

# Ekofyziologie rostlin a mikroklima porostu

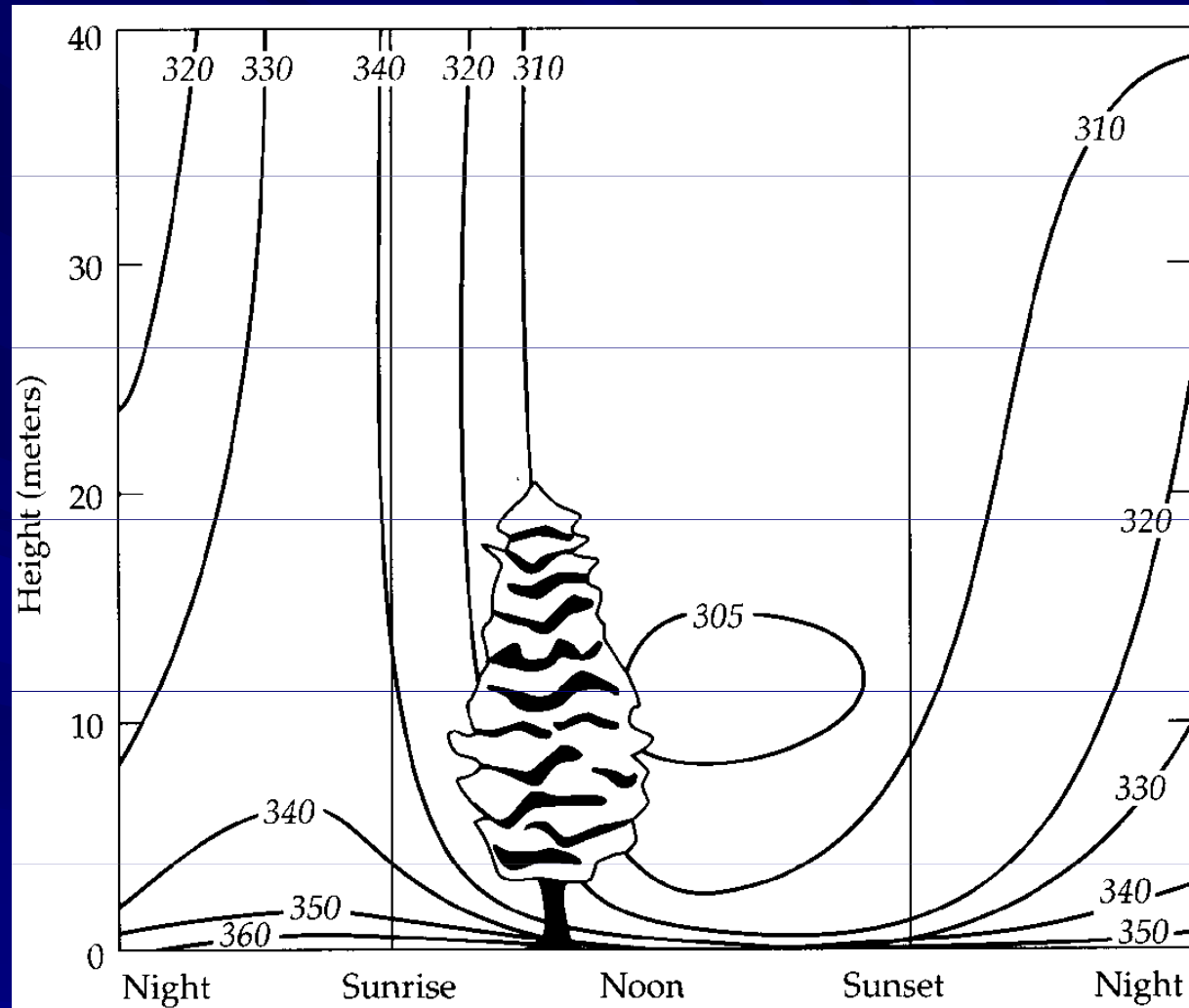
(fotosyntéza a transpirace jsou spřaženy,  
vliv CO<sub>2</sub>, teploty a vlhkosti vzduchu)

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podzim 2012

Ústav experimentální biologie  
Oddělení fyziologie a anatomie rostlin  
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# Isolines of CO<sub>2</sub> concentration in a stand



**Figure 12-10** Typical profiles of concentrations of CO<sub>2</sub> for a forest canopy at different times of day. Isopleth lines for CO<sub>2</sub> are in parts per million (ppm). From Holmén, K. 1992. "The global carbon cycle." In *Global Biogeochemical Cycles*, pp. 239–262. London: Academic Press. Used with permission.

# Stoma

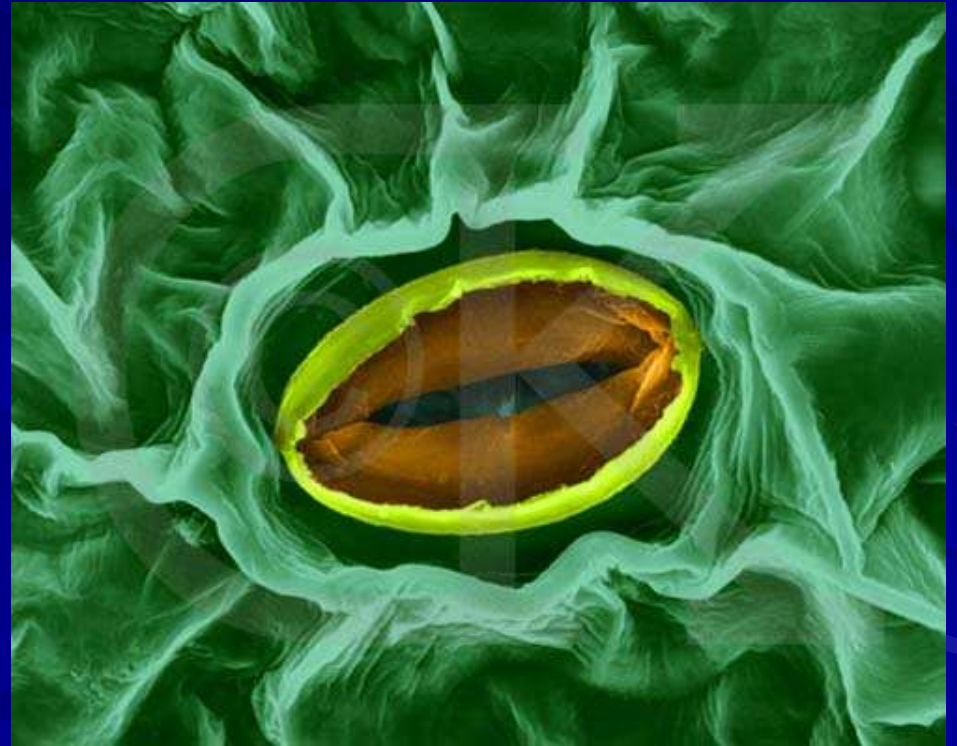
Výměna plynů mezi rostlinou a okolím:

