Stomatal Responses to Climate Change: Impact on Terrestrial Carbon and Water Cycles

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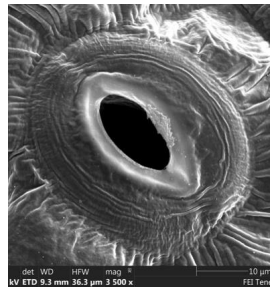
Lab: Plant Environmental Physiology and Stress Signaling

BIAM

Green Solutions for Tomorrow

Institut de Biosciences et biotechnologies d'Aix-Marseille



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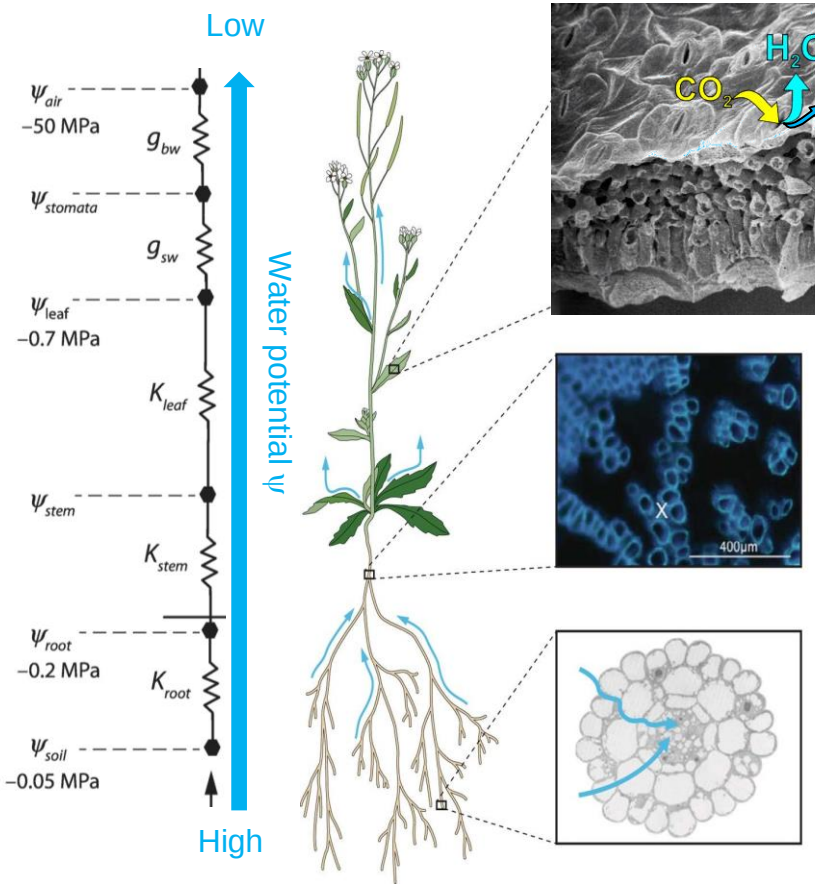
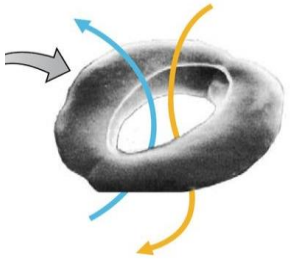
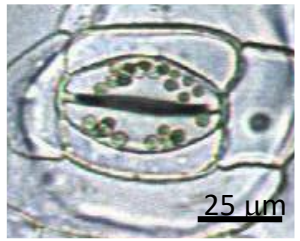
The stomata control gas exchanges between plants and the atmosphere



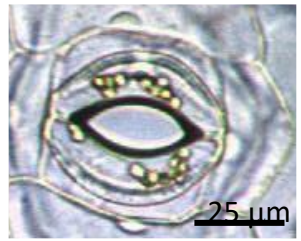


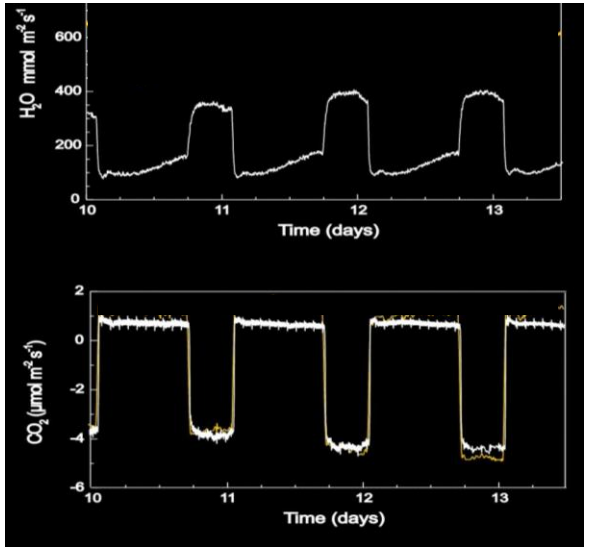


Light

Dark

CO_2





Modified from Maurel C. *et al*. (2015) *Physiol Rev*. **95**, 1321-58.

Stomatal conductance, gs (mmol m^{-2} s^{-1}), represents the rate of gas exchange (CO_2 uptake) and transpiration through leaf stomata

