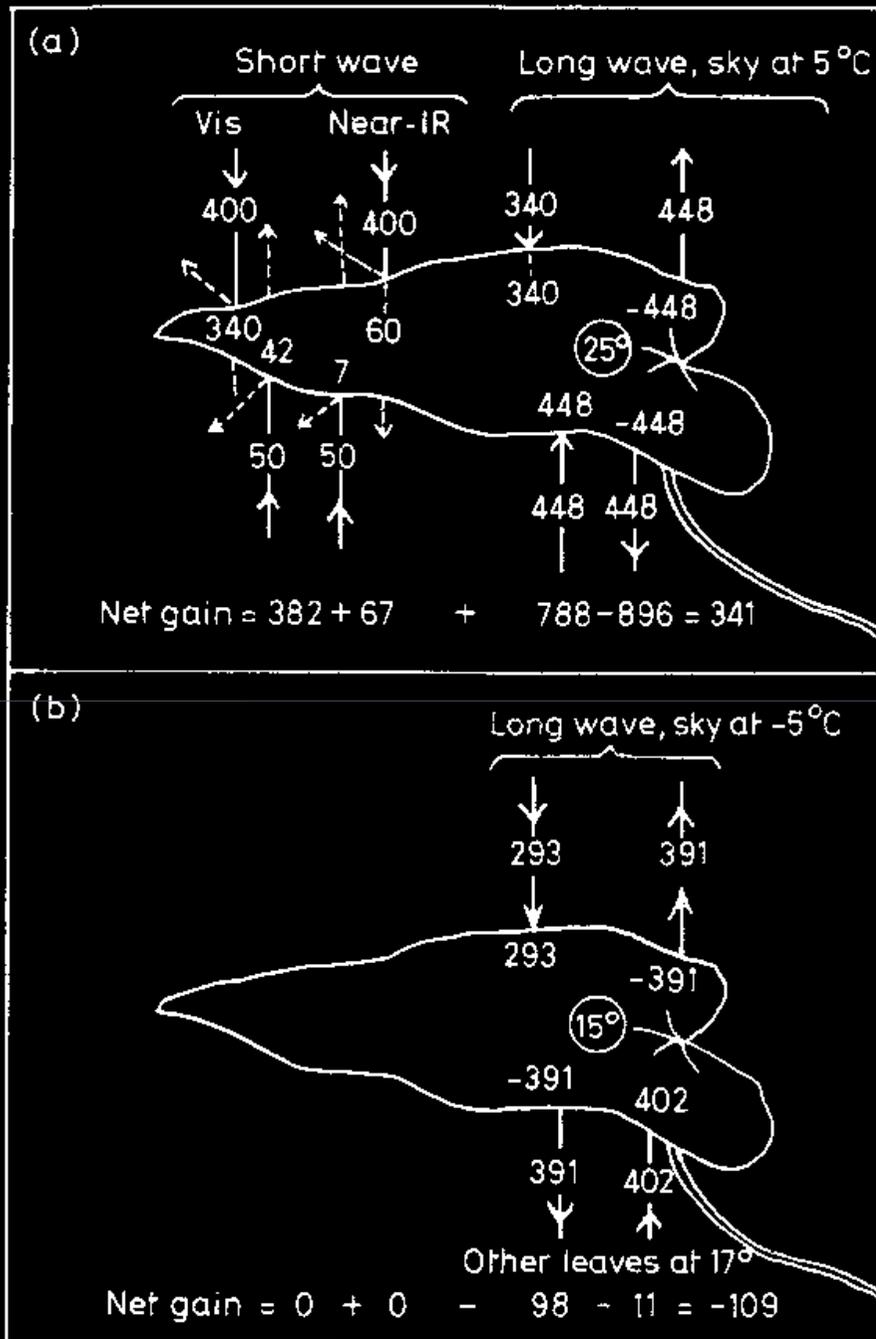


- Balanço radiativo de ondas curtas e ondas longas em uma folha no período diurno e noturno.



- $\Phi_n - C - \lambda E = M + S$

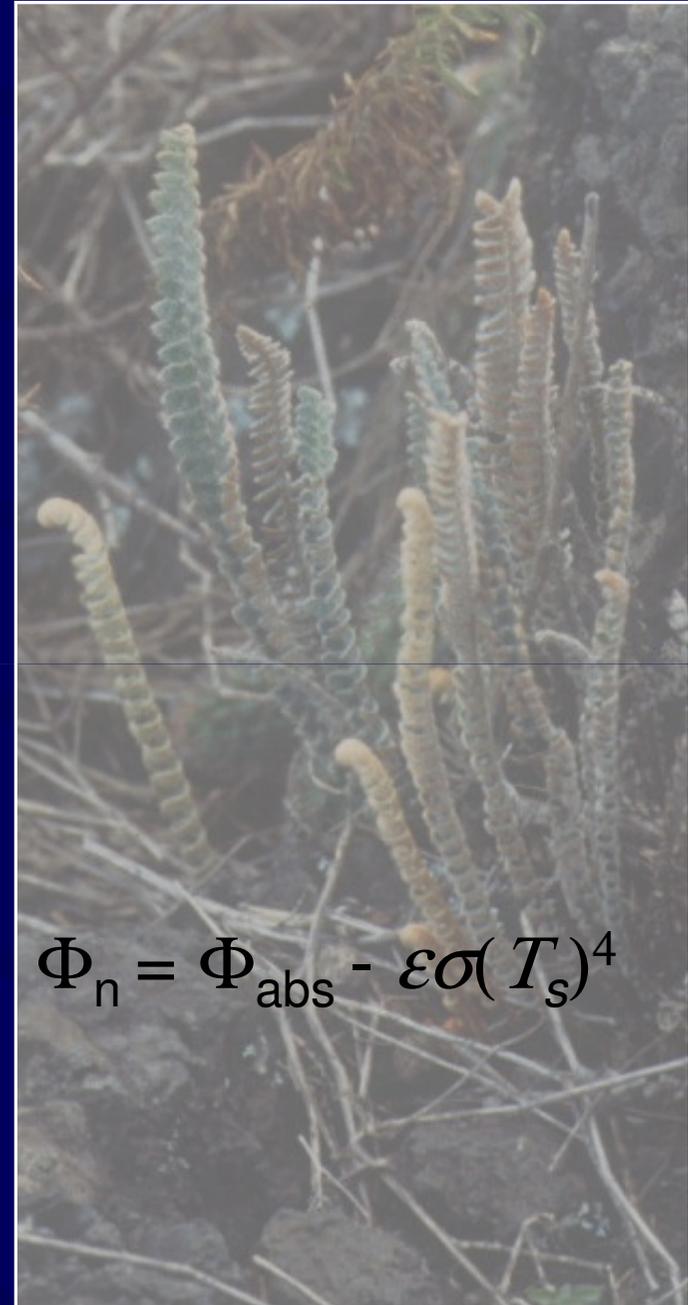
$\Phi_n$  = ganho líquido pelo balanço de radiação;

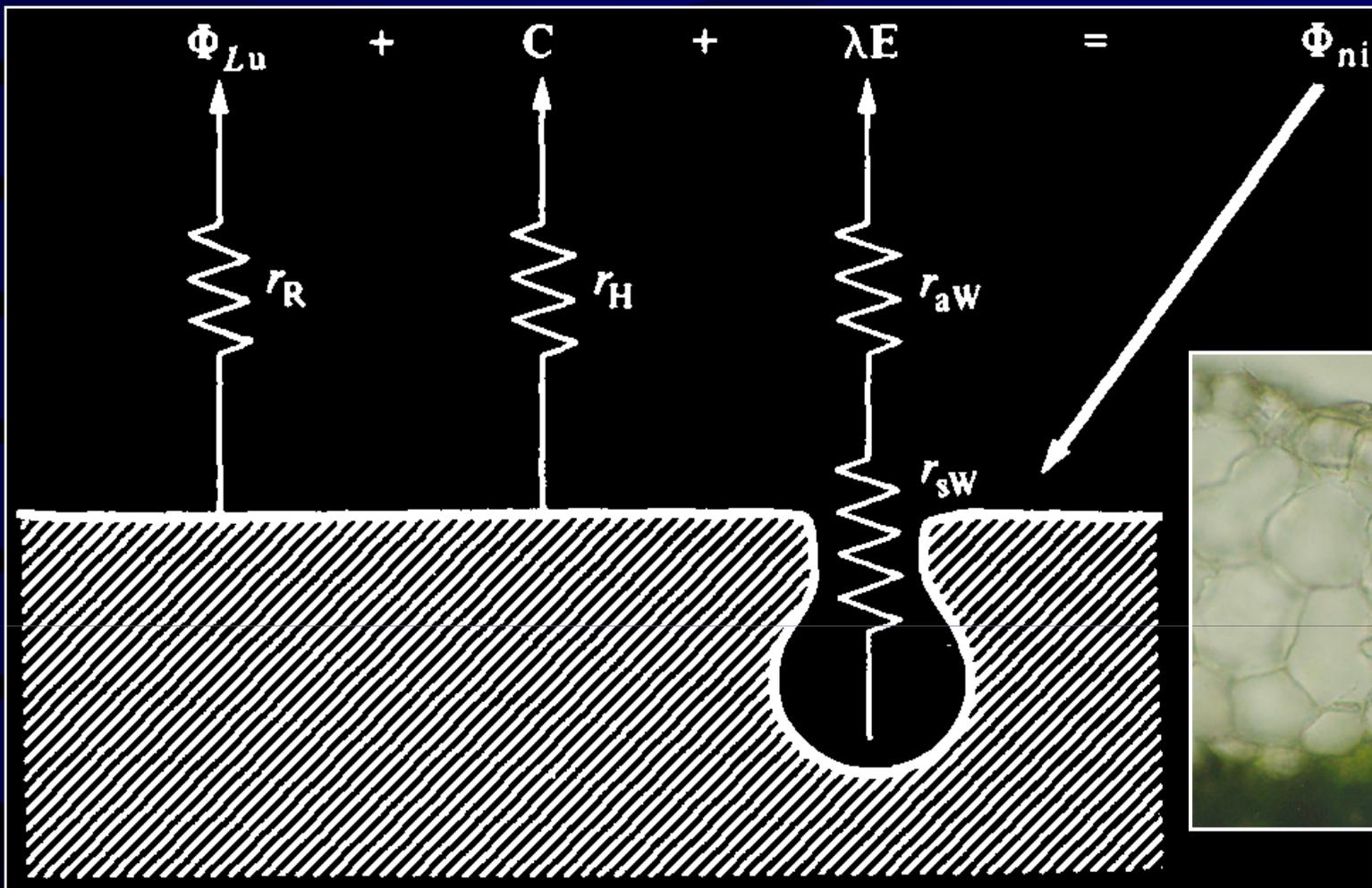
$C$  = perda de calor por condução e convecção;

$\lambda E$  = perda de calor latente (por evaporação da água,  $\lambda=2.454$  MJ kg<sup>-1</sup> (20 °C));

$M$  = energia armazenada bioquimicamente;

$S$  = armazenamento estrutural.



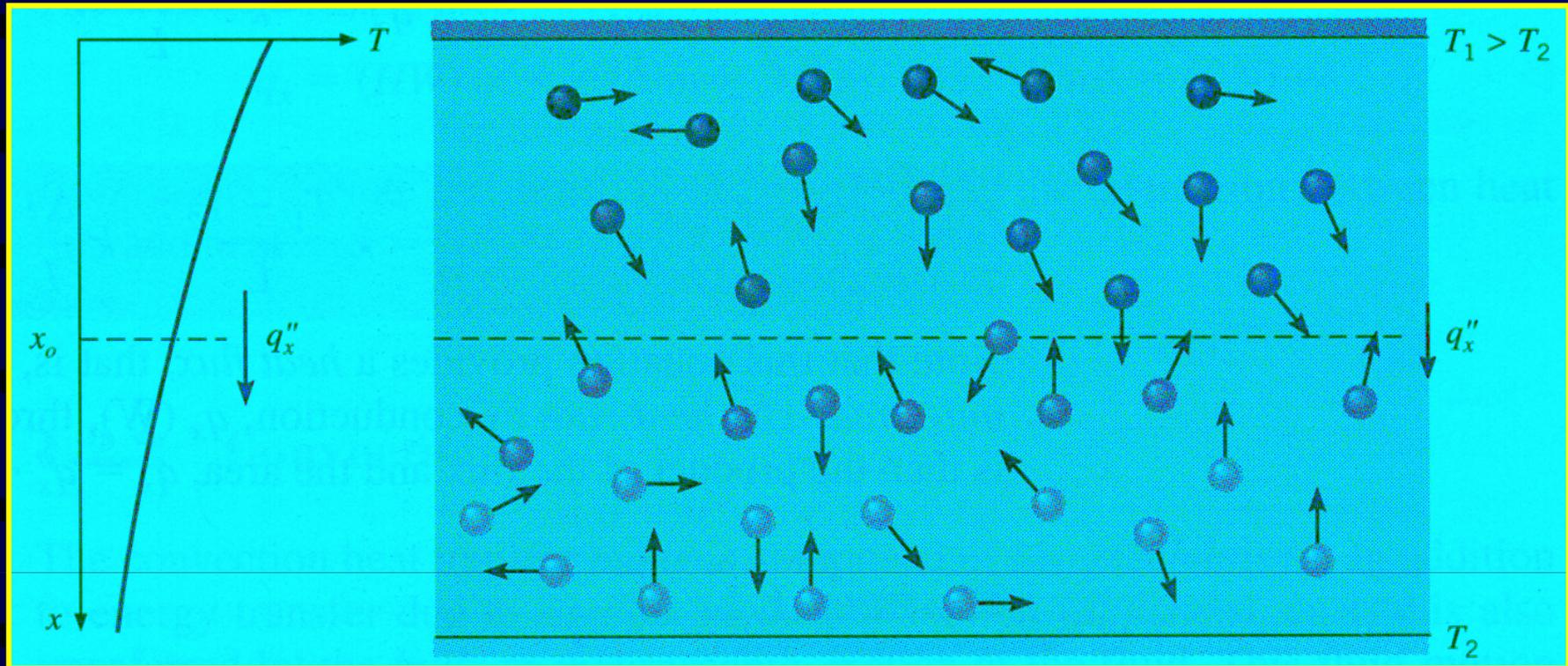


$\Phi_{Lu}$  = emissão do ganho líquido pelo balanço de radiação;

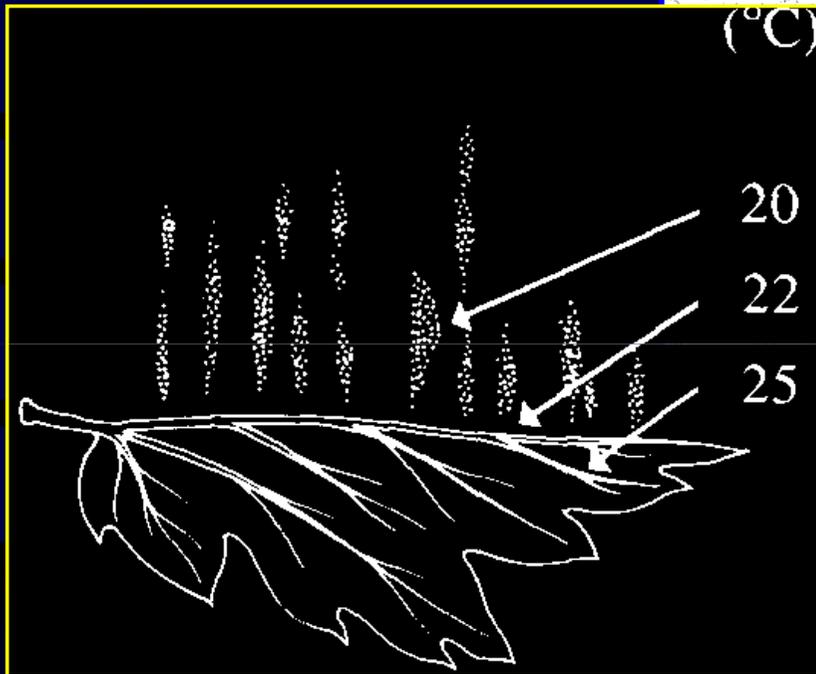
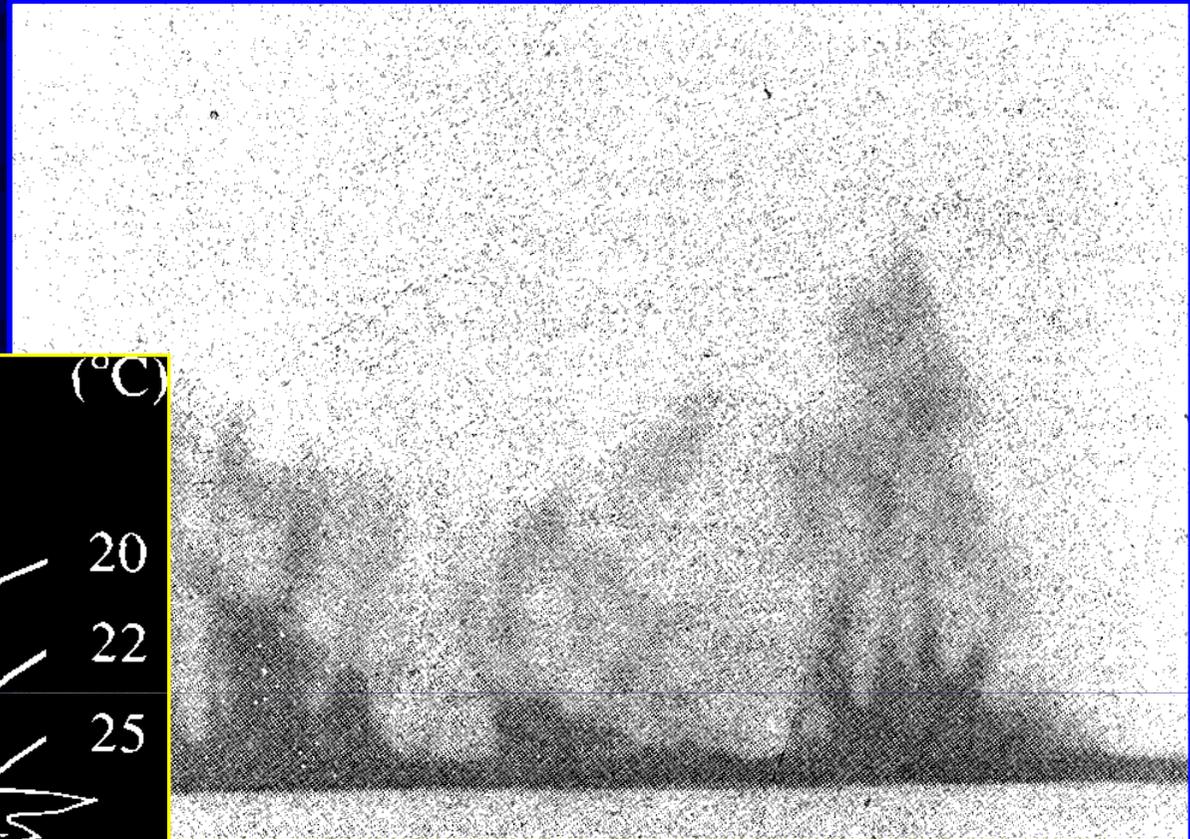
$C$  = perda de calor por condução e convecção;

$\lambda E$  = perda de calor latente (por evaporação da água,  $\lambda=2.454 \text{ MJ kg}^{-1}$  (20 °C));

