



# Tree Biology

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# Tree Biology

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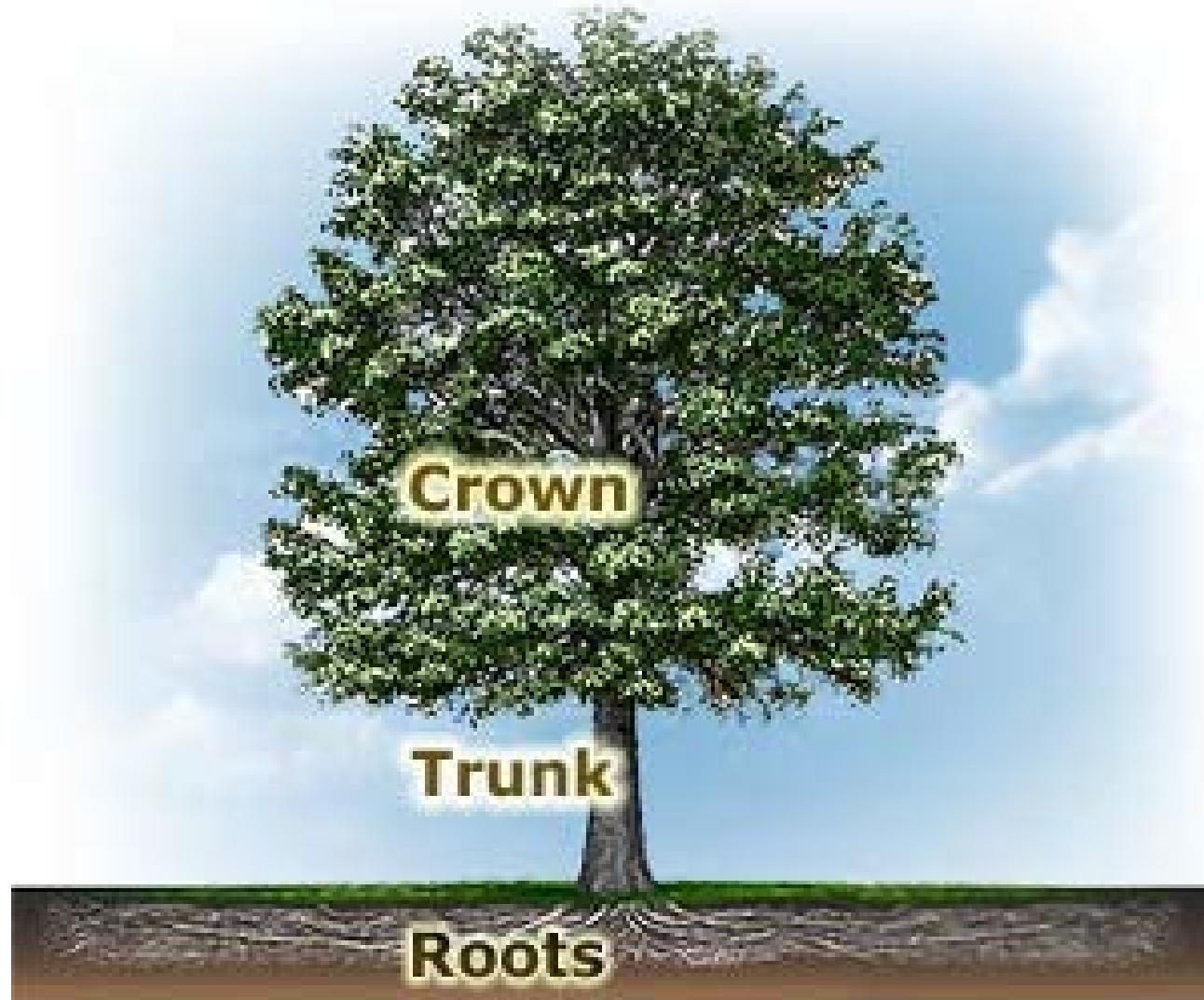
- **“If you can work on CARS, you can work on ANYTHING.”**

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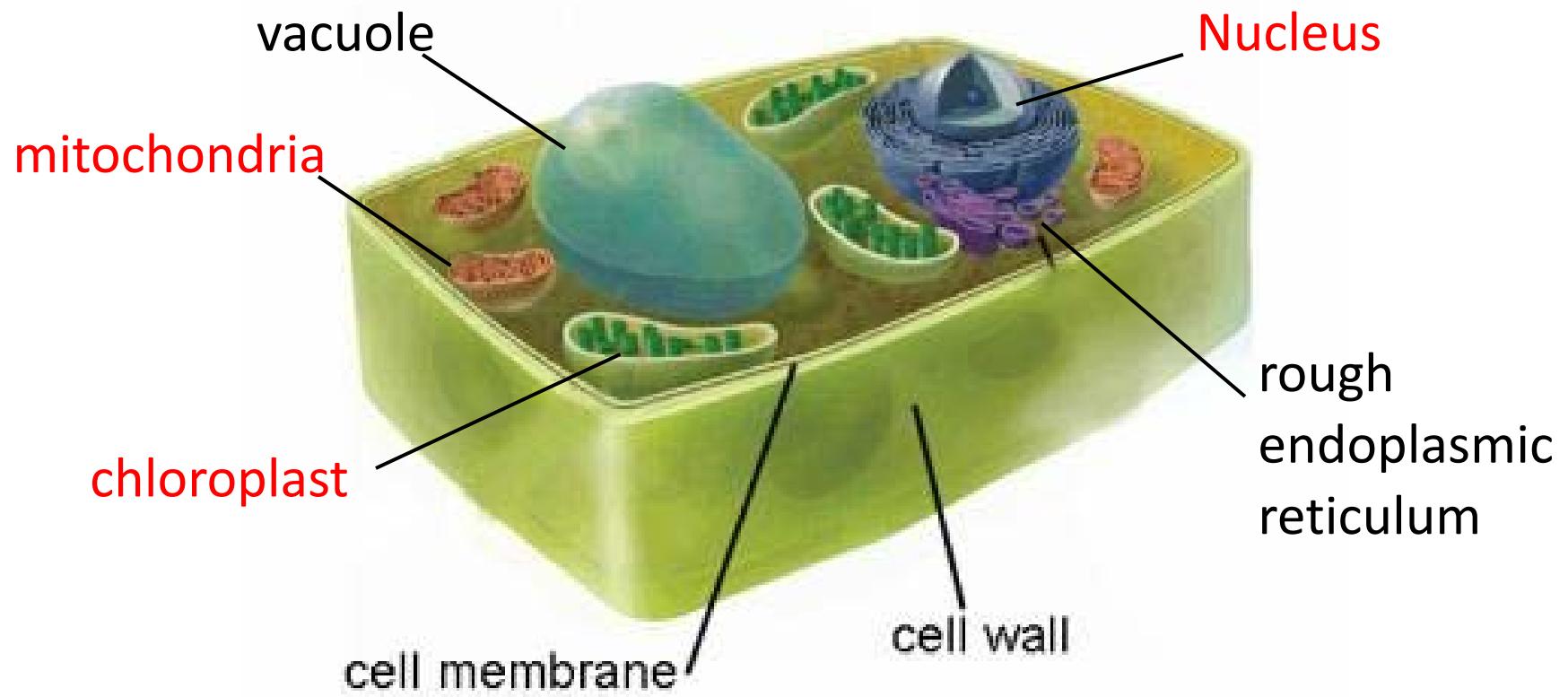
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- “If you can work on CARS, you can work on ANYTHING.”
  - “If you can work on ANYTHING, then you can figure out how TREES WORK.”