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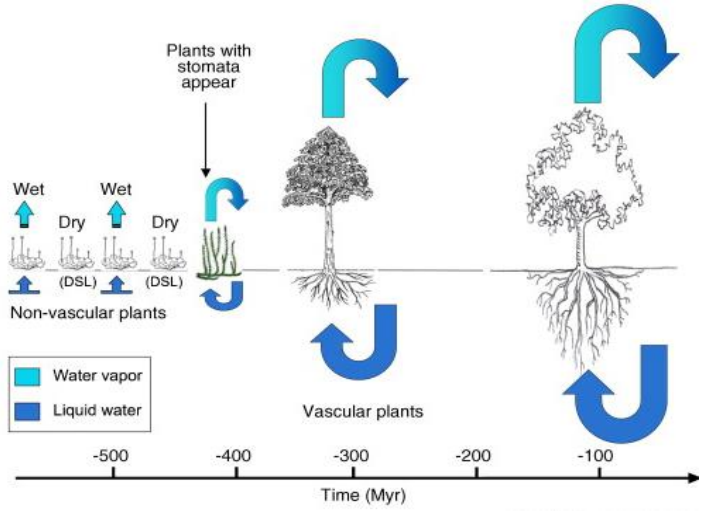
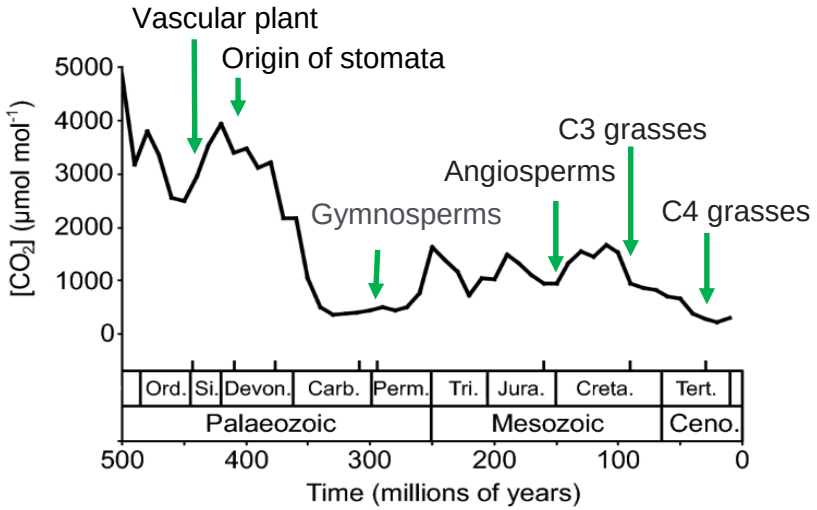
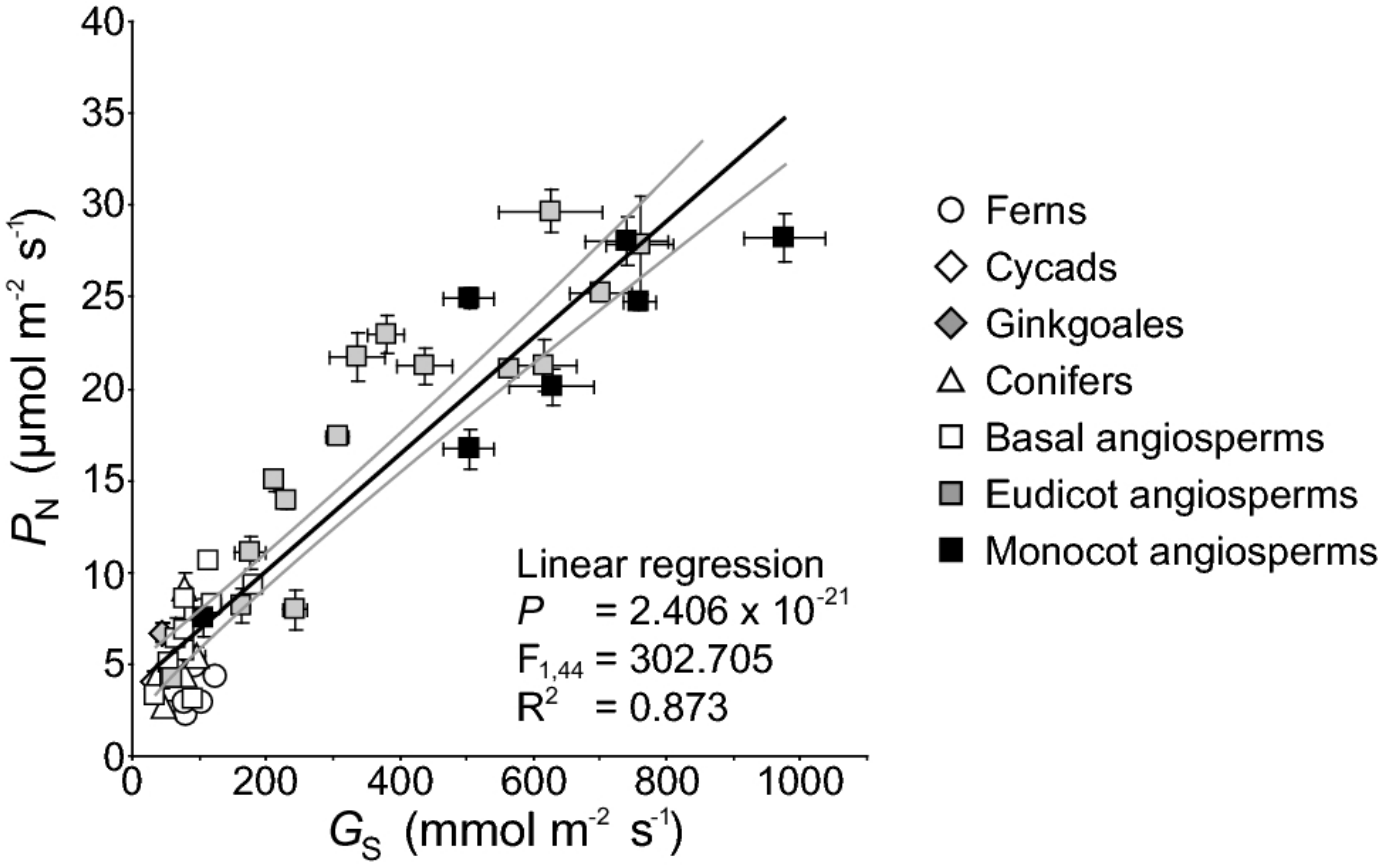
The climate of Earth was and will be influenced by the evolution and expansion of vegetation







Berry JA et al. (2010) Curr Opin Plant Biol.**13**, 233-40.
Haworth, M. *et al.* (2021). *Oecologia* **197**, 867–883.

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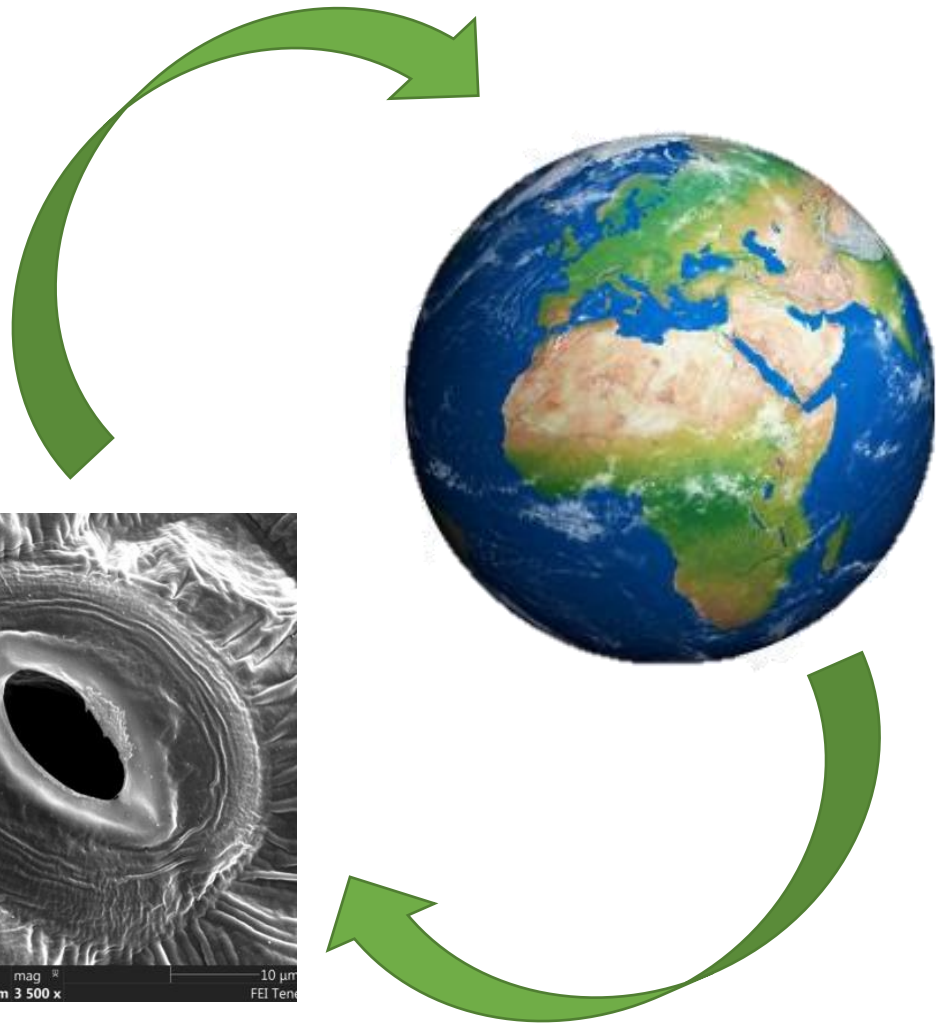
Stomata respond to global carbon and water cycles

