



LICHEN

**MUTUALISTIC
SYMBIOTIC
RELATIONSHIP
CYANOBACTERIUM**

LICHEN



LICHEN

**MUTUALISTIC
SYMBIOTIC
RELATIONSHIP**

CYANOBACTERIUM & FUNGUS

LICHEN



**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

L.S.

LICHEN THALLUS





**CYANOBACTERIUM
SYMBIONT**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

L.S.

LICHEN THALLUS





**CYANOBACTERIUM
SYMBIONT**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

**FUNGUS
SYMBIONT**

L.S.

LICHEN THALLUS





CYANOBACTERIUM
PHOTOSYNTHESIS
GLUCOSE

MUTUALISTIC SYMBIOTIC
RELATIONSHIP

FUNGUS
SYMBIONT

L.S.

LICHEN THALLUS





**CYANOBACTERIUM
PROVIDES:
FUNGUS
WITH GLUCOSE**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

**FUNGUS
GLUCOSE**

L.S.

LICHEN THALLUS





**CYANOBACTERIUM
SYMBIONT**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

**FUNGUS
SYMBIONT**

L.S.

LICHEN THALLUS





**CYANOBACTERIUM
SECURITY**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

**FUNGUS
PROVIDES:
CYANOBACTERIUM
WITH SECURITY**

L.S.

LICHEN THALLUS





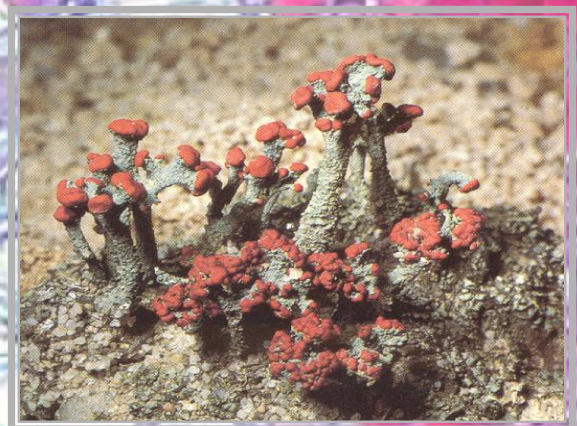
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PROVIDES:
FUNGUS
WITH GLUCOSE**

**MUTUALISTIC SYMBIOTIC
RELATIONSHIP**

**FUNGUS
PROVIDES:
CYANOBACTERIUM
WITH SECURITY**

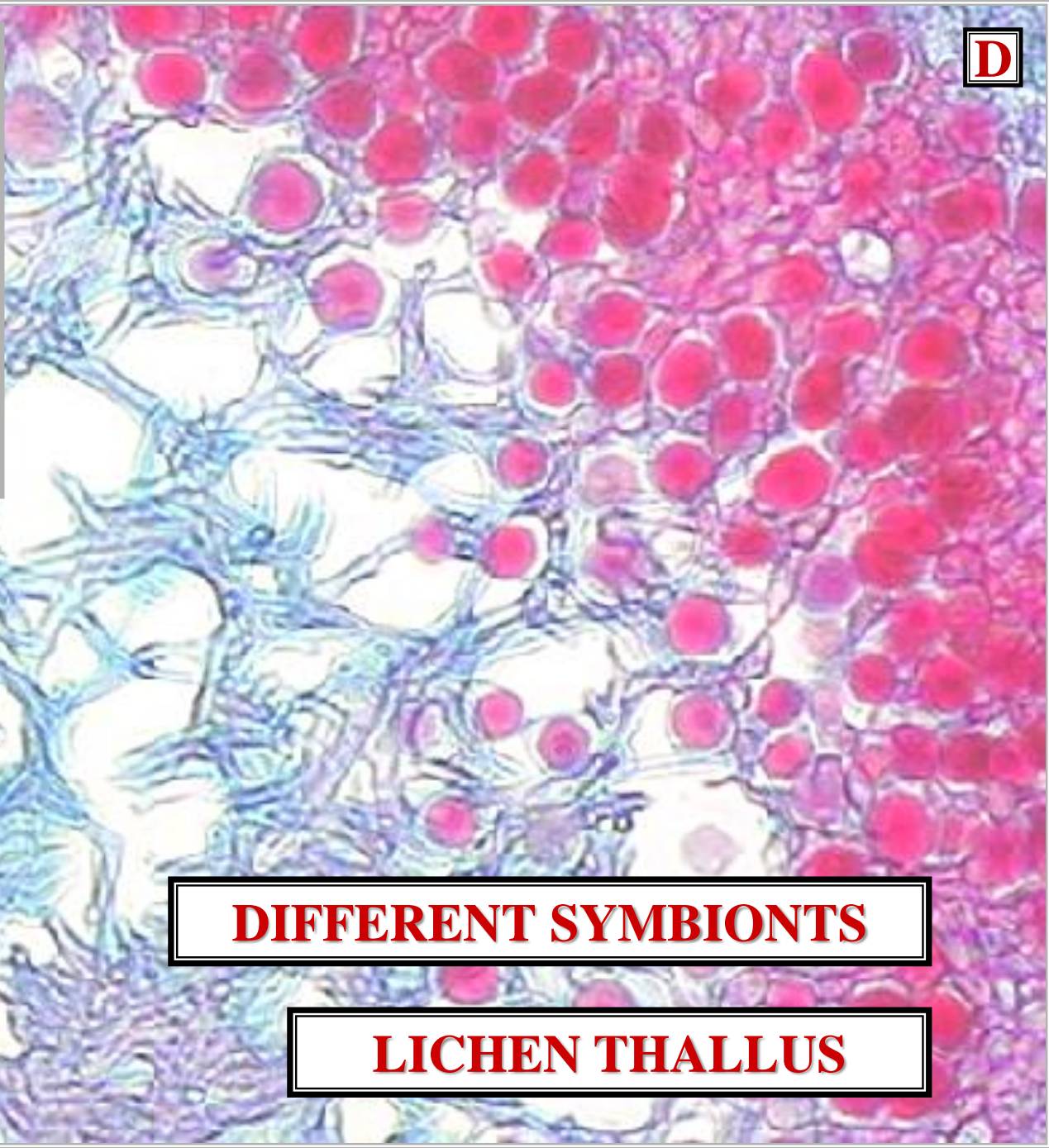
L.S.

LICHEN THALLUS





LICHEN GOWTH FORMS



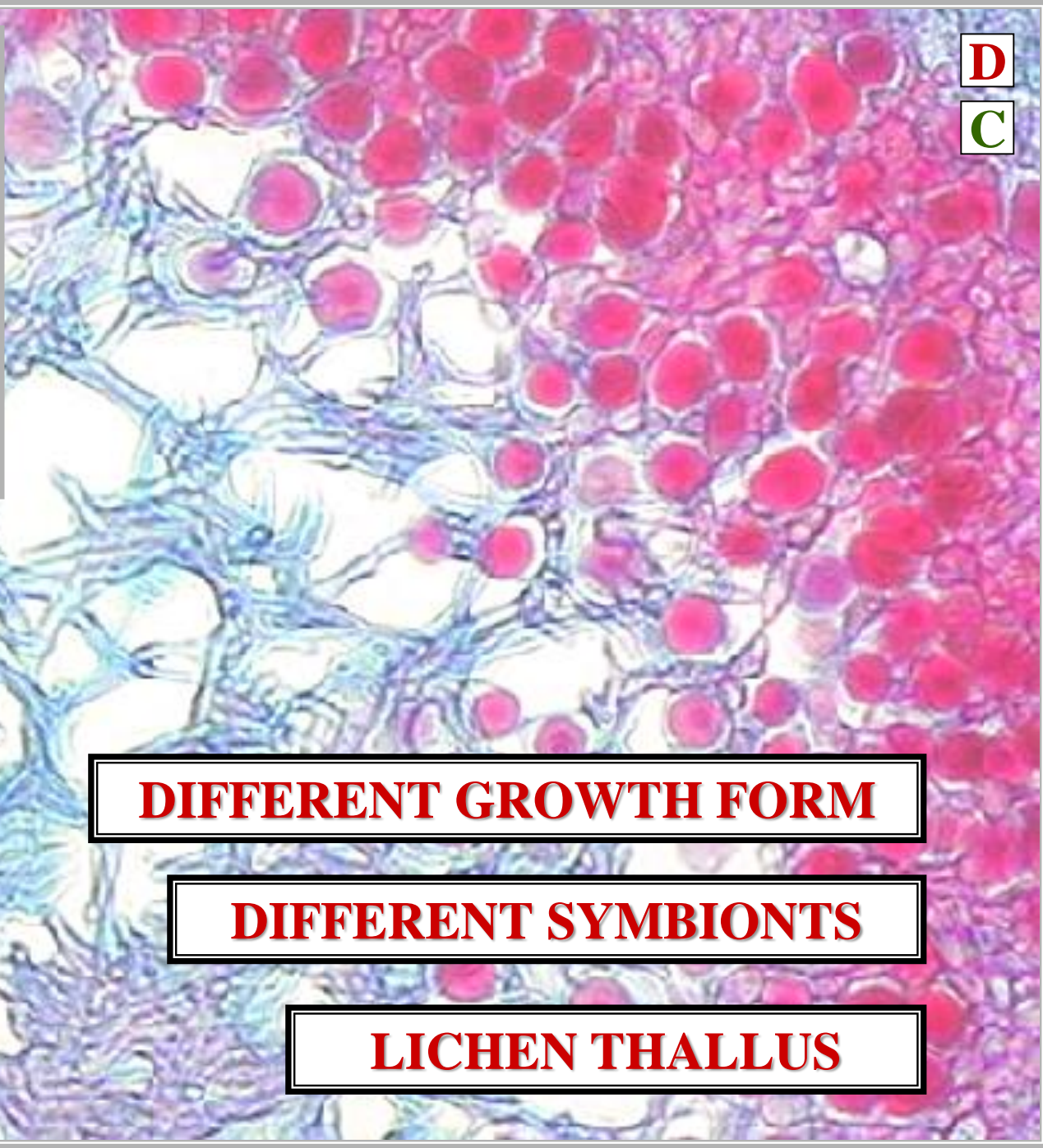
L.S.

DIFFERENT SYMBIONTS

LICHEN THALLUS

D

C



DIFFERENT GROWTH FORM

DIFFERENT SYMBIONTS

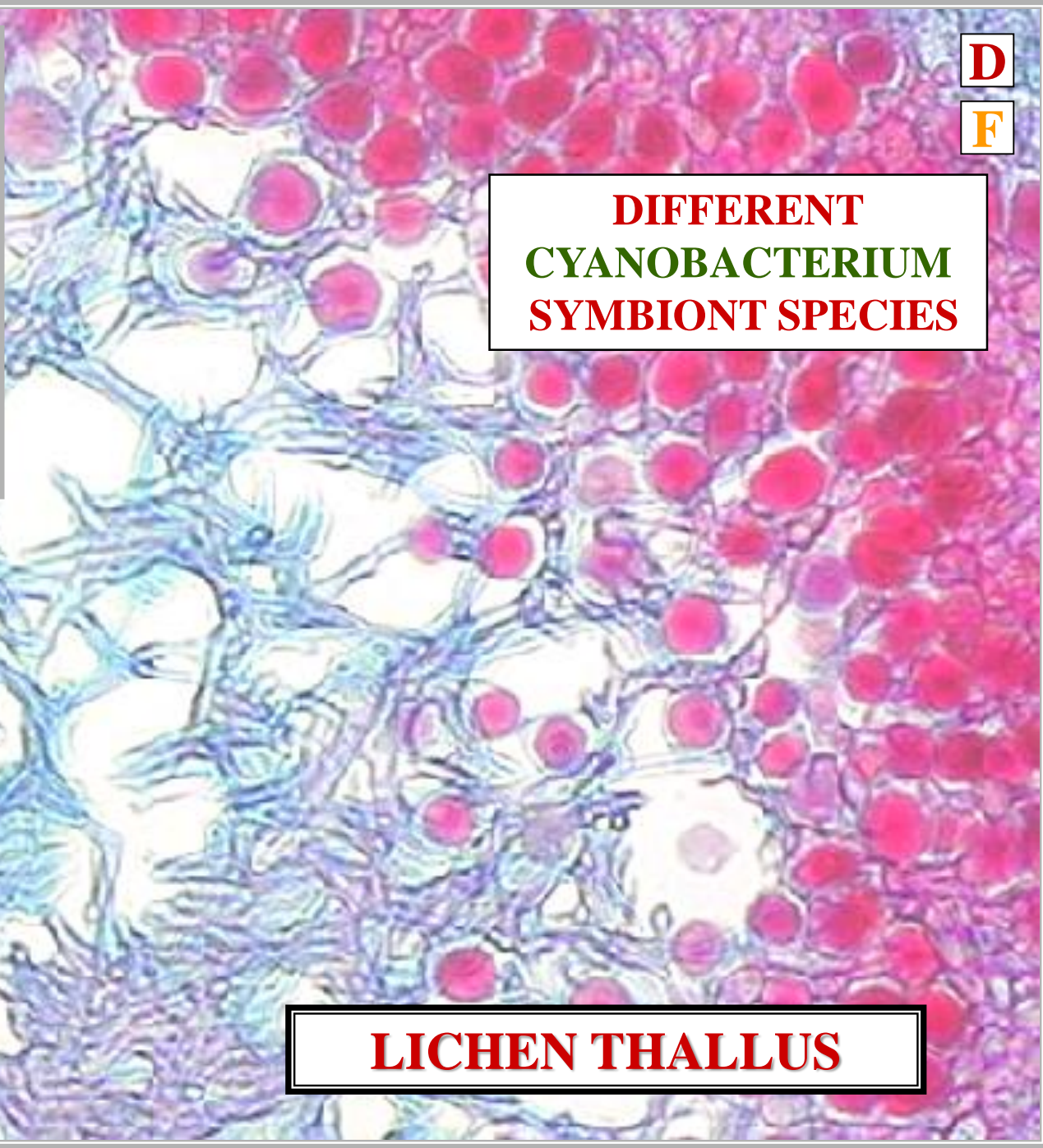
L.S.

LICHEN THALLUS

D

F

**DIFFERENT
CYANOBACTERIUM
SYMBIONT SPECIES**



L.S.

LICHEN THALLUS

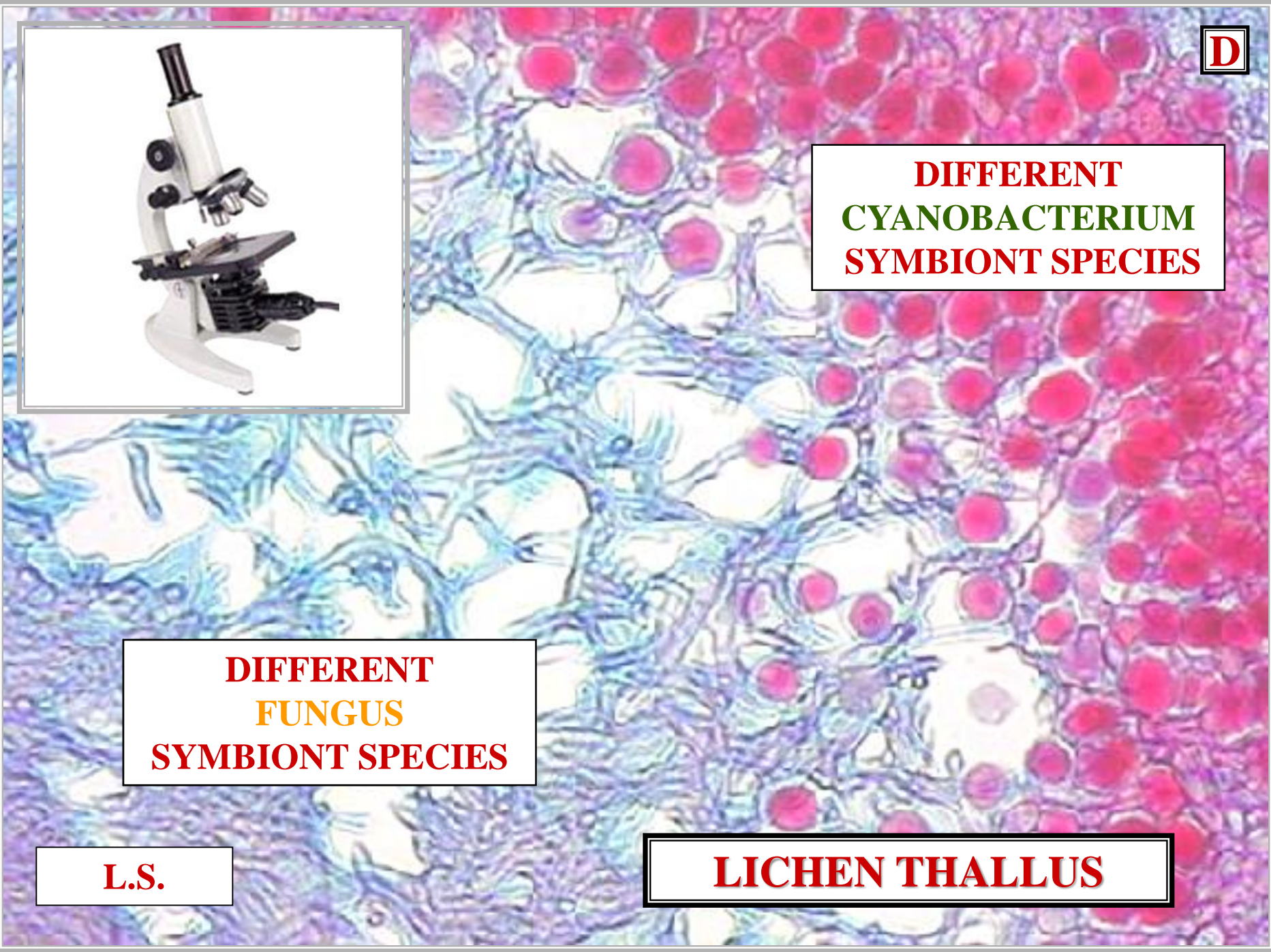


**DIFFERENT
CYANOBACTERIUM
SYMBIONT SPECIES**

**DIFFERENT
FUNGUS
SYMBIONT SPECIES**

L.S.

LICHEN THALLUS





**DIFFERENT
CYANOBACTERIUM
SYMBIONT SPECIES**

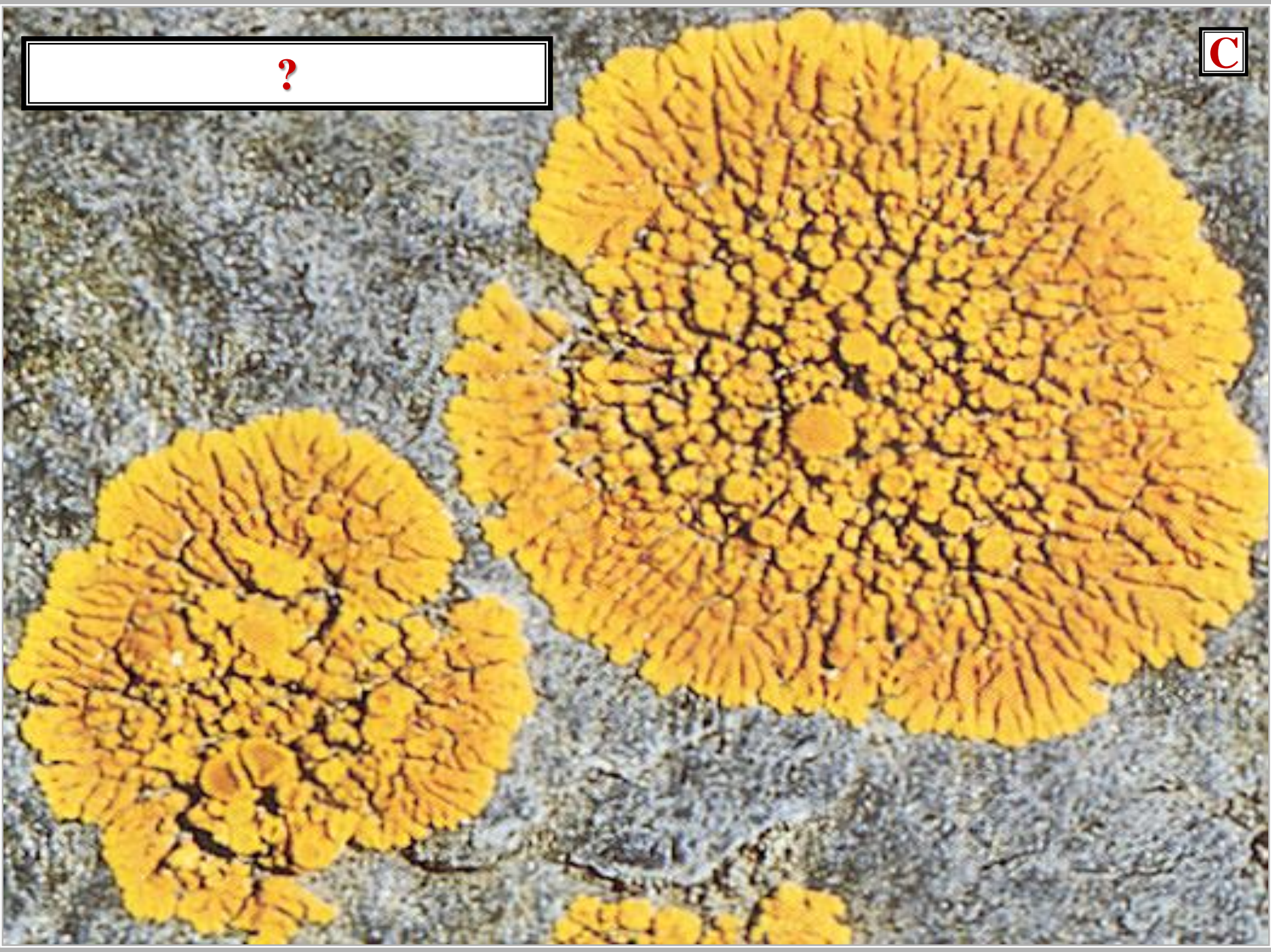
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GROWTH FORM**

**DIFFERENT
FUNGUS
SYMBIONT SPECIES**

L.S.