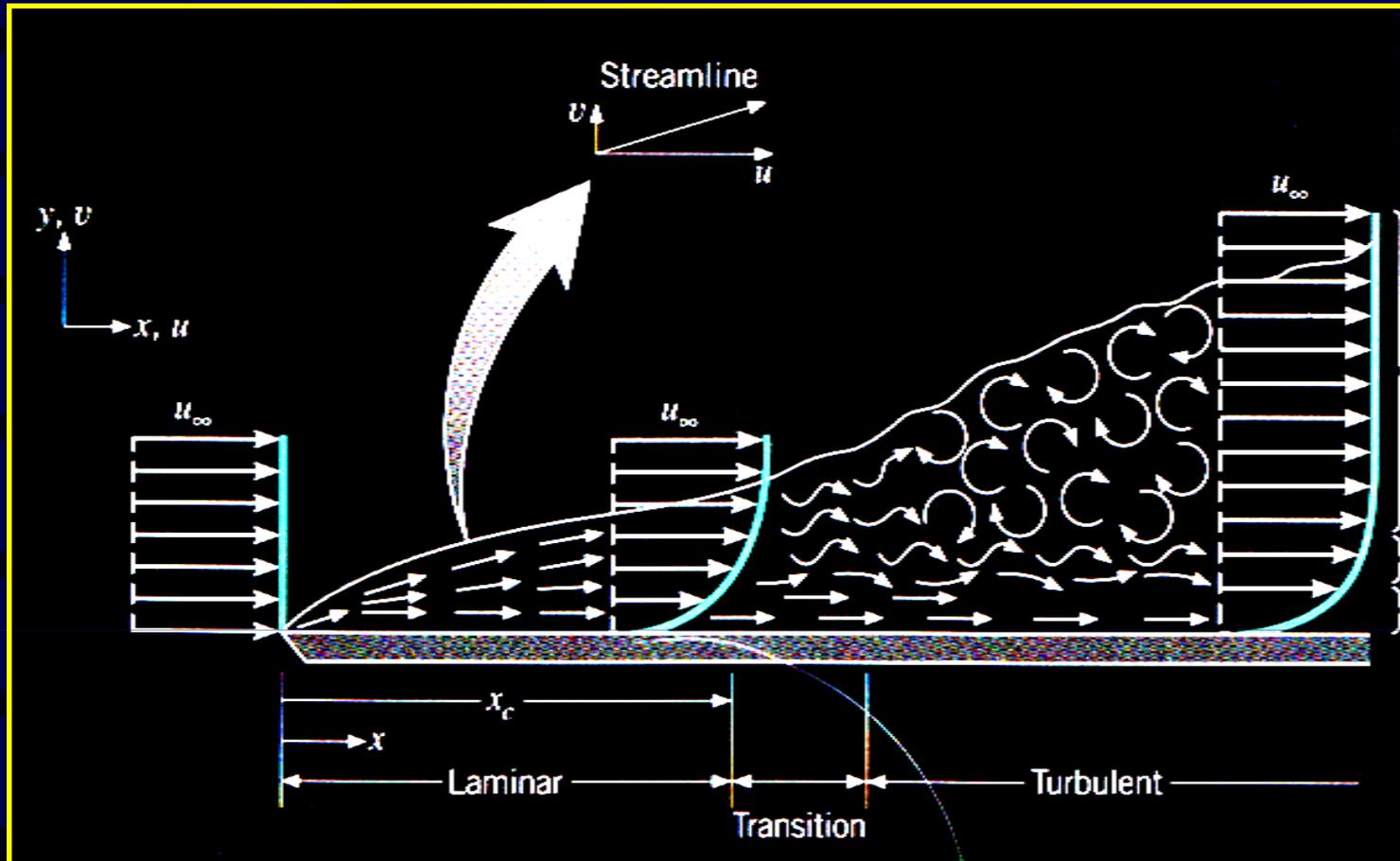
$r$  = termos de resistência:  $r_R$  - perda radiativa;  $r_H$  - perdas de calor por condução e convecção;  $r_W$  - resistência à perda de água:  $r_{aW}$  - resistência da camada envolvente;  $r_{sW}$  - resistência estomática e da câmara sub-estomática.



- Condução - transferência de calor da folha diretamente para o ar sem fluxo de massa.  $C = -k (\delta T / \delta x)$
- Difusão - transferência de massa por movimentos aleatórios das moléculas.  $J_i = -D_i (\delta c_i / \delta x)$

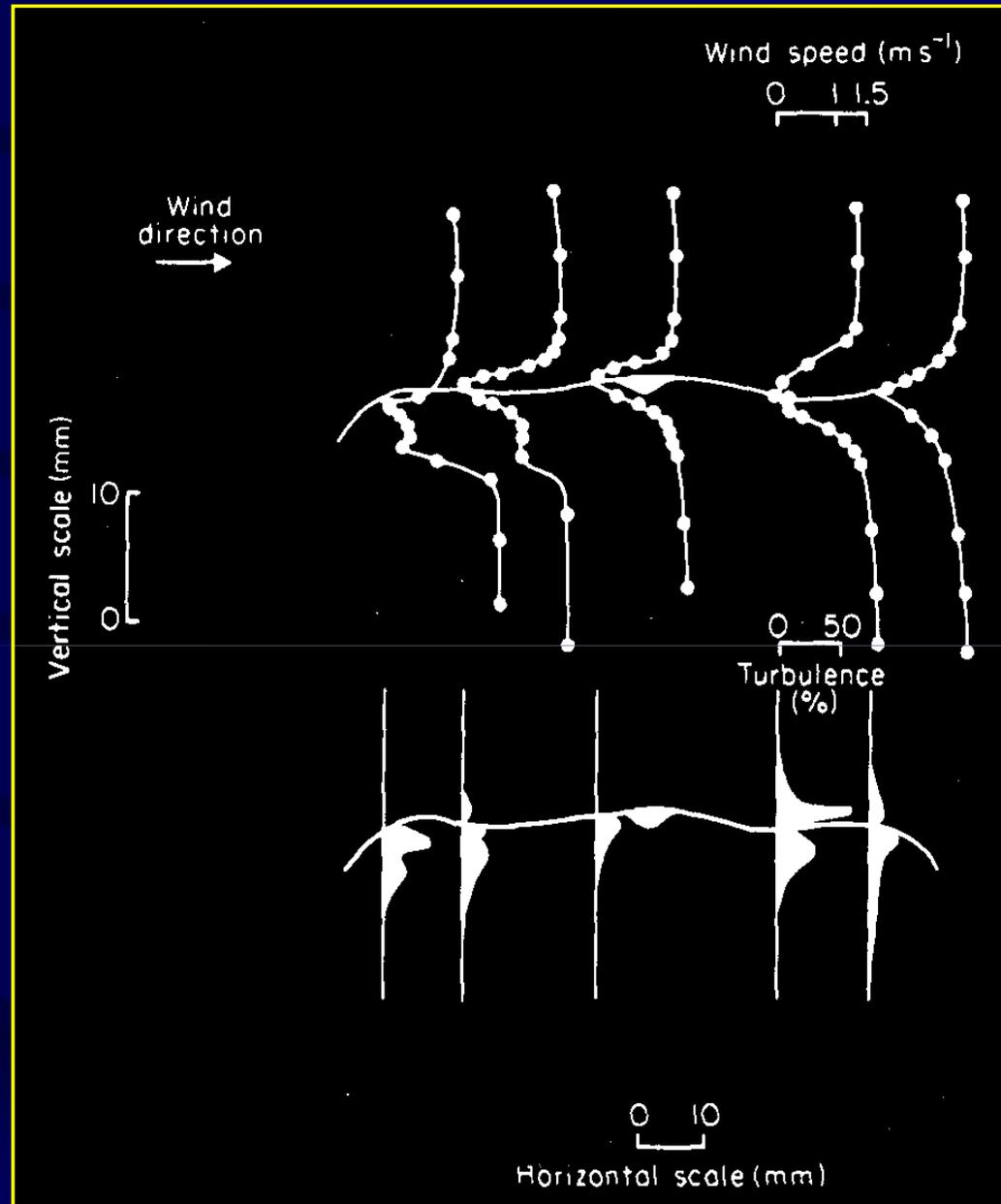


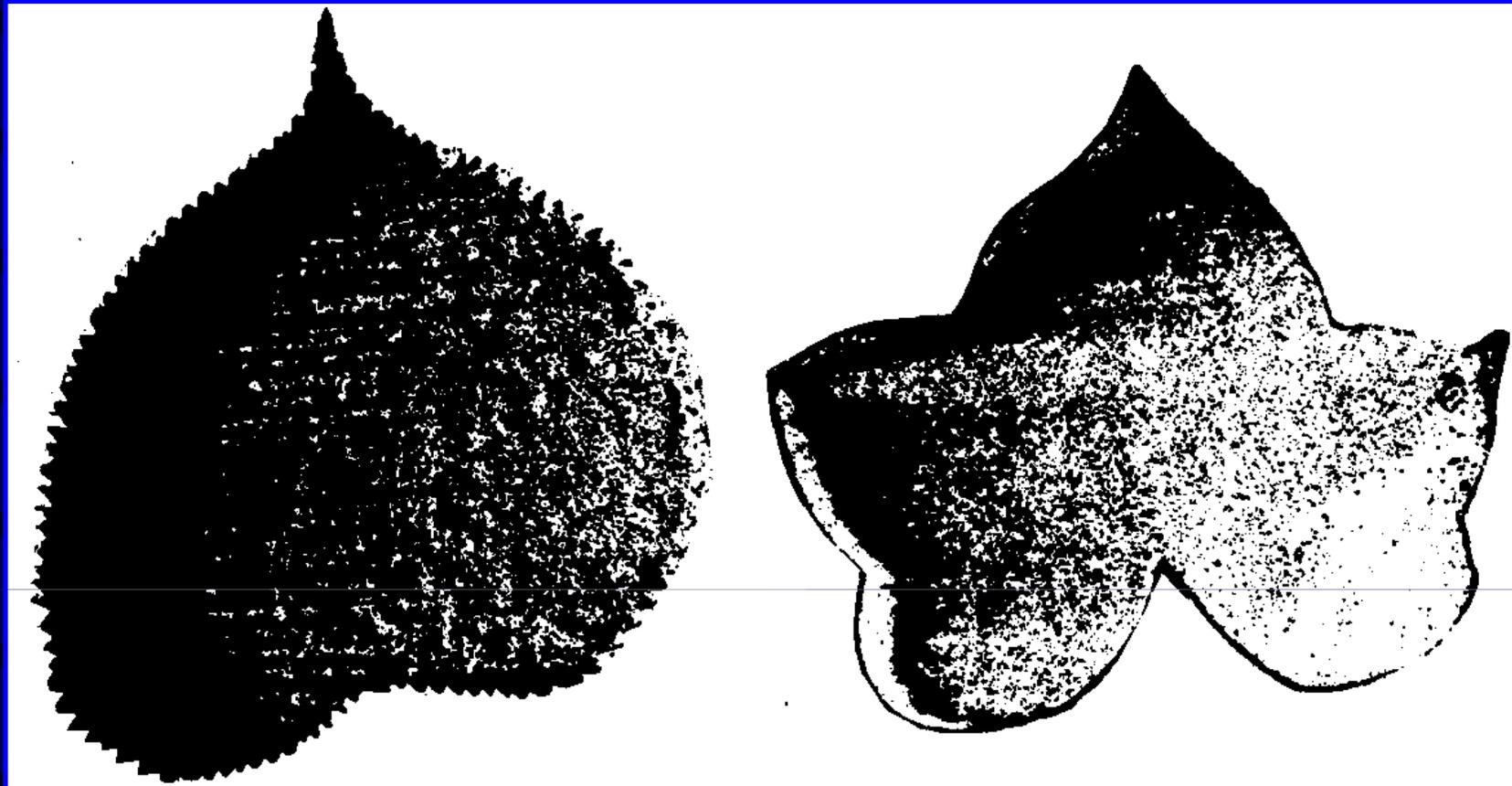
- Convecção - transferência de energia por fluxo de massa
- Livre - o fluxo se deve a mudanças na densidade do ar;
- Forçada - diferenças de pressão externas, vento.



- Camada envolvente em uma folha e zonas de fluxo laminar e turbulento.

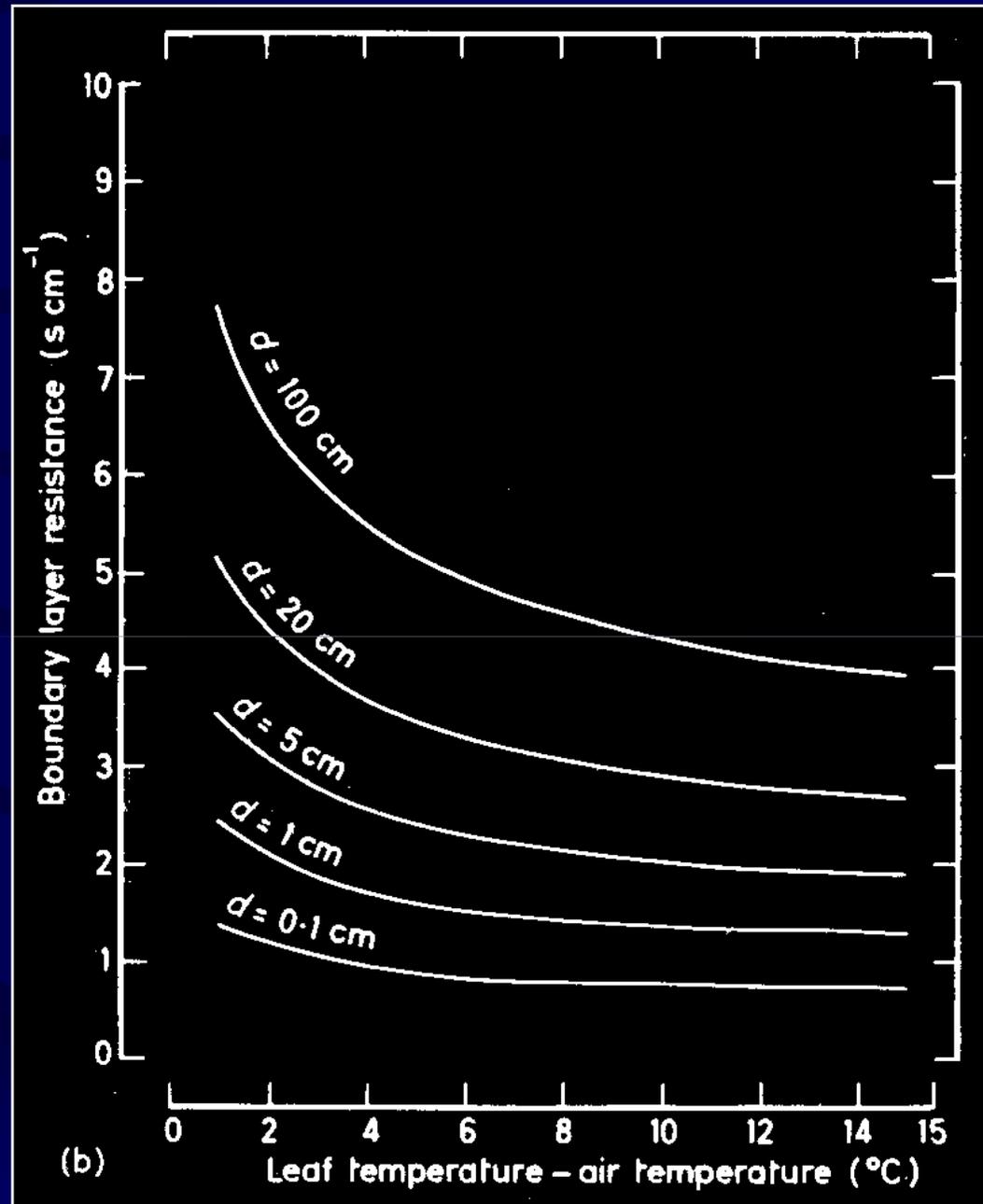
- Padrões de fluxo na superfície de uma folha presumidos através da formação de camada de fluxo turbulento.