Atmospheric water content:
13.000 Km^3

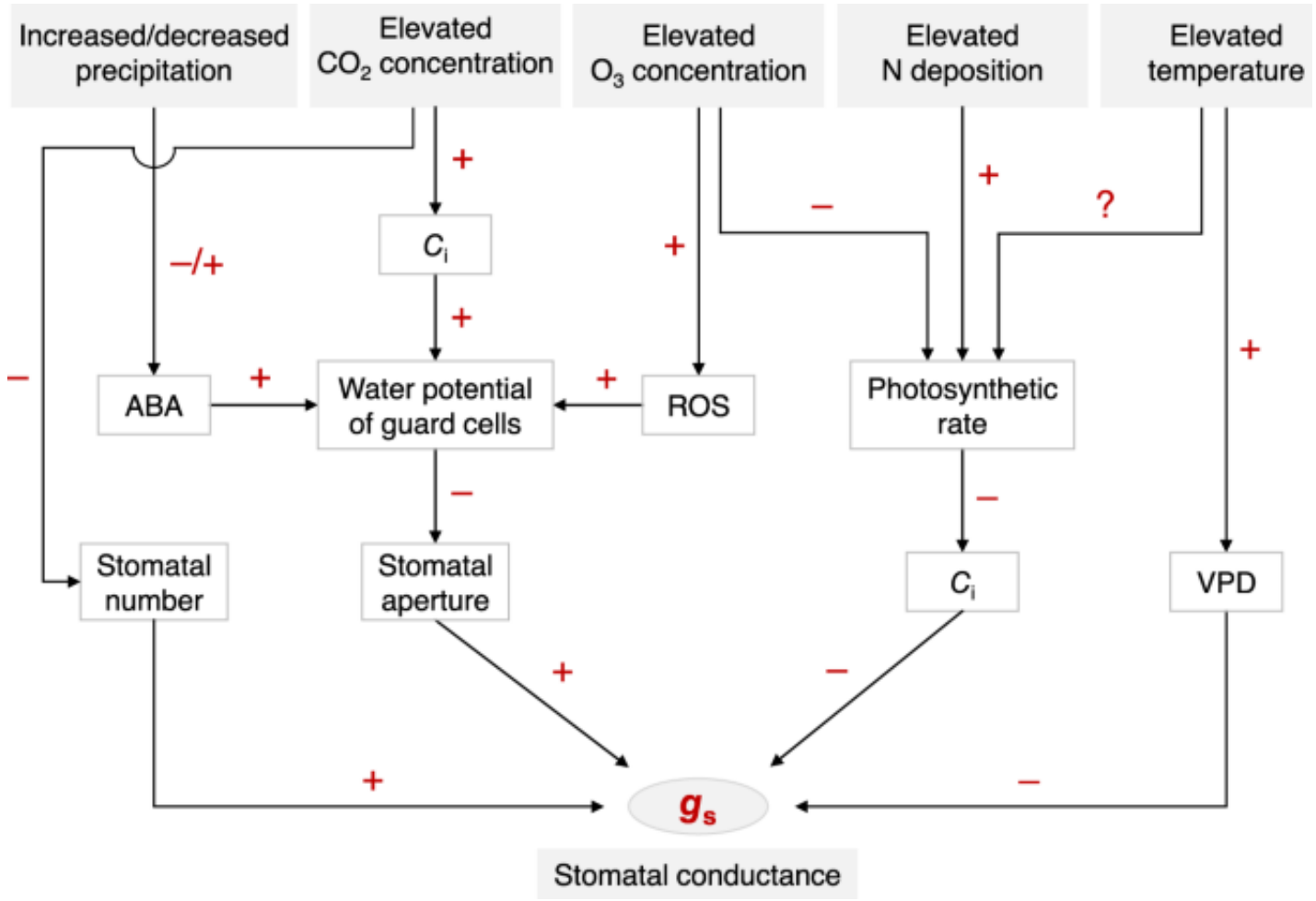
Atmospheric CO_2 :
875Gt



Evapotranspiration:
60.000 Km^3 /year

Amount of CO_2 assimilated
40 Gt /year

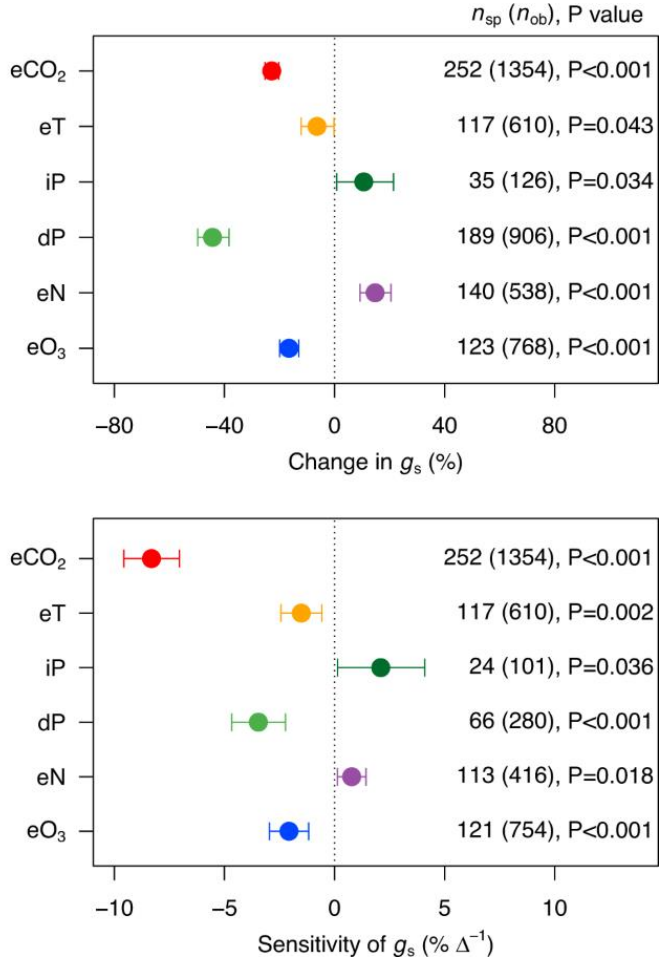
Global change factors' impact stomatal conductance



Liang, X. *et al.* (2023). *Nat Commun* **14**, 2188.

