明治大学
MEIJI UNIVERSITY

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LECTURE 1-
PLANT ENVIRONMENT.
PLANT STRESS RESPONSES: OXIDATIVE STRESS AND SENESCENCE

LECTURE 2-
PLANT ENVIRONMENT.
LEGUME-RHIZOBIA SYMBIOTIC INTERACTION

LECTURE 3-
PLANT ENVIRONMENT.
AUTOPHAGY IN PLANTS: ONE PROCESS, MULTIPLE PHYSIOLOGICAL FUNCTIONS

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LECTURE 1-

PLANT ENVIRONMENT.

PLANT STRESS RESPONSES: OXIDATIVE STRESS AND SENESCENCE

- **Argentina's agriculture**
- **National Institute of Agricultural Technology (INTA)**

- **Plant stress responses: oxidative stress and senescence**

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FAR FAR AWAY


ARCTIC OCEAN
GREENLAND
ARCTIC OCEAN
UNITED STATES OF AMERICA
CANADA
NORWAY
SWEDEN
FINLAND
RUSSIA
YOU ARE HERE
KAZAKHSTAN
MONGOLIA
UNITED STATES OF AMERICA
ATLANTIC OCEAN
TURKEY
IRAN
AFG.
CHINA
JAPAN
PACIFIC OCEAN
PACIFIC OCEAN
MEXICO
ALGERIA
LIBYA
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SUDAN
INDIA
SOMALIA
GABON
DEM. REP. OF CONGO
ANGOLA
ZAMBIA
NAMIBIA
MADAGASCAR
SOUTH AFRICA
BRAZIL
ARGENTINA
INDONESIA
PAPUA NEW GUINEA
INDIAN OCEAN
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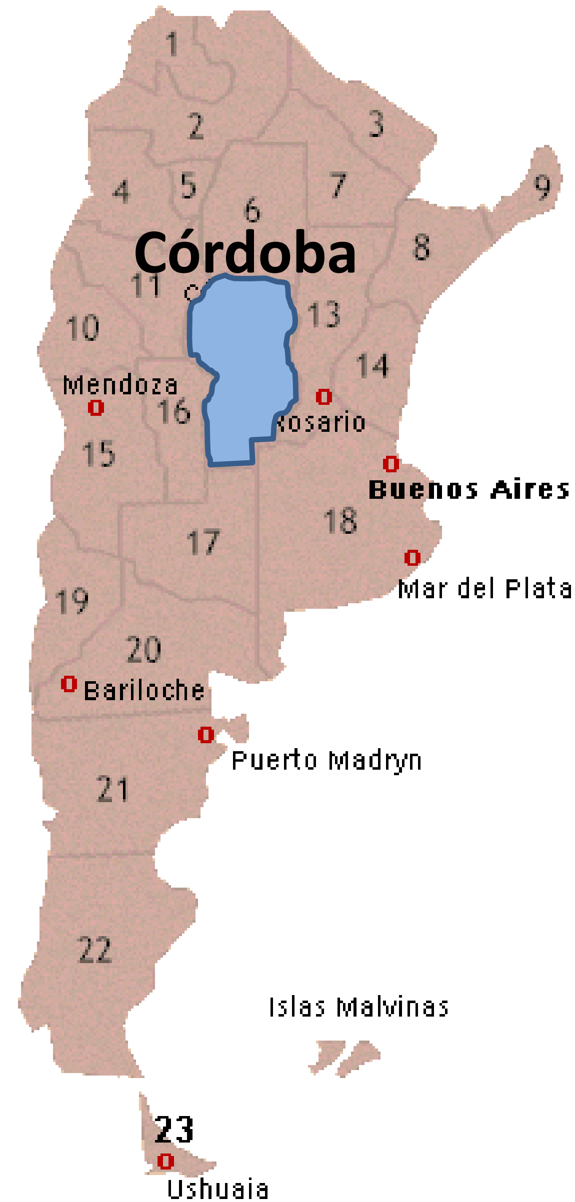
South America

Argentina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Rosario
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Buenos Aires
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Mar del Plata
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Bariloche
Puerto Madryn
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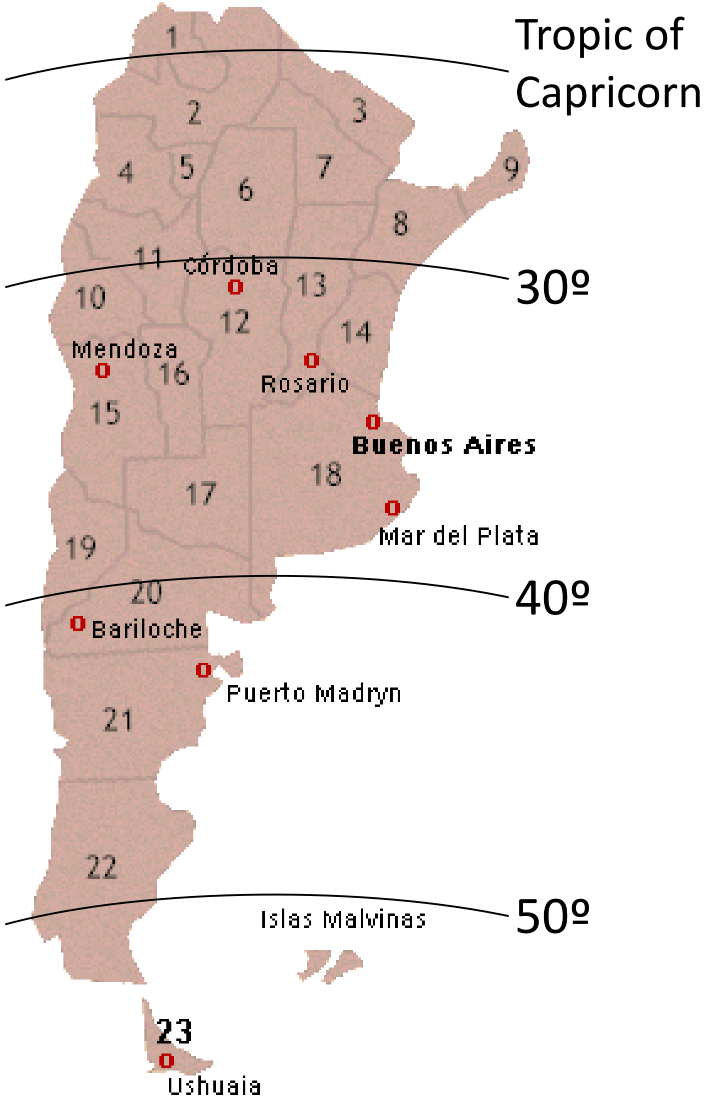
22
Islas Malvinas
23
Ushuaia

NATIONAL UNIVERSITY OF CÓRDOBA (1613)

Faculties..15
High Schools...2
Institutes and Research Centers...........145
Libraries..25
Museums...17
Radios / TV channels..............................4
Hospitals / Laboratories / Blood Bank.....4

Argentina: 2.78 millions km²
Population: 45 millions



PRODUCTION OF THE AGRICULTURAL SECTOR (2014/2015)

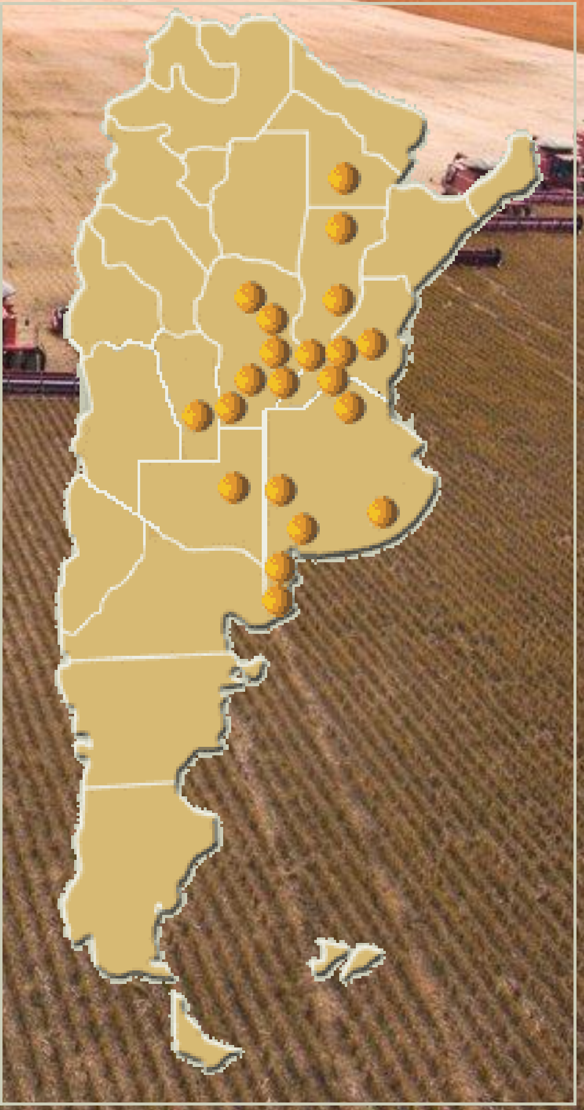
Product	Production
Grains	122,4 million tonnes
Citrics	2,6 million tonnes
Wine	13,4 million hectoliters
Beef	3 million tonnes
Poultry	2 million tonnes
Pig	441 thousand tons
Bovine Milk	11 billion litres
Biofuels	3.900 million litres

21.170.000 ha oilseed crops
16.120.000 ha cereals

PRODUCTION OF THE AGRICULTURAL SECTOR

Argentina produces enough *food* for 450 million people (10 times the Argentine population)

However, almost four million of our own citizens face serious food insecurity...



PRODUCTION OF THE AGRICULTURAL SECTOR (2014/2015)

Journal of Social and Development Sciences (ISSN 2221-1152)
Vol. 7, No. 2, pp. 79-87, June 2016

Organics Olympiad 2016: Global Indices of Leadership in Organic Agriculture

Table 1: Organic agriculture hectares(Willer & Lernoud, 2016).

MEDAL	Country	Statistic
Gold	Australia	17,150,000 hectares
Silver	Argentina	3,061,965 hectares
Bronze	USA	2,178,471 hectares

Organic agriculture is reported as just 0.99% of world agriculture

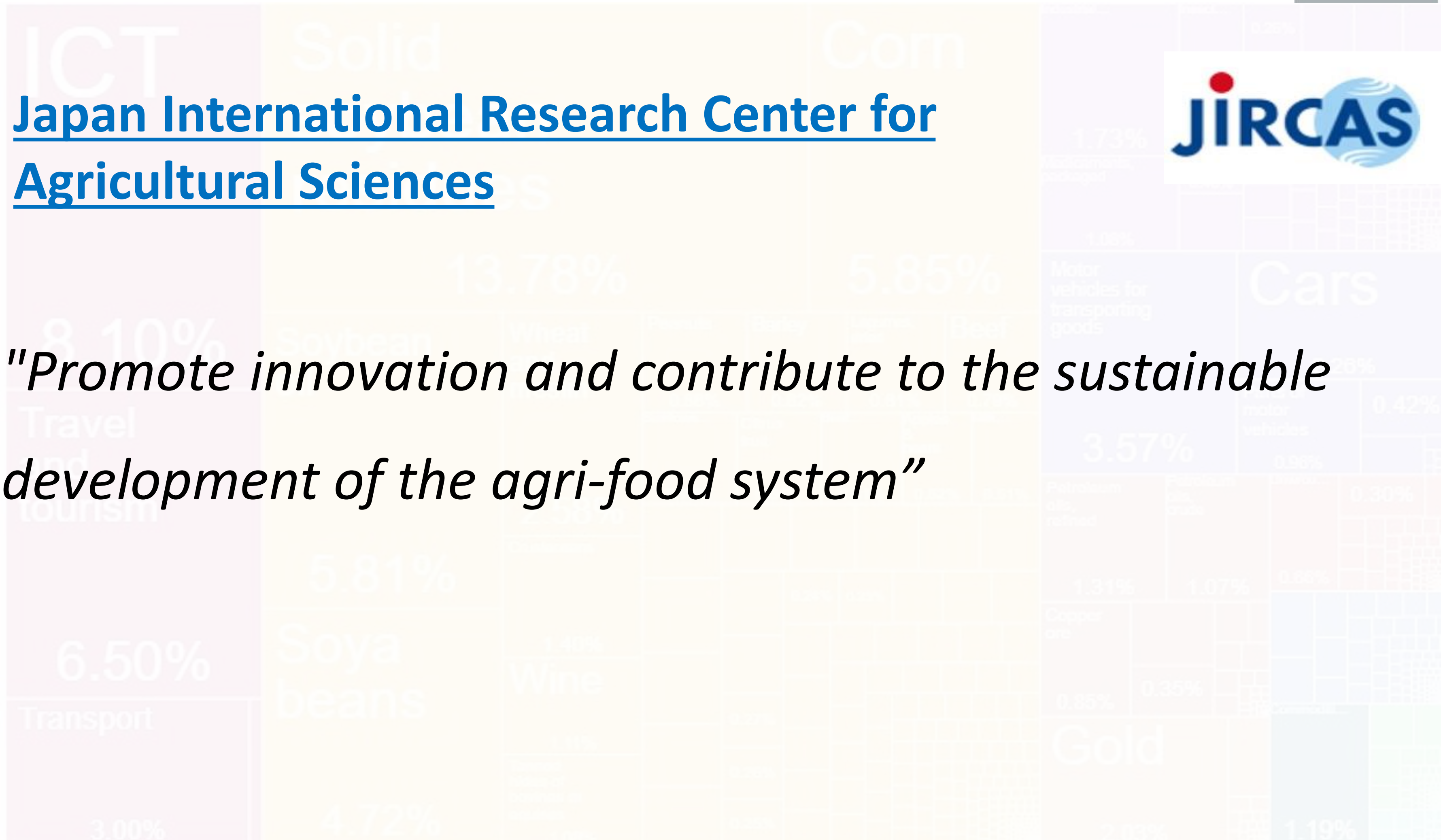
John Paull , 2016. Journal of Social and Development Sciences

ARGENTINEAN EXPORTS - 2016

[National Institute of Agricultural Technology (INTA)]

[Japan International Research Center for Agricultural Sciences]

"Promote innovation and contribute to the sustainable development of the agri-food system"



Atlas of Economic Complexity – Center for International Development, Harvard University

National Institute of Agricultural Technology (INTA)

National Institute of Agricultural Technology (INTA)

- Agroindustry
- Political, Economic and Social Sciences
- Veterinary and Agronomic Sciences
- Research and Technological Development for Family Farming
- Natural Resources
- Agricultural Research

CIAP Centro de Investigaciones Agropecuarias

Center of Agricultural Research

INTA

- **15 Regional Centers**
  - **52 Agronomical Experimental Stations**
  - **9 Extention Units (advisers)**
- **6 Research Centers**
  - **22 Research Institutes**

➢ **Institute of Physiology and Plant Genetic Resources**

➢ **Institute of Plant Pathology**

➢ **Institute of Semi-arid Chaco Animal Research**

How do plants respond to stress conditions, and how do these affect plant growth and yield?

PLANT ENVIRONMENT
WHY STUDING THE RESPONSES OF PLANTS TO STRESS?

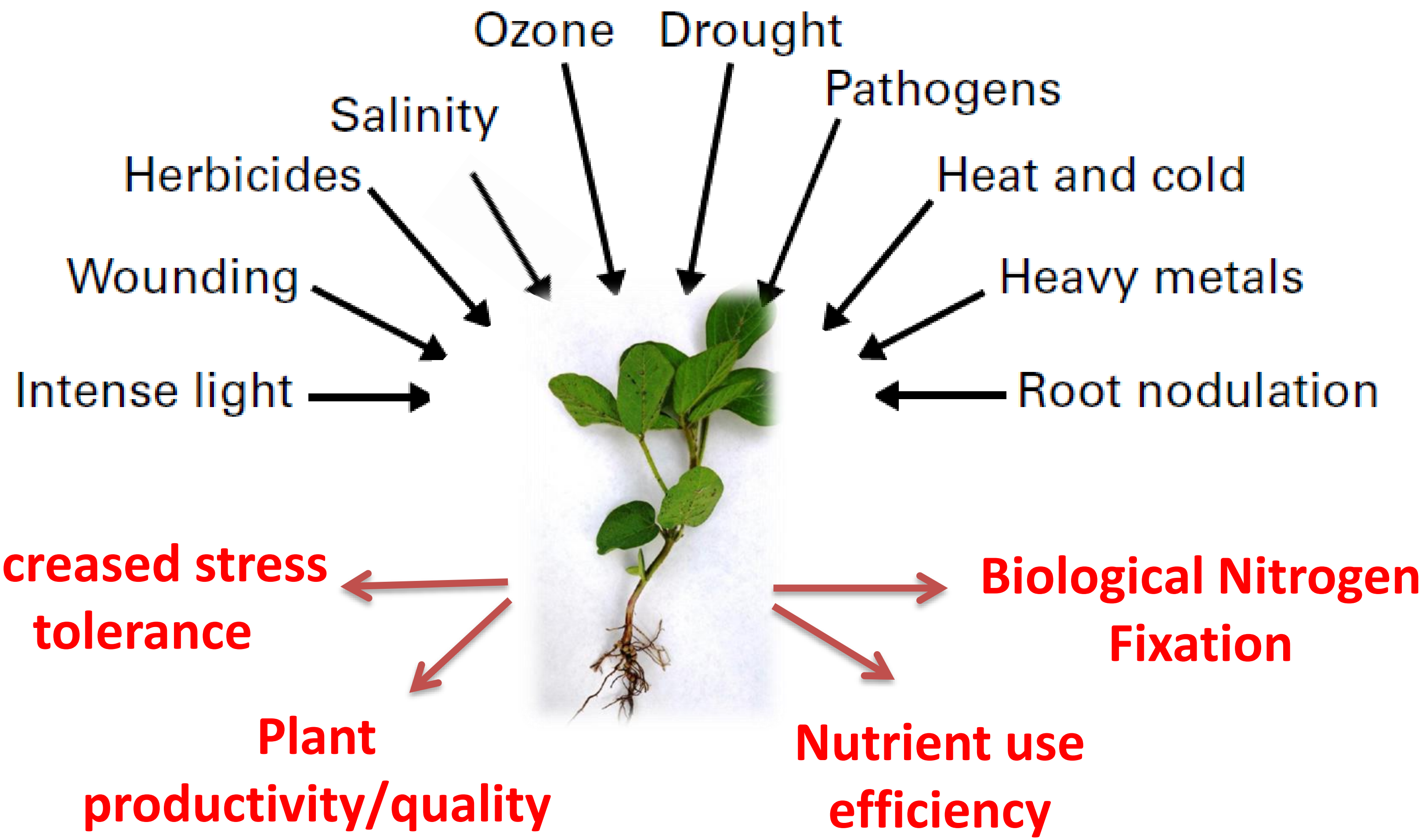
Stress conditions are the main factor affecting plant growth and productivity

Plants are sessile organisms

Even in the most adverse conditions...

PLANT ENVIRONMENT

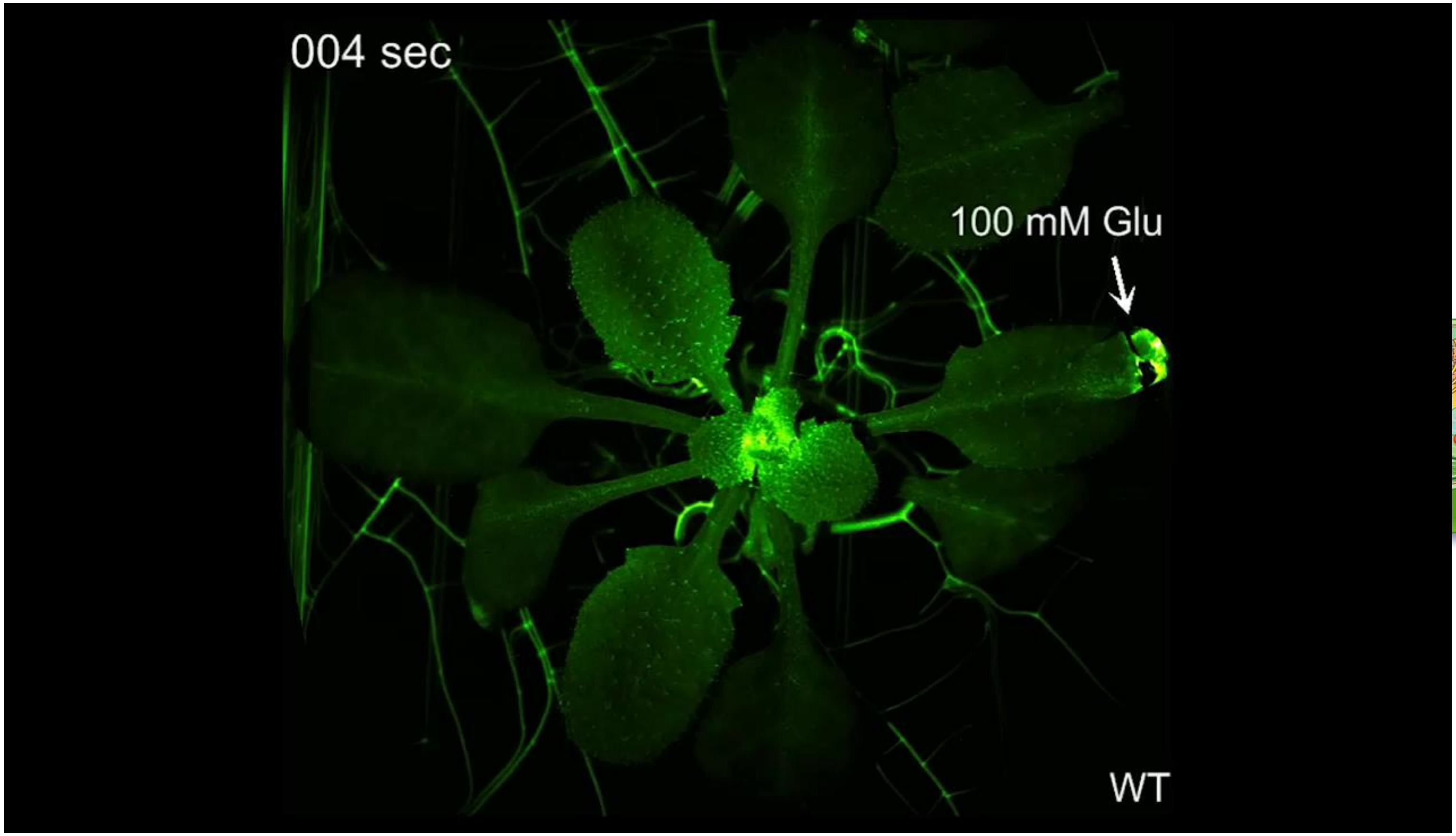
HOW DO PLANTS RESPOND “PROPERLY” TO THE ENVIRONMENT?



HOW DO PLANTS RESPOND TO THE ENVIRONMENT?

FROM CELL BIOLOGY TO PLANT PHYSIOLOGY

Environmental conditions are sensed and transformed by the plants into biochemical signals. **For example, hervivore attack…**



Toyota et al. 2018. Science

HOW DO PLANTS RESPOND TO THE ENVIRONMENT?