LICHEN THALLUS

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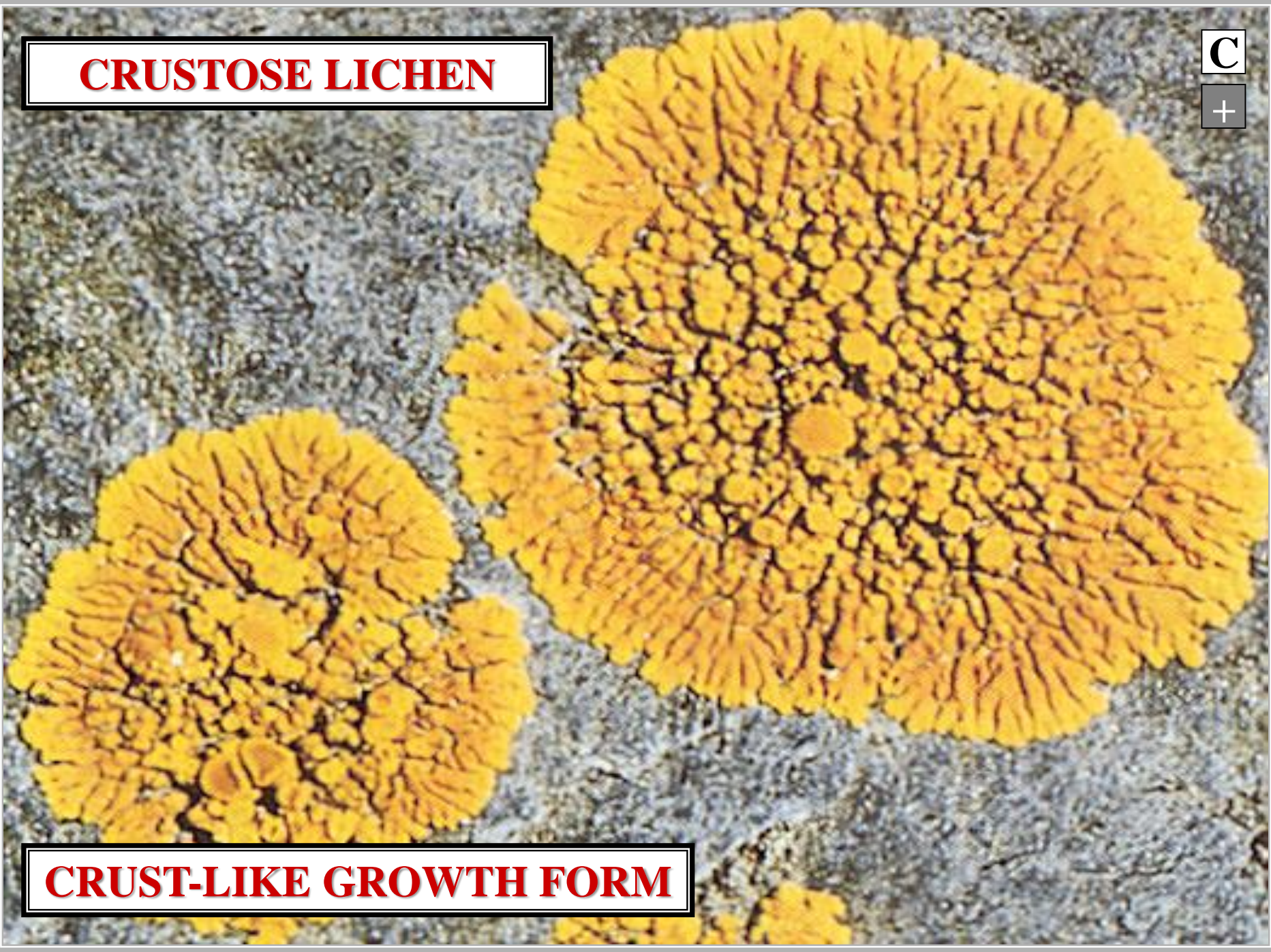


CRUSTOSE LICHEN

C

+

CRUST-LIKE GROWTH FORM



CRUSTOSE

CRUSTOSE LICHEN GROWTH FORM



**CRUST-LIKE
GROWTH FORM**

**CRUSTOSE LICHEN
GROWTH FORM**

?



FOLIOSE LICHEN

F

+

LEAF-LIKE GROWTH FORM



FOLIOSE

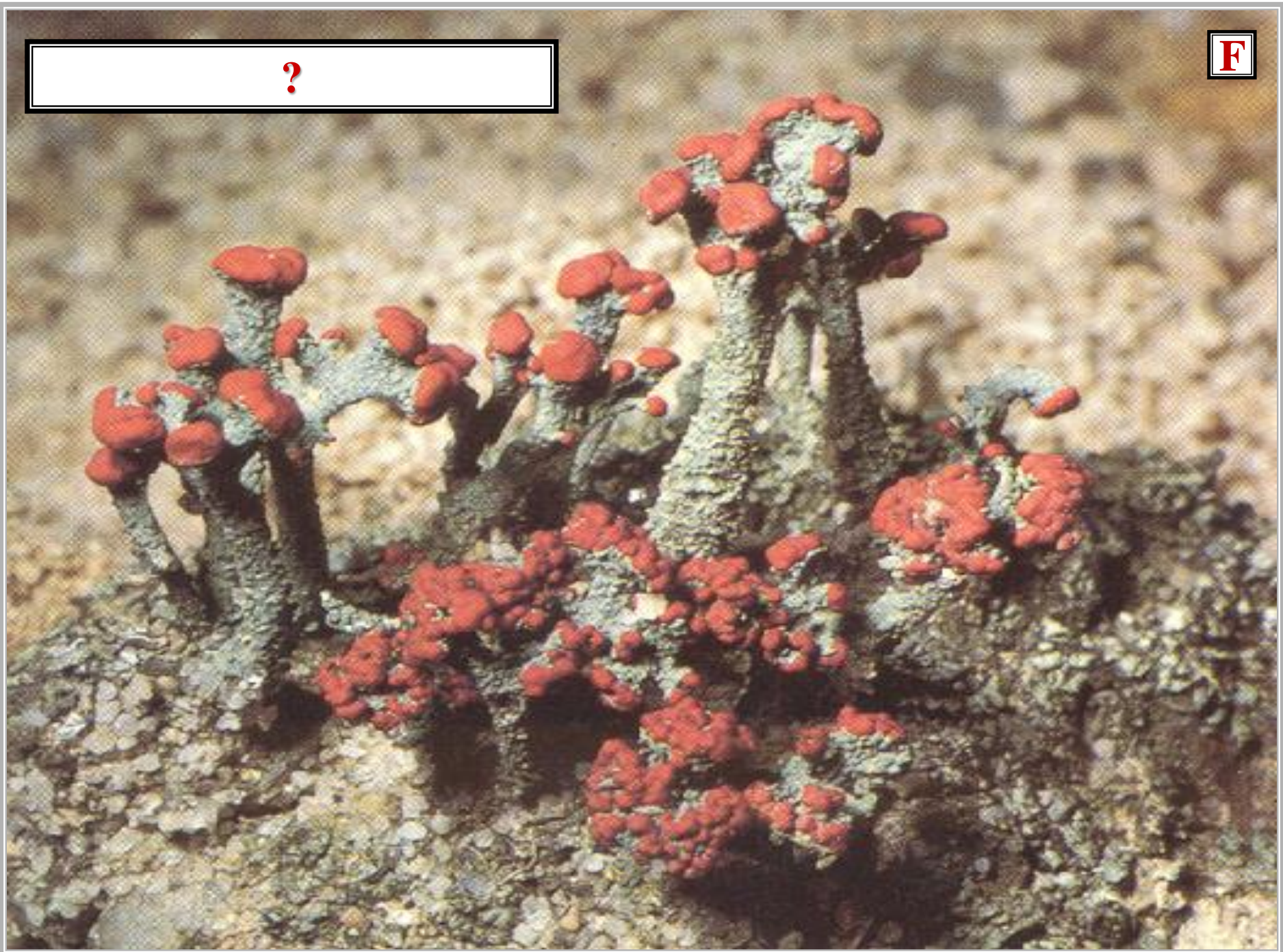
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GROWTH FORM**



**LEAF-LIKE
GROWTH FORM**

**FOLIOSE LICHEN
GROWTH FORM**

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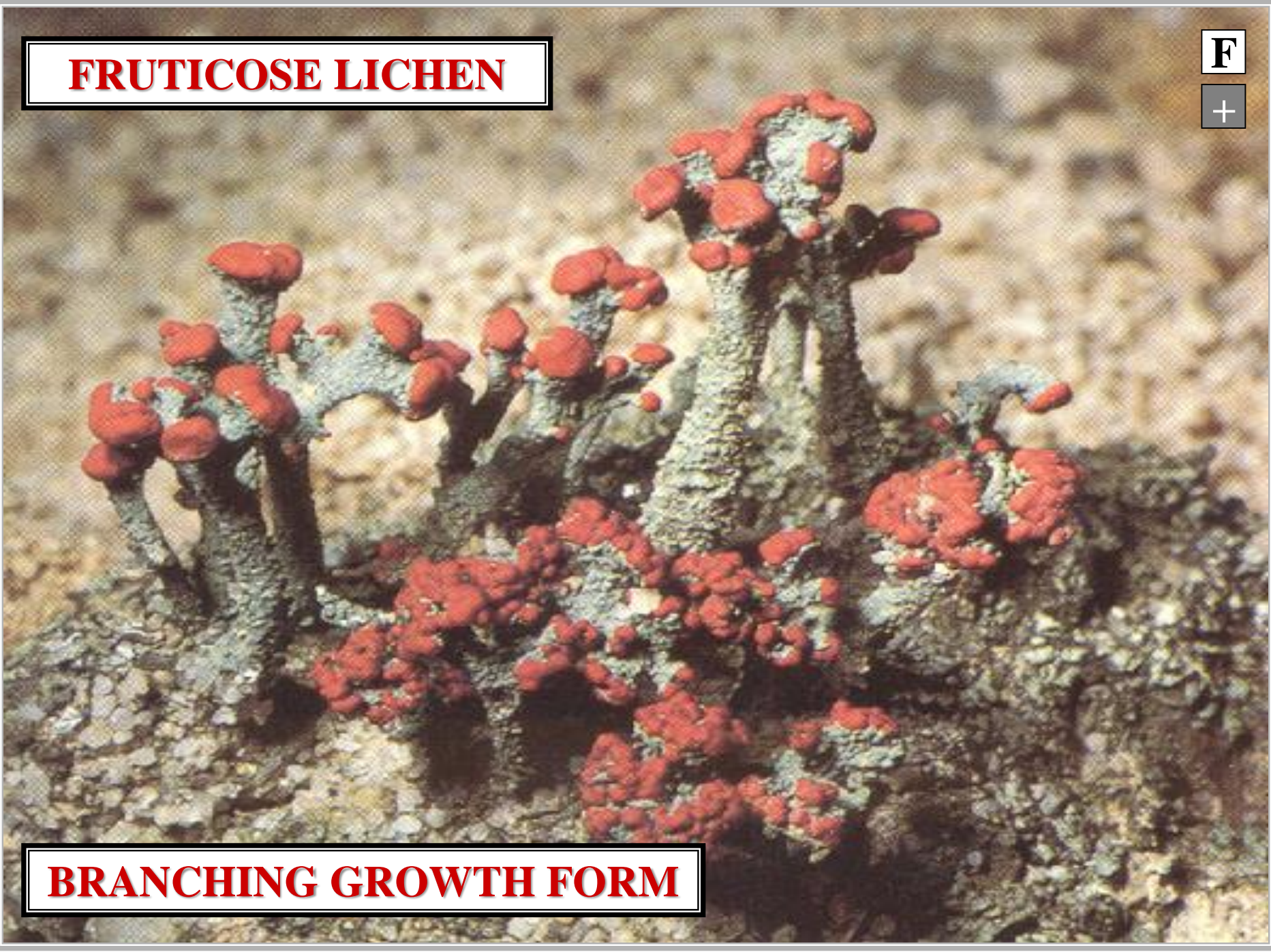


FRUTICOSE LICHEN

F

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BRANCHING GROWTH FORM



FRUTICOSE

**FRUTICOSE LICHEN
GROWTH FORM**



S

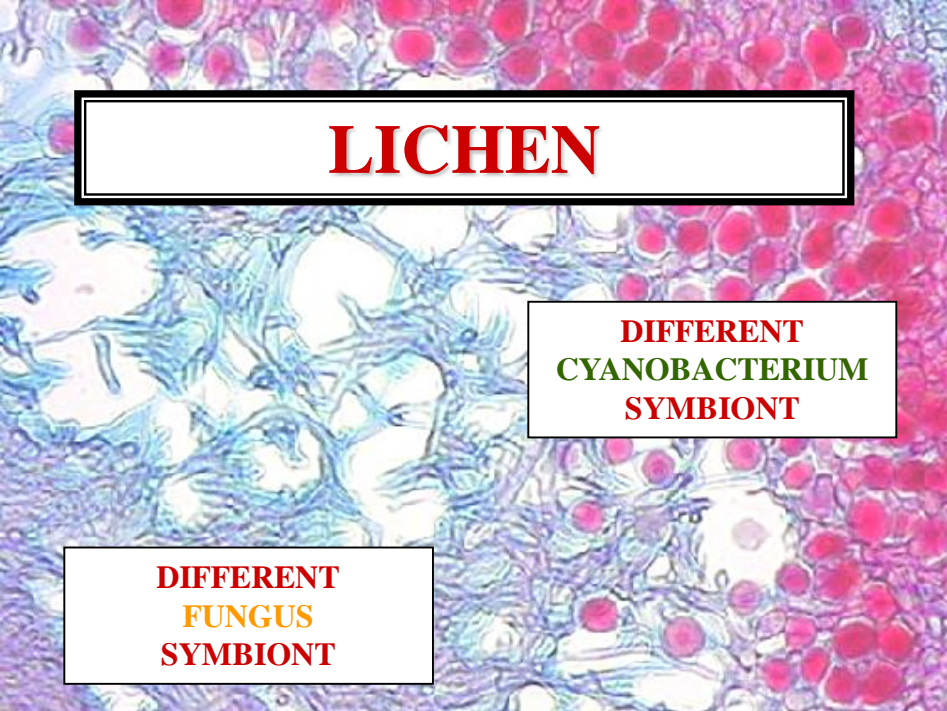
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GROWTH FORM**

**FRUTICOSE LICHEN
GROWTH FORM**

LICHEN

DIFFERENT
CYANOBACTERIUM
SYMBIONT

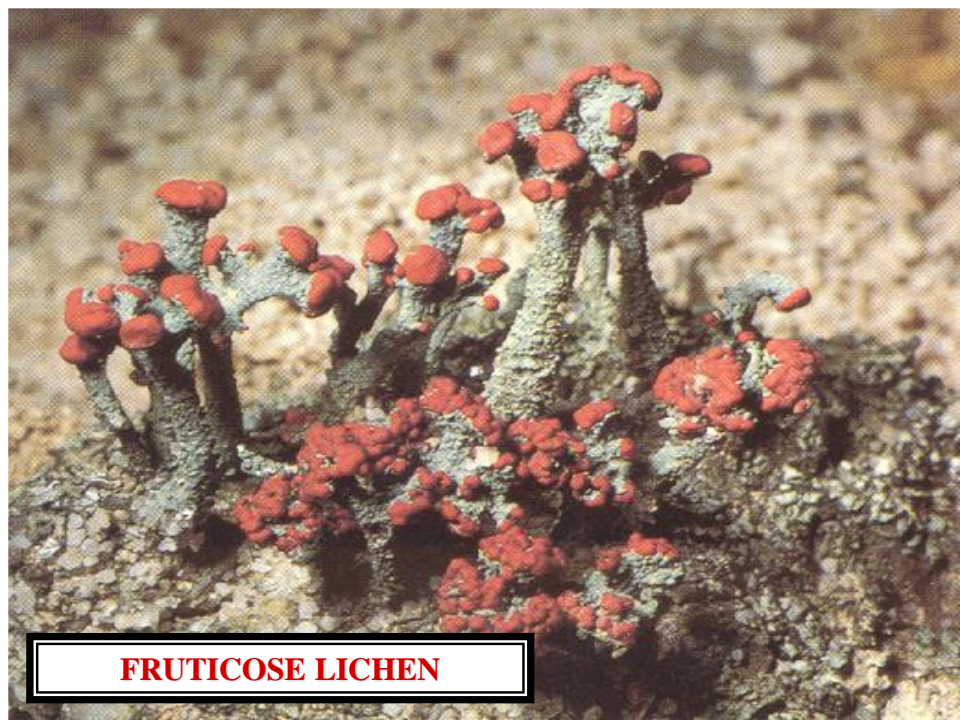
DIFFERENT
FUNGUS
SYMBIONT



CRUSTOSE LICHEN



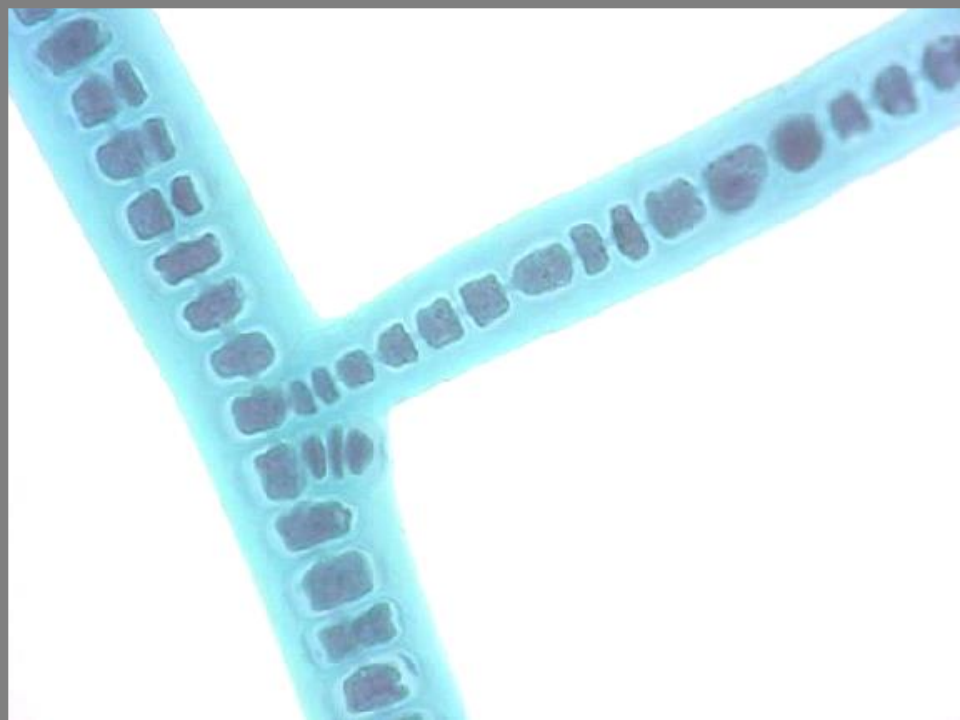
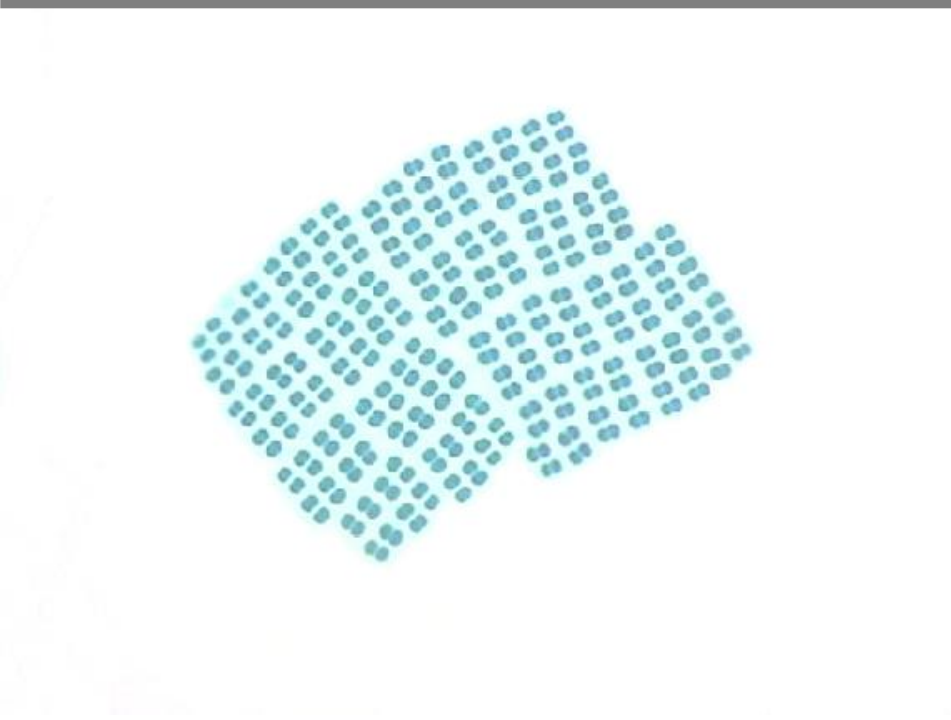
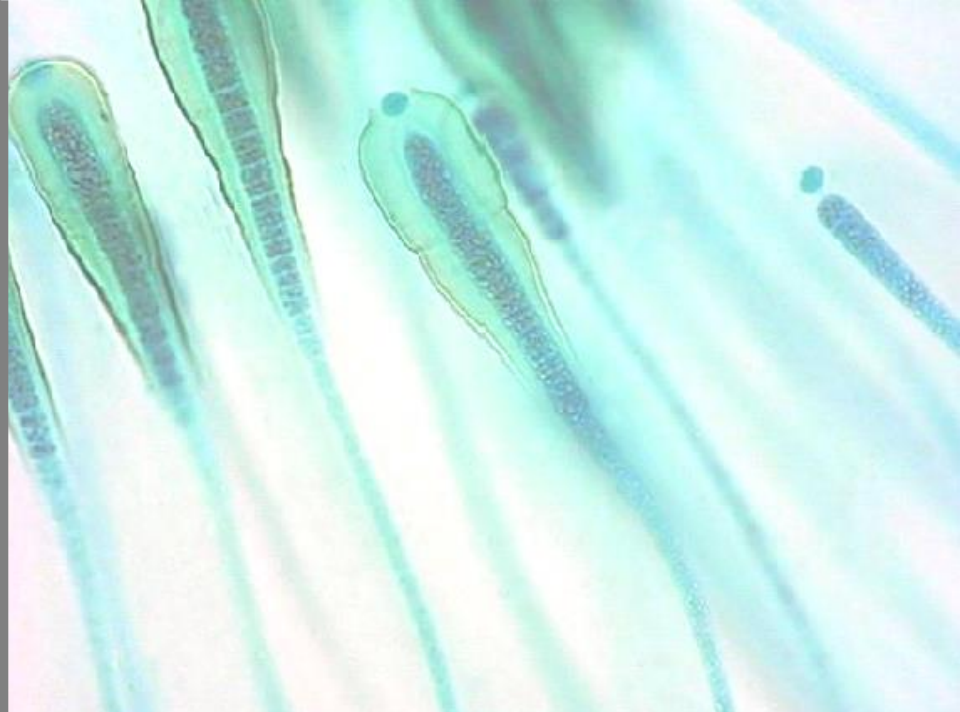
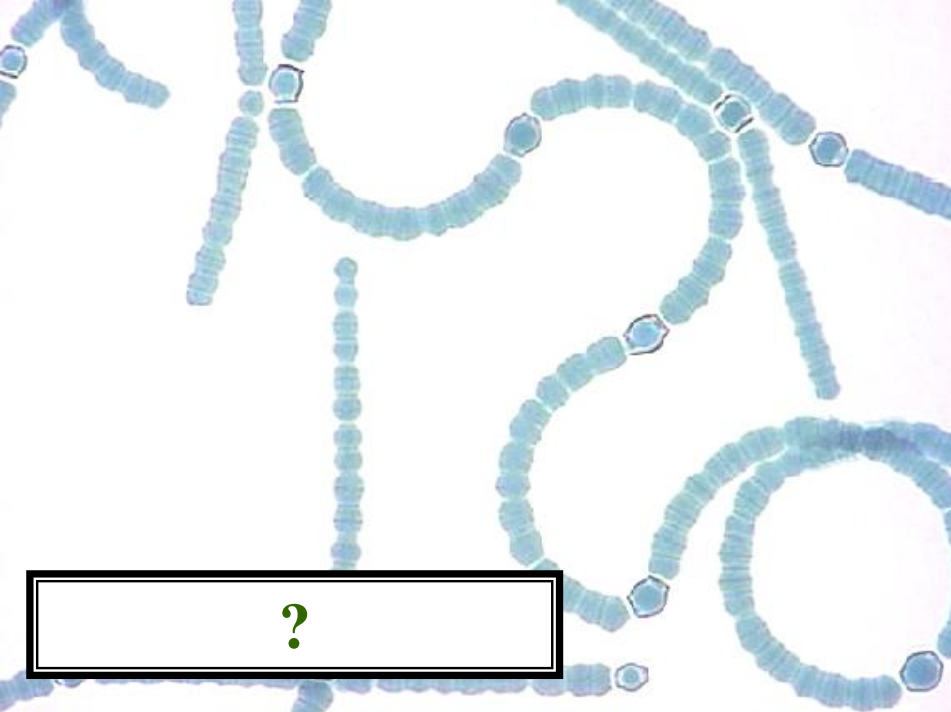
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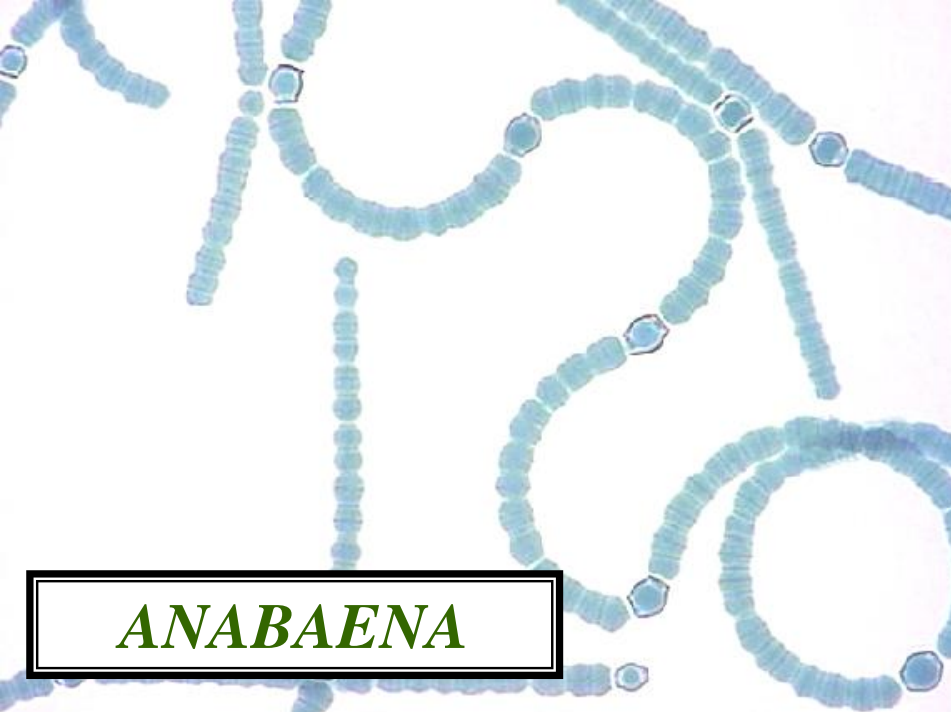


