Mineral Nutrition

Nitrogen fixation

Ion movement in plants

Review - Big questions

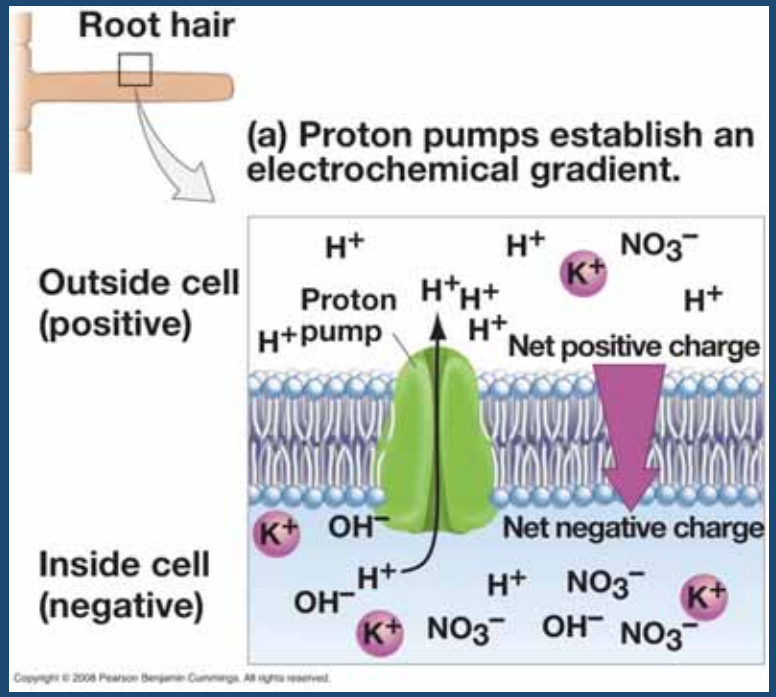
- How is ATP synthesis related to transport of minerals into the plant root hairs?
- Can you explain how “burning” your plant with fertilizer is related to the concept of cation exchange?
- Explain the process of how a root hair obtains a single Potassium ion.
- Explain the process of how a root hair obtains a single Nitrate molecule. How is this process similar to the acquisition of the potassium ion?
- Where are cations and anions located in the soil surrounding the root hair and how does that affect their availability after a flood?

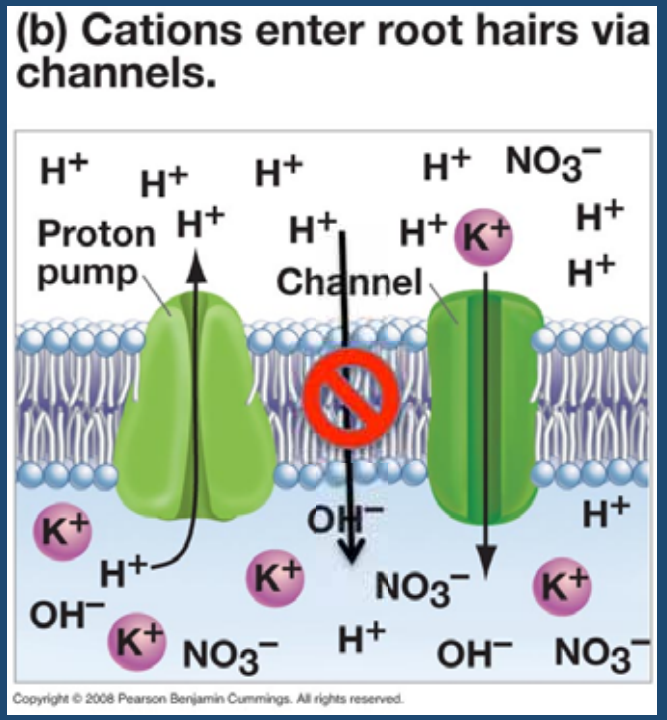
Nutrient transport

http://longorshortcapital.com/stick-and-the-eskimo.htm

1. Establish an charge difference

2. Positively charged ions pass with the help of channel proteins





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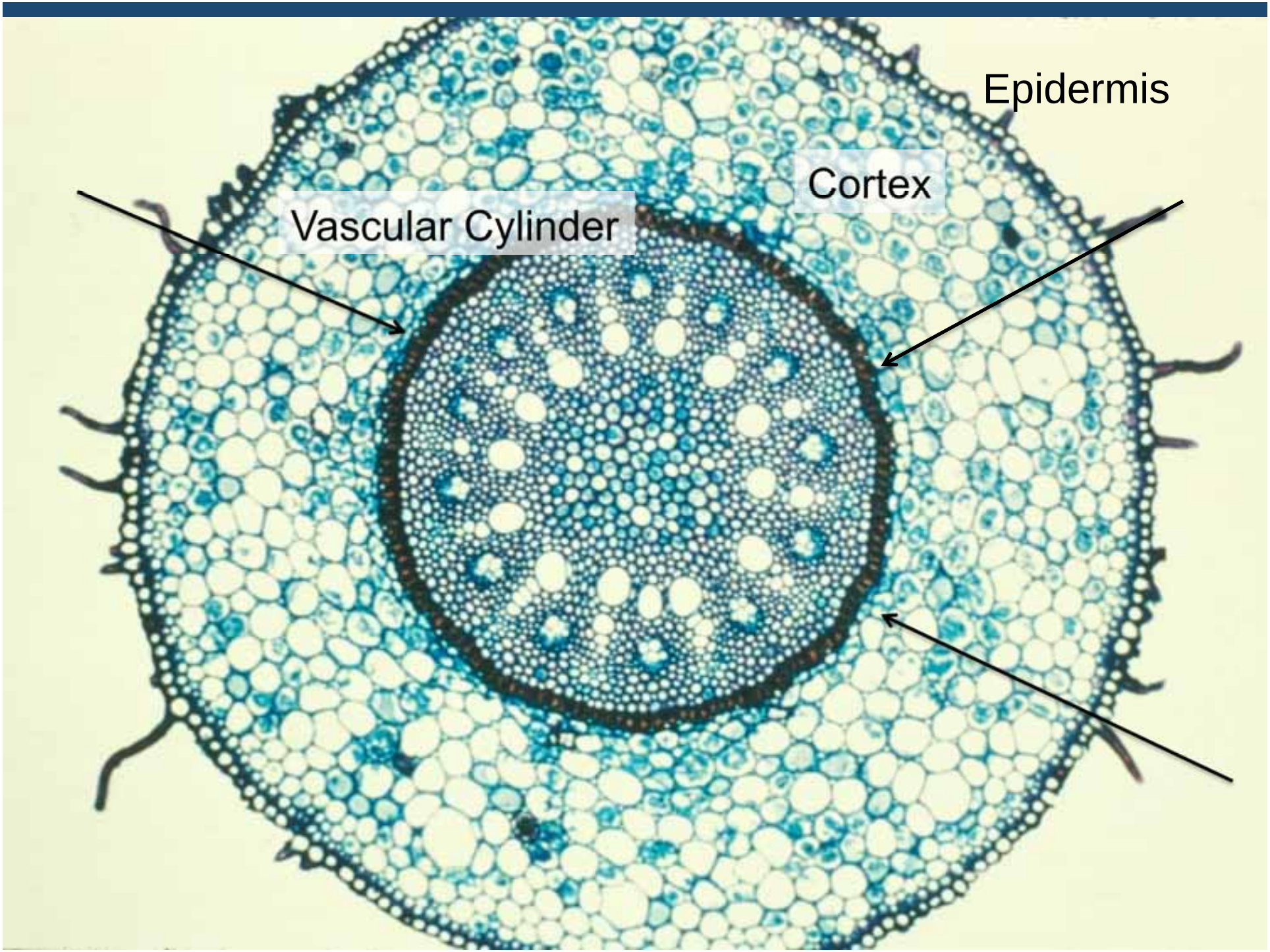
Explain the process of how a root hair obtains a single potassium ion.