# Tree Biology



# Tree Biology



Cell => Tissue => Organ => Organism  
Cell Wall, Cellulose, Lignin

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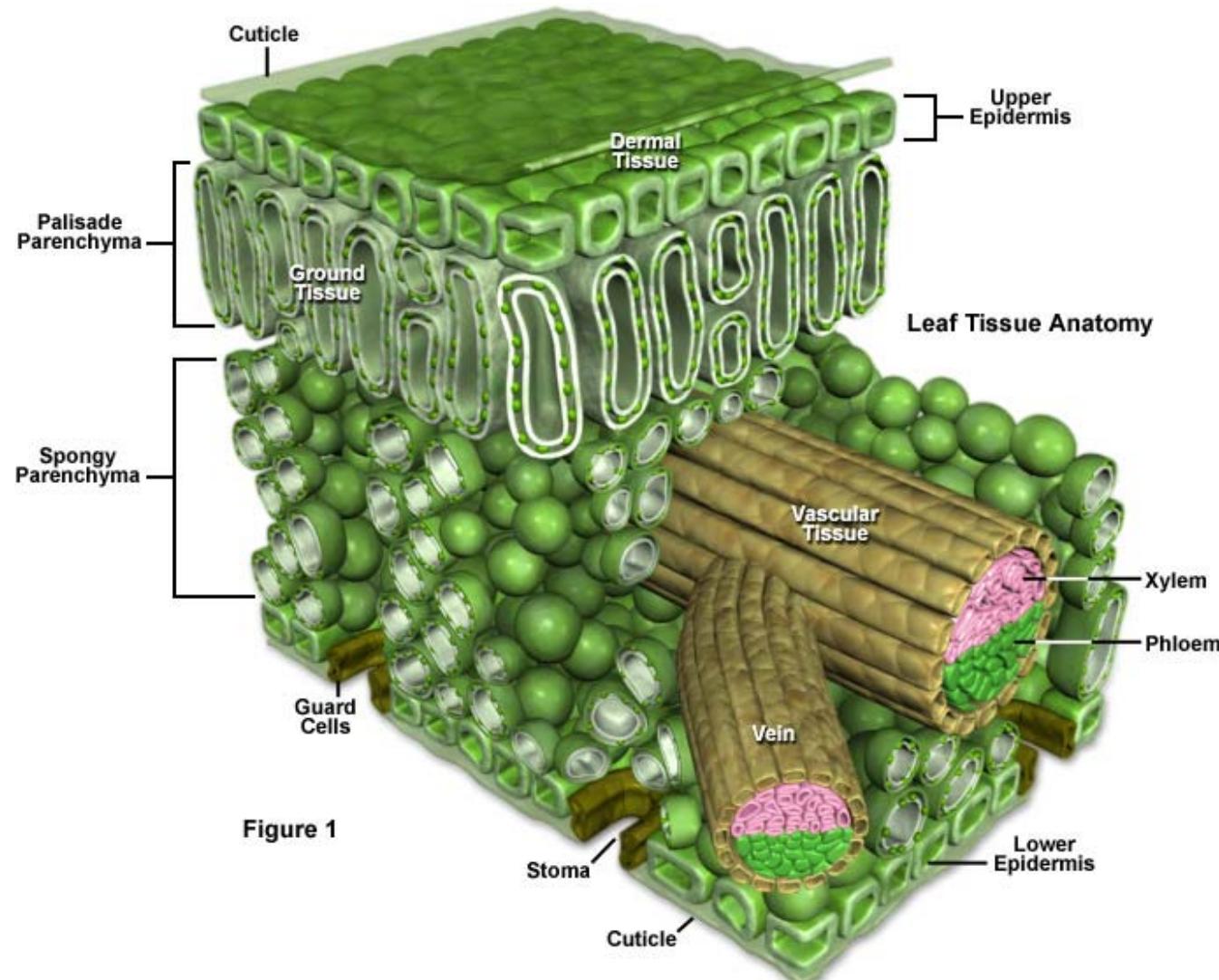
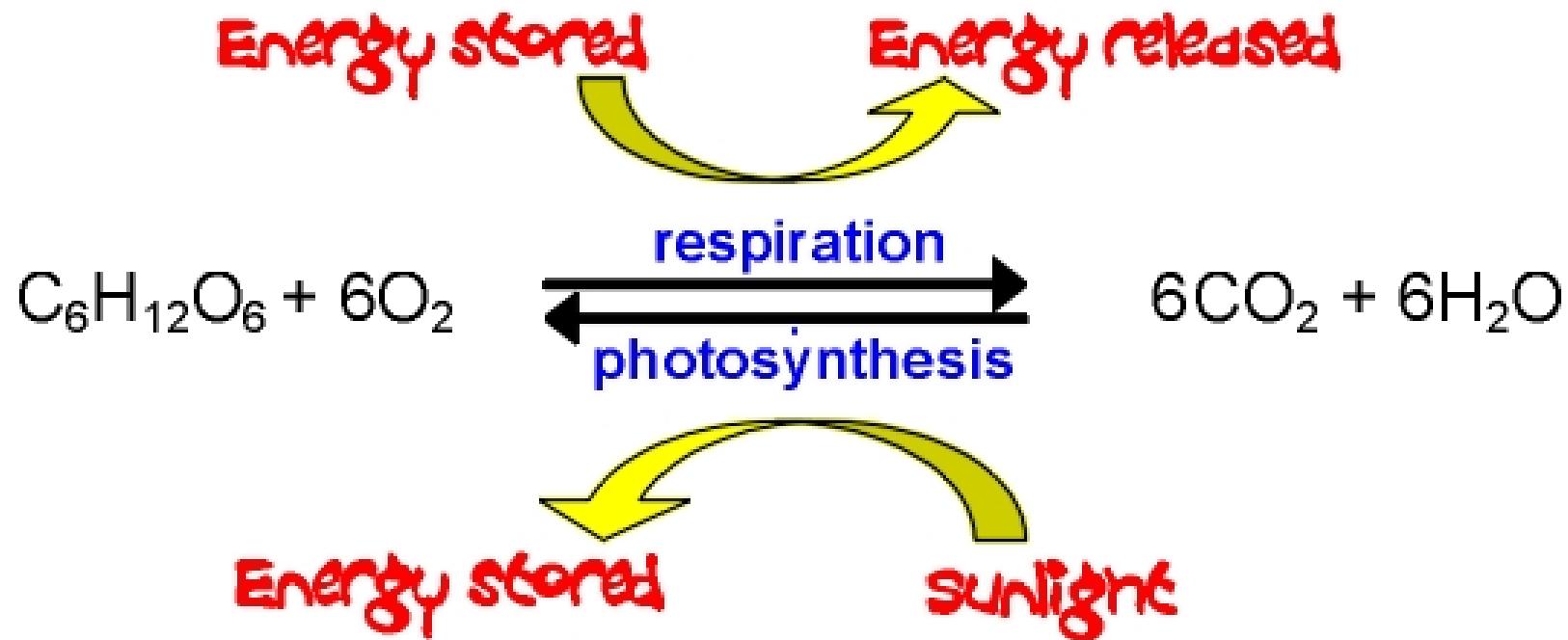