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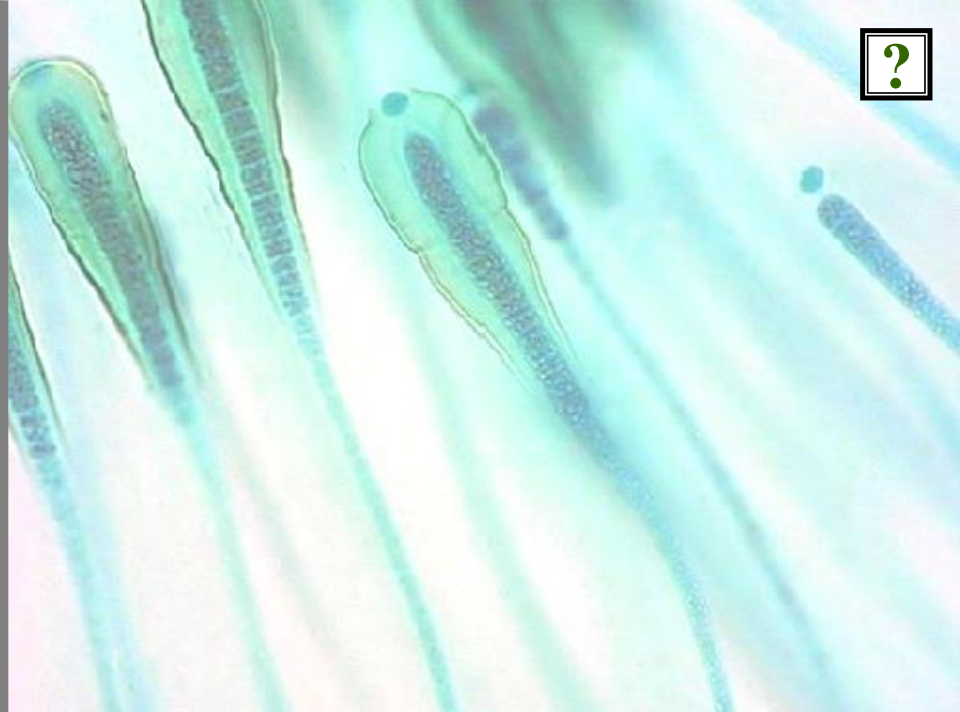


REPRESENTATIVE GENERA

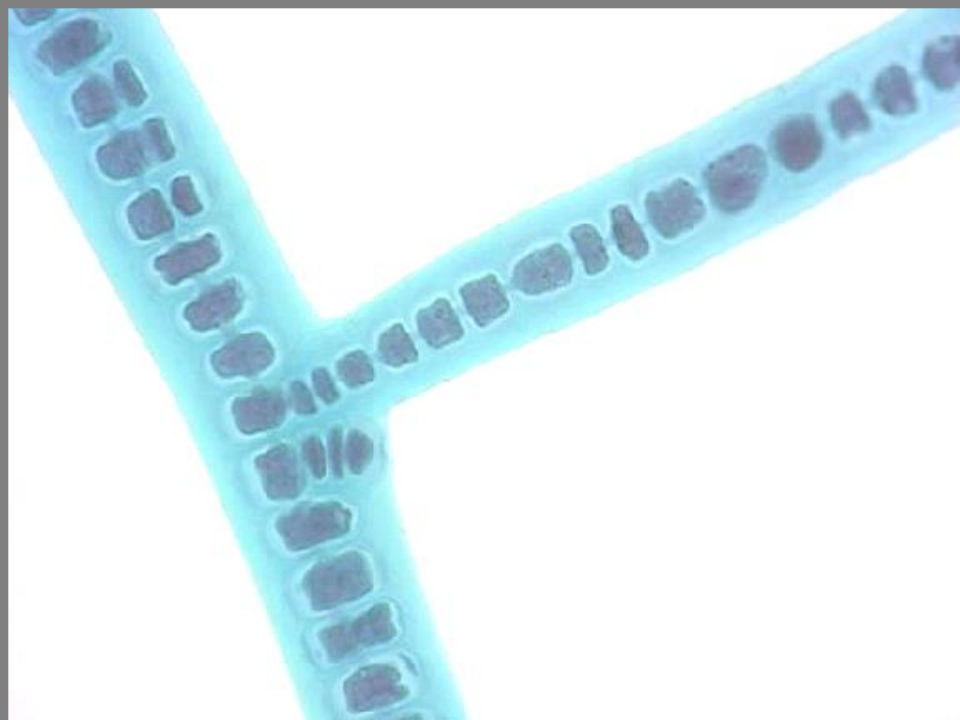
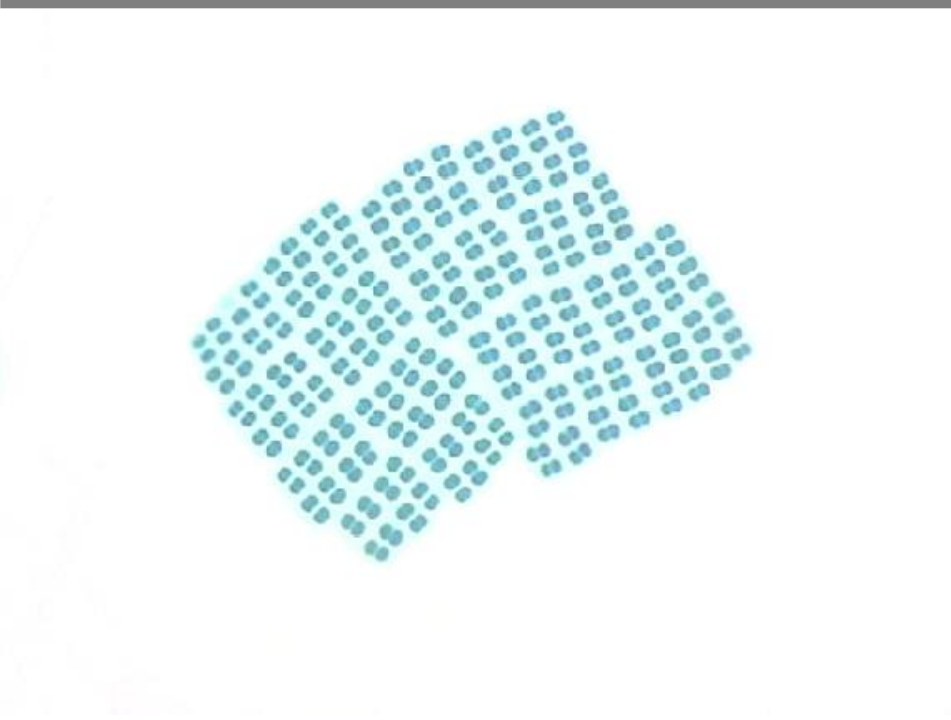


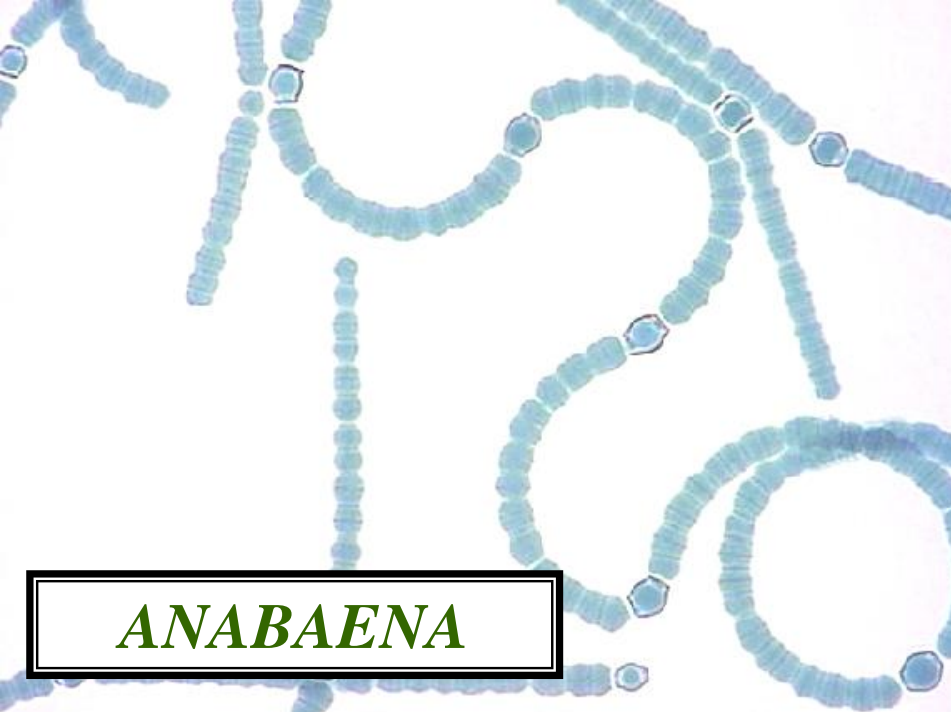


ANABAENA

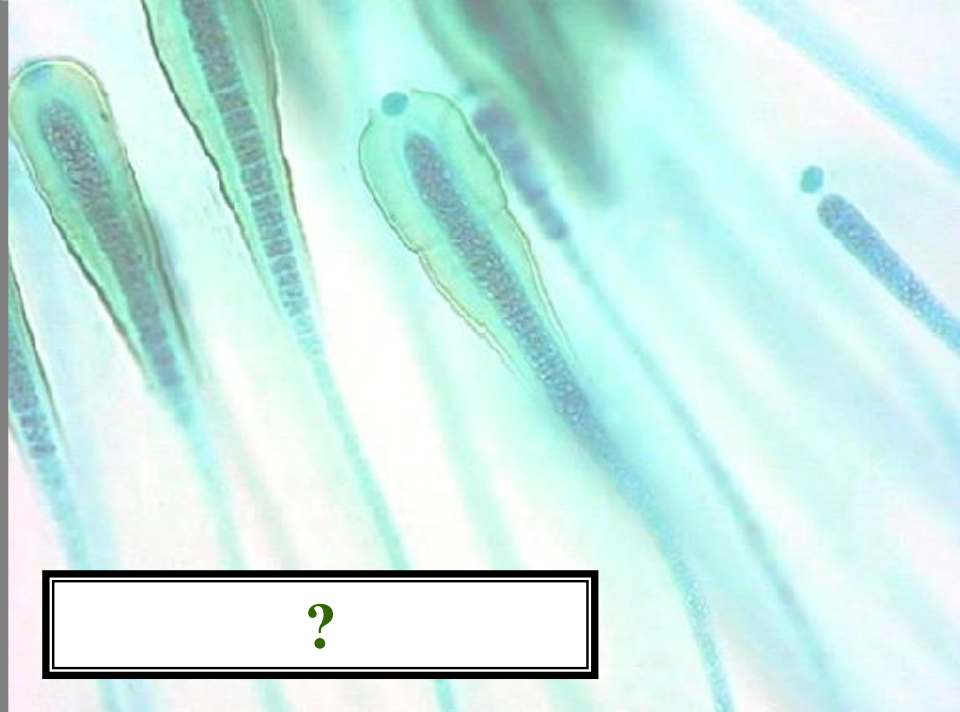


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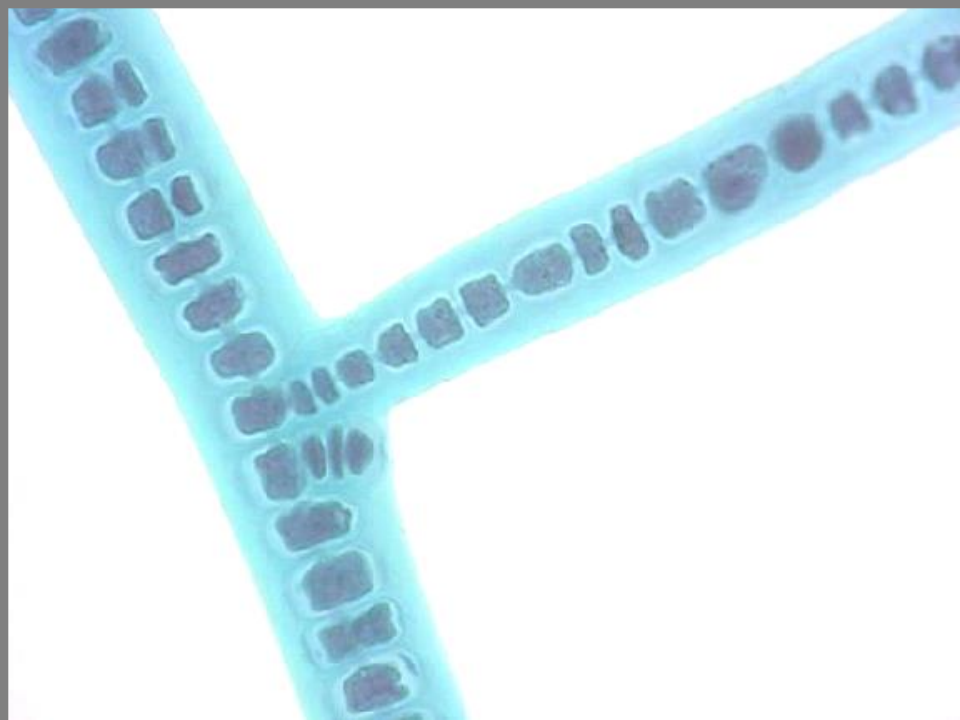
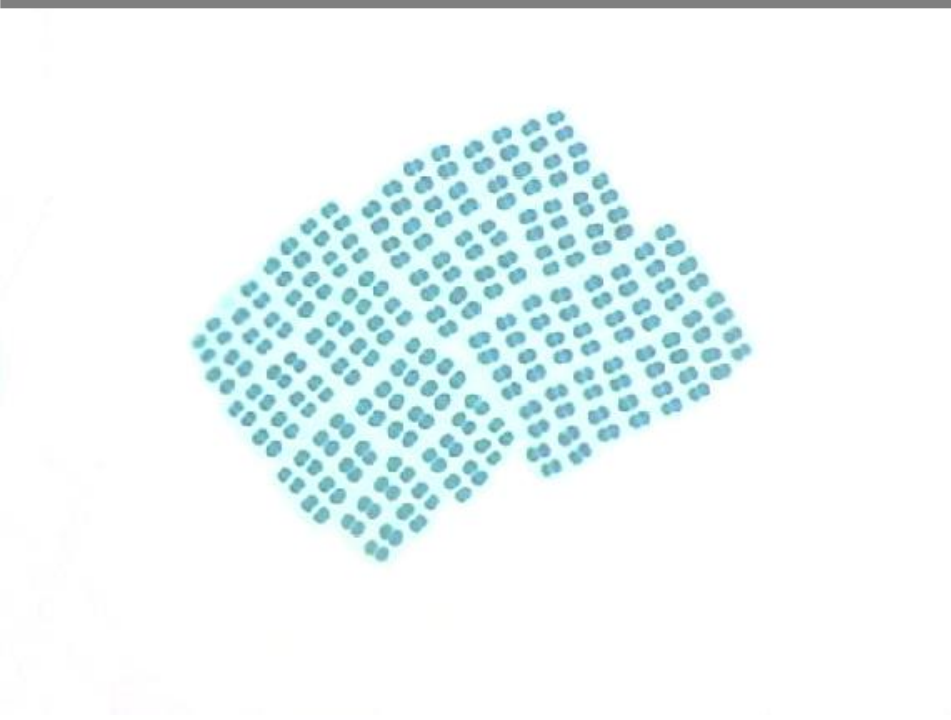