In order to establish an electrochemical gradient, ATPase uses ATP to pump protons (hydrogen cations) outside the cell. This electrochemical gradient must be balanced by the movement of cations back into the cell. Postassium (a cation) is transported via a channel protein back to the inside of the cell, helping to balance the electrochemical gradient, but increasing the concentration gradient of Potassium molecules inside the cell.

Movement of Ions in Plants

Movement of Ions in plants

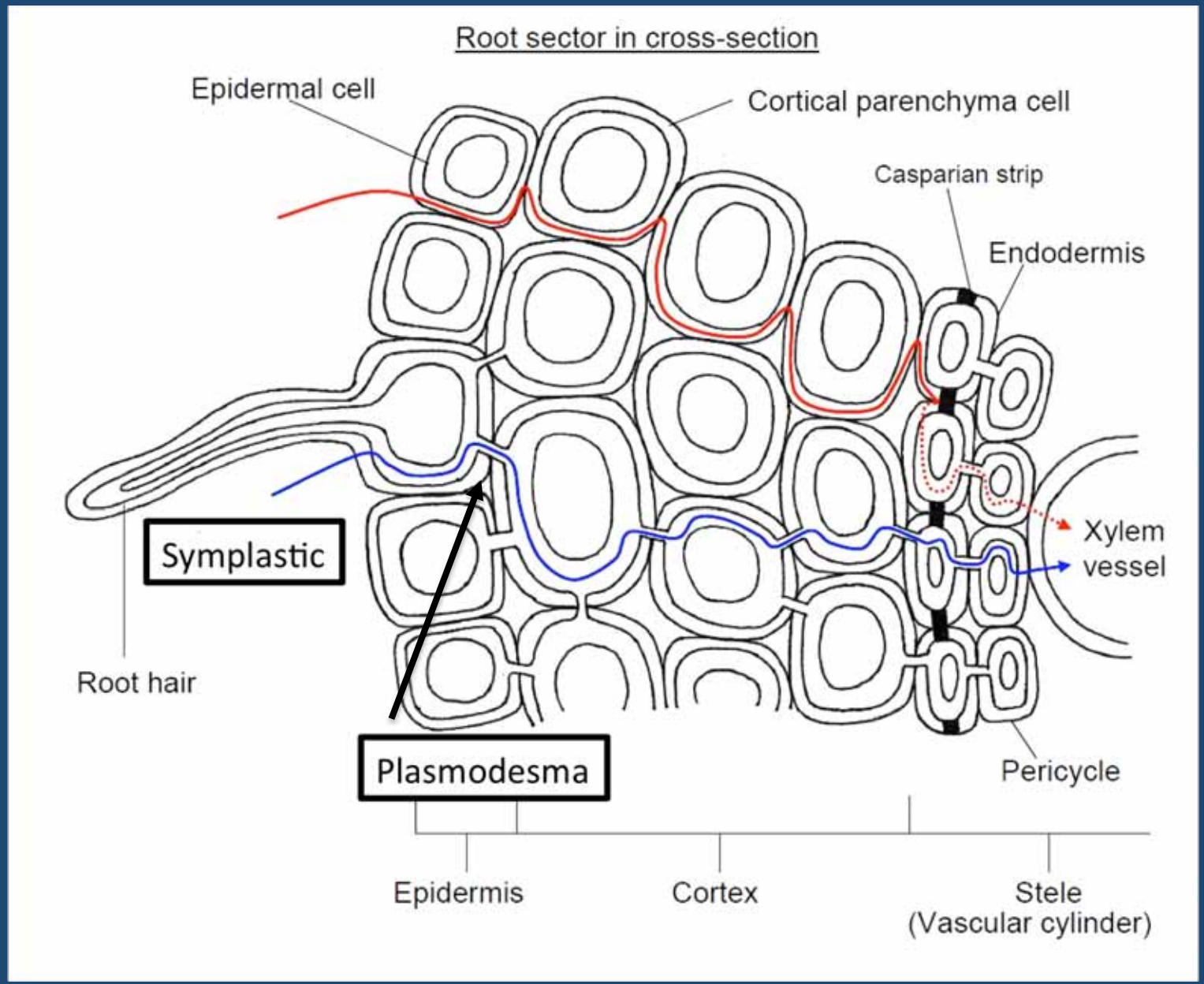
- We know how plants use proton gradients to acquire nutrients in the soil.
- How does that plant get those nutrients to the rest of the plant (into circulation)?


Epidermis
Cortex
Vascular Cylinder

Movement into the plant

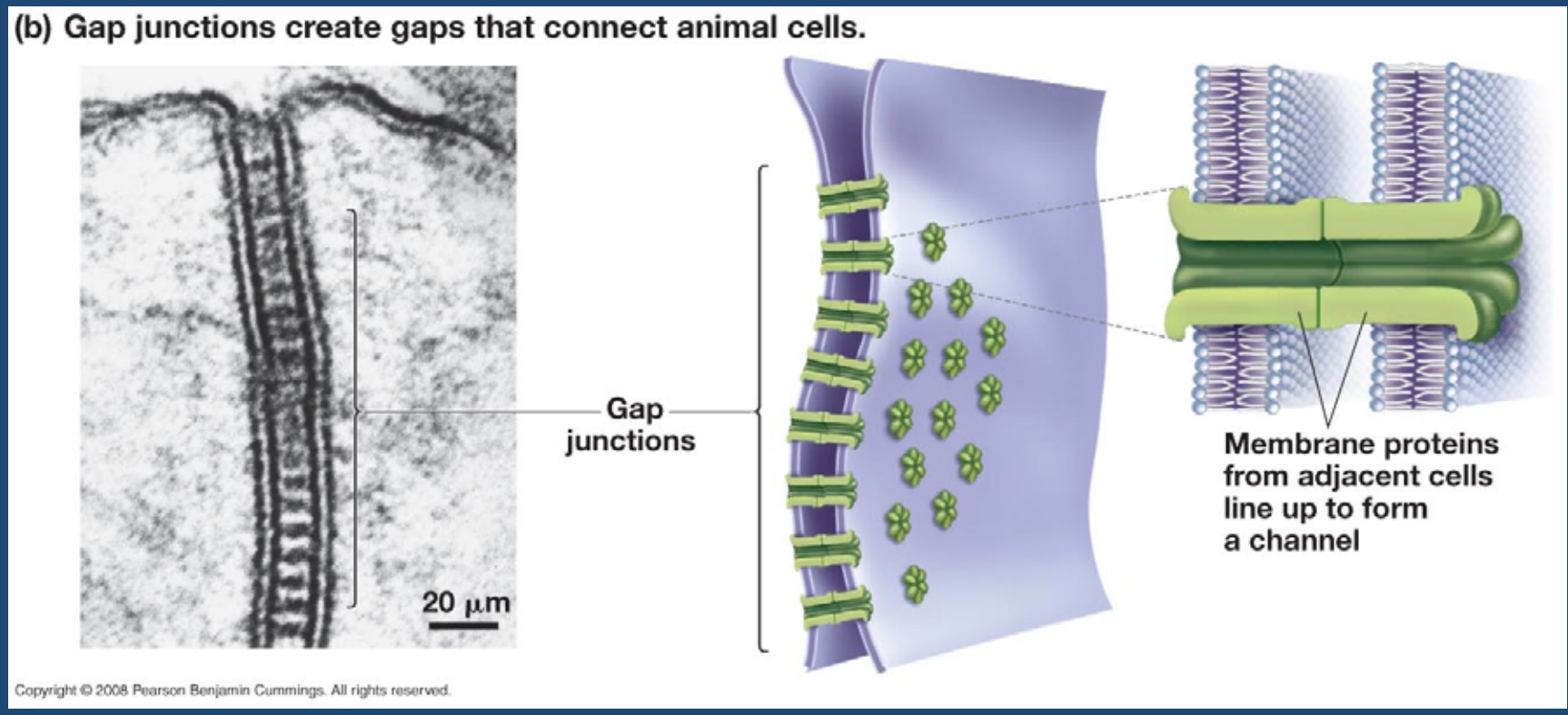
- Symplastic movement
- Water and solutes enter the root hairs and travel to the xylem intracellularly
- Travel between cells via plasmodesmata

