Colloque
Santé globale et nouveaux flux de risques
Impacts des changements climatiques et anthropiques

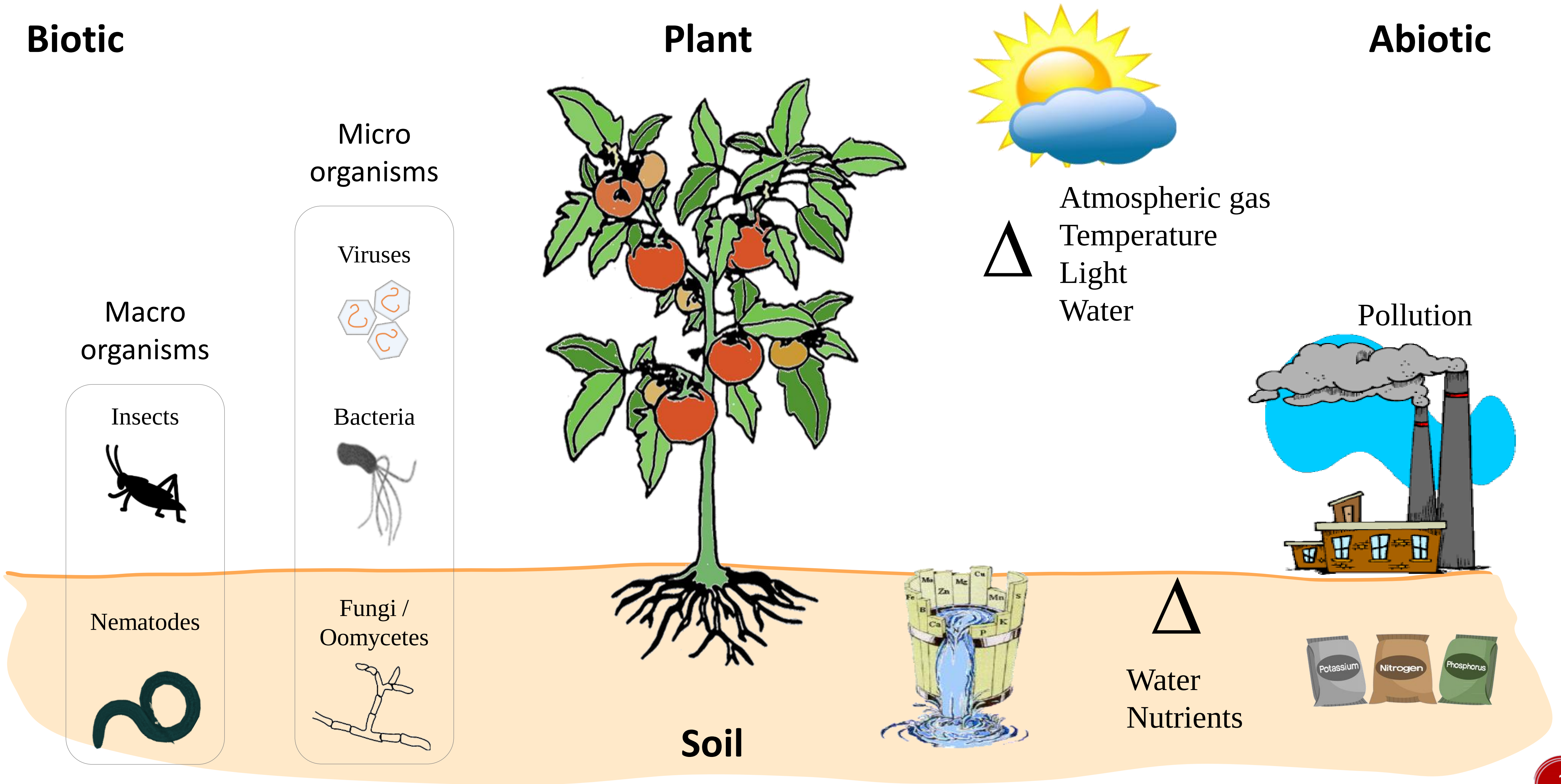
Mardi 15 décembre 2020 - Colloque en webinaire