Stomatal responses to single global change factors

- 5352 pairs of treatment versus control observations for 444 species across different vegetation biomes



- Stomatal conductance was reduced by:
  - eCO_2 : –8.3% per 100 ppm CO_2 increase
  - eT : –1.5% per 1 °C temperature increase
  - dP: –3.5% per 10% precipitation decrease
  - eO_3: and –2.1% per 10 ppb O_3 increase
- Stomatal conductance was enhanced by:
  - iP: of +2.1% per 10% precipitation increase
  - eN: +0.8% per 1 g m^{-2} $year^{-1}$ nitrogen increase

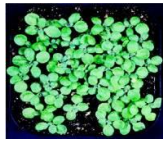
➡ How might the responses of gs to multiple-factor combinations vary, additive, synergistic, or antagonistic ?

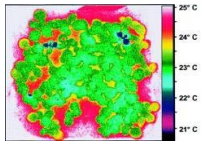
Liang, X. *et al.* (2023). *Nat Commun* **14**, 2188.

Understanding the physiological and molecular mechanisms involved in the regulation of stomatal conductance

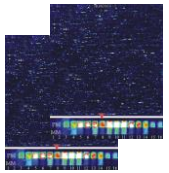
❖ Physiological mechanisms :

Genetic screens

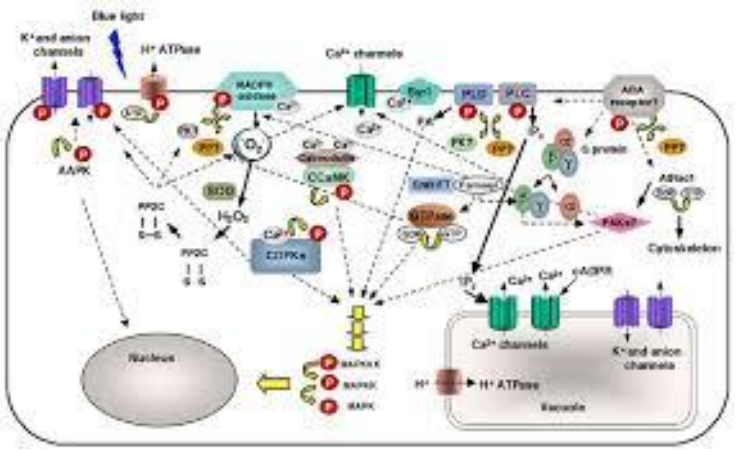




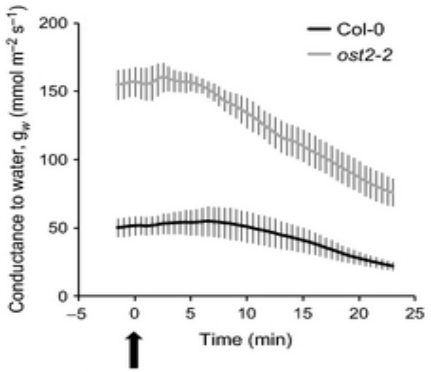
Gene chip experiments with RNA extracted from guard cell

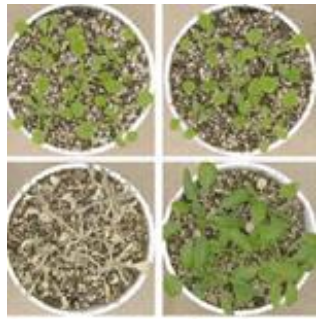


❖ Molecular mechanims:



Isolation of guard cell signal transduction related-genes





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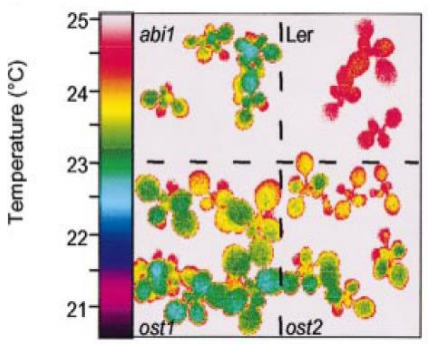
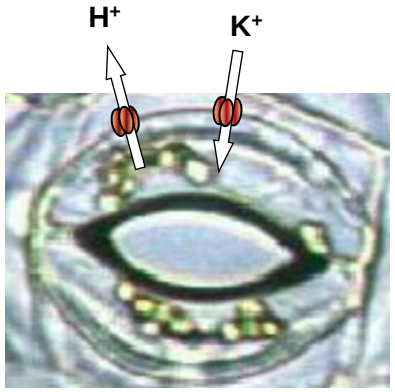
Dissection of guard cell signal transduction pathways



