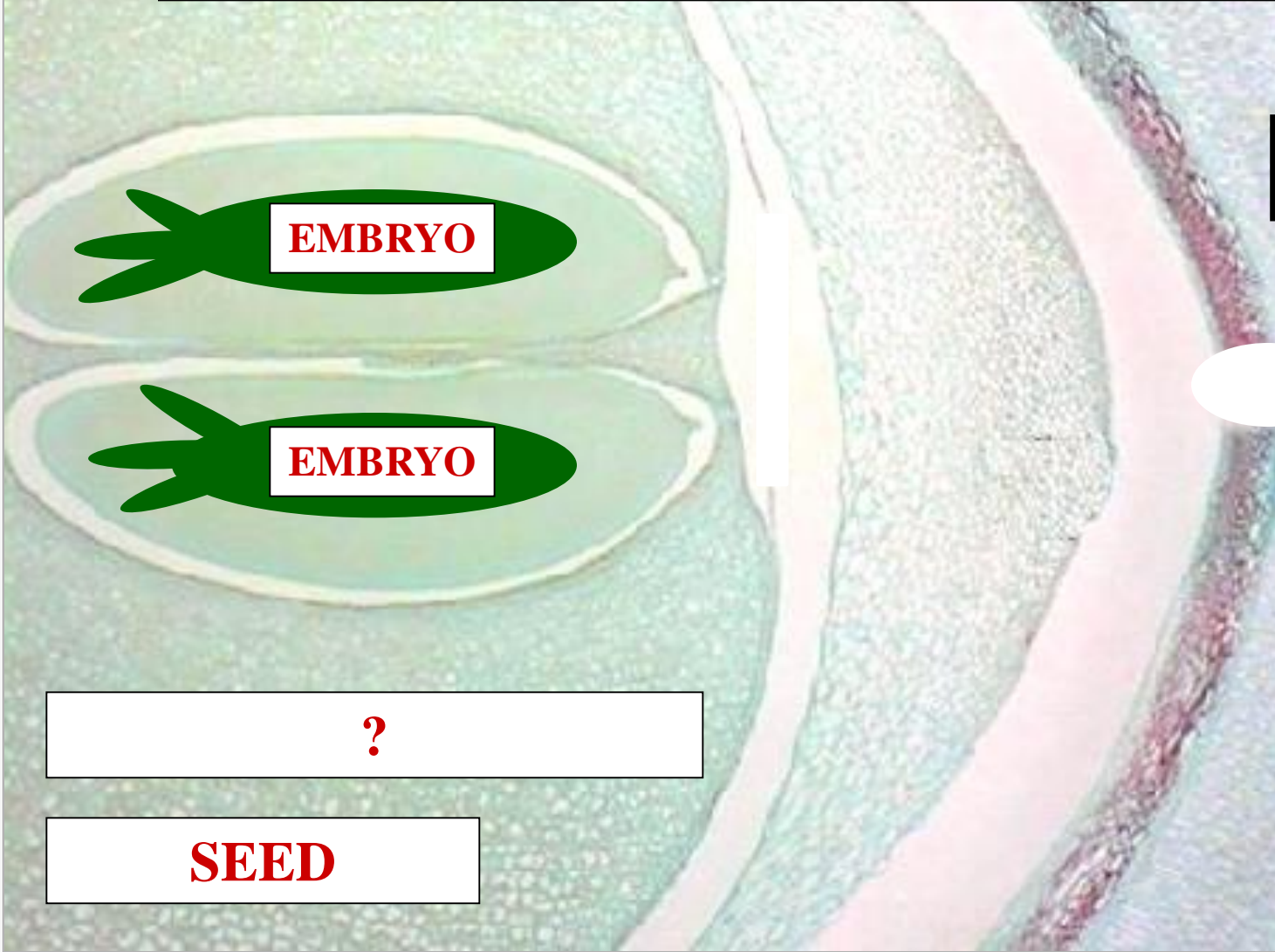


ZAMIA

SEED

POLYEMBRYONY

ZAMIA



EMBRYO

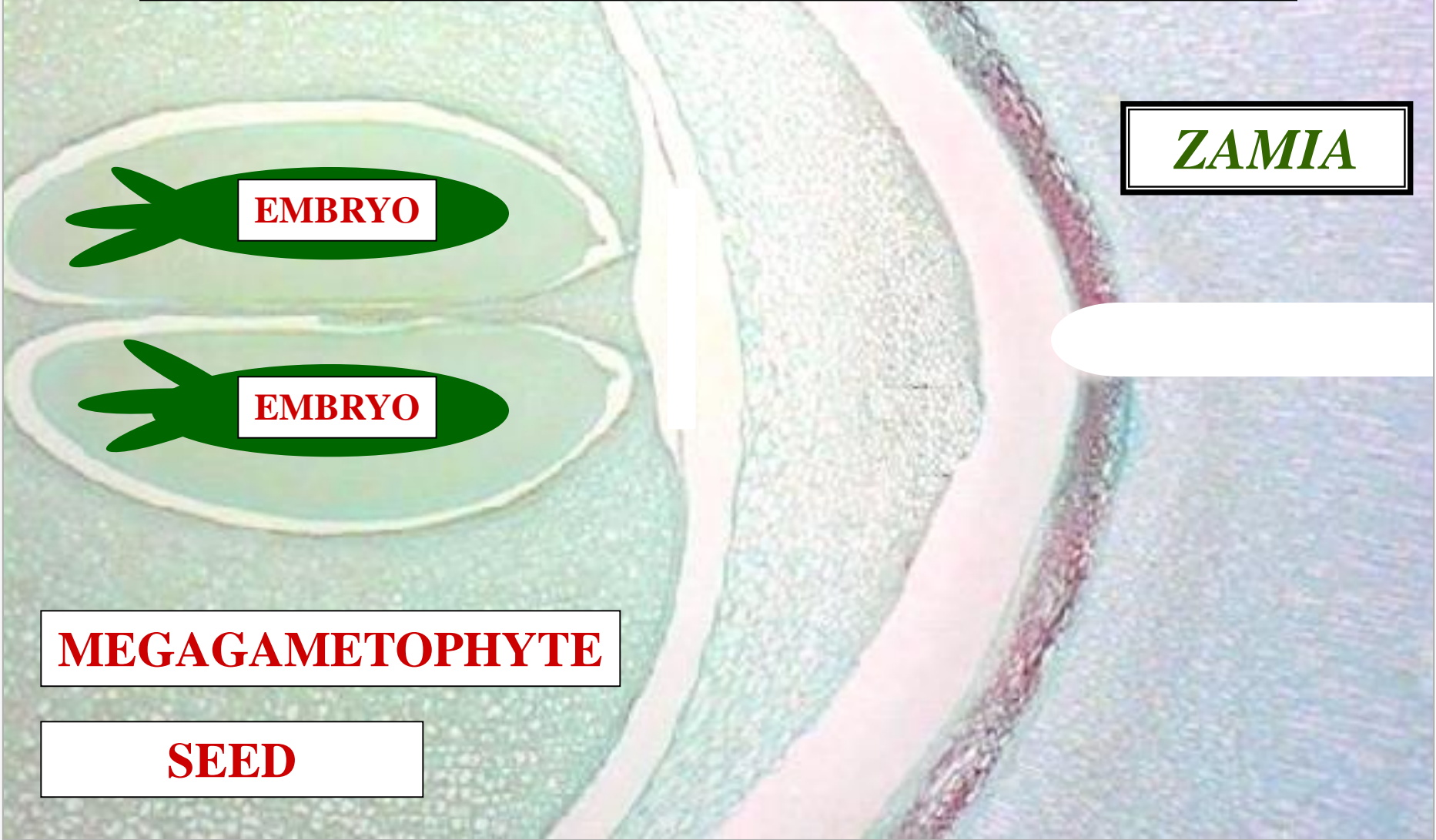
EMBRYO

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SEED



POLYEMBRYONY



ZAMIA

EMBRYO

EMBRYO

MEGAGAMETOPHYTE

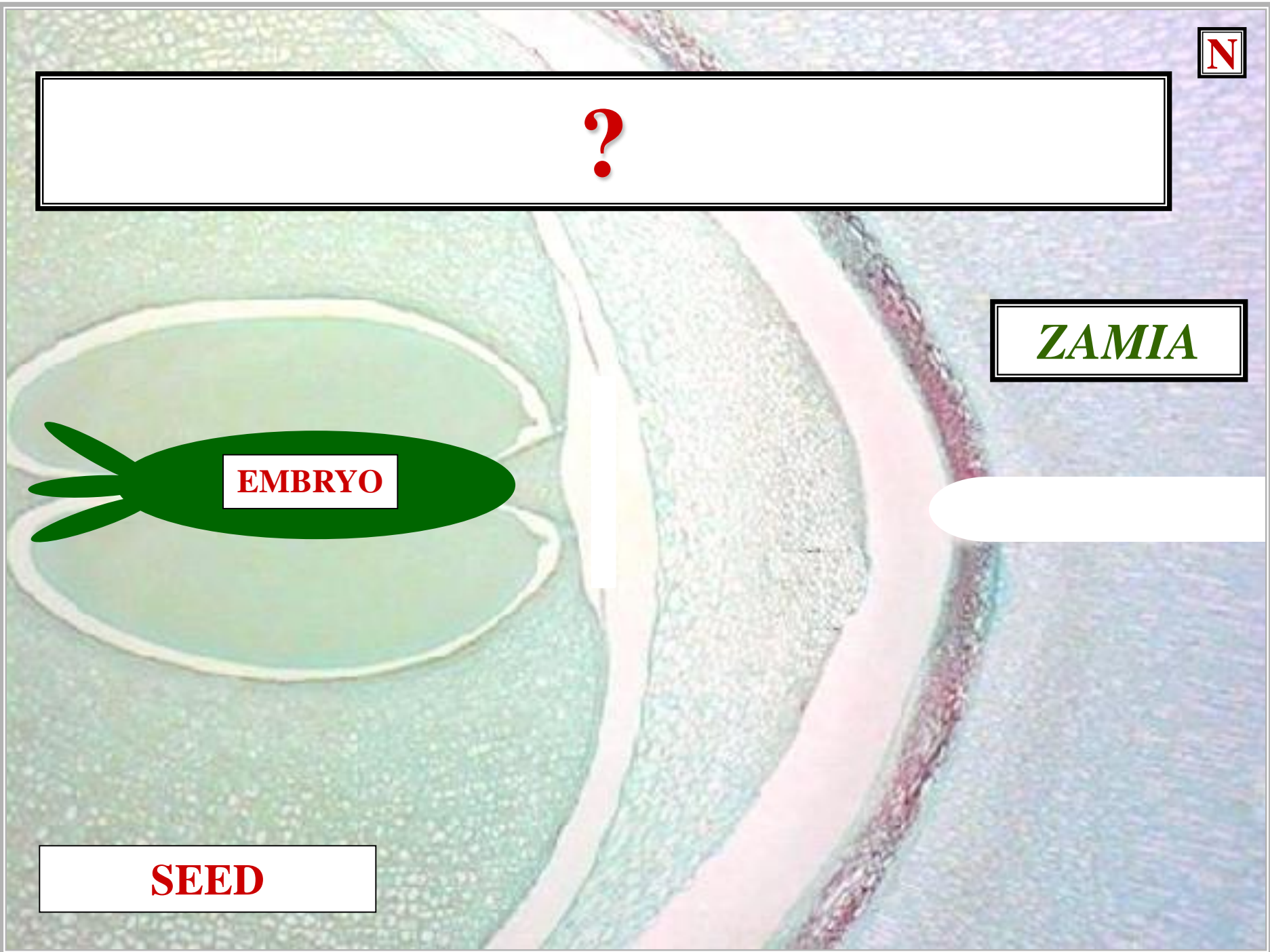