Effect of climate change on plant immunity: towards robust resistance to *Ralstonia solanacearum*

Richard Berthomé

LIPM, REACH team led by L. deslandes
“Plant ***RE****sistance pathway dynamics and* ***A****daptation to climate* ***CH****ange”*

Plants are submitted to a large variety of stresses

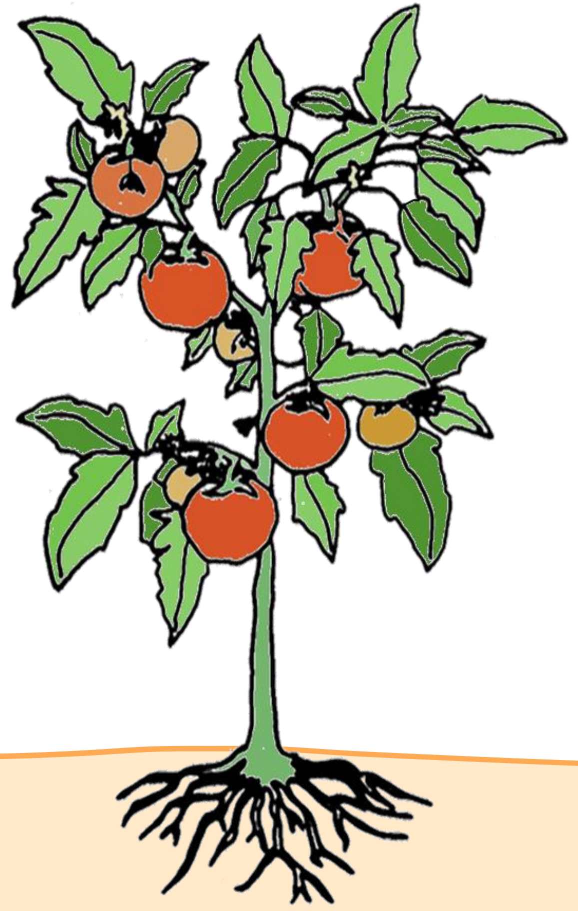


Plants are submitted to a large variety of stresses

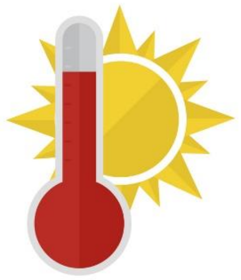
Biotic

Bacteria

Plant



Abiotic