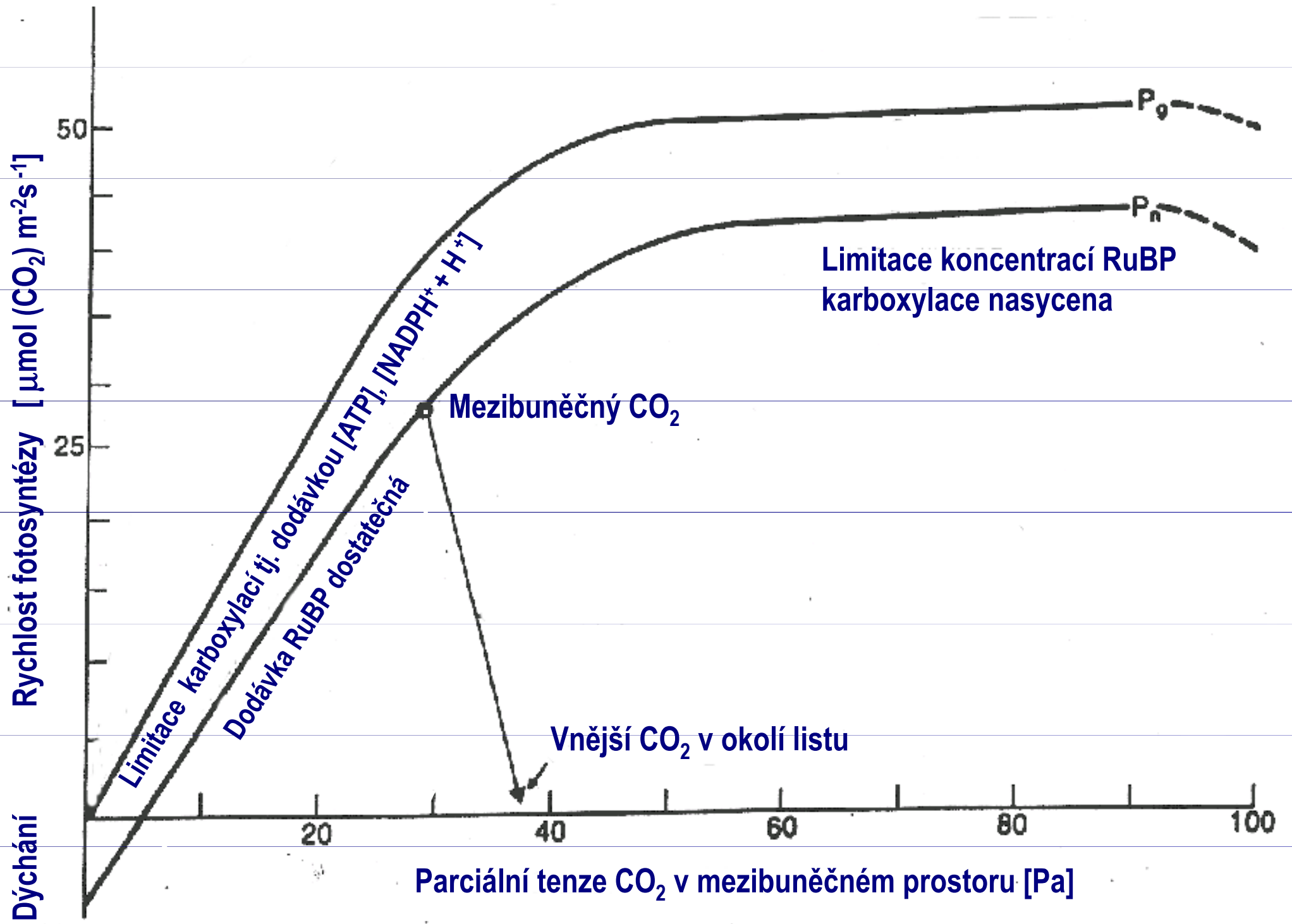
$\text{CO}_2$

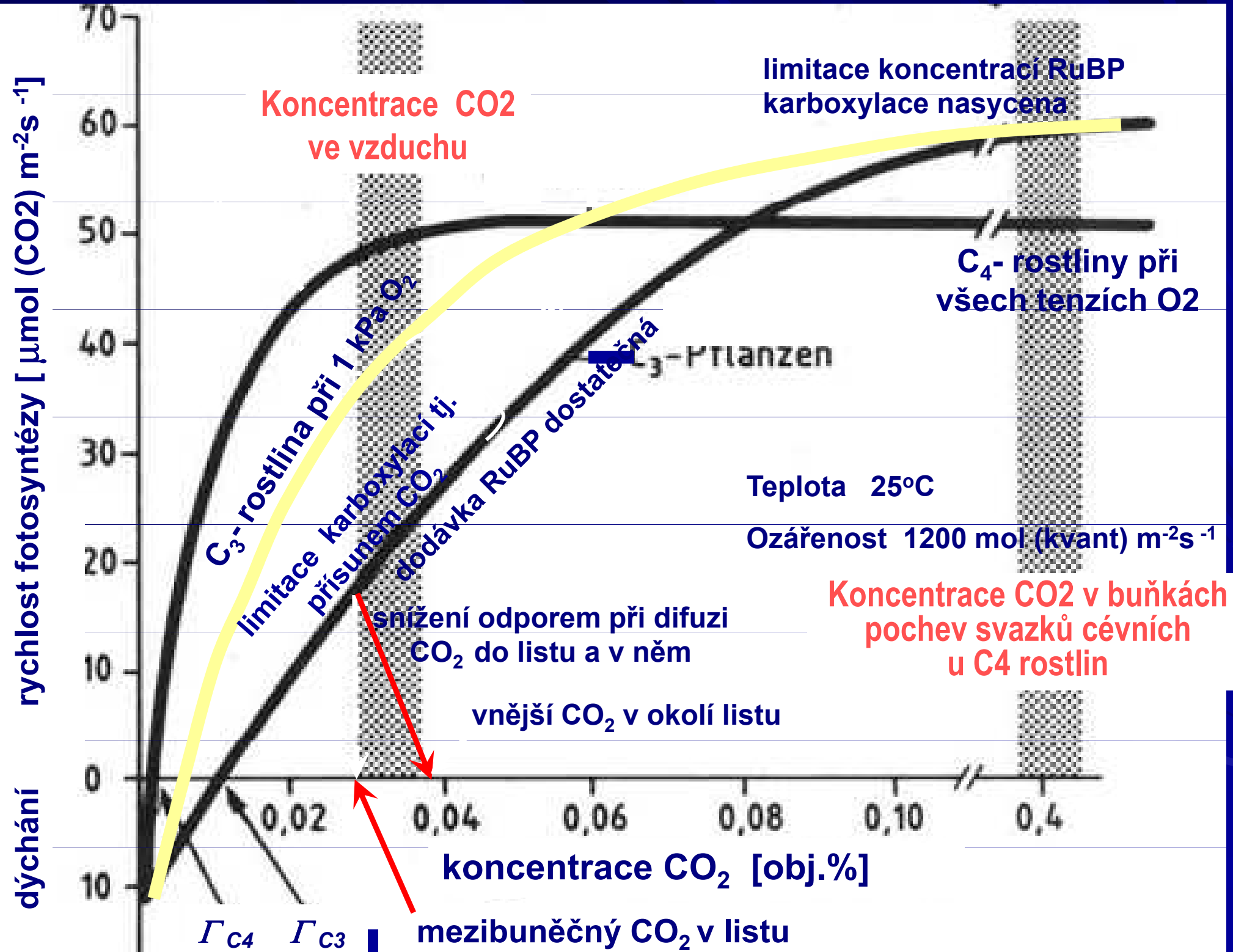
(Ci/Ca)

$\text{H}_2\text{O}$

T







## Ekologie fotosyntézy - zásobení vodou

*Přímo* – inhibice metabolismu (elektronový transport, fosforylace).

*Nepřímo* – zavírání průduchů.

*Vlhkostní kompenzační bod* – u poikilohydrických rostlin, limitní hodnoty relativní vzdušné vlhkosti, při kterých fotosyntéza ustává.

*Koeficient využití vody ve fotosyntéze*:  $WUE_{ph} = \text{fotosyntéza/transpirace}$  [ $\mu\text{mol CO}_2/\text{mmol H}_2\text{O}$ ].

# Přístroje a metody měření transpirace



Spektrální metody

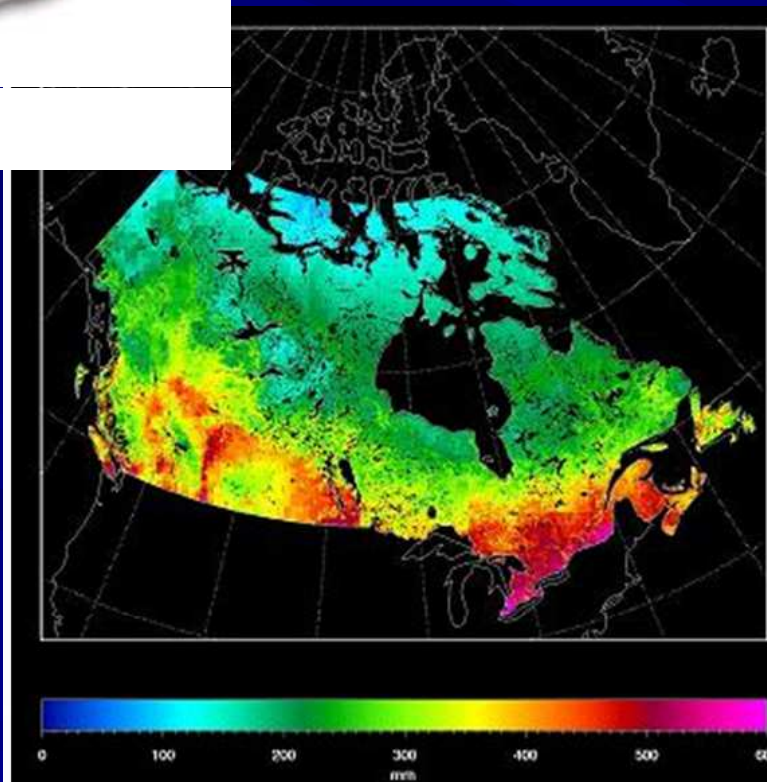
Letecké, satelitní  
Multispektrální  
snímky



Měření rychlosti toku  
Vody stonkem  
(kmenem)

Infračervené  
Analyzátořy plynů

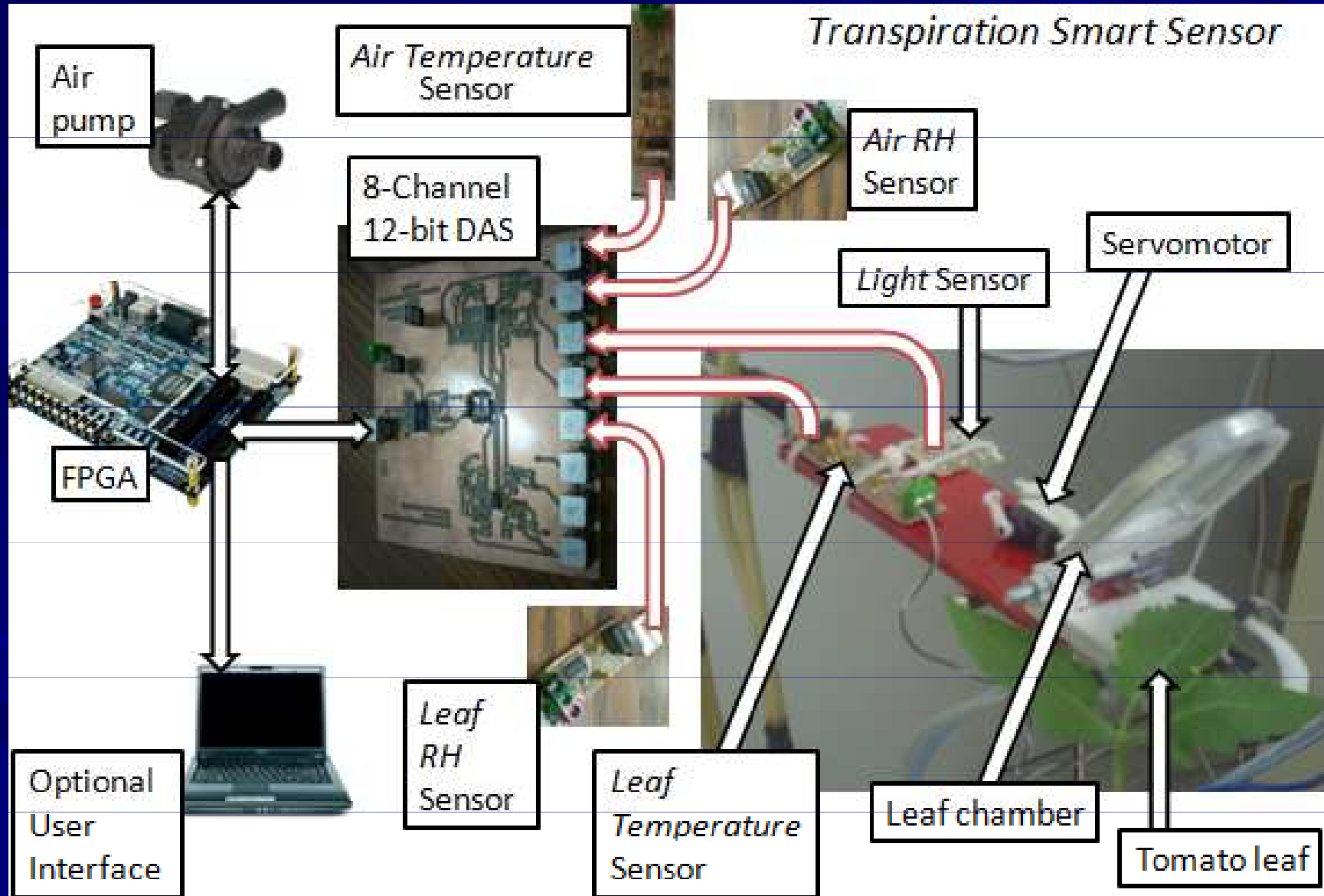
Měření změny  
vlhkosti v listové  
komoře