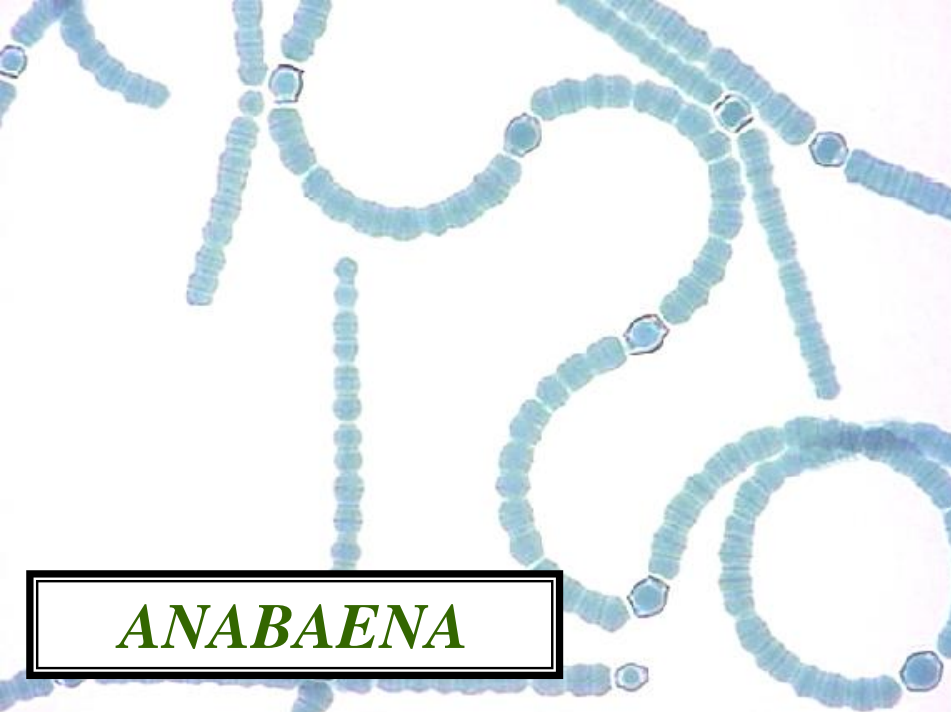


ANABAENA



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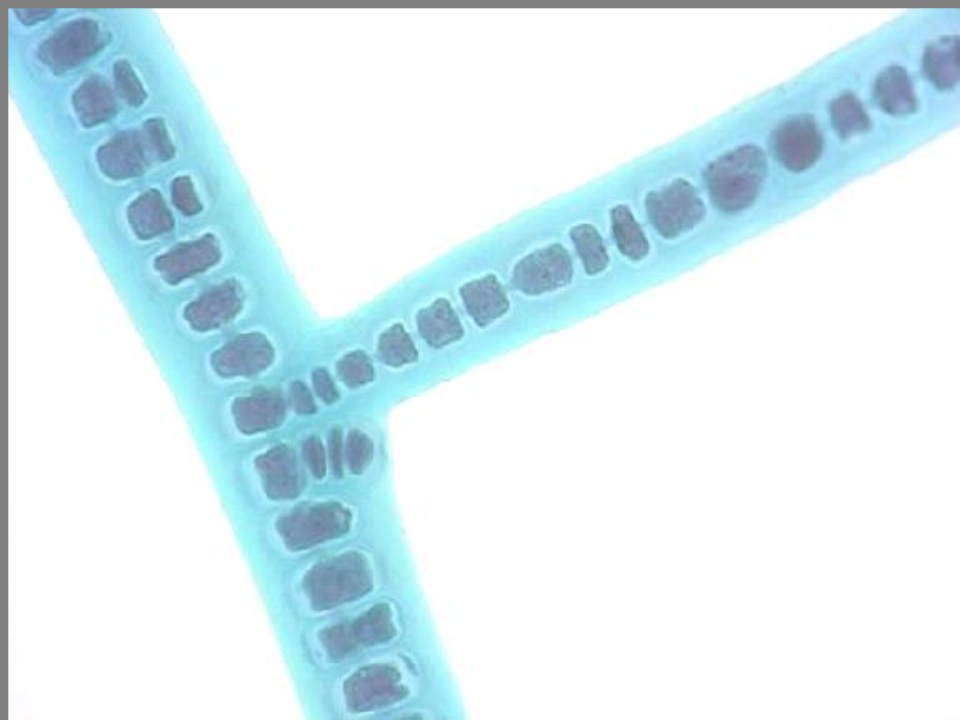
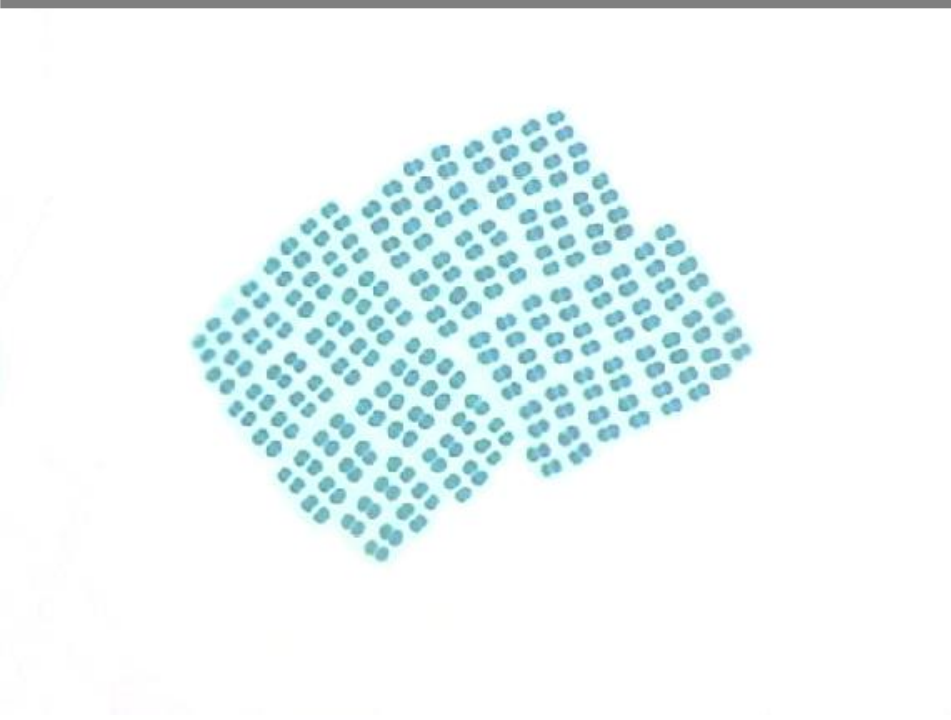


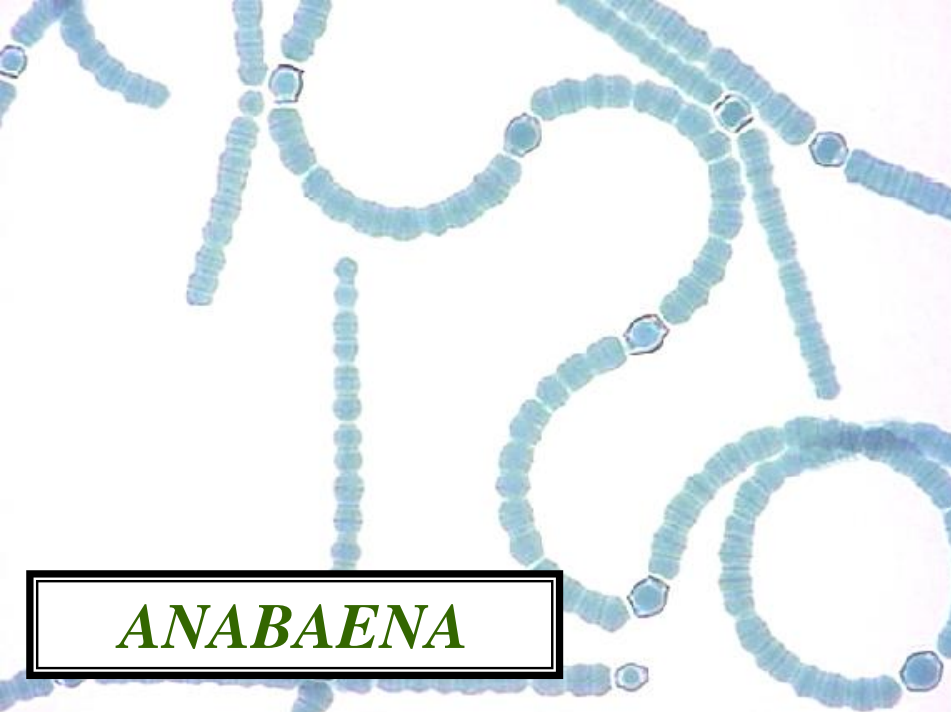


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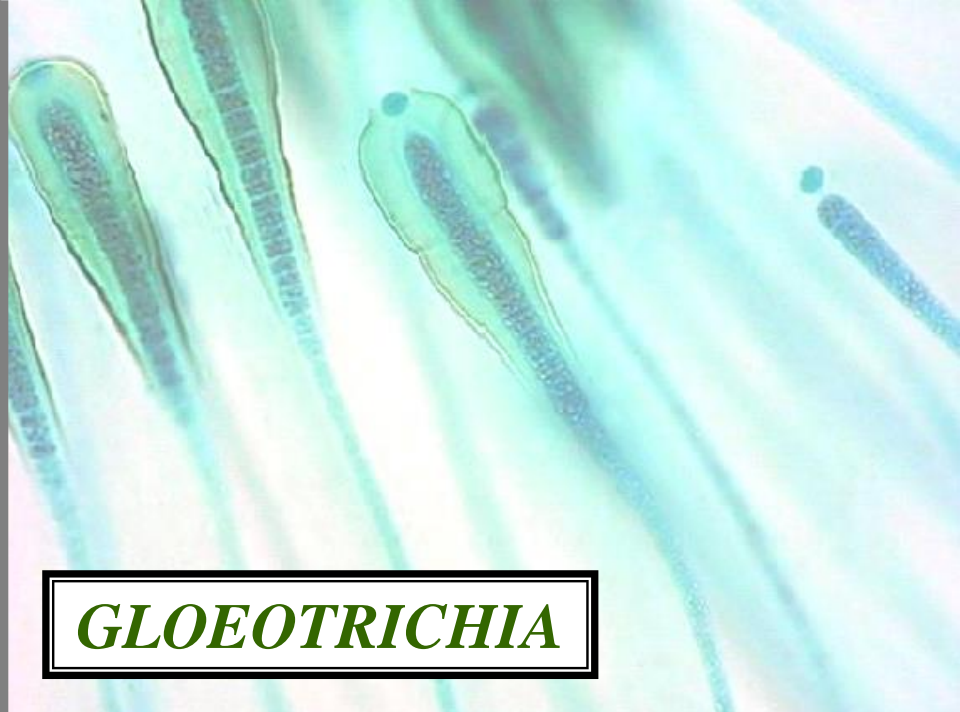


GLOEOTRICHIA

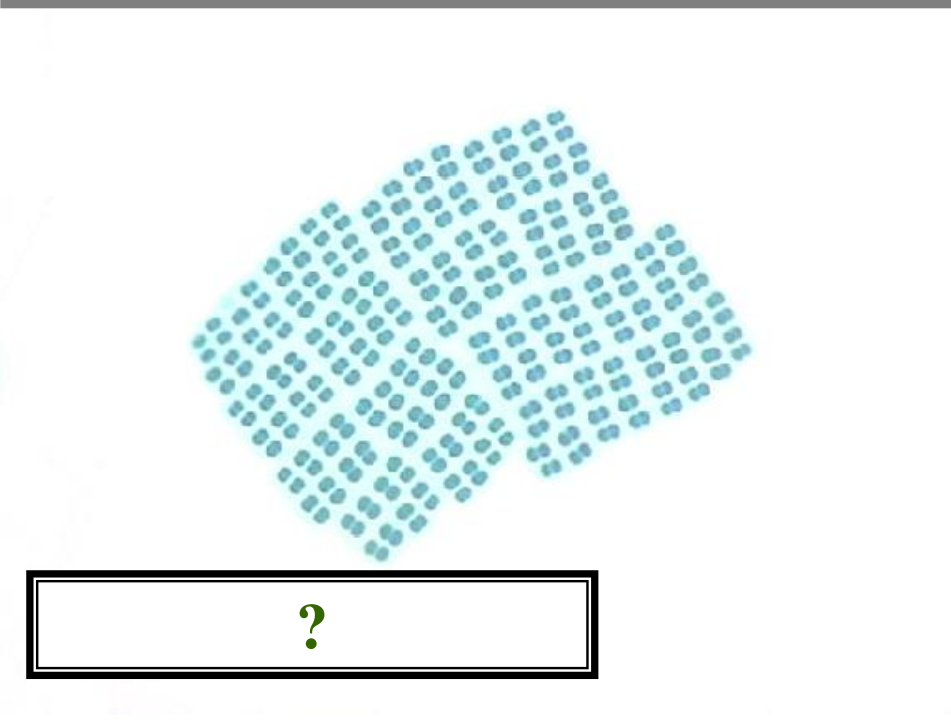




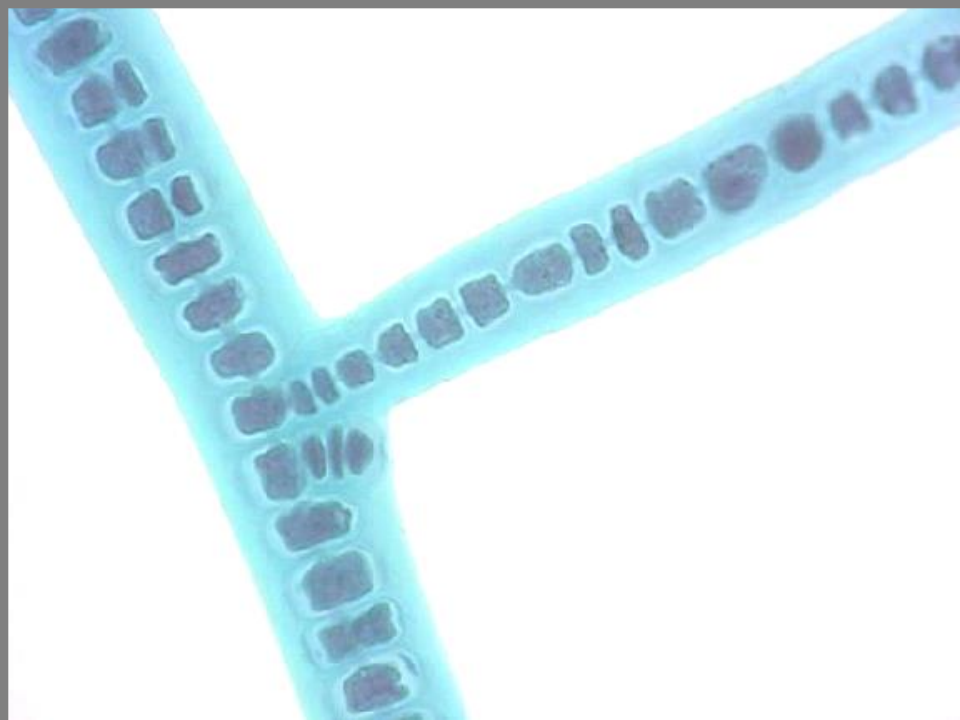
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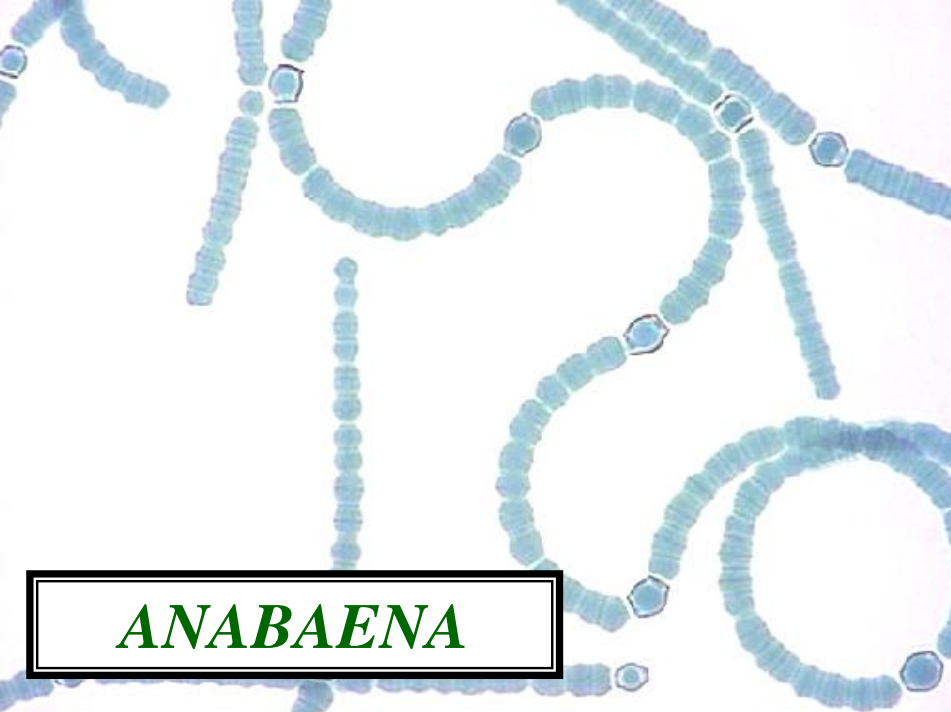


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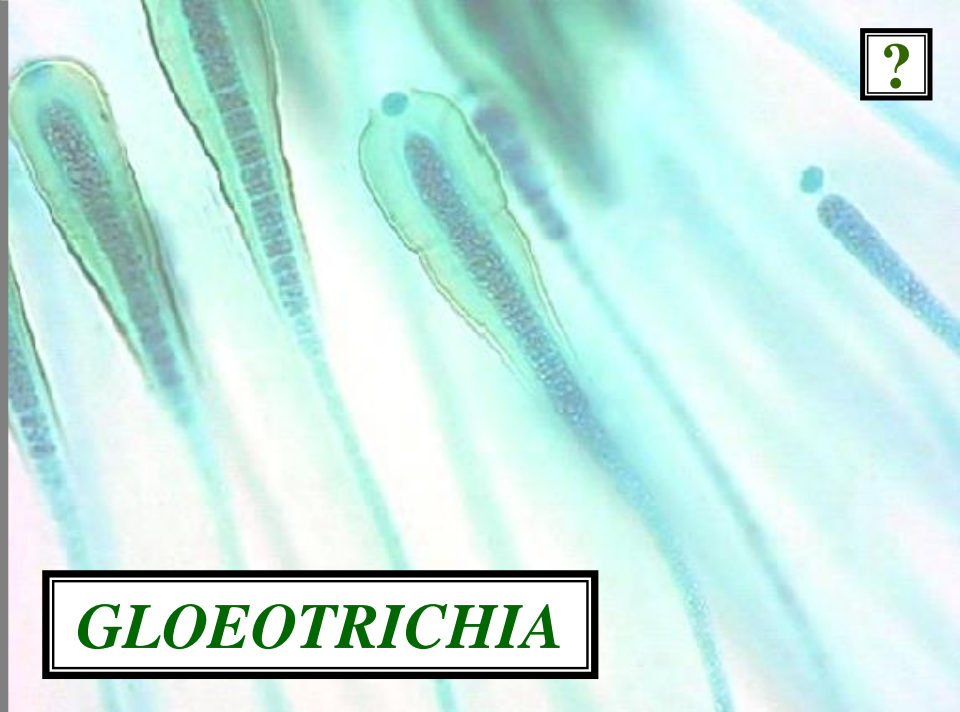


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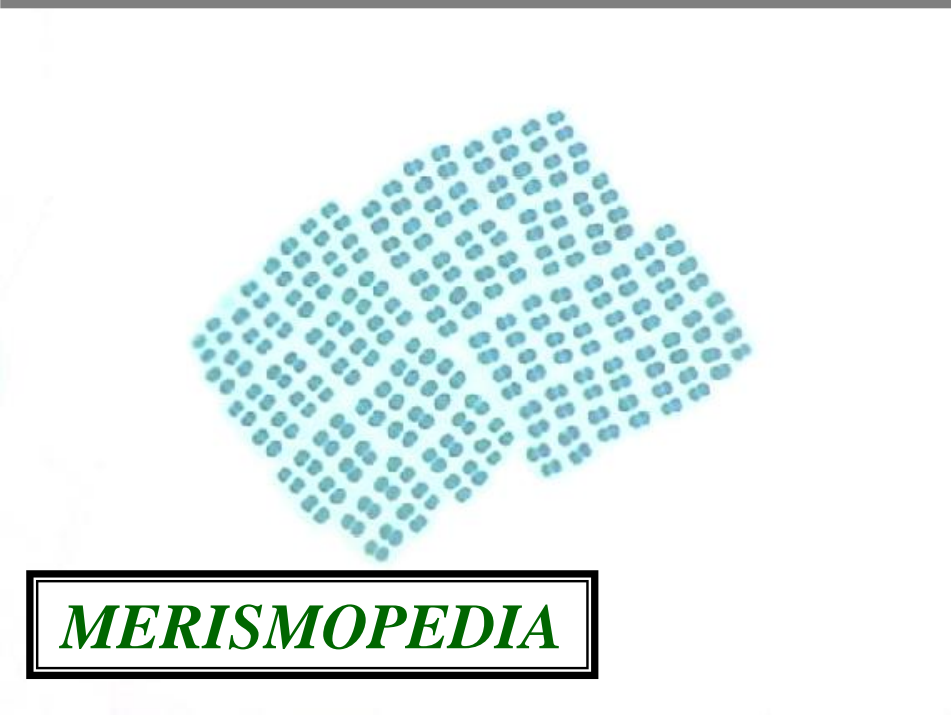


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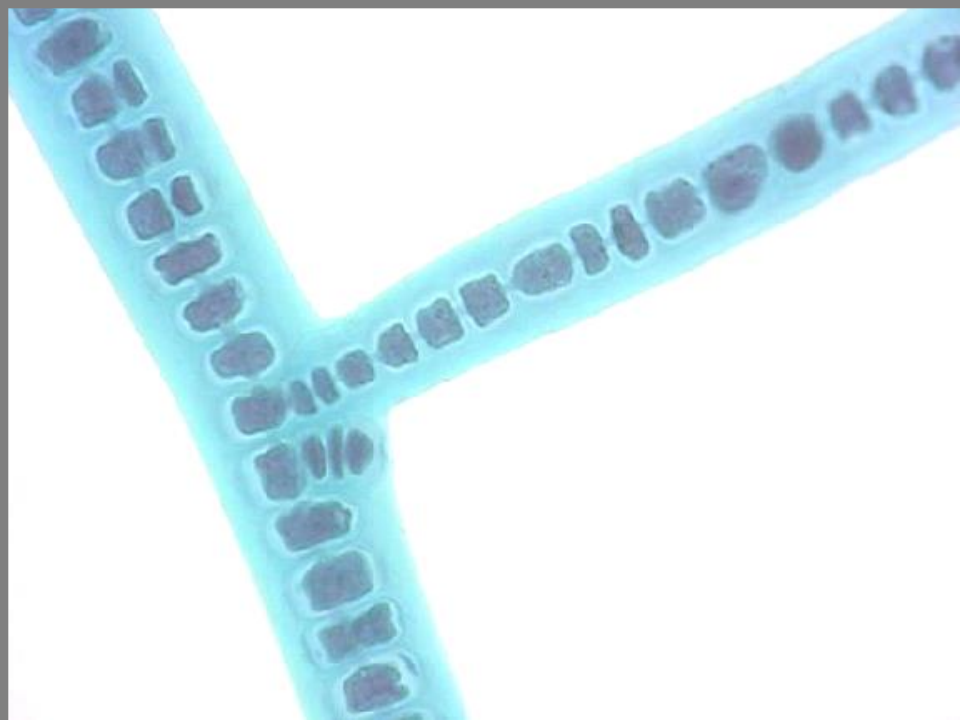