AHA2

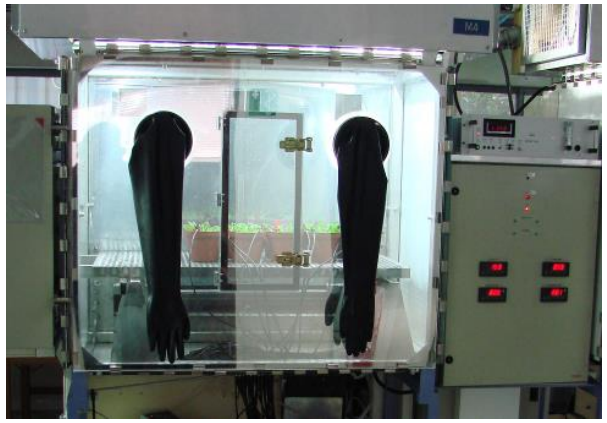
AHA1
EMBO 2007

CAX1/CAX3
Plant Physiol. 2012

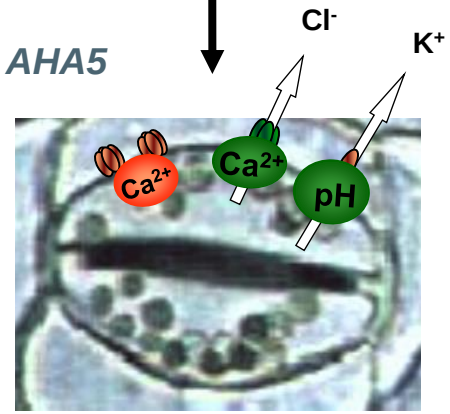


KAT1/KAT2
PNAS 2008
Plant Physiol. 2014

MYB60 *(TF)*
Current Biol. 2005



AHA5



At*MRP5*
JBC 2008
Plant Cell 1999
PNAS 1997

At*CIC-C*
Plant J 2010

GORK
FEBS 2017

HSP70/HSP90
Plant Physiol. 2011

ALIX
Current Biol. 2005

PIP2;1
PNAS 2017

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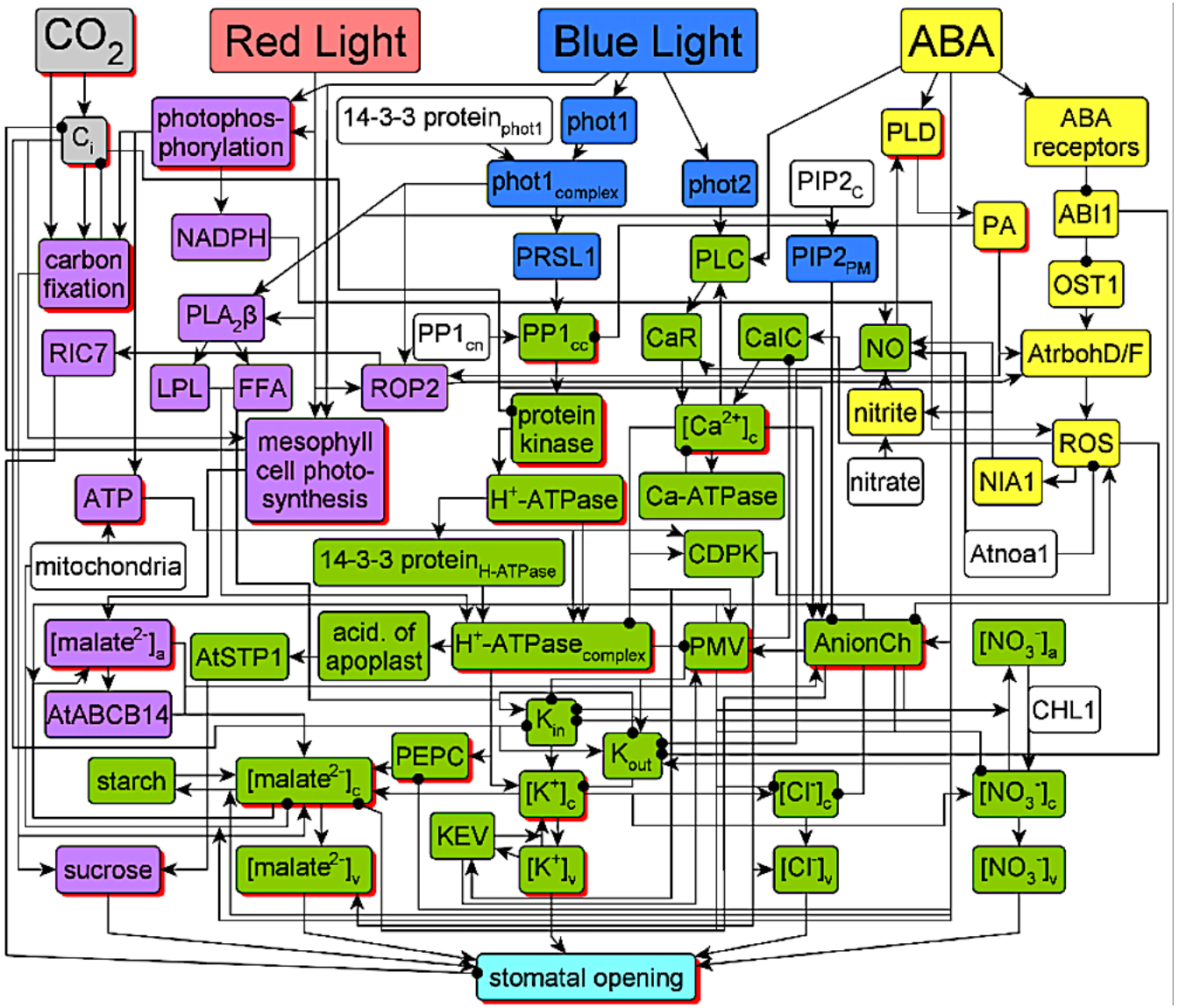
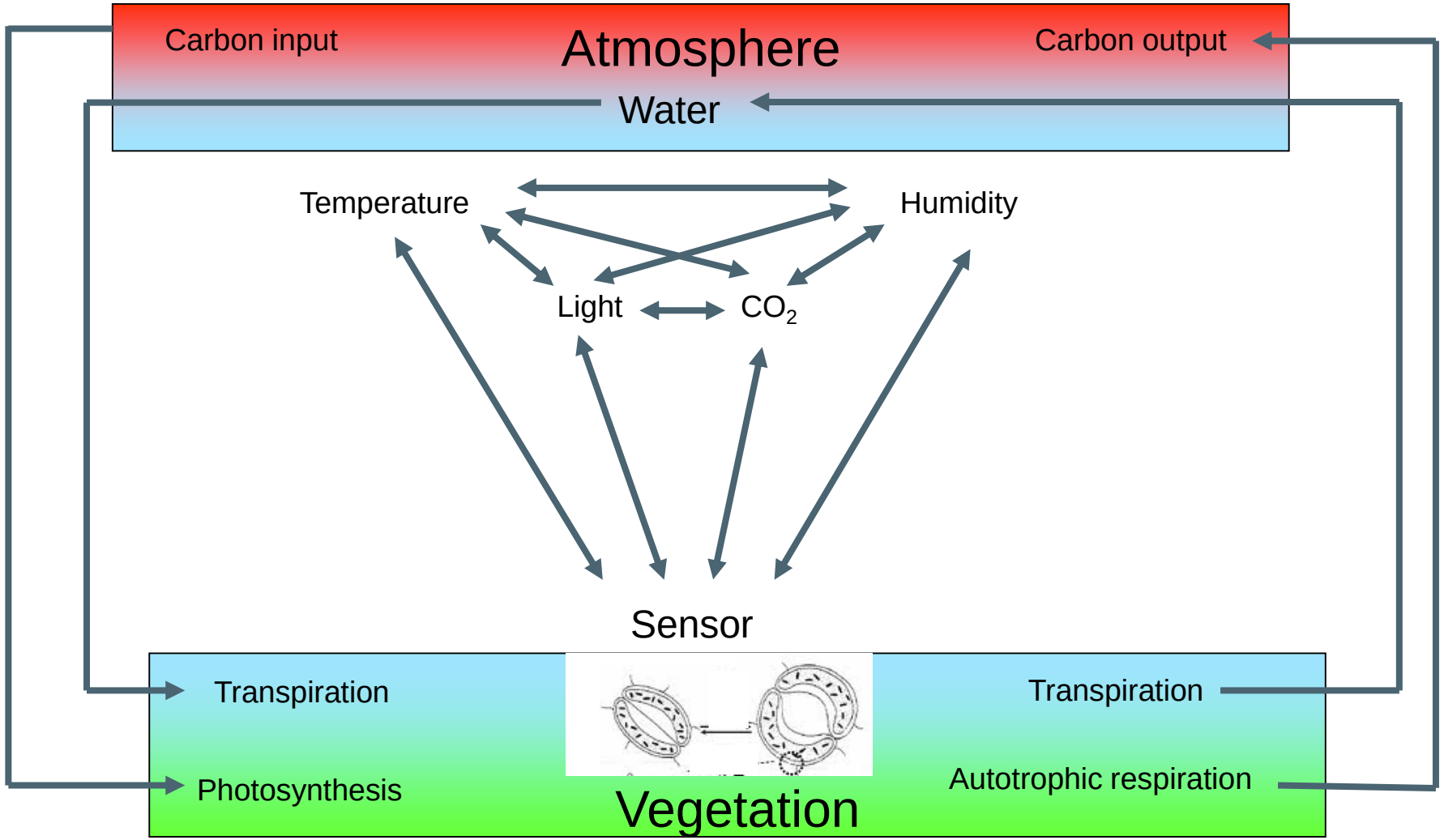
From one signaling component to a regulatory network