- Apoplastic movement



http://cronodon.com/BioTech/Plant_Transport.html

Plasmodesmata



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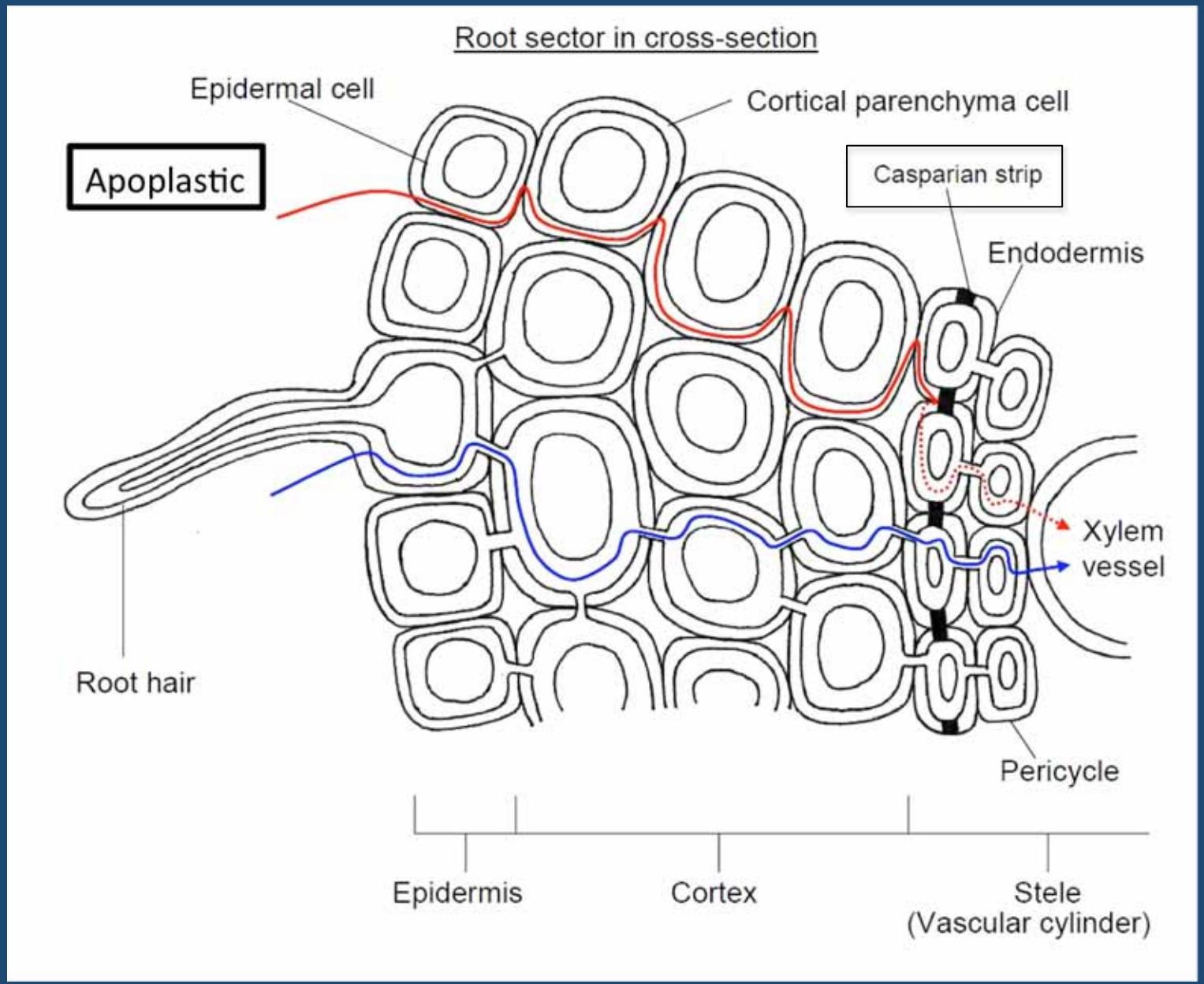
Movement into the plant

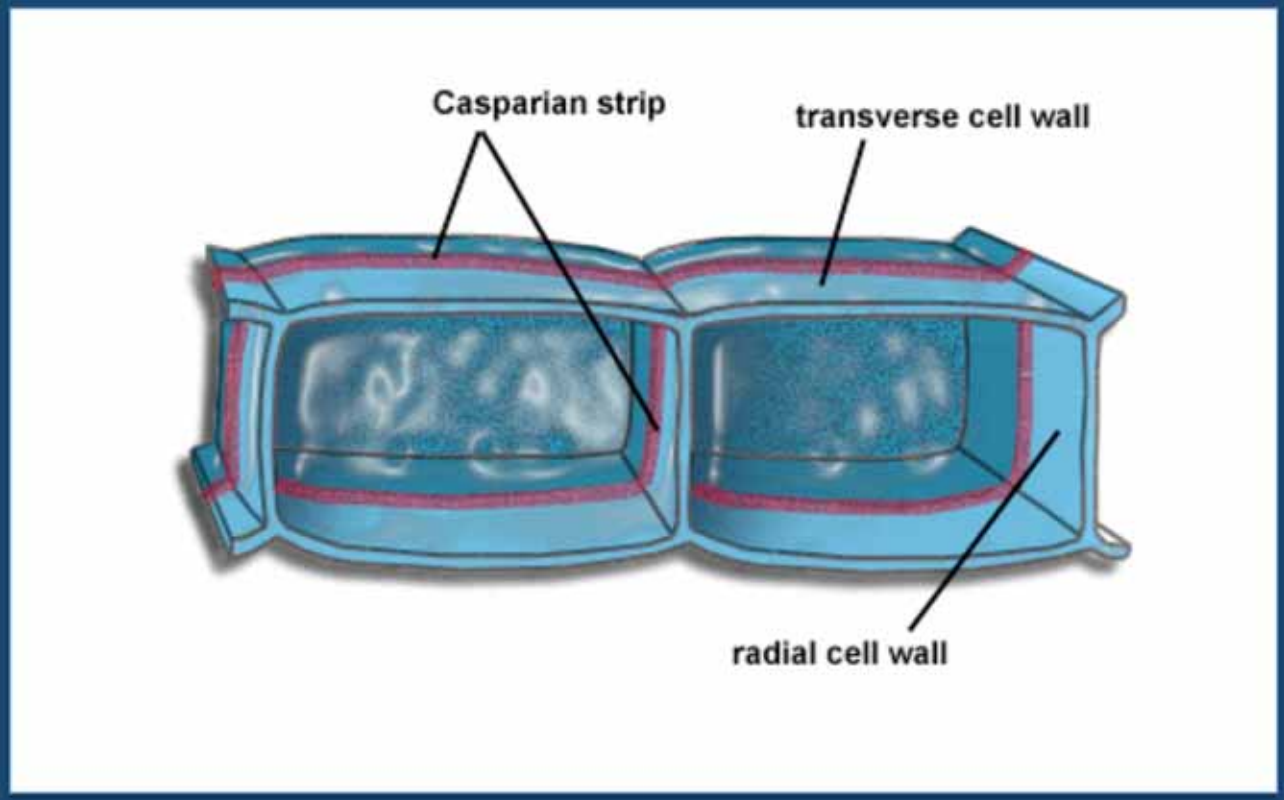
- Symplastic movement
- Water and solutes enter the root hairs and travel to the xylem intracellularly
- Travel between cells via plasmodesmata