Figure 1

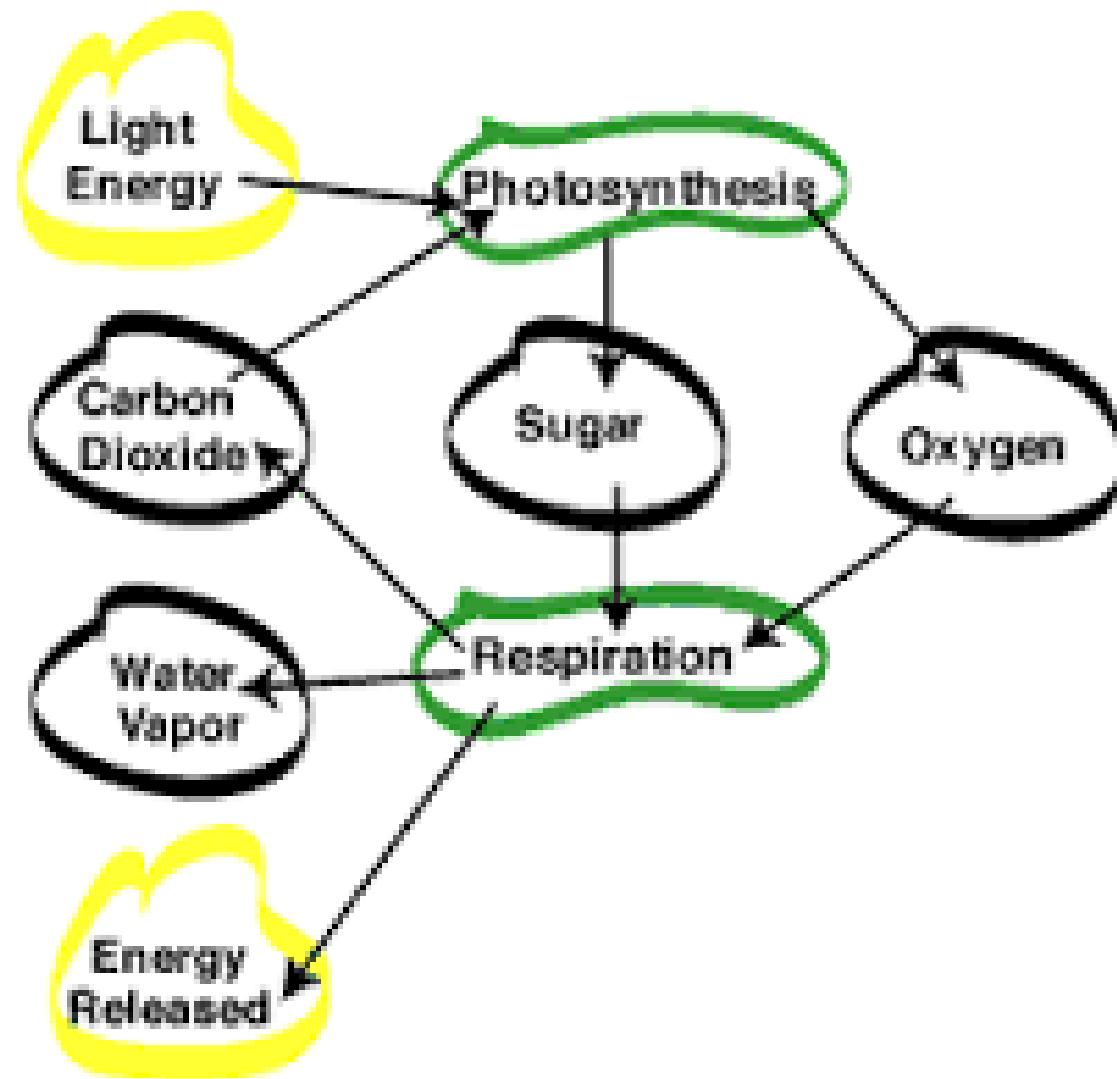
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Occurs in mitochondria



Occurs in cells that  
contain chloroplasts

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# Tree Biology

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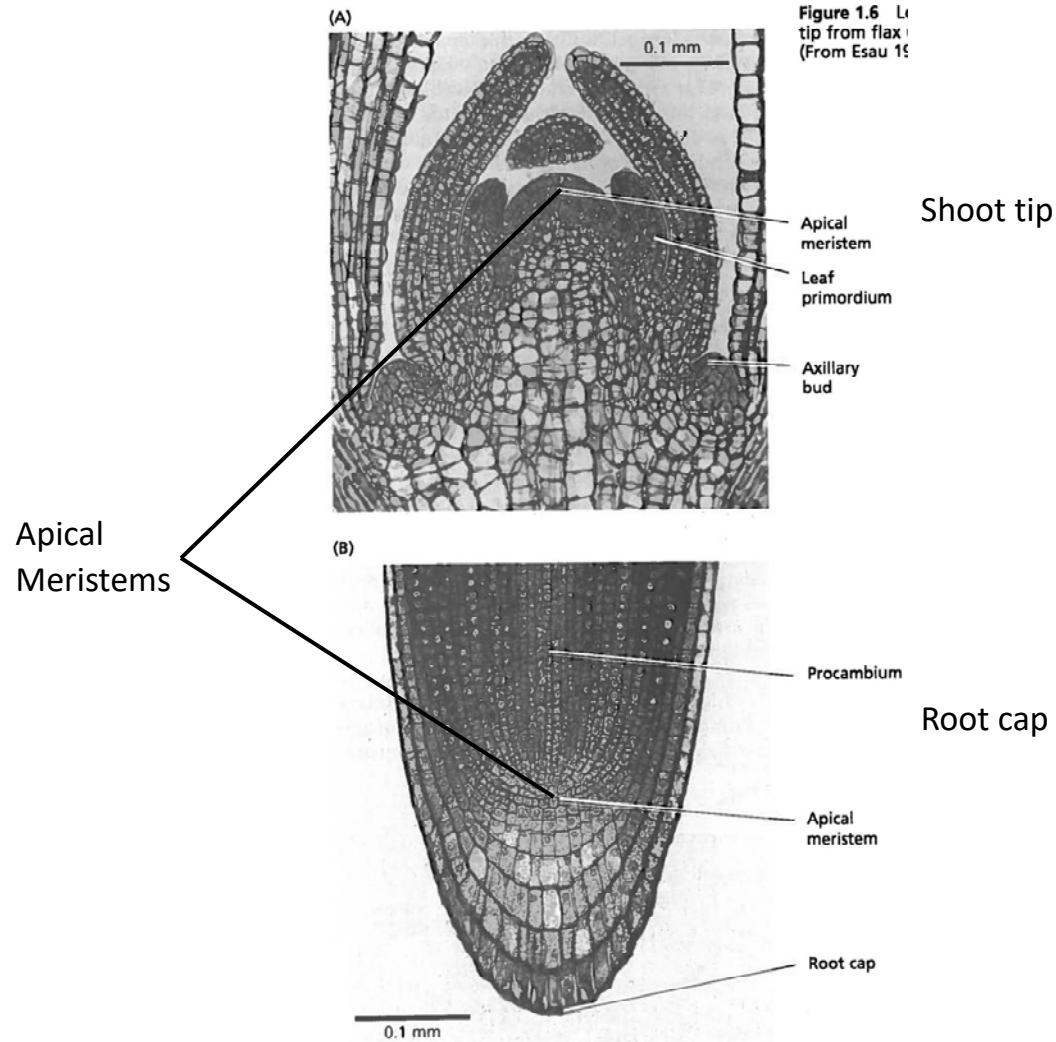