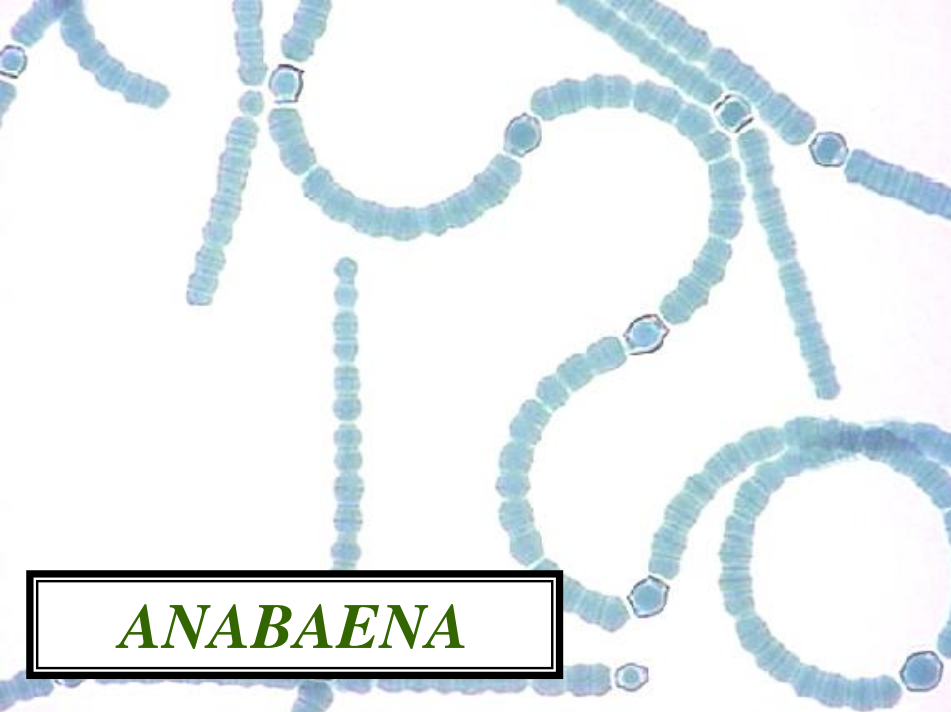
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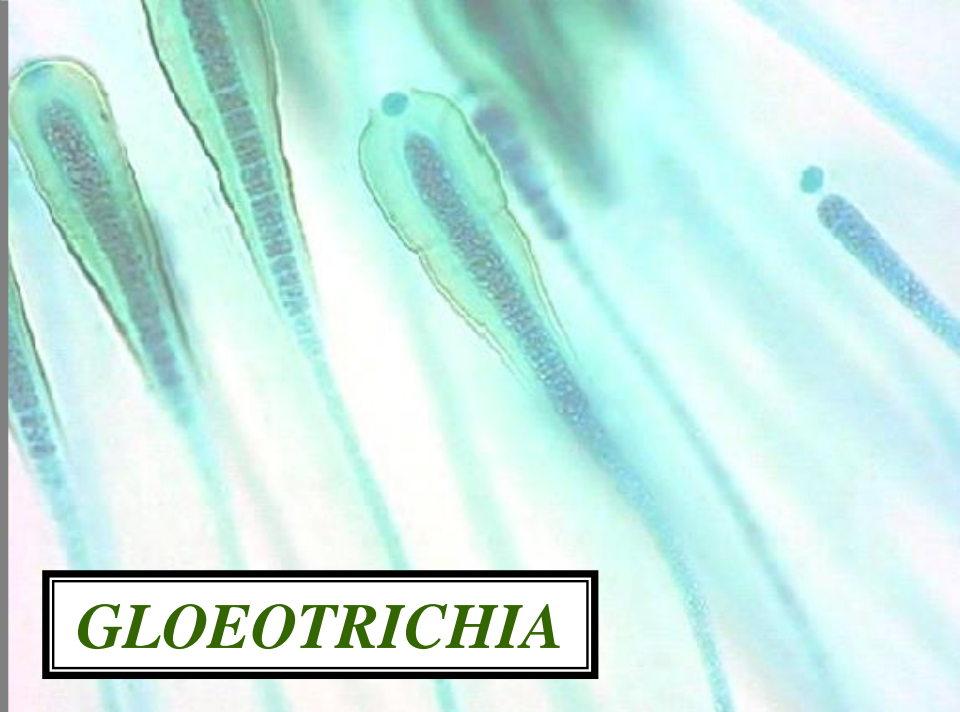


MERISMOPIEDIA

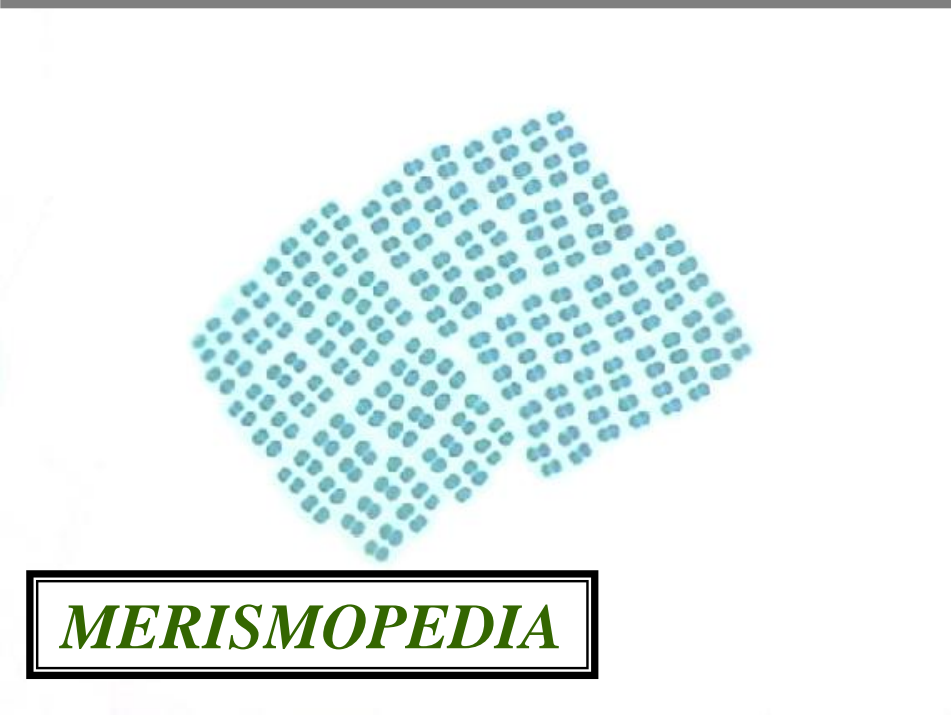




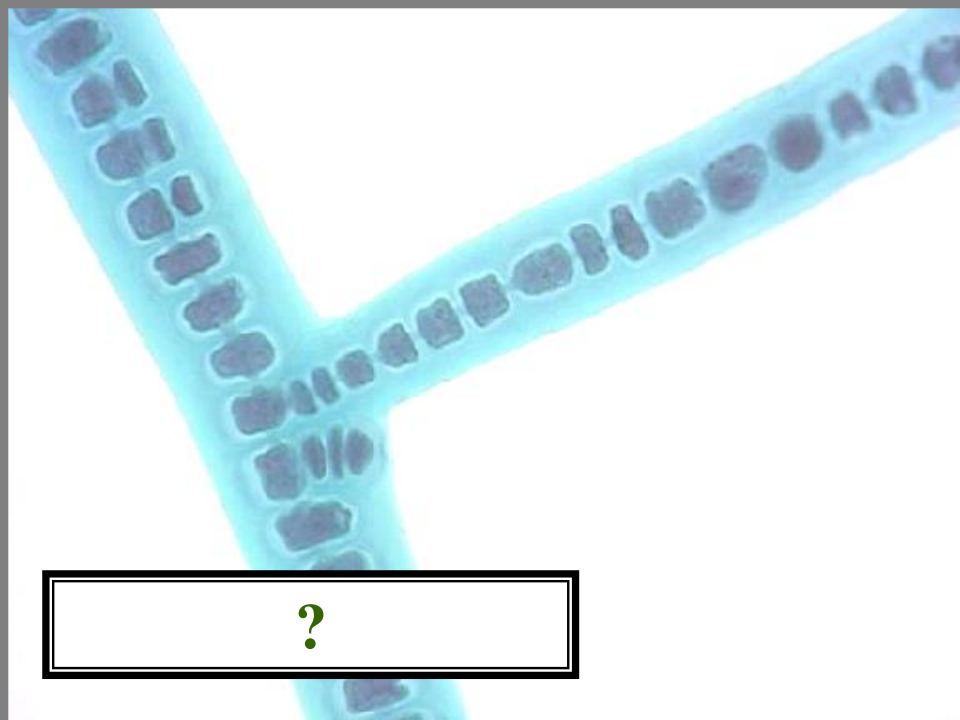
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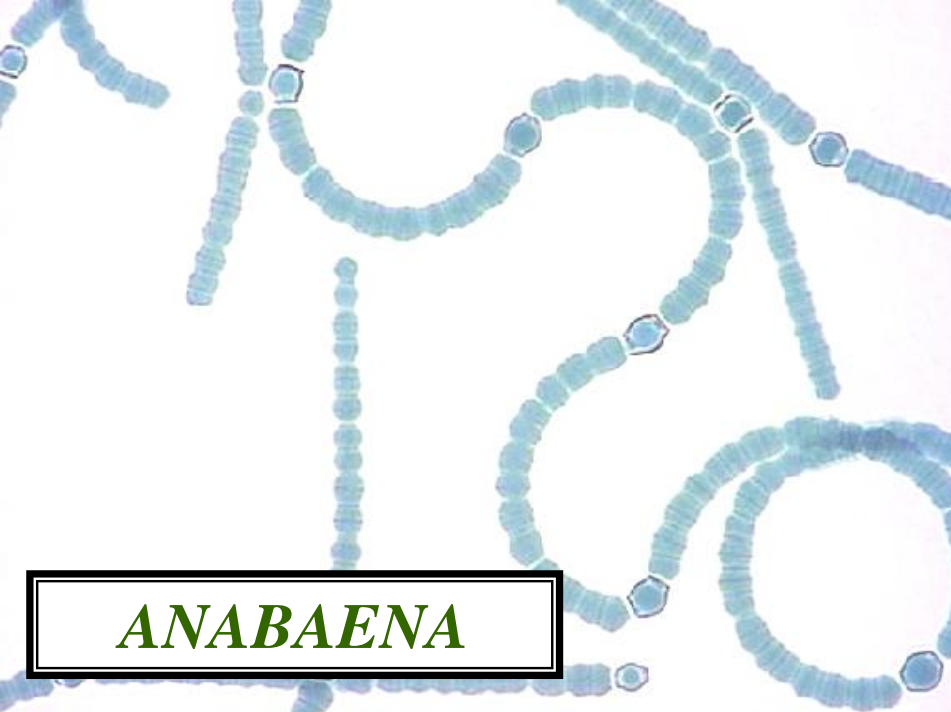
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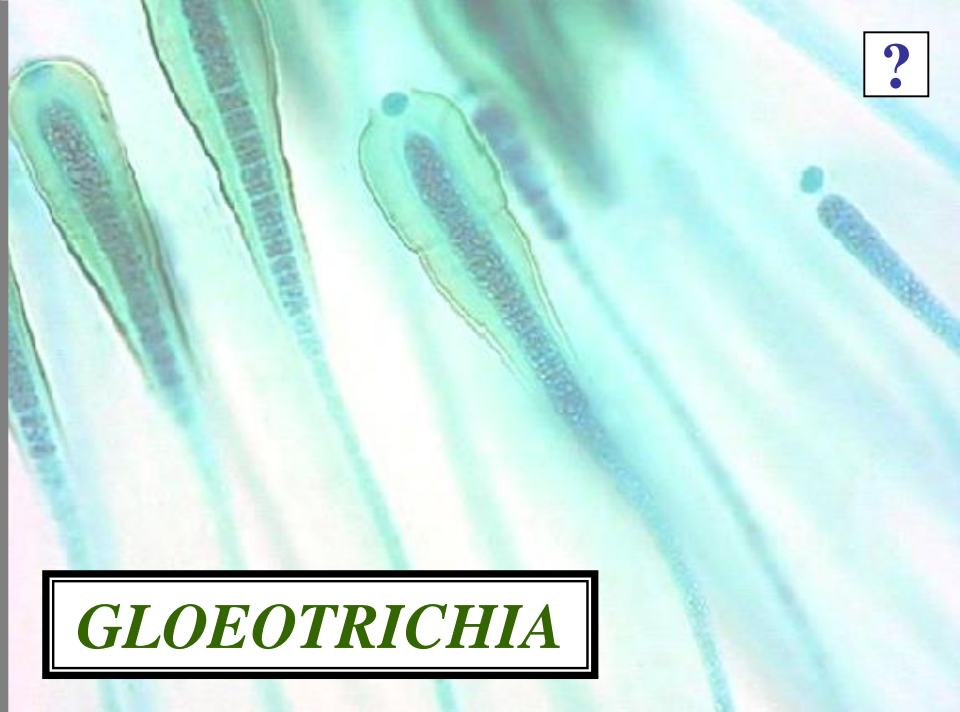
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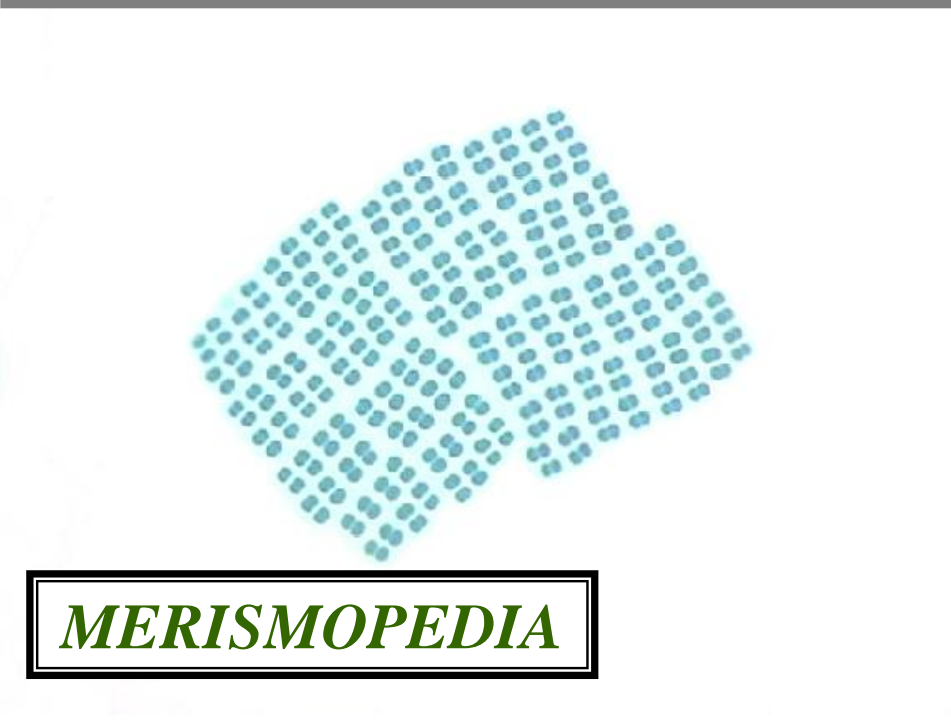
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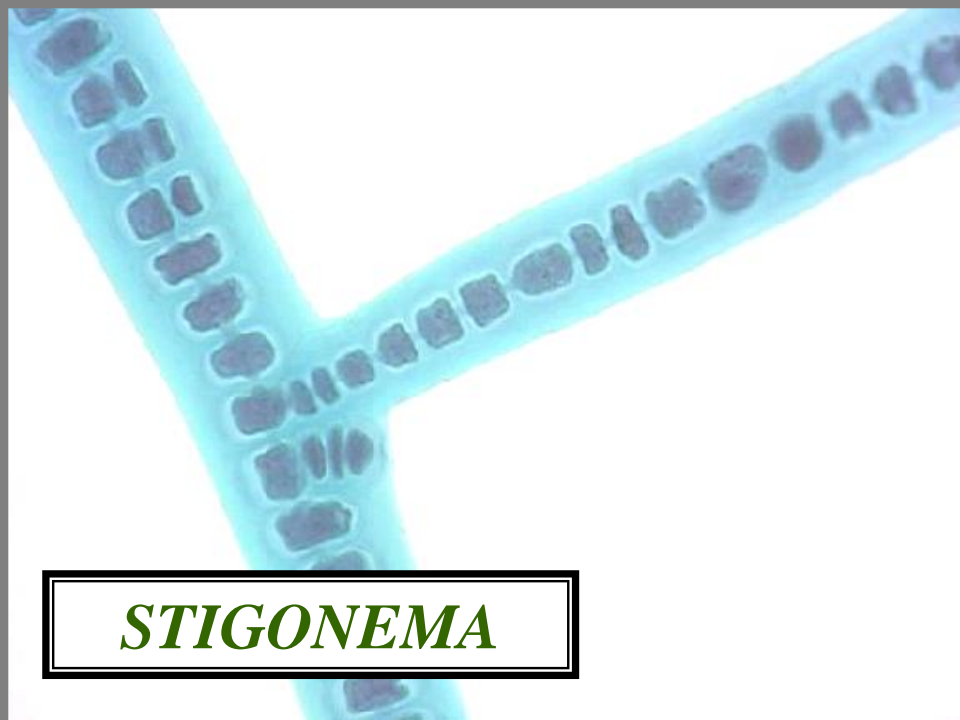
ANABAENA



GLOEOTRICHIA



MERISMOPIEDIA



STIGONEMA

QUESTION

**IS A
CYANOBACTERIUM
BL-GR BACTERIUM
A PLANT?**

QUESTION



ANSWER

NO

PLASTIDS

ABSENT

ANSWER

QUESTION

**WHY ARE WE
STUDYING
CYANOBACTERIA
BL-GR BACTERIA?**

QUESTION



ANSWER

**BL-GR BACTERIA
EVOLVED
GREEN BACTERIA**

ANSWER



PHYLUM CYANOPHYTA

A microscopic view of several green, spherical cyanobacteria cells. The cells are arranged in a cluster, with some overlapping. They have a distinct outer layer and a lighter green interior. The background is a light blue color.

GREEN BACTERIA

CYANOBACTERIA

A microscopic view of several green, circular cyanobacteria cells. The cells are arranged in a somewhat regular pattern, with some overlapping. They have a distinct outer boundary and a lighter green center. The background is a light blue color.

GREEN BACTERIA

DIFFERENT CLASS

CYANOBACTERIA

COMMON NAMES

The image shows a microscopic view of several prochlorophytes. These are unicellular, green, spherical organisms. They have a distinct outer boundary and a slightly darker green center. The background is a light, pale blue color. The organisms are scattered across the field of view, with some appearing more prominent than others.

PROCHLOROPHYTES

A microscopic view of several cyanobacteria cells. The cells are spherical and arranged in a chain. They have a distinct outer layer and a lighter inner region. The background is a light blue color.

CYANOBACTERIA

GREEN BACTERIA

GREEN BACTERIA

P

RECENTLY DISCOVERED

GREEN BACTERIA



POORLY KNOWN

Photosynth Res. 2002;73(1-3):59-61.

GREEN BACTERIA

PROCHLOROPHYTA

P

A MATTER OF CLASS DISTINCTIONS

Ralph A. Lewin

Scripps Institution of Oceanography, University of California (San Diego), La Jolla, CA, 92093-0202, USA, rlewin@ucsd.edu.

Prochloron (a marine symbiont) and Prochlorothrix (from freshwater plankton) contain chlorophylls a and b; Prochlorococcus (common in marine picoplankton) contains divinyl-chlorophylls a and b. Like cyanophytes they are all clearly photosynthetic prokaryotes, but since they contain no blue or red bilin pigment they were assigned to a new algal sub-class, the Prochlorophyta. However, since their possible phylogenetic

PREVIOUSLY ASSIGNED:

Photosynth Res. 2002;73(1-3):59-61.

GREEN BACTERIA

PROCHLOROPHYTA

B

A MATTER OF CLASS DISTINCTIONS

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PHYLUM: PROCHLOROPHYTA

Photosynth Res. 2002;73(1-3):59-61.

GREEN BACTERIA

PROCHLOROPHYTA

C

A MATTER OF CLASS DISTINCTIONS

Ralph A. Lewin

BLUE-GREEN BACTERIA

Scripps Institution of Oceanography, University of California (San Diego), La Jolla, CA, 92093-0202, USA, rlewin@ucsd.edu.

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CLOSELY RELATED

Photosynth Res. 2002;73(1-3):59-61.

GREEN BACTERIA

PROCHLOROPHYTA

D

A MATTER OF CLASS DISTINCTIONS

Ralph A. Lewin

BLUE-GREEN BACTERIA

Scripps Institution of Oceanography, University of California (San Diego), La Jolla, CA, 92093-0202, USA, rlewin@ucsd.edu.

Prochloron (a marine symbiont) and Prochlorothrix (from freshwater plankton) contain chlorophylls a and b; Prochlorococcus (common in marine picoplankton) contains divinyl-chlorophylls a and b. Like cyanophytes they are all clearly photosynthetic prokaryotes, but since they contain no blue or red bilin pigment they were assigned to a new algal sub-class, the Prochlorophyta. However, since their possible phylogenetic

PHYLUM: CYANOPHYTA

Photosynth Res. 2002;73(1-3):59-61.

GREEN BACTERIA

PROCHLOROPHYTA

A MATTER OF CLASS DISTINCTIONS

Ralph A. Lewin

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PHYLUM: CYANOPHYTA
DIFFERENT CLASSES





DIVERSITY

~12 SPECIES

EARTH



~3 GENERA

EARTH



DISTRIBUTION

T

TEMPERATE

EARTH

A satellite photograph of the Earth showing the Western Hemisphere, including North and South America, the Atlantic Ocean, and the Pacific Ocean. The image shows cloud patterns and the curvature of the planet.