- Temperature elevation
- Climate warming

Soil

Consequences and predictions of climate warming

- Global mean surface temperature augmentation

2.0 ⟶ 4.9°C by 2100

- Consequences

Heat waves frequency, intensity and duration

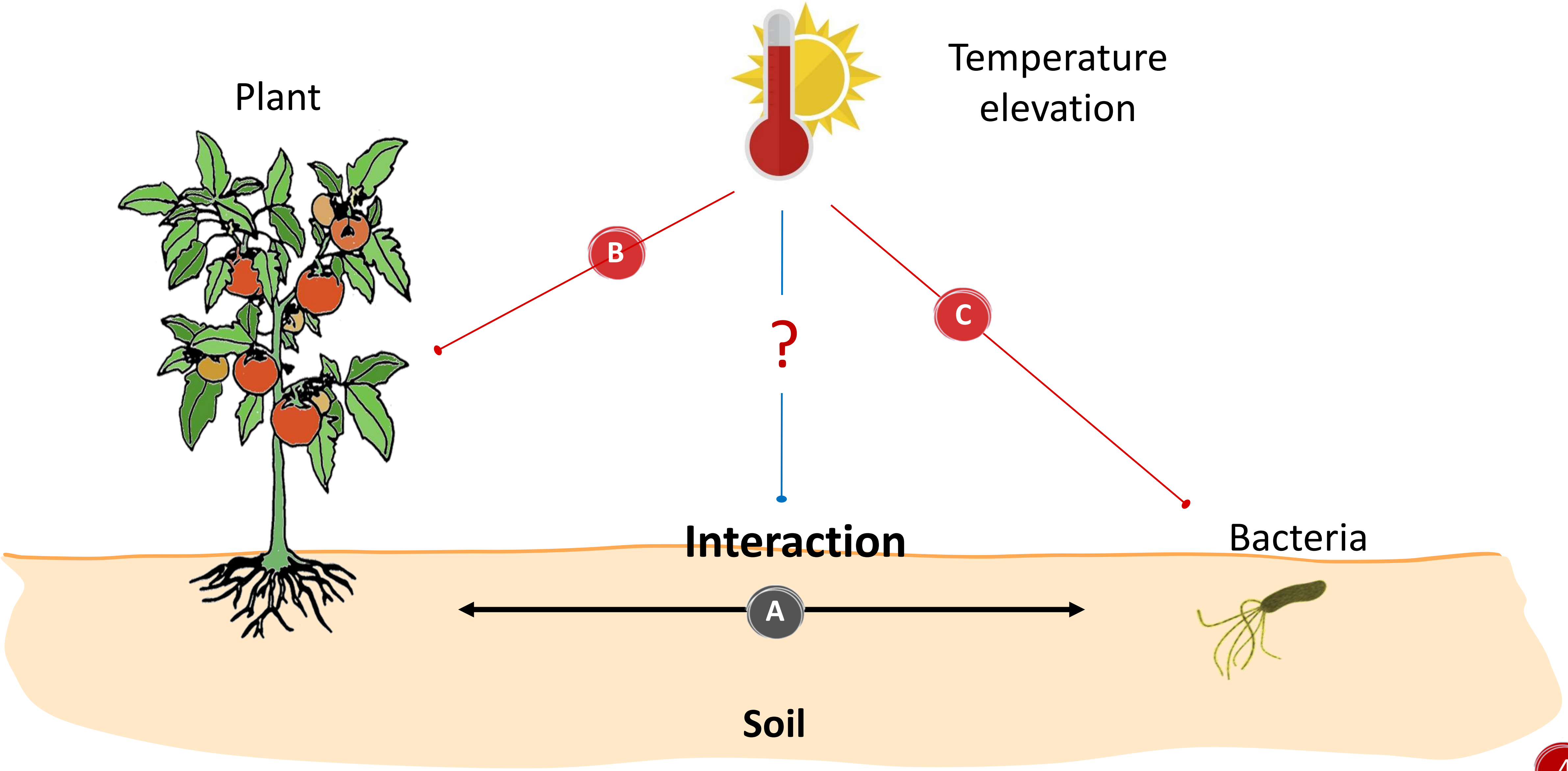
! Species extinction, ecosystem destruction, diversity depletion, pathogens emergence and distribution

! Humans: social and economical disparities, epidemics, food security, hunger, health, migrations….