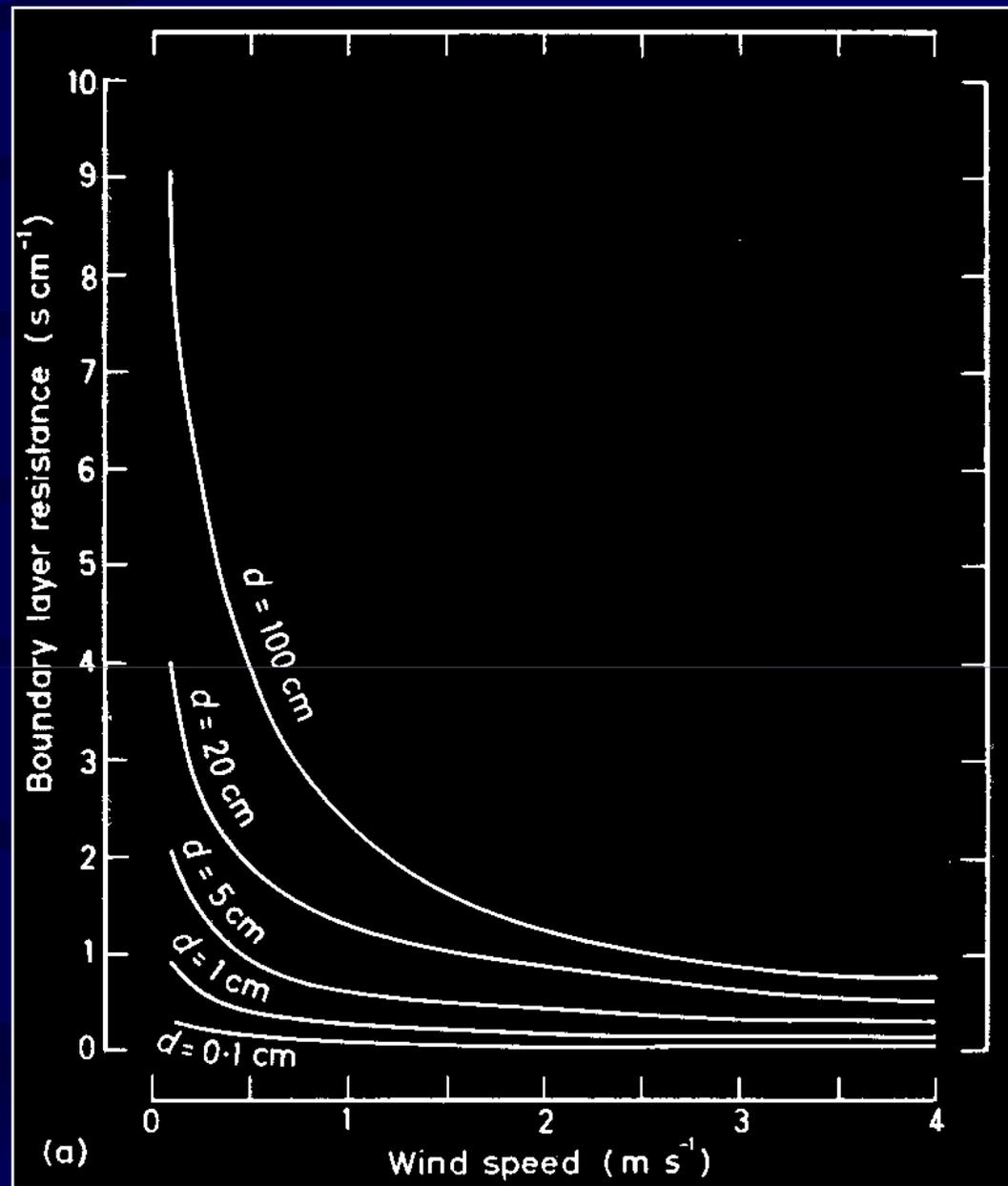


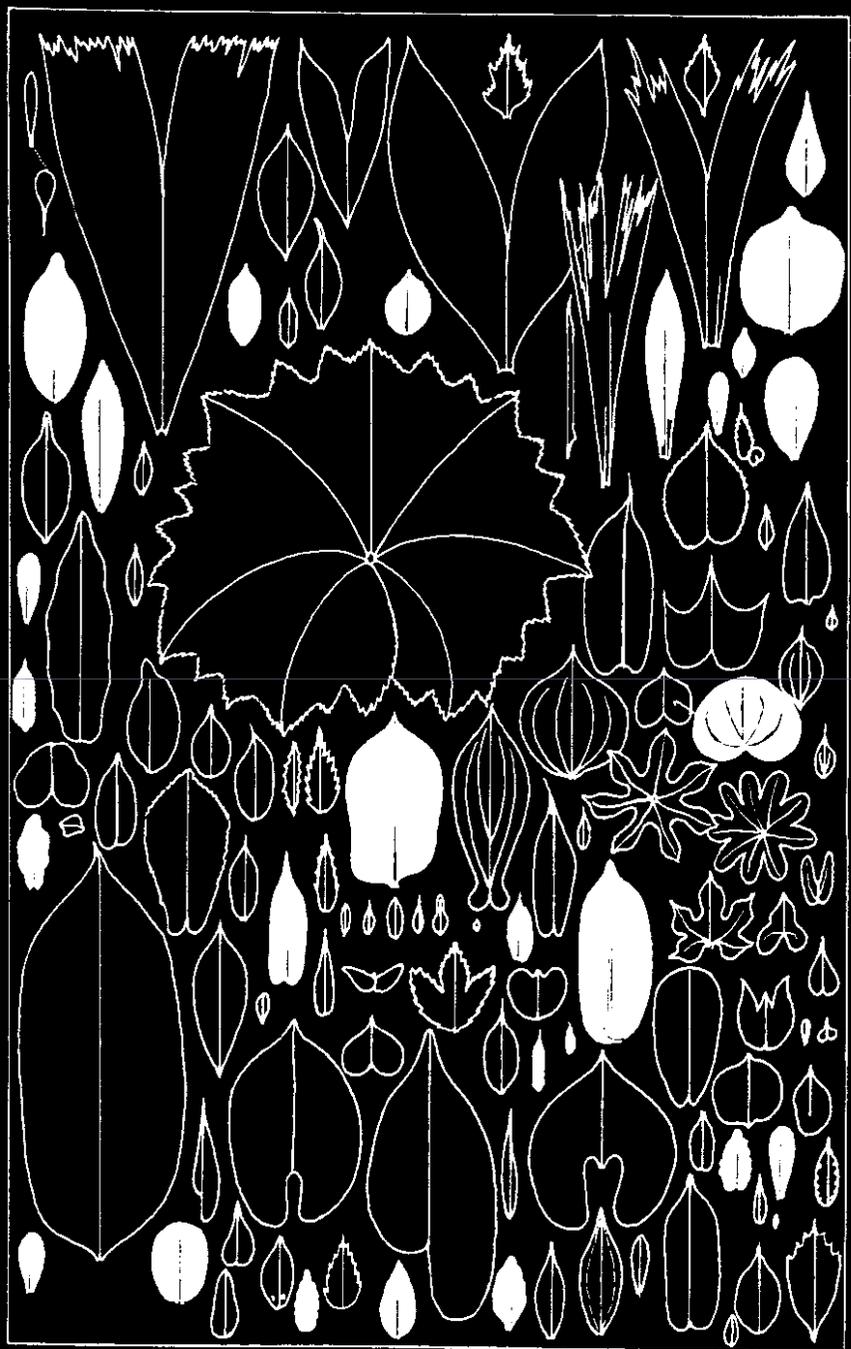
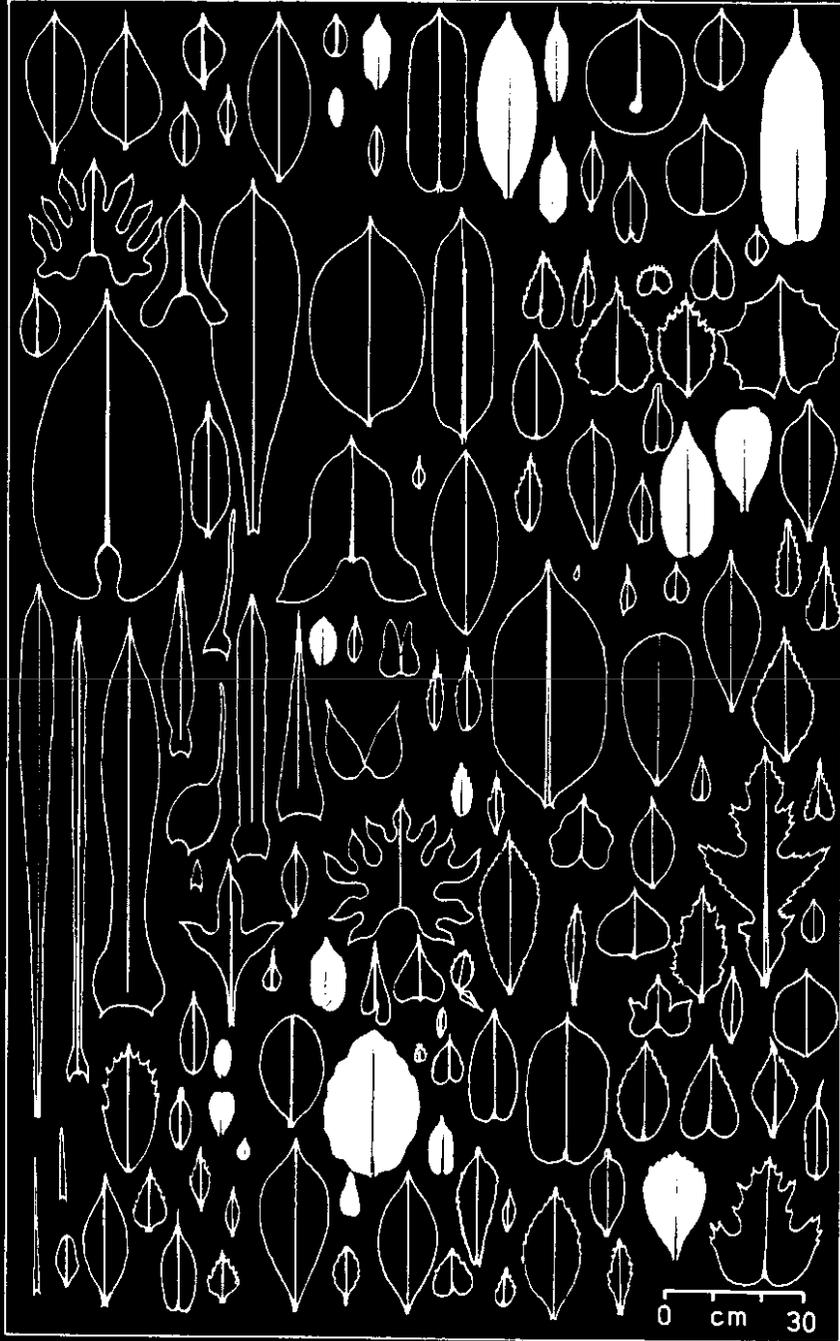
- Variação nos padrões de fluxo de massa em folhas expostas em um túnel de vento, cobertas com naftaleno (branco). O vento intercepta a borda das folhas à esquerda. As zonas de fluxo turbulento apresentam maior sublimação do material claro, dando origem a faixas escuras.

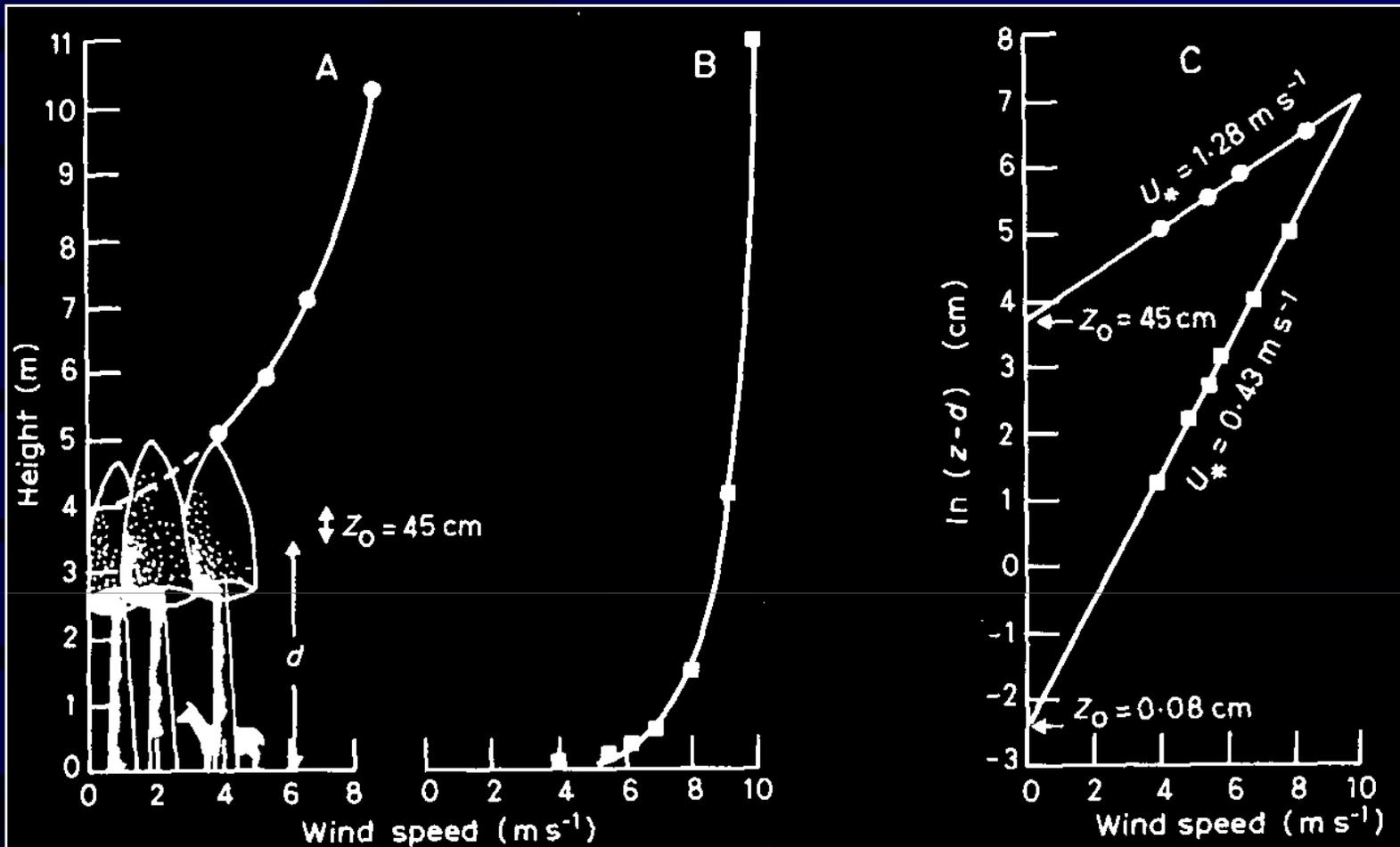
- Resistência por convecção livre dada a largura foliar e a diferença de temperatura entre a folha e o ar.



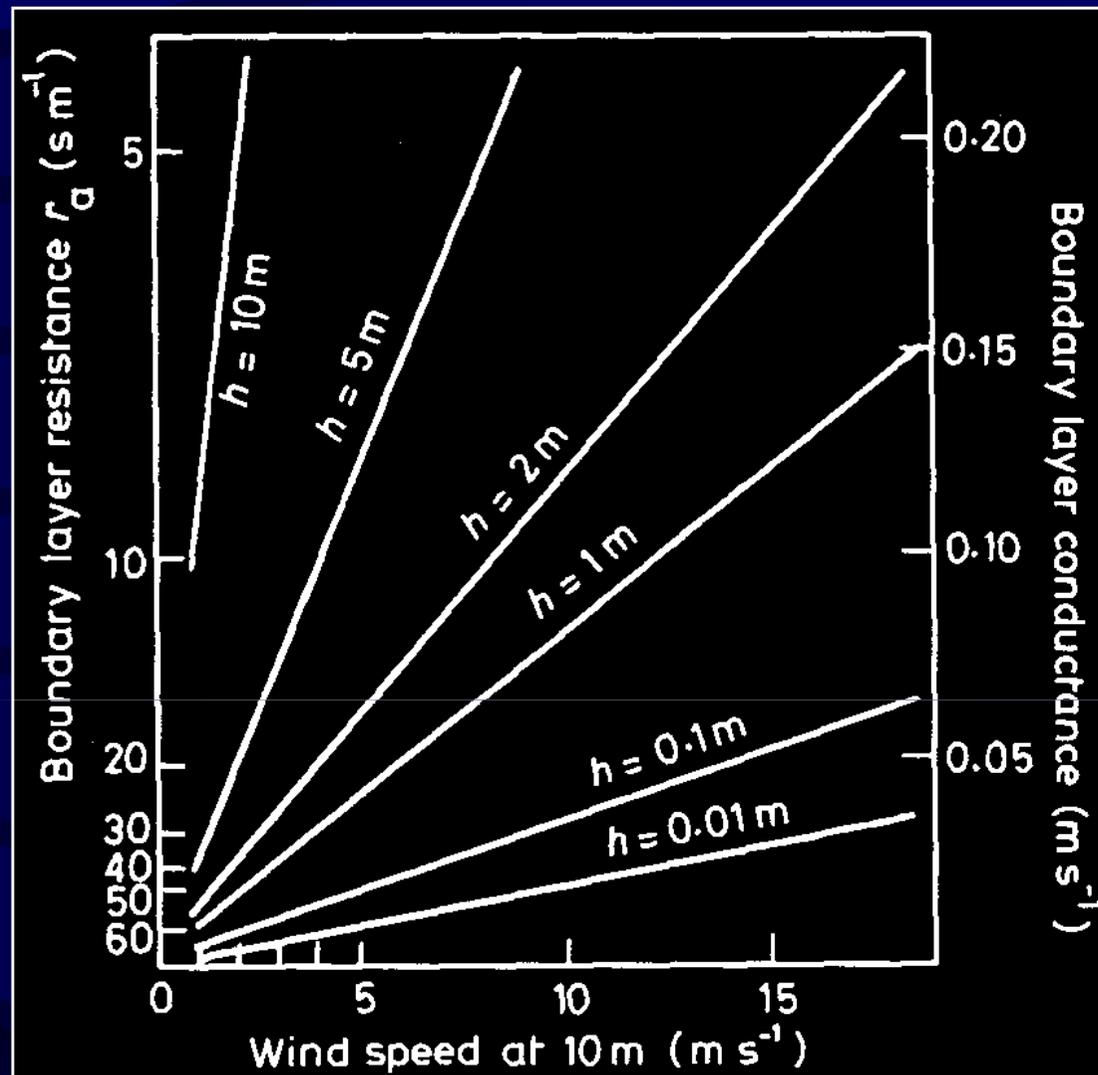
- Largura da folha e resistência da camada envolvente de fluxo turbulento em função da velocidade do vento.