TROPICAL

EARTH

HABITAT



MARINE HABITATS



AQUATIC HABITATS



FRESHWATER HABITATS





GREEN BACTERIA: 1ST DISCOVERED AS A MARINE SYMBIONT





SEA-SQUIRTS





GENERAL CHARACTERS

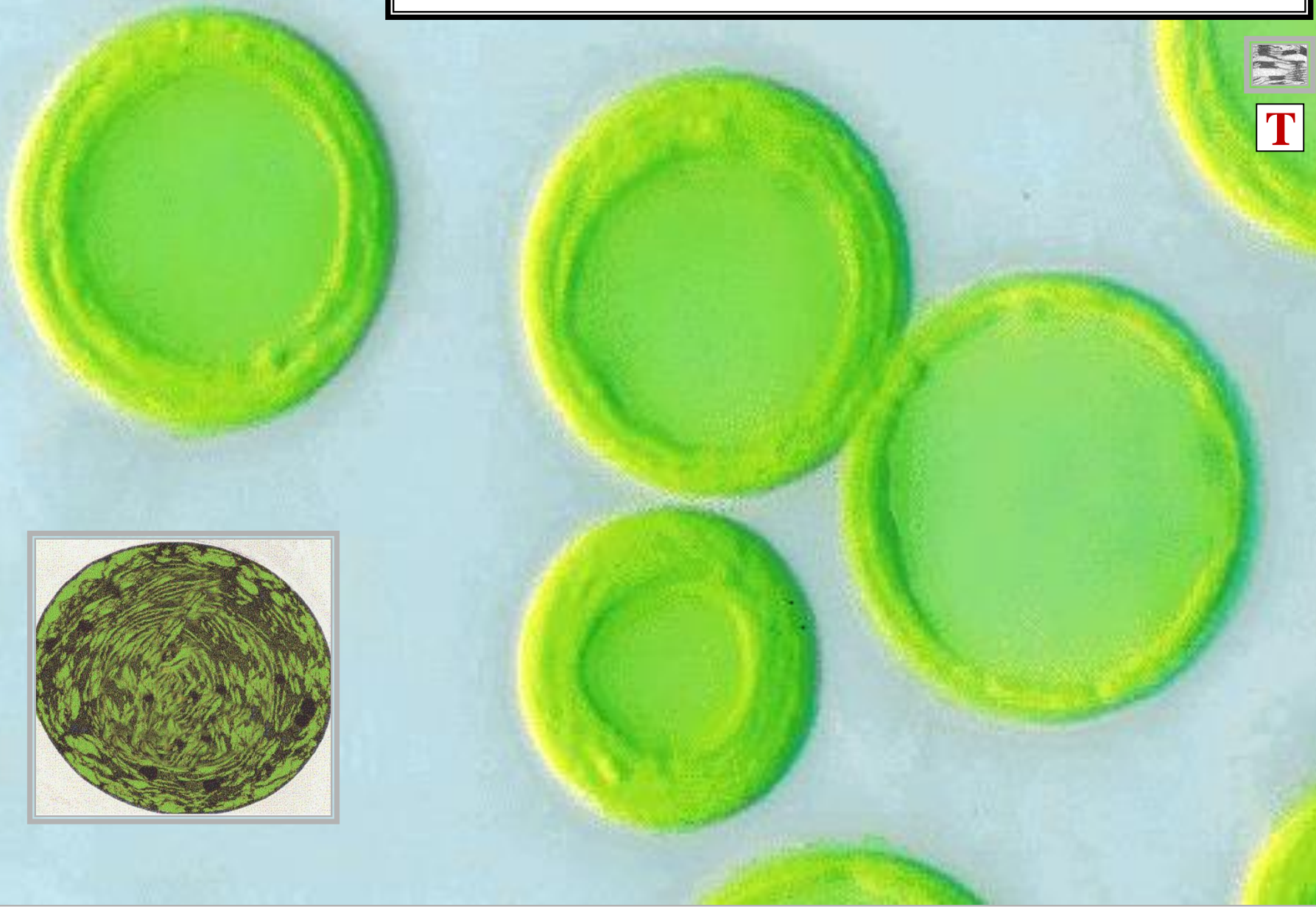


CYTOLOGY

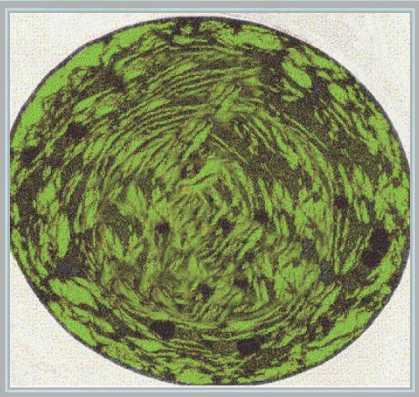


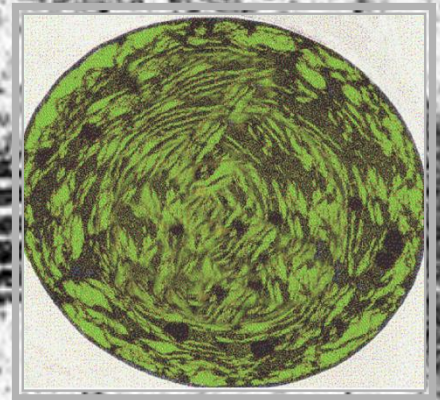
THYLAKOID

GREEN BACTERIA



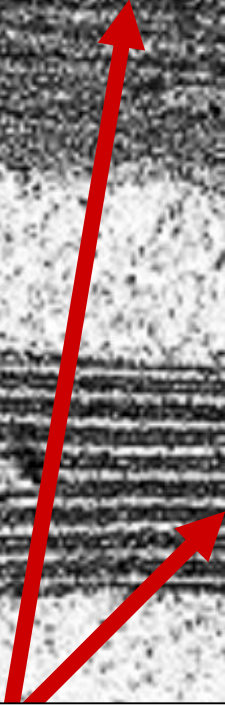
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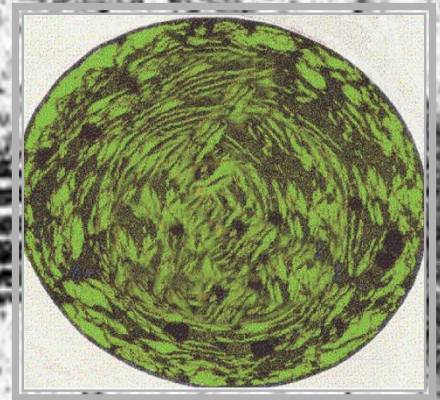


THYLAKOID

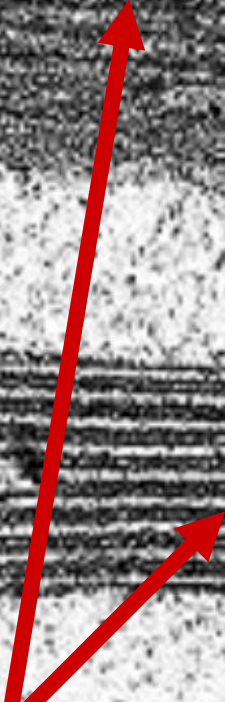
CYANOBACTERIA

GREEN BACTERIA

L.S.



S

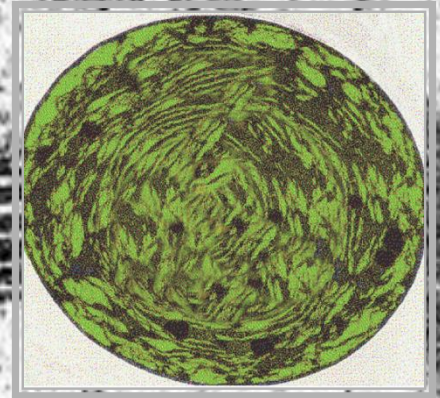


VESICLES

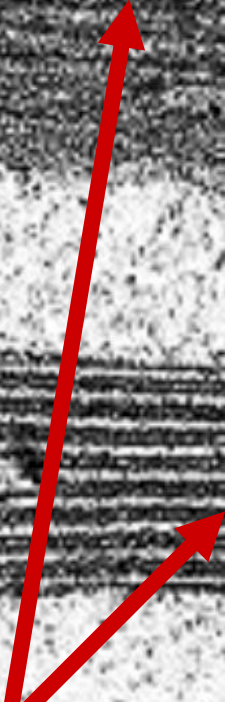
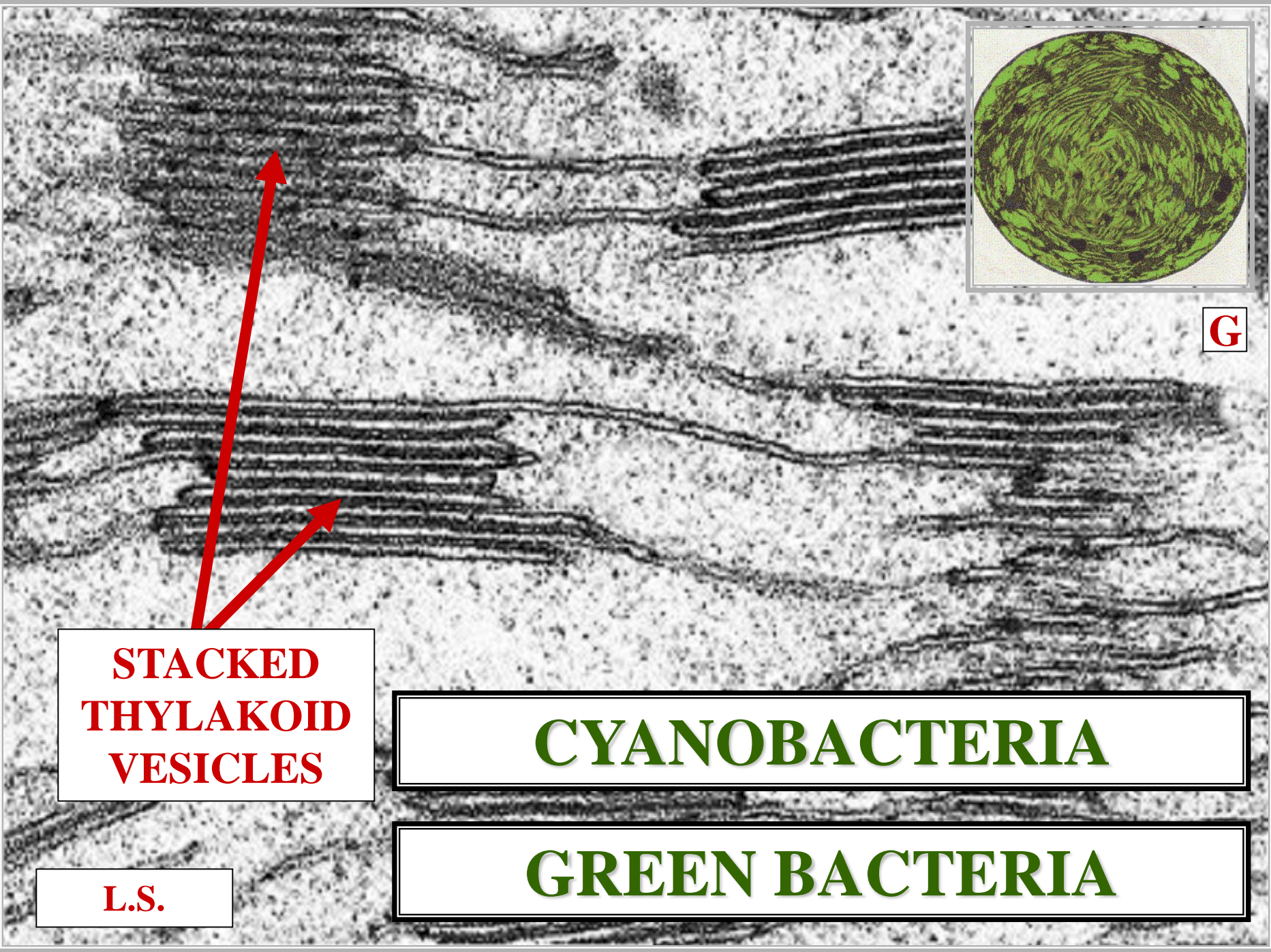
CYANOBACTERIA

GREEN BACTERIA

L.S.



G

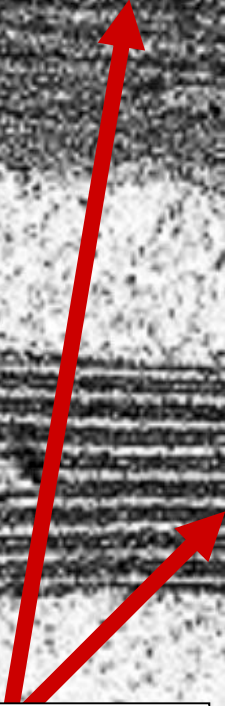
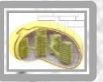


**STACKED
THYLAKOID
VESICLES**

L.S.

CYANOBACTERIA

GREEN BACTERIA



**GRANA
PRESENT**

CYANOBACTERIA

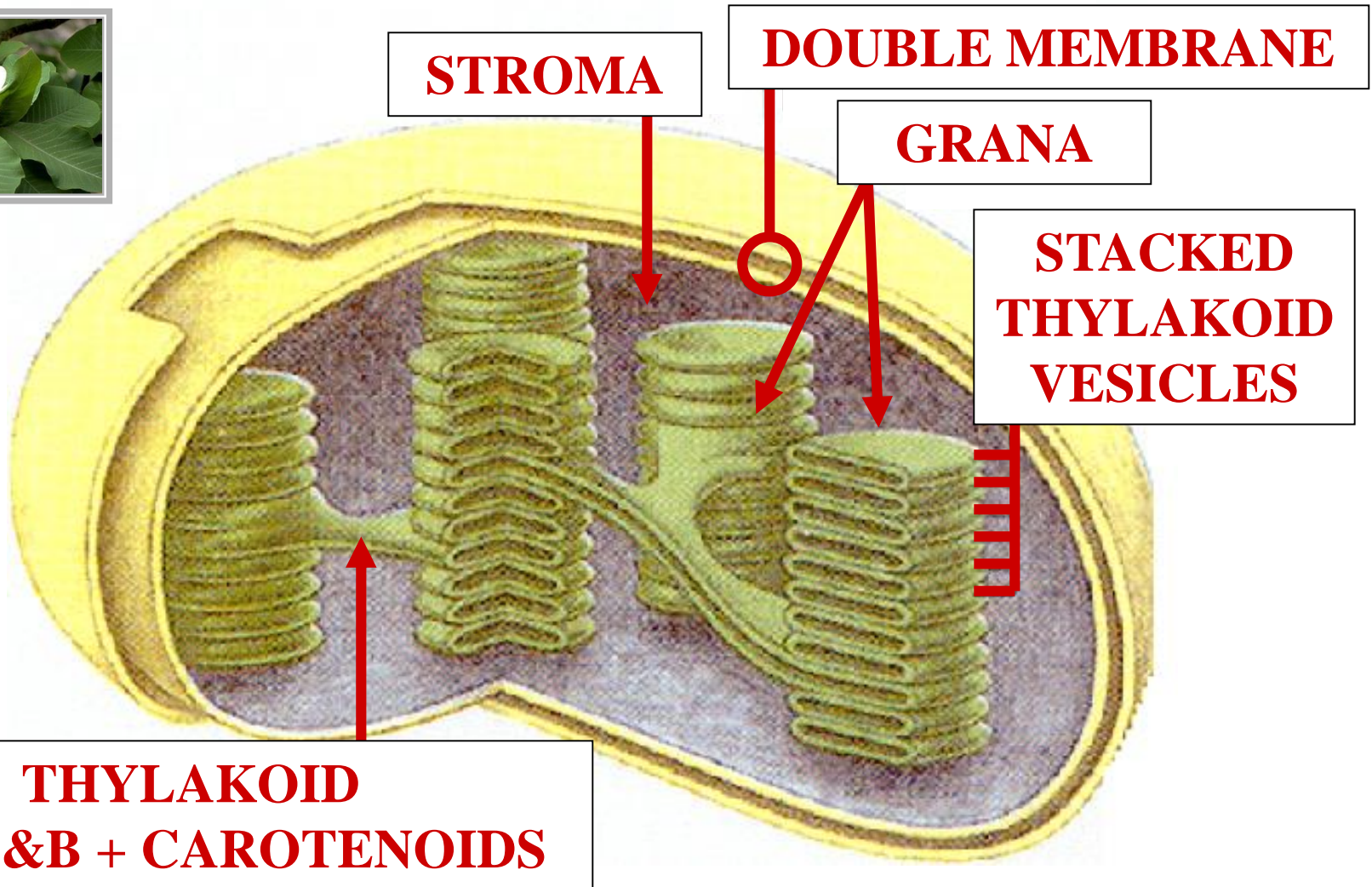
GREEN BACTERIA

L.S.

TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

S

>



CYANOBACTERIA / GREEN BACTERIA

GREEN BACTERIA

**GRANA
PRESENT**

TRUE PLANT CHLOROPLASTS

**GRANA
PRESENT**

CYANOBACTERIA / GREEN BACTERIA



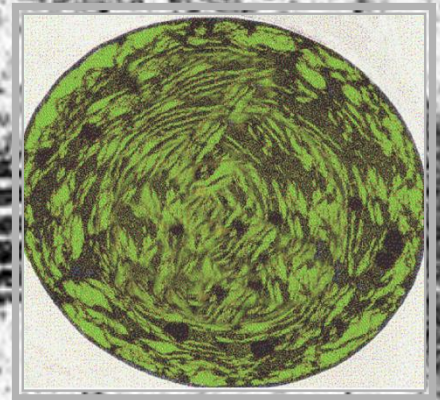


PIGMENTATION



T

PRIMARY PHOTOSYNTHETIC PIGMENTS



~1

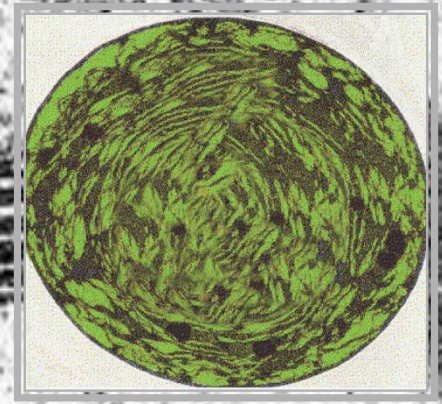
THYLAKOID

CYANOBACTERIA

GREEN BACTERIA

L.S.

**~1 PSYN PIGMENTS
HIGH
CONCENTRATION**



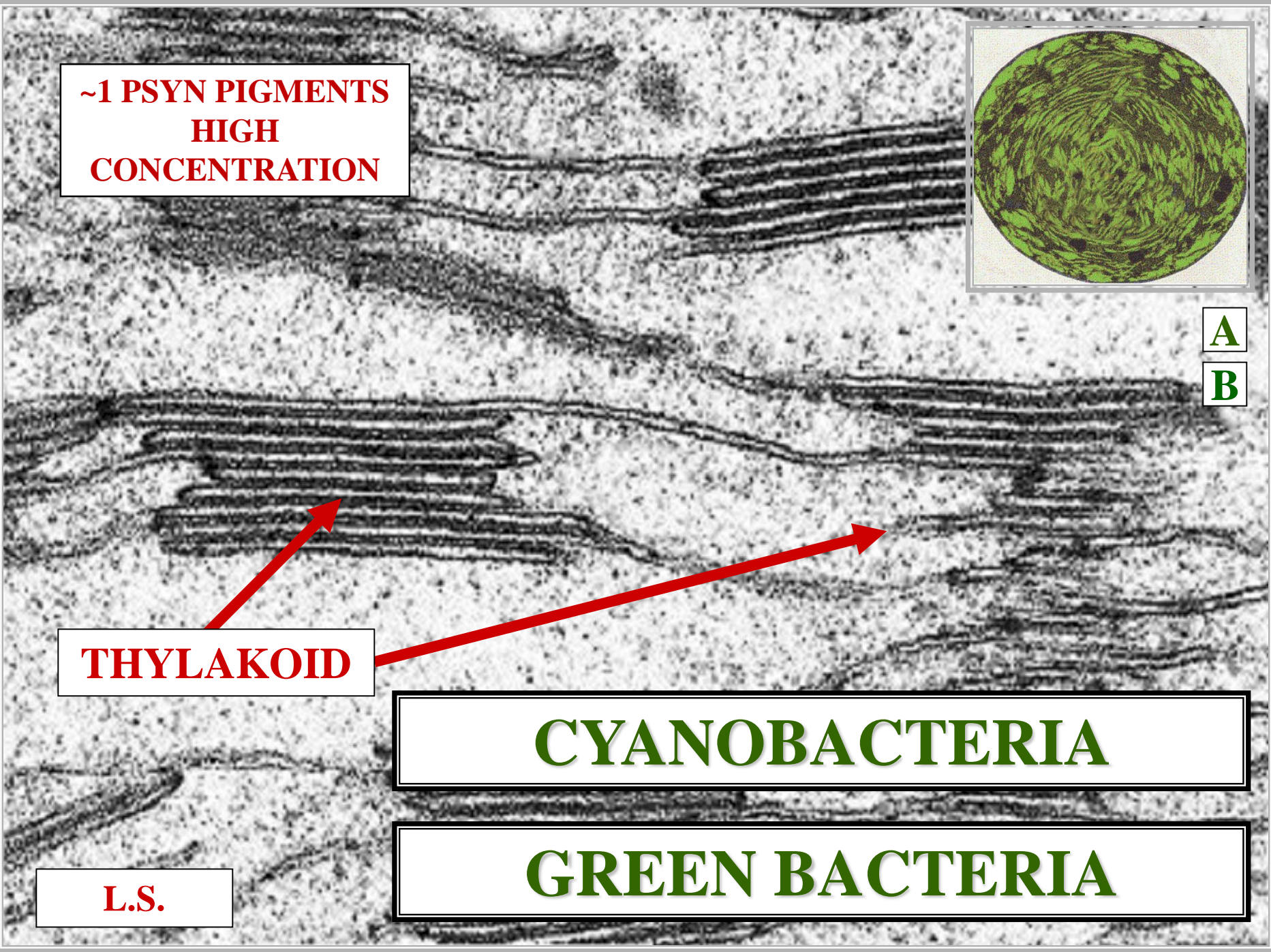
A
B

THYLAKOID

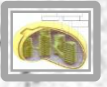
CYANOBACTERIA

GREEN BACTERIA

L.S.