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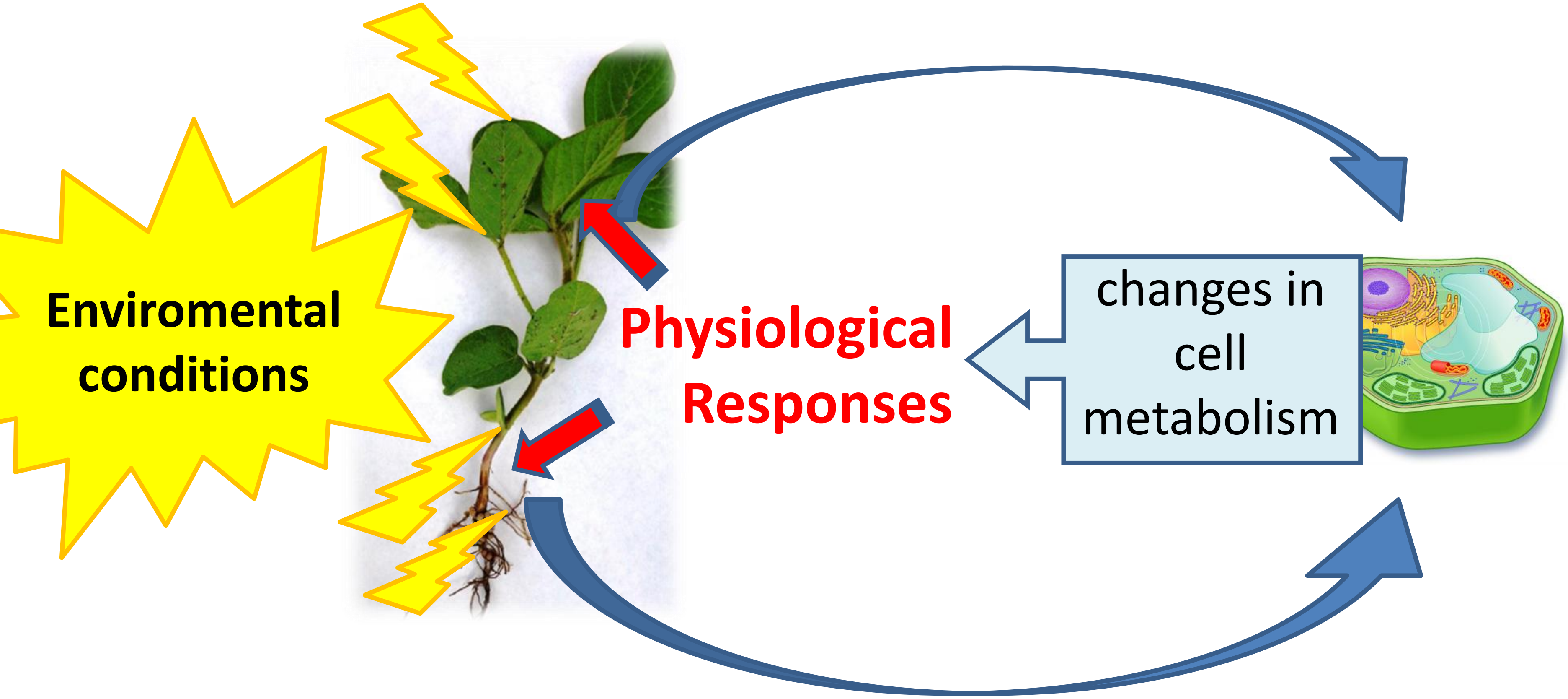
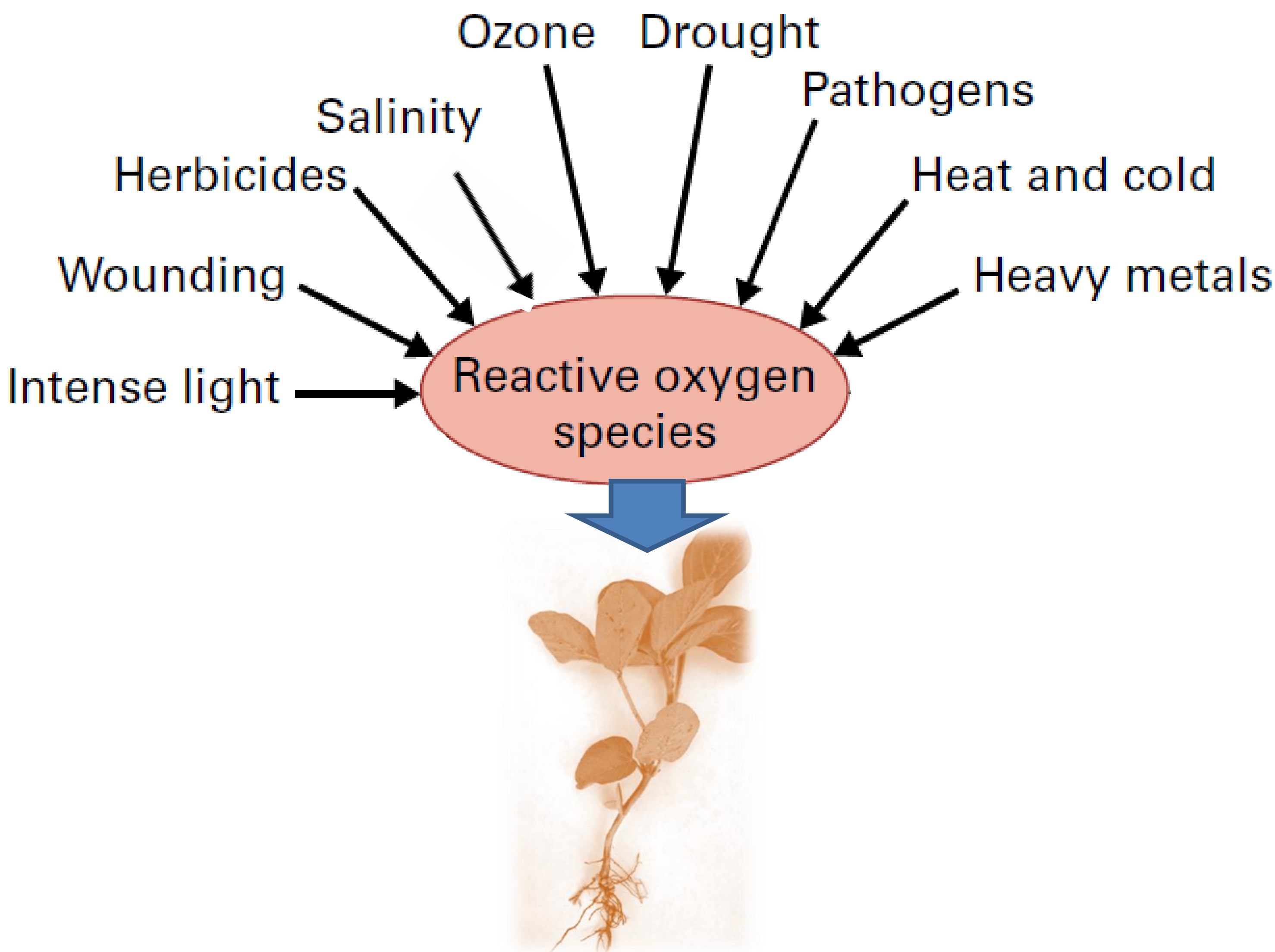
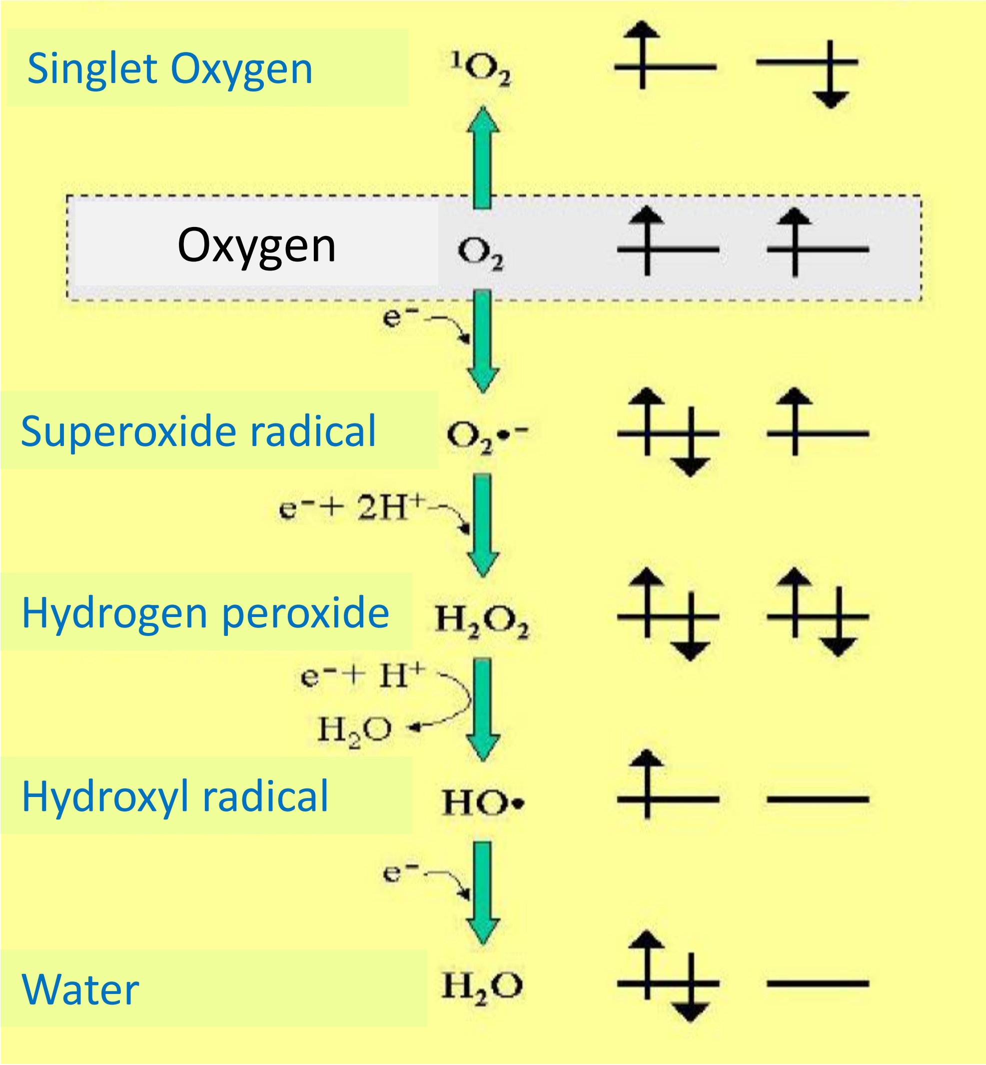


OXIDATIVE STRESS AND ACCELERATED SENESCENCE: A COMMON FEATURE OF STRESS CONDITIONS



REACTIVE OXIGEN SPECIES (ROS)



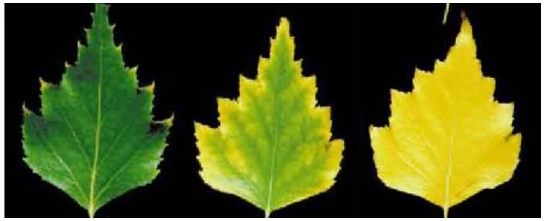
Different energy and reduction states of the oxygen molecule

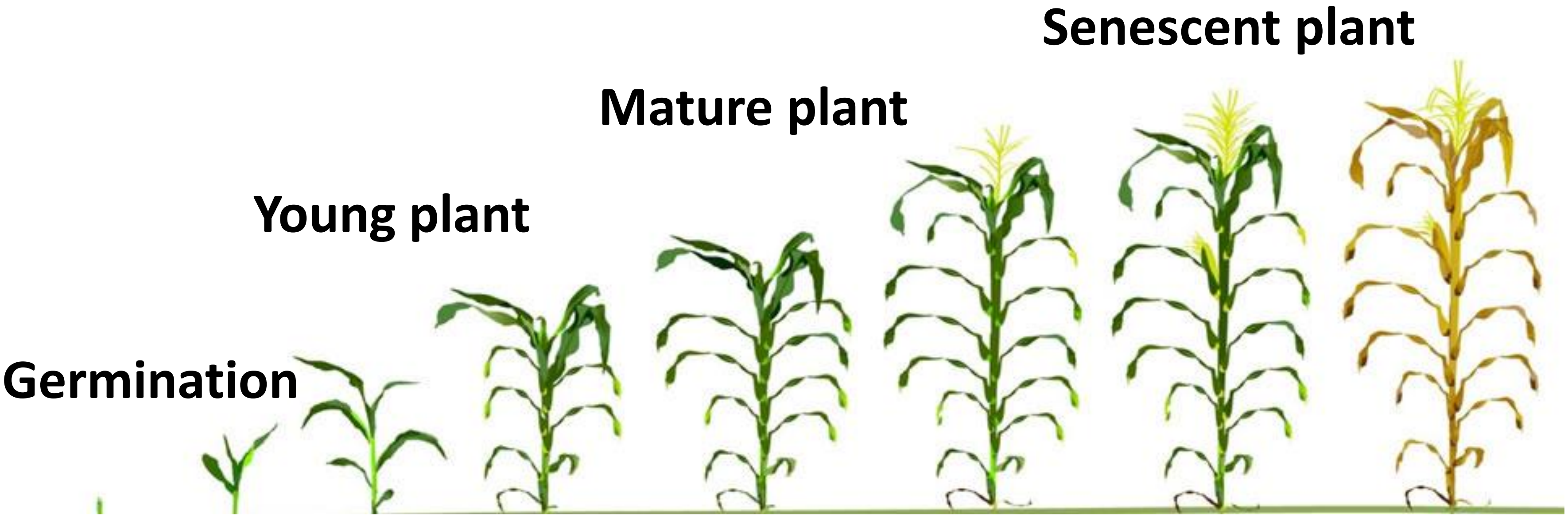
Because of their oxidative capacity, ROS are toxic molecules

SENESCENCE

SENESCENCE AND CELL DEATH

Stage of the ontogeny of the plant that culminates in the death of a part of the plant (leaves, roots, flower parts, tissues of ripening fruits) or the whole organism

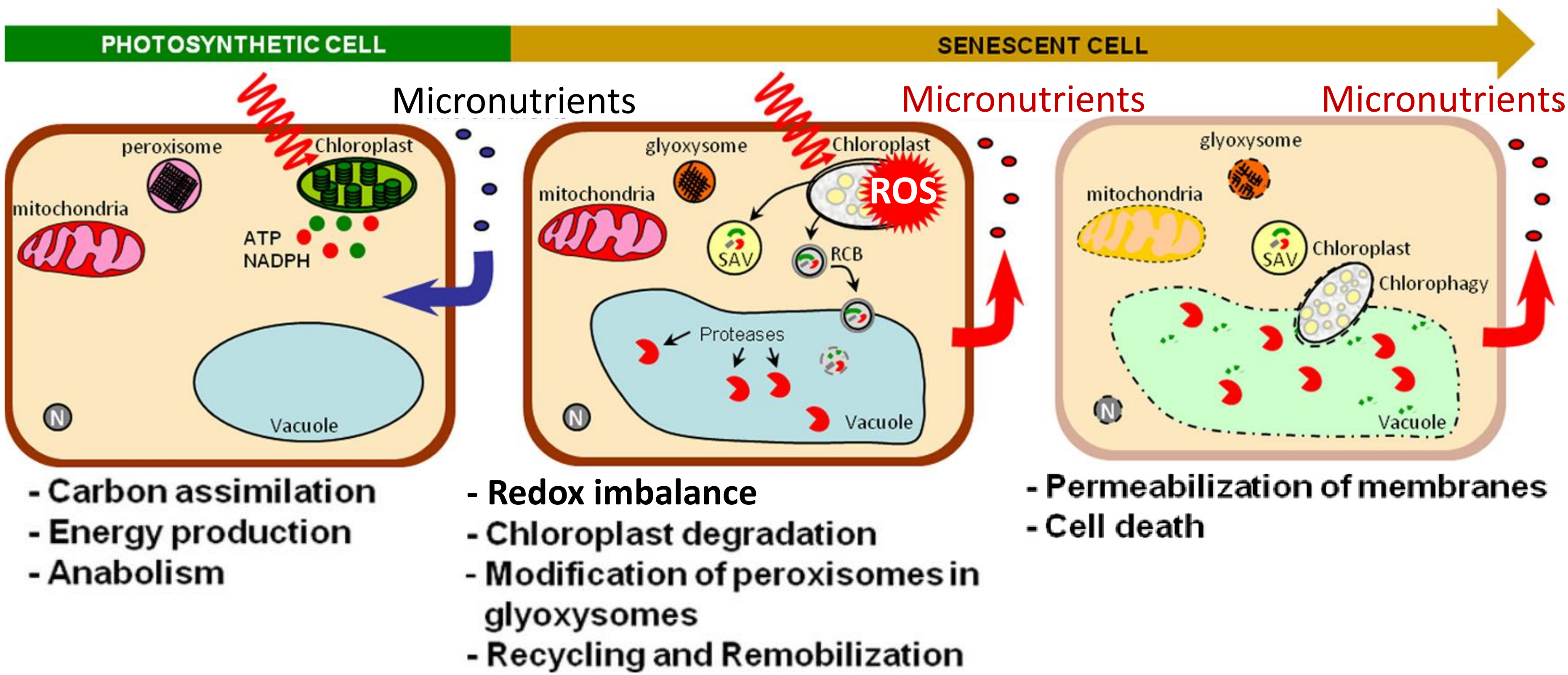




SENESCENCE AND CELL DEATH

Stage of the ontogeny of the plant that culminates in the death of a part of the plant (leaves, roots, flower parts, tissues of ripening fruits) or the whole organism

Highly regulated process characterized by the disassembly and remobilization of components of cellular structures



Pottier et al. (2014) Frontiers in Plant Science

SENESCENCE AND CELL DEATH

Stage of the ontogeny of the plant that culminates in the death of a part of the plant (leaves, roots, flower parts, tissues of ripening fruits) or the whole organism

Highly regulated process characterized by the disassembly and remobilization of components of cellular structures

SENESCENCE IS A YIELD LIMITING FACTOR

SENESCENCE AND CELL DEATH

Stage of the ontogeny of the plant that culminates in the death of a part of the plant (leaves, roots, flower parts, tissues of ripening fruits) or the whole organism

Highly regulated process characterized by the disassembly and remobilization of components of cellular structures

SENESCENCE IS A YIELD LIMITING FACTOR

- **Accelerated Senescence**

Reduction of the total capacity to assimilate CO_2

SENESCENCE AND CELL DEATH

Stage of the ontogeny of the plant that culminates in the death of a part of the plant (leaves, roots, flower parts, tissues of ripening fruits) or the whole organism

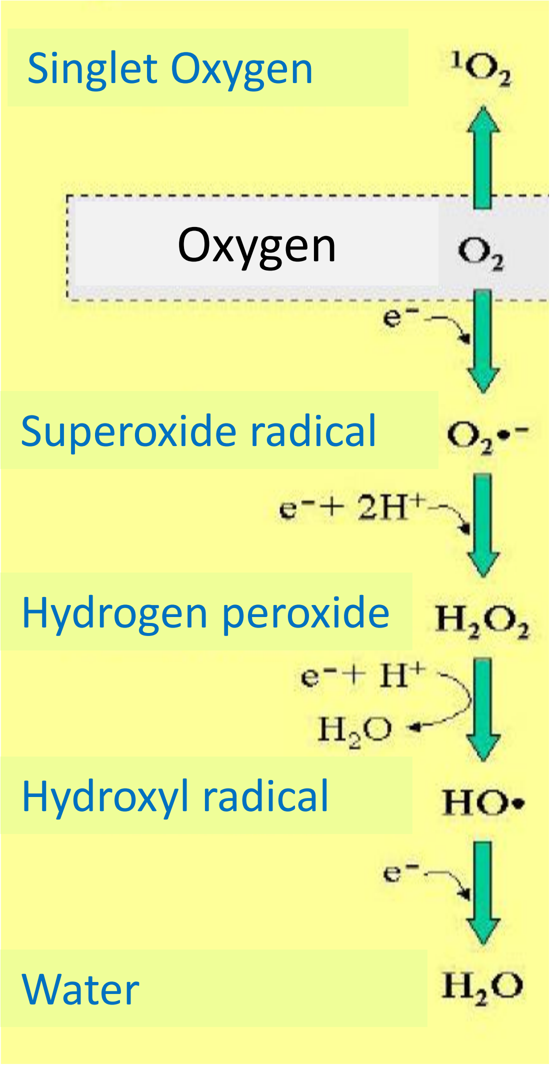
Highly regulated process characterized by the disassembly and remobilization of components of cellular structures

SENESCENCE IS A YIELD LIMITING FACTOR

- **Delayed Senescence**

Maintenance of CO_2 assimilation, but reduction of nutrient remobilization

REACTIVE OXIGEN SPECIES (ROS) AND ANTIOXIDANT SYSTEM



Non-enzimatic components

- Glutathione
- Ascorbate
- Tocoferol
- Carotenoid

Enzimatic components

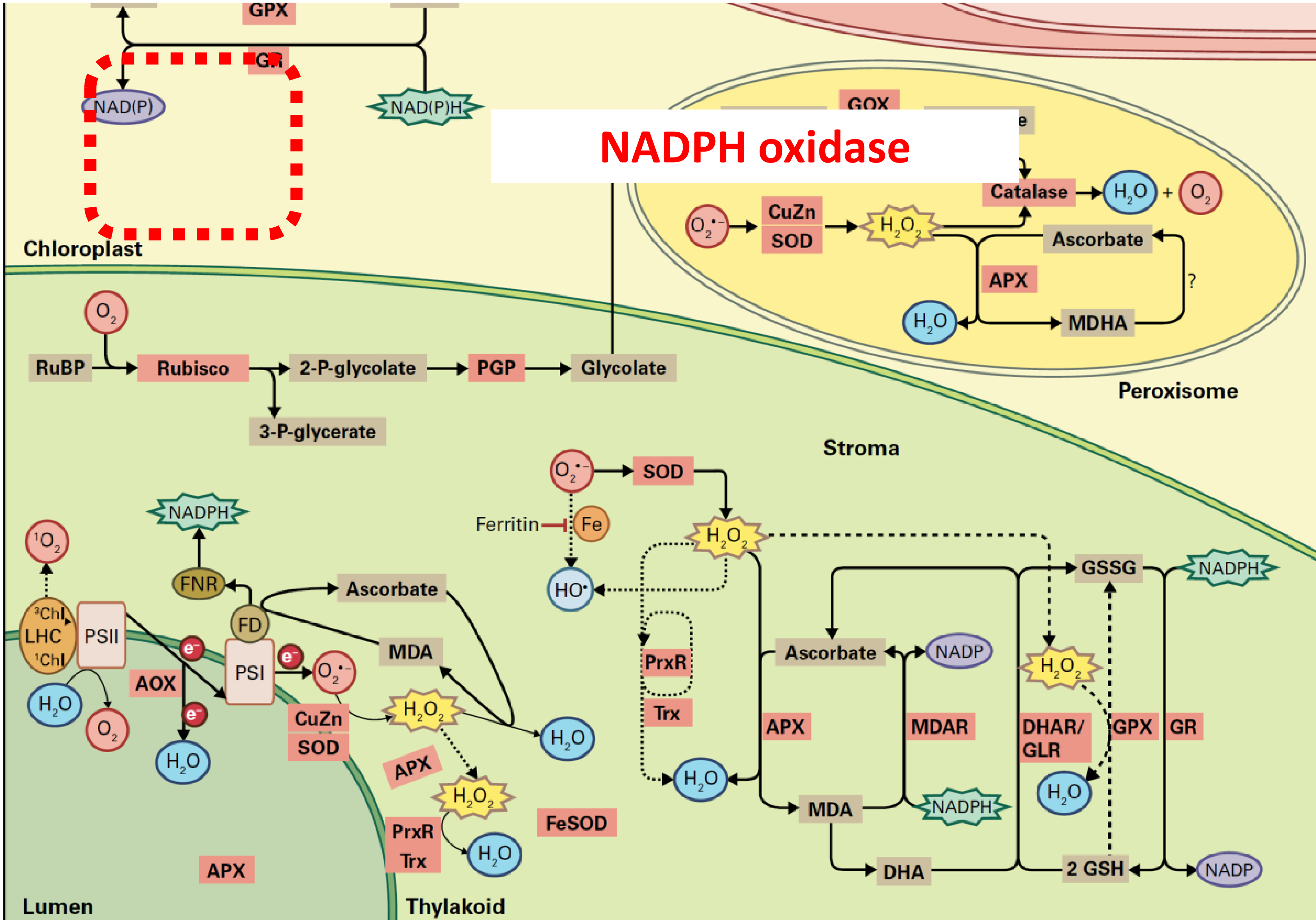
- Enzymes that degrade ROS

superoxide dismutase (SOD), peroxidases (PX), catalase (CAT)

- Enzymes that regenerate non enzimatic antioxidants

gluthatione reductase (GR), dihydro- and monodihydro-ascorbate peroxidase (DHAR, MDHAR)