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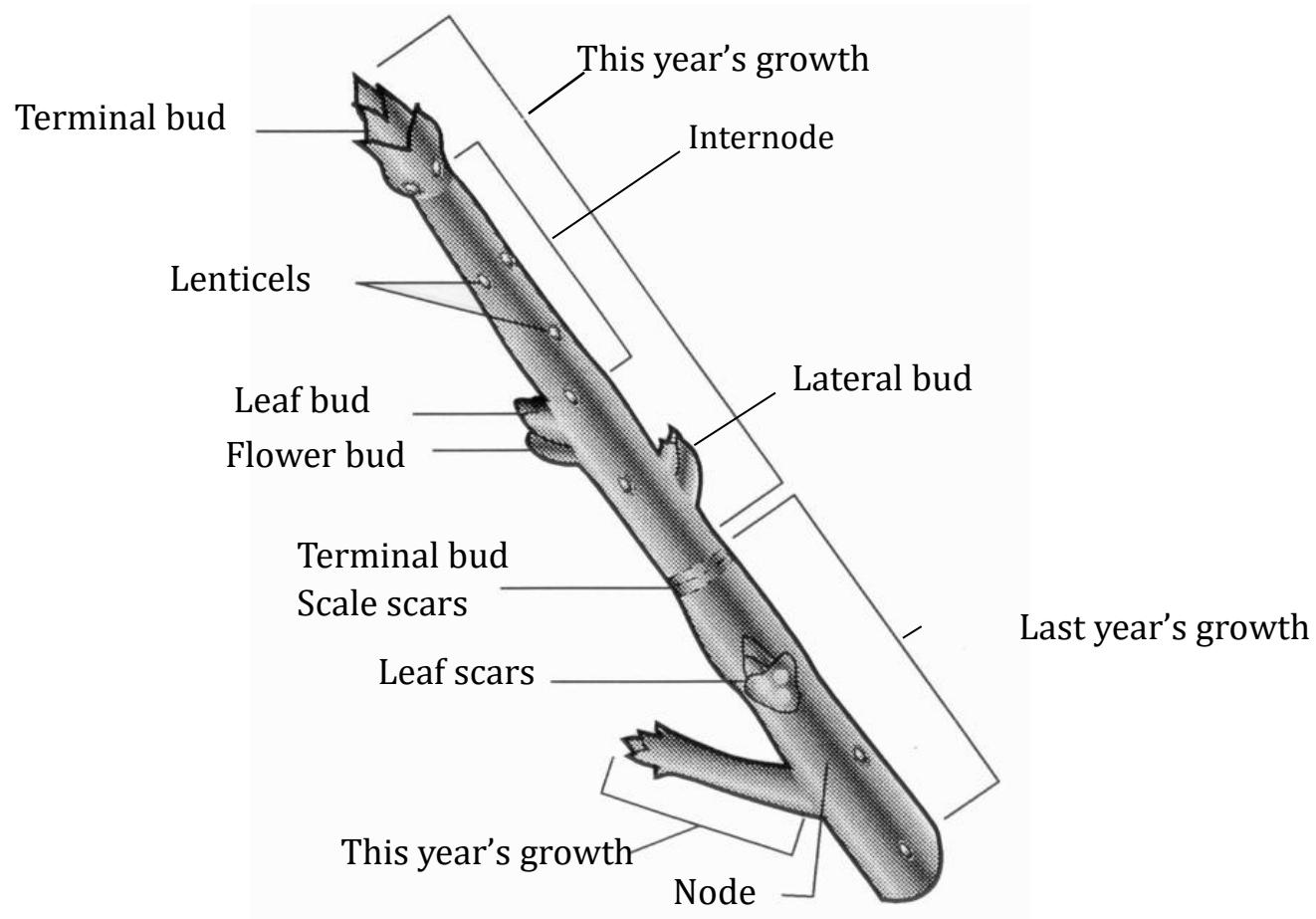
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- What makes stomata open and close?
  - Responses to signals from the environment
    - Light: stomata are open
    - Dark: stomata are closed
    - High CO<sub>2</sub> inside leaf: stomata are closed
    - Low CO<sub>2</sub> inside leaf: stomata are open
    - Drought stress: stomata are closed

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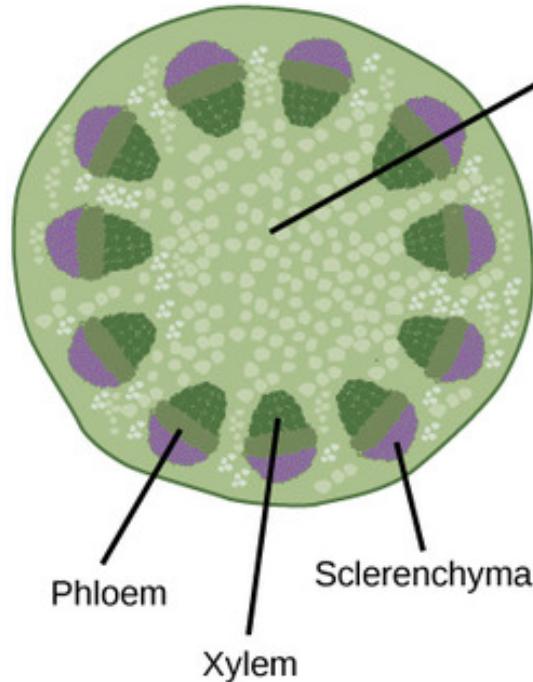


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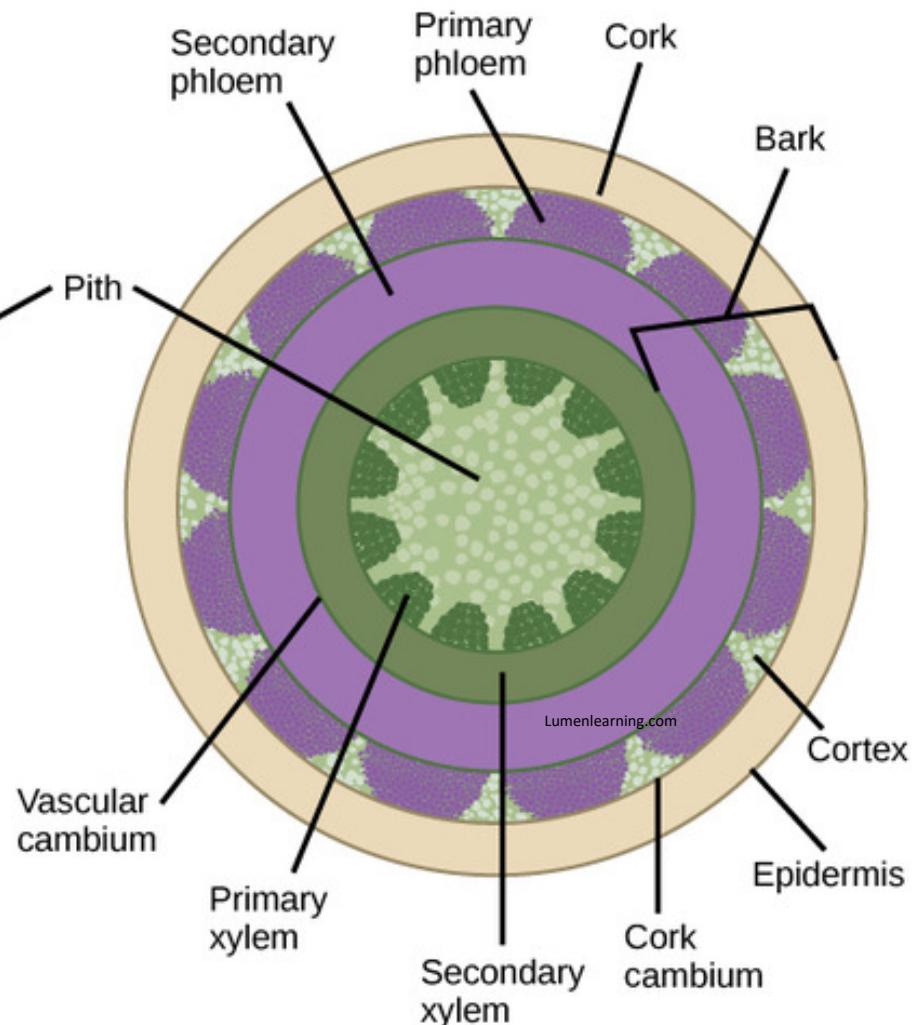