SEED

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ZAMIA

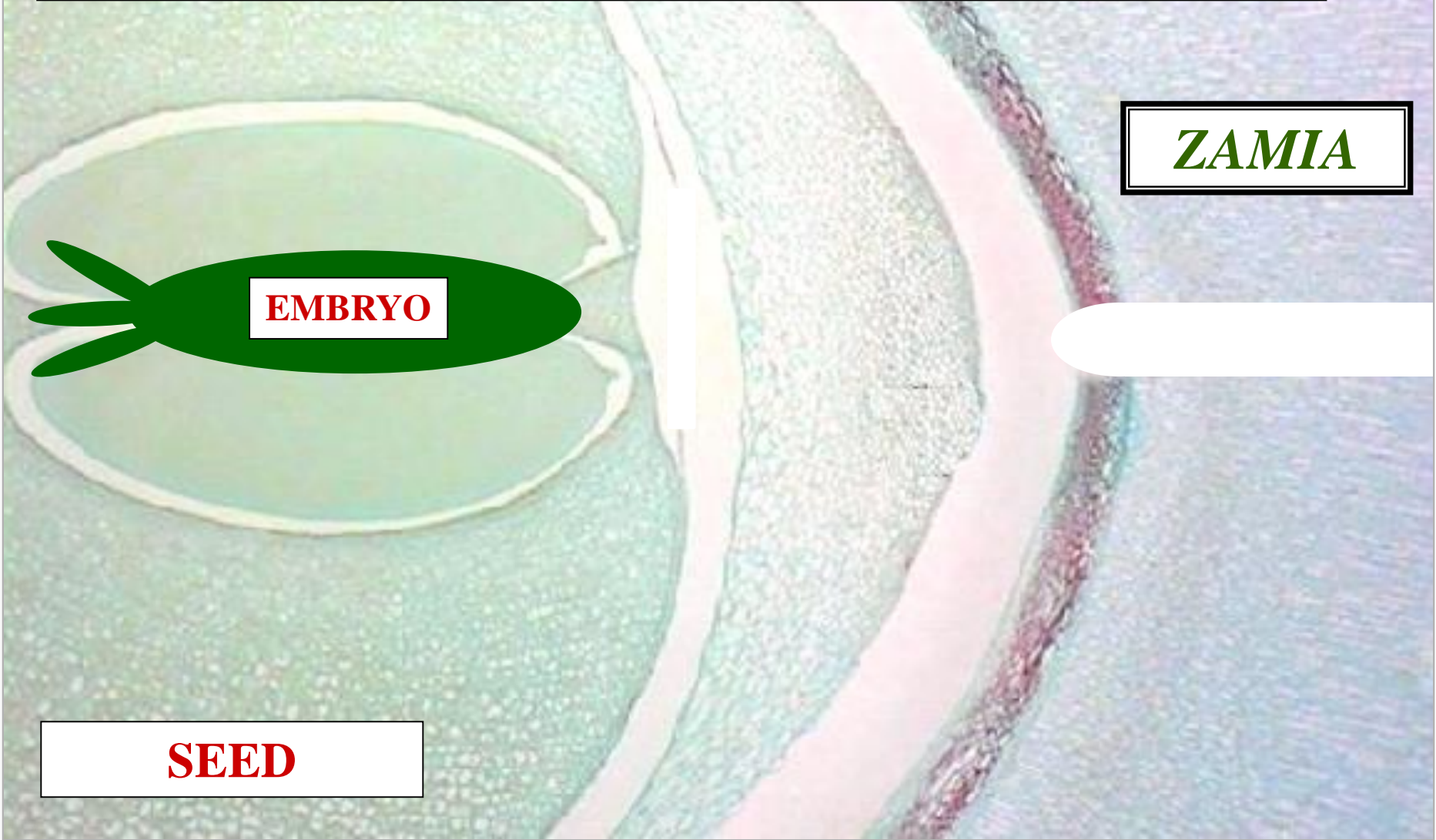
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SEED





NATURAL SELECTION



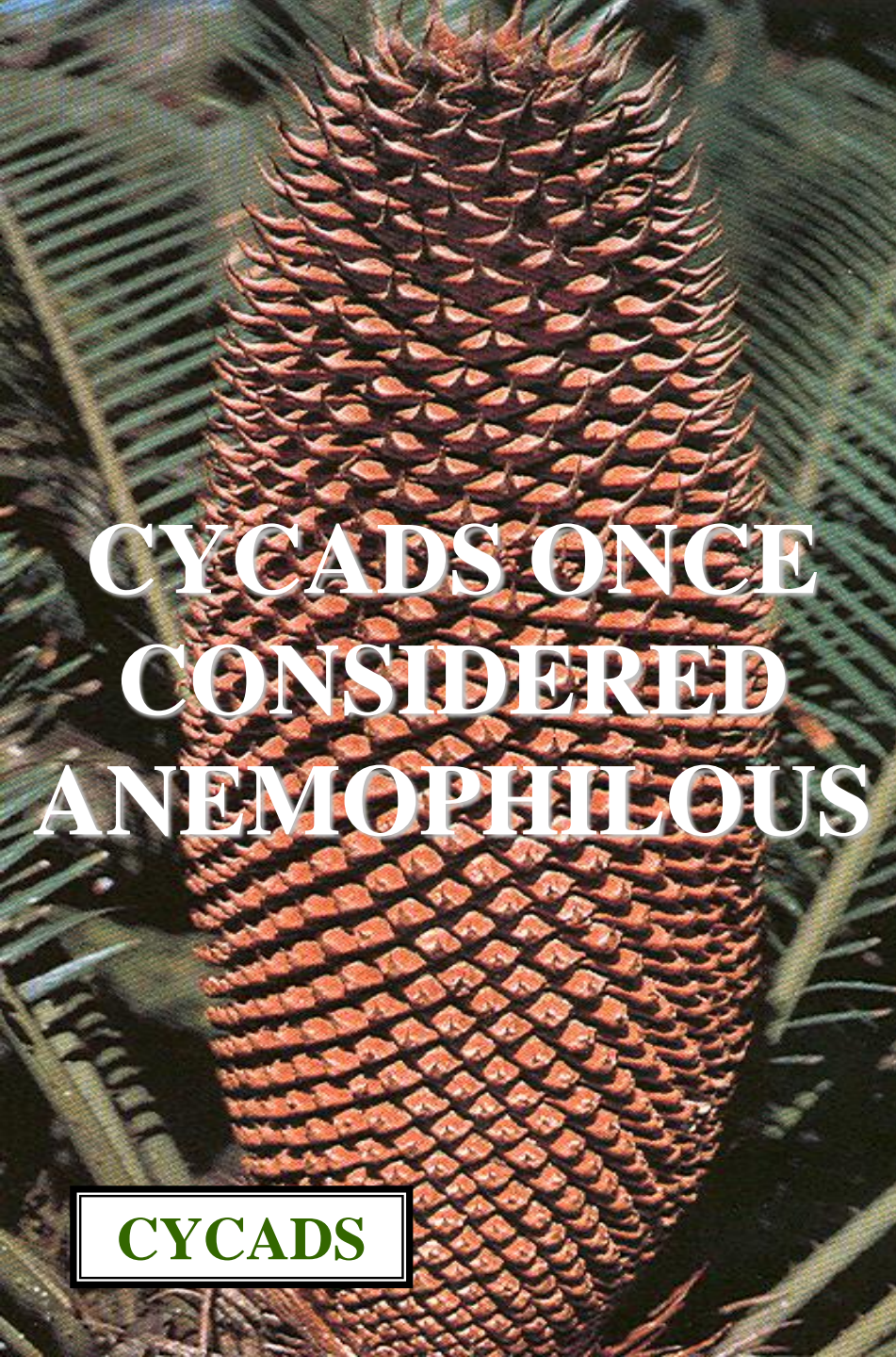
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EMBRYO