REACTIVE OXIGEN SPECIES (ROS) AND ANTIOXIDANT SYSTEM

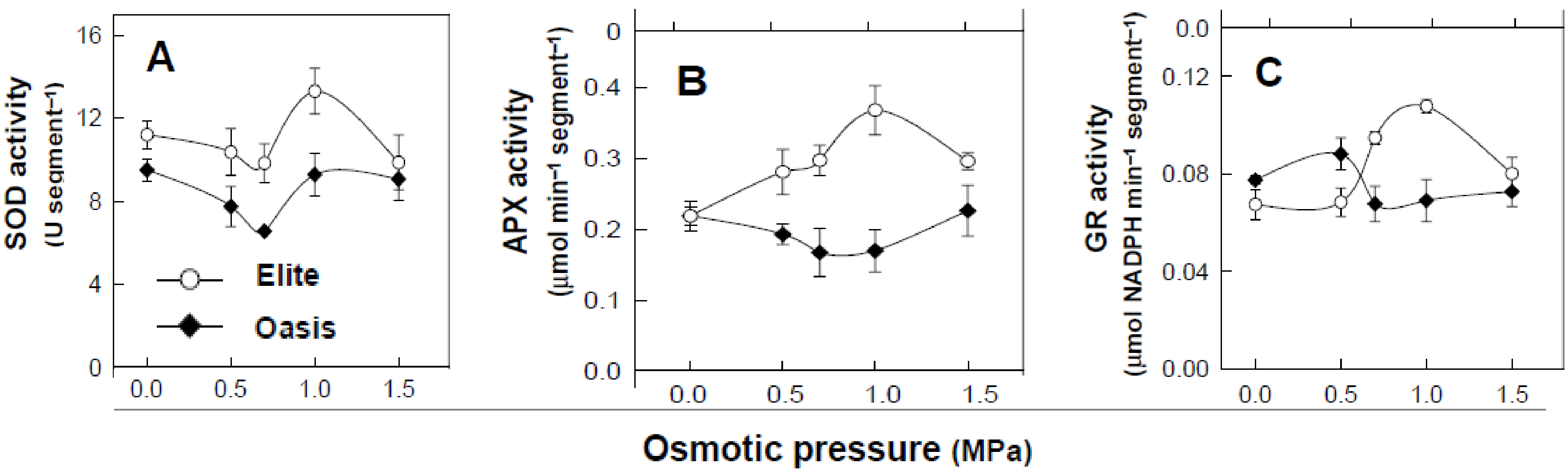


ANTIOXIDANT SYSTEM:
KEY ELEMENT IN TOLERANCE TO STRESSFUL SITUATIONS

➢ **Positive correlation between antioxidant enzyme activity and tolerance to different stress conditions**

Antioxidant system response of different wheat cultivars under drought: field and *in vitro* studies

Hernán R. Lascano[AC], Gerardo E. Antonicelli[A], Celina M. Luna[A], Mariana N. Melchiorre[A], Leonardo D. Gómez[A], Roberto W. Racca[A], Victorio S. Trippi[A] and Leonardo M. Casano[B]

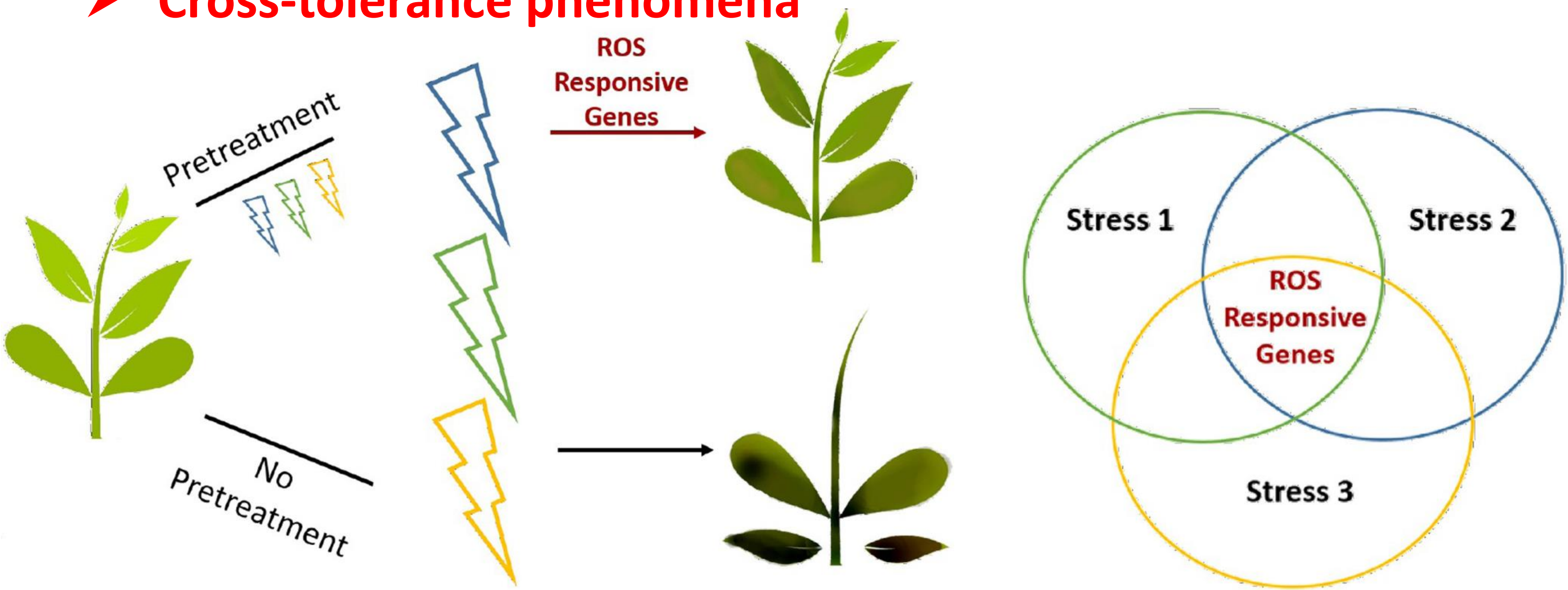


Lascano et al. (2001) Australian Journal of Plant Physiology

ANTIOXIDANT SYSTEM:
KEY ELEMENT IN TOLERANCE TO STRESSFUL SITUATIONS

- Positive correlation between antioxidant enzyme activity and tolerance to different stress conditions

- **Cross-tolerance phenomena**



INDUCED CROSS-TOLERANCE: Priming of resistance through previous exposure to another biotic, abiotic, or chemical stress inducer

SHARED TRANSCRIPTIONAL RESPONSE: Overlap of differentially expressed gene networks between stresses

Barrios Perez and Brown (2014) Frontiers in Plant Science

ANTIOXIDANT SYSTEM:
KEY ELEMENT IN TOLERANCE TO STRESSFUL SITUATIONS

- Positive correlation between antioxidant enzyme activity and tolerance to different stress conditions

- Cross-tolerance phenomena

- **Overexpression of antioxidant enzymes**

Wild-type SOD

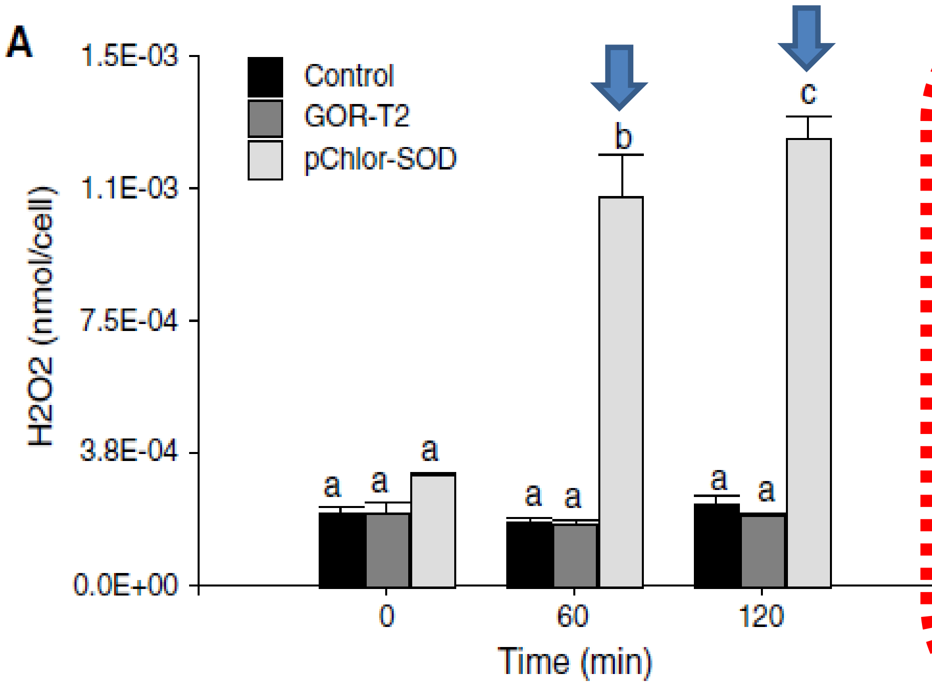
Transgenic cotton plants expressing chloroplast-localized SOD have increased tolerance to chilling-induced oxidative stress

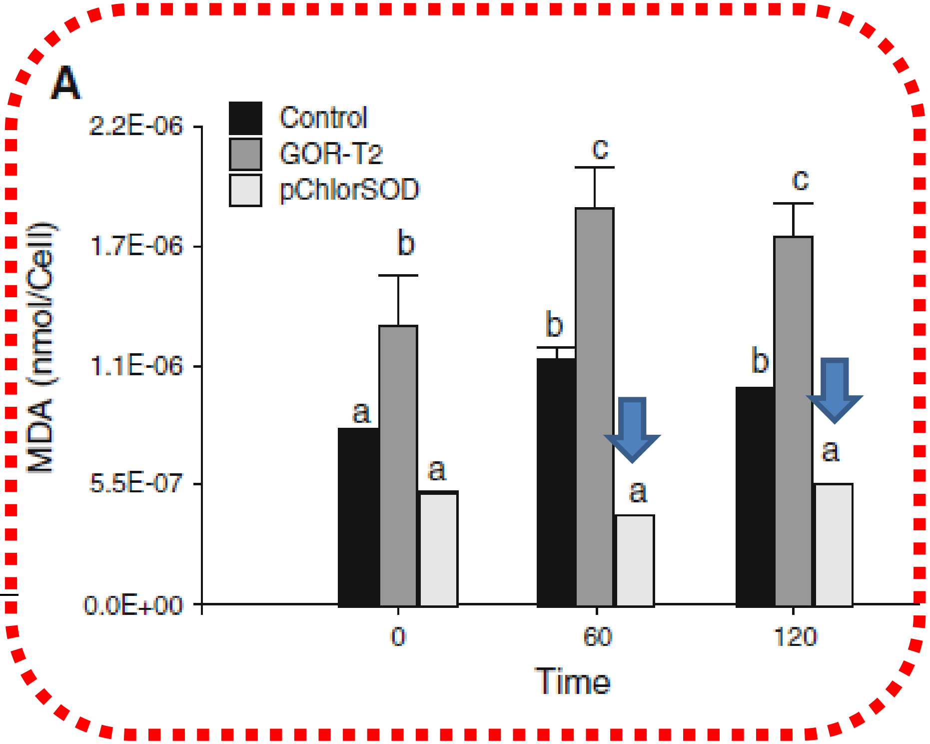
Allen (1995) Plant Physiology

HOWEVER...
ENHANCED ROS, ENHANCED TOLERANCE?

Superoxide dismutase and glutathione reductase overexpression in wheat protoplast: photooxidative stress tolerance and changes in cellular redox state

Mariana Melchiorre · Germán Robert · Victorio Trippi · Roberto Racca · H. Ramiro Lascano

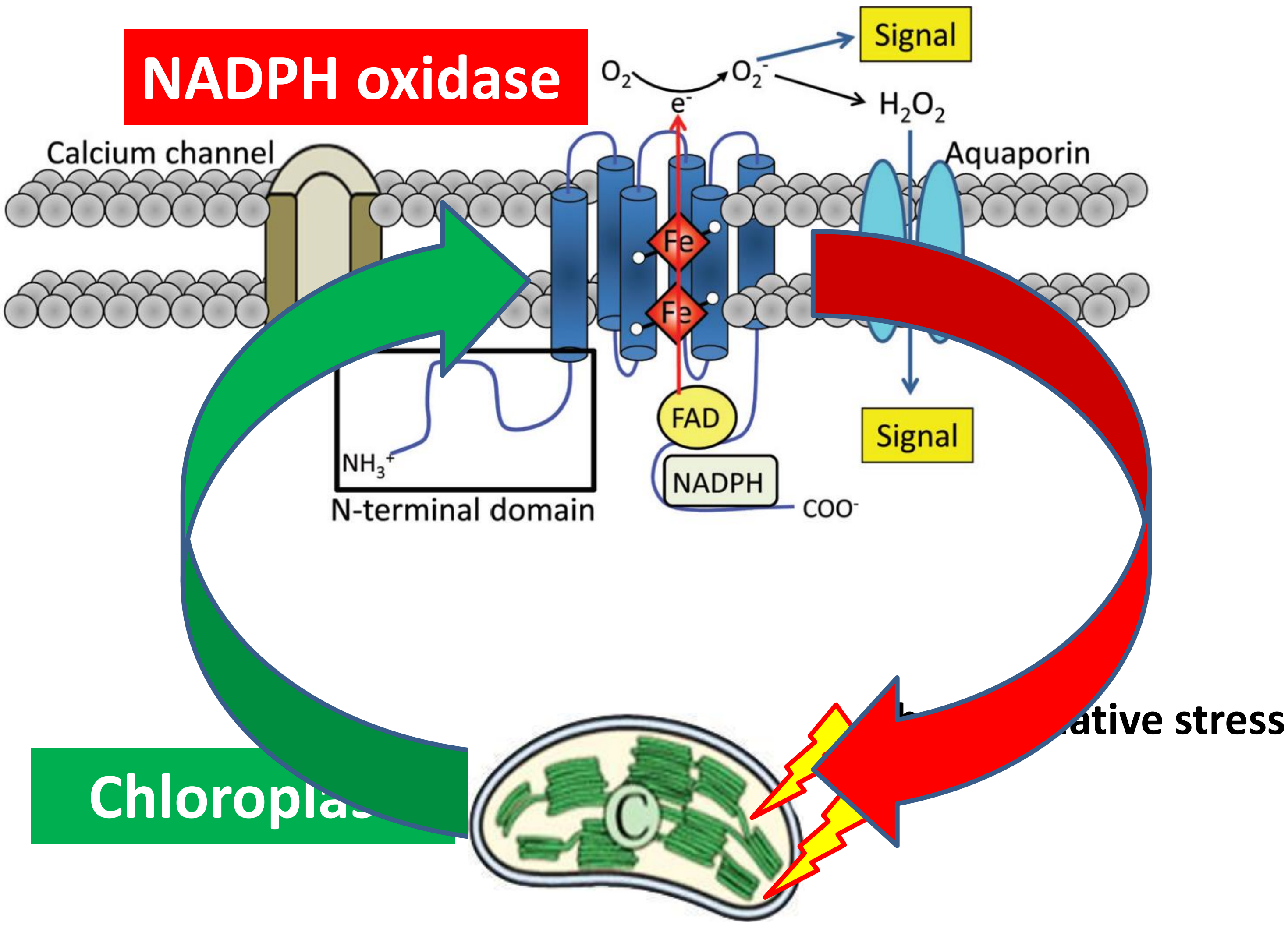




$O_2^- \xrightarrow{SOD} H_2O_2 \xrightarrow{GR} H_2O$

Melchiorre et al. (2009) Plant Growth Regulation

REACTIVE OXIGEN SPECIES (ROS) AND ANTIOXIDANT SYSTEM: <u>OXIDATIVE SIGNALING</u>



Robert *et al.* (2009) Plant Science

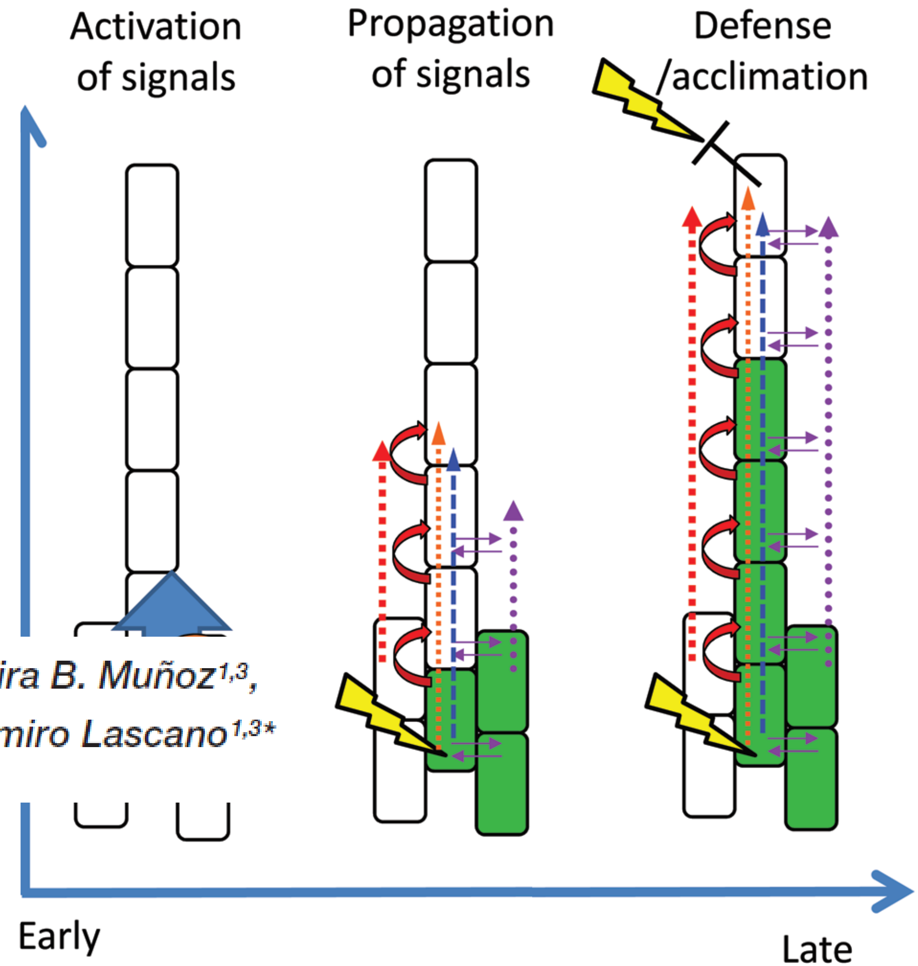
REACTIVE OXIGEN SPECIES (ROS) AND ANTIOXIDANT SYSTEM: SYSTEMIC OXIDATIVE SIGNALING

frontiers in Plant Science

ORIGINAL RESEARCH
published: 15 February 2019
doi: 10.3389/fpls.2019.00141

Redox Systemic Signaling and Induced Tolerance Responses During Soybean–*Bradyrhizobium japonicum* Interaction: Involvement of Nod Factor Receptor and Autoregulation of Nodulation

Tadeo F. Fernandez-Göbel[1], Rocío Deanna[2], Nacira B. Muñoz[1,3], Germán Robert[1,3], Sebastian Asurmendi[4] and Ramiro Lascano[1,3]*



wounding, heat, cold, high-intensity light, salinity stresses, **and symbiosis**

Miller *et al.* (2009) Science
Baxter et al. (2014) Journal of Experimental Botany
Fernandez Göbel et al. (2019) Frontiers in Plant Science

REACTIVE OXIGEN SPECIES (ROS) AND ANTIOXIDANT SYSTEM:
SYSTEMIC OXIDATIVE SIGNALING

frontiers in Plant Science

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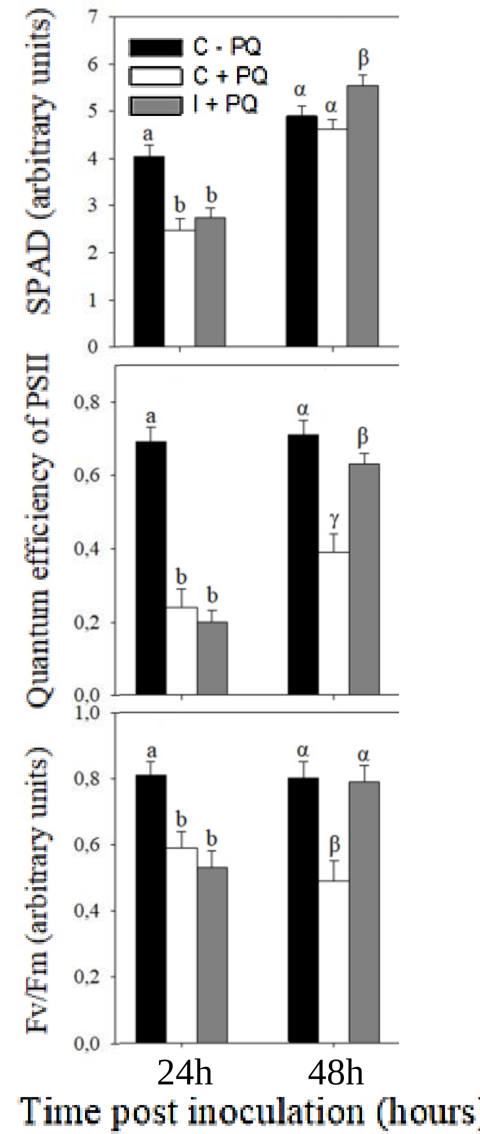
wounding, heat, cold, high-intensity light, salinity stresses, **and symbiosis**

Reduced Senescence symptoms



Fernandez Göbel et al. (2019) Frontiers in Plant Science

SUMMARIZING...

THE DARK SIDE OF ROS

ROS are highly reactive and induced

OXIDATIVE DAMAGE = OXIDATIVE STRESS

ROS are highly reactive and induced

OXIDATIVE CHANGES = OXIDATIVE SIGNALING

THE BRIGHT SIDE OF ROS

SUMMARIZING...

OUR HYPOTHESIS

Controlling the processes associated with senescence (i.e. ROS production, disassembly/remobilization and cell death) **increases stress tolerance and yield**




KNOWLEDGE CONSTRUCTION IS A DYNAMIC AND COLLECTIVE PROCESS

OUR TEAM

Ramiro Lascano (Group Leader)
Germán Robert (Researcher)
Laura Saavedra (Researcher)
Santiago Otaiza (Postdoc)
Alejandro Enet (PhD student)
Tadeo Fernández (PhD student)
Sofía Andreola (PhD student)
Georgina Pettinari (PhD student)
Tatiana Bellagio (undergraduate student)
Juan Finello (undergraduate student)

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Claudia Vega (INTA Manfredi)
Constanza Carrera (INTA Manfredi)
Vanina Davidenco (FCA, UNC)

Overseas Collaborators:
Kohki Yoshimoto (Meiji University)
Céline Masclaux (INRA Versailles)

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THANK YOU FOR YOUR
ATTENTION!