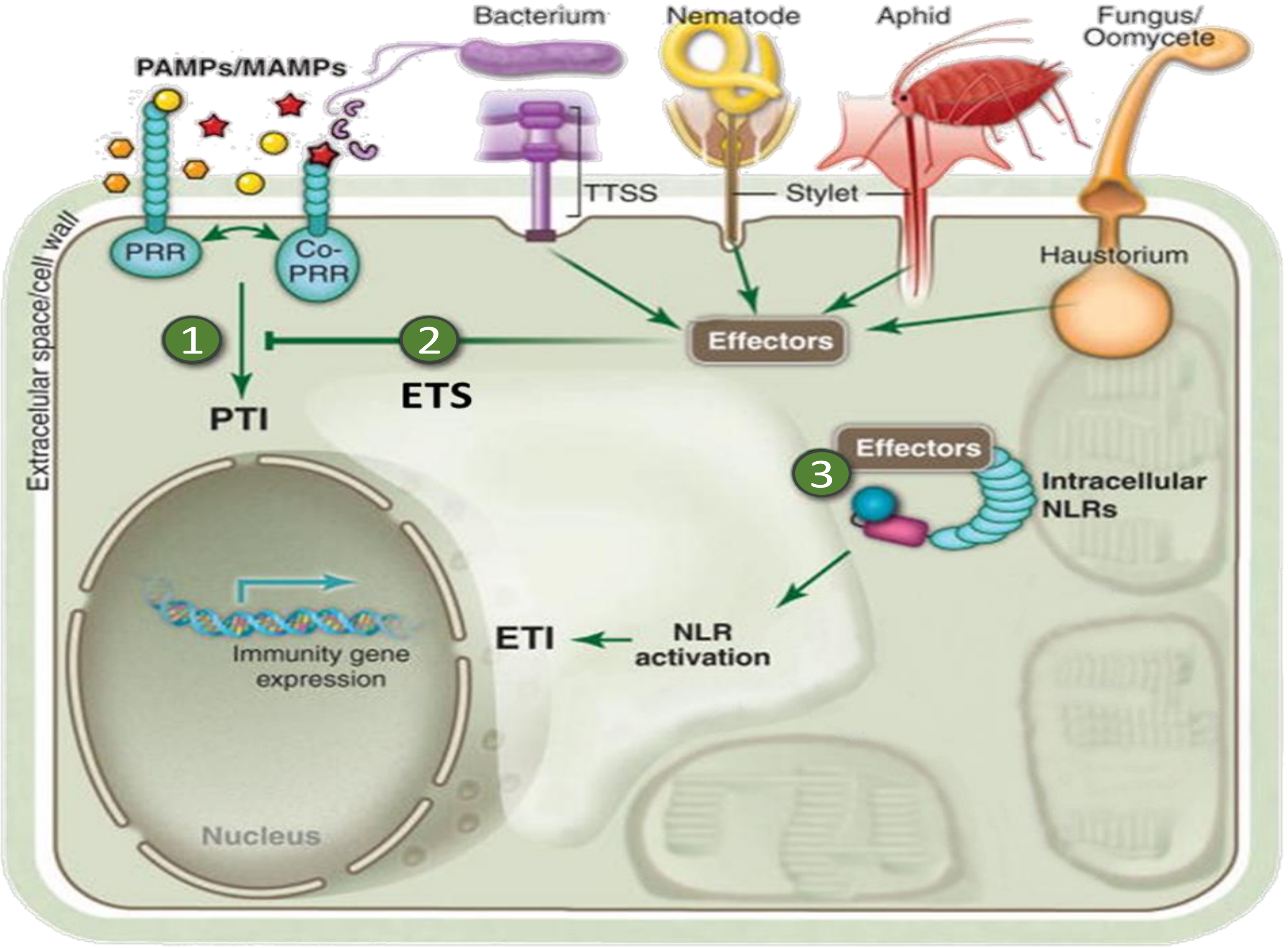
Describe, limit… adapt

Pachaury *et al.* (2014); Bebber *et al* (2015)
Raftery *et al.* (2017); Savary *et al.* (2019)