- Apoplastic movement
- Water and solutes enter epidermis and cortex via cell walls and inter cellular spaces (porous)



http://cronodon.com/BioTech/Plant_Transport.html

Casparian Strip



http://www.bcb.uwc.ac.za/ecotree/root/images/Endodermis.GIF

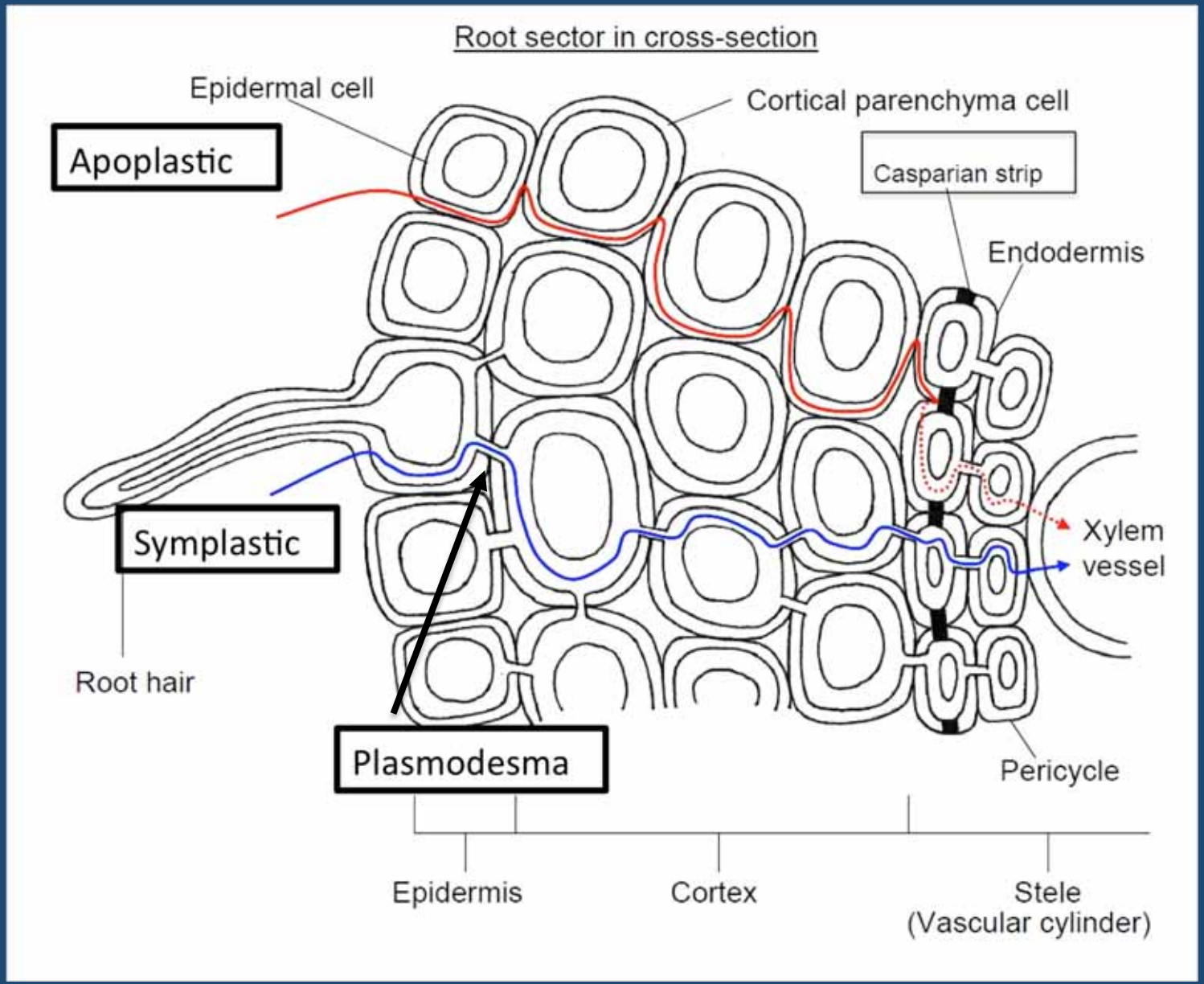
Movement into the plant

Symplastic movement

- Slow movement
- Regulated at root hair
  - Numerous channel proteins

Apoplastic movement

- Fast movement
- Unregulated at root hair
- Highly regulated at endoderm
  - Casparian Strip
    - Fewer channel proteins



Everything enters xylem symplastically

http://cronodon.com/BioTech/Plant_Transport.html

Questions

- The movement of water through the cortex via the plasmodesmata is called what?

- Which one of the two types of water movement through the cortex shows the most regulation at the level of the root hair?



Nitrogen and you

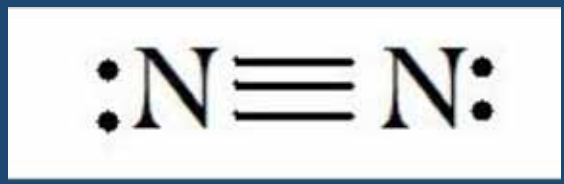
http://my.opera.com/m2m99/albums/showpic.dml?album=604687&picture=9813236