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MEIJI UNIVERSITY

LECTURE 2-
PLANT ENVIRONMENT.
BIOLOGICAL NITROGEN FIXATION: LEGUME-RHIZOBIA SYMBIOTIC INTERACTION

Germán Robert - robert.german@inta.gob.ar

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IFRGV Instituto de Fisiología y Recursos Genéticos Vegetales

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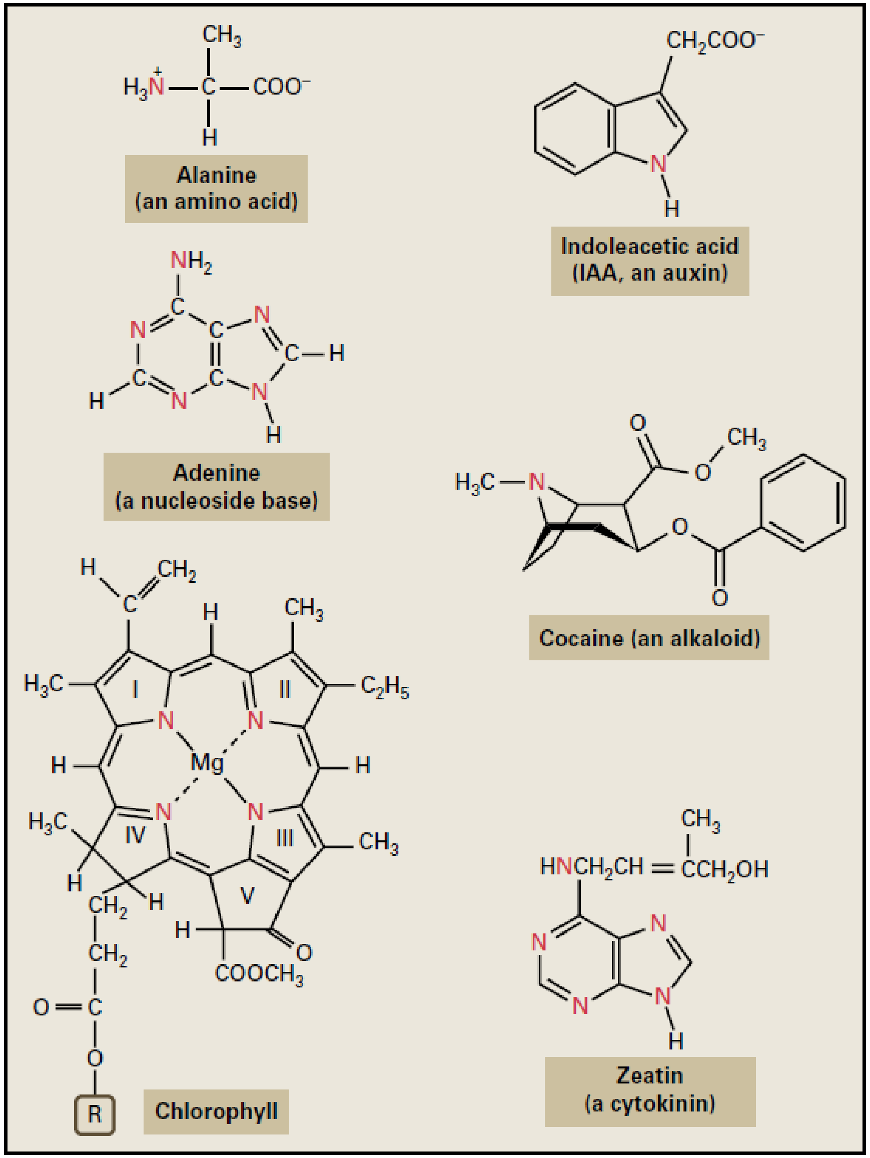
PLANT ENVIROMENT
PLANT GROWTH AND DEVELOPMENT



Agroecosystems:

Nitrogenous fertilizer

- Contributes to greenhouses emissions

- Highest cost in crop management

NITROGEN

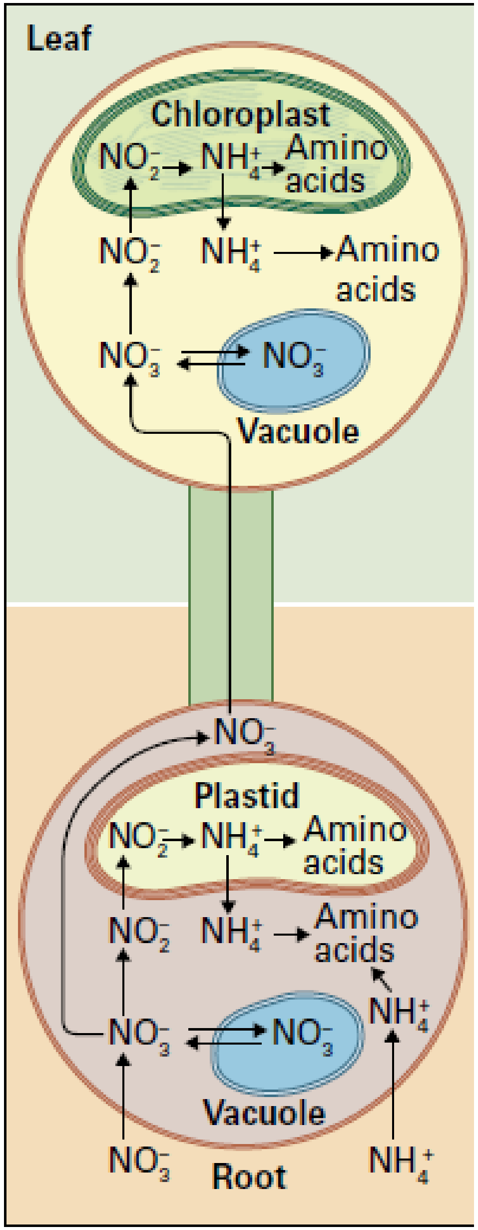
OVERVIEW OF NITROGEN UPTAKE IN PLANTS

Natural ecosystems:

80–90% of the N available to plants originates from reduction of atmospheric N_2 to NH_4^+

Biological Nitrogen Fixation (BNF)

≈ **80%** is produced in symbiotic associations



OVERVIEW OF NITROGEN UPTAKE IN PLANTS

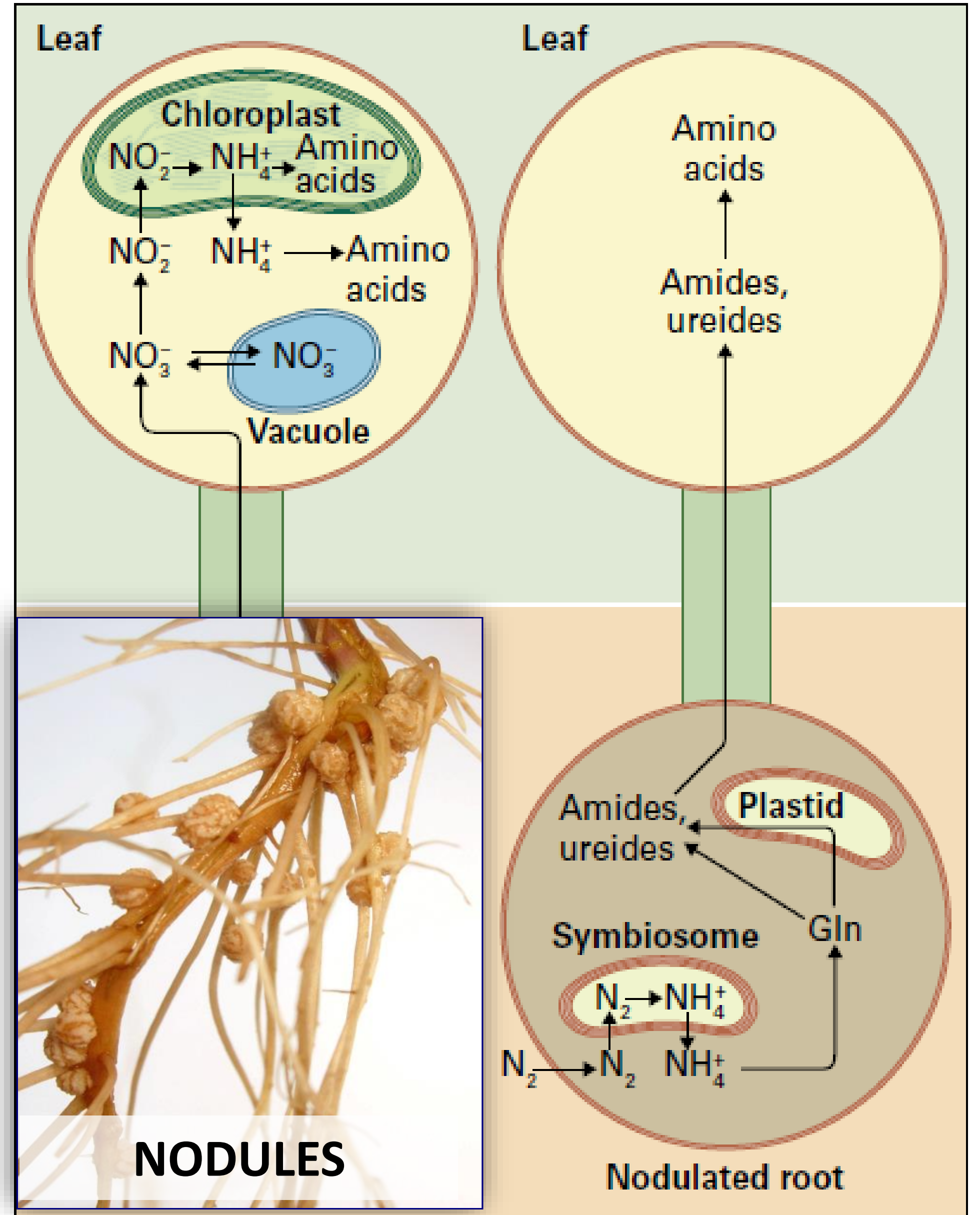
Legume-rhizobia interaction

Agroecosystems:

Nitrogenous fertilizer

- Highest cost in crop management
- Contributes to greenhouses emissions

-including legumes in crop management (crop rotation)



LEGUME – RHIZOBIA INTERACTION:
BIOLOGICAL NITROGEN FIXATION

However, the benefits of nitrogen fixation are not without cost…

LEGUME NODULE PROVIDES:

* Carbohydrates
* Microaerobic conditions

High %BNF played a pivotal role in determining neutral soil N balance

Vessey (2004) Crop Management
Santachiara et al. (2017) Plant Soil

LEGUME – RHIZOBIA INTERACTION:
BIOLOGICAL NITROGEN FIXATION

However, the benefits of nitrogen fixation are not without cost…

ENZYMATIC REDUCTION of N_2 to NH_4 → <u>NITROGENASE</u>

- … $16P_i$
-

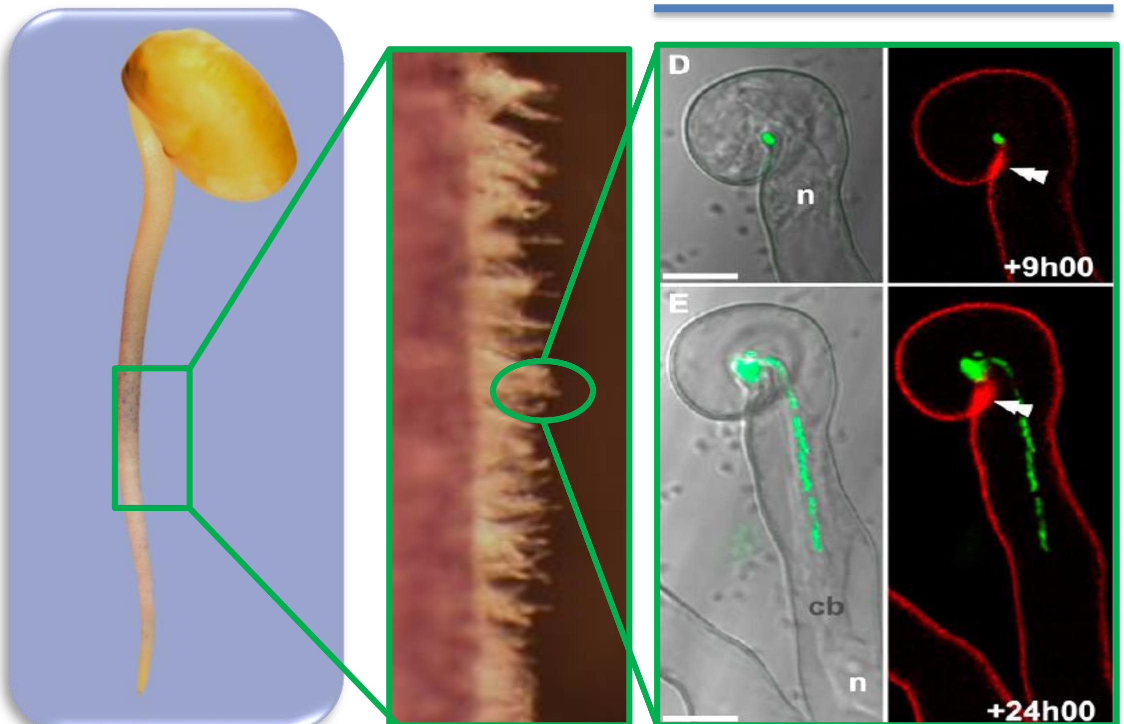
Legumes suppress nodule formation and function when nitrate or ammonia is available.

Symbiotic interaction is strictly controlled.

STRICT NODULATION CONTROL MECHANISM
FROM ROOT INFECTION TO NODULE DEVELOPMENT

Ros and cell death modulating the nodulation process

Early events

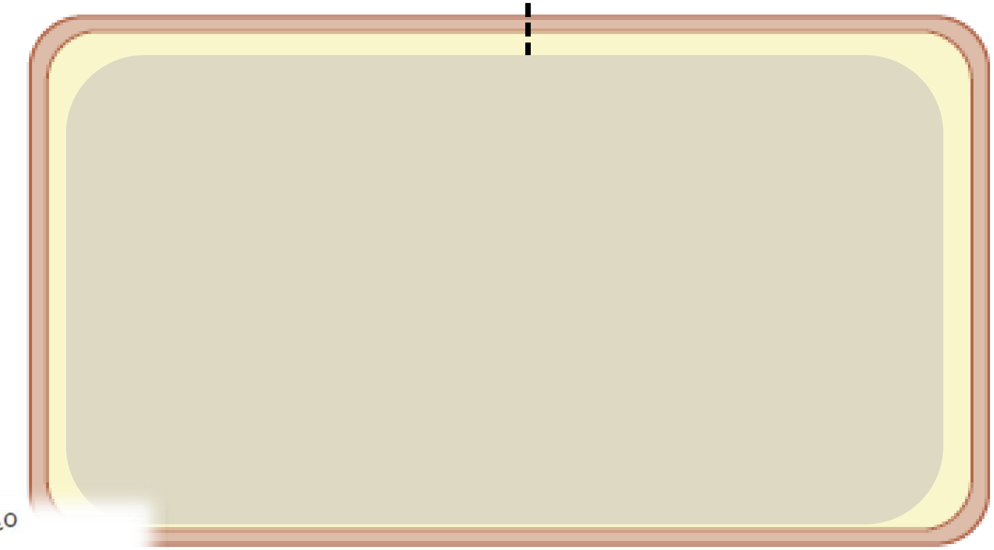


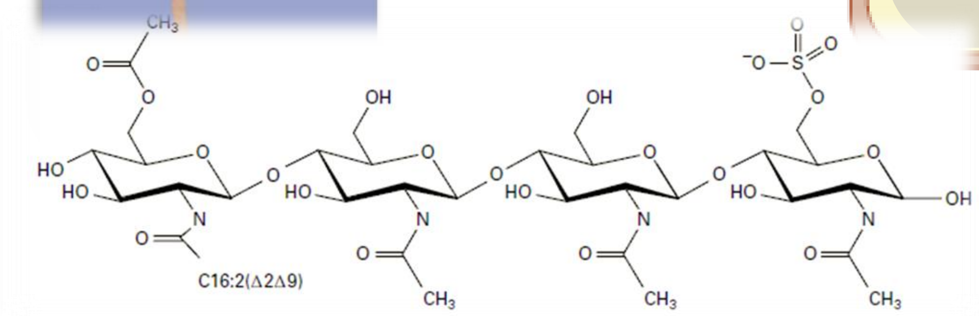
Late events

STRICT NODULATION CONTROL MECHANISM
Molecular dialog between plant and bacteria

Flavonoids

Bacteria



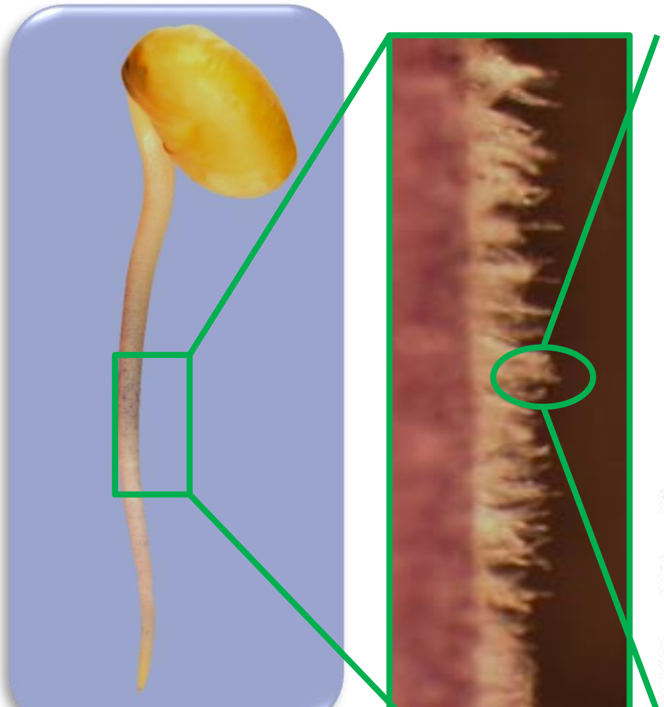


Nod factors ≈ Chitin
(lipochitooligosaccharides)

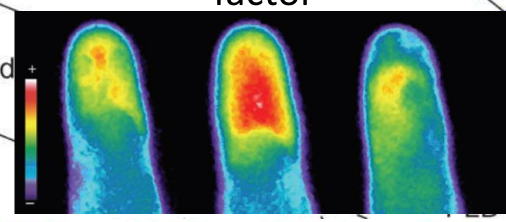
Nodulation shares features of signaling pathways involved in other symbioses, and in plant-pathogen interactions

STRICT NODULATION CONTROL MECHANISM

Very early host responses

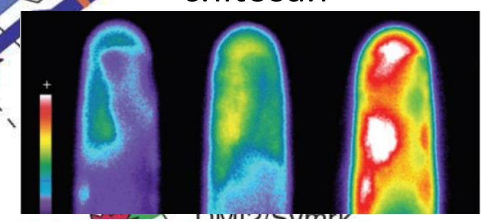


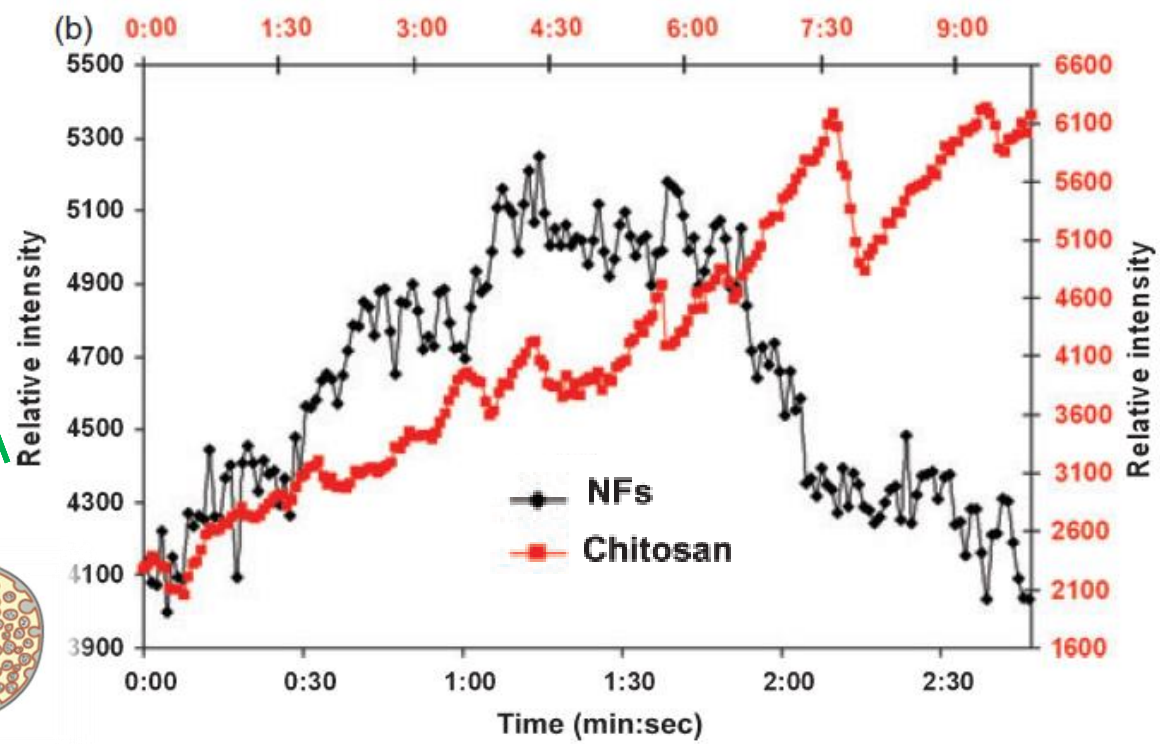
Intracellular ROS after Nod factor

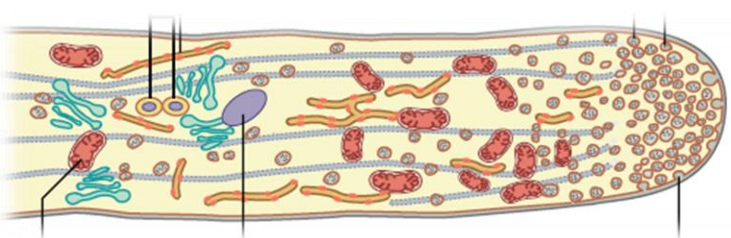


Intracellular ROS after chitosan

Nod factor

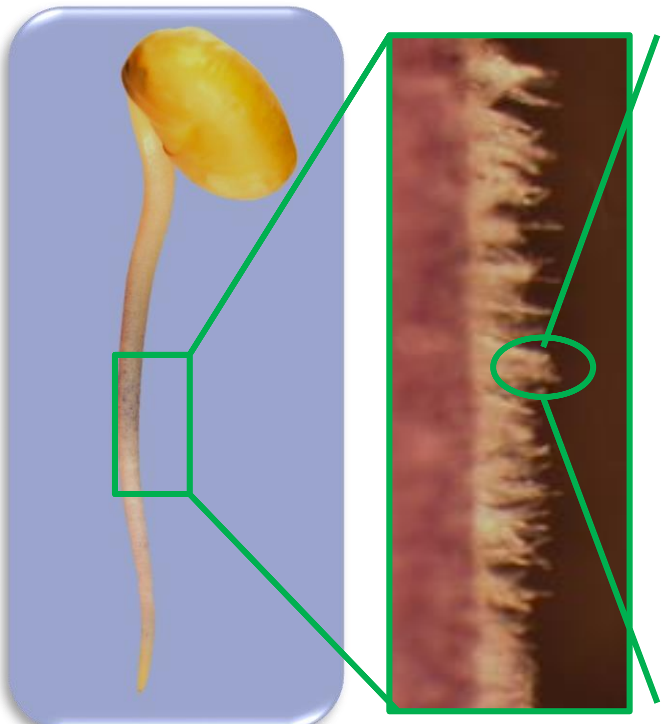


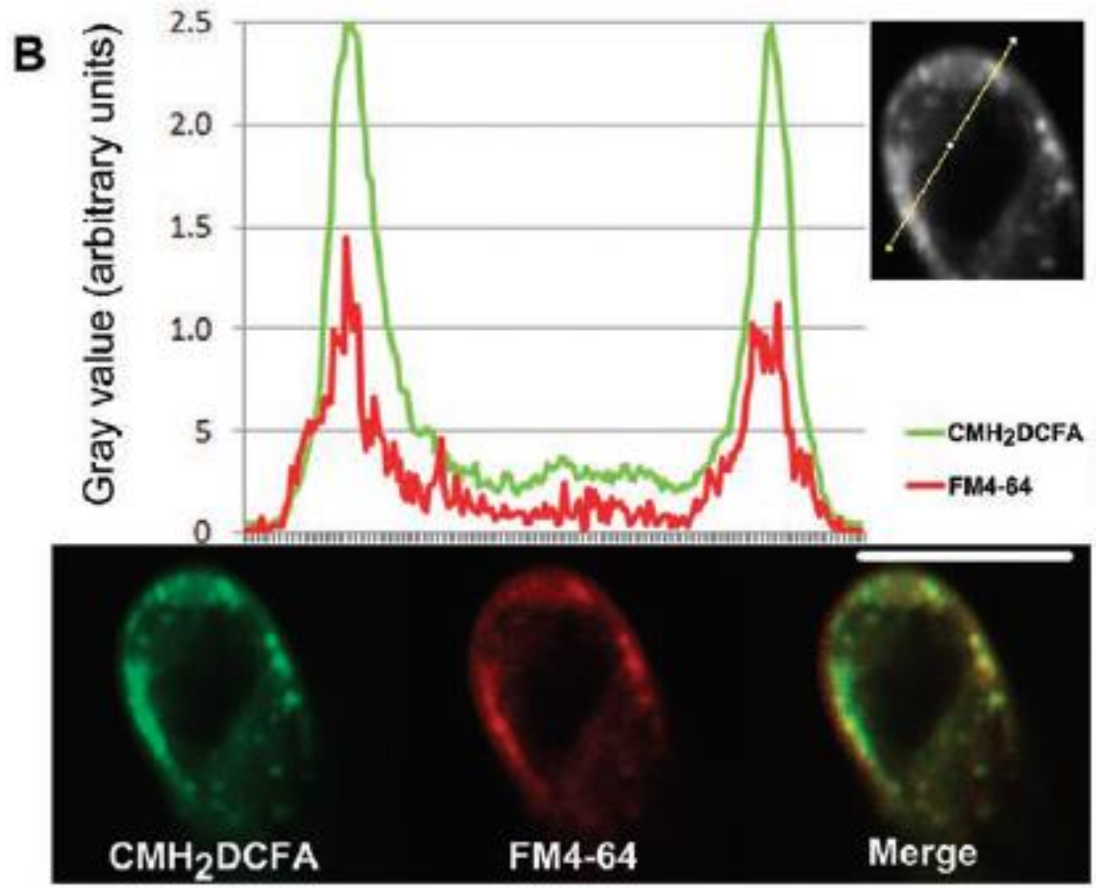




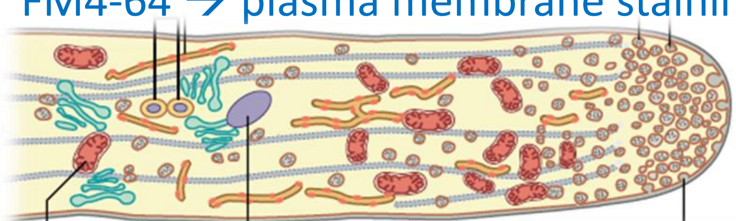
Cárdenas *et al*. The Plant Journal (2008)