SEED

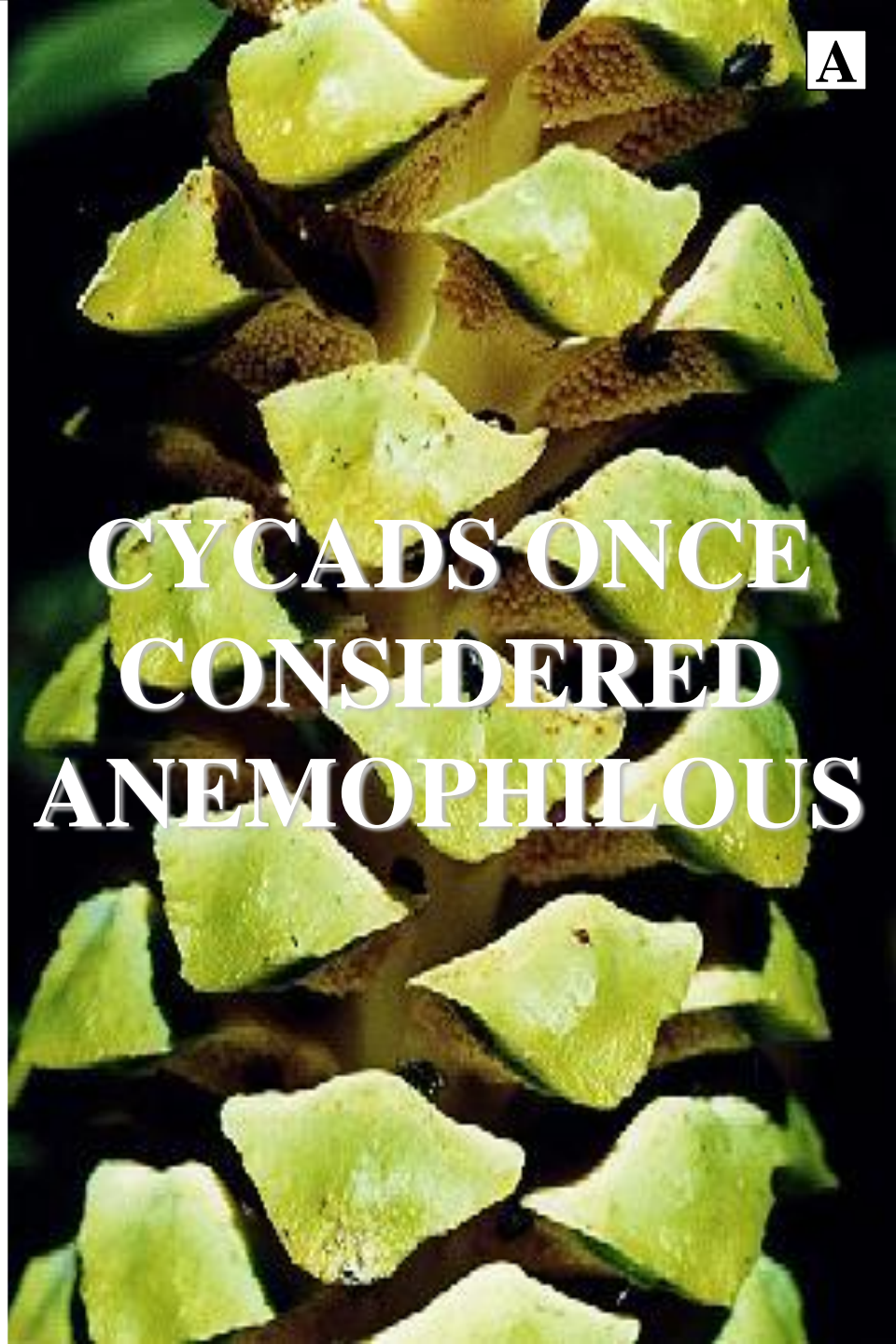


POLLINATION



CYCADS ONCE
CONSIDERED
ANEMOPHILOUS

CYCADS



CYCADS ONCE
CONSIDERED
ANEMOPHILOUS

A

ANEMOPHILOUS

CYCADOPHYTA



ANEMOPHILOUS POLLINATION

WIND POLLINATION

CYCADOPHYTA

ANEMOPHILOUS POLLINATION

**WIND
POLLINATION**

+

A



PINUS

**WIND
POLLINATION**

**ANEMOPHILOUS
POLLINATION**

^

E



PINUS

**WIND
POLLINATION**

ENTOMOPHILOUS

CYCADOPHYTA

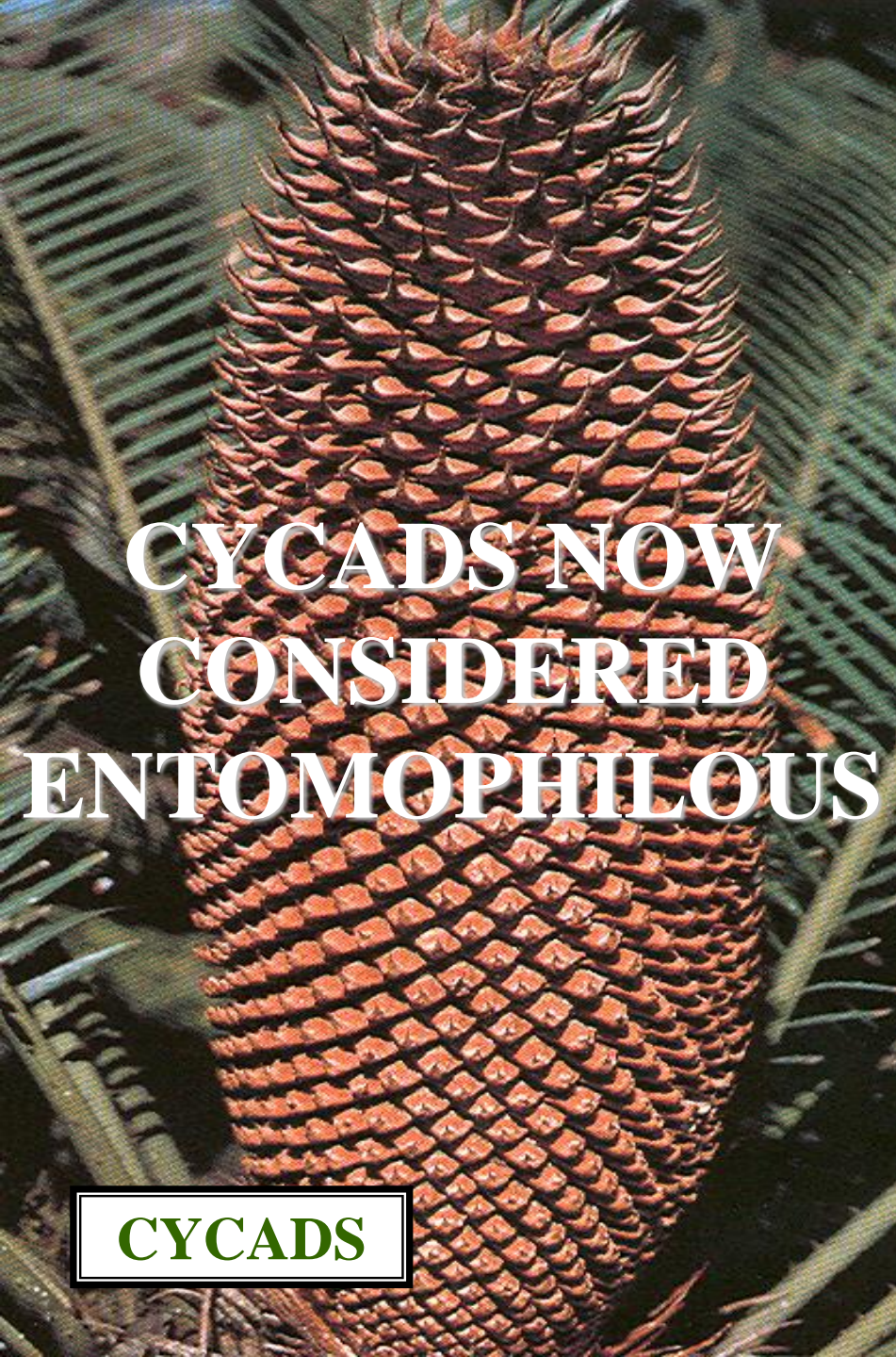