# Tree Biology

Primary growth



Secondary growth



# Tree Biology



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- Symplasm (sapwood) vs. Apoplasm (heartwood)
- Xylem of Gymnosperms (pines, spruces)
  - Tracheids (dead)
  - Fibers (sclerenchyma)
  - Parenchyma cells (live)
- Vessels (xylem of hardwoods)
  - Stacks of dead, hollow cells

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- Phloem (conifers)
  - Sieve cells
- Phloem (hardwoods)
  - Sieve tube elements
  - Companion cells
- Movement of carbohydrates (sugars) is slow and requires energy

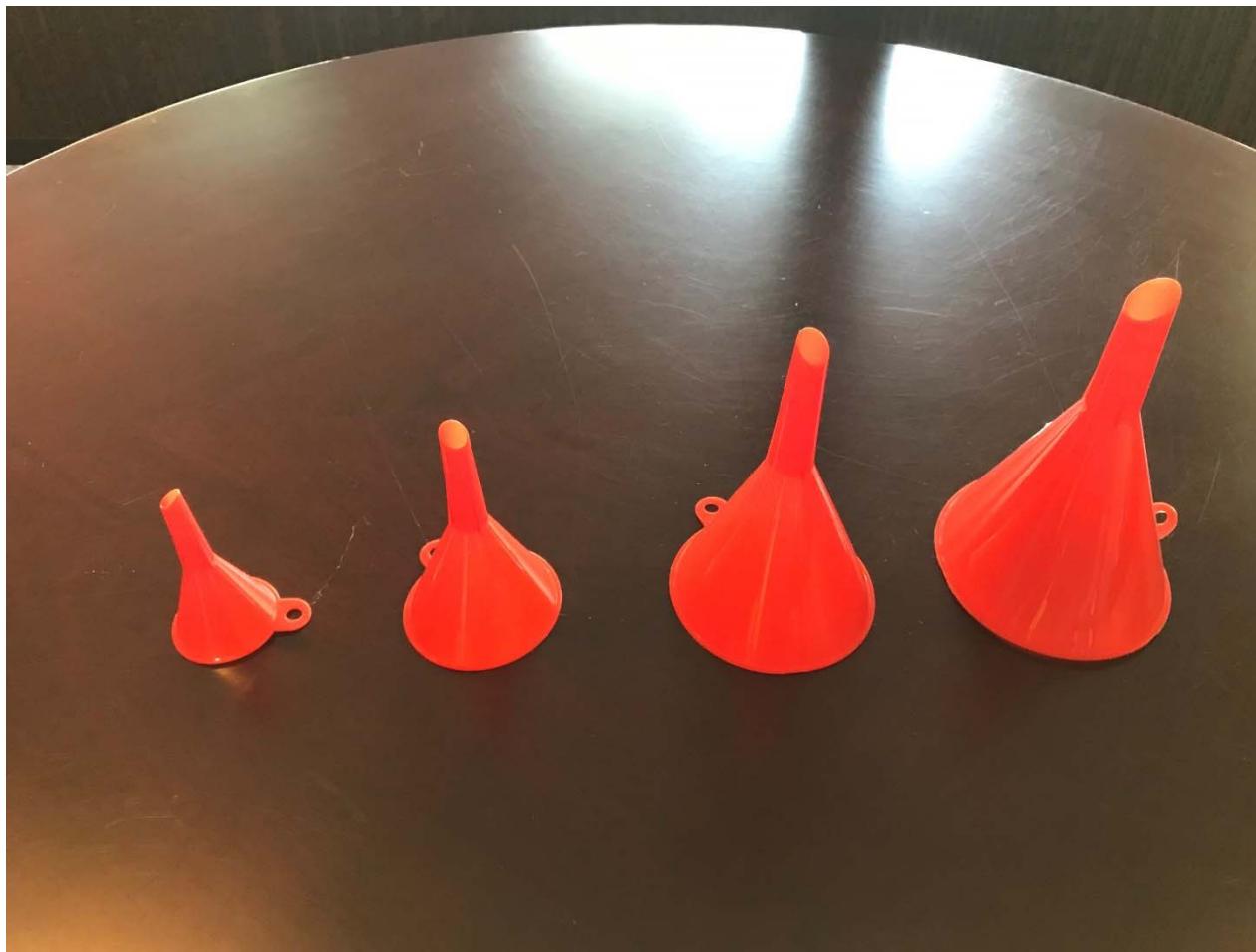
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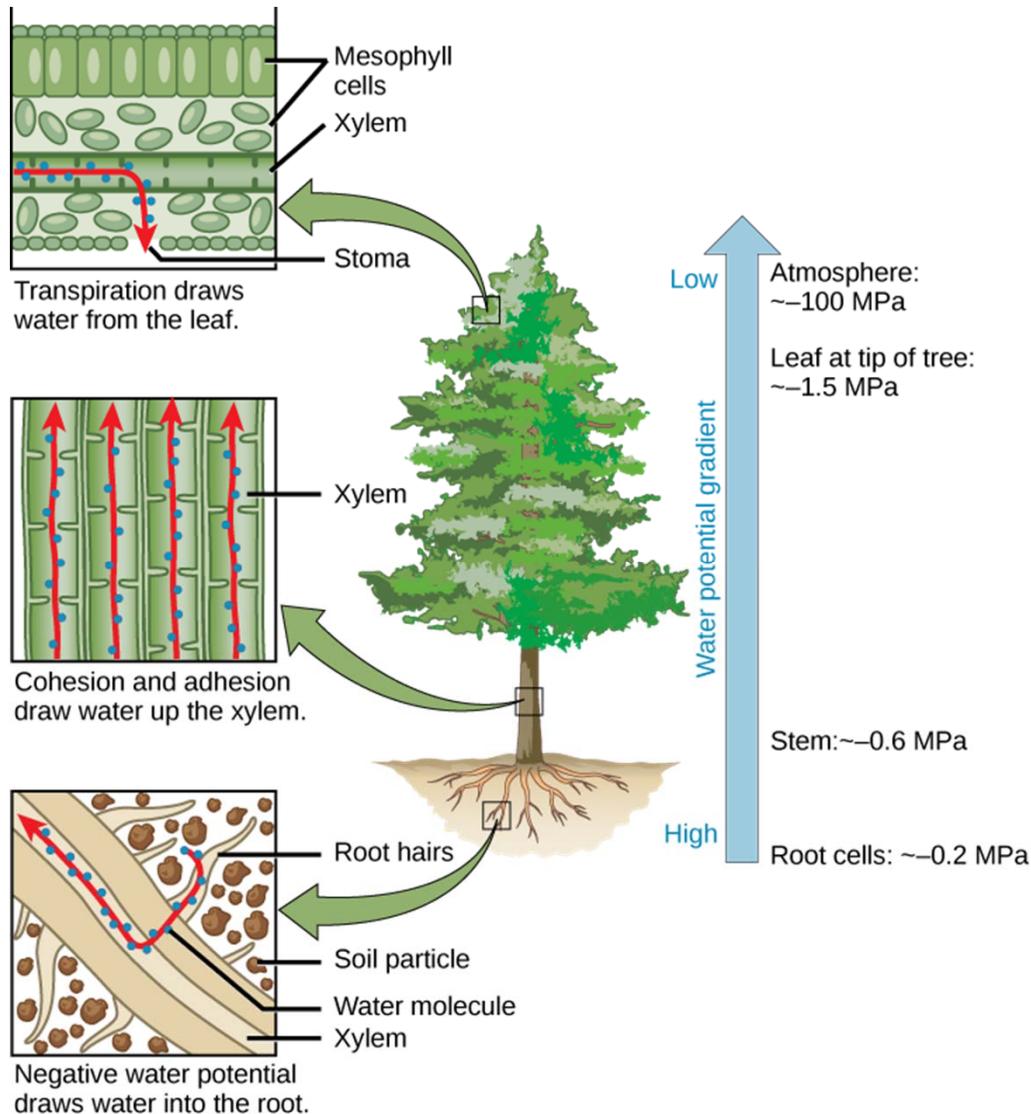
- Phloem
  - Rays
    - Transport and store carbohydrates
    - Restrict decay (CODIT)
- Bark
  - Old phloem
    - Crushed & living cells reabsorbed into tree
    - Cell walls incorporated into bark
      - Impregnated with wax and oil
  - Lenticles
    - Gas exchange