STRICT NODULATION CONTROL MECHANISM
Very early host responses





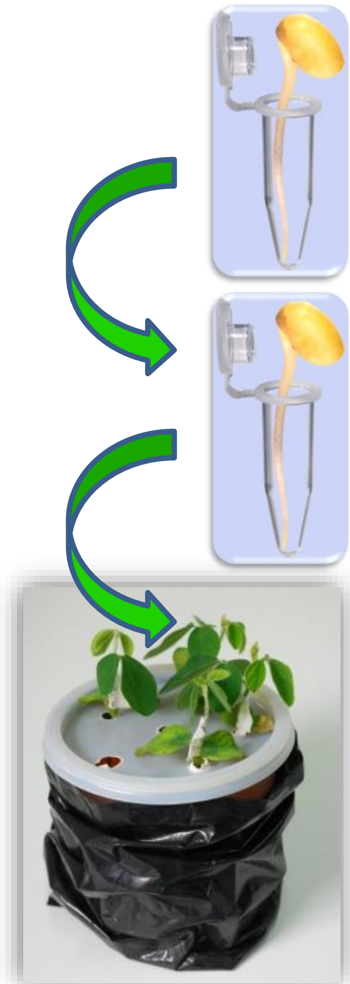
DPI → NADPH oxidase-inhibitor
LY294002 → PI3K-inhibitor
FM4-64 → plasma membrane staining



Muñoz et al. (2012) Environmental and Experimental Botany
Robert *et al*. (2018) Journal of Experimental Botany

STRICT NODULATION CONTROL MECHANISM

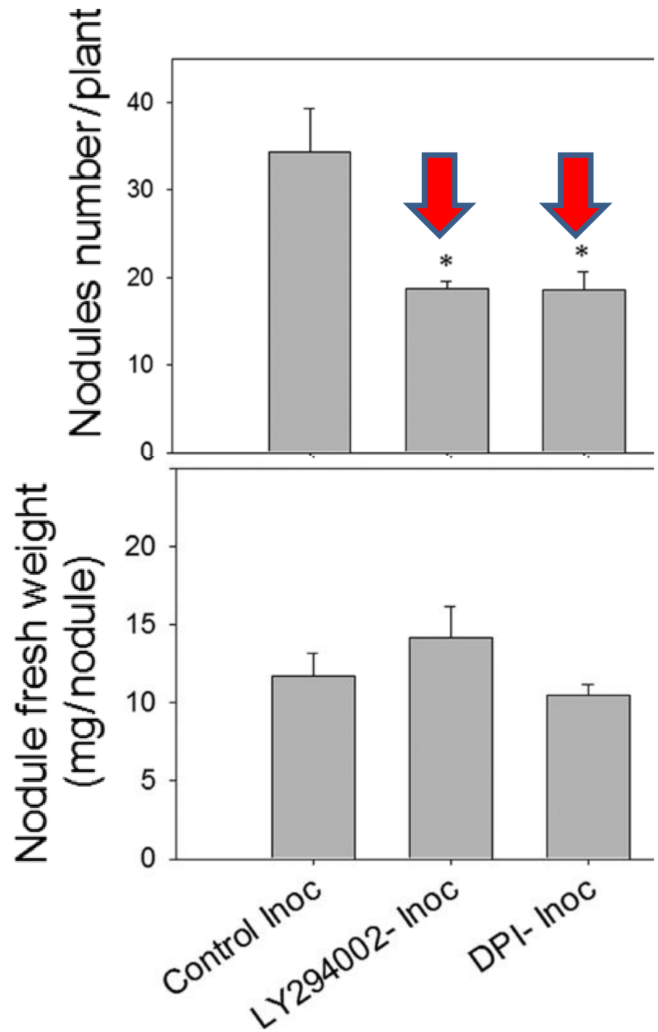
Very early host responses: a very early control of nodulation



Tube 1:
Pre-treatment
(30 min)
DPI or LY294002

Tube 2:
Inoculation (30 min)
B. japonicum

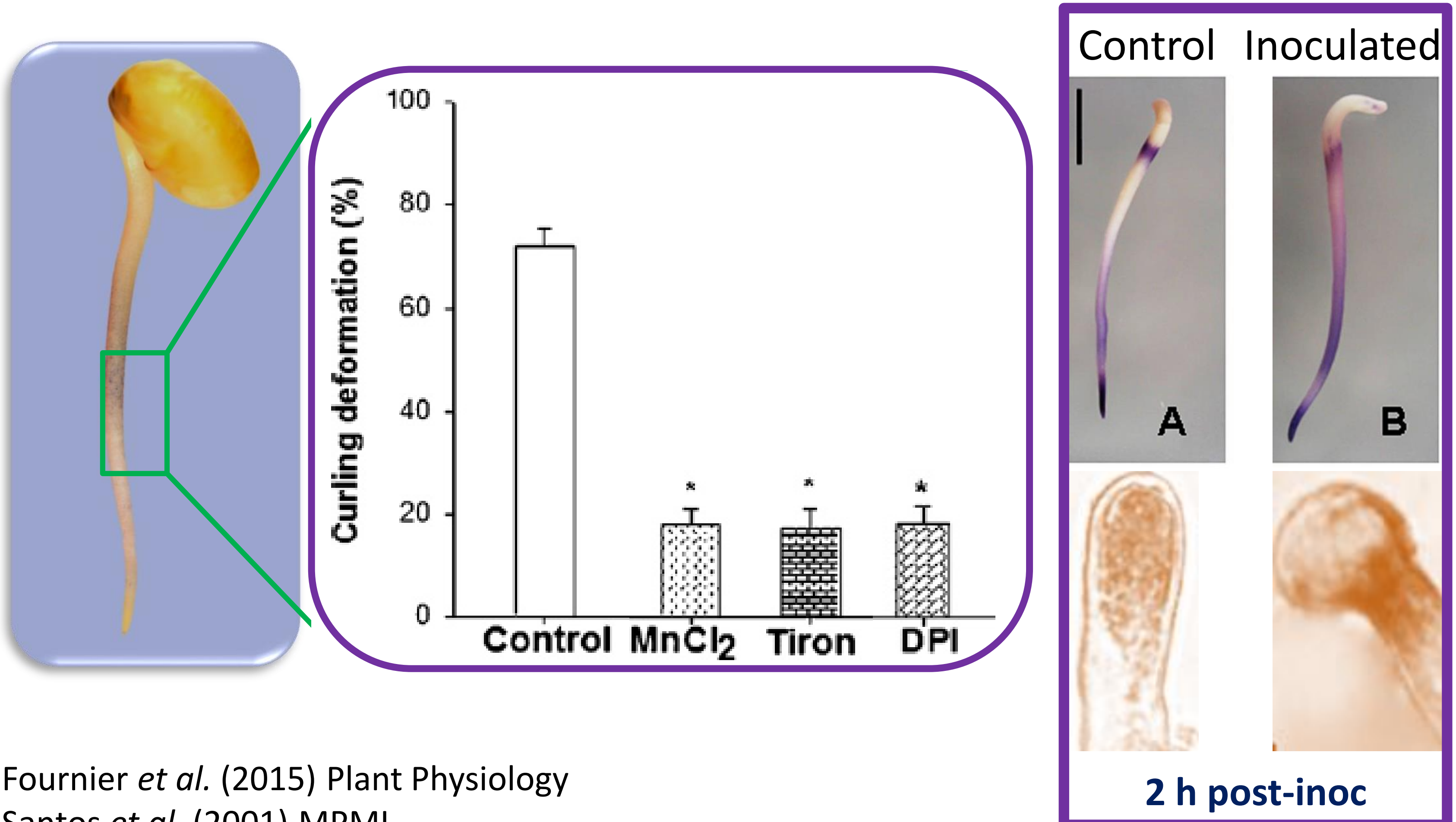
Hydroponic medium:
(24 days)
Nodule formation



DPI → NADPH oxidase-inhibitor
LY294002 → PI3K-inhibitor

Robert *et al*. (2018) Journal of Experimental Botany

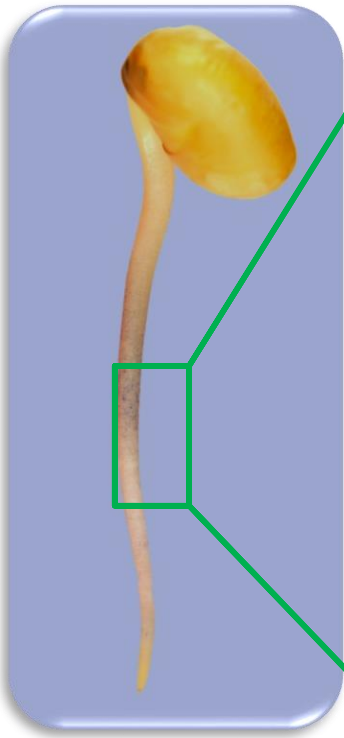
STRICT NODULATION CONTROL MECHANISM
Early host responses: root hair curling and infection thread formation

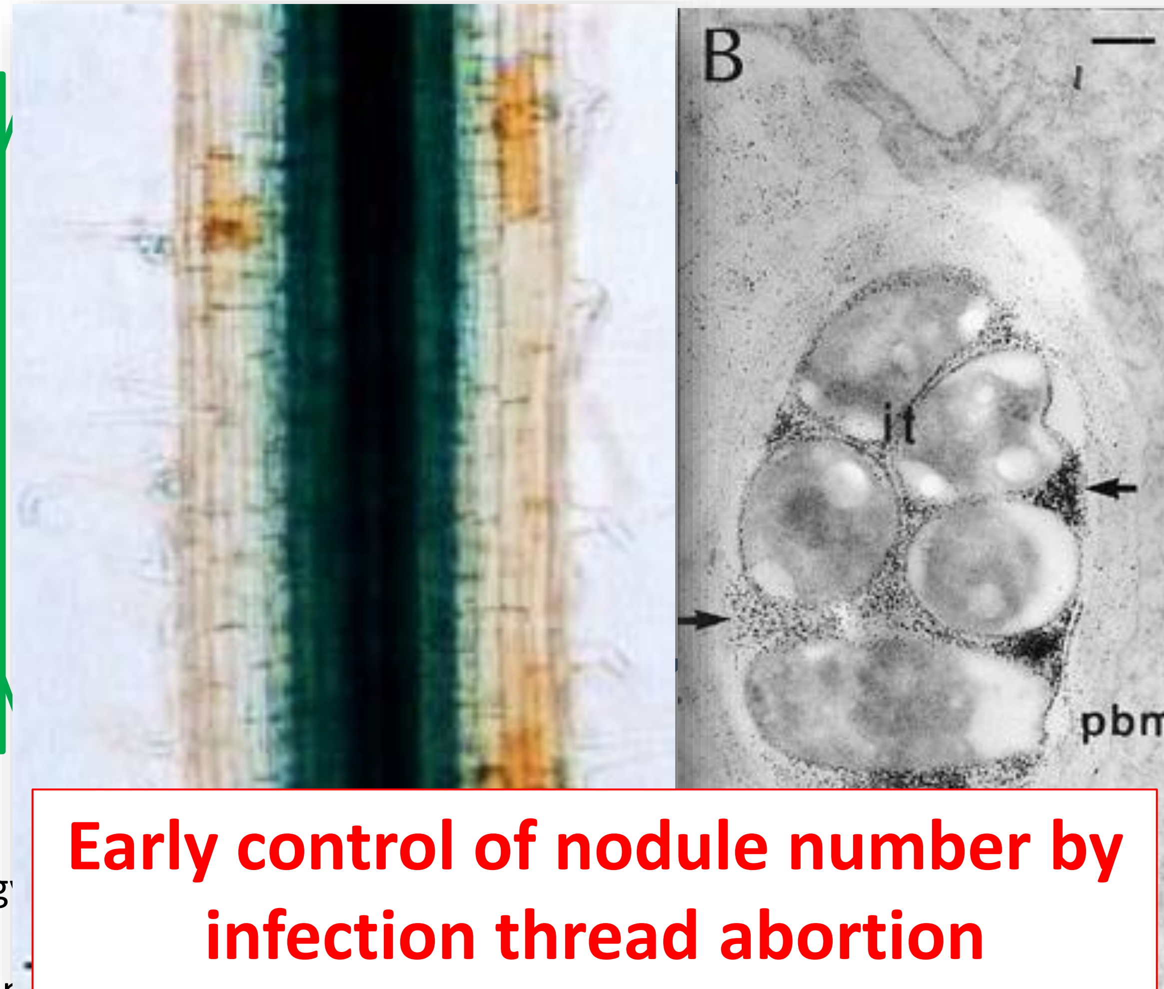


Fournier *et al.* (2015) Plant Physiology
Santos *et al*. (2001) MPMI
Muñoz *et al*. (2012) Environmental and Experimental Botany
Robert *et al.,* (2018) Journal of Experimental Botany

STRICT NODULATION CONTROL MECHANISM

Early host responses: root hair curling and infection thread formation

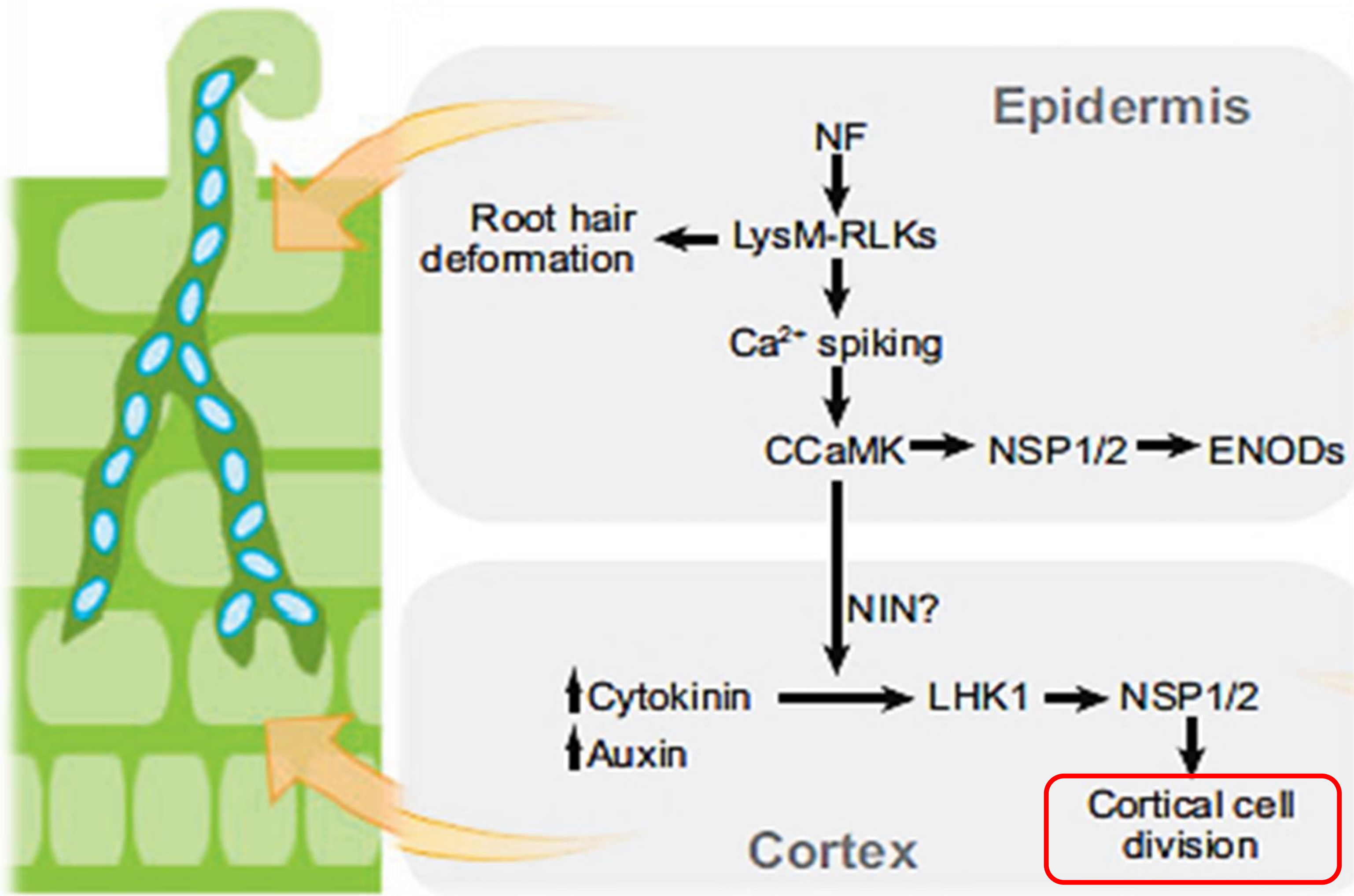




Early control of nodule number by infection thread abortion

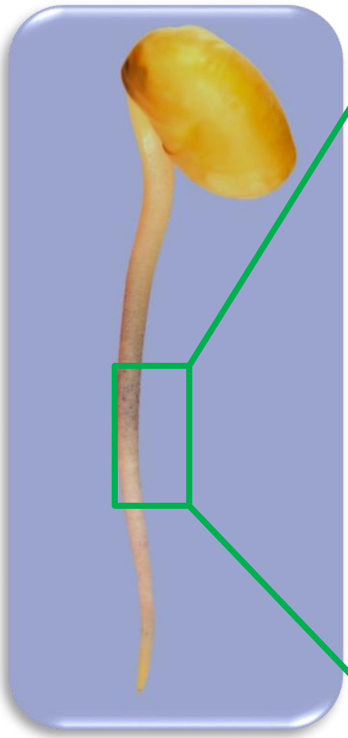
Fournier *et al.* (2015) Plant Physiology
Santos *et al.* (2001) MPMI
Muñoz *et al.* (2012) Environmental and Experimental Botany
Robert *et al.*, (2018) Journal of Experimental Botany

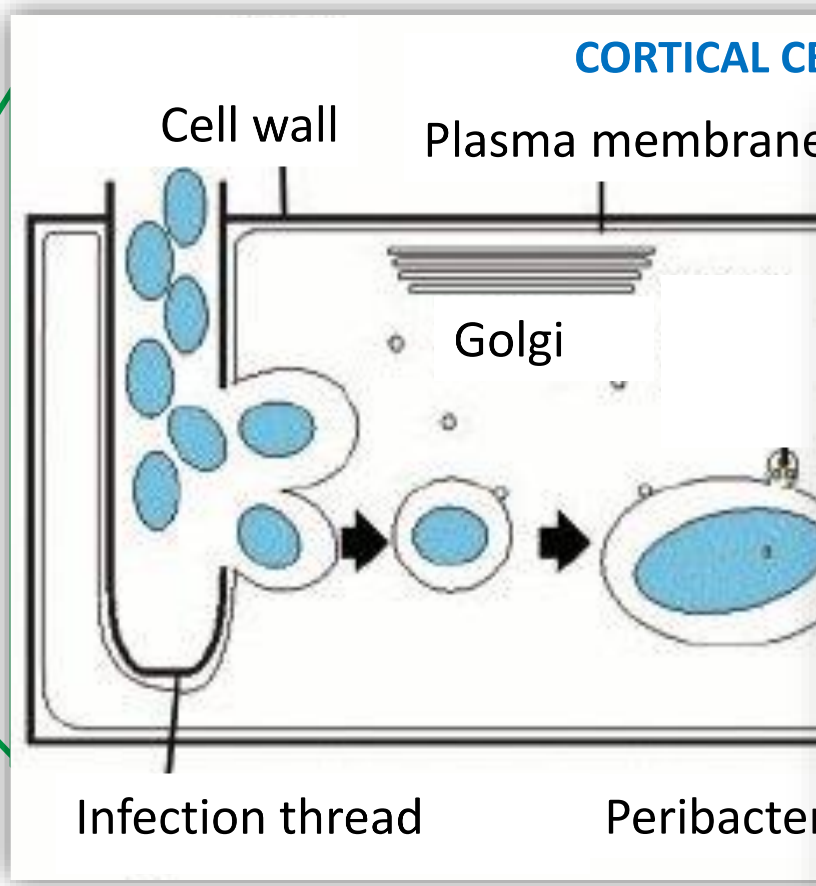
STRICT NODULATION CONTROL MECHANISM
Bacterial infection (epidermis) and nodule development (cortex)



Oldroyd and Downie. Annual review of plant biology (2008)

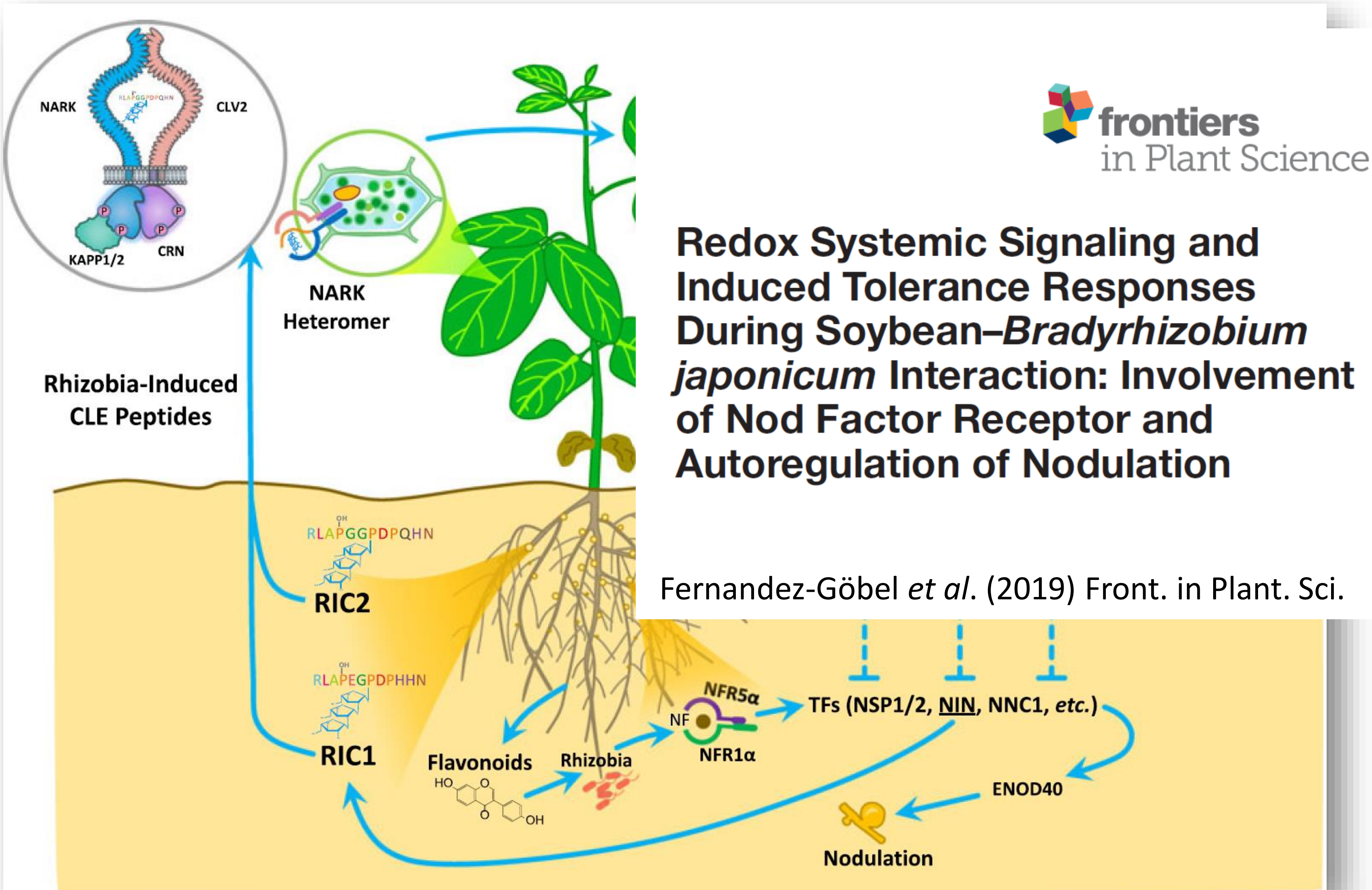
STRICT NODULATION CONTROL MECHANISM
Local responses involved on nodulation