ENTOMOPHILOUS POLLINATION

INSECT POLLINATION

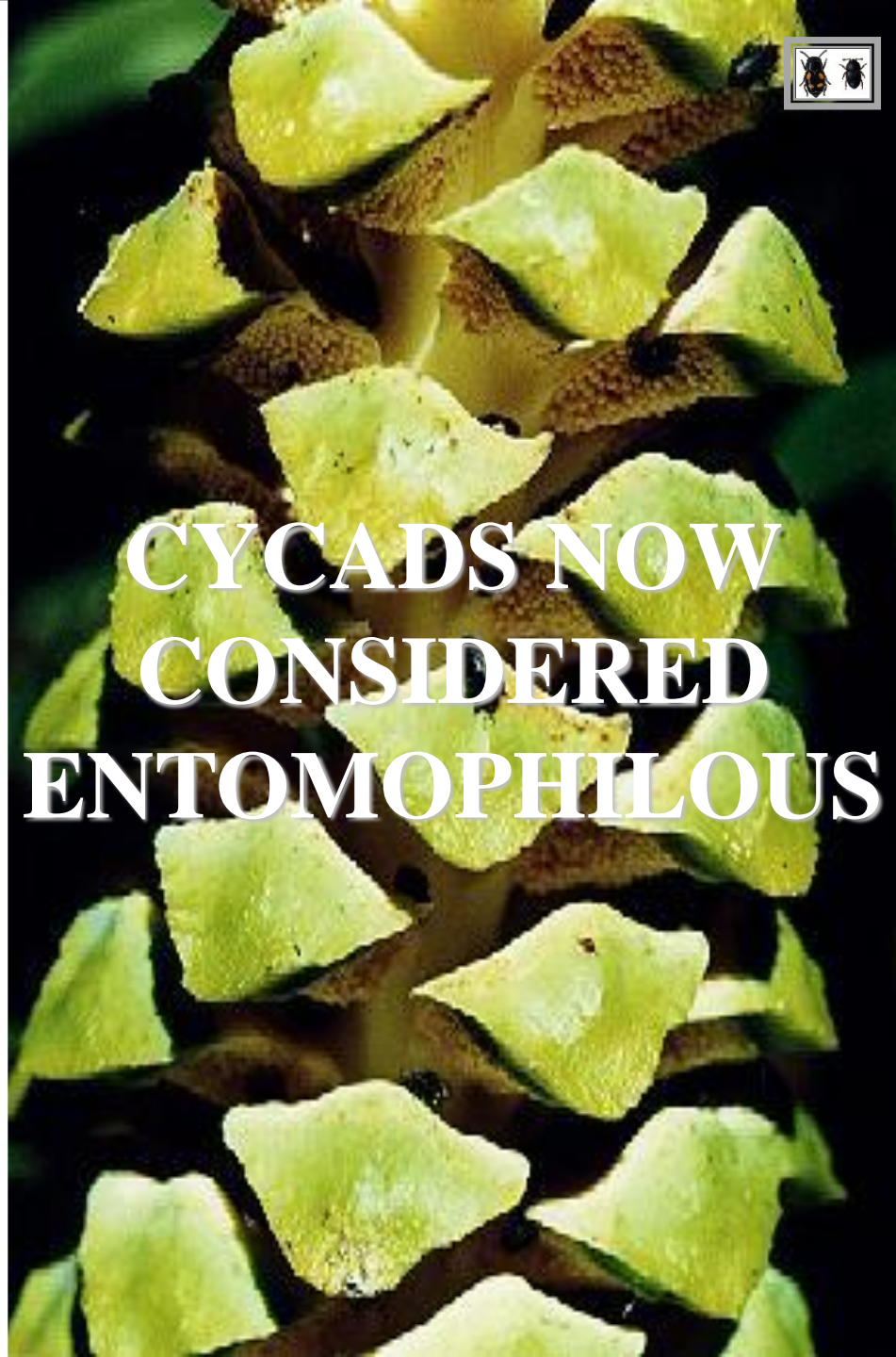
CYCADOPHYTA

ENTOMOPHILOUS POLLINATION



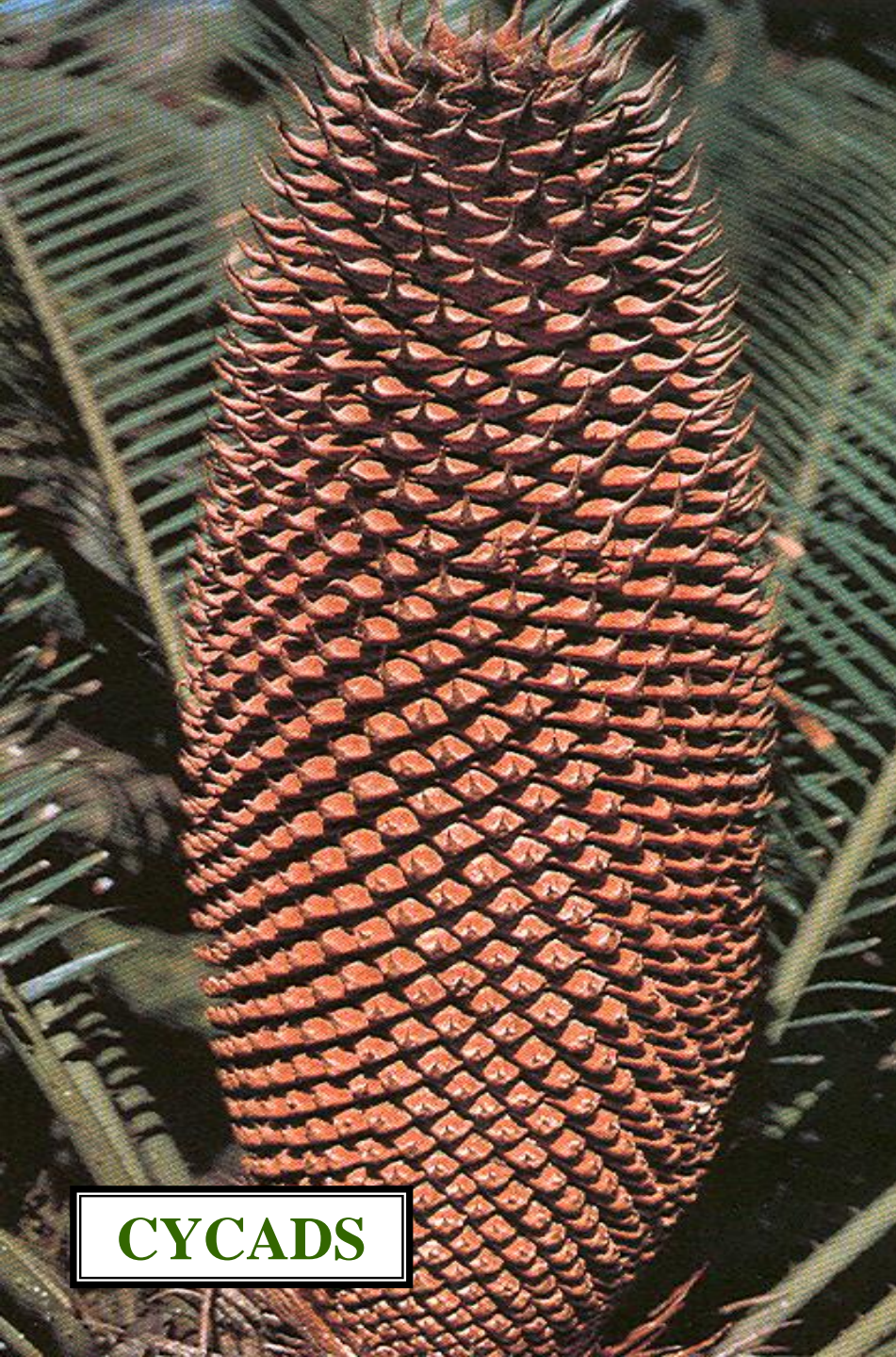
CYCADS NOW
CONSIDERED
ENTOMOPHILOUS

CYCADS



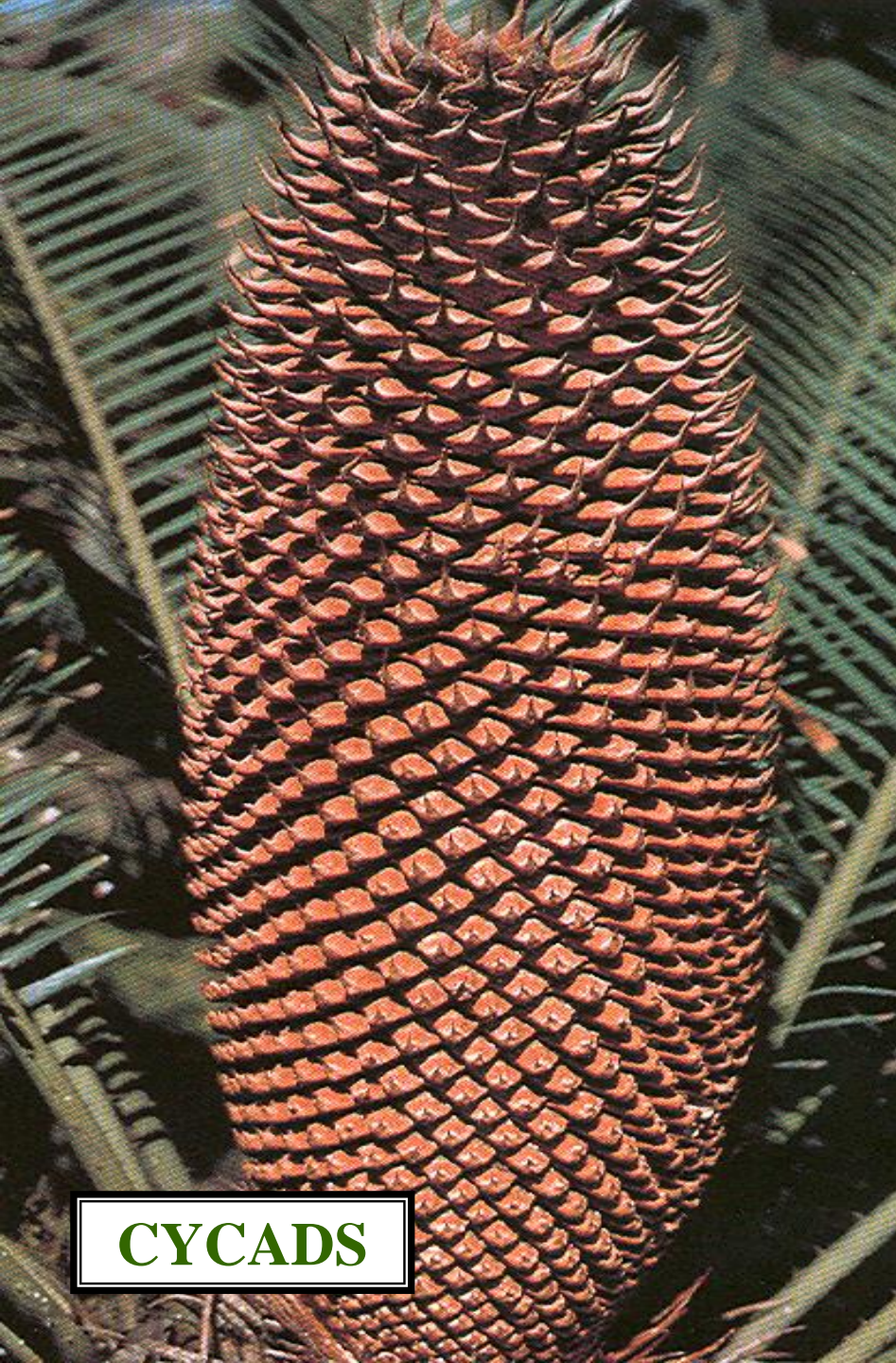
CYCADS NOW
CONSIDERED
ENTOMOPHILOUS





CYCADS





CYCADS



OVULE

INTEGUMENT

M

MICROPYLE

POLLINATION

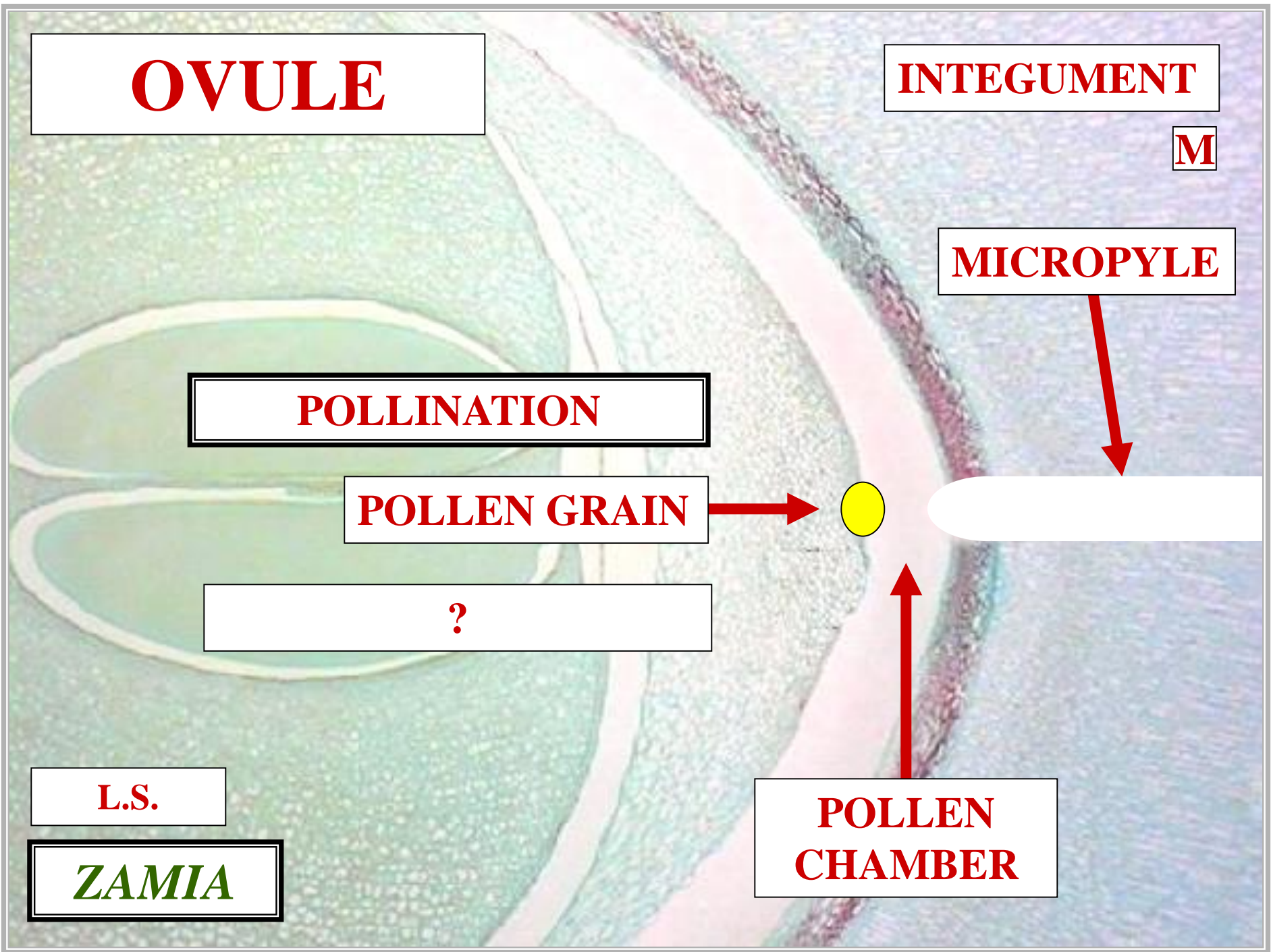
POLLEN GRAIN

?

L.S.