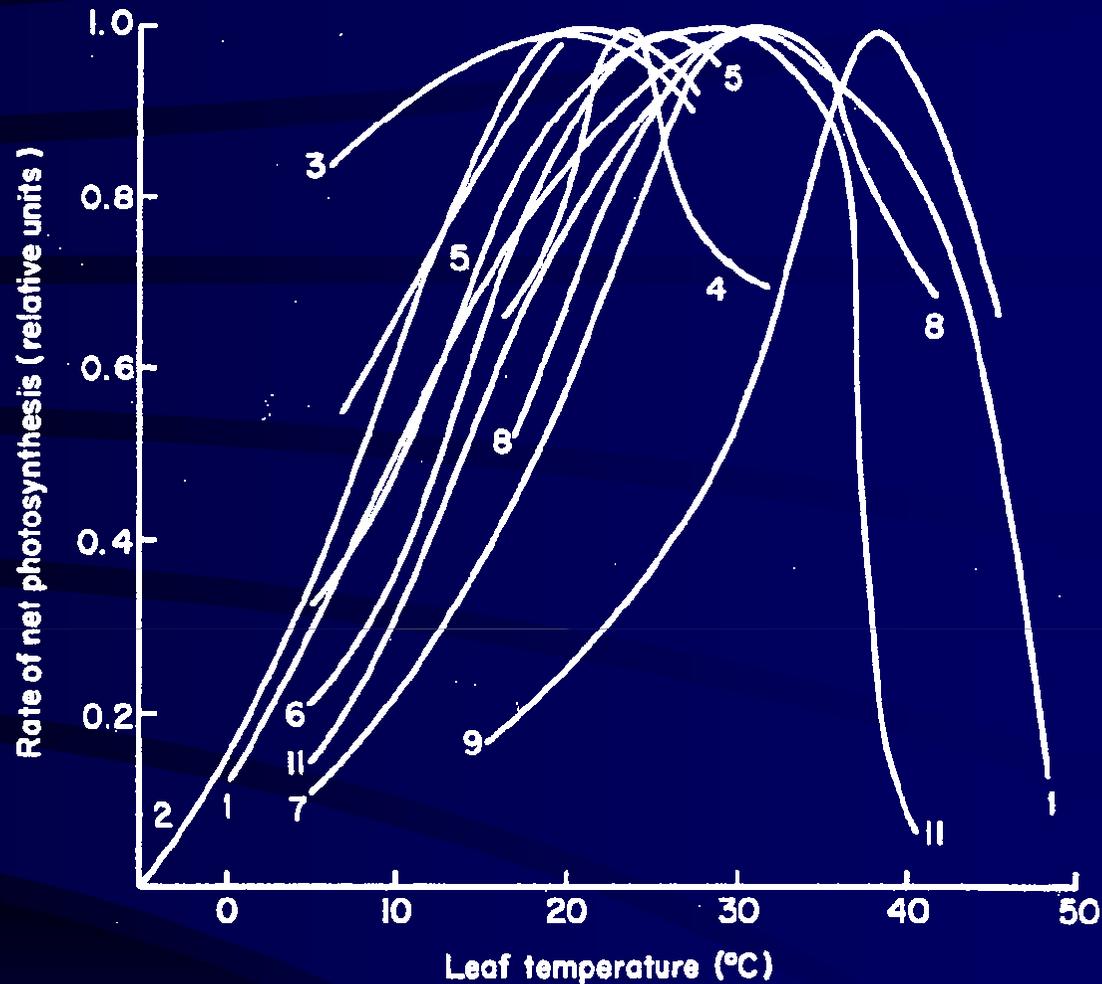




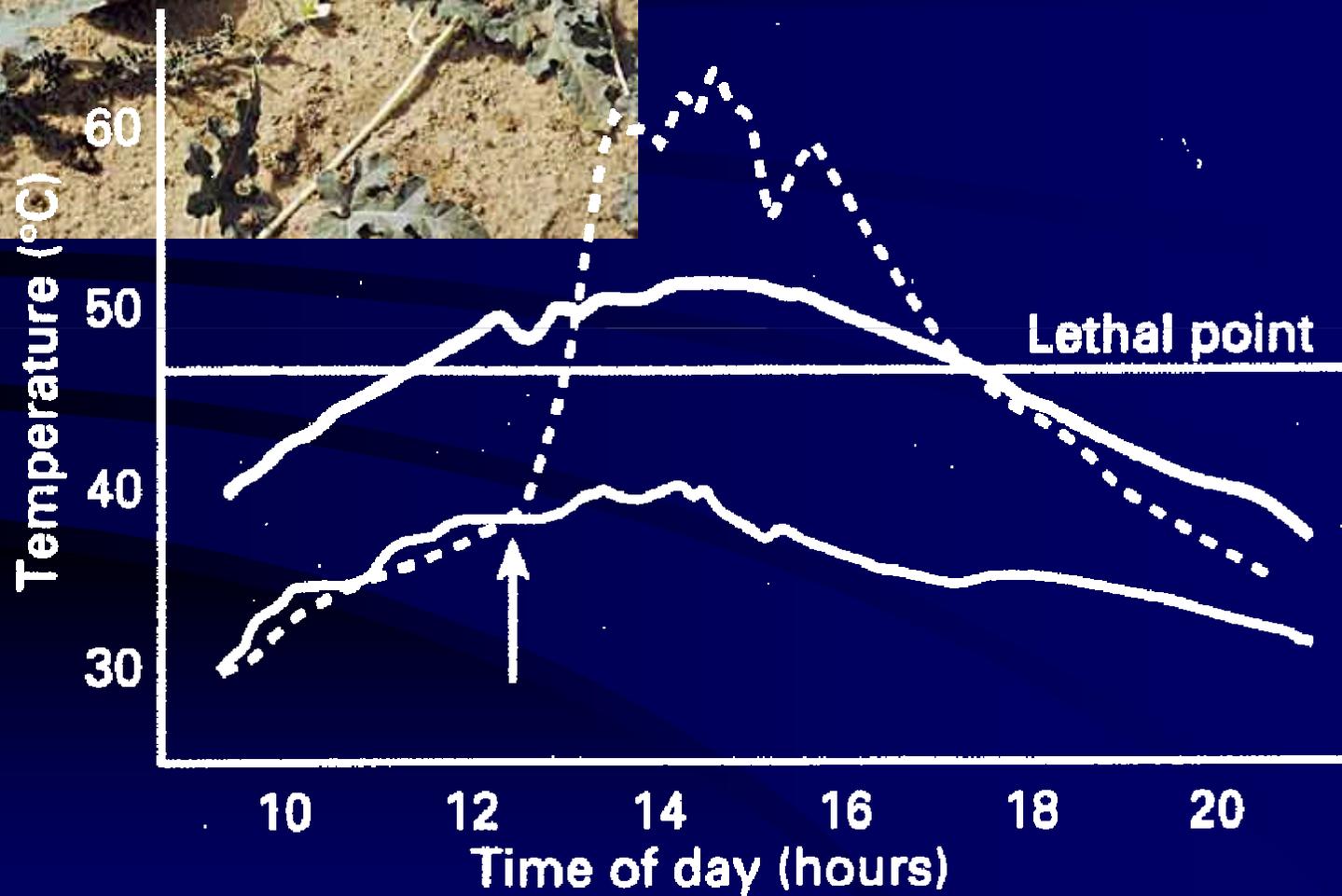
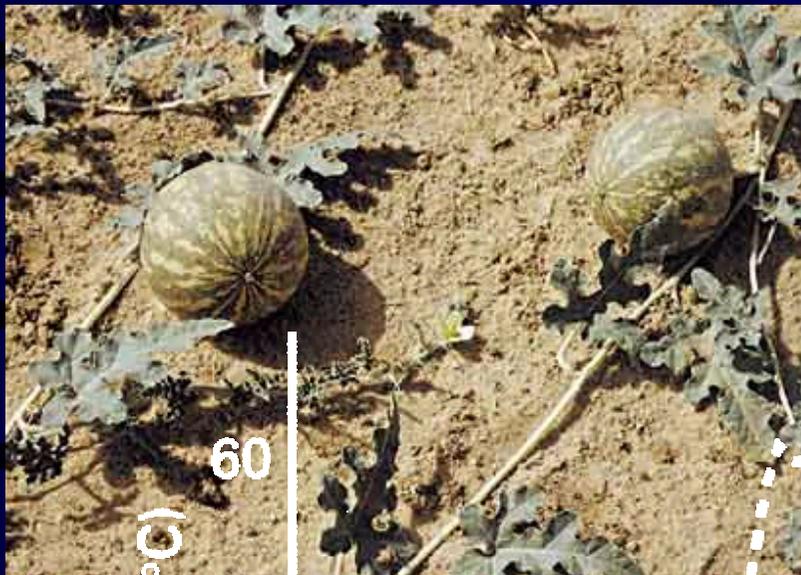
- A,B - Padrões de fluxo sobre a comunidade vegetal em função da velocidade do vento, altura e da rugosidade do dossel. C -  $U_*$  - velocidade de fricção.

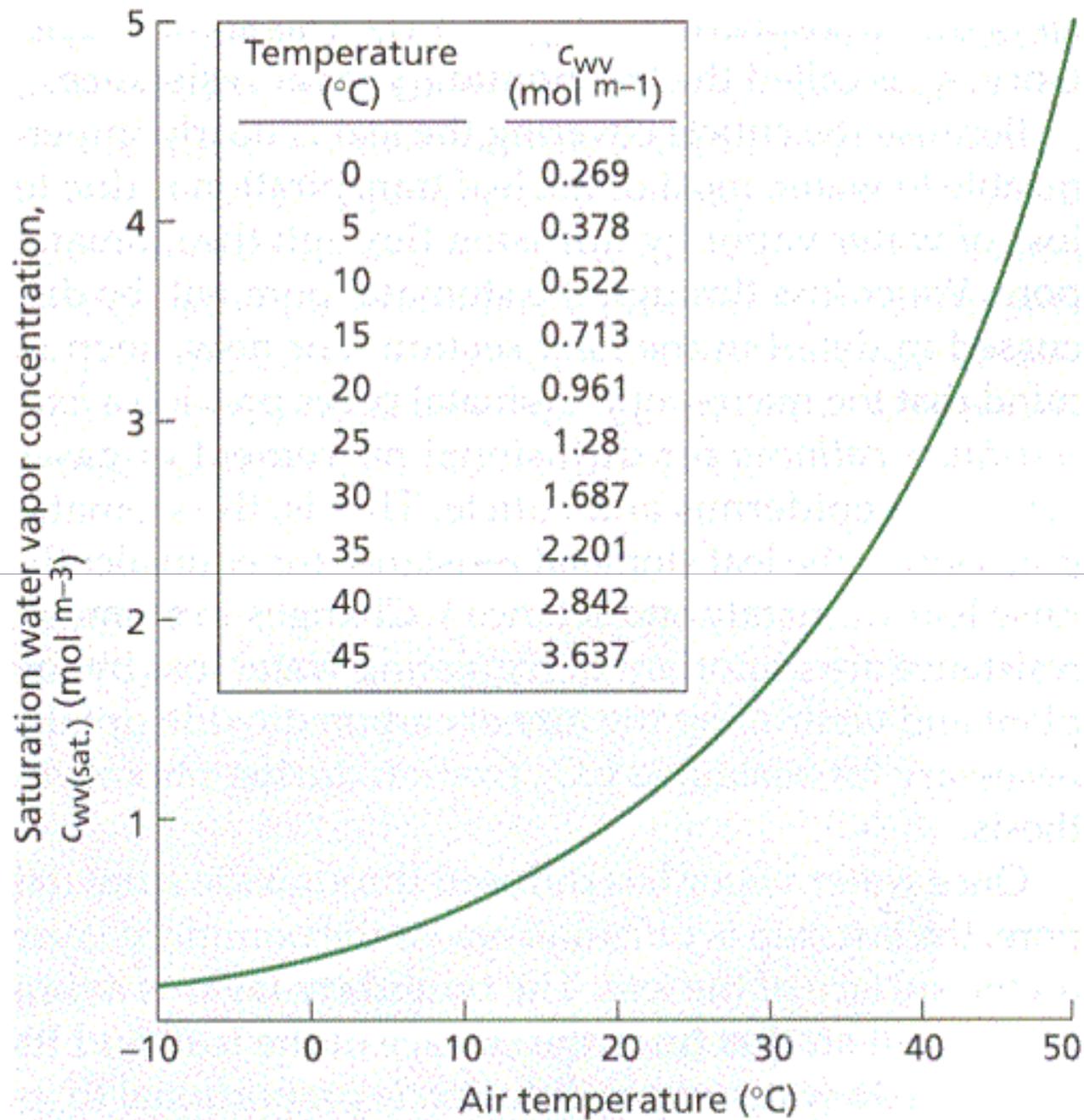


- Resistência da camada envolvente da vegetação em função de sua altura e da velocidade do vento a 10 m acima da copa.



**Fig. 7.** Effect of temperature on the rate of photosynthesis at high irradiance. 1, *Mimulus cardinalis* (Milner and Hiesey, 1964); 2, *Picea sitchensis* (Neilson *et al.*, 1972); 3, *Calluna vulgaris* (Grace and Woolhouse, 1970); 4, *Dactylis glomerata* (Charles-Edwards *et al.*, 1971); 5, *Marchantia polymorpha*; 6, *Atriplex patula*; 7, *Atriplex rosea* (Björkman, 1971); 8, *Phragmites communis* (Pearcy *et al.*, 1974); 9, *Pennisetum albicans*; 10, *Sesleria albicans*; 11, *Spartina townsendii* (Long *et al.*, 1975).





Angiospermas  
típicas

Cenozoic Era  
(65 mya to today)

Quaternary (1.8 mya to today)  
Holocene (11,000 years to today)  
Pleistocene (1.8 mya to 11,000 yrs)  
Tertiary (65 to 1.8 mya)  
Pliocene (5 to 1.8 mya)  
Miocene (23 to 5 mya)  
Oligocene (38 to 23 mya)  
Eocene (54 to 38 mya)  
Paleocene (65 to 54 mya)

Pteridófitas e  
Pteridospermas

Mesozoic Era  
(245 to 65 mya)

Cretaceous (146 to 65 mya)  
Jurassic (208 to 146 mya)  
Triassic (245 to 208 mya)

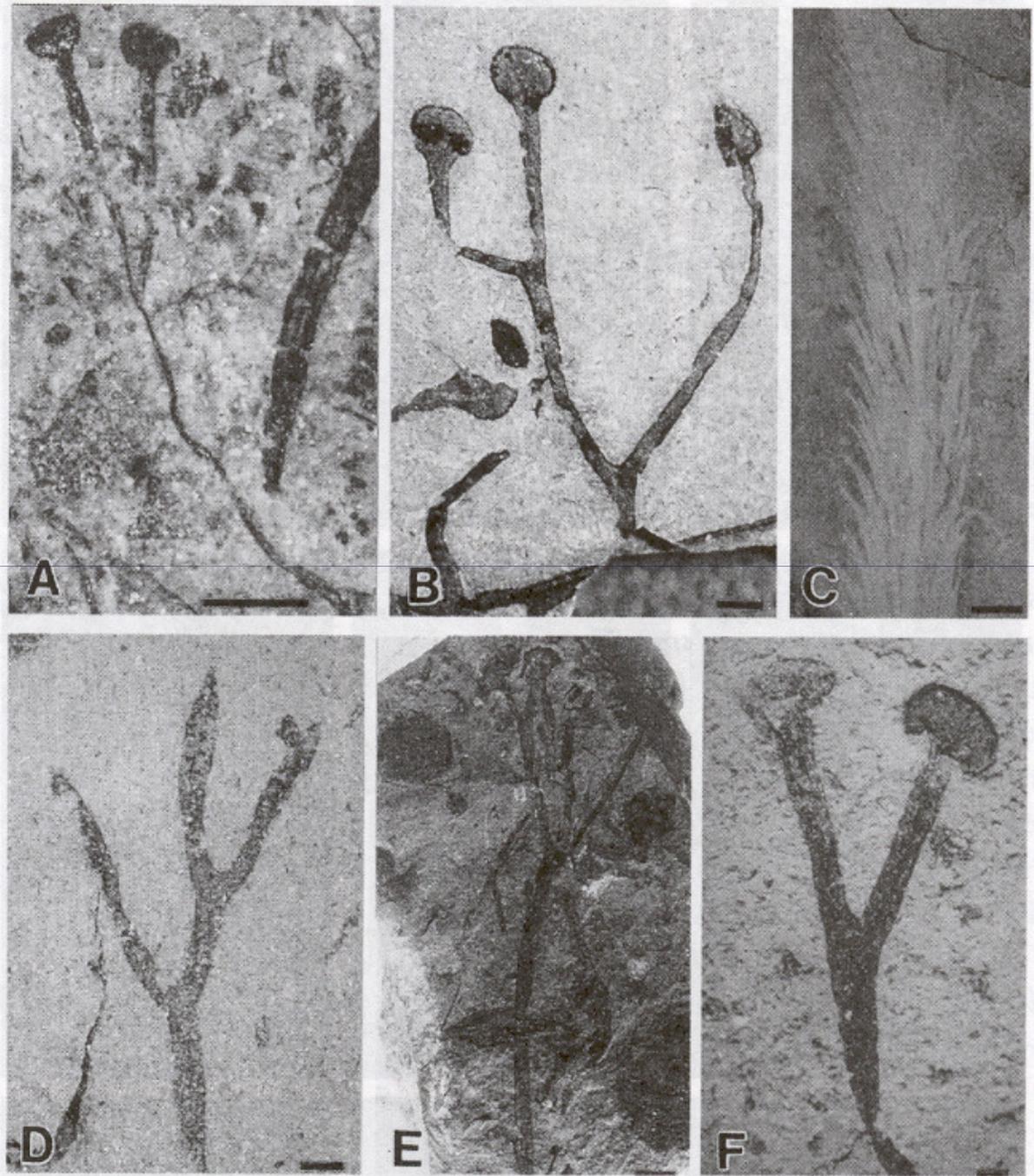
Primeiras  
plantas  
vasculares

Paleozoic Era  
(544 to 245 mya)

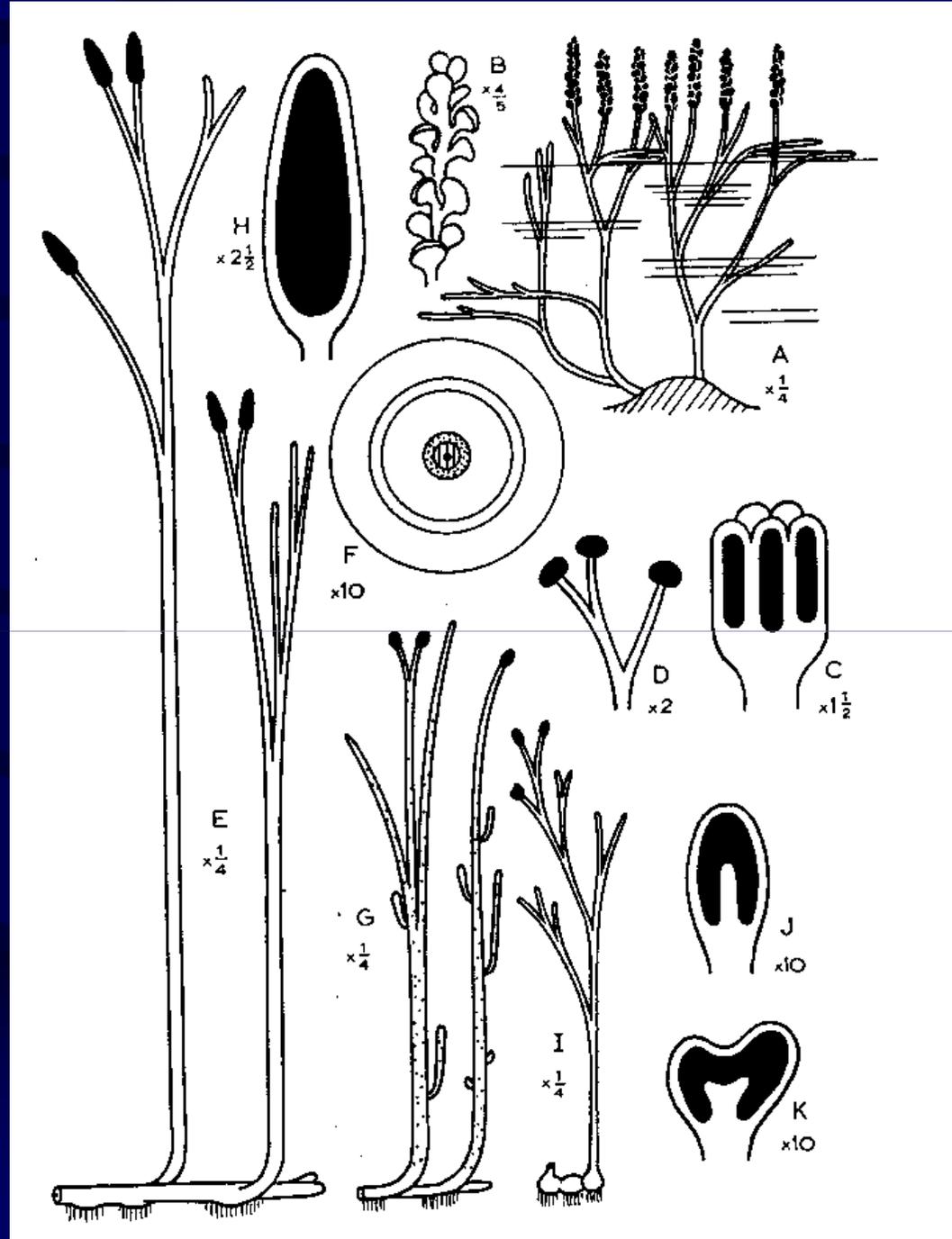
Permian (286 to 245 mya)  
Carboniferous (360 to 286 mya)  
Pennsylvanian (325 to 286 mya)  
Mississippian (360 to 325 mya)  
Devonian (410 to 360 mya)  
Silurian (440 to 410 mya)  
Ordovician (505 to 440 mya)  
Cambrian (544 to 505 mya)