http://paranormalpointofview.blogspot.com/2011/05/inspiration.html

http://pixeltango.com/articles/creative-ways-to-kill-your-inspiration-dry-out/

Nitrogen

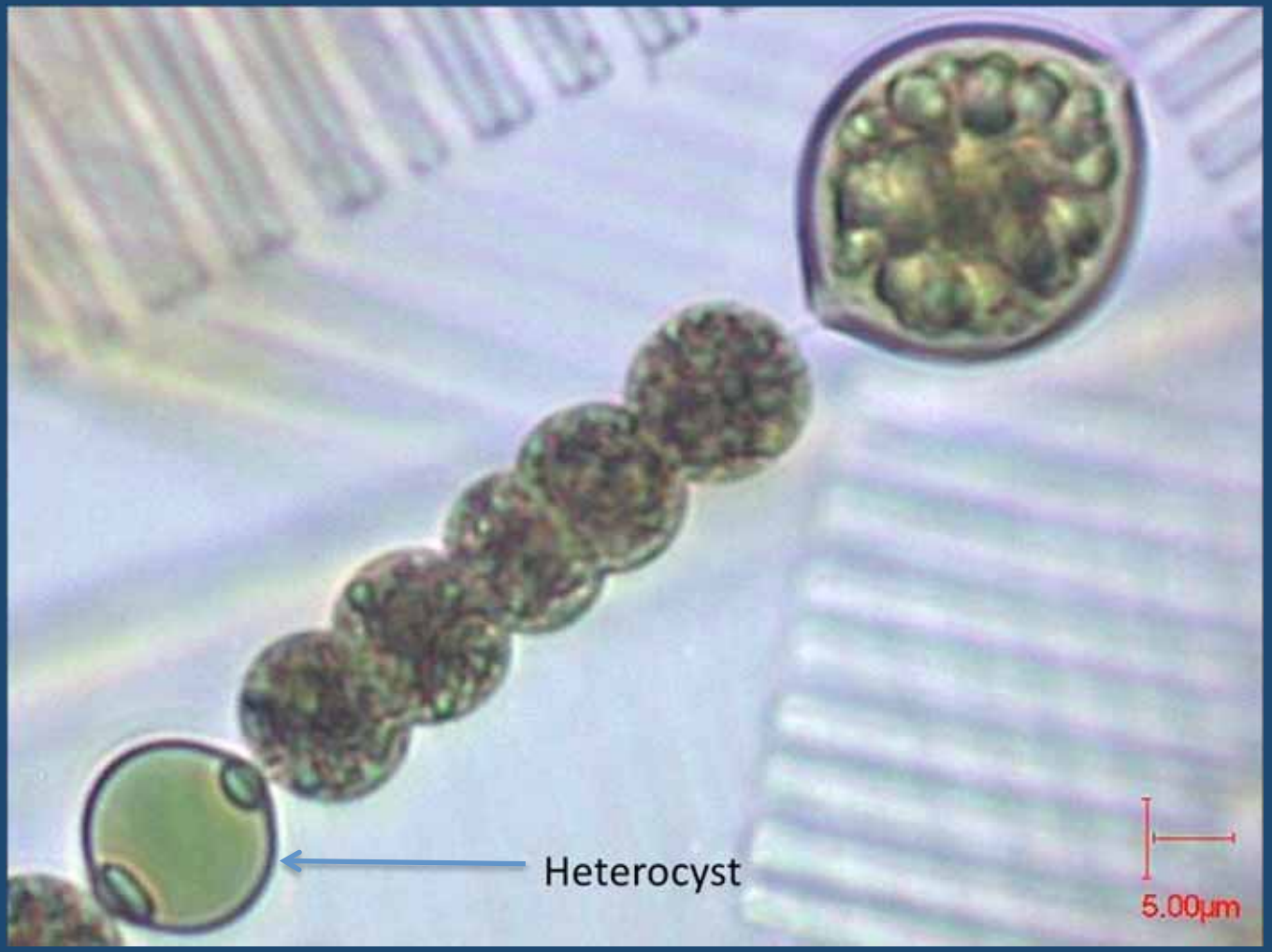
- Most common usable forms of nitrogen
  - NH_3 (ammonia)
  - NO_3 (nitrate)
- Most common form of nitrogen
  - N_2
  - 80% of the atmospheric gas
  - Inert, unreactive, unusable



http://chemwiki.ucdavis.edu/Inorganic_Chemistry/Descriptive_Chemistry/Main_Group_Elements/Group_15%3A_The_Nitrogen_Family

Where is nitrogen fixed?

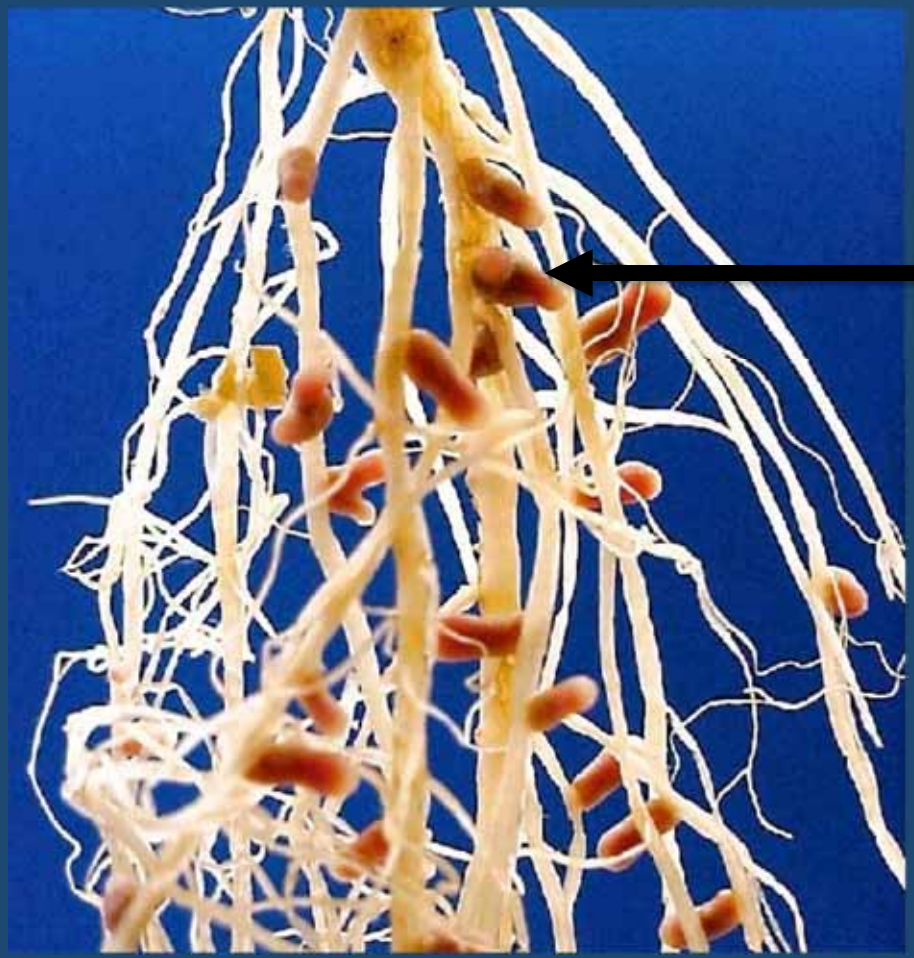
Nitrogen-fixing *Anabaena*



http://plantphys.info/organismal/lechtml/images/anabaena.jpg

Mutualism!

Rhizobium and legumes



Root Nodules
of Rhizobium

http://www.interet-general.info/IMG/rhizobium-nodule-1.jpg

What turns nitrogen from N_2 to NH_3?