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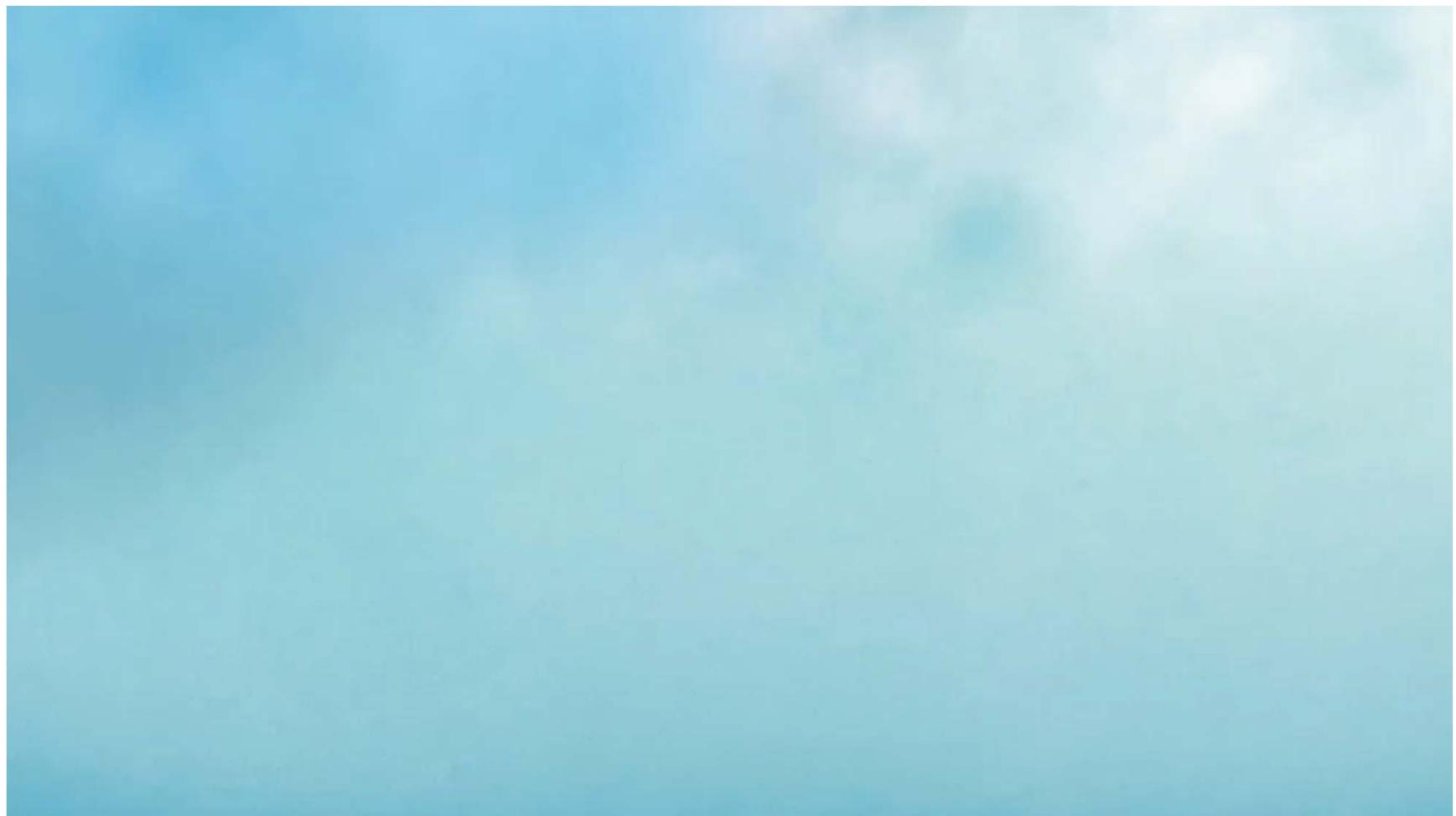
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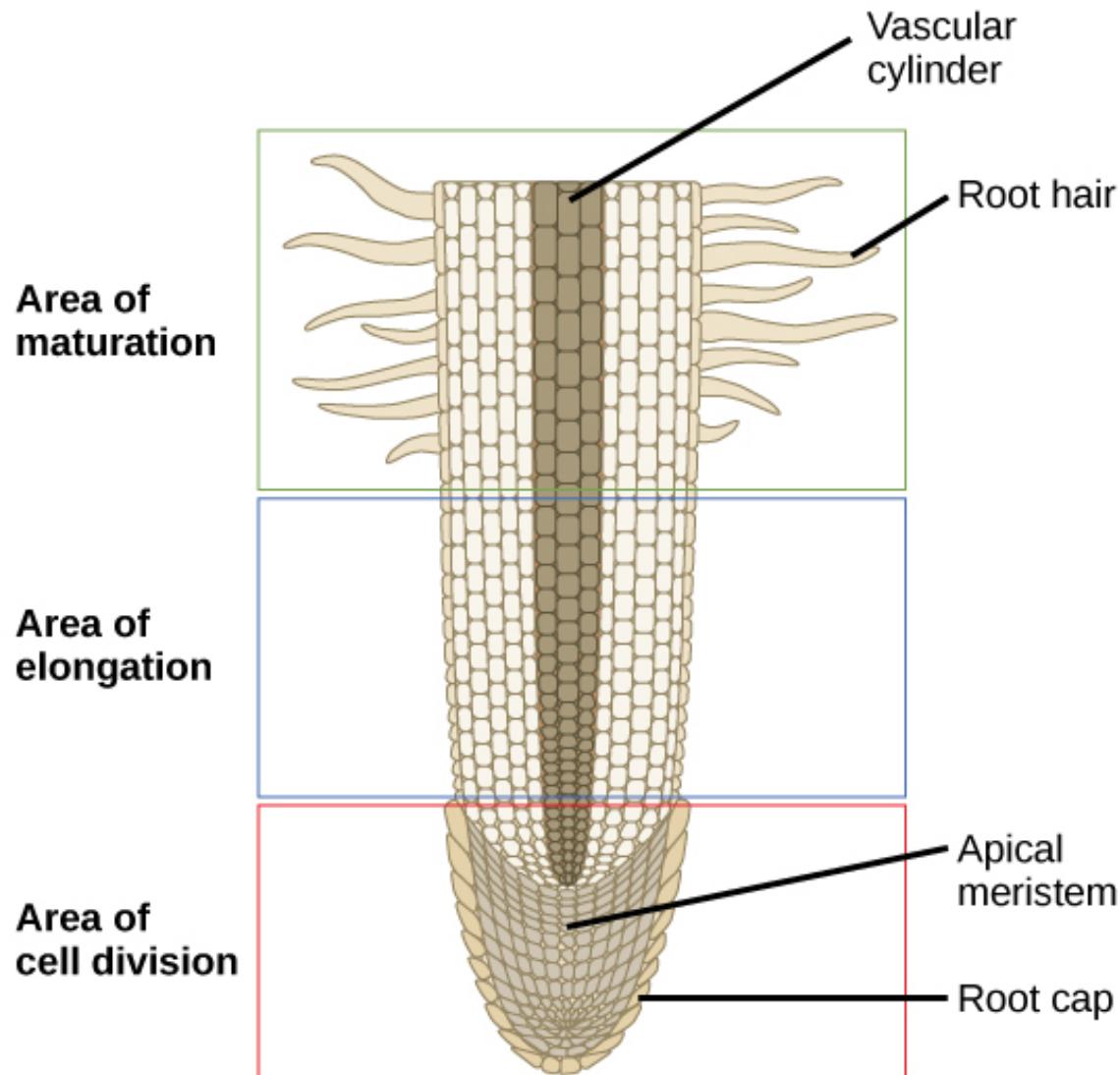
The cohesion-tension theory of sap ascent is shown. Evaporation from the mesophyll cells produces a negative water potential gradient that causes water to move upwards from the roots through the xylem. Image credit: OpenStax Biology