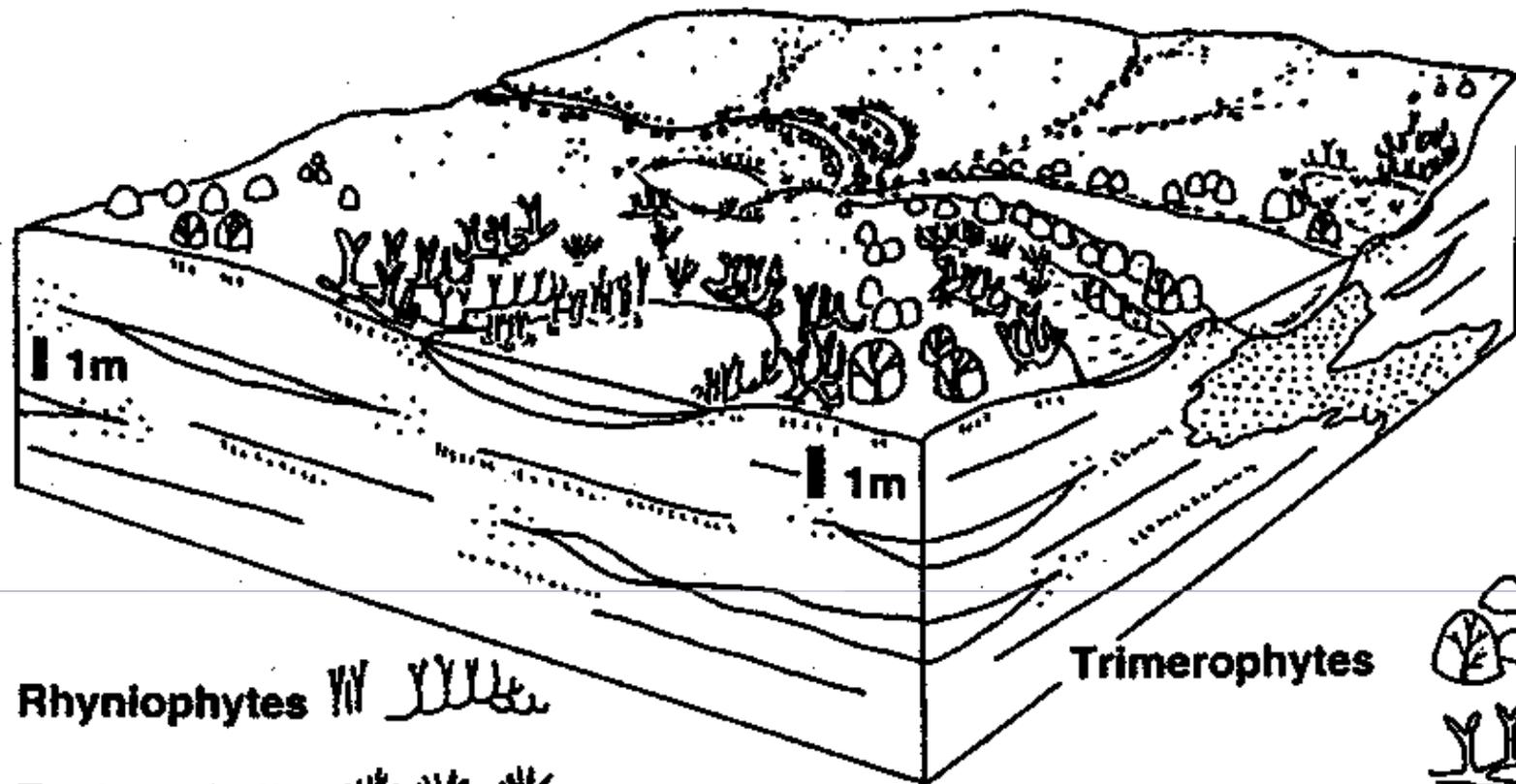
*Cooksonia* e  
*Baragwanathia*

Siluriano



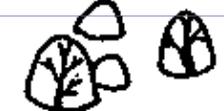
# Rhyniophyta do Devoniano médio





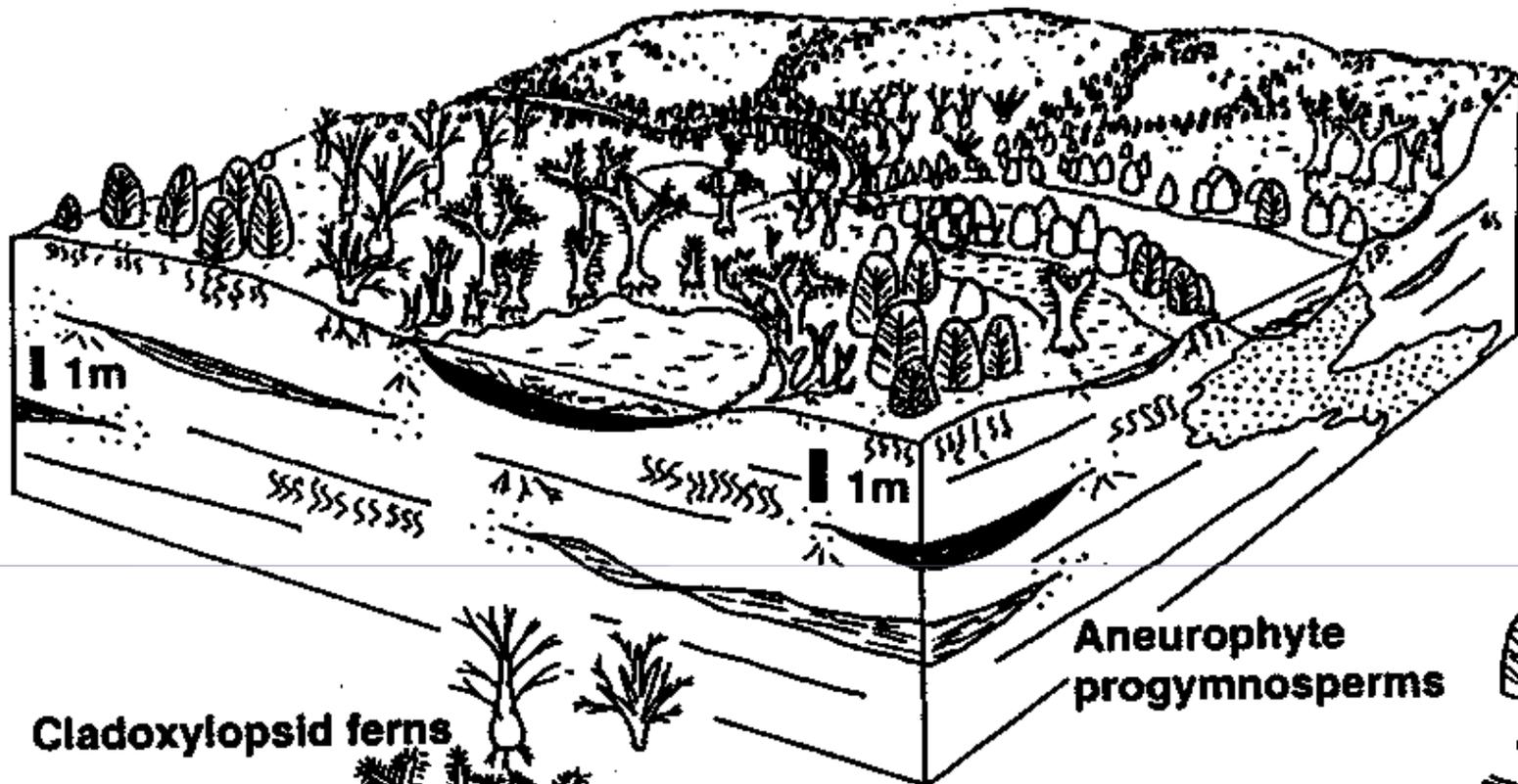
Rhyniophytes 

Zosterophylls 

Trimerophytes 

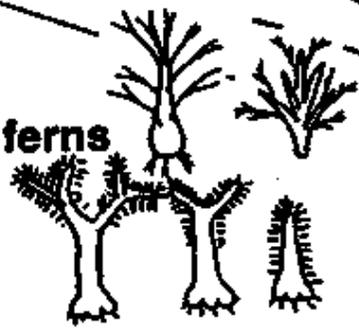
Drepanophycalean lycopsids 

**A** Early Devonian (Siegenian/Pragian - Emsian)



Cladoxylopsid ferns

Tree lycopsids



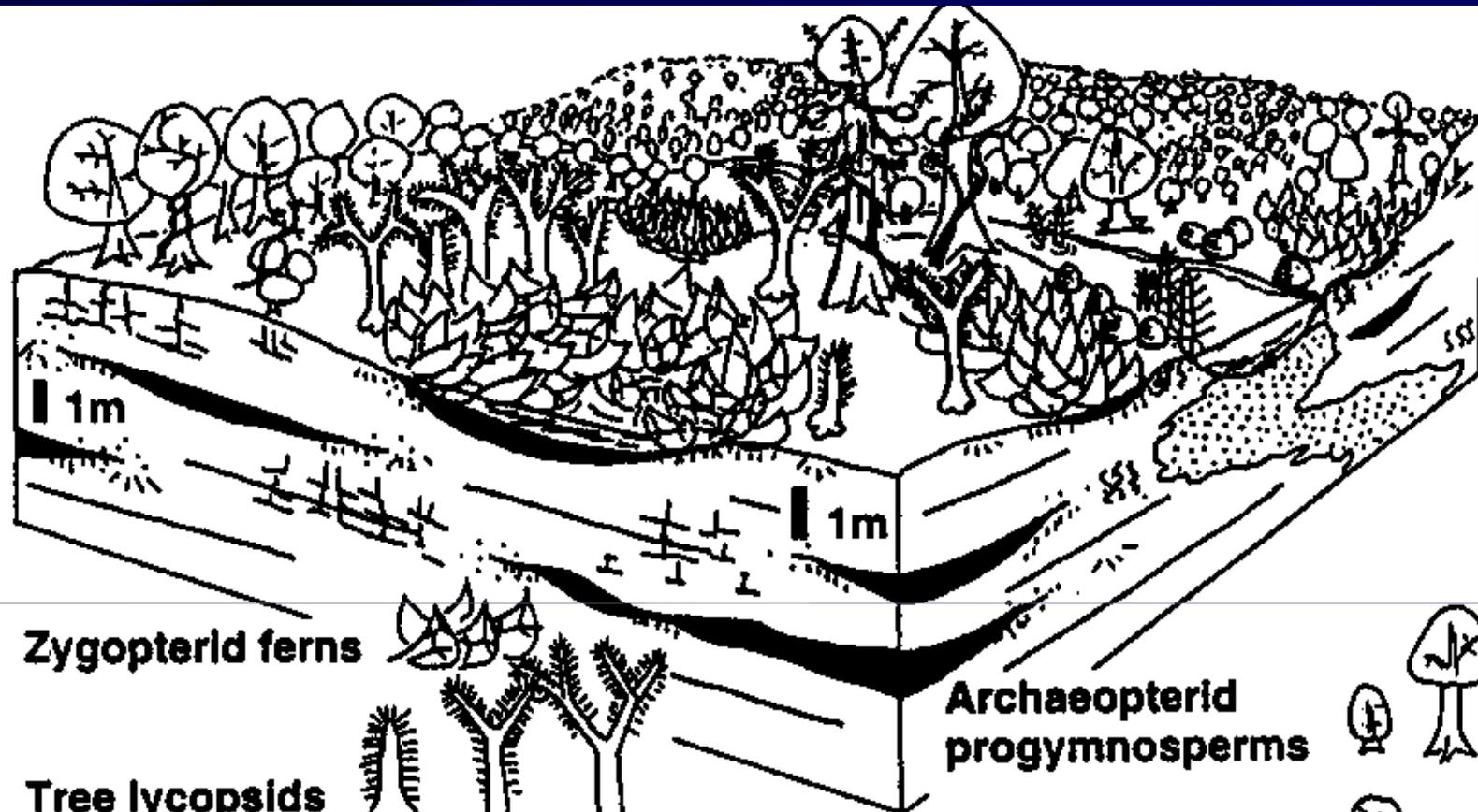
Aneurophyte  
progymnosperms

Drepanophycalean &  
Leclercqian lycopsids

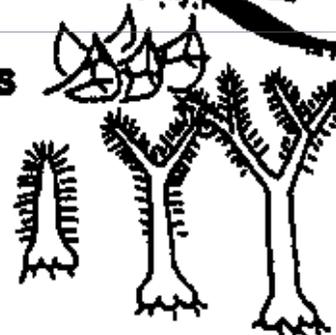


**B**

**Middle Devonian (Eifelian - Givetian)**



Zygopterid ferns



Tree lycopsids



Pseudobornean trees



Archaeopterid  
progymnosperms



Gymnosperms



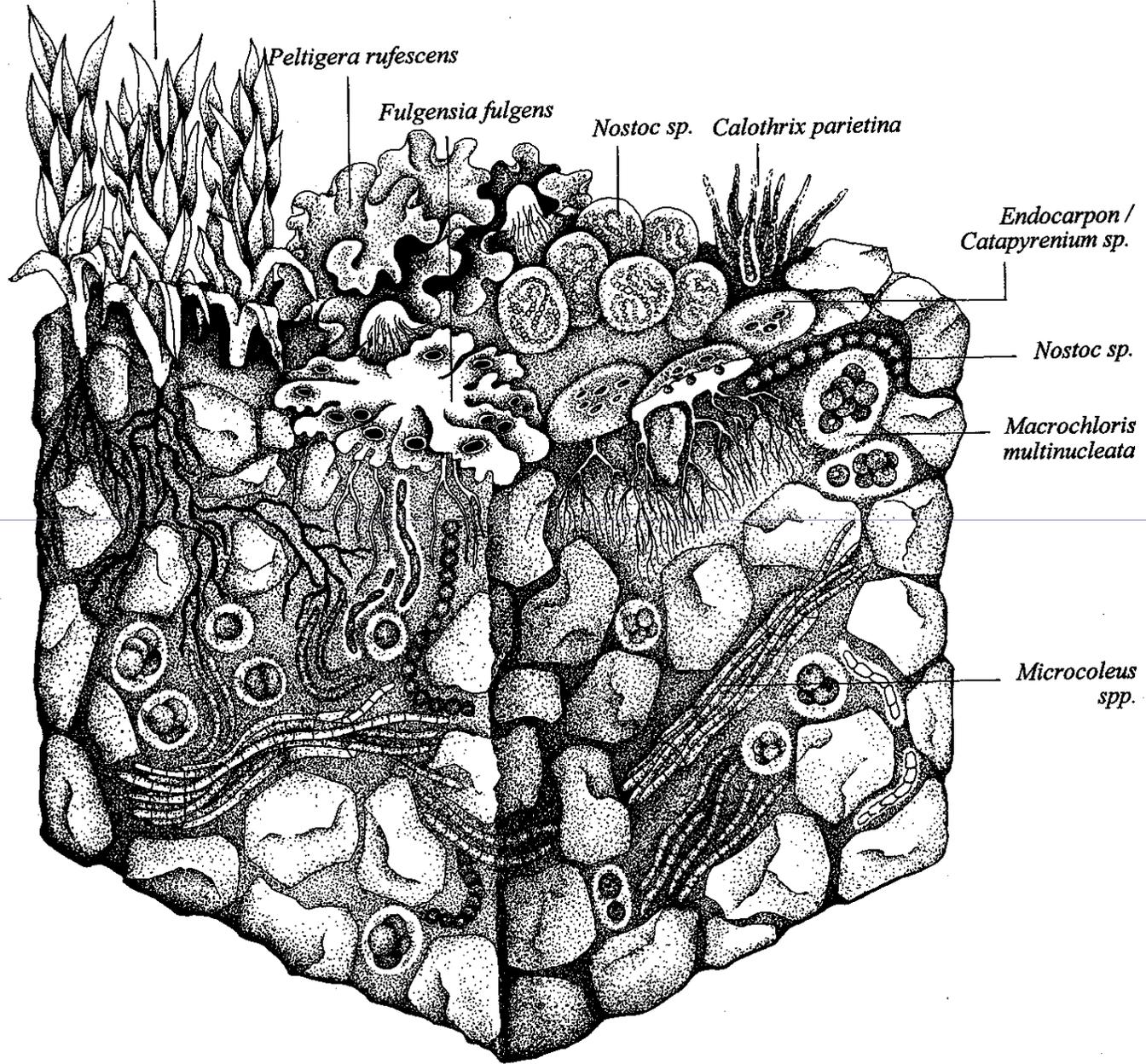
Sphenophyll vines  
Cladoxylopsid vines



**C**

**Late Devonian (Famennian)**

*Bryum bicolor* agg./ *Brachymenium* *exile*



*Peltigera rufescens*

*Fulgensia fulgens*

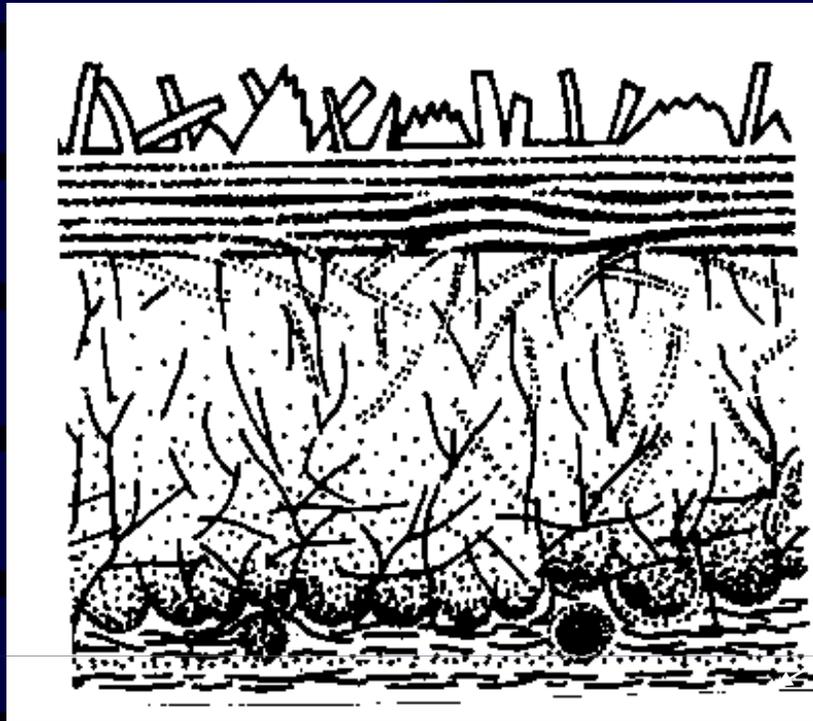
*Nostoc* sp. *Calothrix parietina*

*Endocarpon /  
Catapyrenium* sp.

*Nostoc* sp.

*Macrochloris  
multinucleata*

*Microcoleus  
spp.*



Cutícula

Cera epicuticular

Camada de Cutina

Camada com predominio de pectina

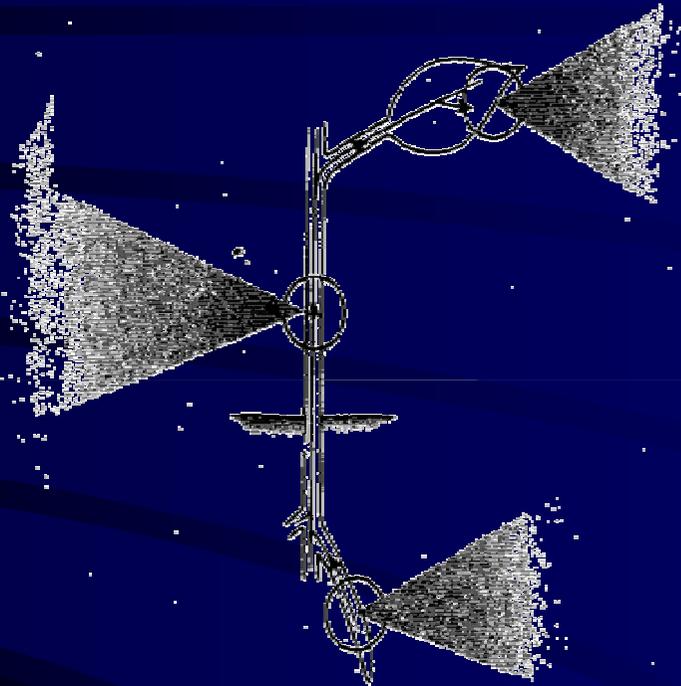
Parede de uma célula epidérmica

Estômatos



Vessel member  
(longitudinal  
section)

Perforation  
plate



ATMOSPHERE



Mesophyll  
cells

Epidermis  
(with stomata)