- Nitrogenase: *the enzyme complex*
  - Found only in certain prokaryotes
  - *Rhizobium* most common genus

- Not perfect!
  - Requires large amounts of energy (24 ATP = $2NH_3$)
  - Deactivated by Oxygen (anaerobic)

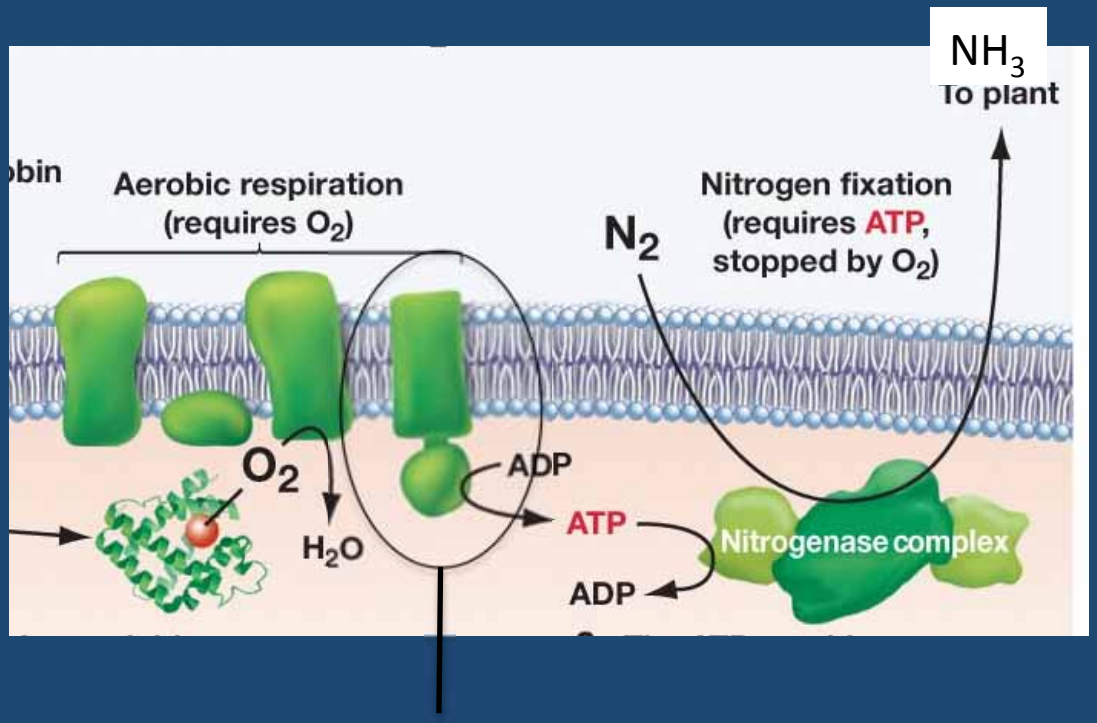
$N \equiv N$

$O=O$

How does Rhizobium compensate for this sub-optimal enzyme?

Getting the Energy

Close to the Nitrogenase enzyme is an electron transport chain used for cellular respiration



How many ATP produced by ETC?

How many ATP required to fix N_2?

Figure 38.16 pg. 851

Starting to get old…

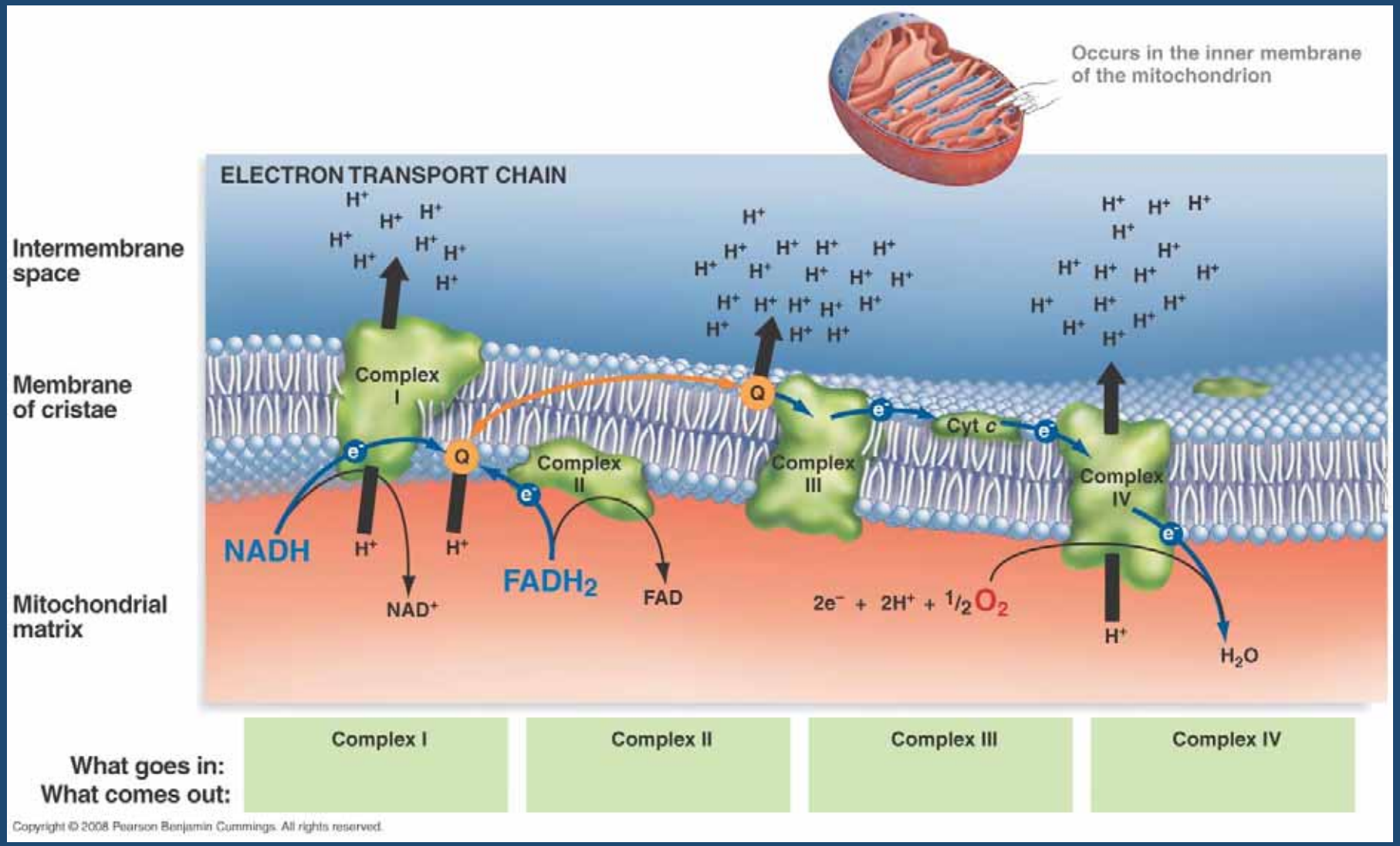
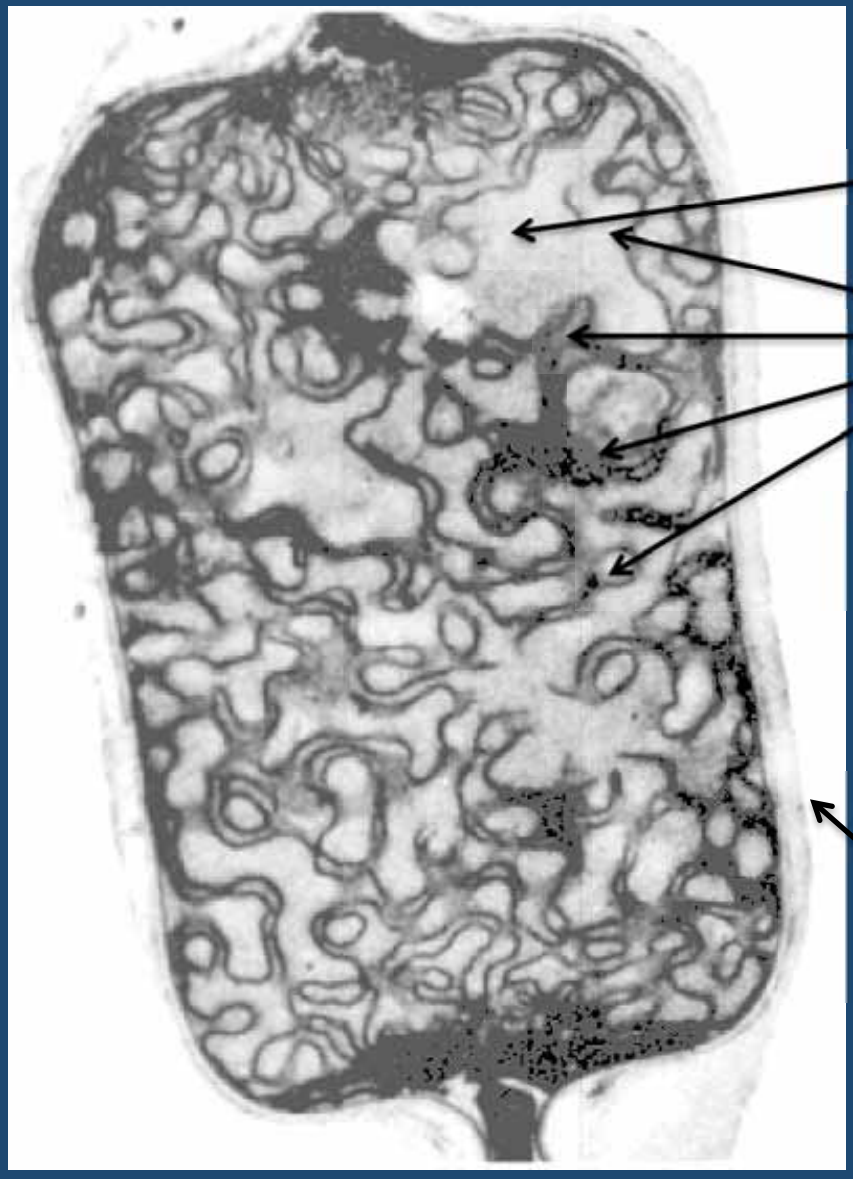