Metoda tepelného  
Pulsu  
Metoda deformace  
Tepelného pole

# Transpiration measurement system

source: [www.adc.com](http://www.adc.com)





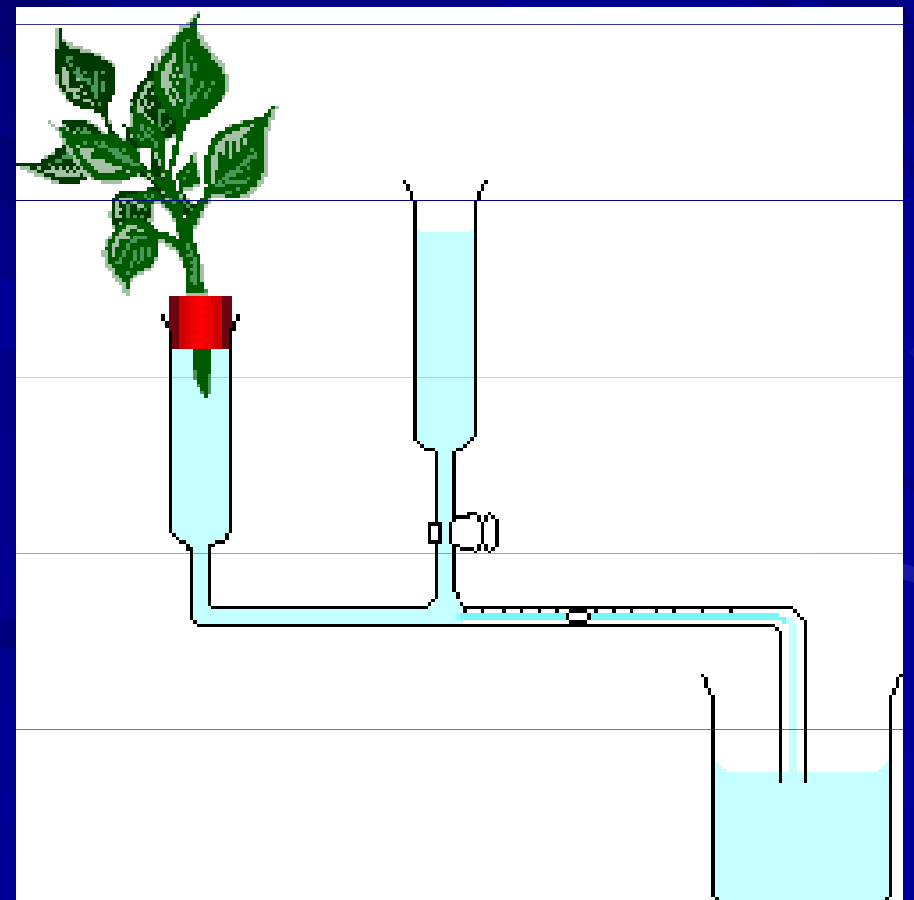
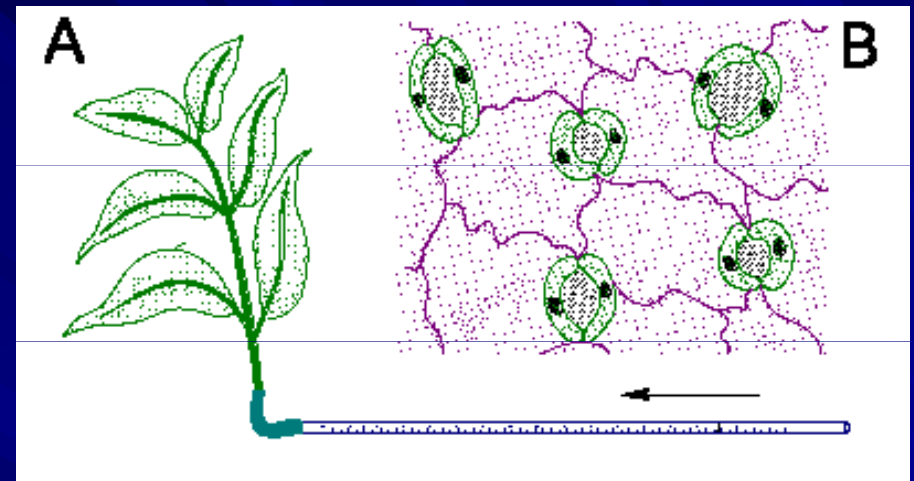
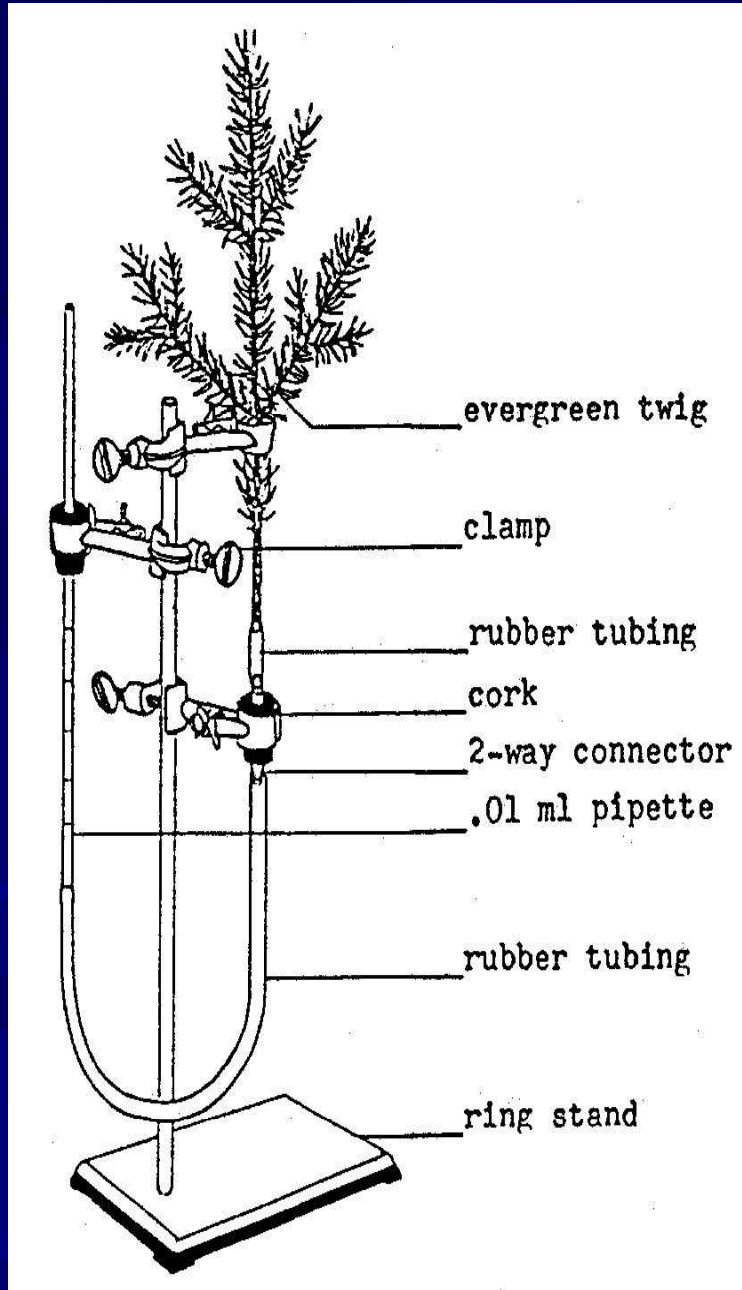
# Současné potometry ve výzkumu a výuce

## Typy potometrů

Ganong's Potometer  
Darwin's Potometer  
Gaurrea's Potometer



# Princip potometru



# Potometrie

- Potometer (z řeckého ποτό = pít a μέτρο = měřit)-někdy označován jako "transpirometer" - je zařízení používané pro měření rychlosti příjmu vody do listových výhonů či stonků. Příčinami příjmu vody jsou fotosyntéza a transpirace.

Potometry je často obtížné nastavit. Všechno musí být zcela vodotěsné, aby nedošlo k žádnému úniku vody.

- Existují dva hlavní typy používaných potometerů - bublinový potometer (jak je uvedeno níže), a hmotový potometer. Hmotový potometer se skládá z rostlin s kořeny ponořenými do kádinky. Tato kádinka je pak umístěna na digitální váhy; čtením lze určit množství vody, kterou rostlina ztratila transpirací.



# Indirect Evapotranspiration Estimation

1. Temperature-Based
  - a. Cannot resolve time intervals less than monthly
  - b. Ignore processes
2. Energy Balance
  - a. Simple
  - b. Relies on differences between uncertain quantities
  - c. Unreliable for large vapor pressure gradients
3. Mass Transfer
  - a. Uses reliable micrometeorological measurements
  - b. Data collection difficult for multiple measurement sites
4. Combination Methods
  - a. Combines benefits of energy balance and mass transfer
  - b. Data intensive

# Kombinovaná metoda

# Combination Formula (Penman, 1948)

Energy

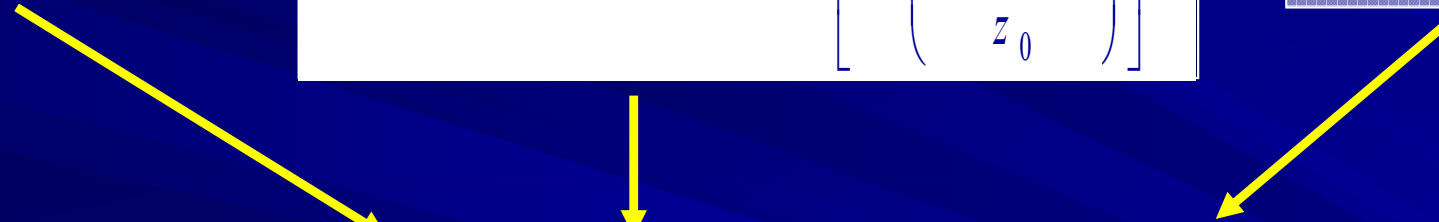
$$E = \frac{R_n - H - G}{\rho_v \lambda}$$

Vertical Transport

$$K_E \equiv \frac{D_{H_2O}}{D_M} \frac{0.622 \rho_a}{P \rho_{H_2O}} \frac{\kappa^2}{\left[ \ln \left( \frac{z - z_d}{z_0} \right) \right]^2}$$