ZAMIA

**POLLEN
CHAMBER**



OVULE

INTEGUMENT



MICROPYLE

POLLINATION

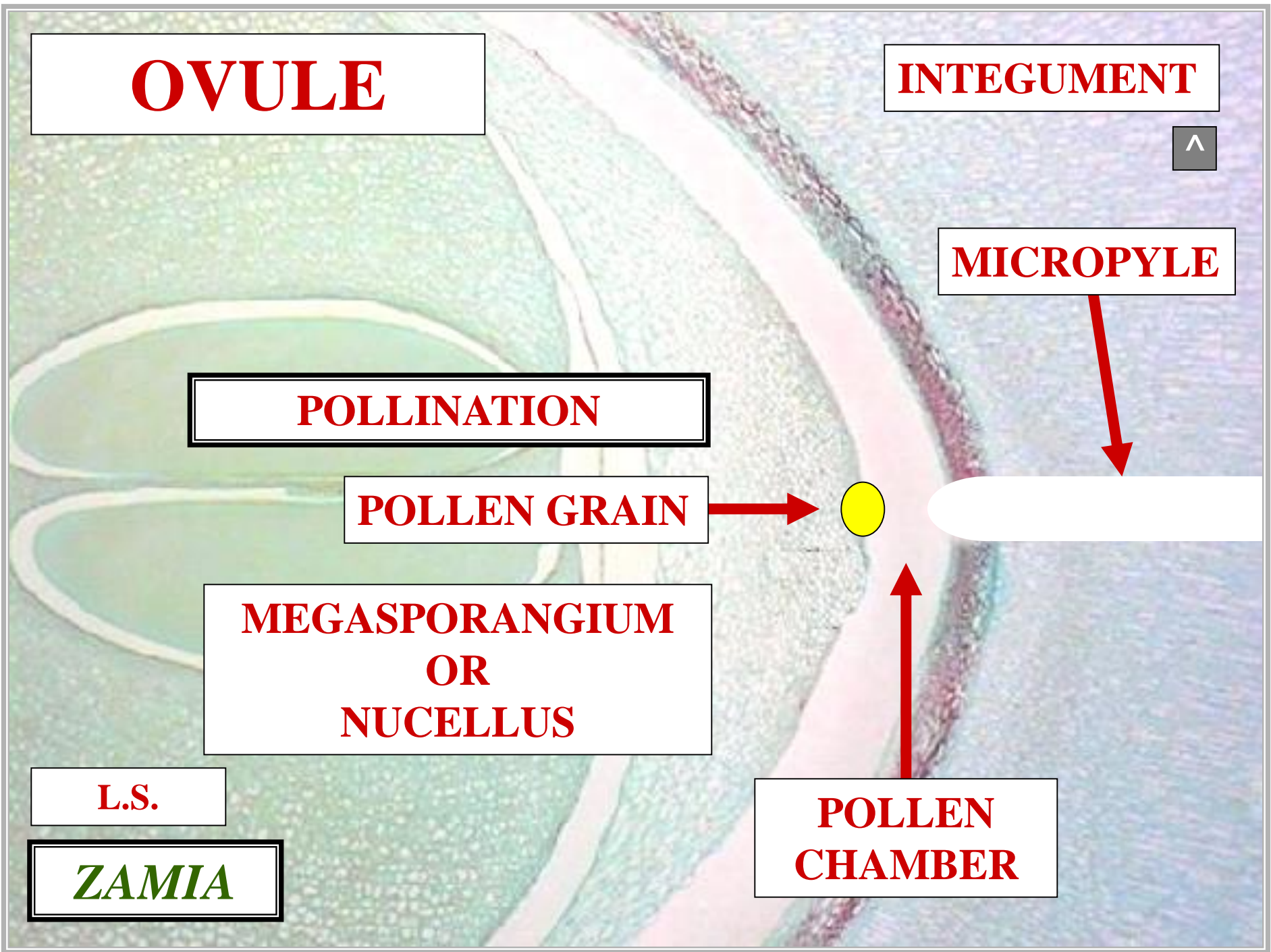
POLLEN GRAIN

**MEGASPORANGIUM
OR
NUCELLUS**

L.S.

ZAMIA

**POLLEN
CHAMBER**





FOSSIL RECORD



~280

MILLION YEARS



TRIASSIC



CRETACEOUS



PERMIAN



TRIASSIC



JURASSIC



CRETACEOUS

CYCADOPHYTA EVOLVE

PERMIAN

TRIASSIC

JURASSIC

CRETACEOUS



LEPTOCYCAS

PERMIAN



~190

MILLION YEARS



PERMIAN



TRIASSIC



?



CRETACEOUS



PERMIAN



TRIASSIC



JURASSIC



CRETACEOUS



PERMIAN



TRIASSIC



D



CYCADOPHYTA ZENITH

JURASSIC



CRETACEOUS



**CYCADOPHYTA
DIVERSITY
CURRENTLY
DECLINING**

EARTH

PHYLOGENETIC RELATIONSHIP

PTERIDOSPERMOPHYTA

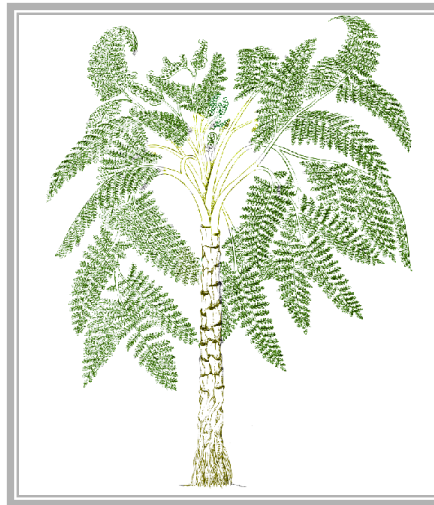
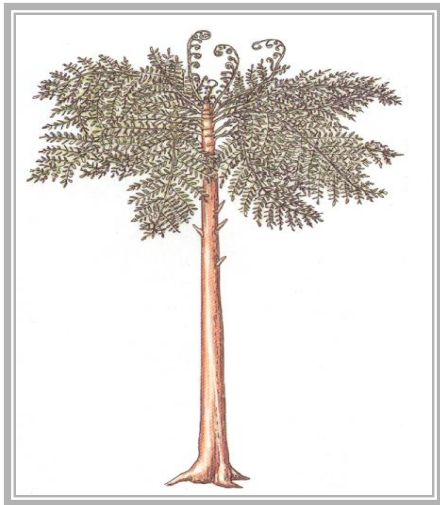
**MANOXYLIC WOOD
COMPOUND LEAF**