**~1 PSYN PIGMENTS
HIGH
CONCENTRATION**

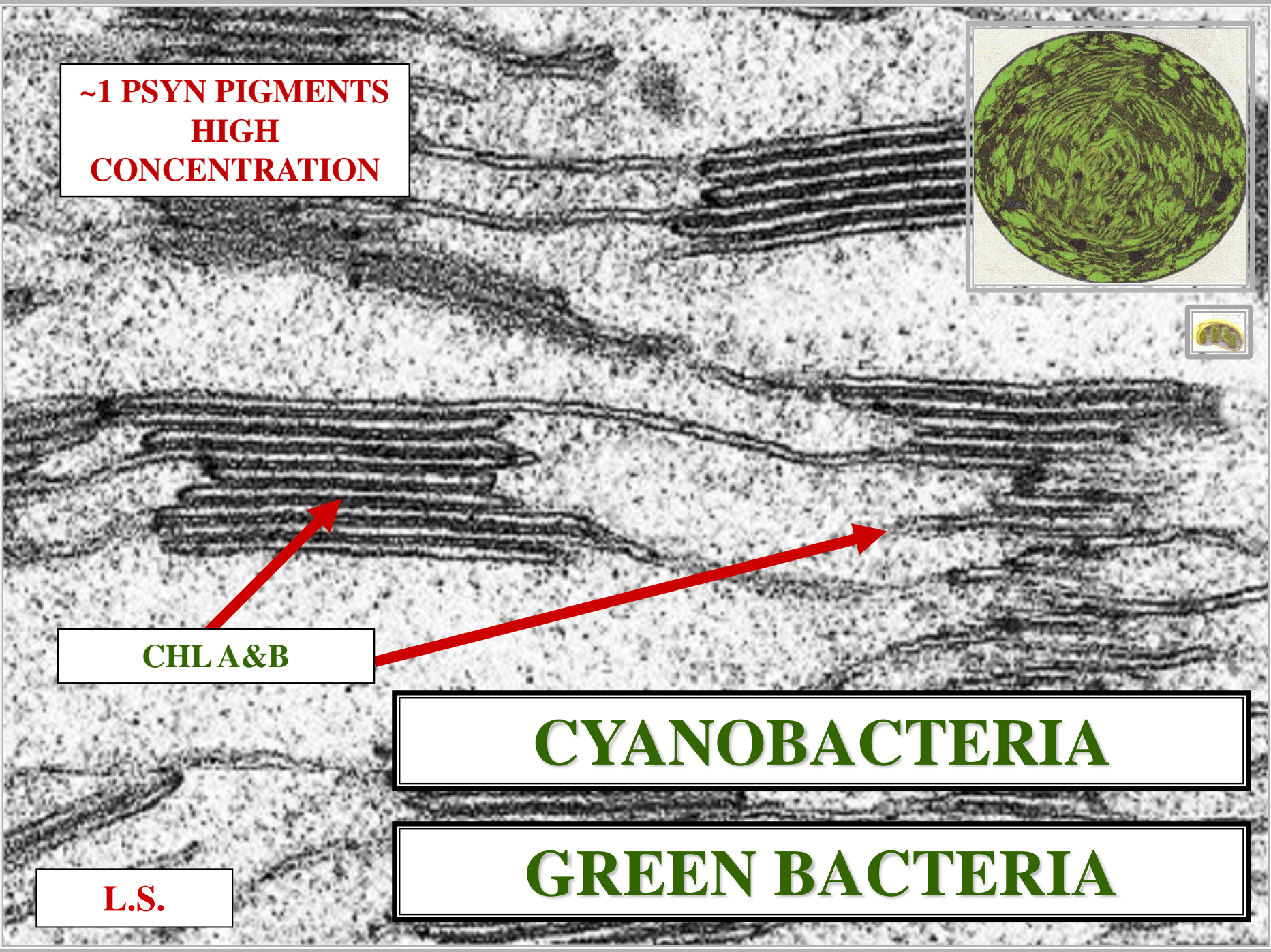


CHL A&B

CYANOBACTERIA

GREEN BACTERIA

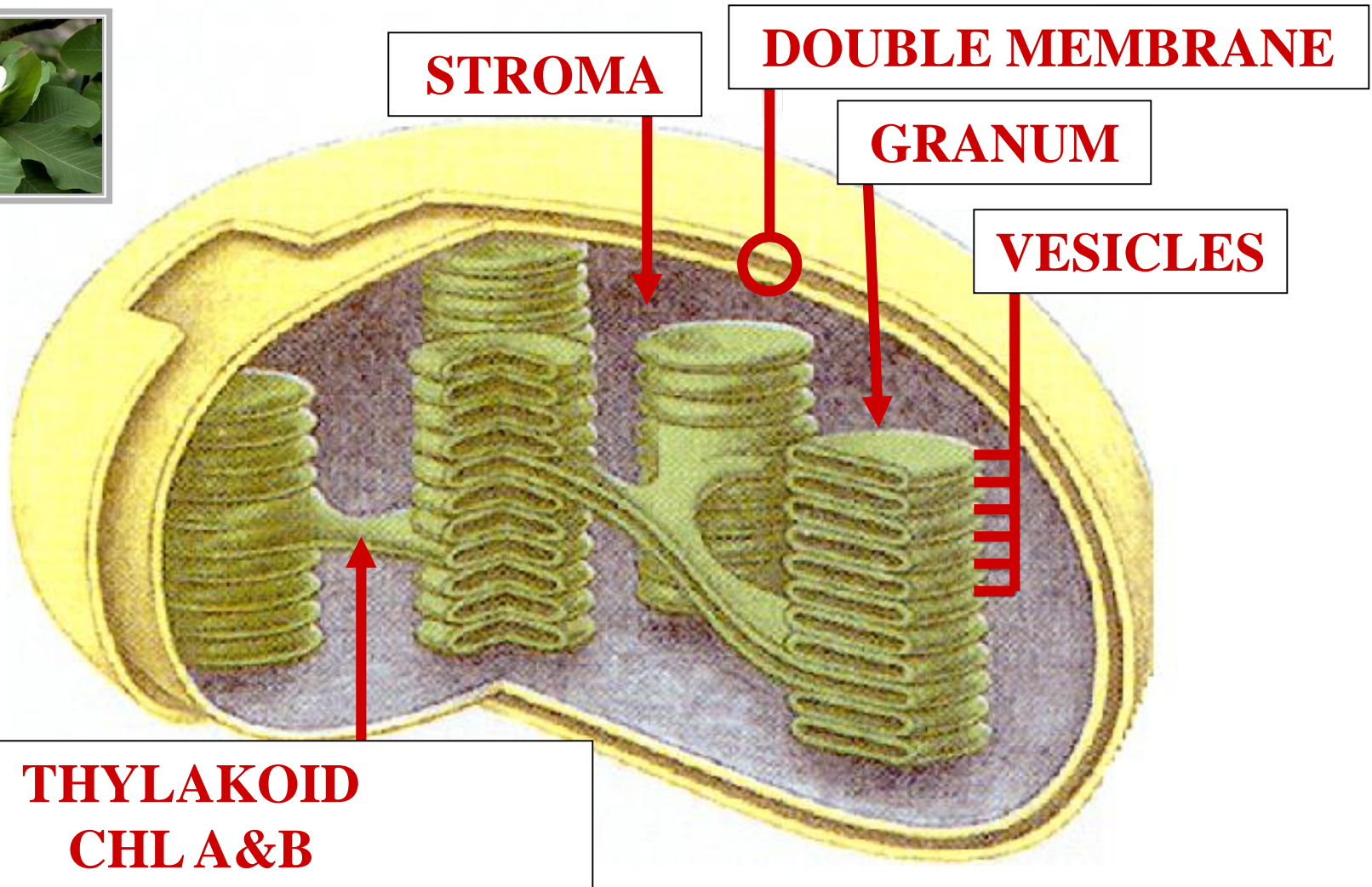
L.S.



TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

S

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CYANOBACTERIA / GREEN BACTERIA

GREEN BACTERIA

~1 PSYN PIGMENTS

CHL-A & CHL-B

TRUE PLANT CHLOROPASTS

~1 PSYN PIGMENTS

CHL-A & CHL-B

CYANOBACTERIA / GREEN BACTERIA



T

SECONDARY PHOTOSYNTHETIC PIGMENTS



~2

THYLAKOID

CYANOBACTERIA

GREEN BACTERIA

L.S.

**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



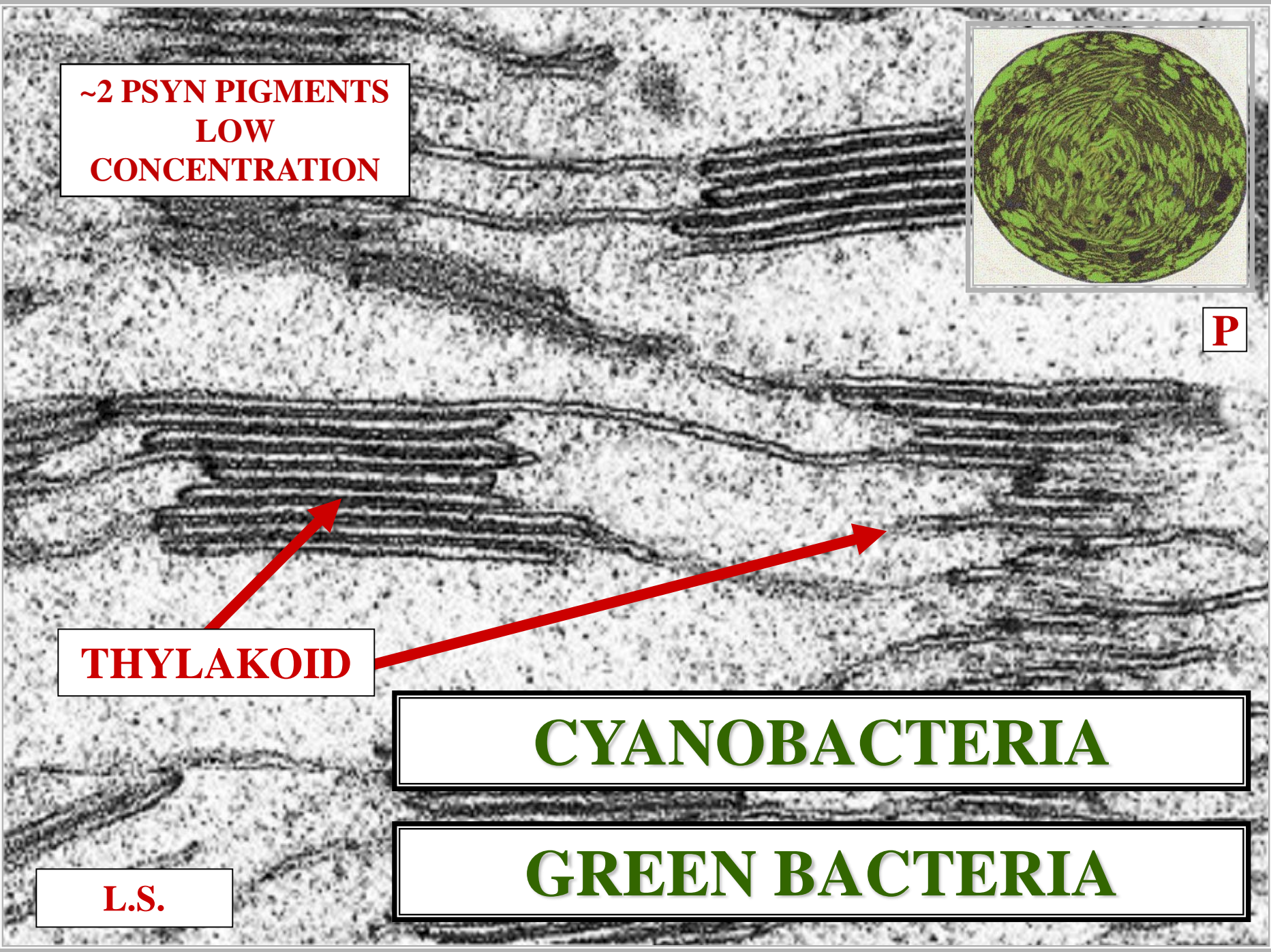
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THYLAKOID

CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



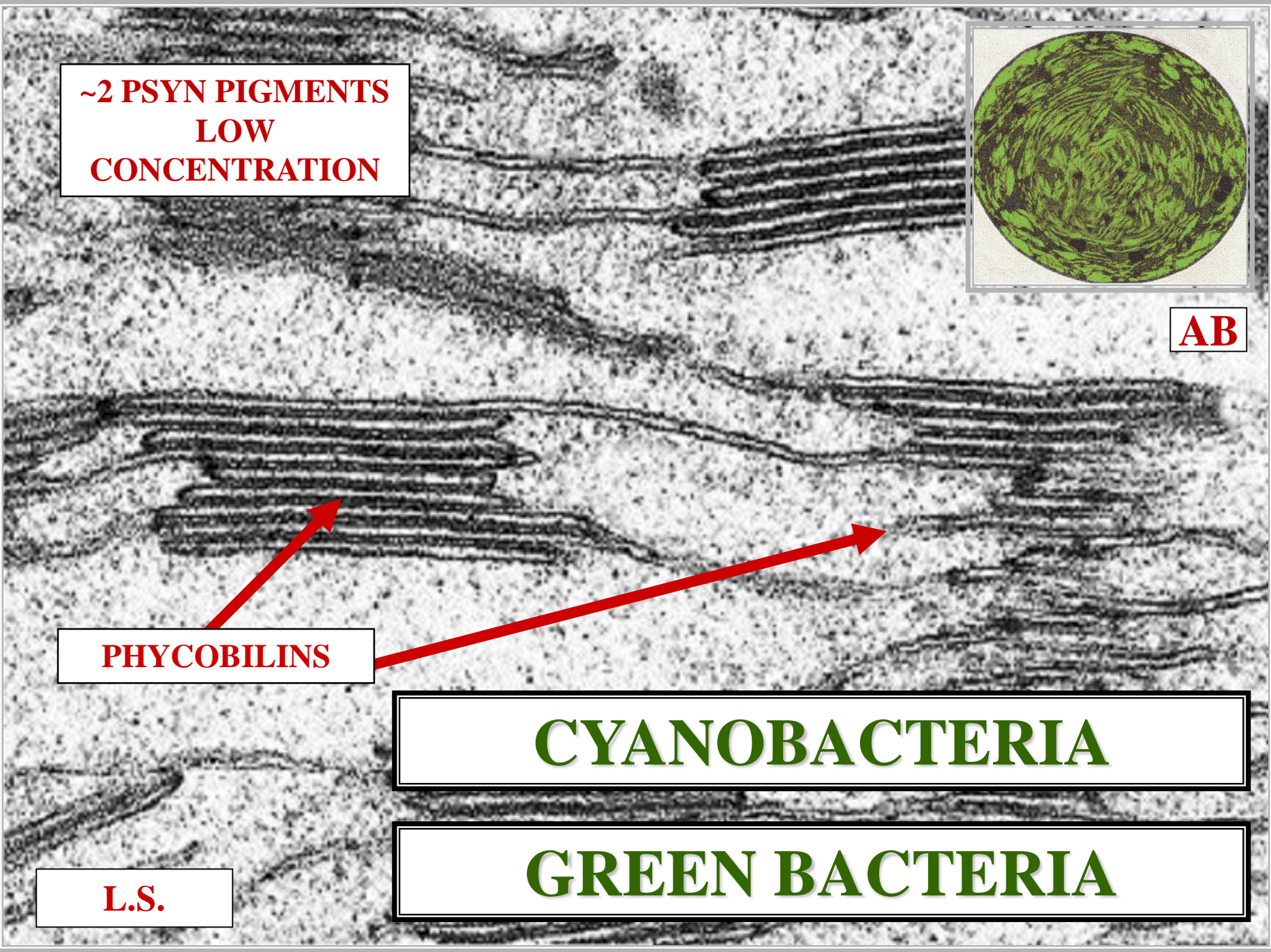
AB

PHYCOBILINS

CYANOBACTERIA

GREEN BACTERIA

L.S.





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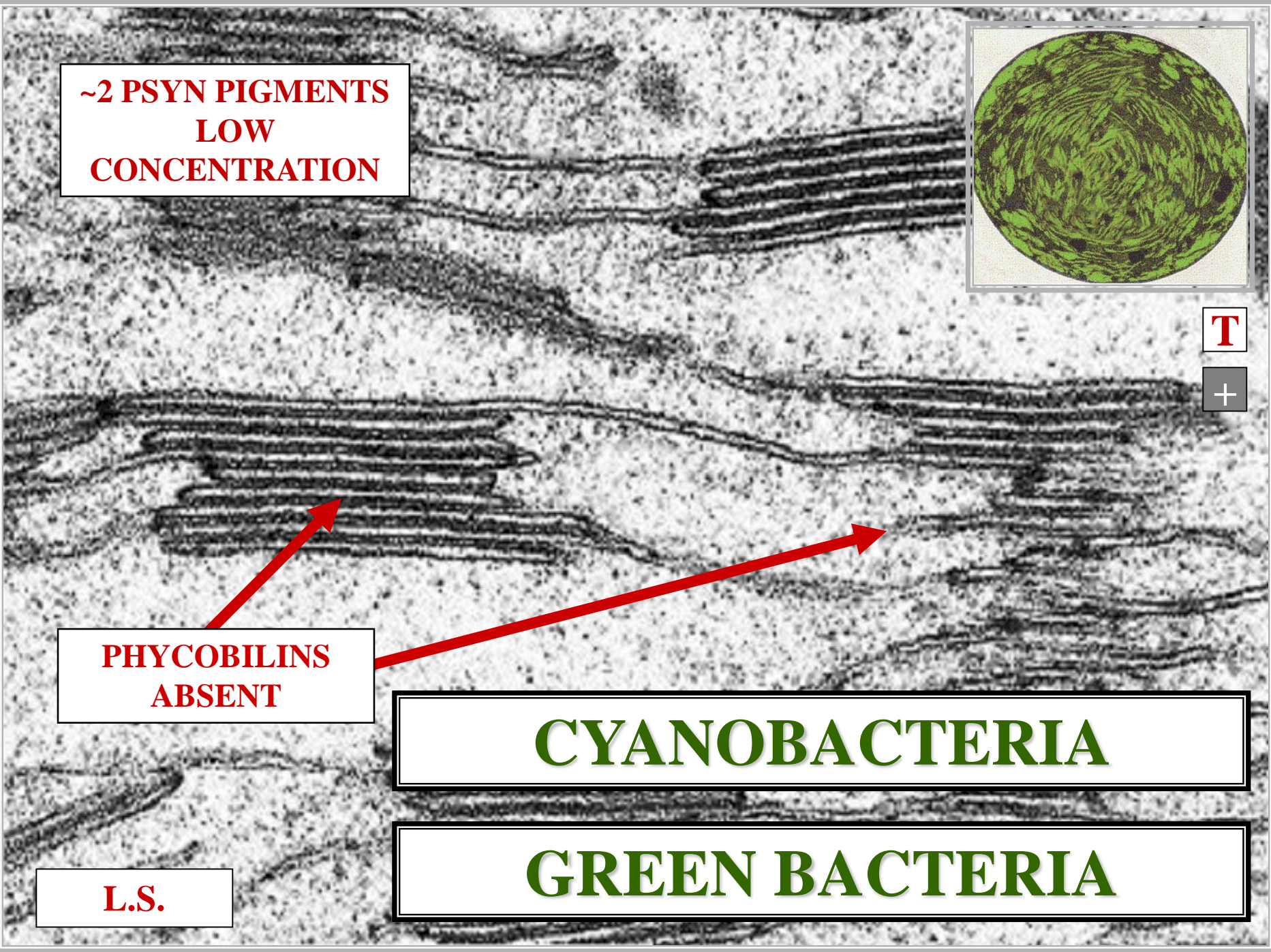
**~2 PSYN PIGMENTS
LOW
CONCENTRATION**

**PHYCOBILINS
ABSENT**

CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



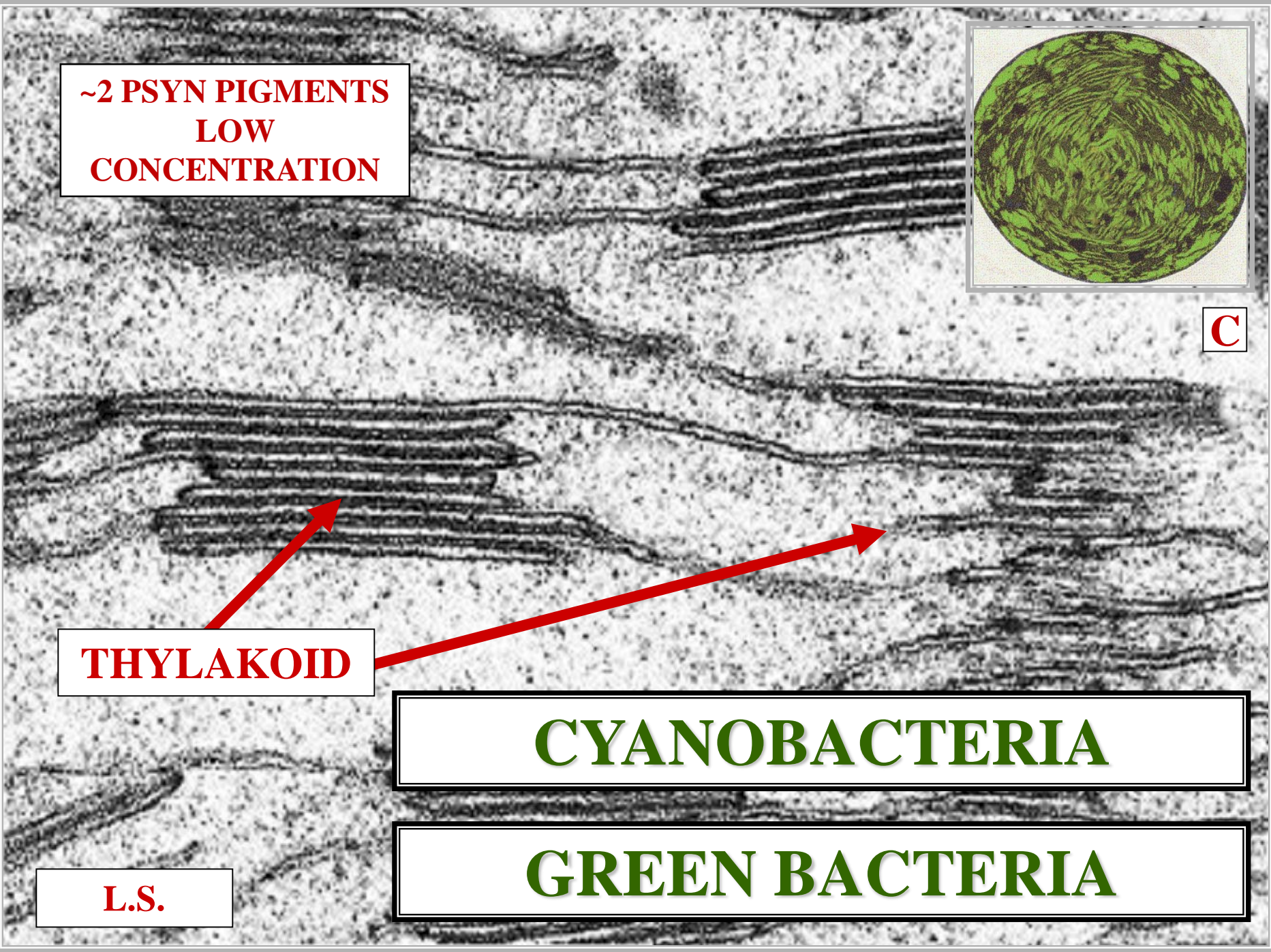
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THYLAKOID

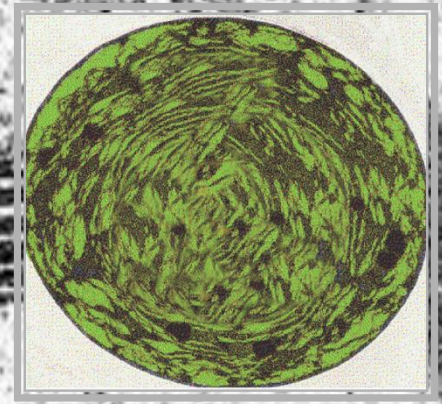
CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