Stomata sense and drive environnemental change



Stomata, an opportunity for improvement climate change models

Arabidopsis mutants affected in signal perception

Evaluation of the impact of environnemental parameters on stomatal conductance by phenotypic analyses

Stomatal parameterization in global models

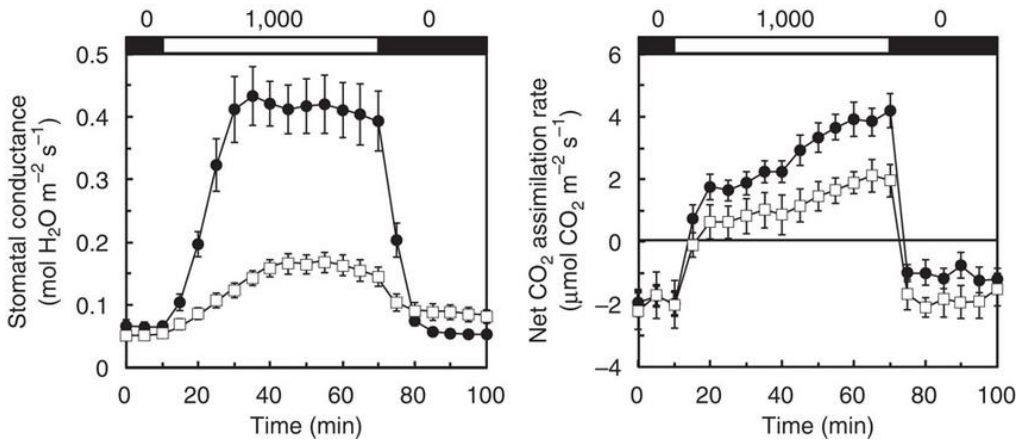
Validation on Arabidopsis and other species