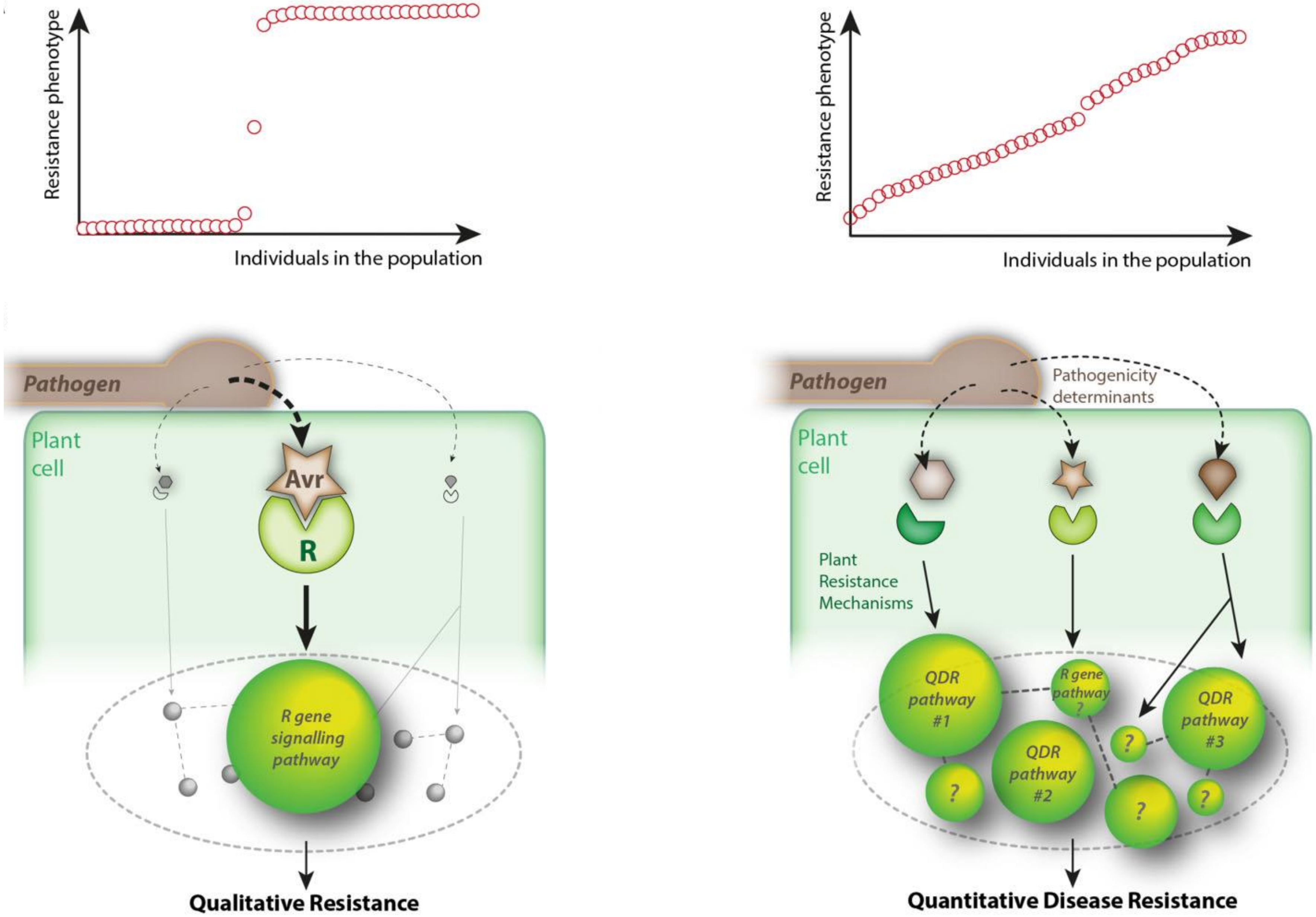
A tripartite interaction: Plant - Biotic stress – Abiotic stress