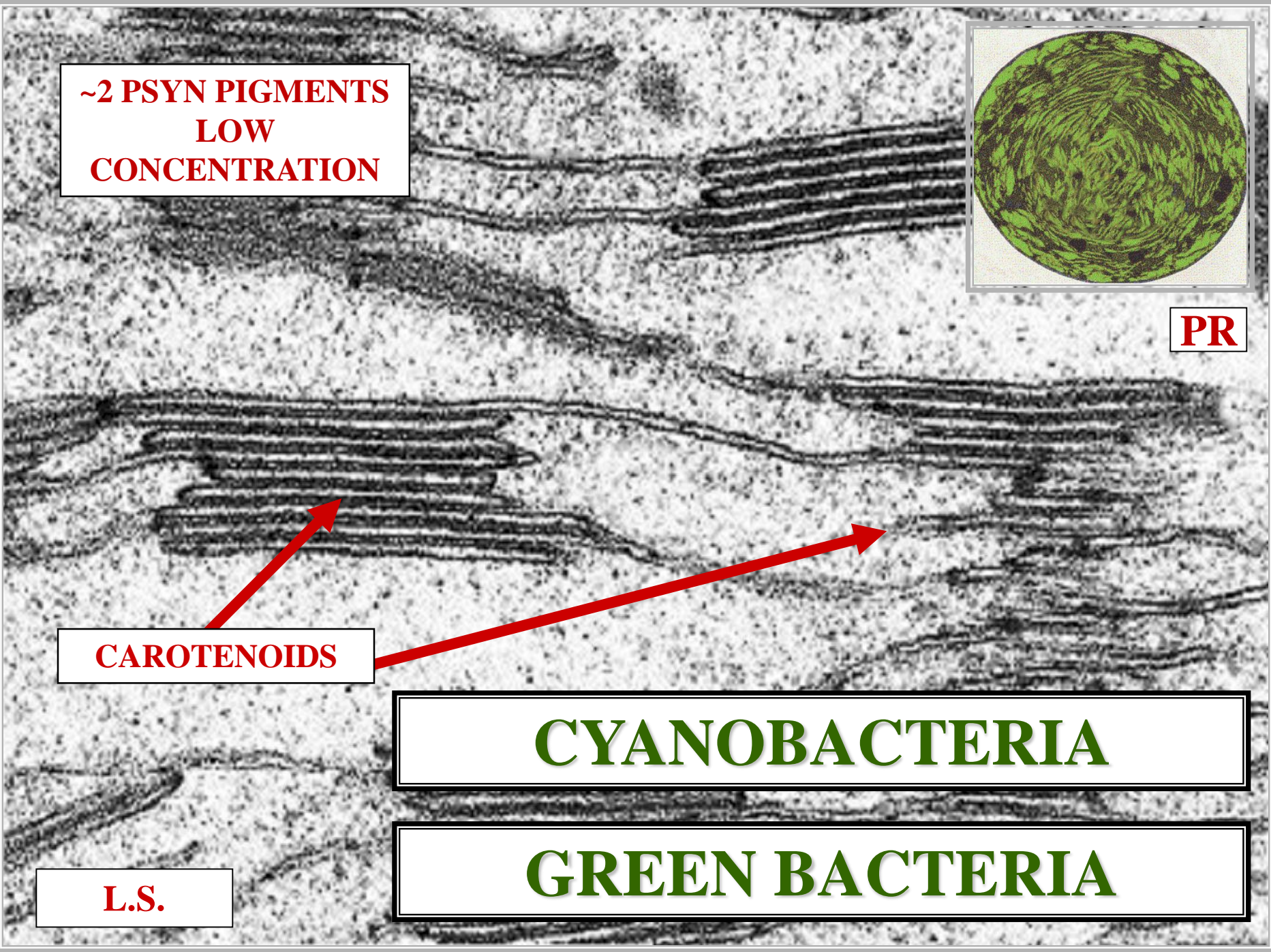
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CAROTENOIDS

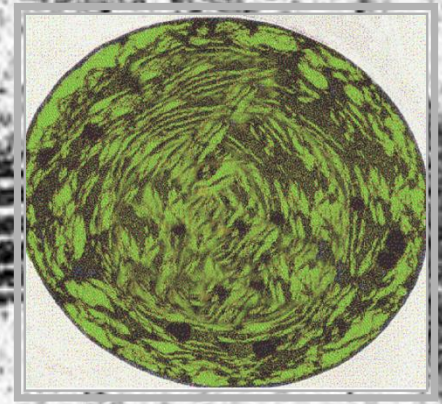
CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



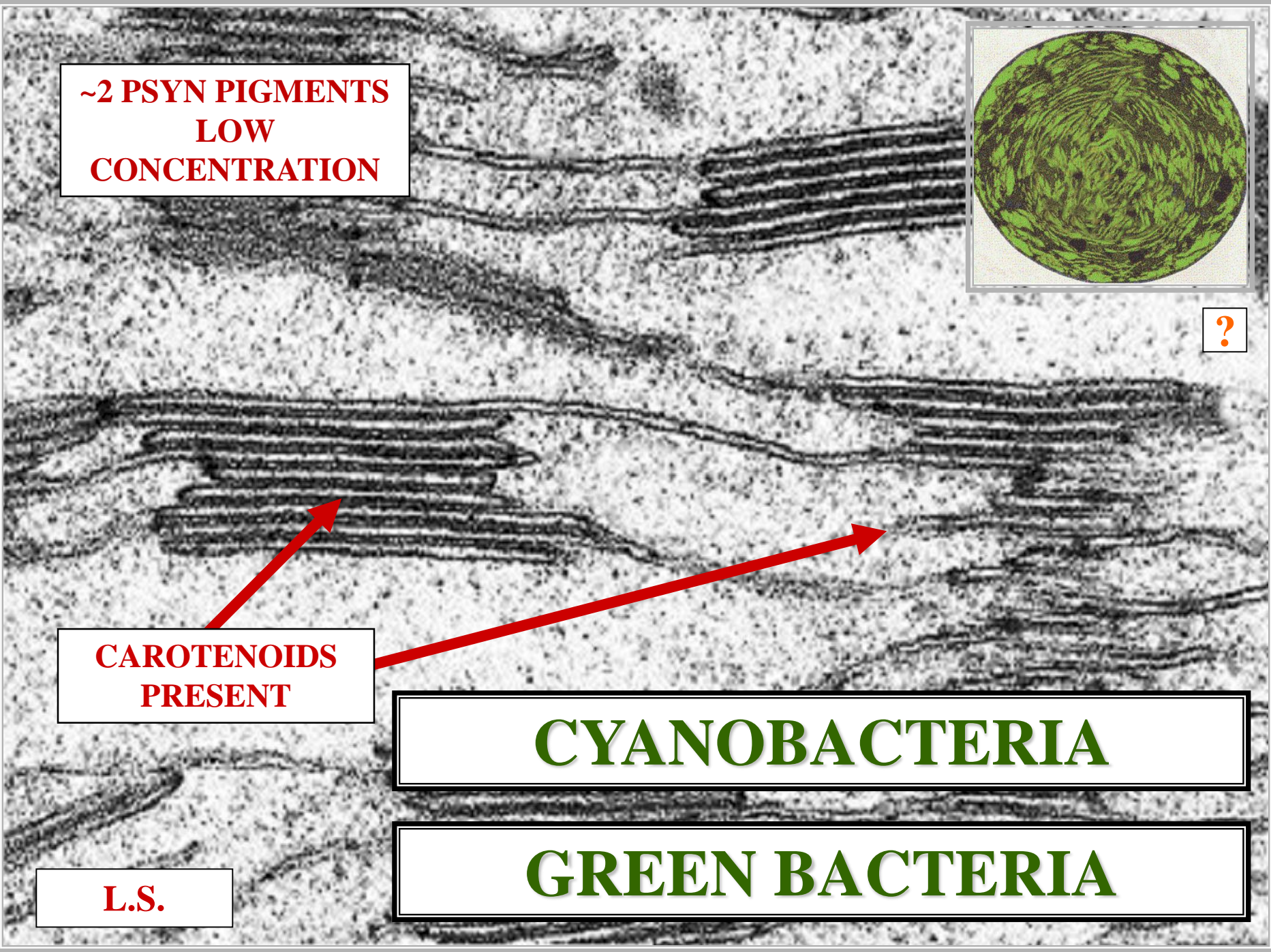
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**CAROTENOIDS
PRESENT**

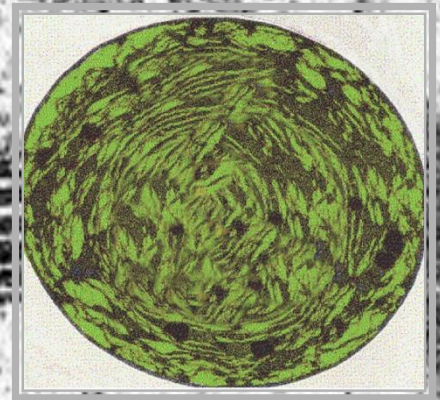
CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



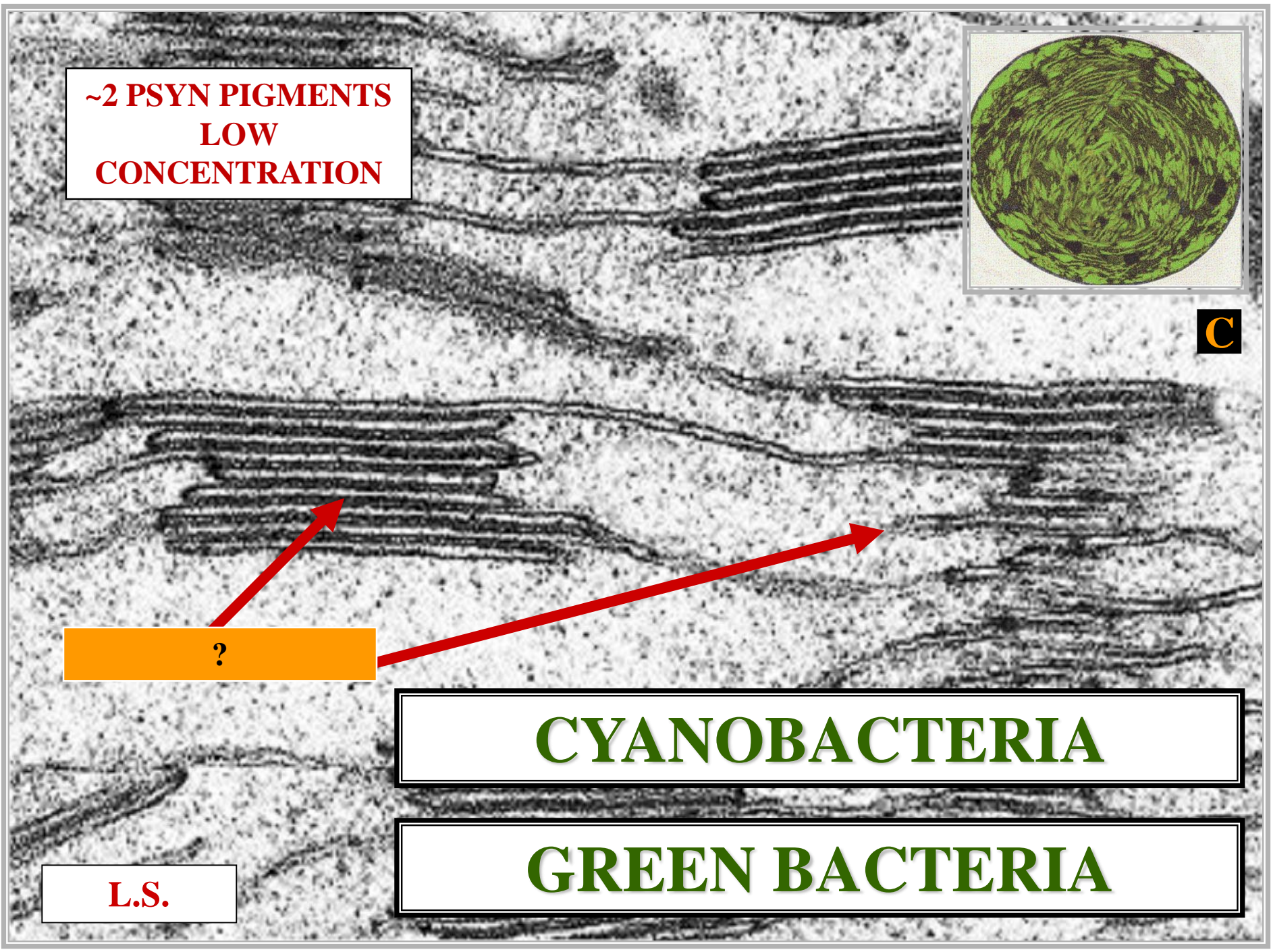
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CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



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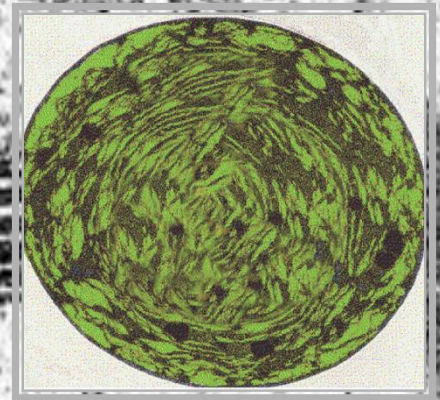
CAROTENES

CYANOBACTERIA

GREEN BACTERIA

L.S.

**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



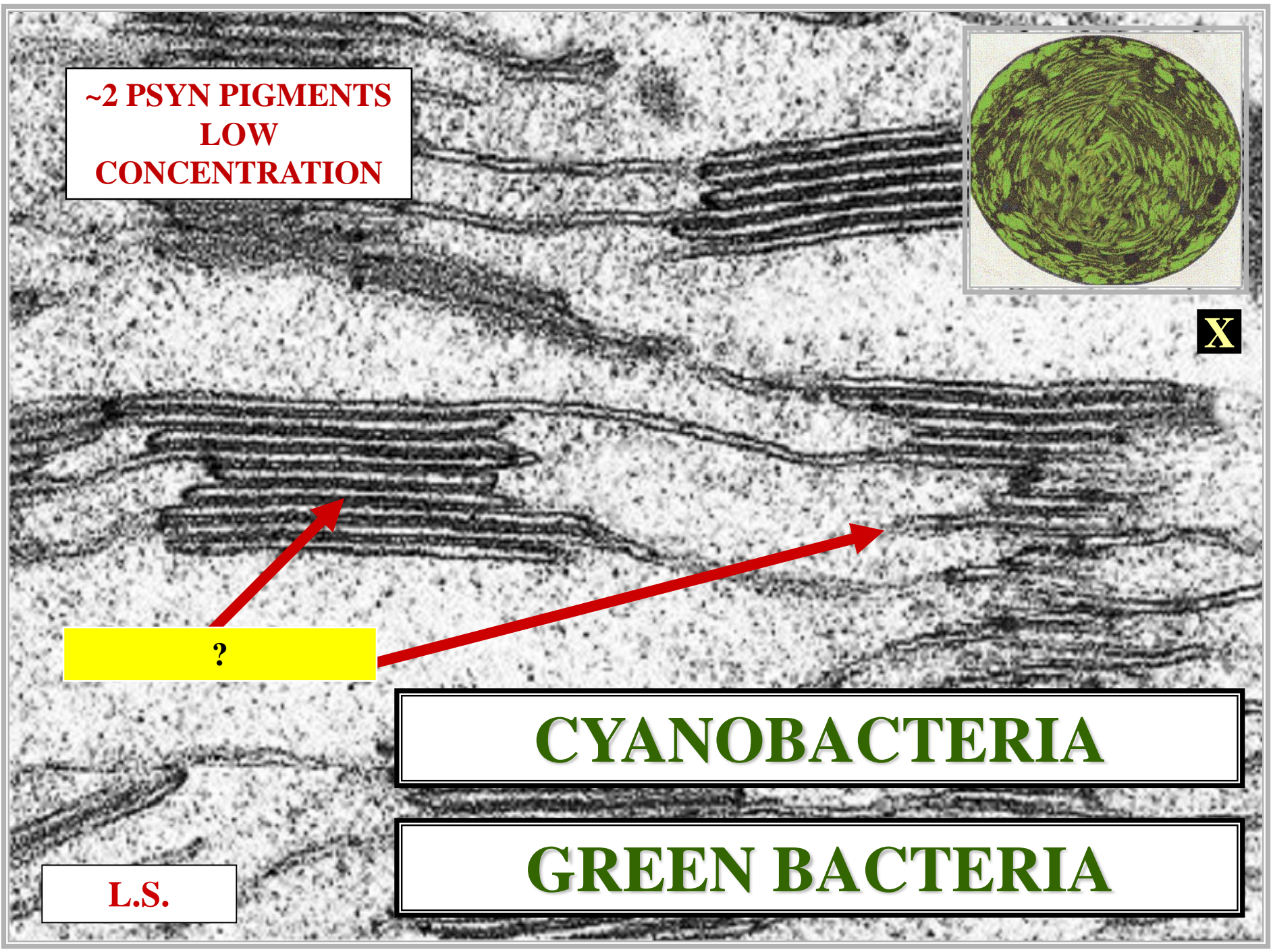
X

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CYANOBACTERIA

GREEN BACTERIA

L.S.



**~2 PSYN PIGMENTS
LOW
CONCENTRATION**



XANTHOPHYLLS

CYANOBACTERIA

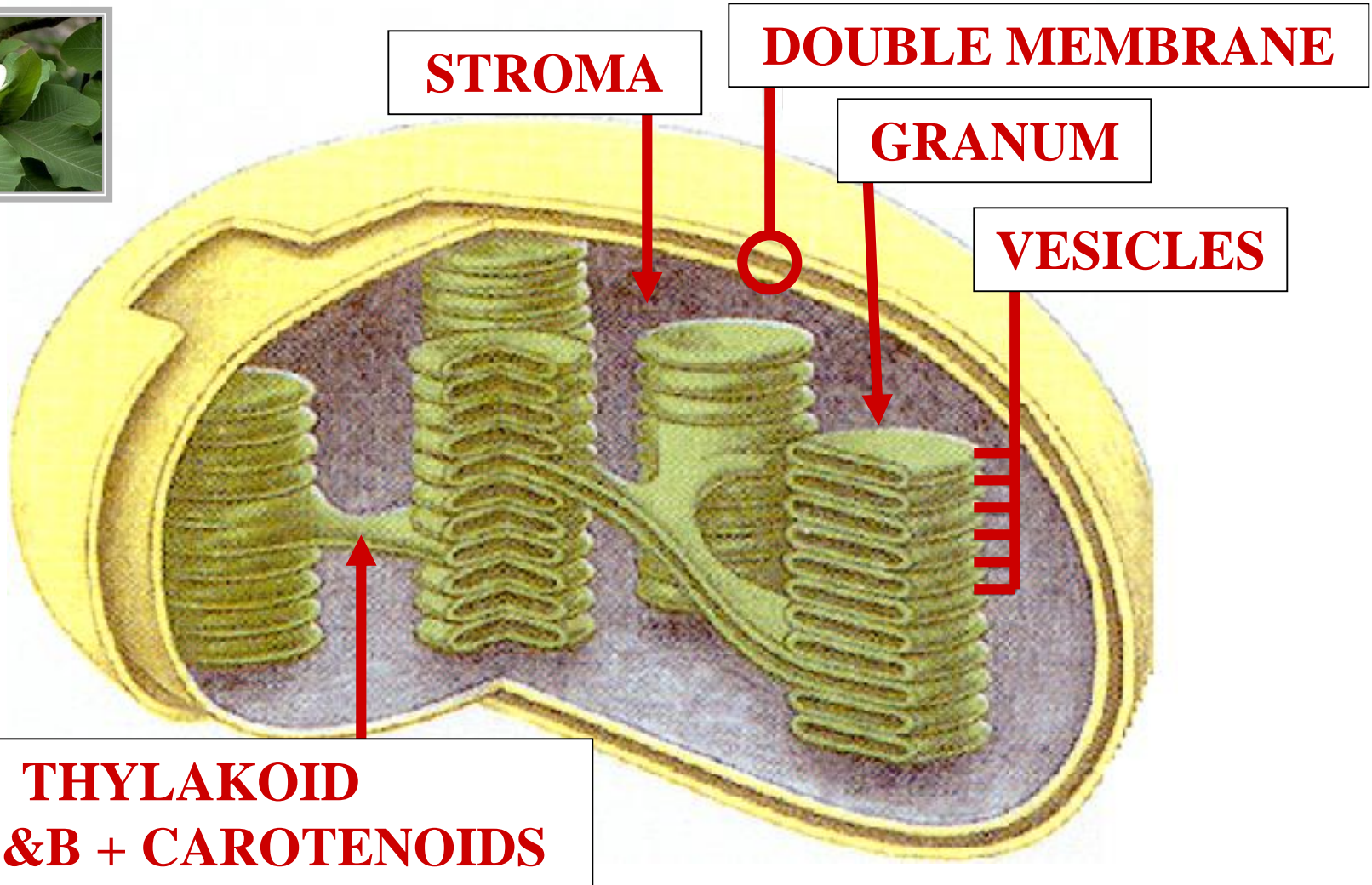
GREEN BACTERIA

L.S.

TRUE PLANT CHLOROPLAST ULTRASTRUCTURE

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CYANOBACTERIA / GREEN BACTERIA

GREEN BACTERIA

~2 PSYN PIGMENTS

CAROTENOIDS

TRUE PLANT CHLOROPLASTS

~2 PSYN PIGMENTS

CAROTENOIDS

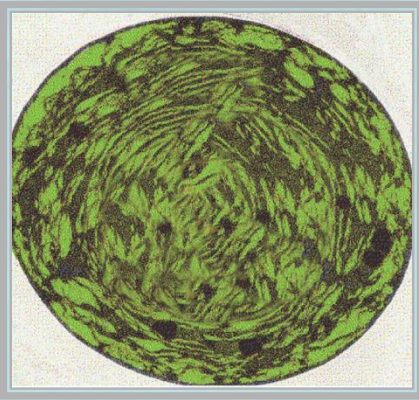
CYANOBACTERIA / GREEN BACTERIA



REPRESENTATIVE GENUS

GREEN BACTERIA

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PROCHLORON

QUESTION

IS A

CYANOBACTERIUM

GREEN BACTRIUM

A PLANT?

QUESTION