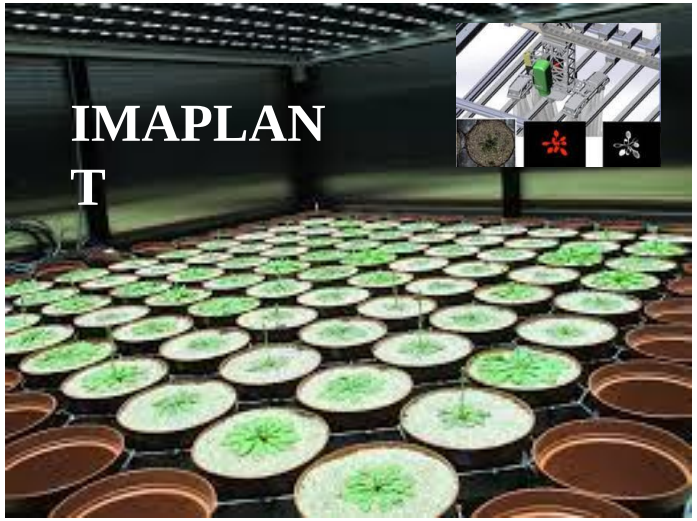
Light

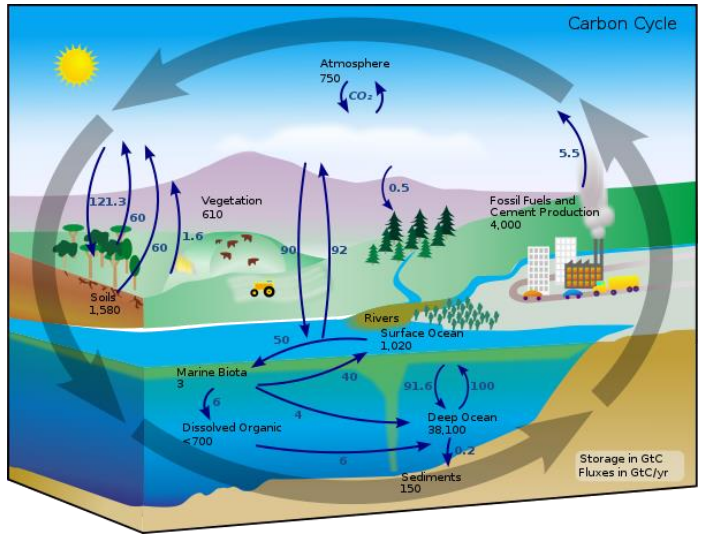
Temperature

CO_2

Humidity







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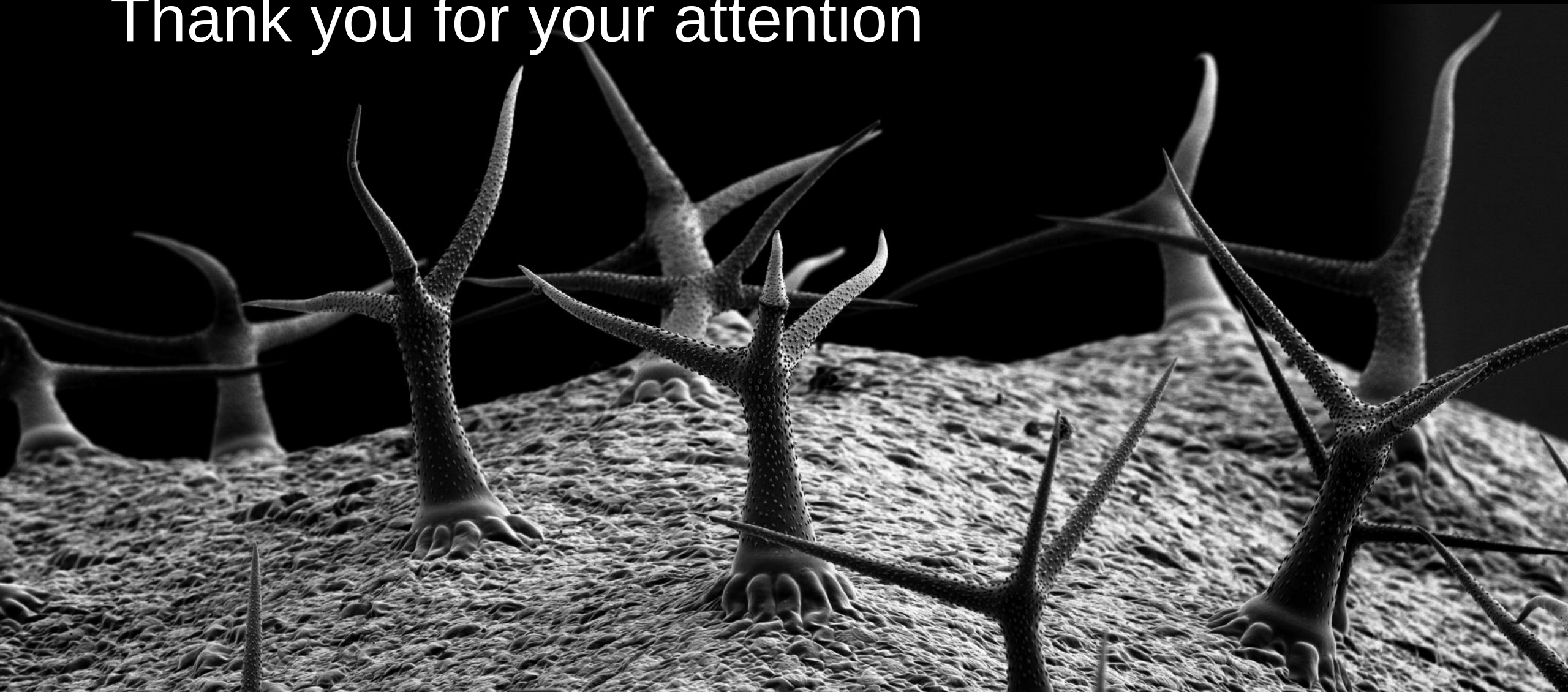
Thank you for your attention



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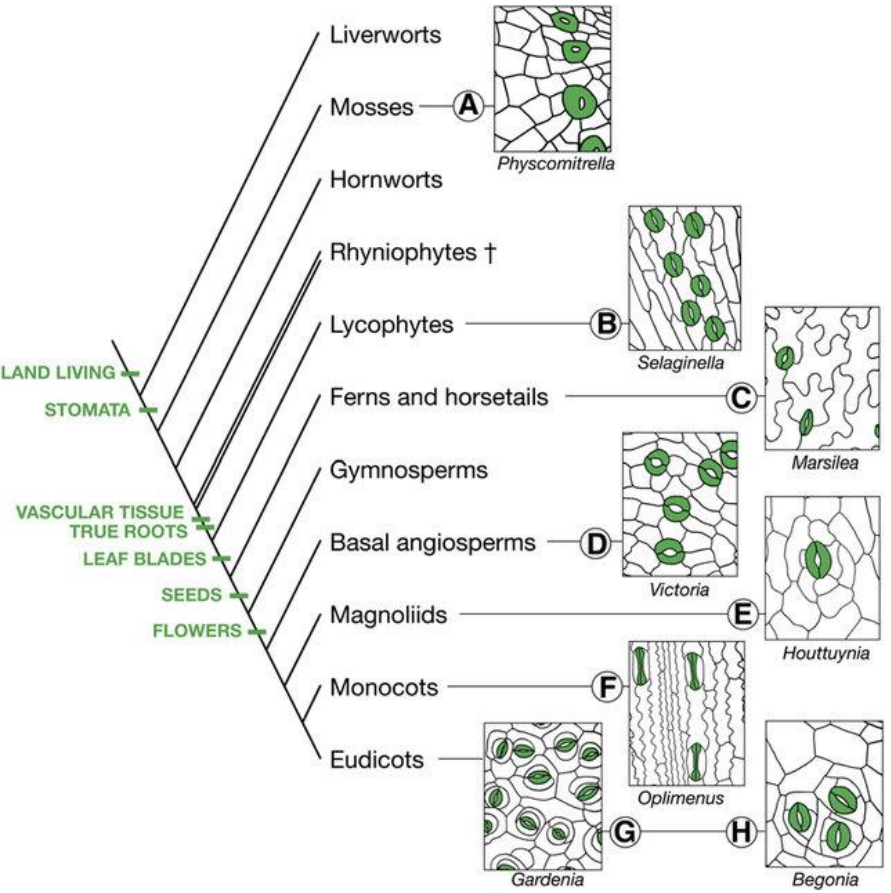
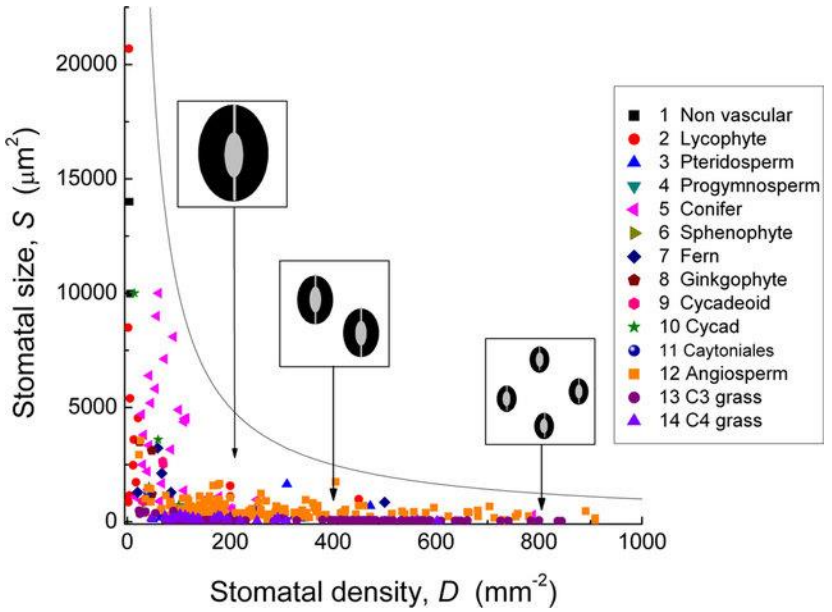
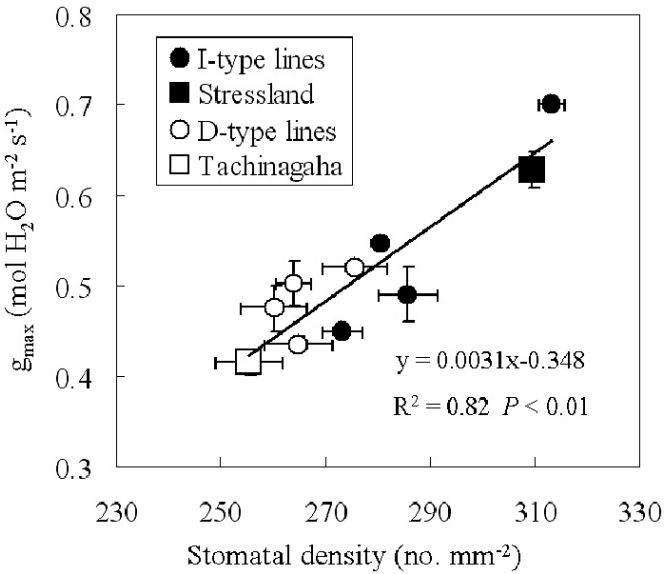
Stomatal conductance is a function of the density, size and degree of opening of the stomata