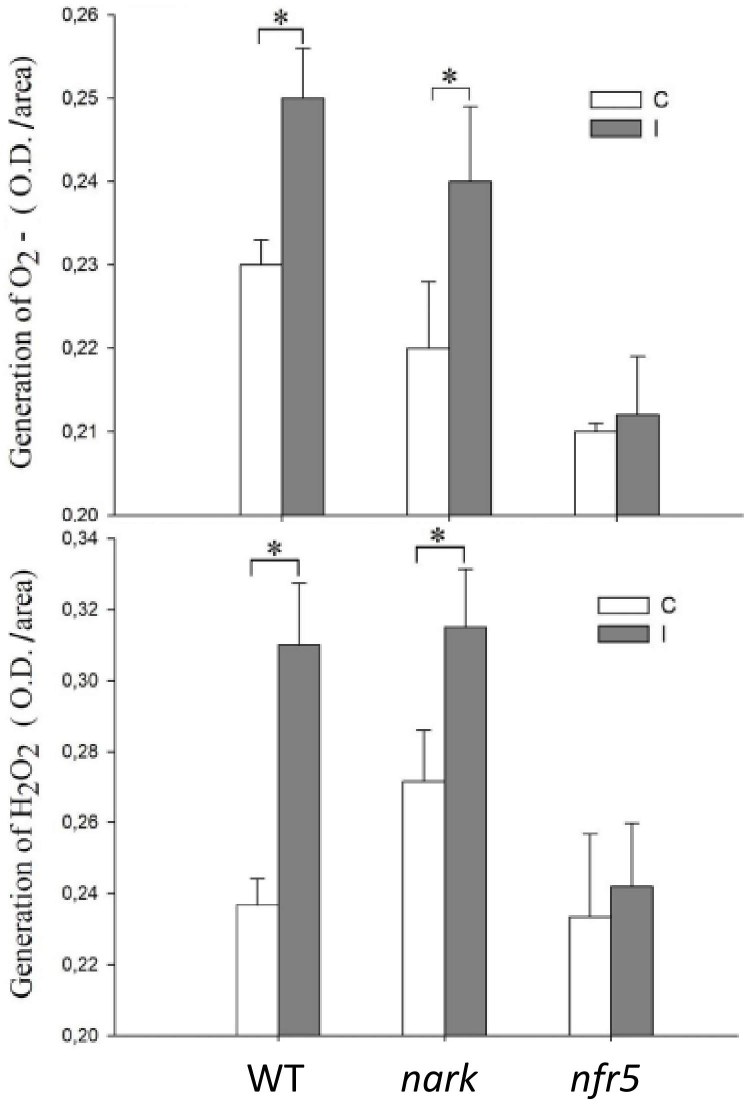
Fournier *et al.* (2015) Plant Physiology
Estrada-Navarrete *et al*. (2016) The Plant Cell

STRICT NODULATION CONTROL MECHANISM
Autoregulation of nodulation: root-to-shoot-to-root signaling



Ferguson *et al*. (2018) Plant, Cell & Environment

STRICT NODULATION CONTROL MECHANISM
Autoregulation of nodulation: root-to-shoot-to-root signaling

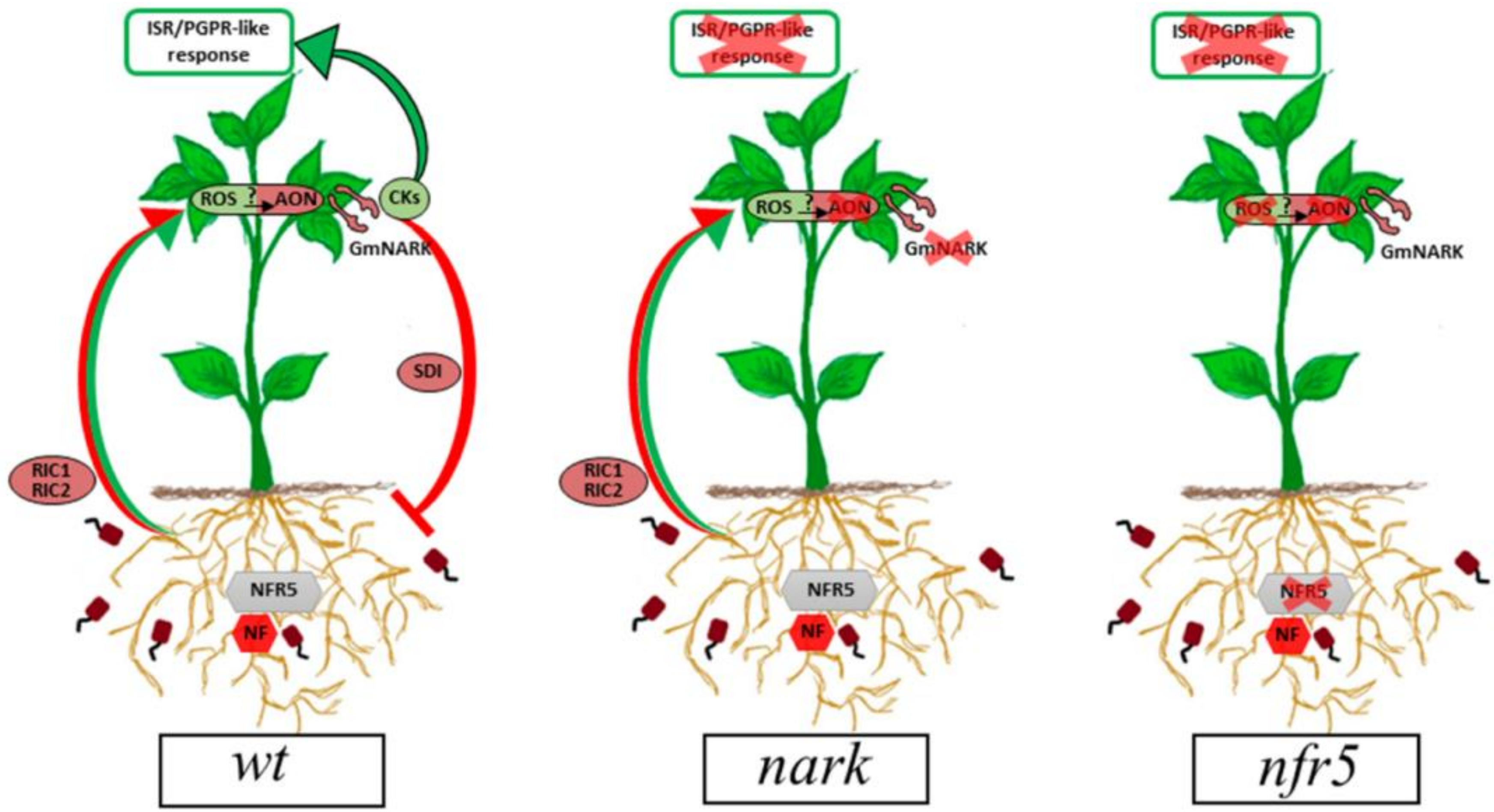


frontiers in Plant Science

Redox Systemic Signaling and Induced Tolerance Responses During Soybean–*Bradyrhizobium japonicum* Interaction: Involvement of Nod Factor Receptor and Autoregulation of Nodulation

Fernandez-Göbel *et al*. (2019) Front. in Plant. Sci.

STRICT NODULATION CONTROL MECHANISM
Autoregulation of nodulation: root-to-shoot-to-root signaling



Fernandez-Göbel *et al*. (2019) Front. in Plant. Sci.

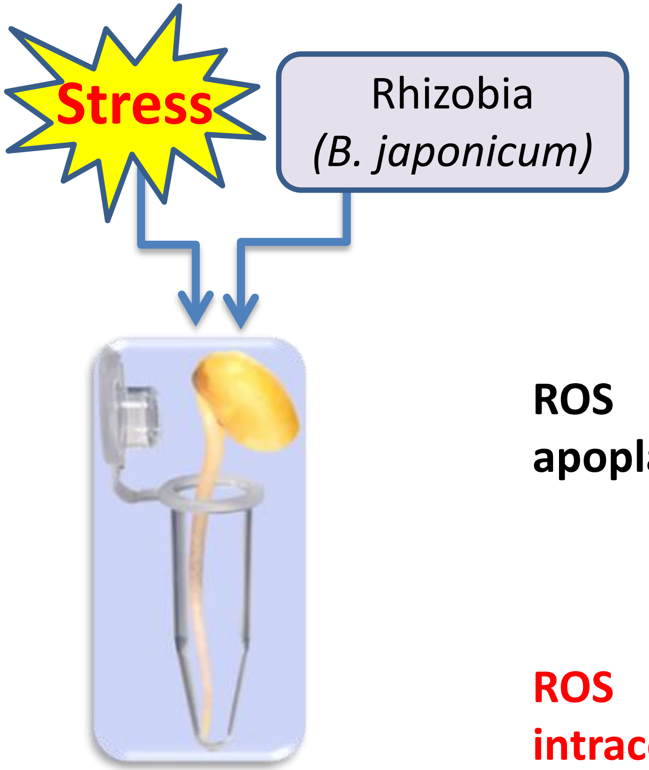
LEGUME – RHIZOBIA INTERACTION
How is it affected under stress conditions?

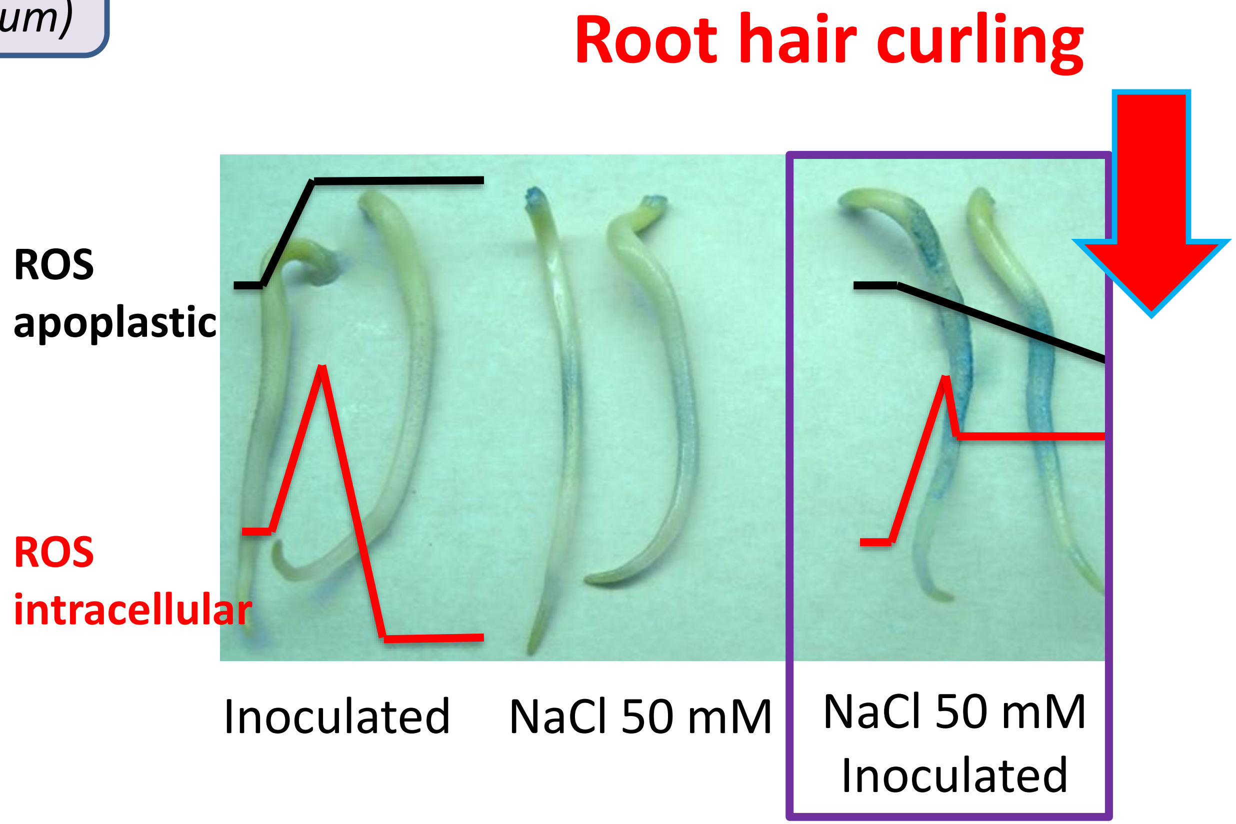
Legume host would suppress nodulation under stressful conditions to conserve resources

What are the underlying molecular mechanisms?

LEGUME – RHIZOBIA INTERACTION UNDER SALINE STRESS

Effects on the very early responses and root hair curling





Muñoz *et al*. (2012) Environmental and Experimental Botany

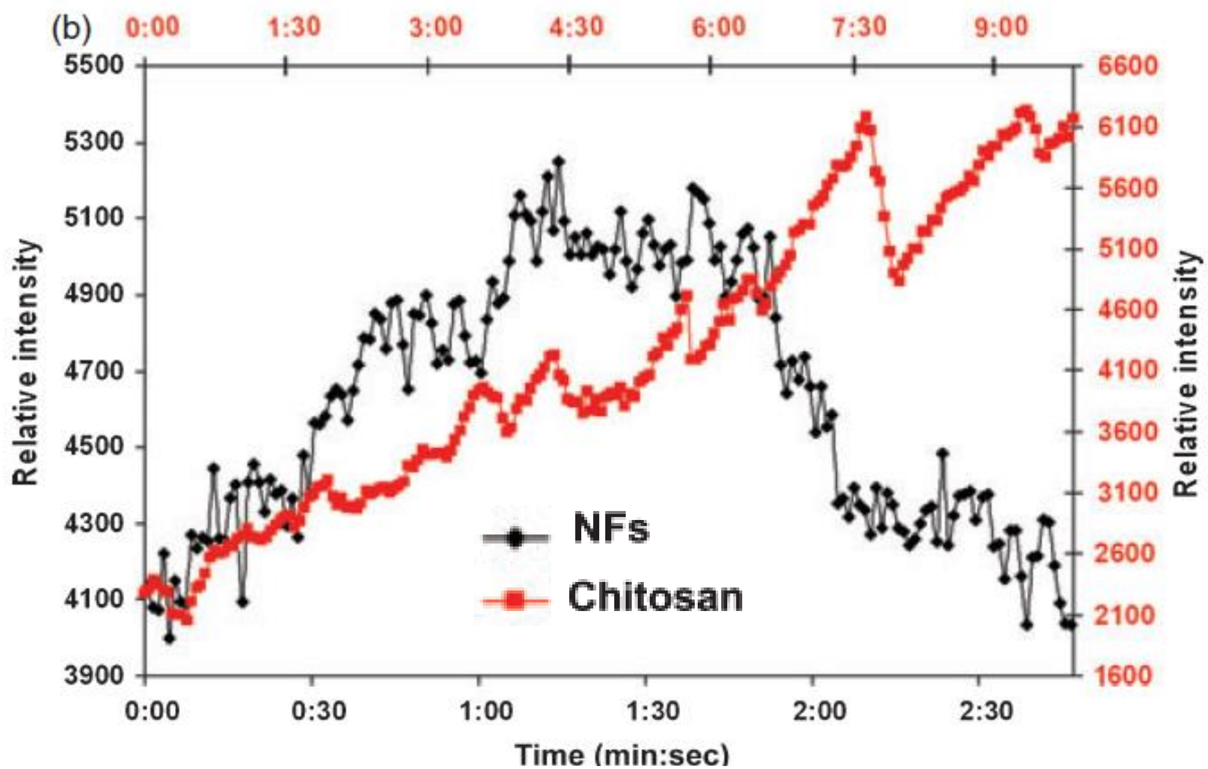
Robert *et al*. (2014) Plos One

LEGUME – RHIZOBIA INTERACTION UNDER SALINE STRESS

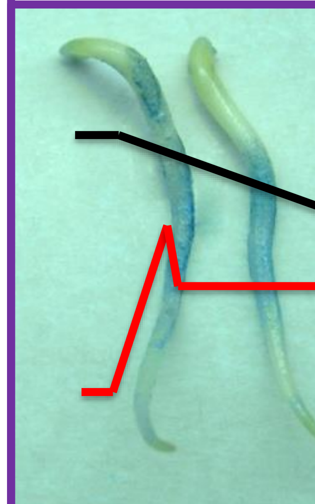
Effects on the very early responses and root hair curling

Stress

Rhizobia



Intracellular ROS generation

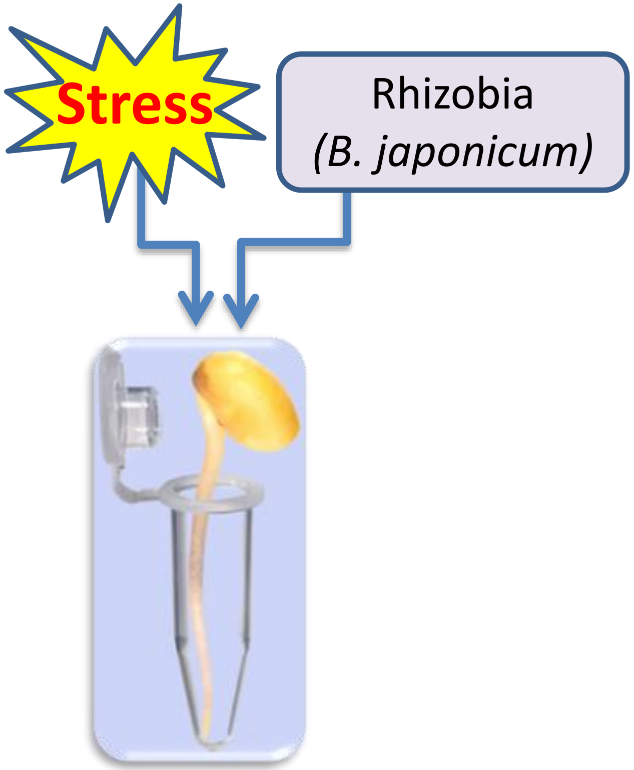


NaCl 50 mM
Inoculated

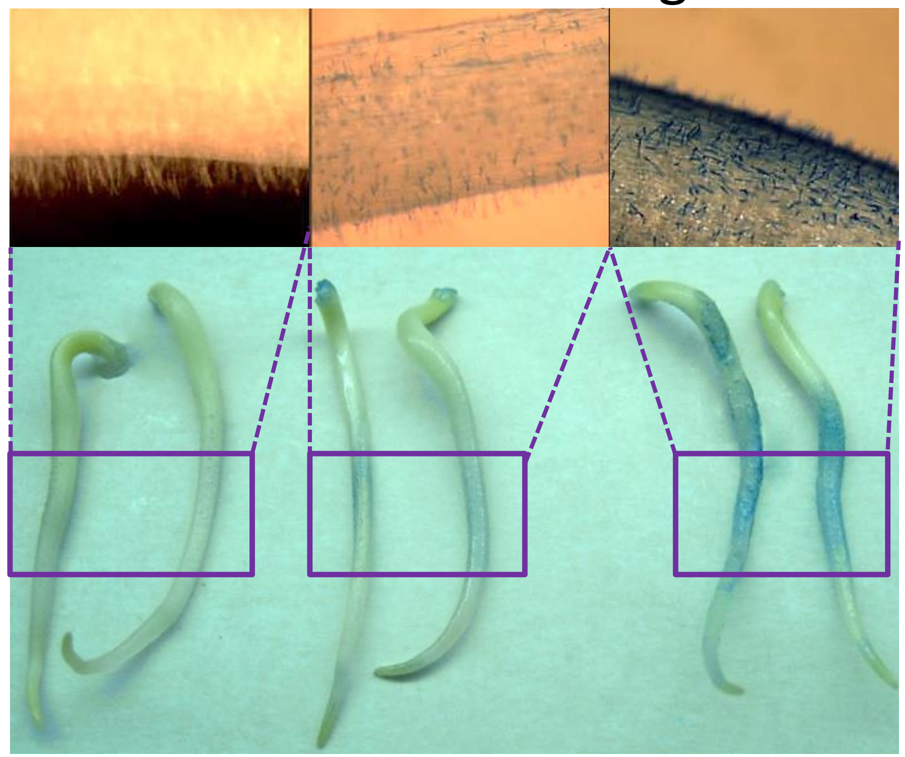
Muñoz *et al*. (2012) Environmental and Experimental Botany
Robert *et al*. (2014) Plos One

LEGUME – RHIZOBIA INTERACTION UNDER SALINE STRESS

Induced root hair death



Evans Blue staining

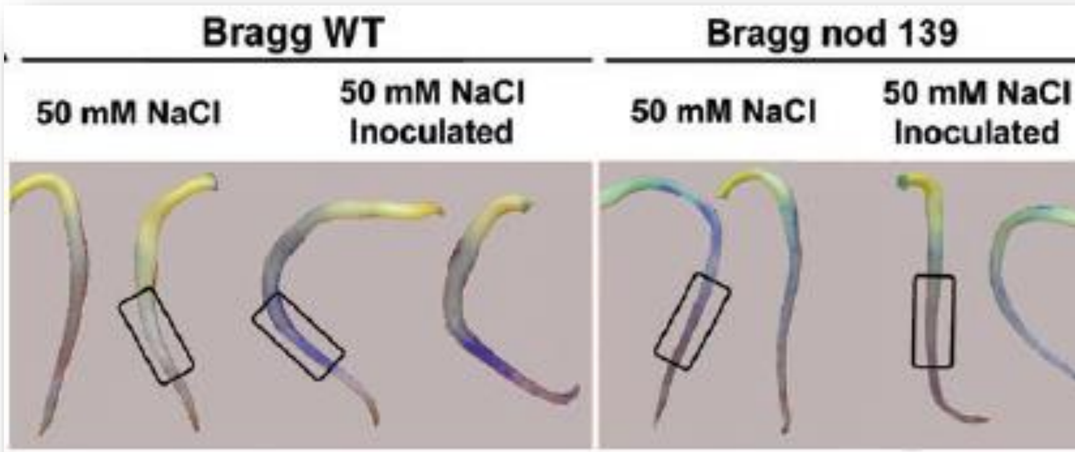


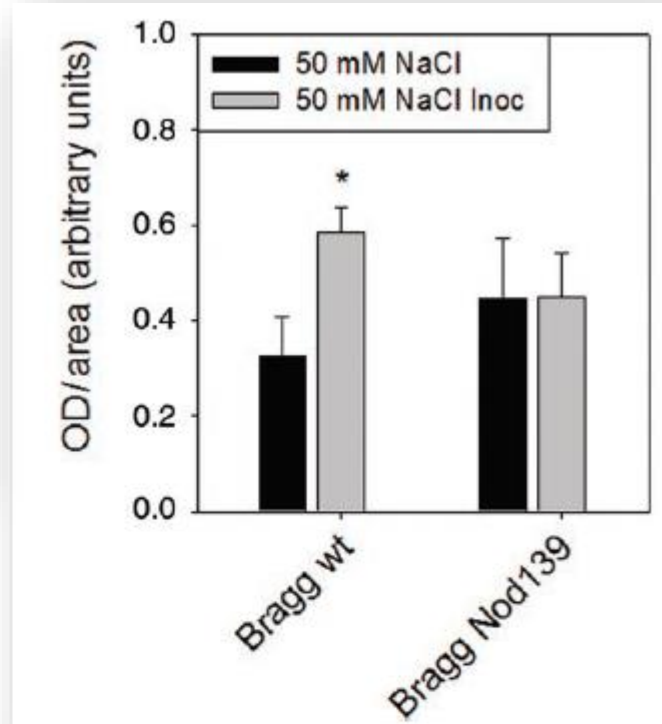
Does rhizobium perception trigger root hair death?