Mass Transfer

$$E \propto [e_{sat}(T_a) - e_a]$$


$$E = \frac{\nabla \cdot R_n + \gamma K_E \rho_{H_2O} \lambda v \cdot [e_{sat}(T_a) - e_a]}{\rho_{H_2O} \lambda \cdot [\nabla + \gamma]}$$

# Penman-Monteith (Monteith, 1965)

$$K_E \equiv \frac{D_{H_2O}}{D_M} \frac{0.622 \rho_a}{P \rho_{H_2O}} \frac{\kappa^2}{\left[ \ln \left( \frac{z - z_d}{z_0} \right) \right]^2}$$

$$E \approx v K_E \cdot [e_{Sat}(T_a) - e_a]$$

$$E = \frac{\nabla \cdot R_n + \gamma K_E \rho_{H_2O} \lambda v \cdot [e_{Sat}(T_a) - e_a]}{\rho_{H_2O} \lambda \cdot [\nabla + \gamma]}$$

$$E_c = \frac{\nabla \cdot R_n + \rho_a c_a g_a \cdot [e_{Sat}(T_a) - e_a]}{\rho_{H_2O} \lambda \cdot \left[ \nabla + \gamma \cdot \left( 1 + \frac{g_a}{g_c} \right) \right]}$$

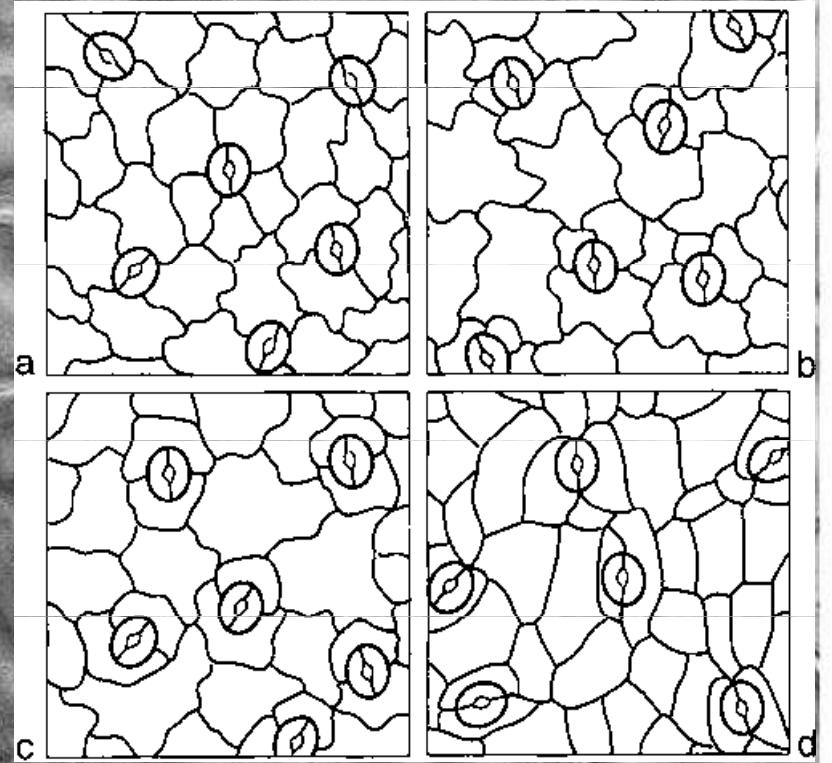
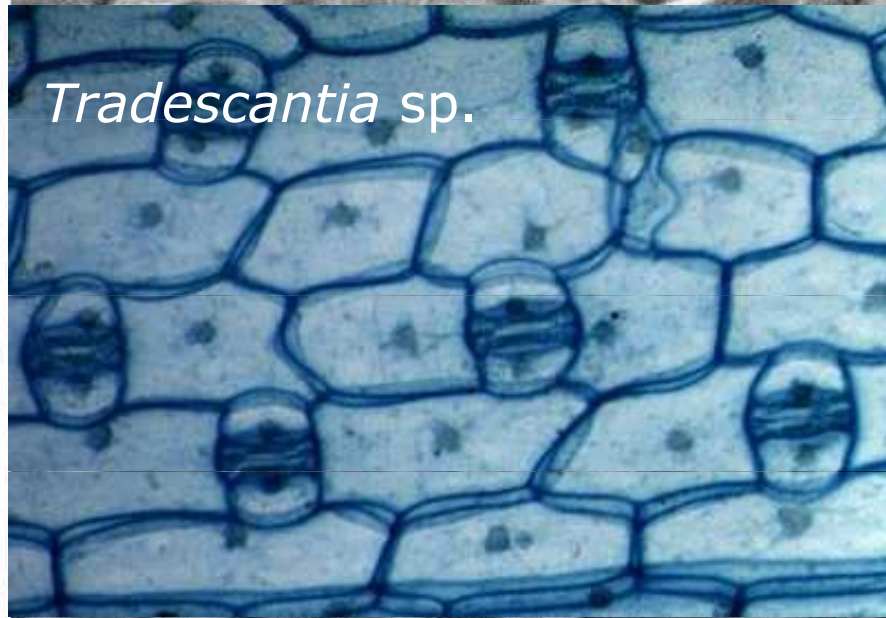
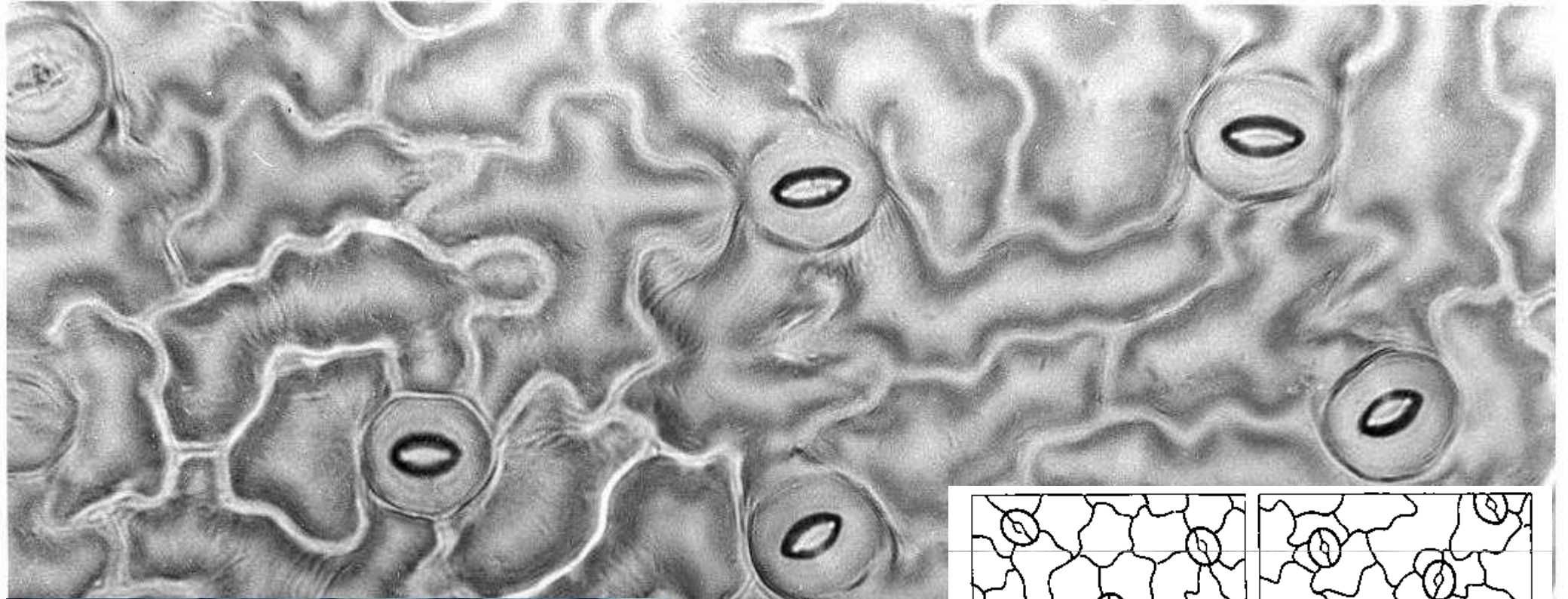
$$g_a = \frac{1}{r_a} = \frac{v \kappa^2}{\left[ \ln \left( \frac{z - z_d}{z_0} \right) \right]^2}$$



# Kombinovaná metoda

- $\lambda_v =$  Latent heat of vaporization. Energy required per unit mass of water vaporized. ( $\text{J g}^{-1}$ )
- $L_v =$  Volumetric latent heat of vaporization. Energy required per water volume vaporized. ( $L_v = 2453 \text{ MJ m}^{-3}$ )
- $E =$  Mass water evapotranspiration rate ( $\text{g s}^{-1} \text{ m}^{-2}$ )
- $ET_o =$  Water volume evapotranspired ( $\text{mm s}^{-1}$ )
- $\Delta =$  Rate of change of saturation specific humidity with air temperature. ( $\text{Pa K}^{-1}$ )
- $R_n =$  Net irradiance ( $\text{W m}^{-2}$ ), the external source of energy flux
- $G =$  Ground heat flux ( $\text{W m}^{-2}$ ), usually difficult to measure
- $c_p =$  Specific heat capacity of air ( $\text{J kg}^{-1} \text{ K}^{-1}$ )
- $\rho_a =$  dry air density ( $\text{kg m}^{-3}$ )
- $\delta e =$  vapor pressure deficit, or specific humidity (Pa)
- $g_a =$  Conductivity of air, atmospheric conductance ( $\text{m s}^{-1}$ )
- $g_s =$  Conductivity of stoma, ( $\text{m s}^{-1}$ )
- $\gamma =$  Psychrometric constant ( $\gamma \approx 66 \text{ Pa K}^{-1}$ )