Figure 9.24

Cyanobacterial Heterocyst (N_2 fixation)



Nitrogenase in cytosol

Membrane-bound ETC

Lots of membranes here!

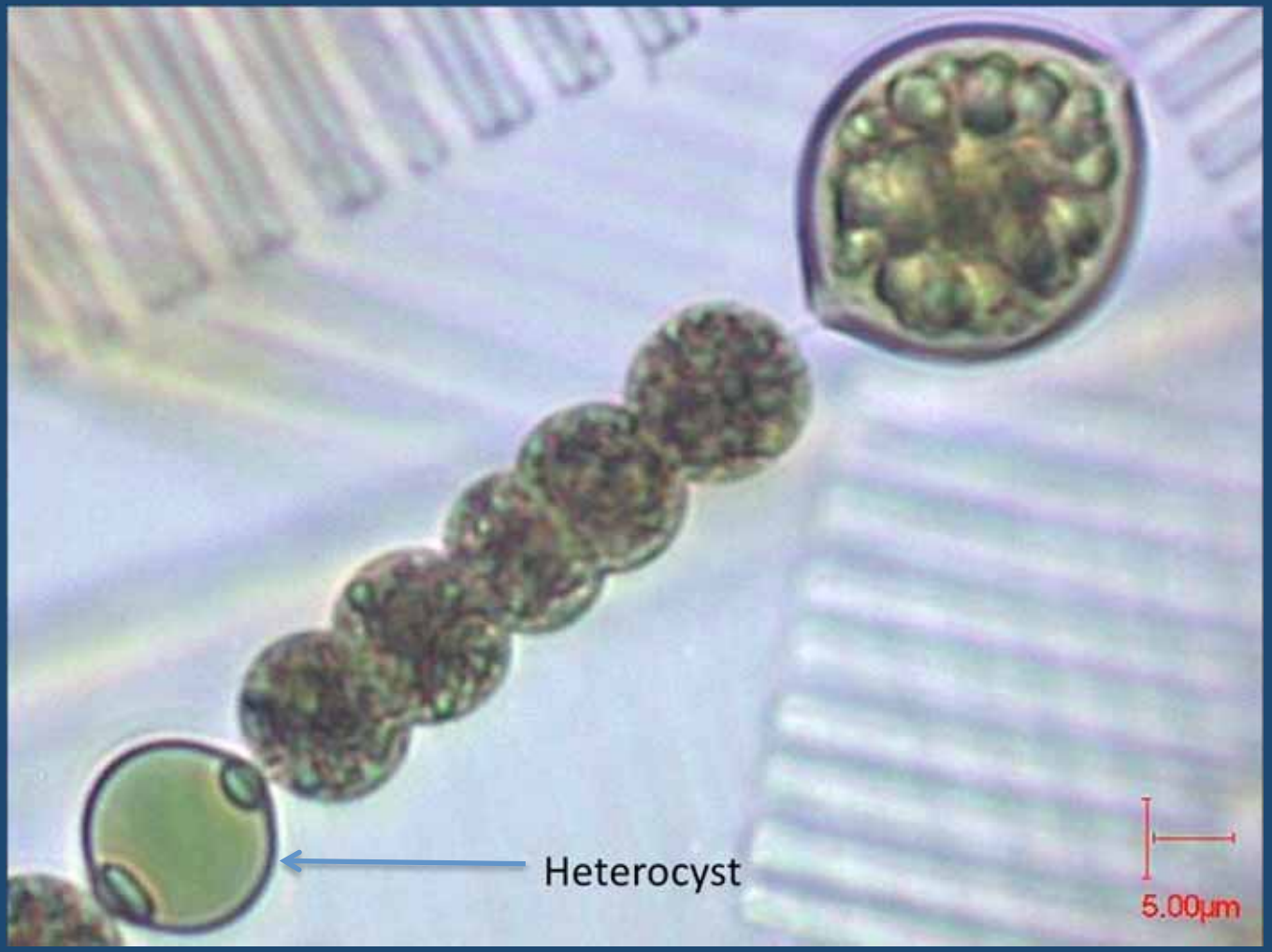
ETC producing energy

ETC using up oxygen

Thick cell wall!