CYCADOPHYTA

**PHYLOGENETIC
DEAD-END**



CYCADOPHYTA EVOLUTION



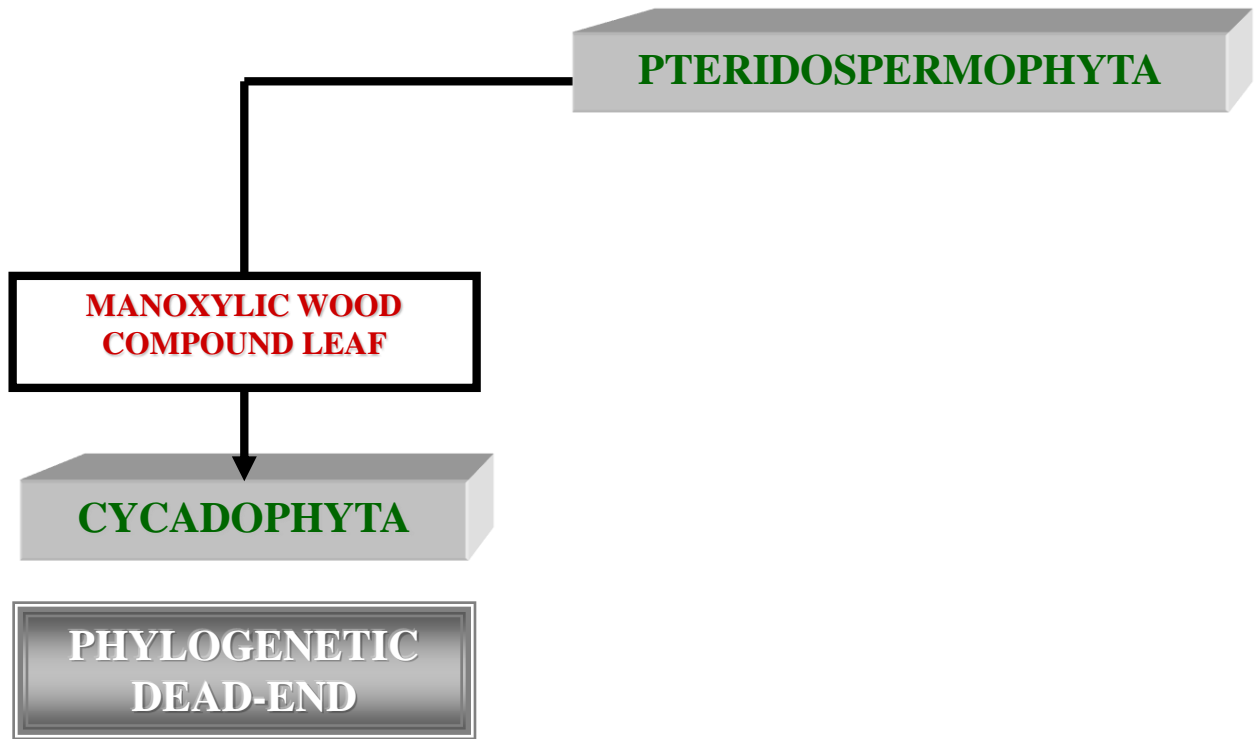
LYGINOPTERIS

MEDULLOSA

CYCADOPHYTA

PTERIDOSPERM

PTERIDOSPERM





VASCULAR PLANT EVOLUTION



~260
MILLION YEARS

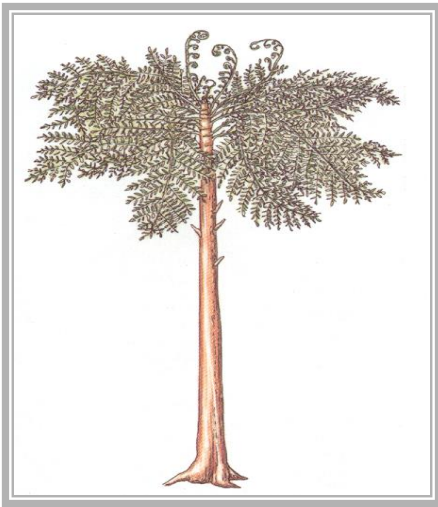
~260 MILLION YEARS AGO



GINKGOPHYTA EVOLVE

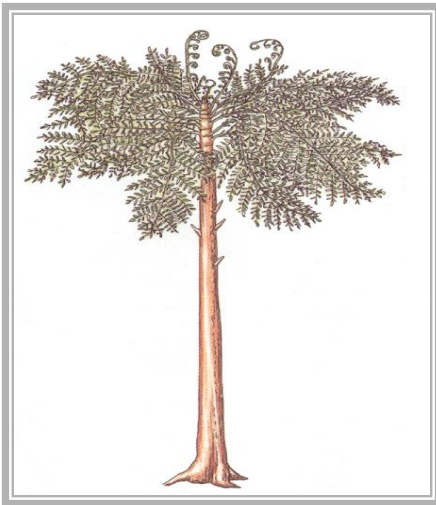


GINKGOPHYTA EVOLUTION



LYGINOPTERIS

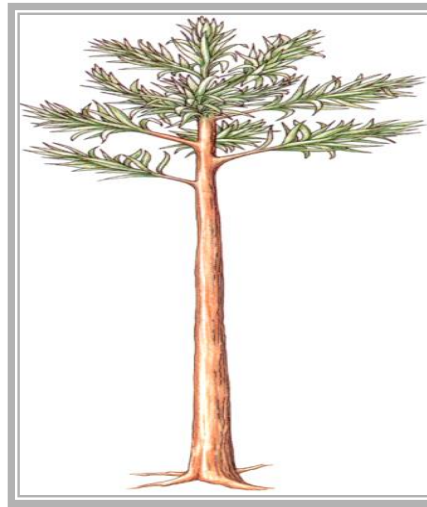
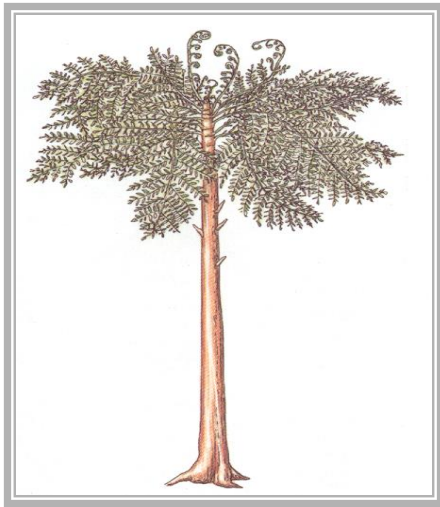
GINKGOPHYTA EVOLUTION



PTERIDOSPERM

GYMNOSPERM

GINKGOPHYTA EVOLUTION

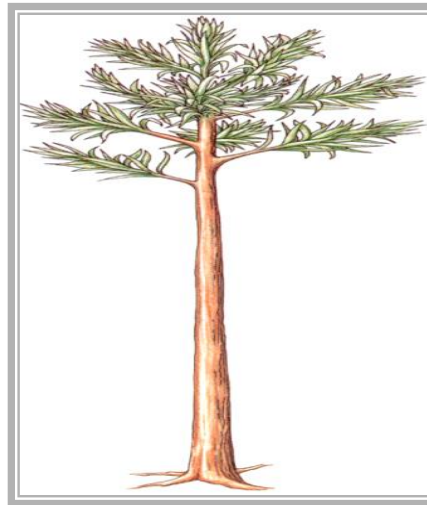
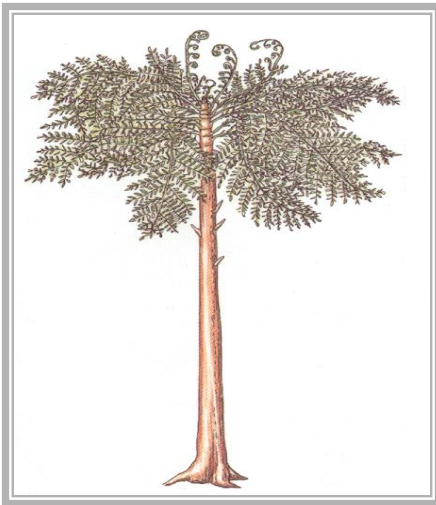


PTERIDOSPERM

CORDAITES

GYMNOSPERM

GINKGOPHYTA EVOLUTION



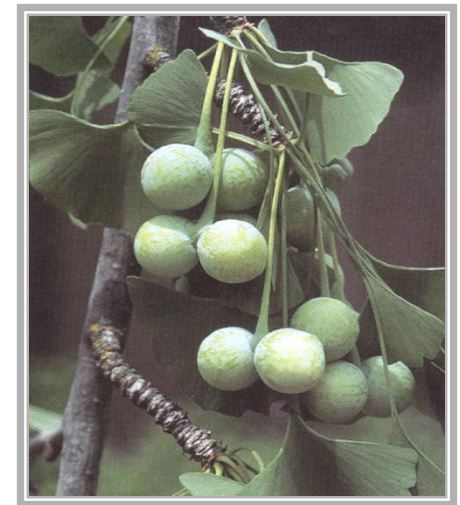
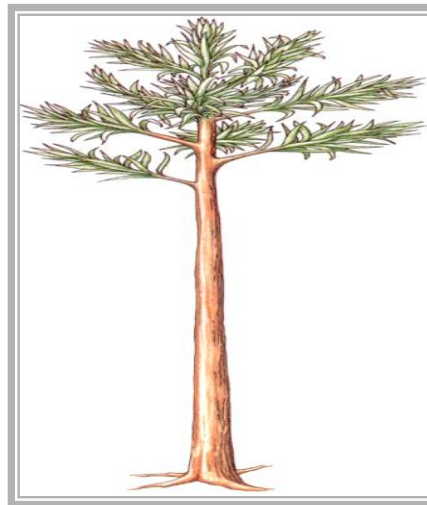
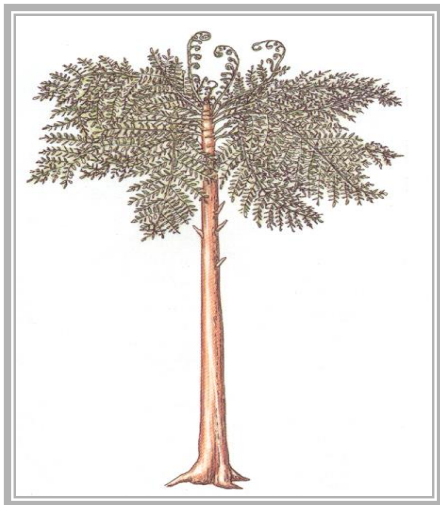
PTERIDOSPERM