# Stomata



# Fotosyntéza – carbon dioxide influx into a leaf, resistances

- $r_{bl}$
- $r_{st}$
- $r_{mes}$
- $r_{chl}$

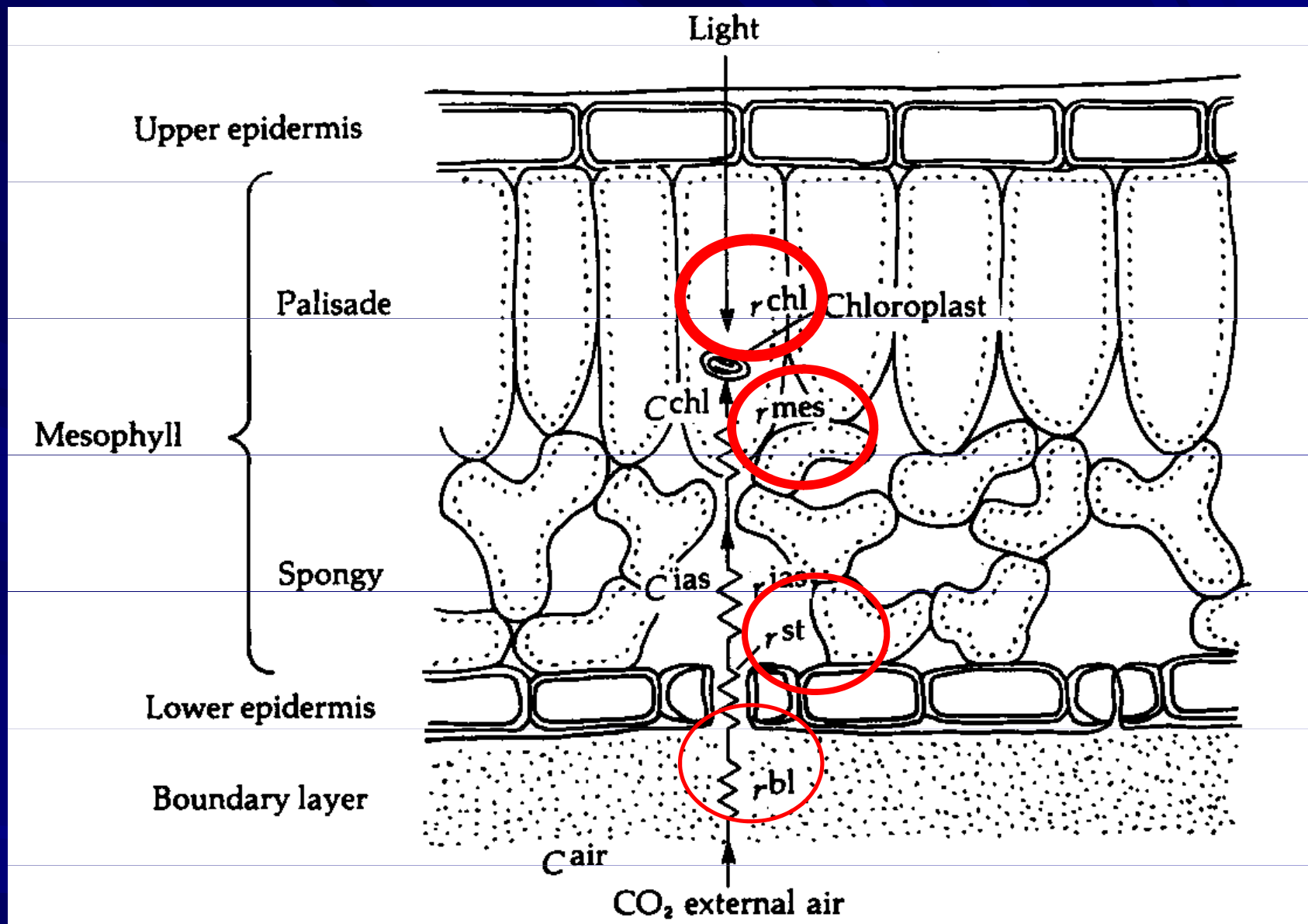
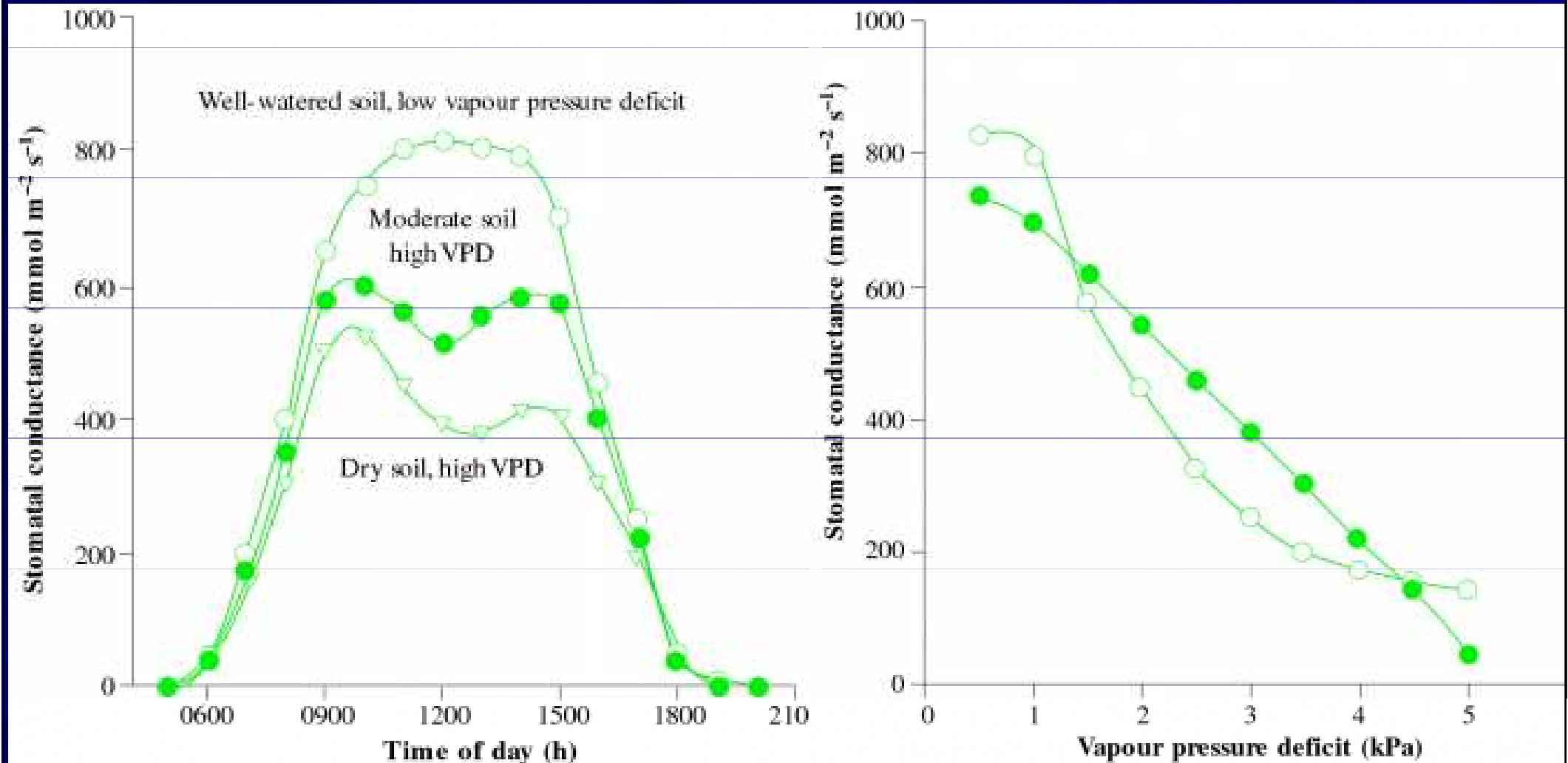


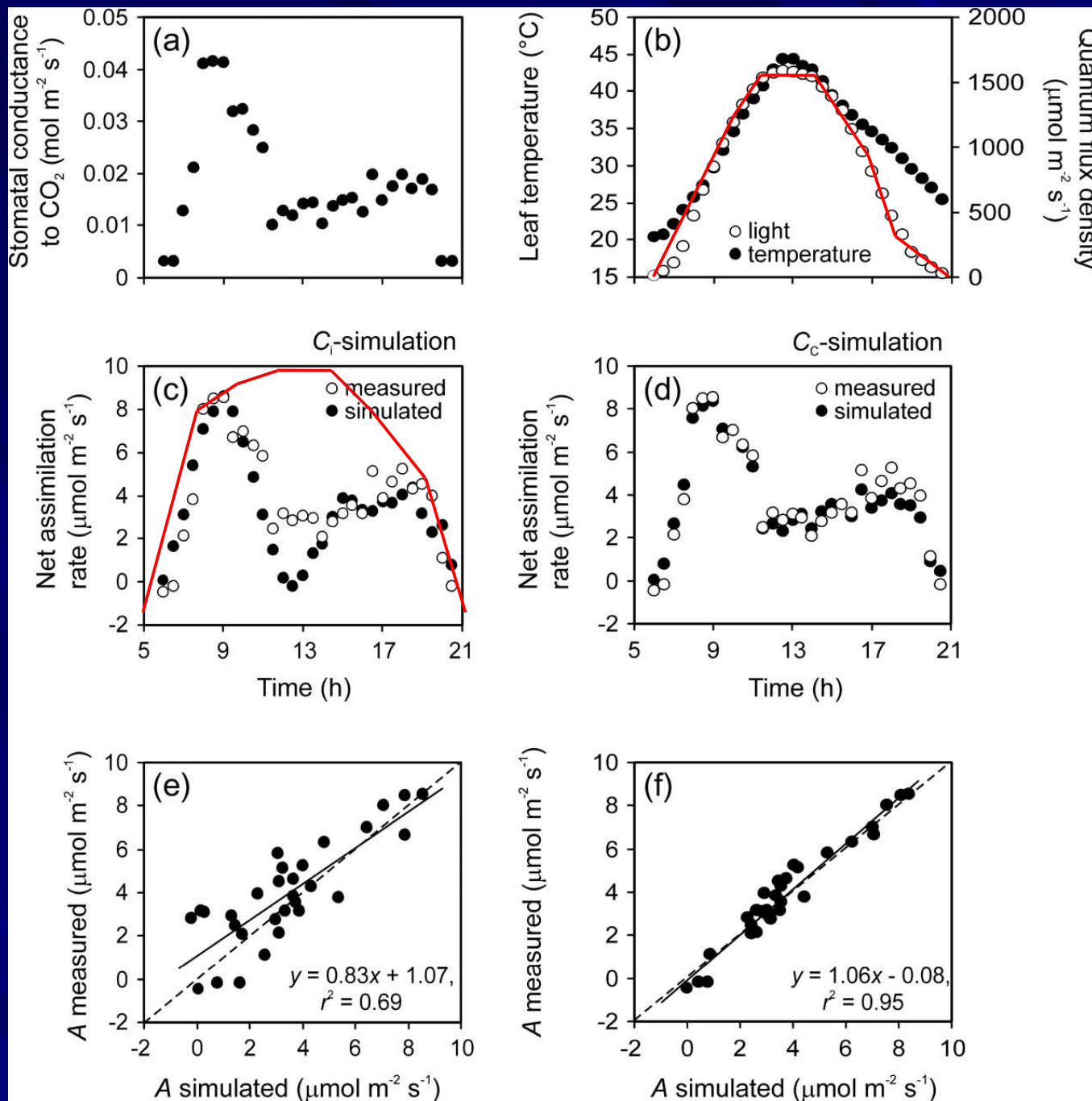
Figure 15-6 Transport pathway, transport resistances, and concentration gradients in a photosynthesizing leaf. See text for definition of terms.