A - Plant immunity

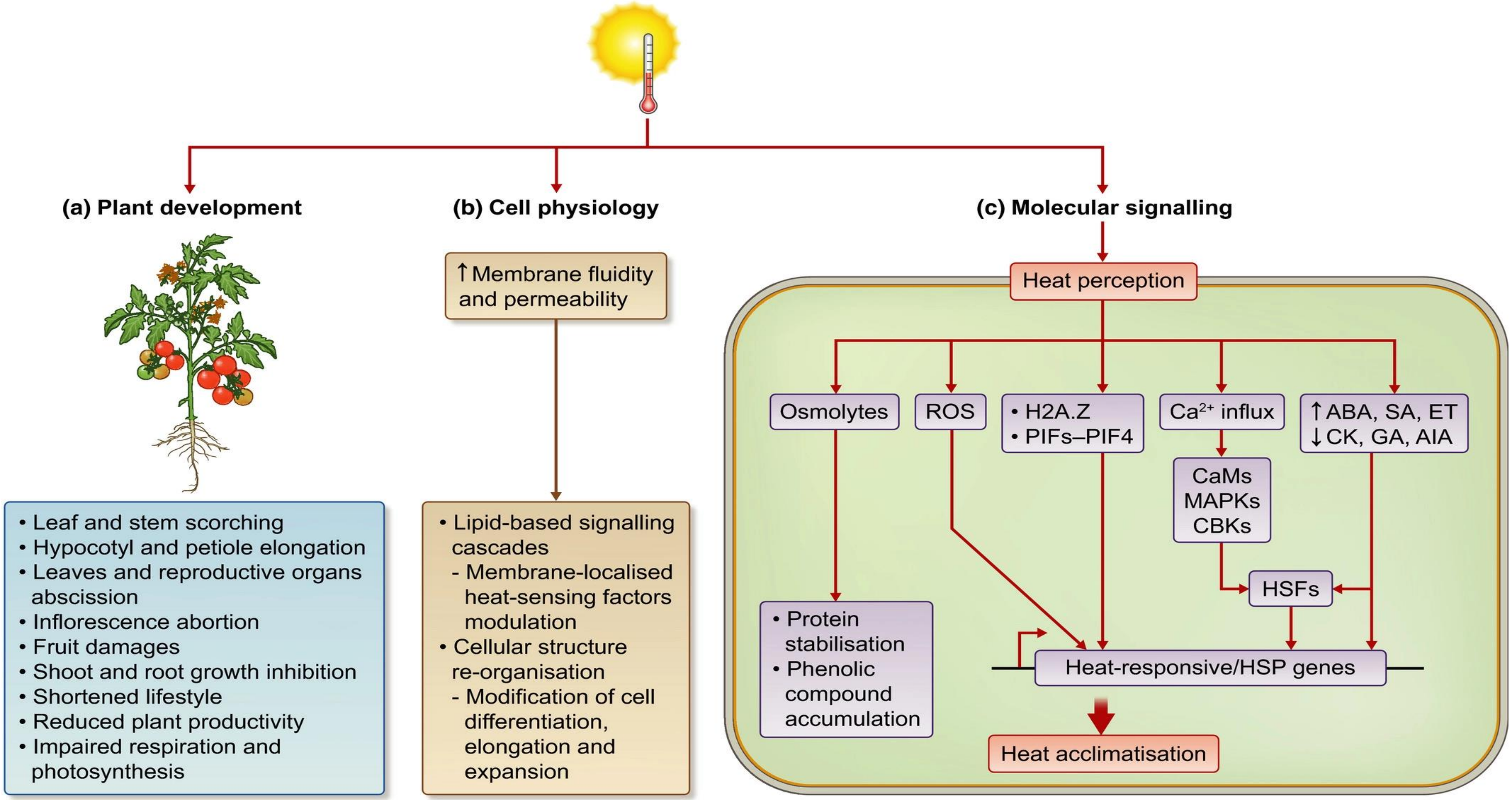


Adapted from Dangl *et al.* (2013)



Roux *et al.* (2014)

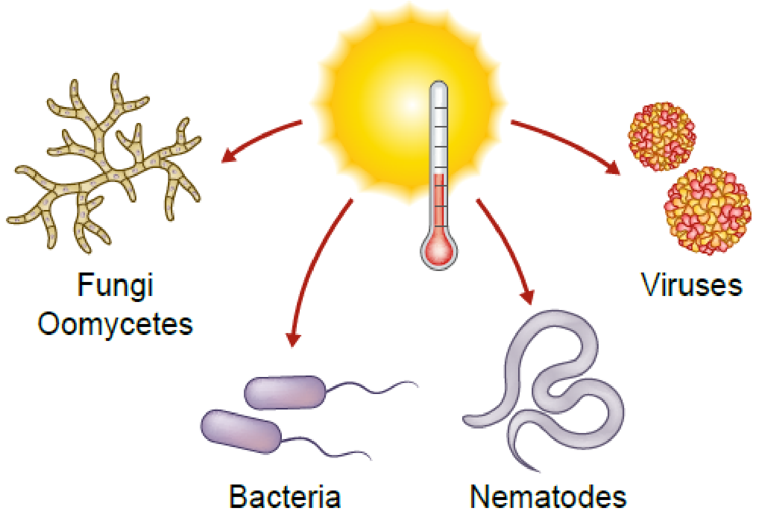
B - Impacts of elevated temperatures on plants