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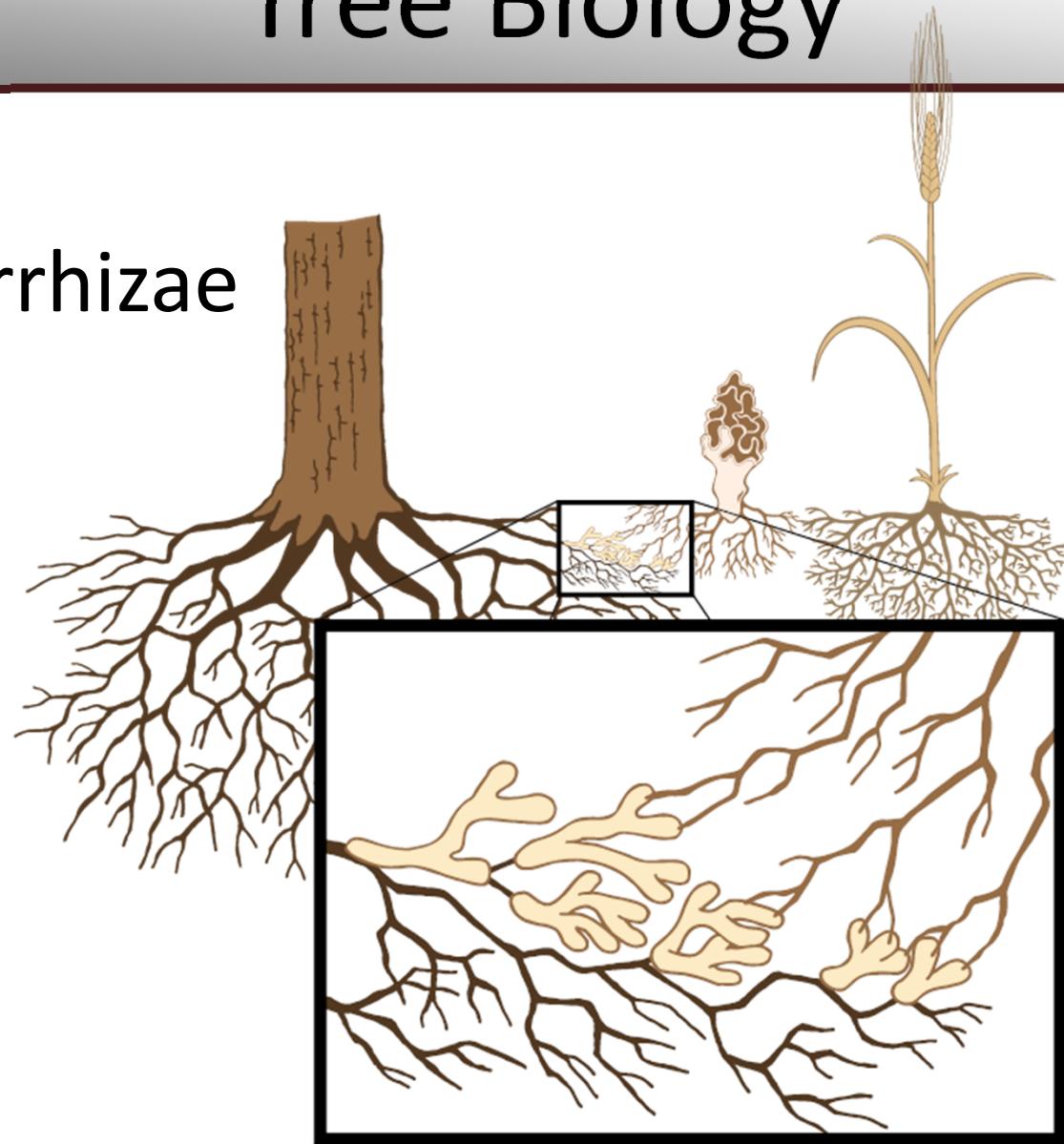