# Daily courses of stomatal conductance (for CO<sub>2</sub> uptake and H<sub>2</sub>O outflow)



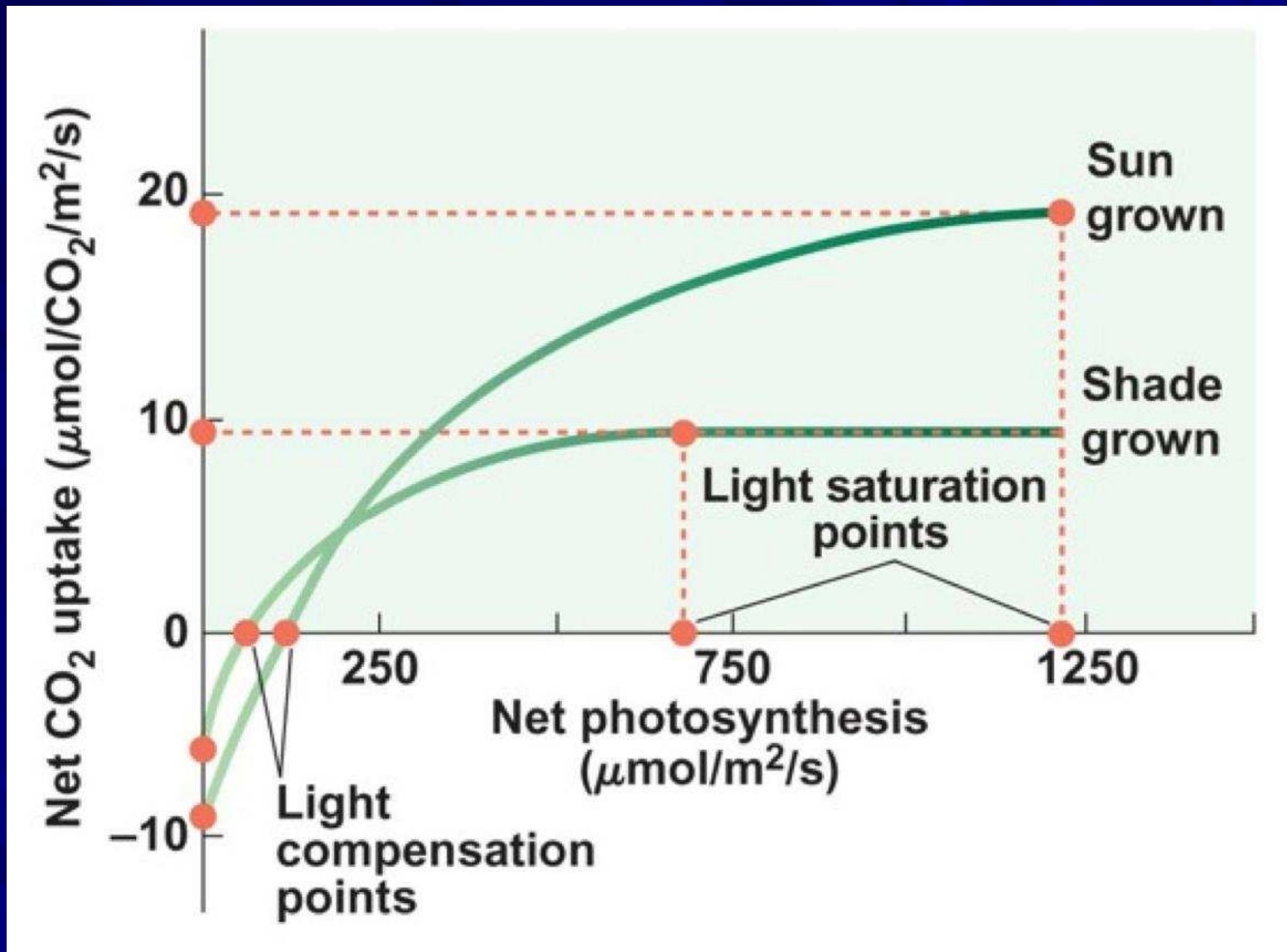
Polední  
deprese fotosyntézy

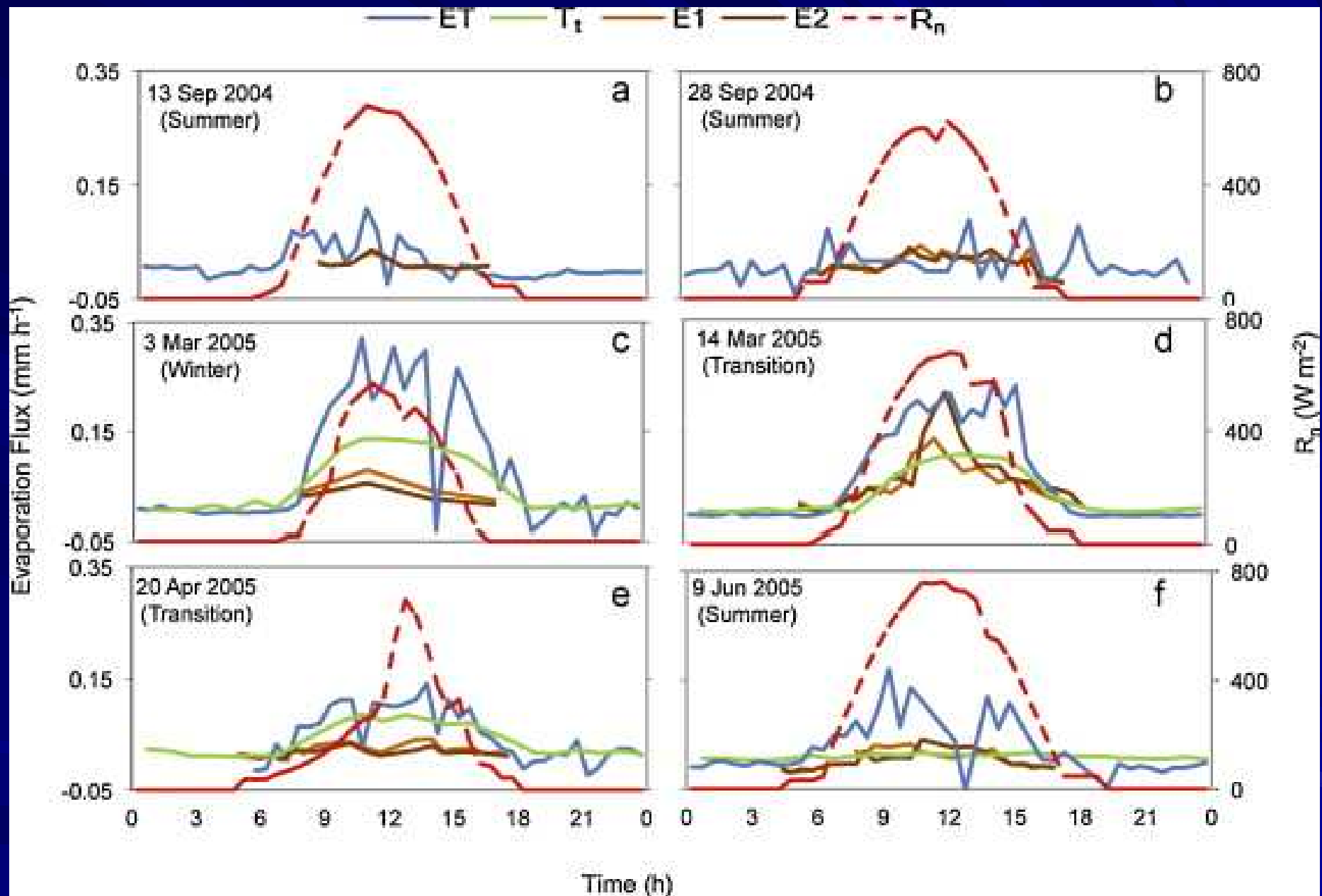
Midday depression  
Of photosynthesis



Niinemets Ü et al. J. Exp. Bot. 2009;60:2271-2282

# Světelná křivka fotosyntézy

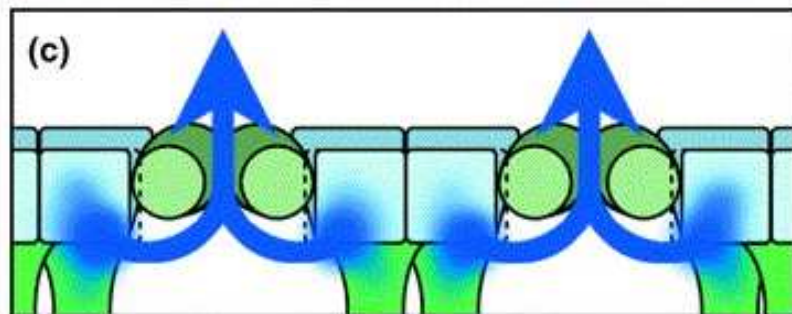
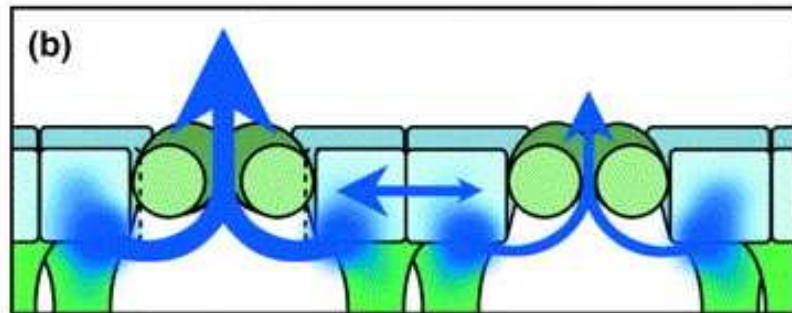