GYMNOSPERM

PTERIDOSPERM

GYMNOSPERM

GINKGOPHYTA EVOLUTION



PTERIDOSPERM

PTERIDOSPERM

GINKGOPHYTA

GYMNOSPERM

GYMNOSPERM



**EXTANT
PHYLUM**

**PHYLUM
GINKGOPHYTA**

**EXTANT
PHYLUM**

COMMON NAMES



GINKGO



MAIDENHAIR TREE



DIVERSITY



G

1 SPECIES

EARTH



GINKGO BILOBA



GINKGOPHYTA
VERY MINOR
COMPONENT
EXTANT FLORA

EARTH



DISTRIBUTION



CHINA ENDEMIC

EARTH

GINKGO



CHINA

**CHINA
ENDEMIC**



GINKGO



**EXTINCT
FROM WILD**



**GINKGO
CULTIVATION
PREVENTED
EXTINCTION**



HABITAT



GINKGO MESIC TEMPERATE FORESTS



ECONOMIC IMPORTANCE



**GINKGO
POPULAR
URBAN
ORNAMENTAL**



GINKGO
POPULAR
URBAN
ORNAMENTAL



**GINKGO
POPULAR
URBAN
ORNAMENTAL**





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D

GINKGO



GINKGO DIETARY SUPPLEMENT



**DIETARY
SUPPLEMENT
PROMOTES MEMORY**

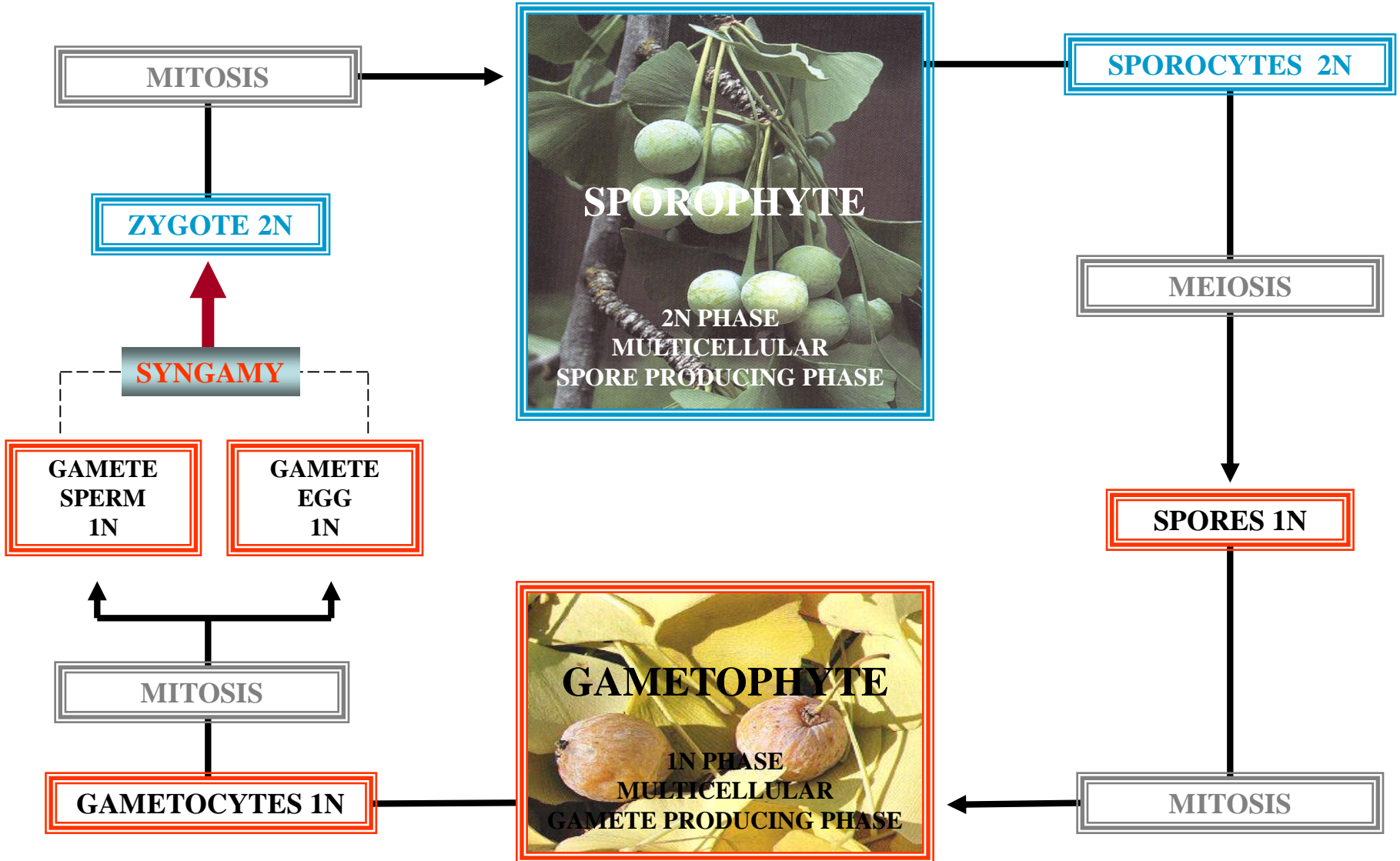




GENERAL CHARACTERS

GINKGOPHYTA

LIFE CYCLE

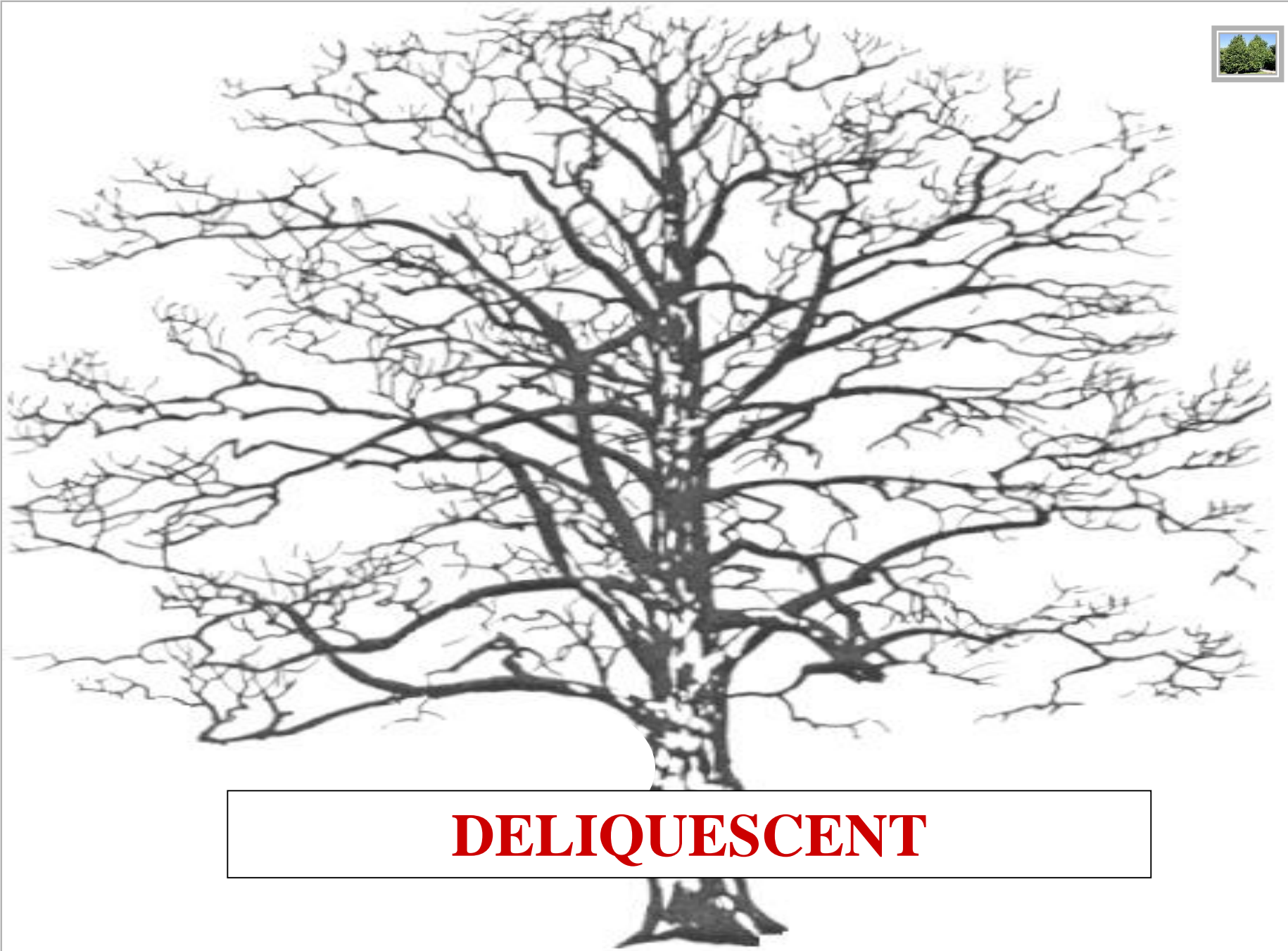




SPOROPHYTE CHARACTERS



GROWTH FORM



DELIQUESCENT



GINKGO

“A”

DELIQUESCENT GROWTH



GINKGO



“ANGIOSPERM-LIKE”



STEM



STEM MORPHOLOGY



DIMORPHIC SHOOTS

GINKGO



DIMORPHIC SHOOTS

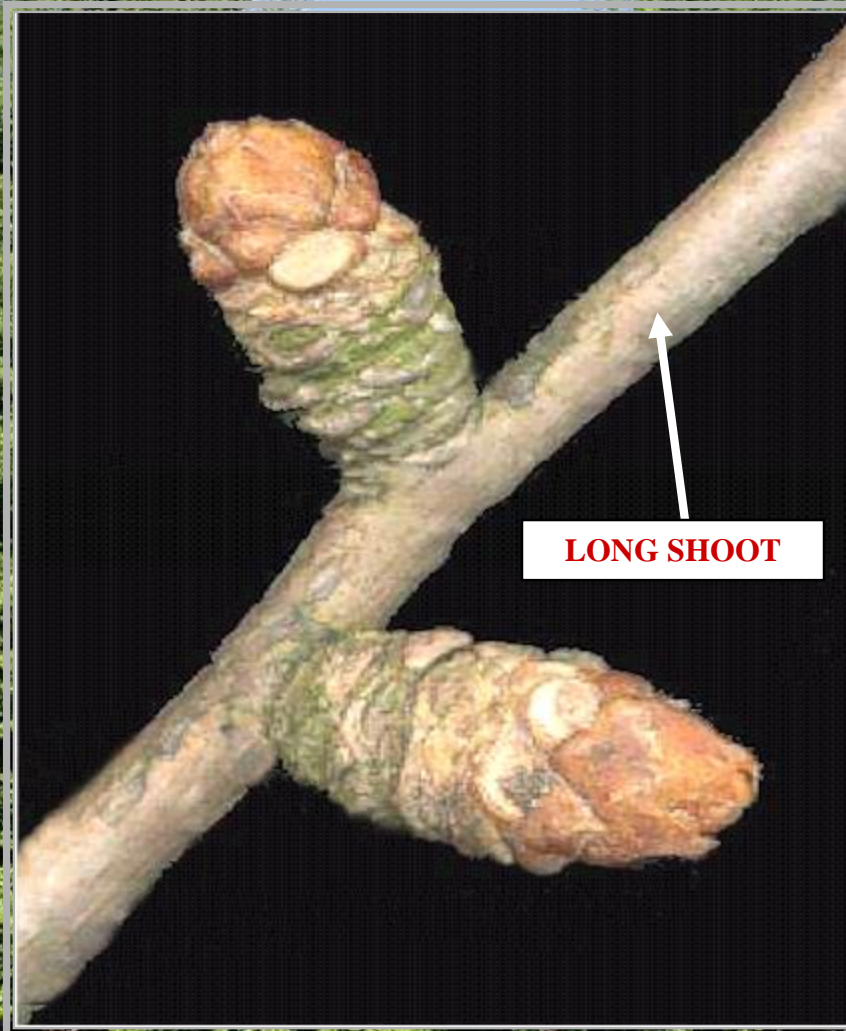


L

DIMORPHIC LONG SHOOTS

GINKGO

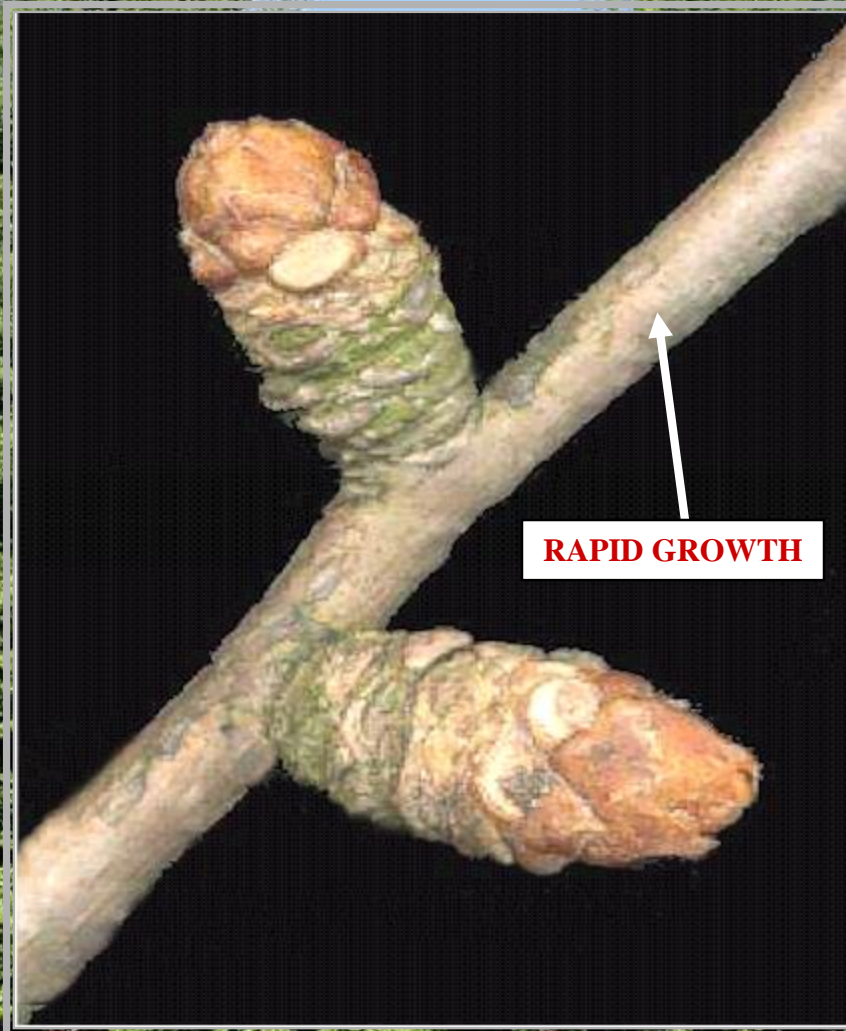
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LONG SHOOT