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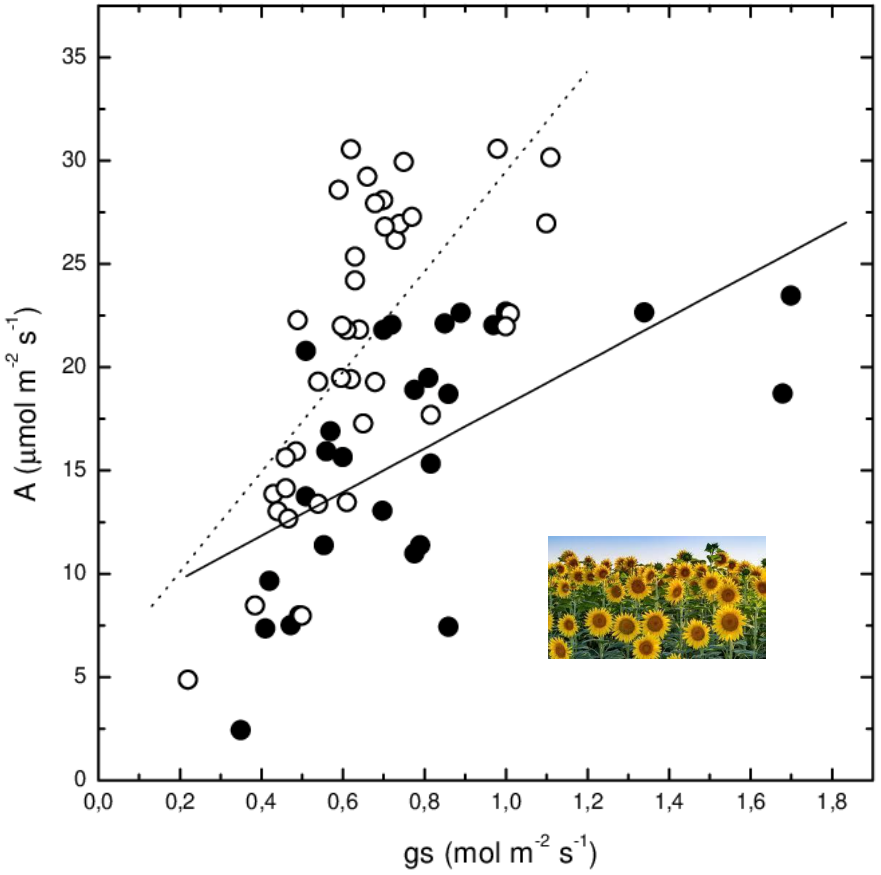
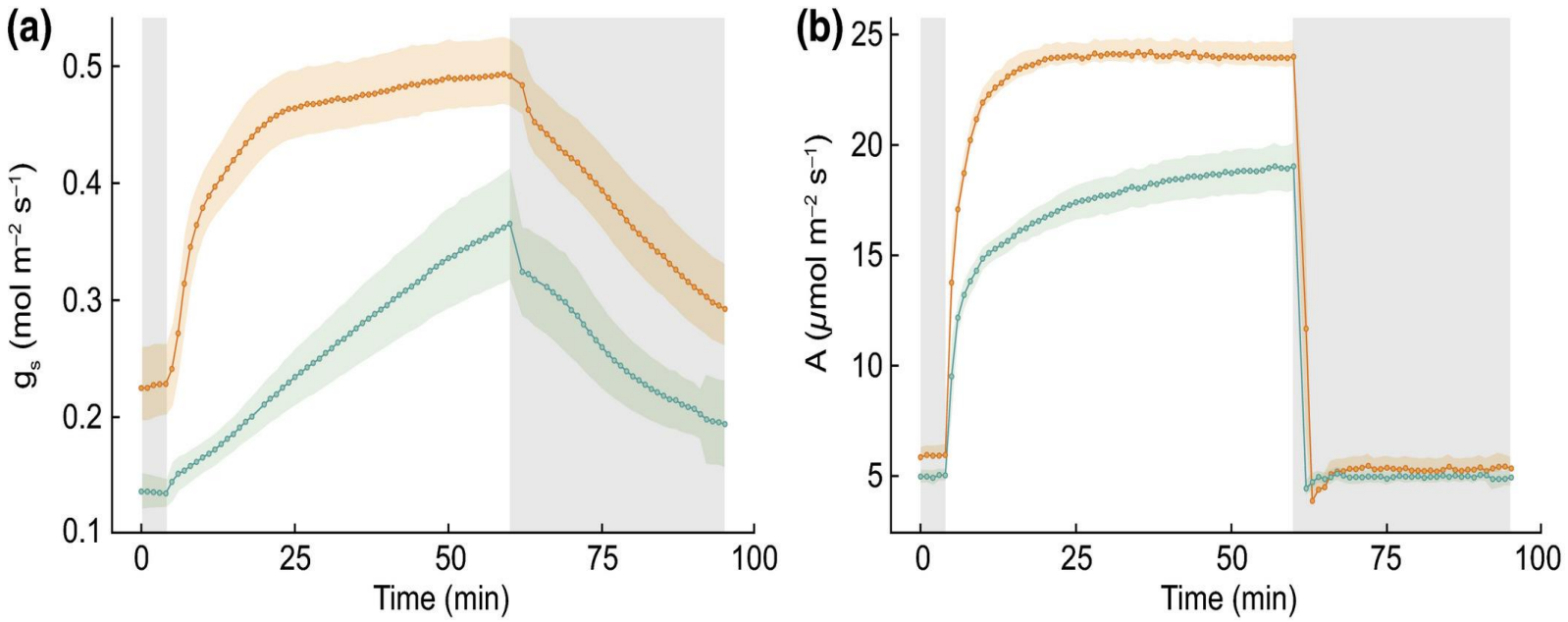


Cechin, I. et al. (2004) *Plant Science*. **166** (5), 1379-1386.



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