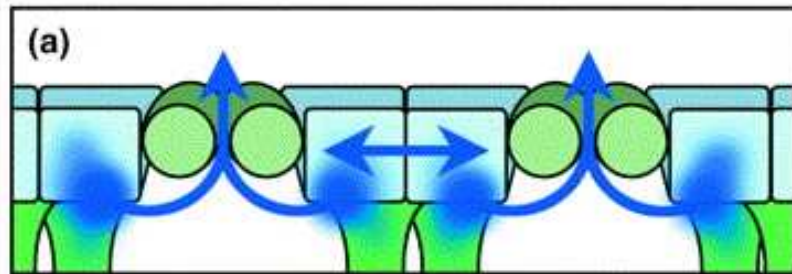
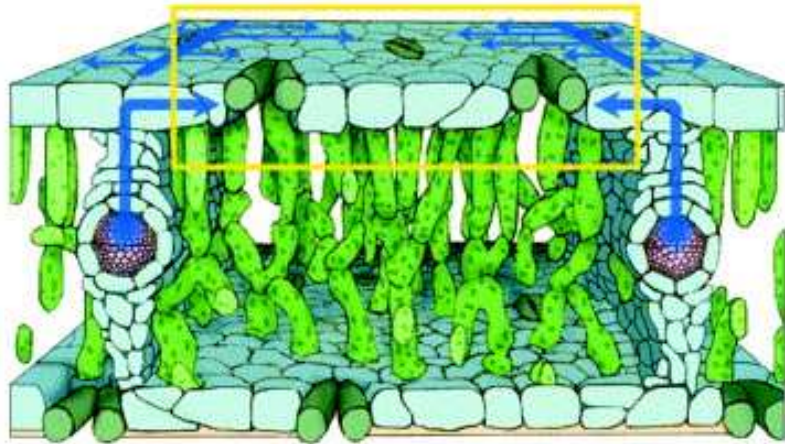




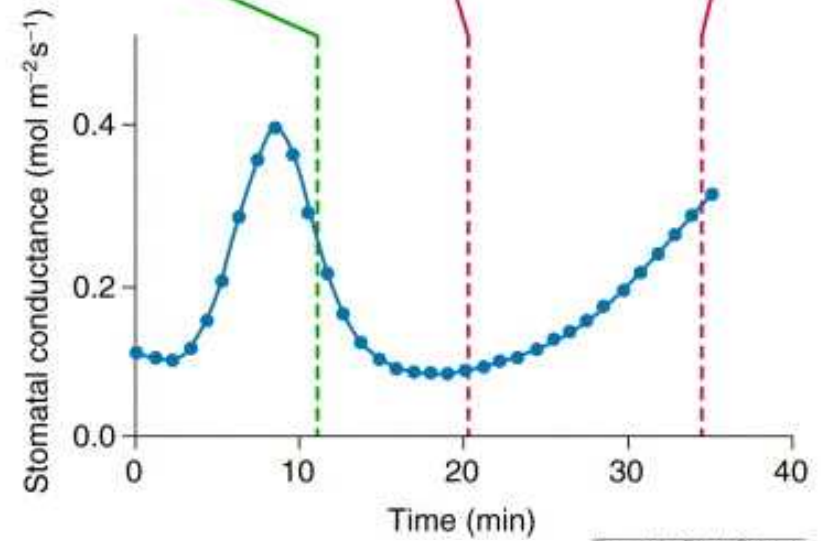
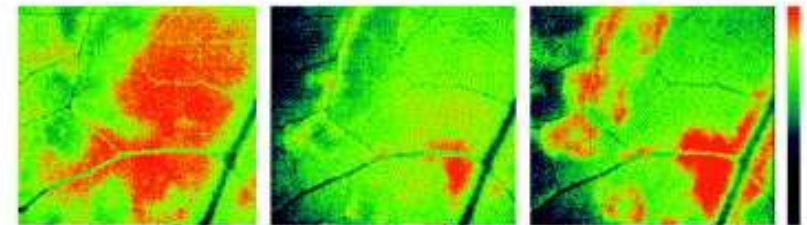
■ Semidesert plants

Daily courses (evapotranspiration) in semiarid plants

# Stomatal patchiness



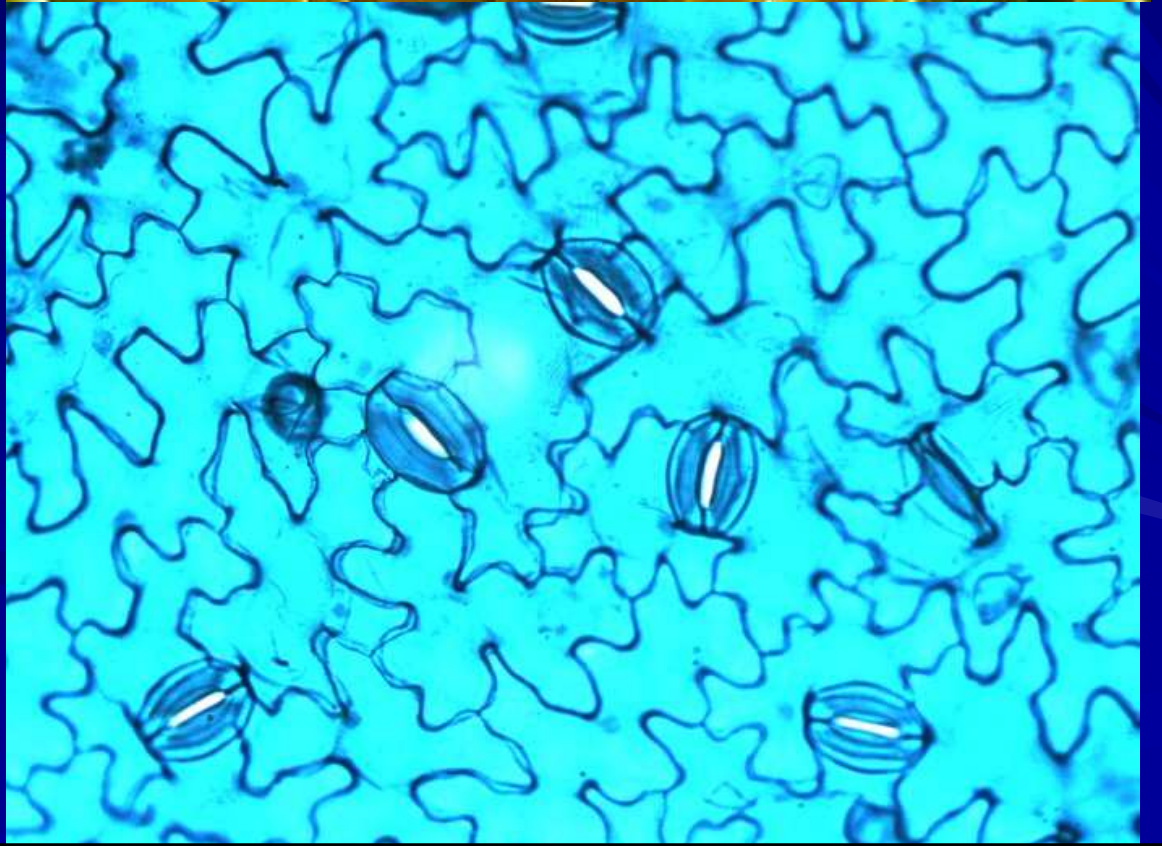
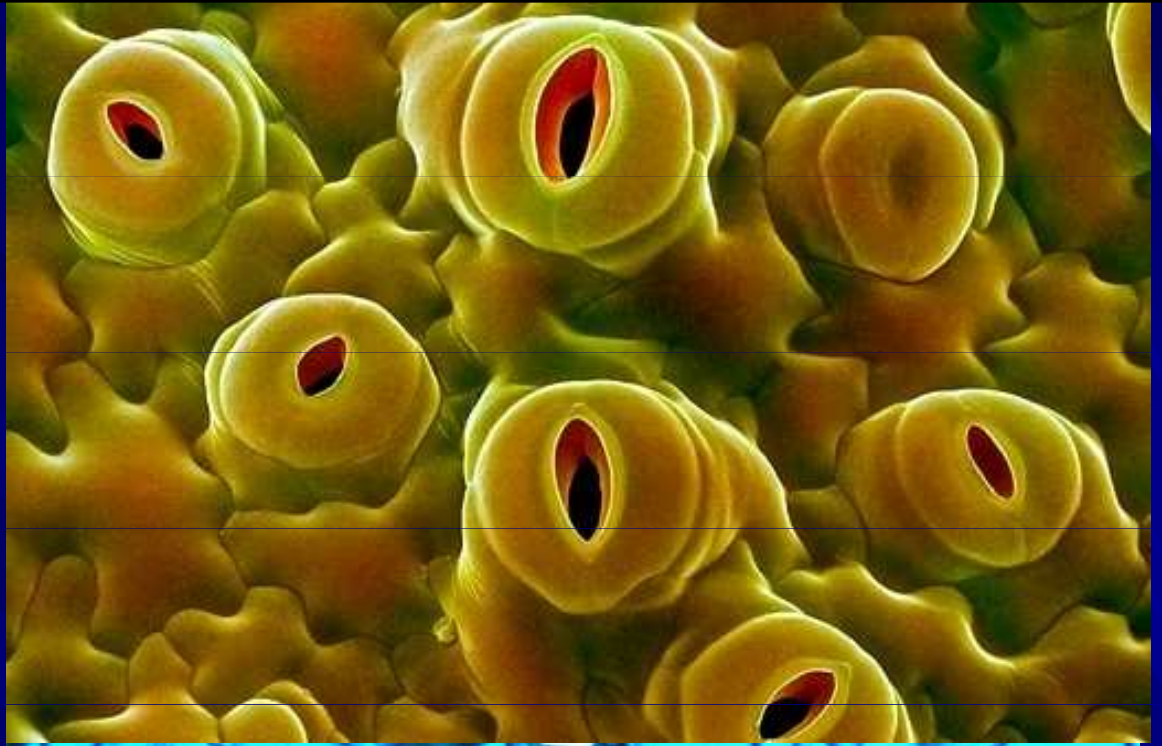
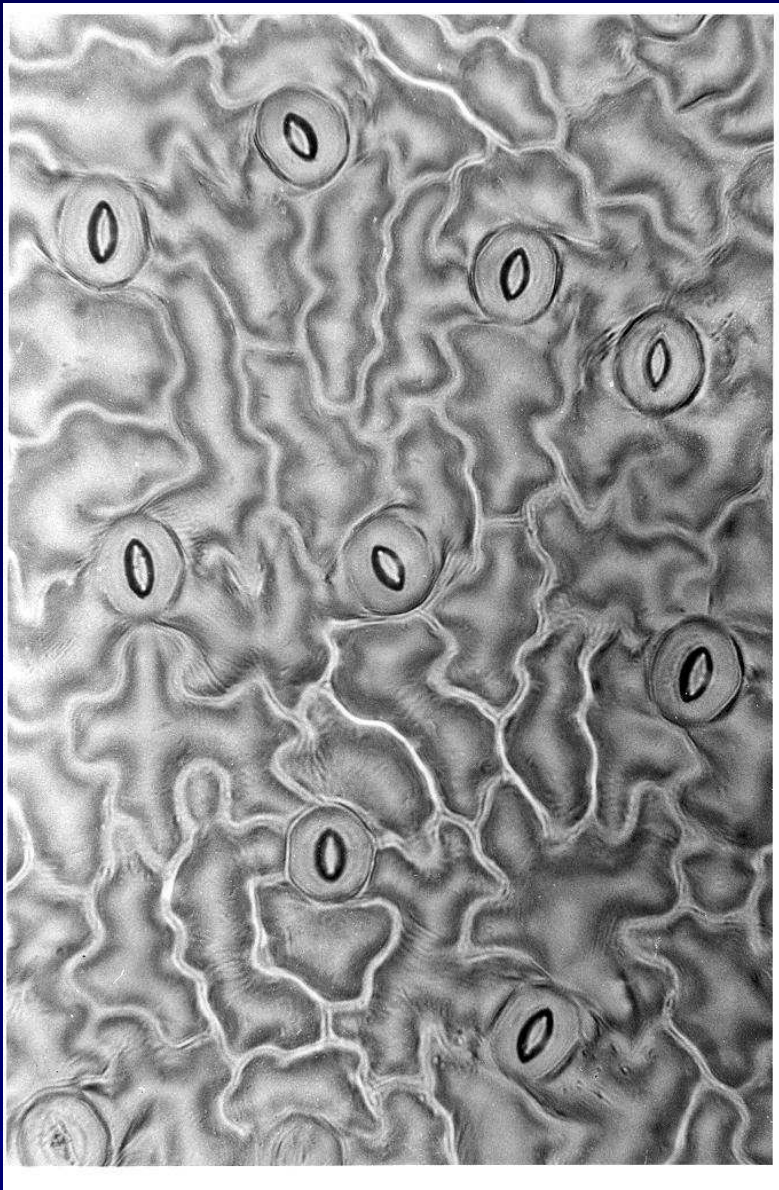
*Trends in Plant Science*