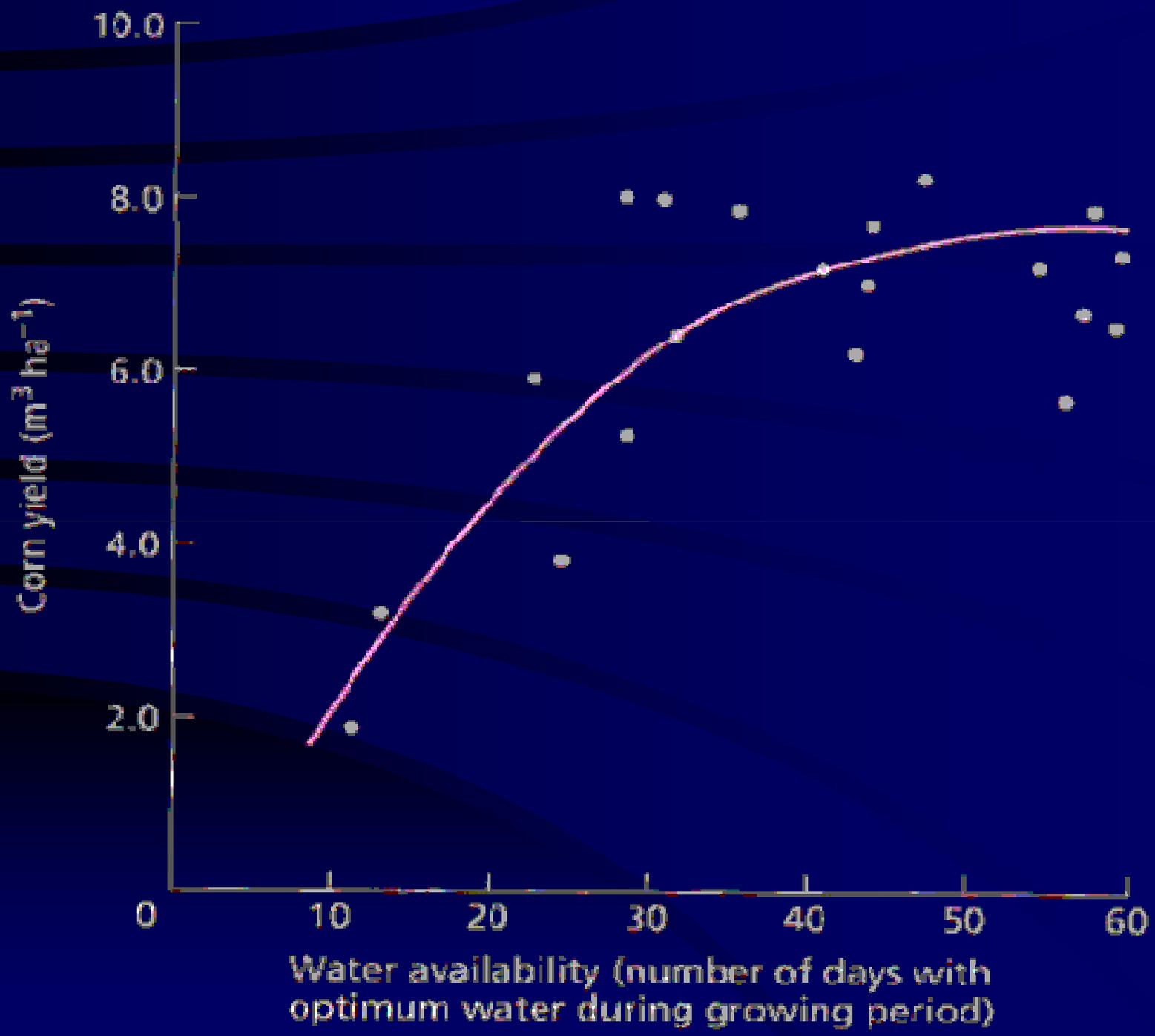
ATMOSPHERE

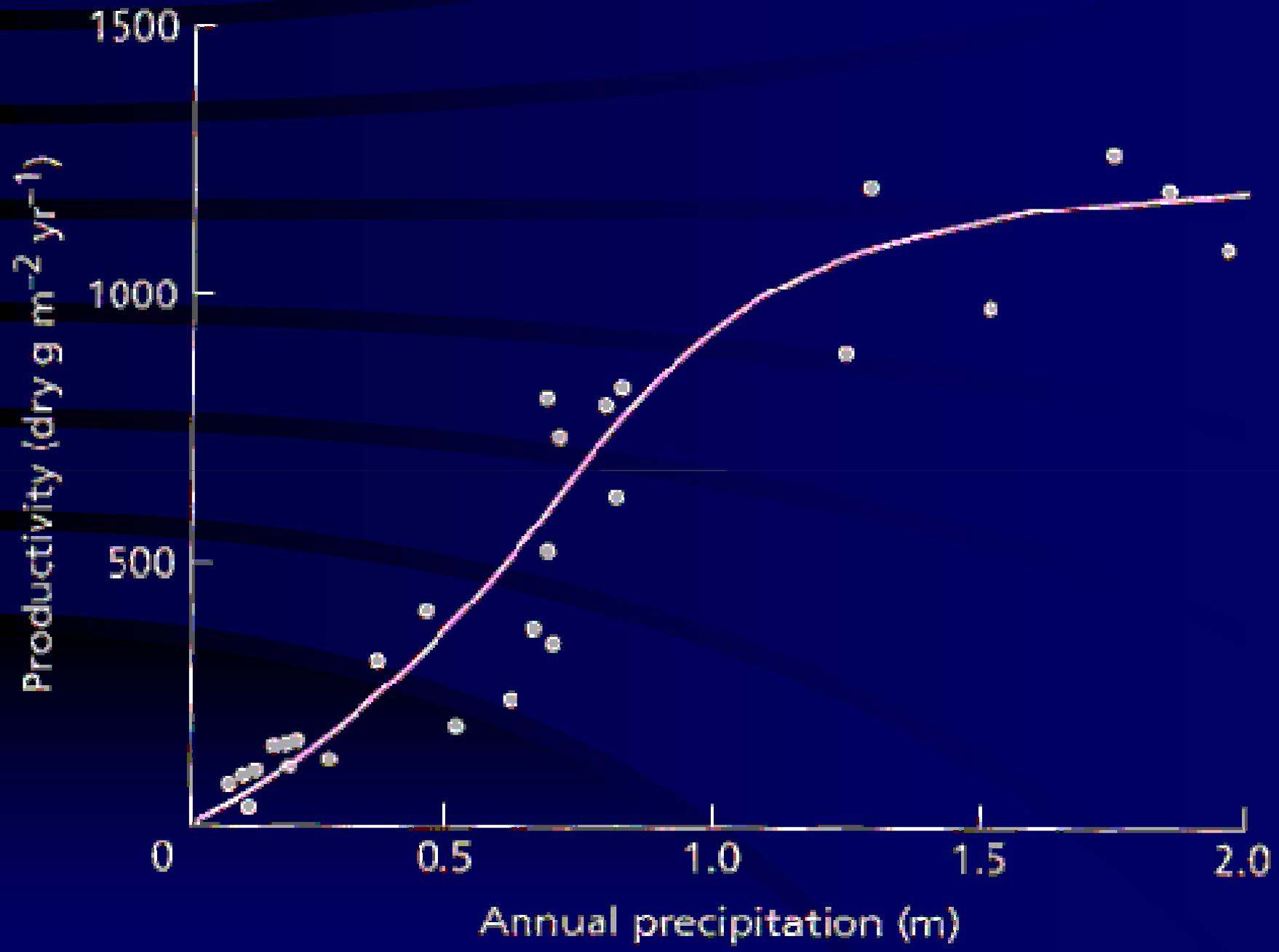


Xylem  
vessel

Endodermis Cortex

Soil





- Difusão:
- primeira lei de Fick
- $J = D( [c_2 - c_1] / (x_2 - x_1) )$
- $J = \text{constante} \times (\text{gradiente de conc.}) / \text{distancia}$

- segunda lei de Fick
- $\text{tempo} = [( \text{distancia} )^2 K ] / D$

- PARA UMA MOLECULA DIFUNDINDO ATRAVES DE UMA CELULA:

- $D = 10^{-9} \text{ m}^2 \text{ s}^{-1}$ ,  $x = 50 \text{ } \mu\text{m} (= 50 \times 10^{-6} \text{ m})$

- $t = \frac{(50 \times 10^{-6} \text{ m})^2}{D} = 2.5 \text{ s}$

- $10^{-9} \text{ m}^2 \text{ s}^{-1}$

- PARA UMA DISTÂNCIA DE 1 METRO

- $t = \frac{1 \text{ m}}{D} = 10^9 \text{ s} = 24 \text{ ANOS}$

- $10^{-9} \text{ m}^2 \text{ s}^{-1}$

$$\Psi_{\text{H}_2\text{O}} = \Psi_{\text{osmótico}} + \Psi_{\text{pressão}} + \Psi_{\text{gravitacional}} + \Psi_{\text{mátrico}}$$

- *Potencial hídrico*
- Água pura =  $0 \Psi$   
maior potencial químico possível, correspondente ao máximo em energia livre associada com a água.
- Solutos, pressão, potencial eletroquímico, força gravitacional etc. interferem na energia livre da água e portanto reduzem o potencial hídrico  $-\Psi < 0 \Psi$ .

$$\Psi_{\text{osmótico}} - \text{efeito dos solutos dissolvidos. } \Psi_s \\ = -RTc_s$$

$\Psi_{\text{pressão}}$  - pressão de turgor originária da parede (positiva ou negativa).

$\Psi_{\text{mátrico}}$  - efeitos de adesão e adsorção das superfícies em contato com a água.

-100 MPa

$$\frac{1000}{10}$$

- Potenciais nos compartimentos do continuum solo-planta-atmosfera.