GINKGO

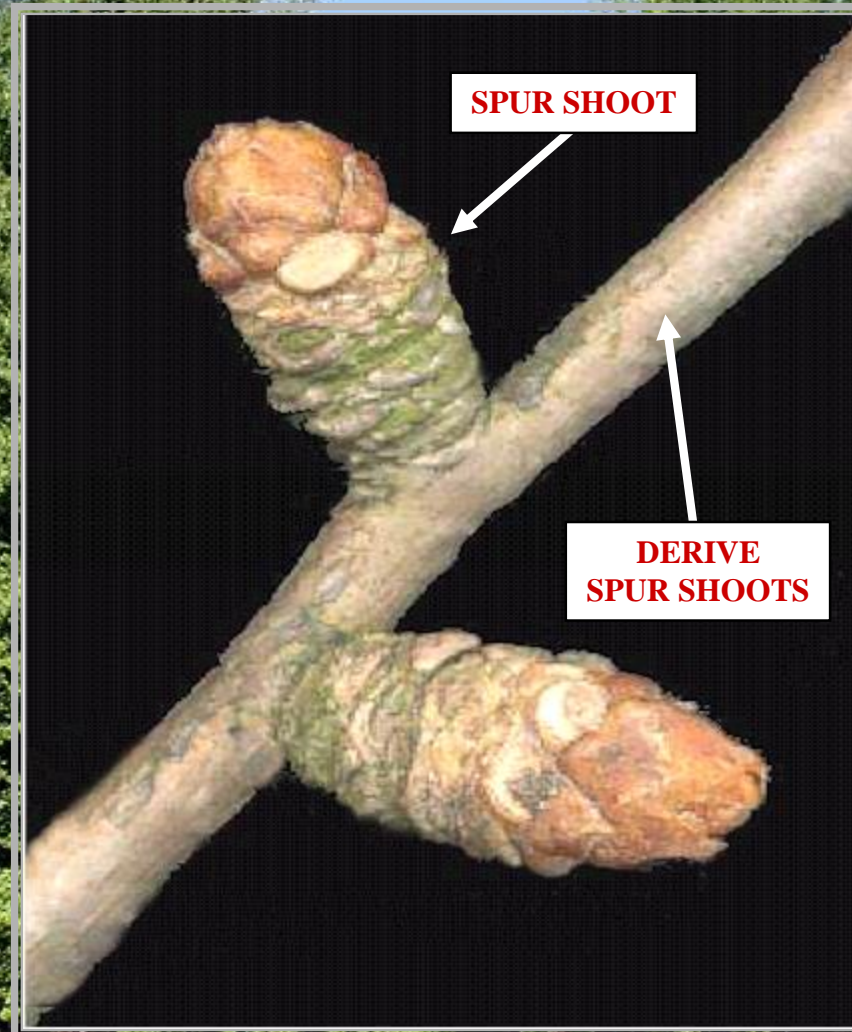
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RAPID GROWTH



GINKGO



SPUR SHOOT

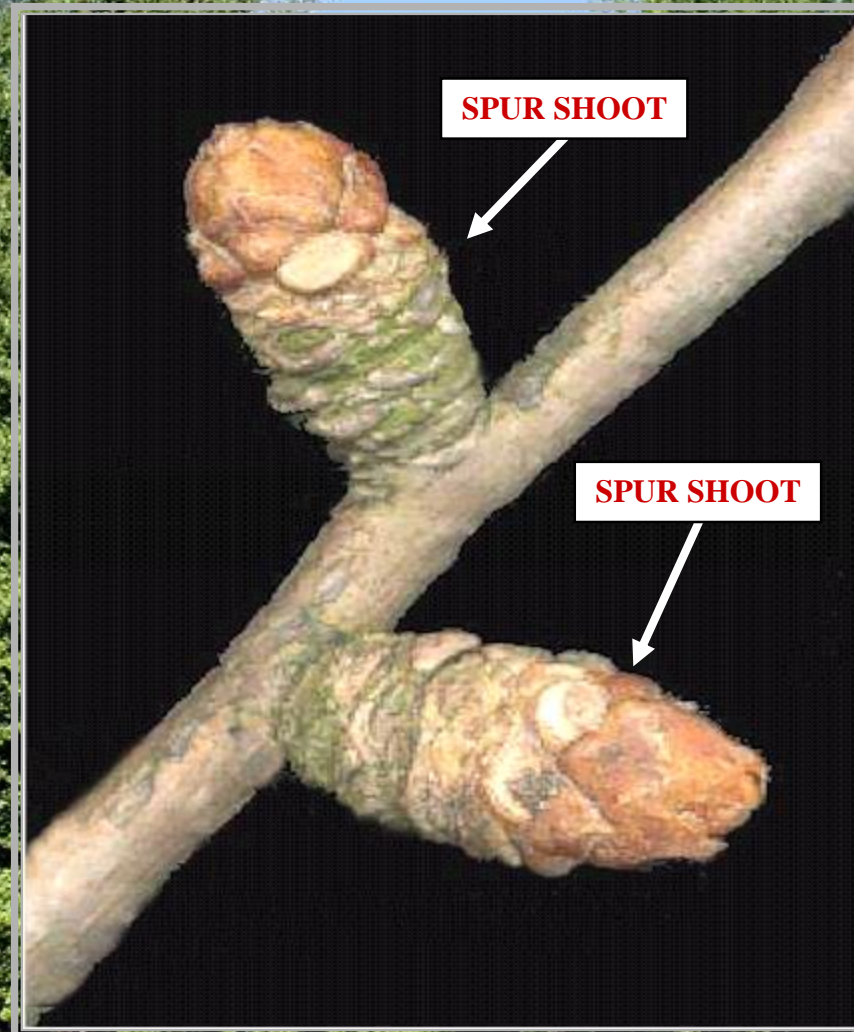
**DERIVE
SPUR SHOOTS**



DIMORPHIC SPUR SHOOTS

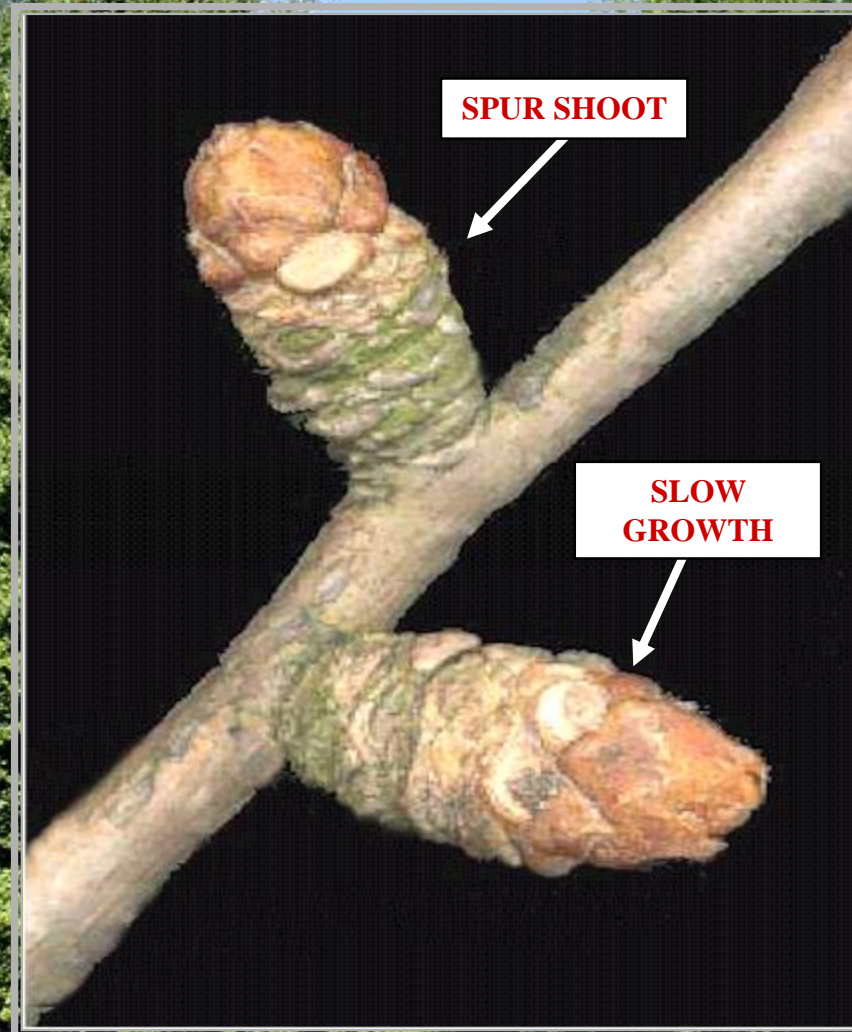
GINKGO

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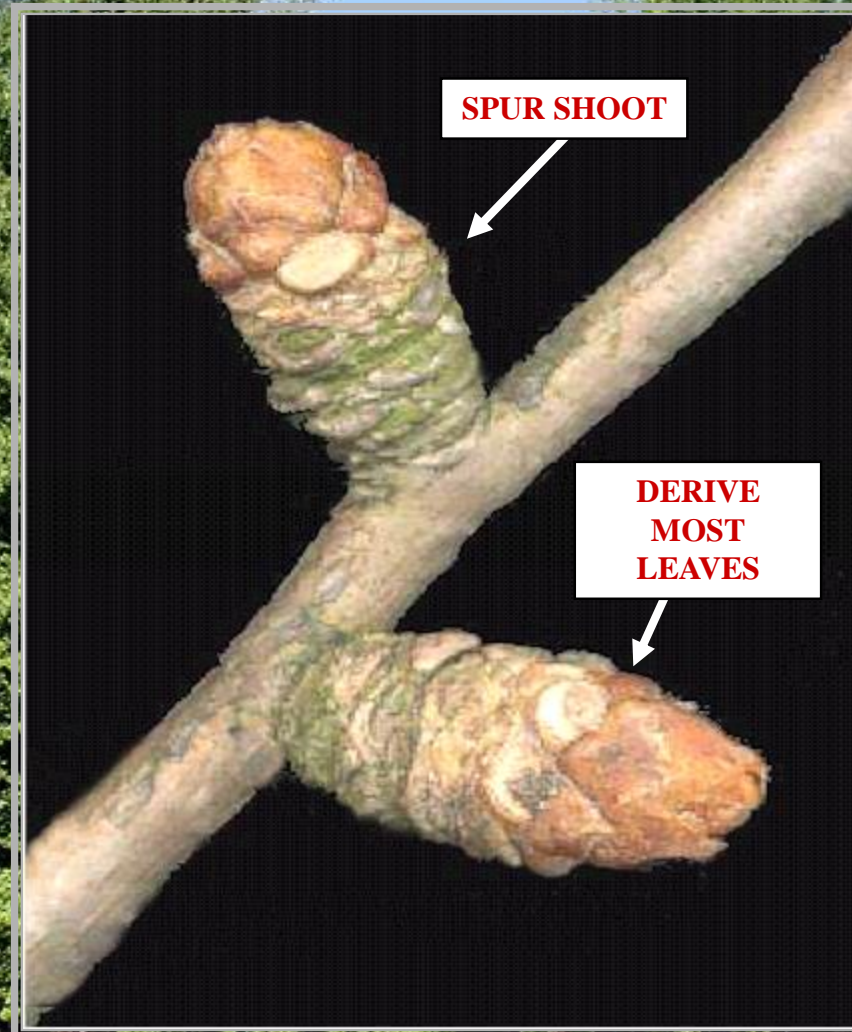


GINKGO

D



GINKGO



SPUR SHOOT

**DERIVE
MOST
LEAVES**