Muñoz *et al*. (2012) Environmental and Experimental Botany
Robert *et al*. (2014) Plos One

LEGUME – RHIZOBIA INTERACTION UNDER SALINE STRESS
Induced root hair death

Evans Blue staining

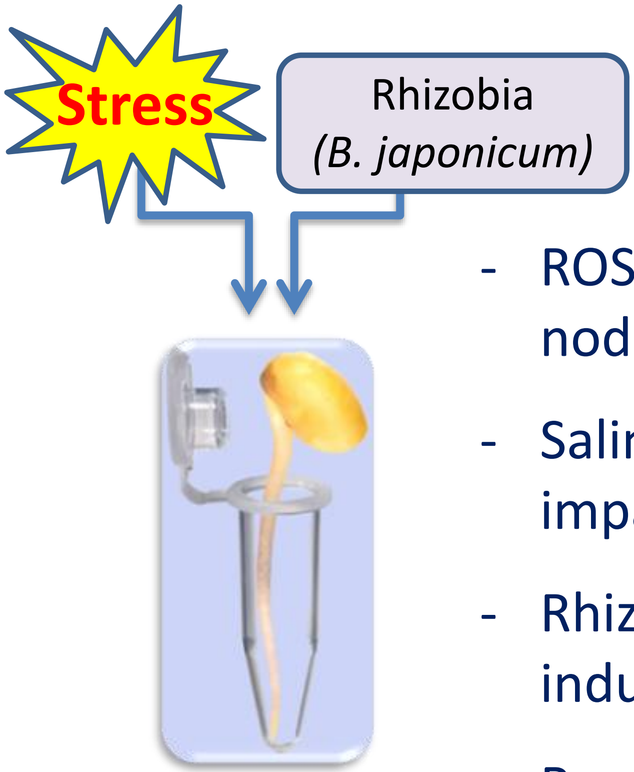




Bragg nod 139 →*nfr5*-mutant

Muñoz *et al*. (2014) Functional Plant Biology
Robert *et al*. (2018) Journal of Experimental Botany

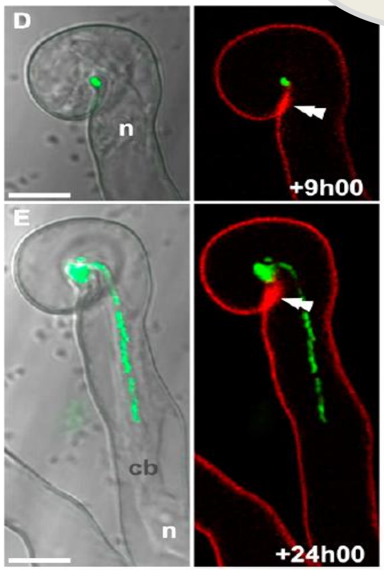
TAKE HOME MESSAGE - CONCLUSION
Root hair death as a very early control of nodulation

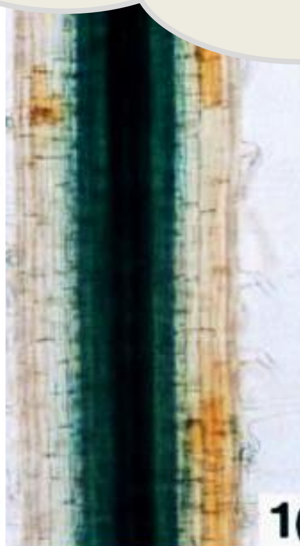


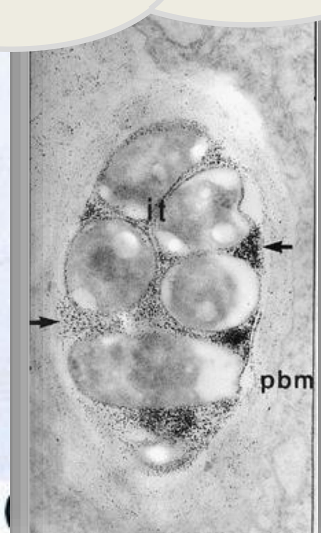
- ROS plays key role in the very early control of nodulation
- Saline stress affects very early host responses impacting on nodule formation
- Rhizobium perception under sublethal saline stress induces root hair death (as if it were a pathogen?)
- Root hair death prevents the allocation of resources/energy for nodule formation under unfavorable environmental conditions

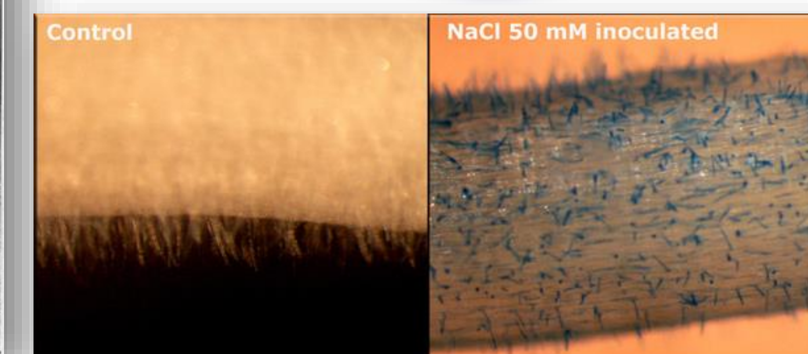
TAKE HOME MESSAGE - CONCLUSION
Root hair death as a very early control of nodulation

Controlling the process of cell death could improve the stress tolerance during legume-rhizobia interaction, and therefore the BNF









Early control of the number of nodules under control and stress conditions by cell death process

EXPRESSION OF ANIMAL CELL DEATH SUPPRESSORS IN PLANTS

Ced-9 and BcL-xL → NO HOMOLOGS IN PLANTS!

Animal cell-death suppressors Bcl-x_L and Ced-9 inhibit cell death in tobacco plants

Ichiro Mitsuhara*†, Kamal A. Malik*‡, Masayuki Miura§ and Yuko Ohashi*†

Plant Cell Physiol. 43(9): 992–1005 (2002)

Enhanced Resistance to Salt, Cold and Wound Stresses by Overproduction of Animal Cell Death Suppressors Bcl-xL and Ced-9 in Tobacco Cells — Their Possible Contribution Through Improved Function of Organella

Jingbo Qiao [1,2,3], Ichiro Mitsuhara [1,2], Yosiaki Yazaki [1], Katsuhiro Sakano [1], Yoko Gotoh [1], Masayuki Miura [4] and Yuko Ohashi [1,2,5]

Journal of Experimental Botany, Vol. 55, No. 408, pp. 2617–2623, December 2004
doi:10.1093/jxb/erh275 Advance Access publication 8 October, 2004

Journal of Experimental Botany

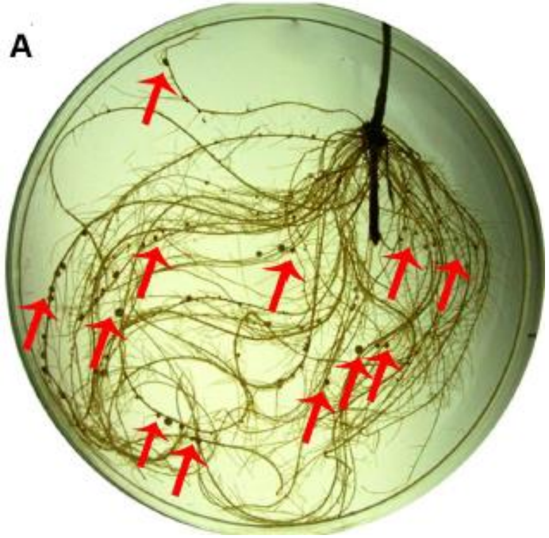
RESEARCH PAPER

Bcl-2 family members localize to tobacco chloroplasts and inhibit programmed cell death induced by chloroplast-targeted herbicides

EXPRESSION OF ANIMAL CELL DEATH SUPPRESSORS IN SOYBEAN
Ced-9-expressing hairy roots

Expression of Animal Anti-Apoptotic Gene Ced-9 Enhances Tolerance during *Glycine max* L.–*Bradyrhizobium japonicum* Interaction under Saline Stress but Reduces Nodule Formation

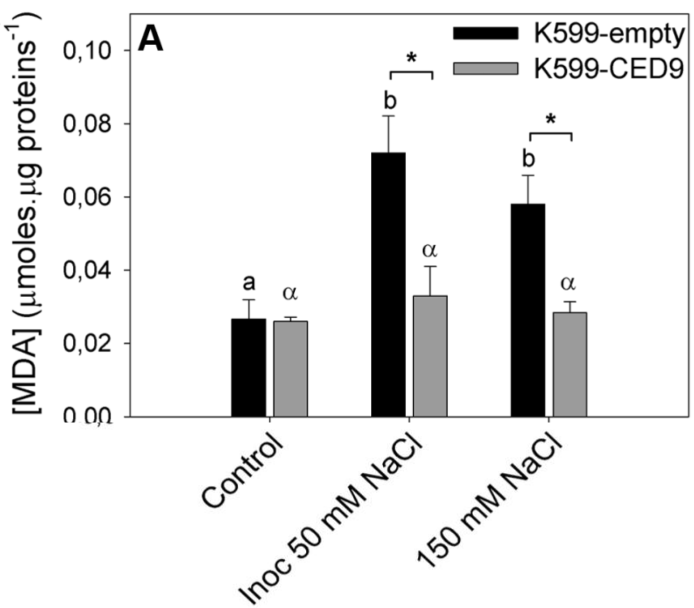
Expression of Ced-9 in transgenic hairy roots by *Agrobacterium rhizogenes* infection

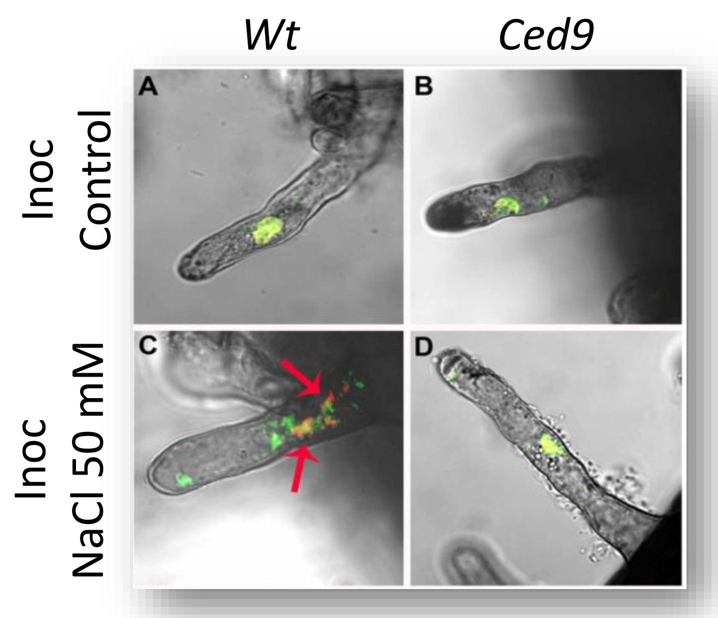


Robert *et al*. (2014) Plos One

EXPRESSION OF CED-9 IN HAIRY ROOTS: ENHANCED TOLERANCE TO STRESS CONDITIONS

Expression of Animal Anti-Apoptotic Gene Ced-9 Enhances Tolerance during *Glycine max* L.–*Bradyrhizobium japonicum* Interaction under Saline Stress but Reduces Nodule Formation

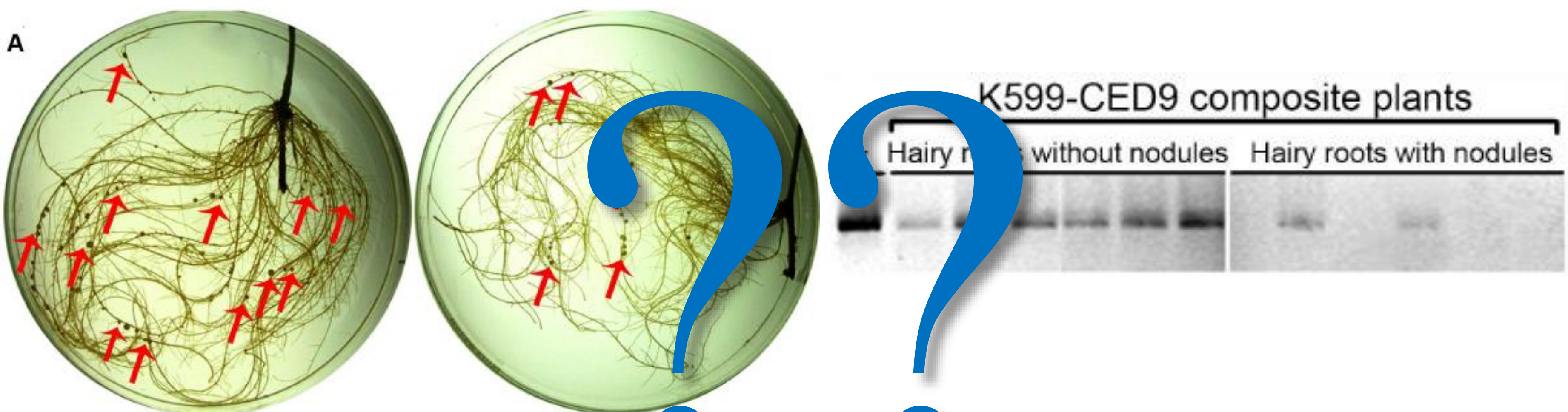




Robert *et al*. (2014) Plos One

EXPRESSION OF CED-9 IN HAIRY ROOTS: INHIBITION OF NODULATION

Expression of Animal Anti-Apoptotic Gene Ced-9 Enhances Tolerance during *Glycine max* L.–*Bradyrhizobium japonicum* Interaction under Saline Stress but Reduces Nodule Formation



TO BE CONTINUED...

Robert *et al*. (2014) Plos One

KNOWLEDGE CONSTRUCTION IS A DYNAMIC AND COLLECTIVE PROCESS

OUR TEAM

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Germán Robert (Researcher)
Nacira Muñoz (Researcher)
Laura Saavedra (Researcher)
Santiago Otaiza (Postdoc)
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明治大学
MEIJI UNIVERSITY

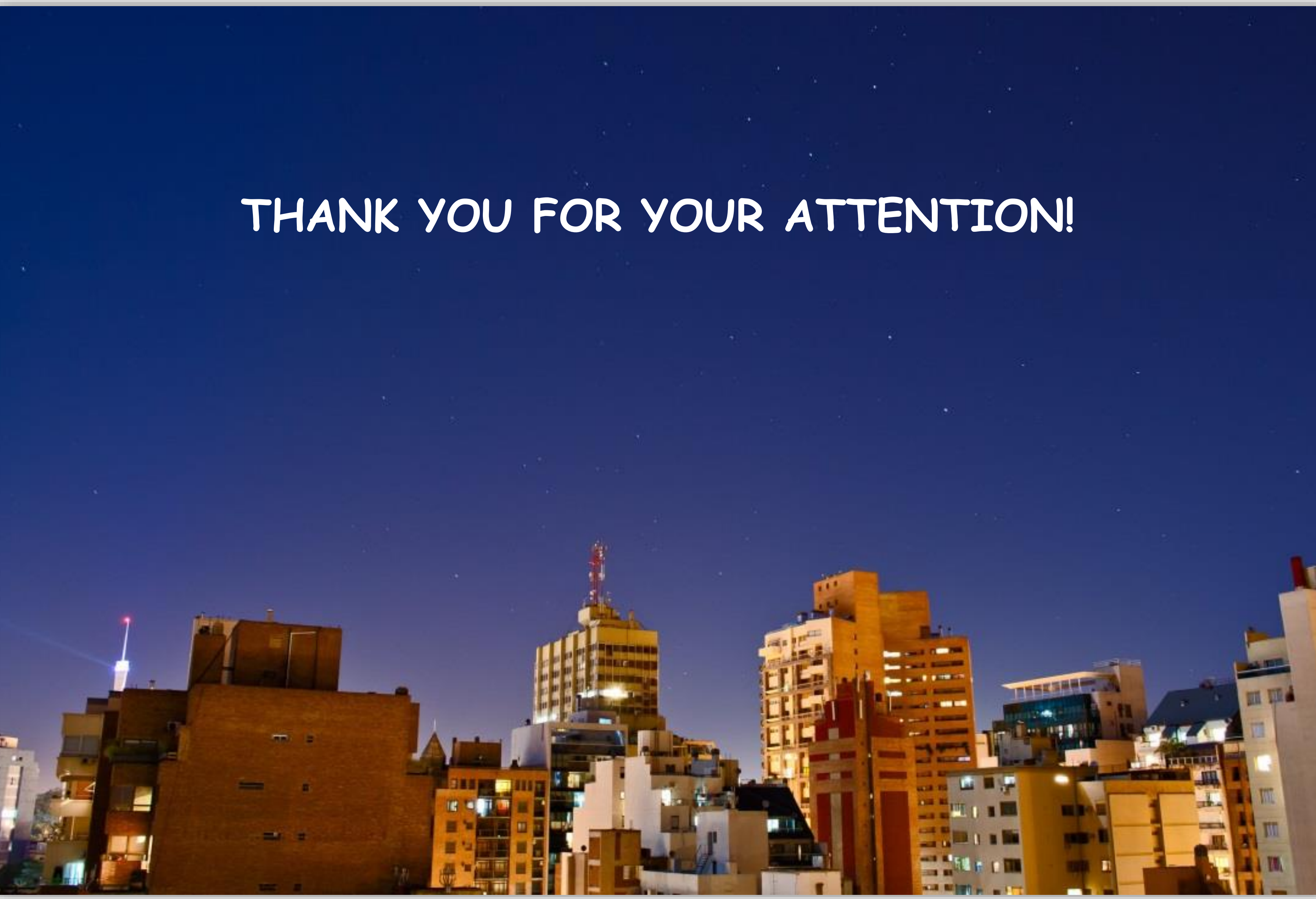
INTA | CIAP Centro de Investigaciones Agropecuarias

Secretaría de Agroindustria

Ministerio de Producción y Trabajo
Presidencia de la Nación

IFRGV
Instituto de Fisiología y Recursos Genéticos Vegetales

FCEFyN
National University of Córdoba


THANK YOU FOR YOUR ATTENTION!

LECTURE 3-

PLANT ENVIRONMENT.

AUTOPHAGY IN PLANTS: ONE PROCESS, MULTIPLE PHYSIOLOGICAL FUNCTIONS

New advances in the role of autophagy on *Nitrogen Use Eficiency (NUE)*

Germán Robert - robert.german@inta.gob.ar

INTA CIAP Centro de Investigaciones Agropecuarias

Secretaría de Agroindustria

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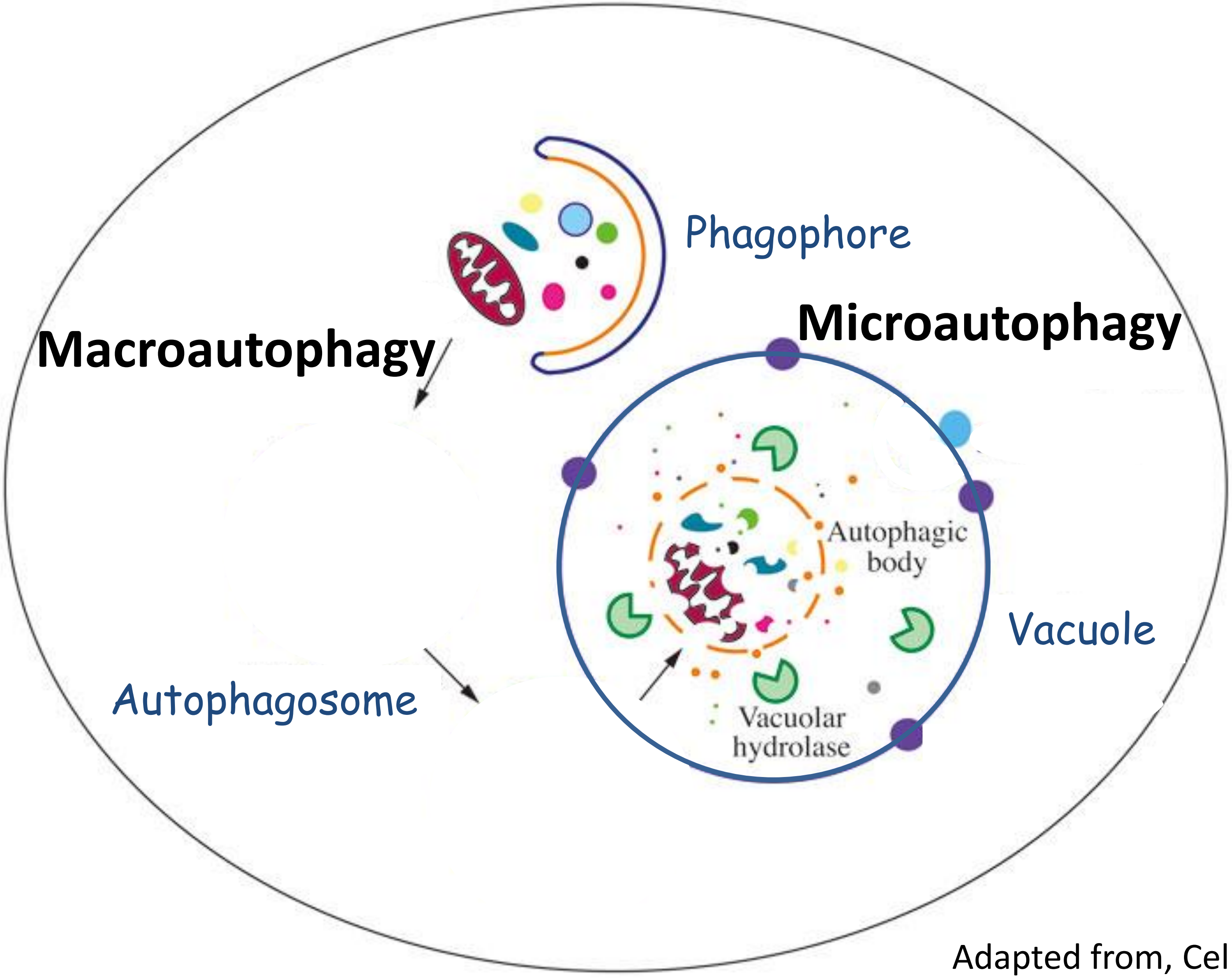
AUTOPHAGY IN EUKARIOTES:
SELF-EATING PROCESS

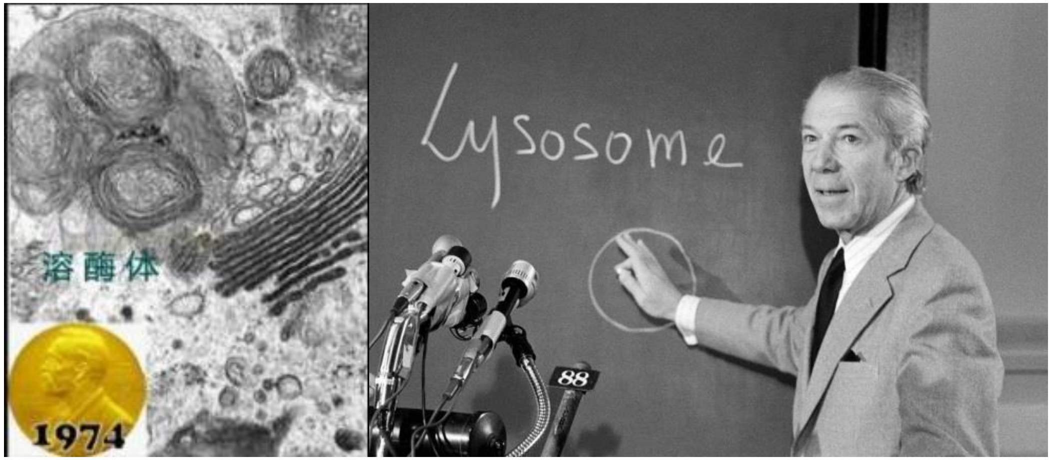
Lysosomal/vacuolar degradation pathway of self-digestion