slight

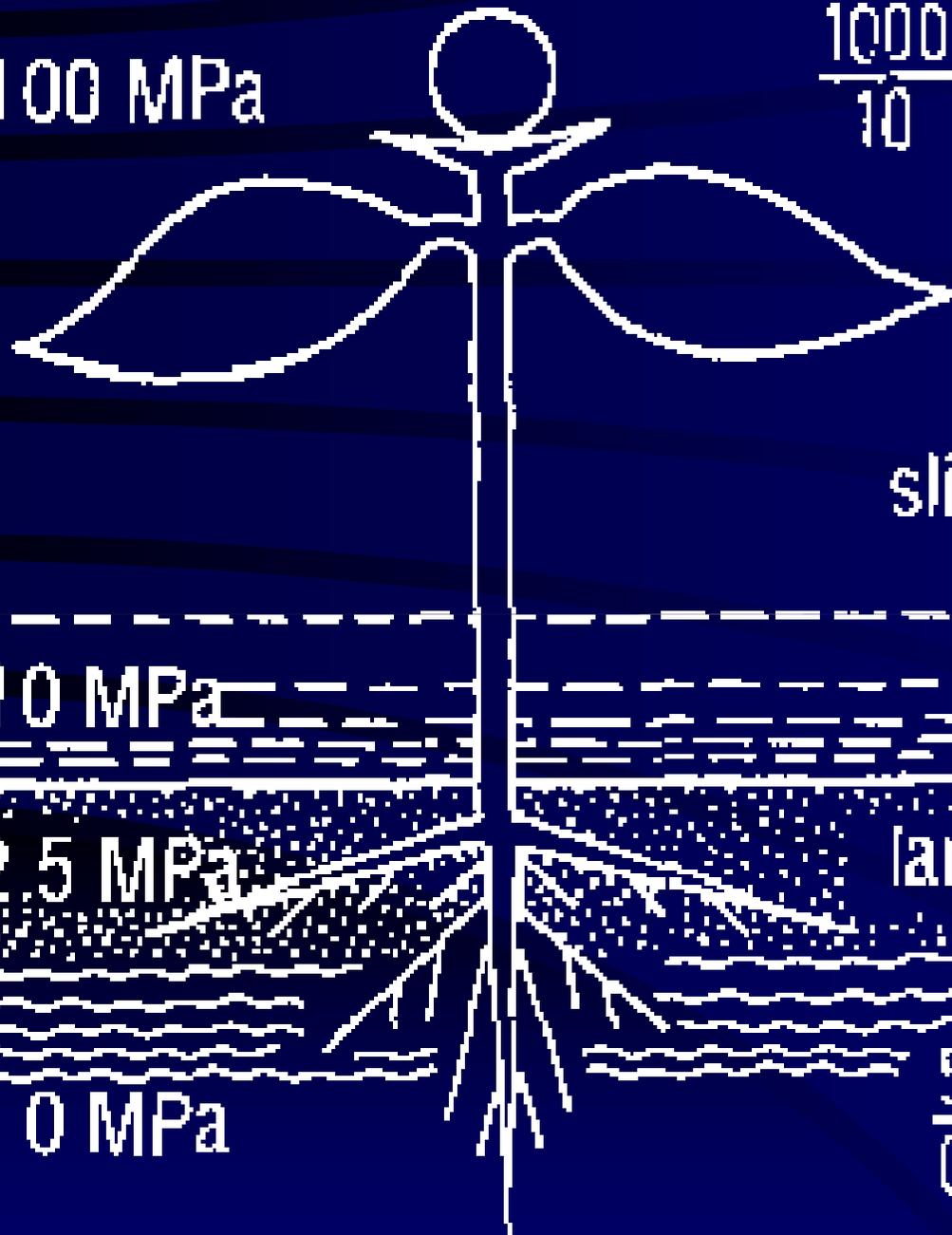
-10 MPa

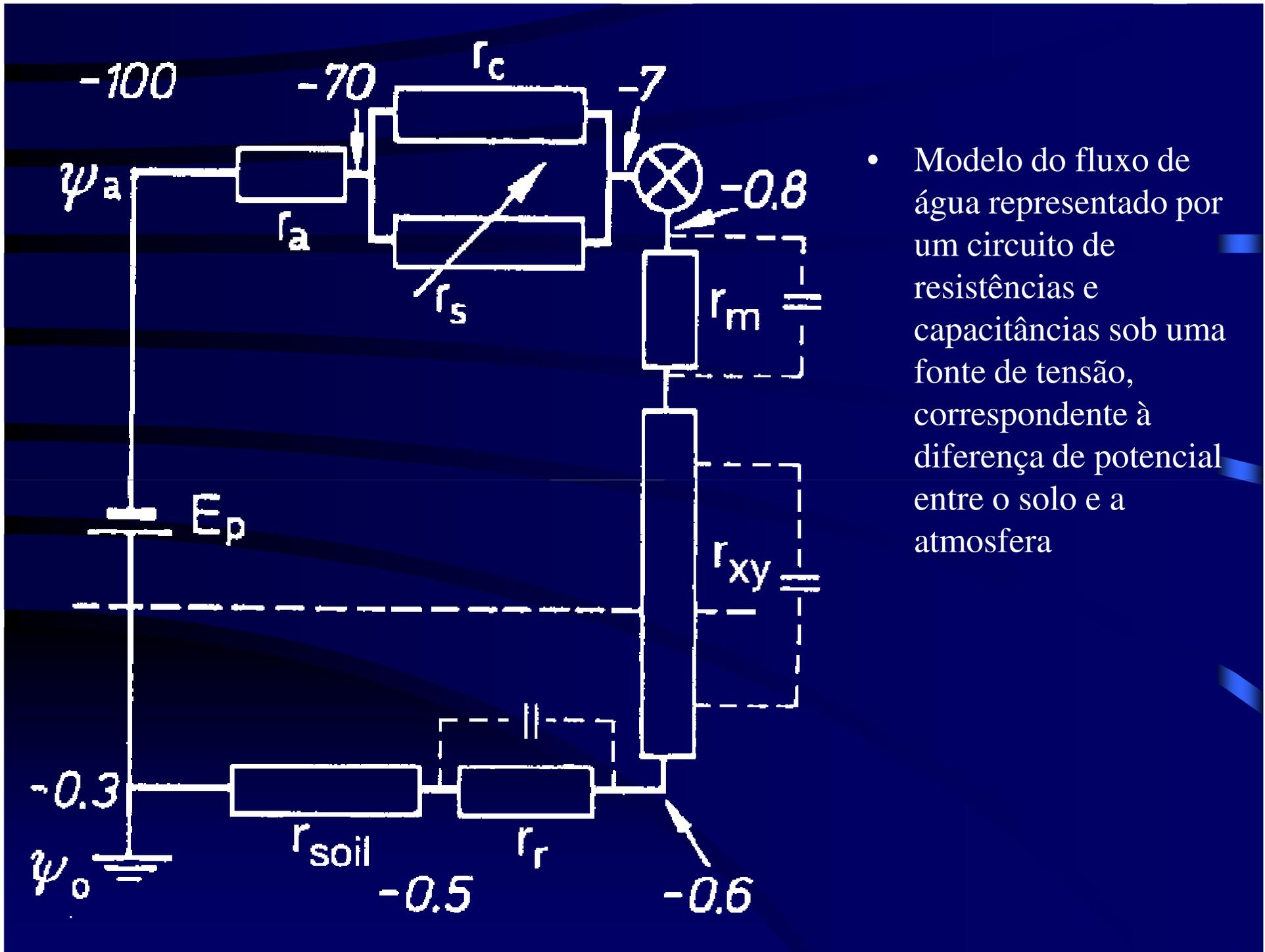
-2.5 MPa

large

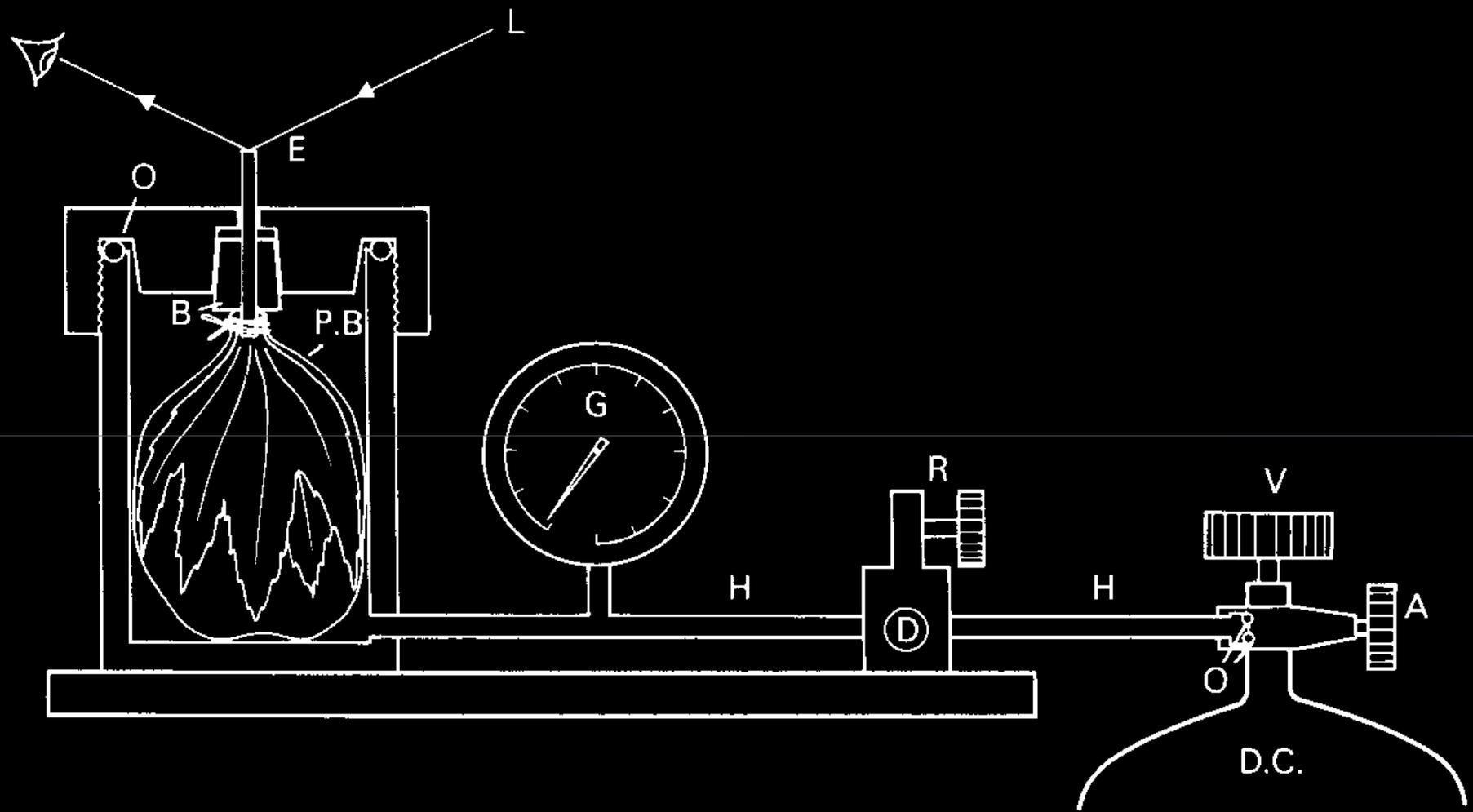
0 MPa

$$\frac{5}{0}$$

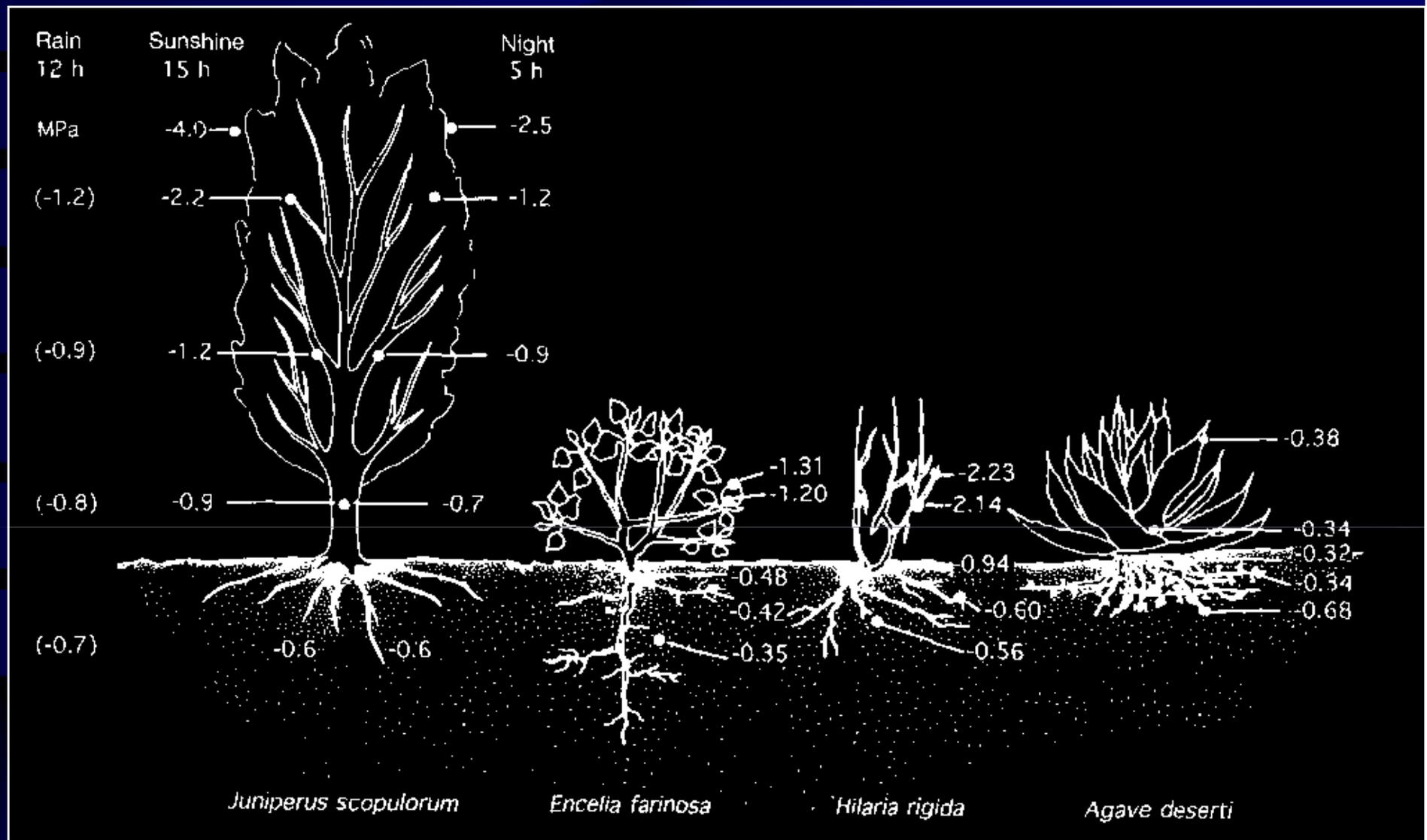




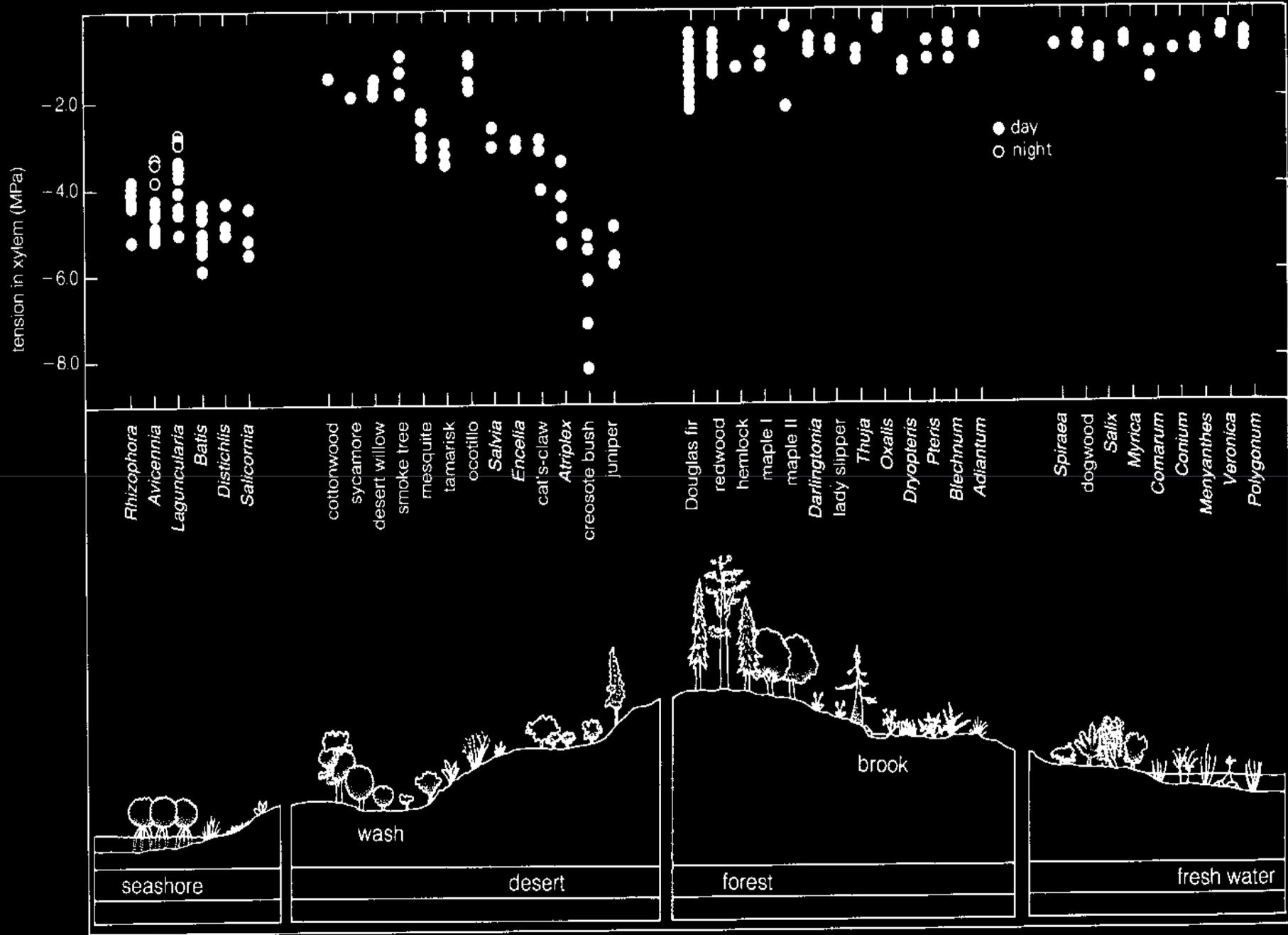
- Modelo do fluxo de água representado por um circuito de resistências e capacitâncias sob uma fonte de tensão, correspondente à diferença de potencial entre o solo e a atmosfera

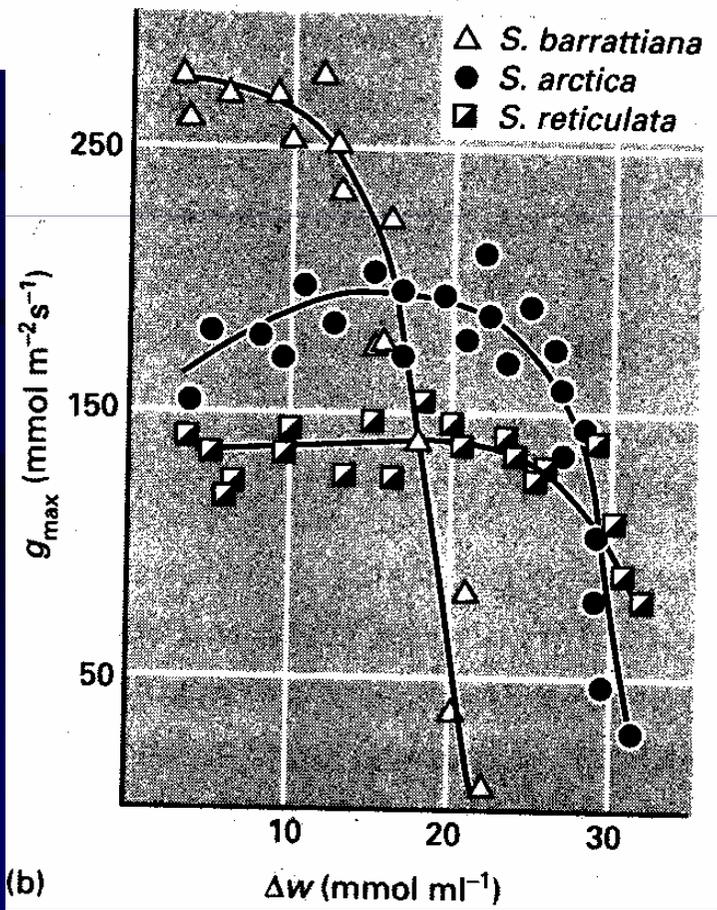
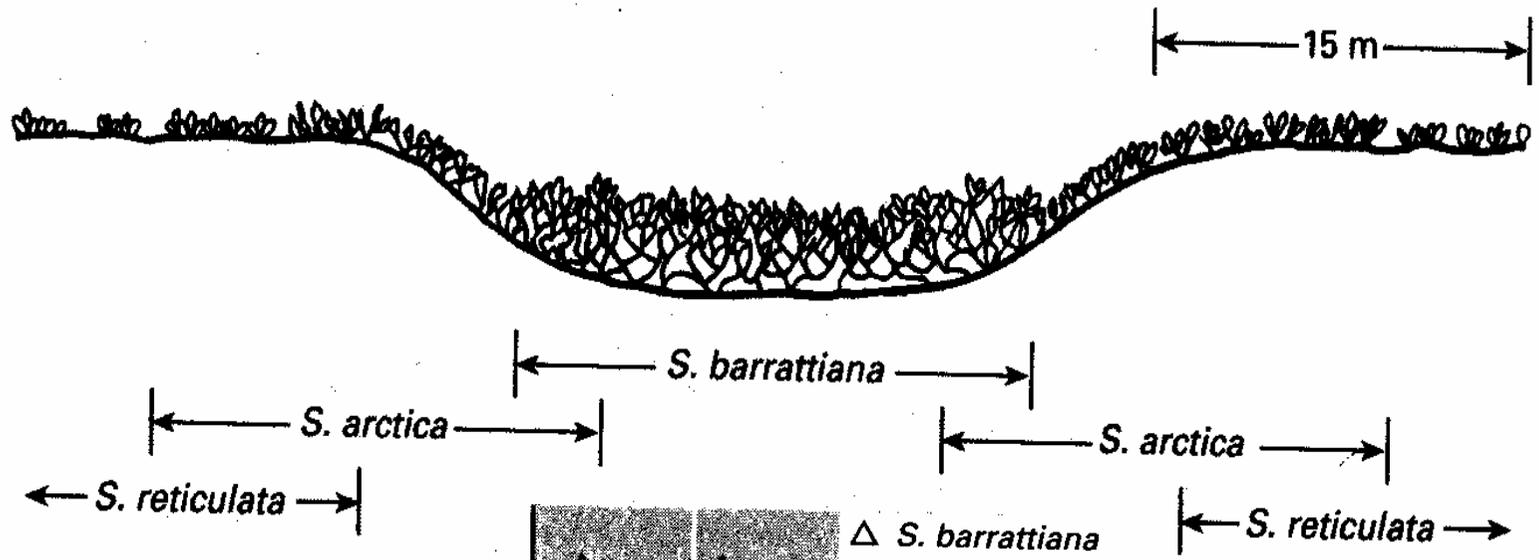






- Perfis do continuum de potenciais hídricos em plantas de regiões áridas e semi-desérticas representando várias formas de crescimento.





(b)

Stomatal resistance ( $s\ cm^{-1}$ )

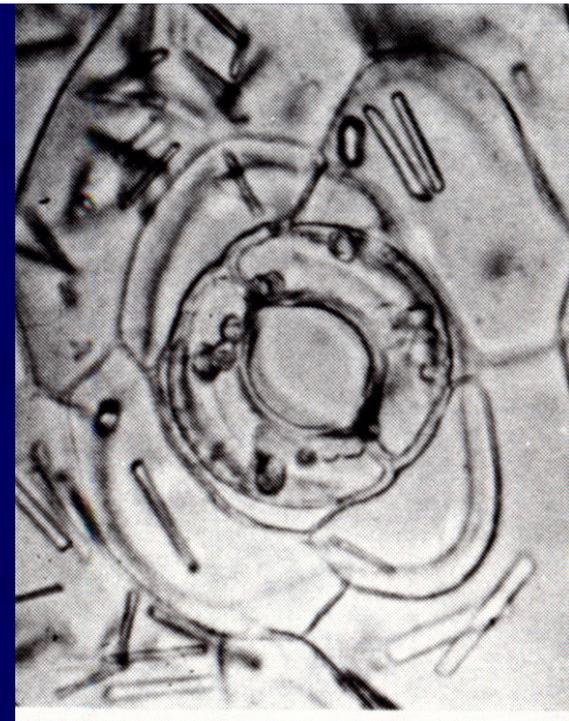
0.4 2 1.0 0.5 0.4

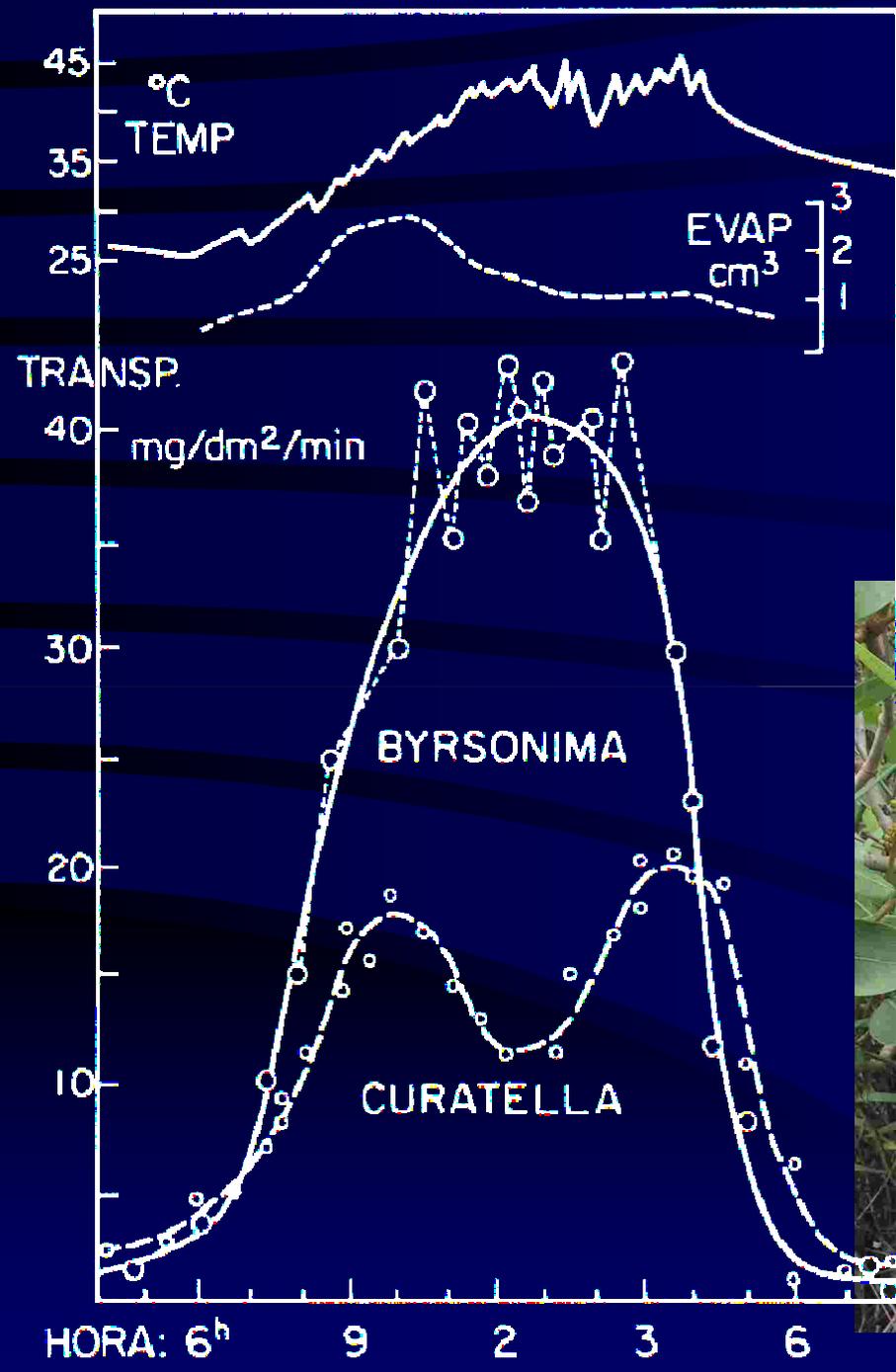


- Succulents
- Evergreen conifer
- Deciduous woody plants
- Herbs from shaded places
- Evergreen woody plants
- Desert and steppe
- Deciduous fruit tree
- Wild graminoids
- Cultivated C3 grasses
- Cultivated C4 grasses
- Herbaceous crops
- Herbs from open habitats
- Wetland plants



Stomatal conductance ( $cm\ s^{-1}$ )





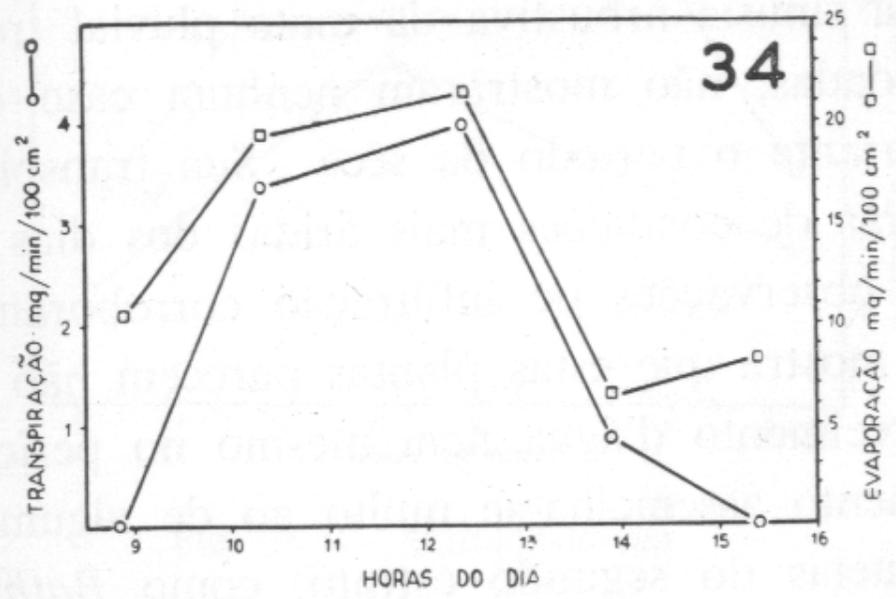


Fig. 34 — *Geonoma schottiana*.

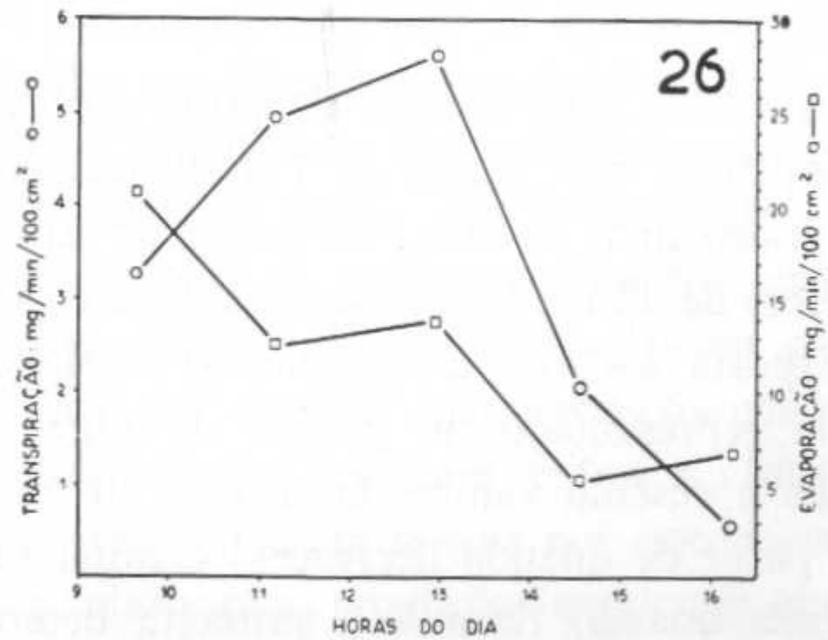


Fig. 26 — *Alchornea triplinervia*.