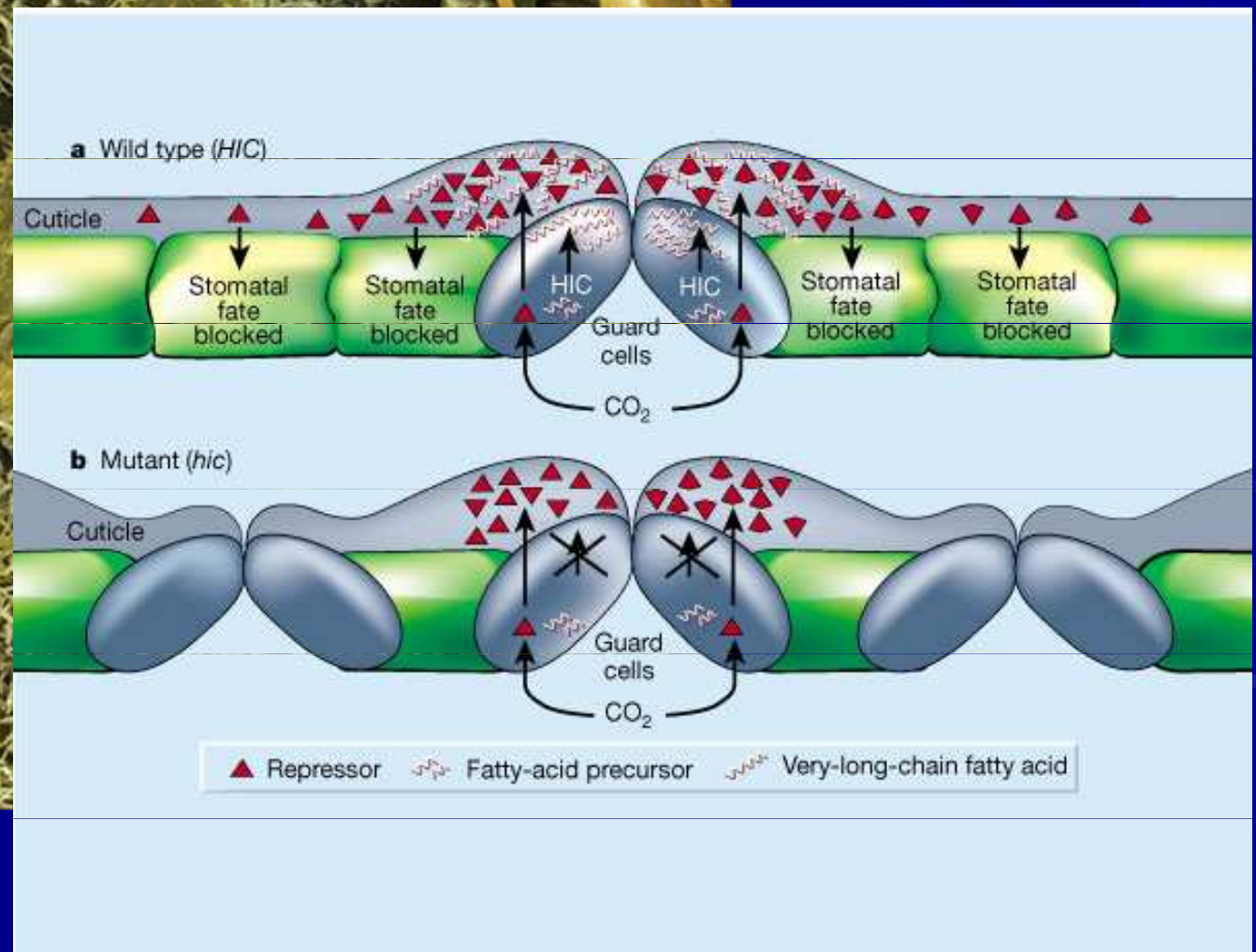
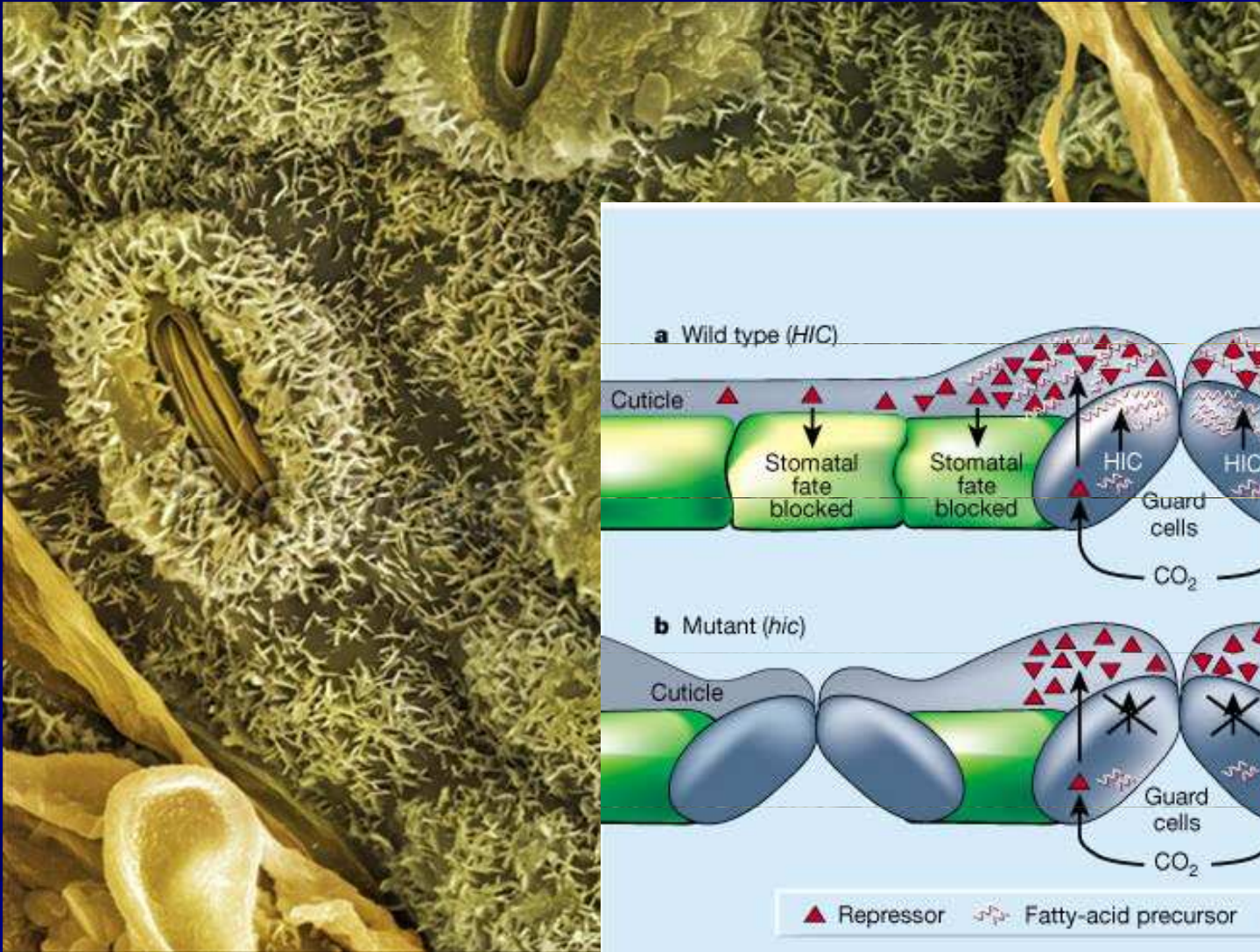
*Trends in Plant Science*

■ Mott et Butler 2001





# Dub (*Quercus robur*),



Cross section of *Lasallia pustulata*  
- marginal thallus part  
- intermediate part  
- pustulus