AUTOPHAGY IN PLANTS:
MACRO- AND MICRO-AUTOPHAGY

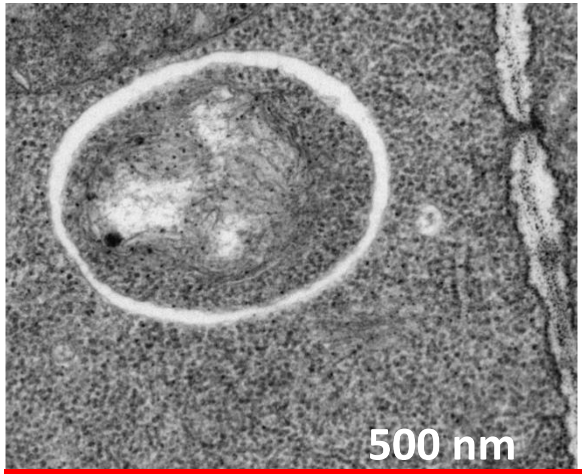


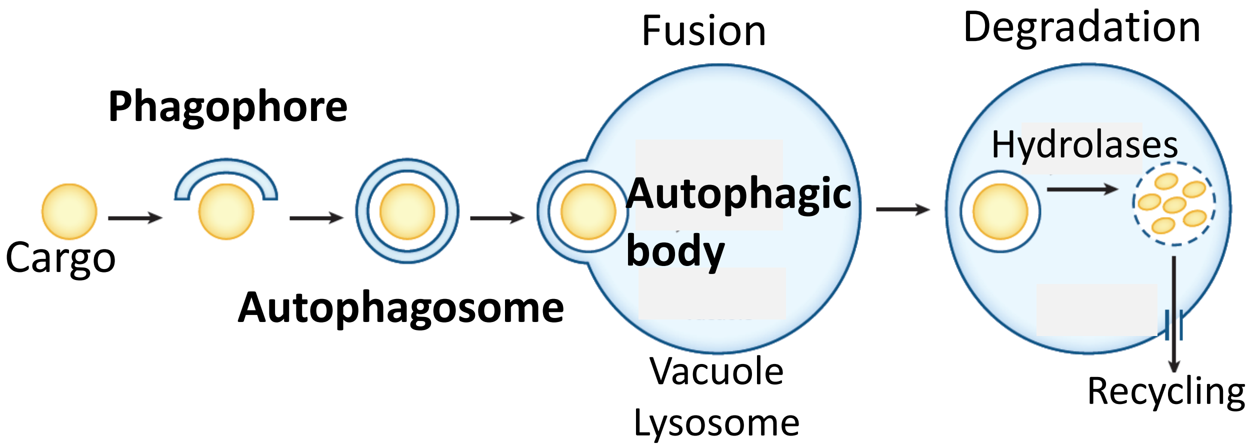
Adapted from, Cell Research (2014)
FEBS Journal (2016)

AUTOPHAGY IN EUKARYOTES



Christian de Duve → proposed the term Autophagy to denote the function of lysosomes in self-eating (Nobel Prize in Physiology or Medicine in 1974)

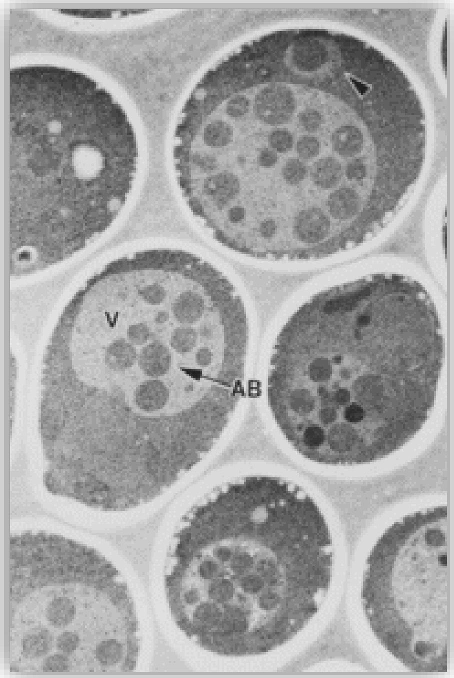


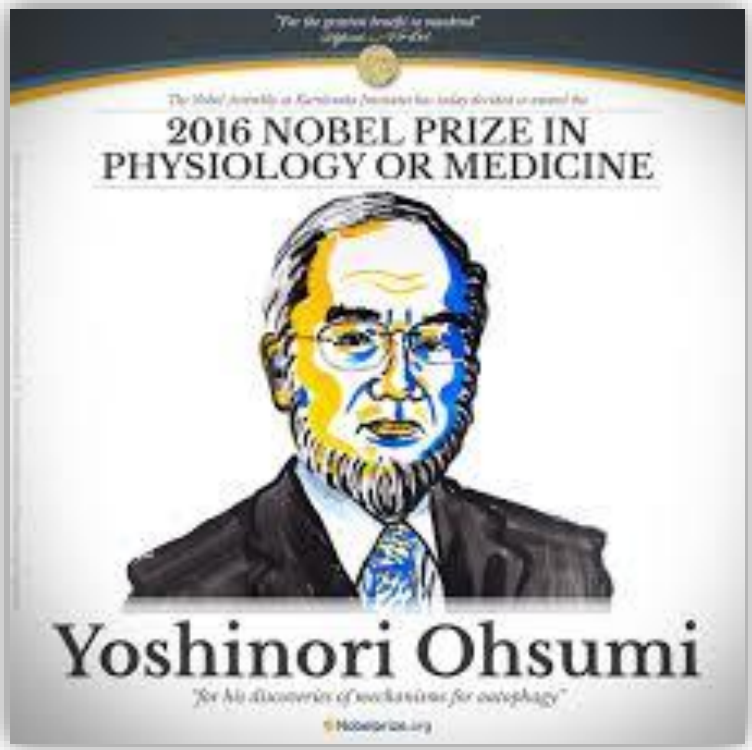


How could autophagy functions be proved by morphological observations?

AUTOPHAGY IN EUKARYOTES
ATG, AUTOPHAGY-RELATED GENES

Autophagic bodies

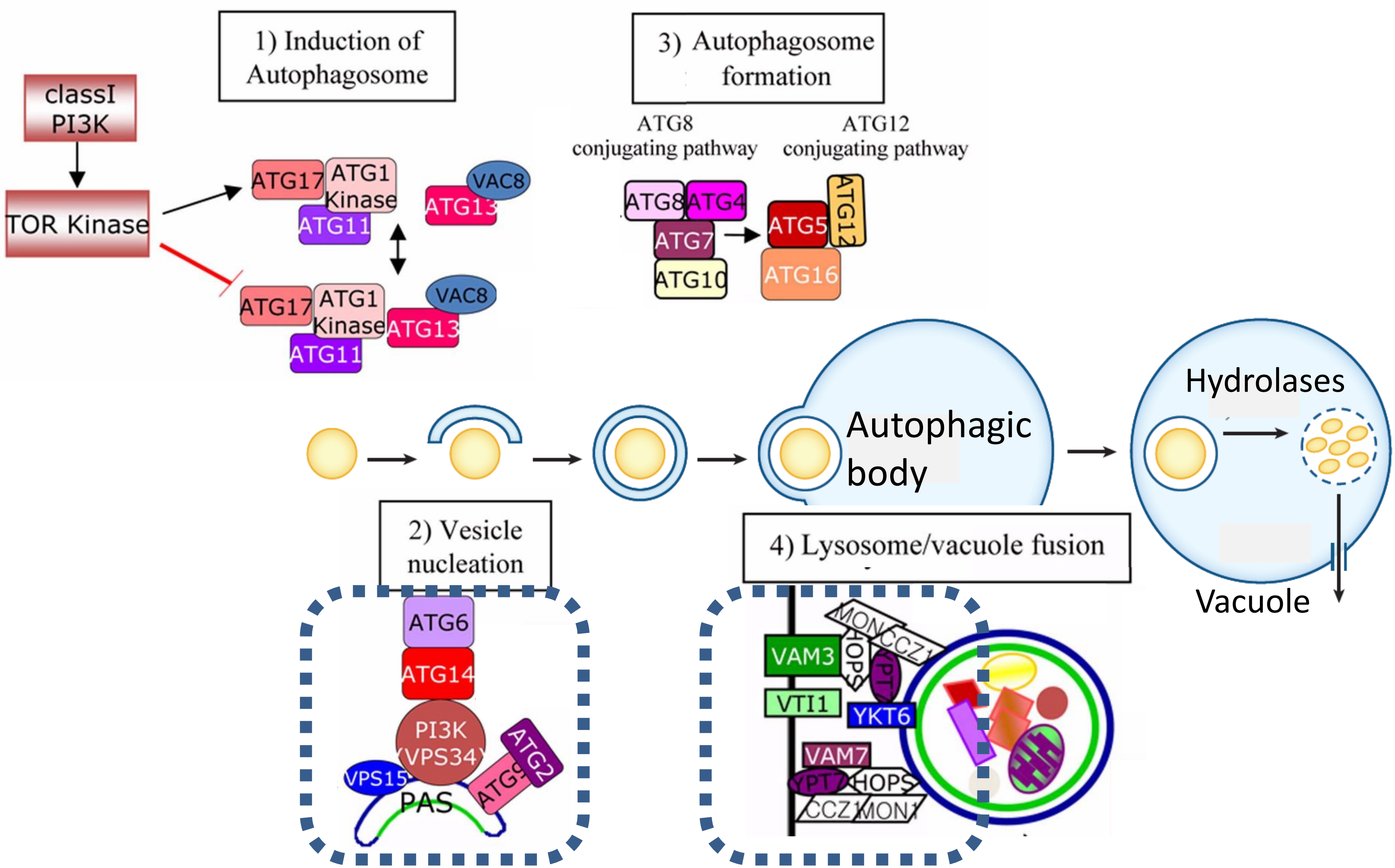




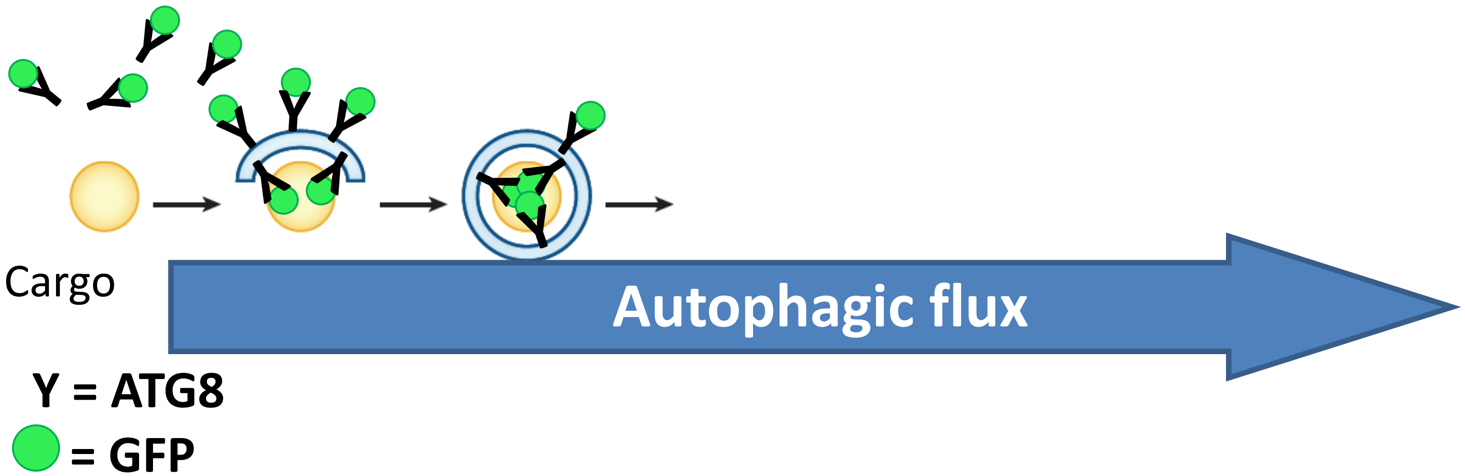
Analysis of mutant-yeast (1993) → identification of *ATG* genes (1995)

AUTOPHAGY IN EUKARYOTES

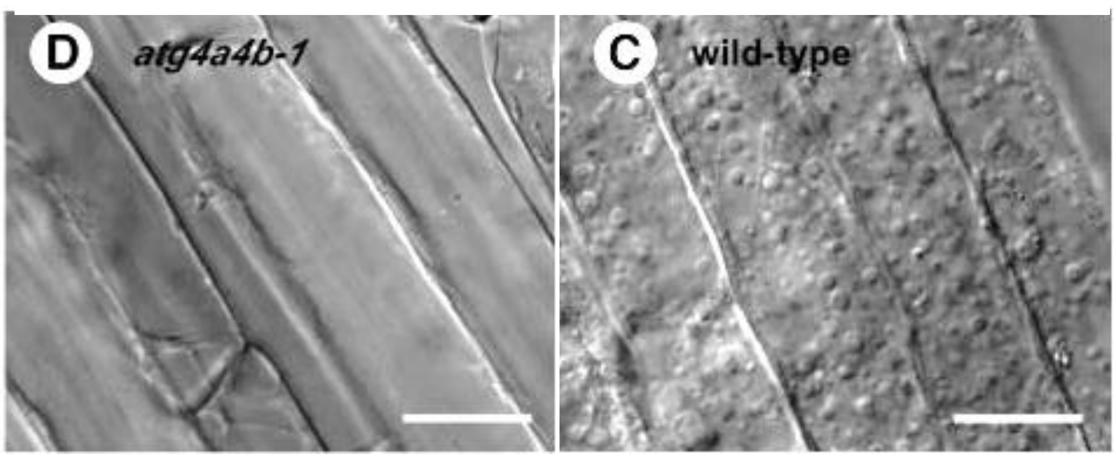
AUTOPHAGIC AND ENDOCYTIC PATHWAYS CROSSTALK



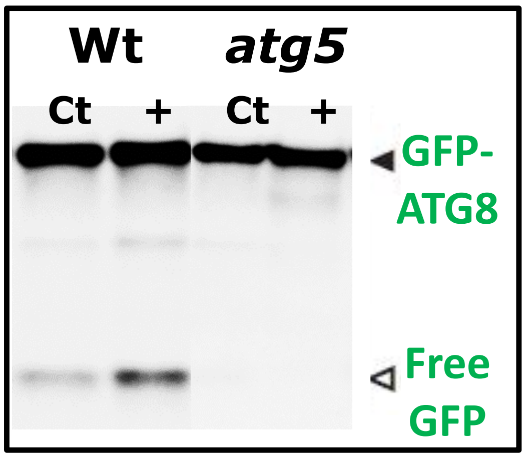
MONITORING AUTOPHAGY IN PLANTS
atg MUTANT AND GFP-ATG8 EXPRESSING PLANTS



Inhibition of vacuole degradation (Conc A)



Autophagic bodies



abGFP

Yoshimoto et al. (2004) Plant Cell

NITROGEN RECYCLING >> NITROGEN USE EFFICIENCY

PHYSIOLOGICAL FUNCTIONS OF AUTOPHAGY

The Plant Cell 2015

Autophagic Recycling Plays a Central Role in Maize Nitrogen Remobilization

Faqiang Li,[a] Taijoon Chung,[a,1] Janice G. Pennington,[b] Maria L. Federico,[c] Heidi F. Kaeppler,[c] Shawn M. Kaeppler,[c] Marisa S. Otegui,[b] and Richard D. Vierstra[a,2]

Journal of Experimental Botany 2016

Nitrogen remobilisation during leaf senescence: lessons from Arabidopsis to crops

Marien Havé[1], Anne Marmagne[1], Fabien Chardon[1] and Céline Masclaux-Daubresse[1,*]

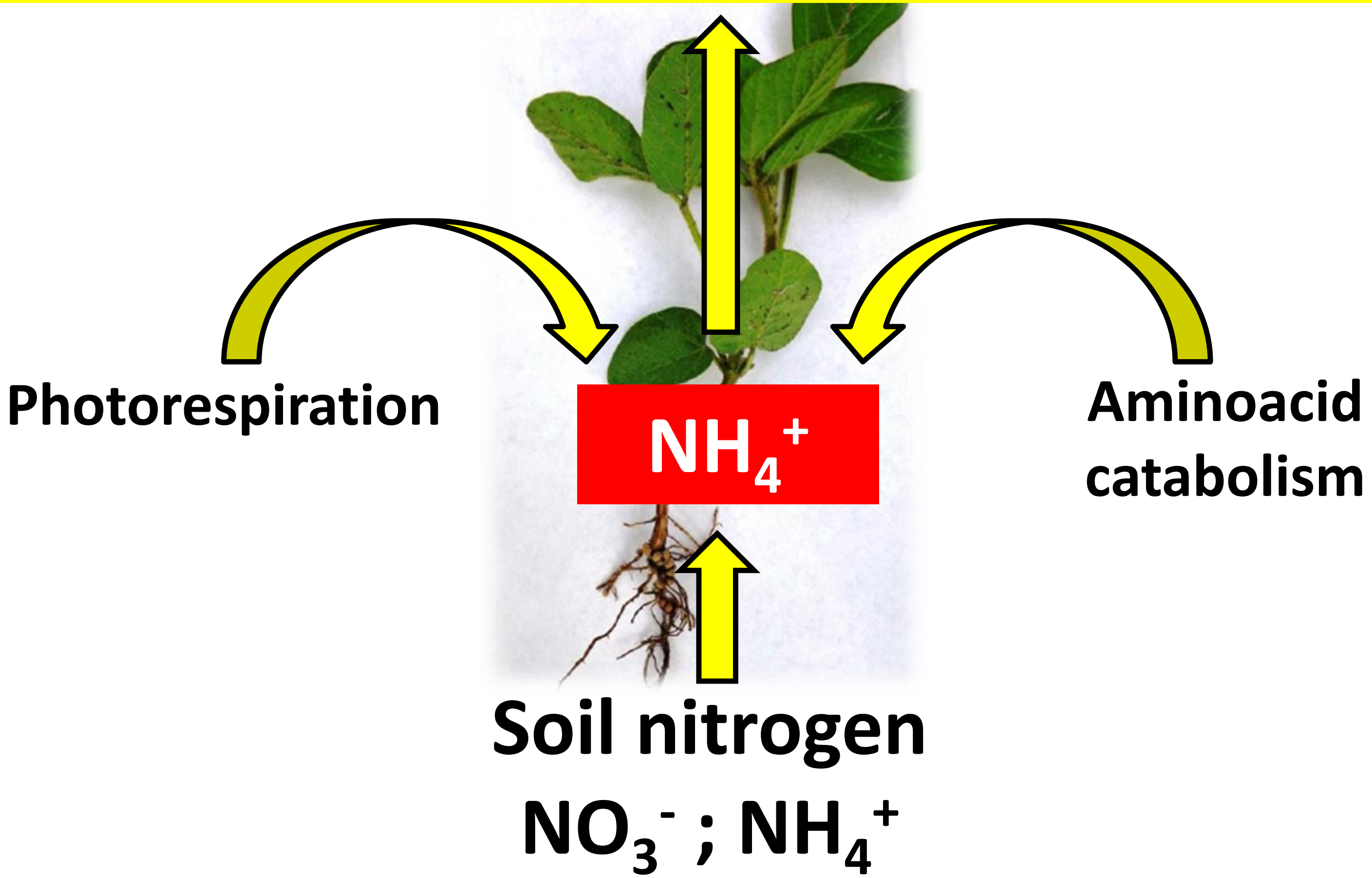
Guiboileau et al (2013). New Phytologist
Masclaux-Daubresse et al. (2018) Curr Opinion in Plant Biol
Wang et al. (2017) Seminars in Cell & Developmental Biology

PHYSIOLOGICAL FUNCTIONS OF AUTOPHAGY

NH_4^+ TOLERANCE >> NITROGEN USE EFFICIENCY

NH_4^+ accumulation >>>> reduced plant growth

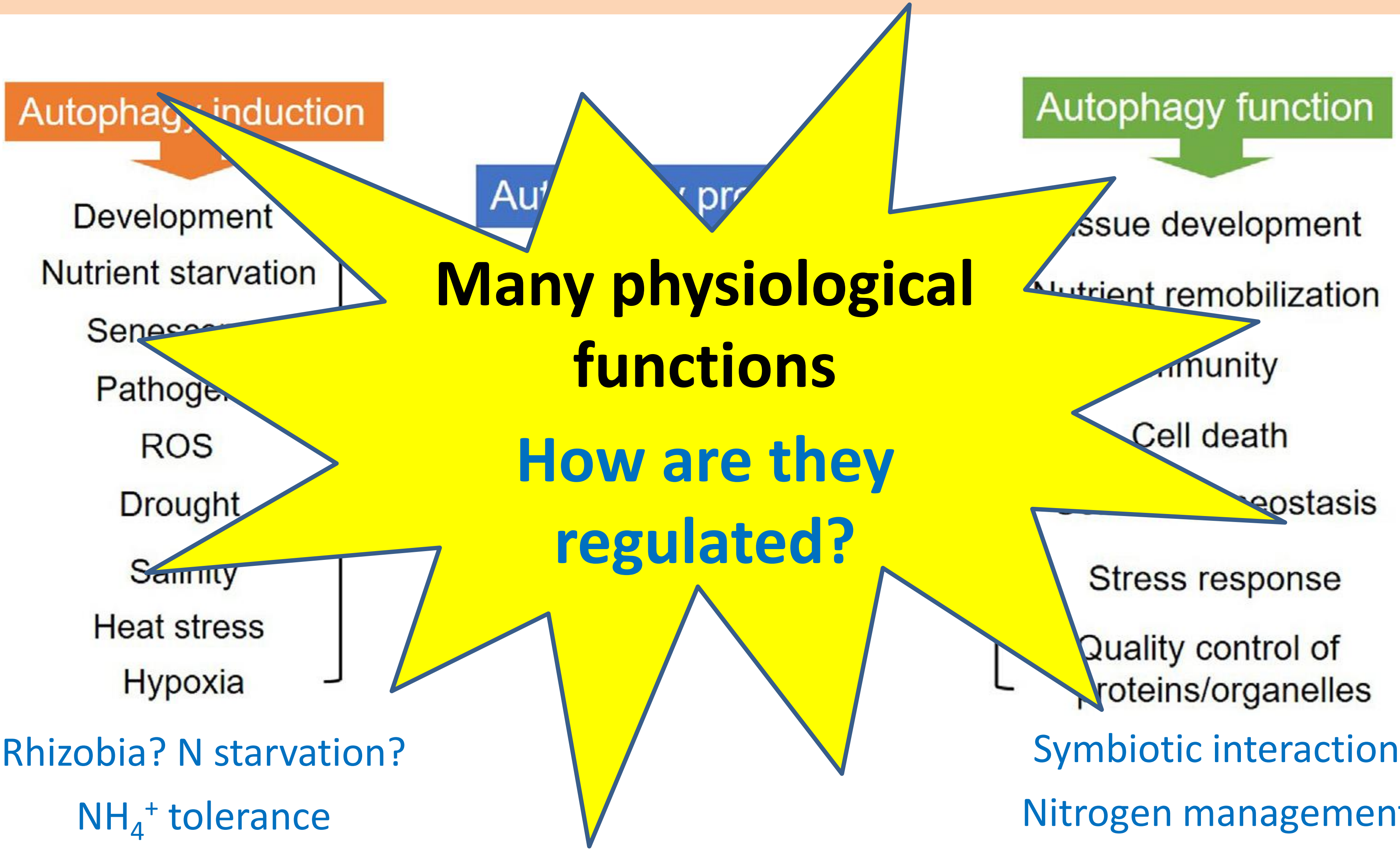
DOES AUTOPHAGY HAVE A ROLE IN NH_4^+ TOLERANCE RESPONSES?



Sarasketa *et al*. (2014) Journal of Experimental Botany

PERSPECTIVES

AUTOPHAGY: ONE PROCESS, MULTIPLE PHYSIOLOGICAL FUNCTIONS



Wang et al. (2017) Seminars in Cell & Developmental Biology

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