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## Mycorrhizae



# Tree Biology

## Periodic Table of Elements

hydrogen 1 <b>H</b> 1.0079	boron 4 <b>Be</b> 9.0122	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.067	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.994	helium 2 <b>He</b> 4.0026																																																																																																																														
lithium 3 <b>Li</b> 6.941	magnesium 12 <b>Mg</b> 24.306	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.066	chlorine 17 <b>Cl</b> 35.463	neon 10 <b>Ne</b> 20.130																																																																																																																														
sodium 11 <b>Na</b> 22.990	aluminum 13 <b>Al</b> 26.982	germanium 32 <b>Ge</b> 72.01	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.964	bromine 35 <b>Br</b> 79.904	argon 18 <b>Ar</b> 39.948																																																																																																																														
potassium 19 <b>K</b> 38.608	calcium 20 <b>Ca</b> 40.078	gallium 31 <b>Ga</b> 69.723	antimony 32 <b>Sb</b> 121.76	tellurium 34 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	krypton 36 <b>Kr</b> 83.80																																																																																																																														
rubidium 37 <b>Rb</b> 81.466	strontium 38 <b>Sr</b> 87.62	germanium 32 <b>Ge</b> 72.01	tin 50 <b>In</b> 113.71	tellurium 34 <b>Te</b> 127.60	iodine 53 <b>I</b> 131.29	xeon 54 <b>Xe</b> 131.29																																																																																																																														
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	indium 31 <b>In</b> 113.71	lead 51 <b>Sn</b> 118.71	bismuth 52 <b>Sb</b> 121.76	polonium 84 <b>Po</b> 126.90	radon 86 <b>Rn</b> 131.29																																																																																																																														
franum 87 <b>Fr</b> 223	radium 88 <b>Ra</b> 226	lutetium 71 <b>Lu</b> 174.97	thallium 72 <b>Hf</b> 178.49	thallium 73 <b>Ta</b> 180.95	thallium 74 <b>W</b> 183.84	thorium 75 <b>Re</b> 186.21	cerium 76 <b>Os</b> 190.23	cerium 77 <b>Ir</b> 192.23	platinum 78 <b>Pt</b> 195.03	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	thallium 82 <b>Pb</b> 207.2	lead 83 <b>Bi</b> 208.99	bismuth 84 <b>Po</b> 209.00	polonium 85 <b>At</b> 210.00	radon 86 <b>Rn</b> 210.00																																																																																																																			
lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	neptunium 93 <b>Np</b> 237.05	curium 94 <b>Cm</b> 247.07	neptunium 95 <b>Np</b> 247.07	curium 96 <b>Cm</b> 247.07	neptunium 97 <b>Np</b> 247.07	curium 98 <b>Cm</b> 247.07	neptunium 99 <b>Np</b> 247.07	curium 100 <b>Cm</b> 247.07	neptunium 101 <b>Np</b> 247.07	curium 102 <b>Cm</b> 247.07	neptunium 103 <b>Np</b> 247.07	curium 104 <b>Cm</b> 247.07	neptunium 105 <b>Np</b> 247.07	curium 106 <b>Cm</b> 247.07	neptunium 107 <b>Np</b> 247.07	curium 108 <b>Cm</b> 247.07	neptunium 109 <b>Np</b> 247.07	curium 110 <b>Cm</b> 247.07	neptunium 111 <b>Np</b> 247.07	curium 112 <b>Cm</b> 247.07	neptunium 113 <b>Np</b> 247.07	curium 114 <b>Cm</b> 247.07	neptunium 115 <b>Np</b> 247.07	curium 116 <b>Cm</b> 247.07	neptunium 117 <b>Np</b> 247.07	curium 118 <b>Cm</b> 247.07	neptunium 119 <b>Np</b> 247.07	curium 120 <b>Cm</b> 247.07	neptunium 121 <b>Np</b> 247.07	curium 122 <b>Cm</b> 247.07	neptunium 123 <b>Np</b> 247.07	curium 124 <b>Cm</b> 247.07	neptunium 125 <b>Np</b> 247.07	curium 126 <b>Cm</b> 247.07	neptunium 127 <b>Np</b> 247.07	curium 128 <b>Cm</b> 247.07	neptunium 129 <b>Np</b> 247.07	curium 130 <b>Cm</b> 247.07	neptunium 131 <b>Np</b> 247.07	curium 132 <b>Cm</b> 247.07	neptunium 133 <b>Np</b> 247.07	curium 134 <b>Cm</b> 247.07	neptunium 135 <b>Np</b> 247.07	curium 136 <b>Cm</b> 247.07	neptunium 137 <b>Np</b> 247.07	curium 138 <b>Cm</b> 247.07	neptunium 139 <b>Np</b> 247.07	curium 140 <b>Cm</b> 247.07	neptunium 141 <b>Np</b> 247.07	curium 142 <b>Cm</b> 247.07	neptunium 143 <b>Np</b> 247.07	curium 144 <b>Cm</b> 247.07	neptunium 145 <b>Np</b> 247.07	curium 146 <b>Cm</b> 247.07	neptunium 147 <b>Np</b> 247.07	curium 148 <b>Cm</b> 247.07	neptunium 149 <b>Np</b> 247.07	curium 150 <b>Cm</b> 247.07	neptunium 151 <b>Np</b> 247.07	curium 152 <b>Cm</b> 247.07	neptunium 153 <b>Np</b> 247.07	curium 154 <b>Cm</b> 247.07	neptunium 155 <b>Np</b> 247.07	curium 156 <b>Cm</b> 247.07	neptunium 157 <b>Np</b> 247.07	curium 158 <b>Cm</b> 247.07	neptunium 159 <b>Np</b> 247.07	curium 160 <b>Cm</b> 247.07	neptunium 161 <b>Np</b> 247.07	curium 162 <b>Cm</b> 247.07	neptunium 163 <b>Np</b> 247.07	curium 164 <b>Cm</b> 247.07	neptunium 165 <b>Np</b> 247.07	curium 166 <b>Cm</b> 247.07	neptunium 167 <b>Np</b> 247.07	curium 168 <b>Cm</b> 247.07	neptunium 169 <b>Np</b> 247.07	curium 170 <b>Cm</b> 247.07	neptunium 171 <b>Np</b> 247.07	curium 172 <b>Cm</b> 247.07	neptunium 173 <b>Np</b> 247.07	curium 174 <b>Cm</b> 247.07	neptunium 175 <b>Np</b> 247.07	curium 176 <b>Cm</b> 247.07	neptunium 177 <b>Np</b> 247.07	curium 178 <b>Cm</b> 247.07	neptunium 179 <b>Np</b> 247.07	curium 180 <b>Cm</b> 247.07	neptunium 181 <b>Np</b> 247.07	curium 182 <b>Cm</b> 247.07	neptunium 183 <b>Np</b> 247.07	curium 184 <b>Cm</b> 247.07	neptunium 185 <b>Np</b> 247.07	curium 186 <b>Cm</b> 247.07	neptunium 187 <b>Np</b> 247.07	curium 188 <b>Cm</b> 247.07	neptunium 189 <b>Np</b> 247.07	curium 190 <b>Cm</b> 247.07	neptunium 191 <b>Np</b> 247.07	curium 192 <b>Cm</b> 247.07	neptunium 193 <b>Np</b> 247.07	curium 194 <b>Cm</b> 247.07	neptunium 195 <b>Np</b> 247.07	curium 196 <b>Cm</b> 247.07	neptunium 197 <b>Np</b> 247.07	curium 198 <b>Cm</b> 247.07	neptunium 199 <b>Np</b> 247.07	curium 200 <b>Cm</b> 247.07	neptunium 201 <b>Np</b> 247.07	curium 202 <b>Cm</b> 247.07	neptunium 203 <b>Np</b> 247.07	curium 204 <b>Cm</b> 247.07	neptunium 205 <b>Np</b> 247.07	curium 206 <b>Cm</b> 247.07	neptunium 207 <b>Np</b> 247.07	curium 208 <b>Cm</b> 247.07	neptunium 209 <b>Np</b> 247.07	curium 210 <b>Cm</b> 247.07	neptunium 211 <b>Np</b> 247.07	curium 212 <b>Cm</b> 247.07	neptunium 213 <b>Np</b> 247.07	curium 214 <b>Cm</b> 247.07	neptunium 215 <b>Np</b> 247.07	curium 216 <b>Cm</b> 247.07	neptunium 217 <b>Np</b> 247.07	curium 218 <b>Cm</b> 247.07	neptunium 219 <b>Np</b> 247.07	curium 220 <b>Cm</b> 247.07	neptunium 221 <b>Np</b> 247.07	curium 222 <b>Cm</b> 247.07	neptunium 223 <b>Np</b> 247.07

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