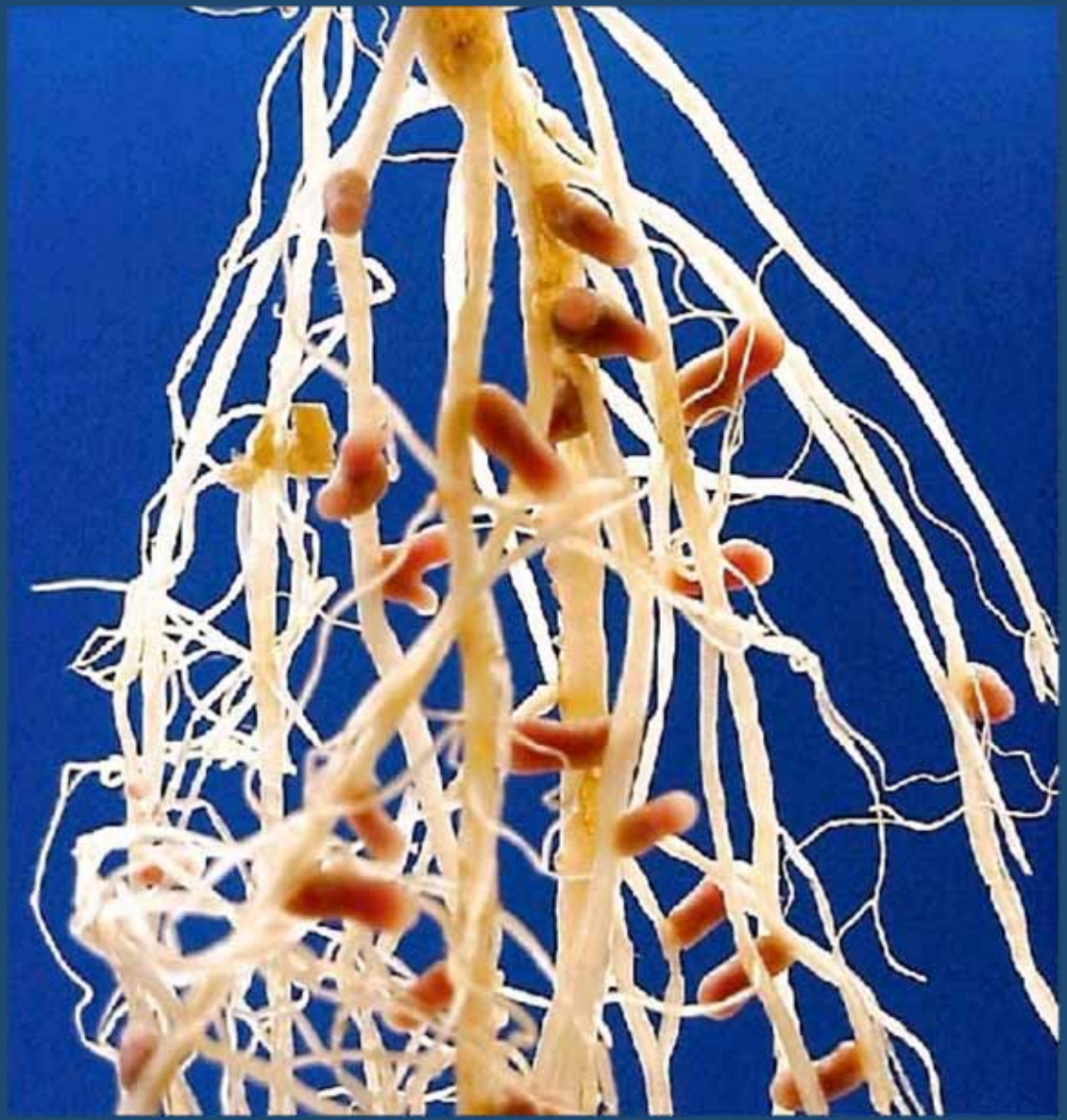
http://www.botany.hawaii.edu/faculty/webb/BOT311/Cyanobacteria/Heterocyst.jpg

Anabaena



http://plantphys.info/organismal/lechtml/images/anabaena.jpg

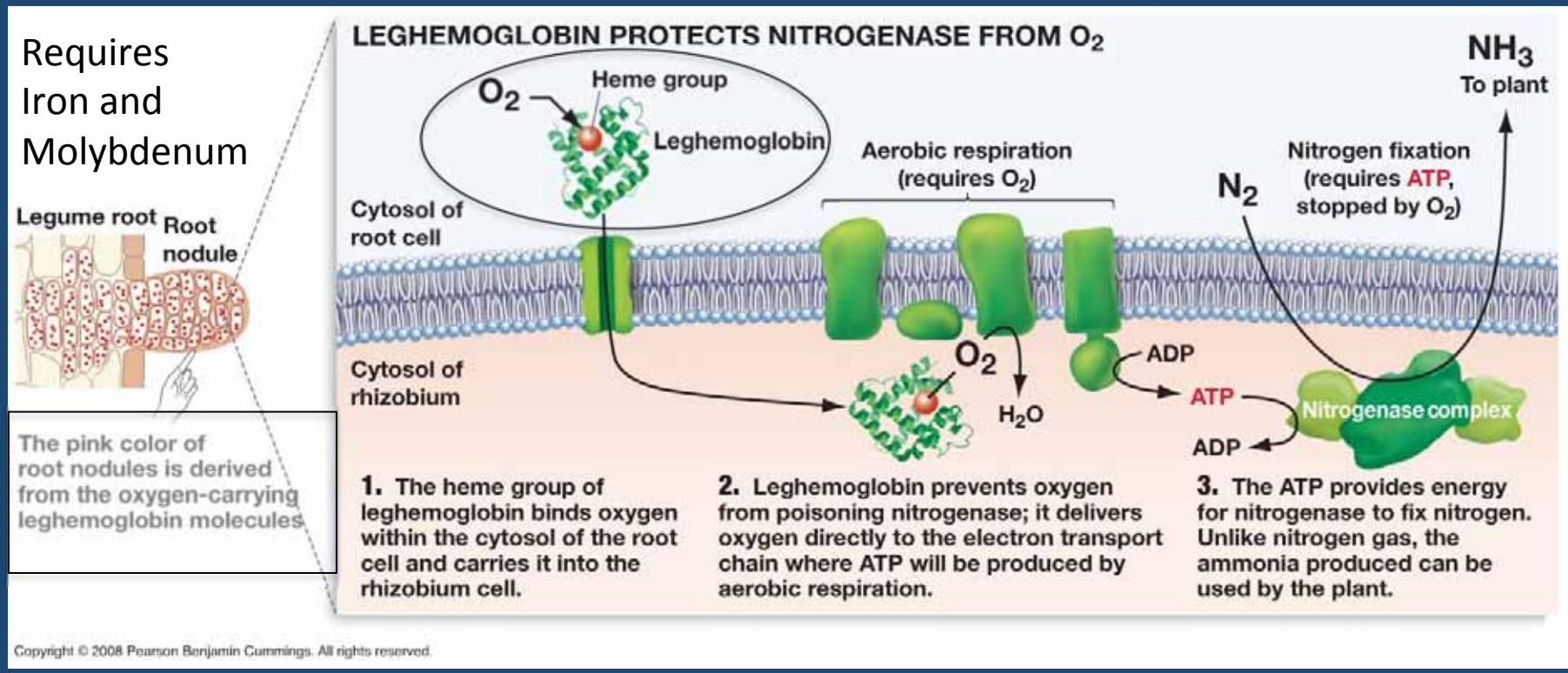
Root nodules help keep oxygen from entering



http://www.interet-general.info/IMG/rhizobium-nodule-1.jpg

But we need the O_2 for the ETC

Requires
Iron and
Molybdenum



Leghemoglobin provides the electron transport chain with oxygen without letting the oxygen disrupt the Nitrogenase complex

Figure 38.16 pg. 851

Here are legumes with *Rhizobium* and without *Rhizobium*

Both groups have access to the normal soil NO_3 and NH_4

Questions

How does the electron transport chain aid the nitrogenase enzyme complex?

What is the most common genus of nitrogen-fixing soil bacterium?