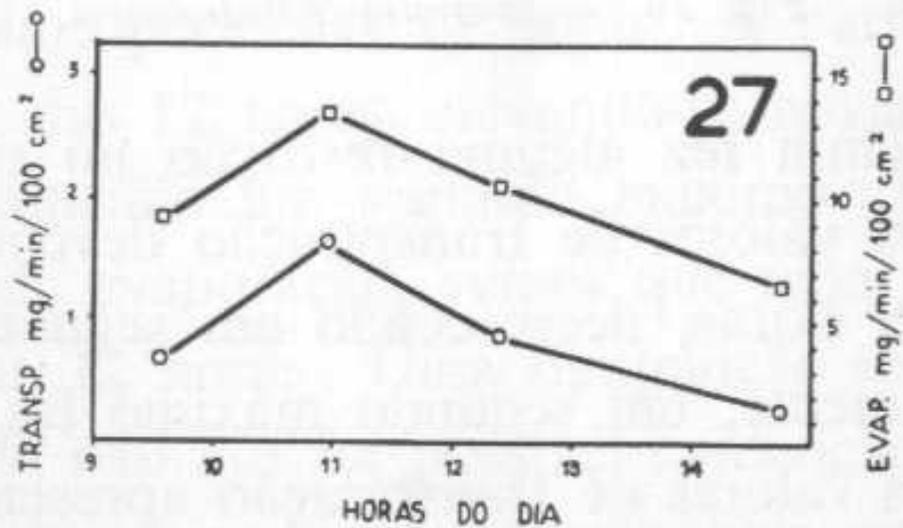


Fig. 27 — *Euterpe edulis*.

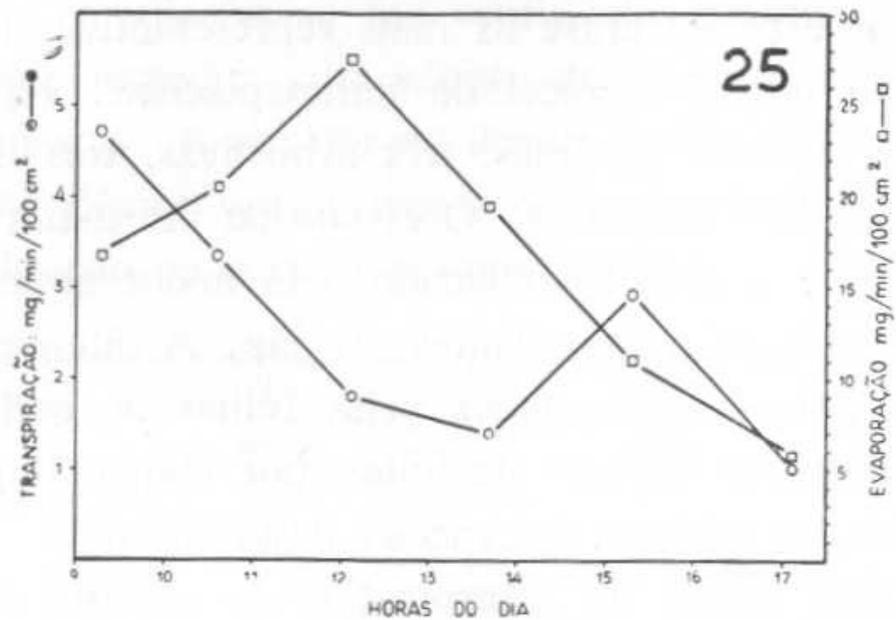


Fig. 25 — *Affonsea edwallii*.

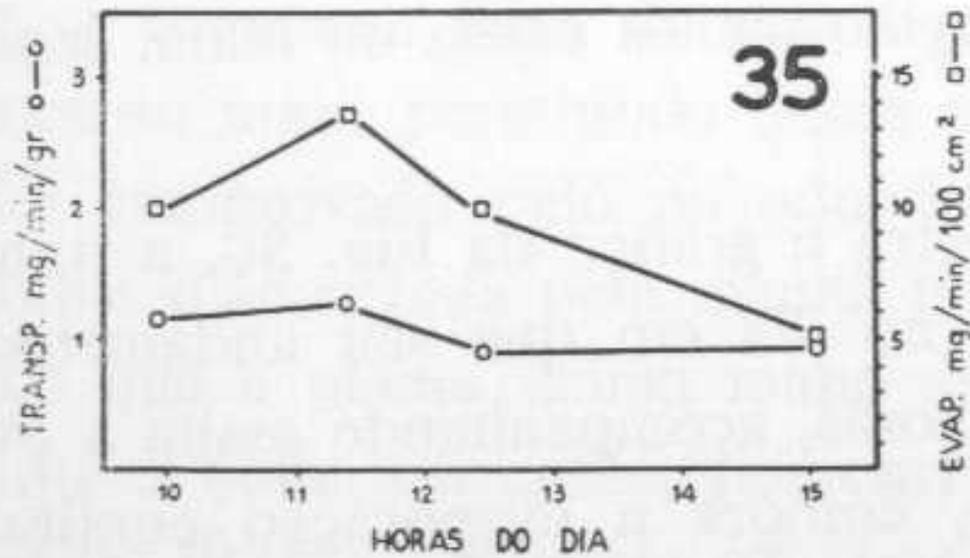


Fig. 35 — *Alsophila longipetiolata*.

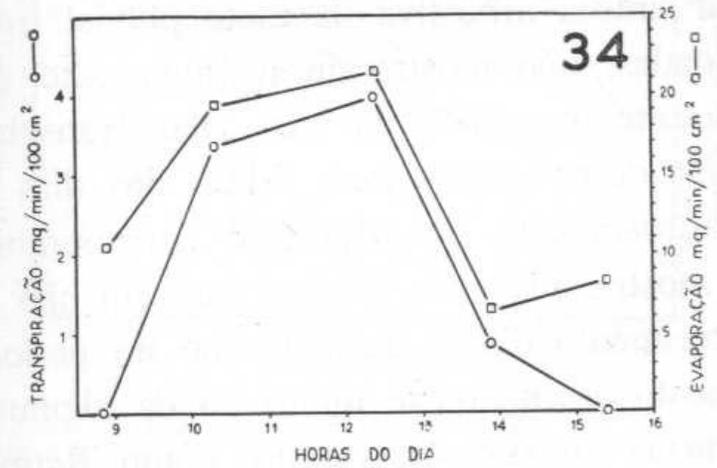


Fig. 34 — *Geonoma schottiana*.

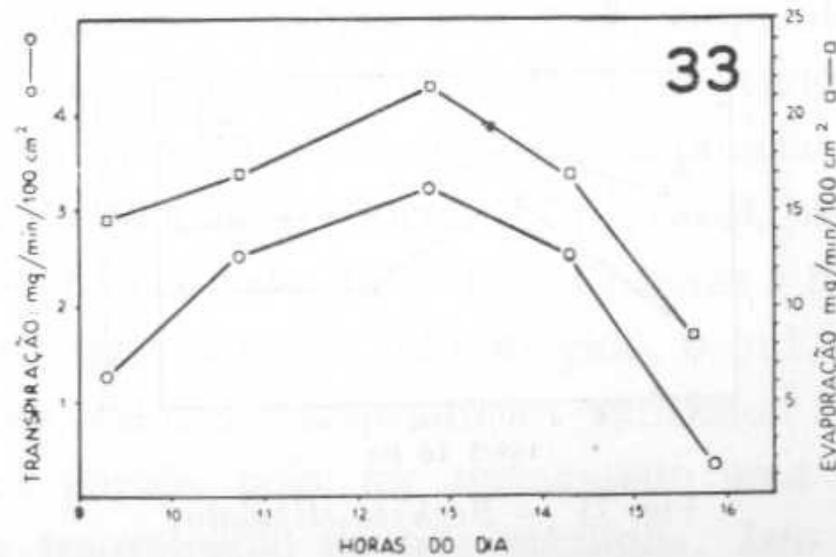
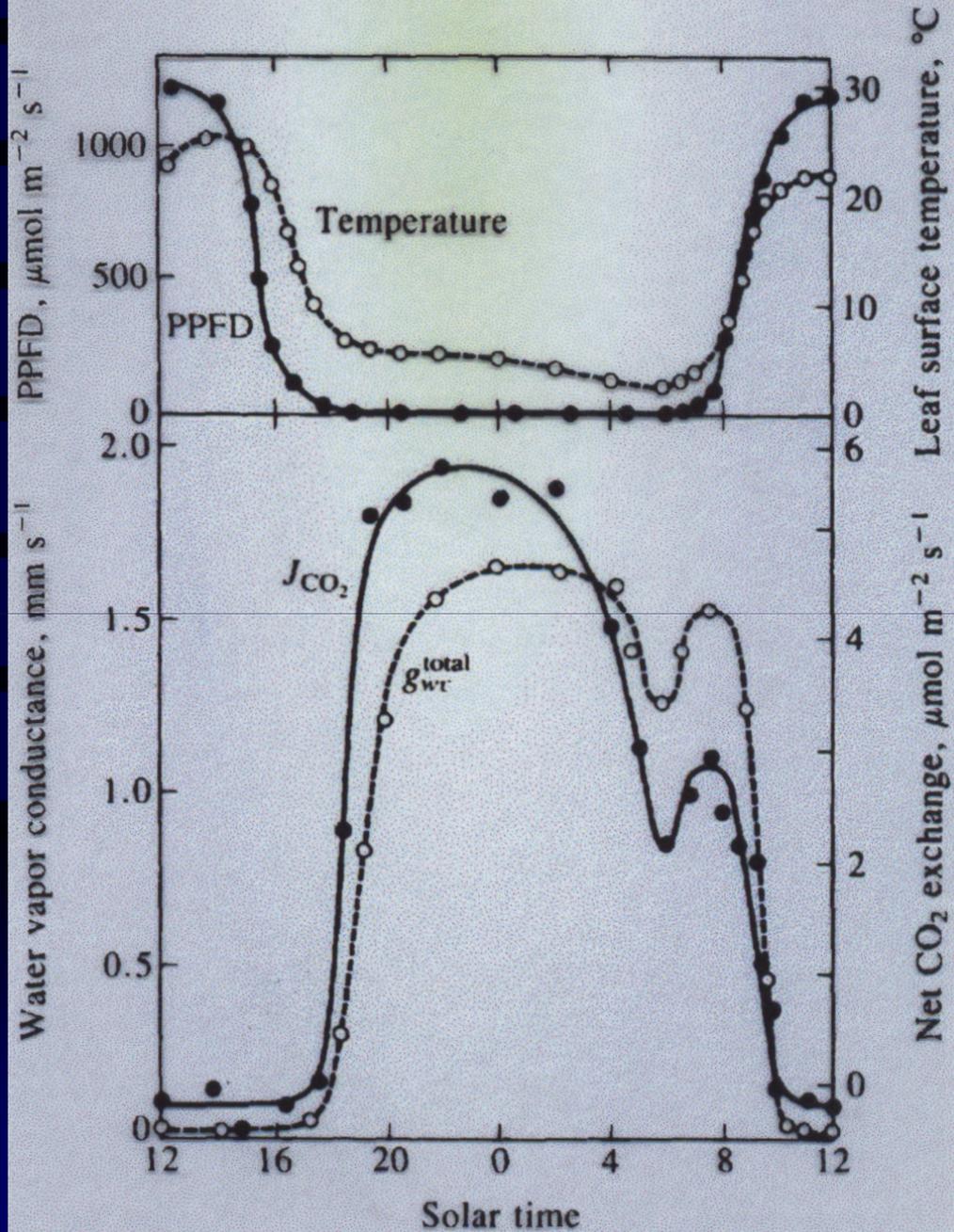
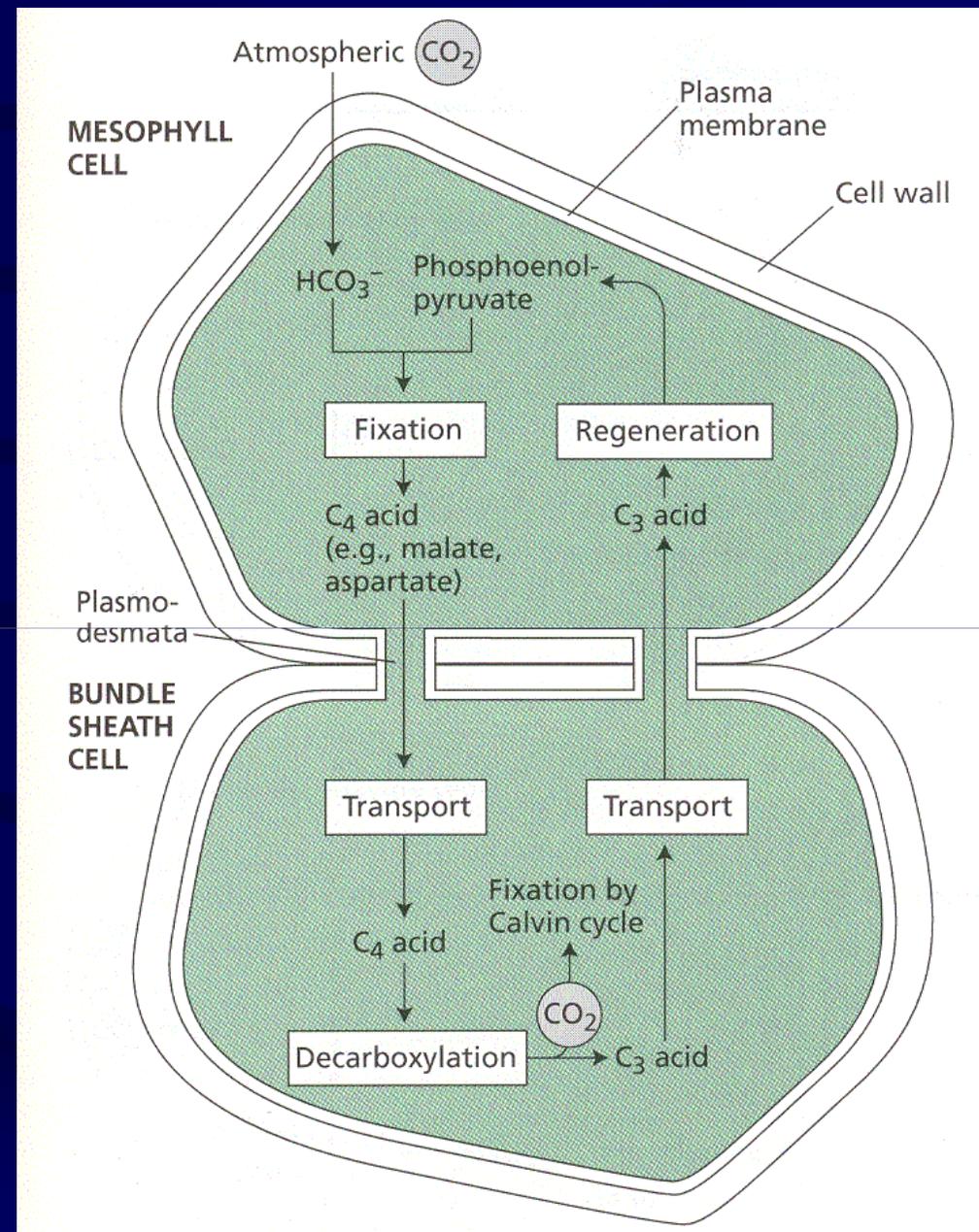
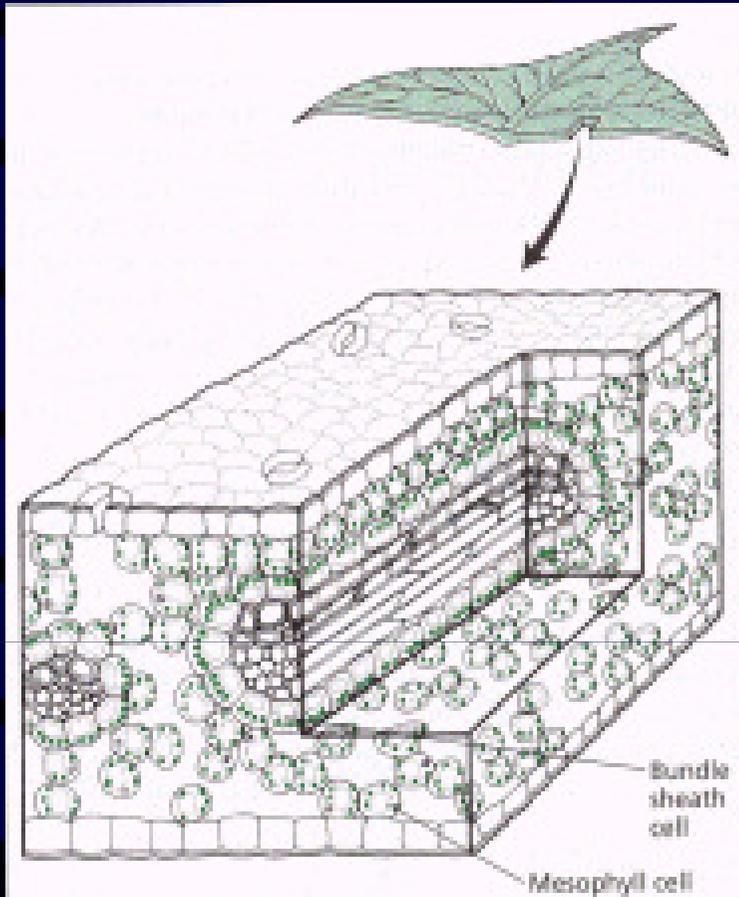


Fig. 33 — *Geonoma gamiova*.



$CO_2$





**CAM**

**C4**

**C3**

Eficiência do uso  
da água  
mol CO<sub>2</sub> : H<sub>2</sub>O

6 a 30 . 10<sup>-3</sup> (N)  
1 a 4 . 10<sup>-3</sup> (D)

1.7 a 1.4 . 10<sup>-3</sup>

0.6 a 1.3 . 10<sup>-3</sup>

Assimilação  
máxima  
micromoles m<sup>-2</sup>s<sup>-1</sup>

0.5 a 2.5 (N)  
7.0 a 8.0 (D)

25-50

10 a 25

Produtividade  
Máxima  
g PS m<sup>-2</sup> d<sup>-1</sup>

1.5 a 1.8

400 a 500

50 a 200

# Poikilohydric plants

# Homoiohydric plants

Bacteriophyta  
Cyanophyta

Lichenes

Mycophyta

very dry air

Xerophytic  
Bryophyta  
Ceterach etc.  
Selaginella  
Myriophyllum

Pleurococcus

Trentepohlia

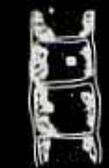


very humid air

Chlorella

water

Bacteriophyta  
Cyanophyta



Ulothrix



Cladophora

Botrydium



Rhynea



Bryophyta



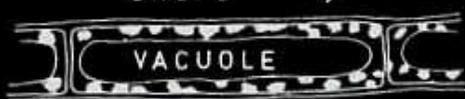
Pteridophyta



Spermalophyta

CUTICLE

Chara



VACUOLE

# RESISTÊNCIA DAS PLANTAS À SECA

Plantas que escapam à seca → EFÊMERAS