Desaint H, Aoun N *et al.* (2020)

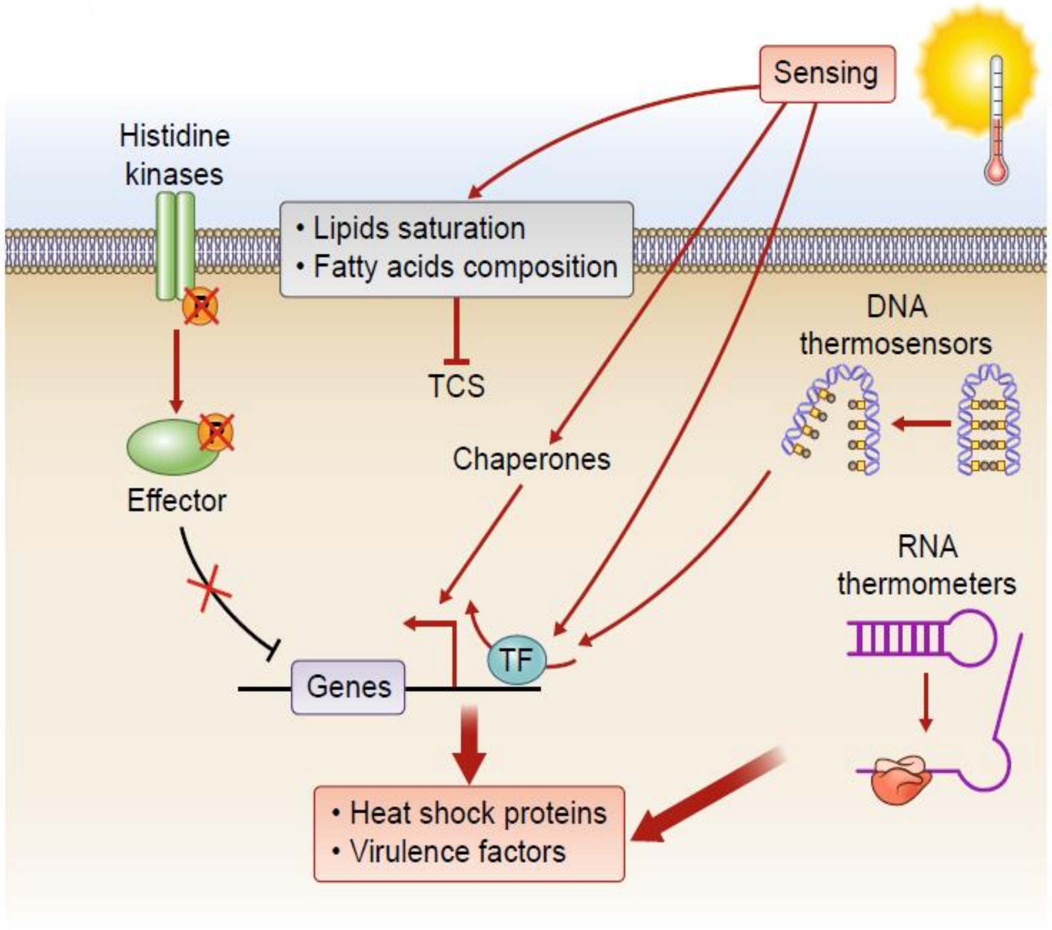
C - Impacts of elevated temperatures on pathogens

Mainly epidemiological



- Improved fitness
- Longer reproduction period
- Increased reproduction rate
- Increased virulence (bacteria and fungi)
- Influence on replication and growth (viruses)
- Increased epidemic risks

Mechanisms: human and mammal pathogens

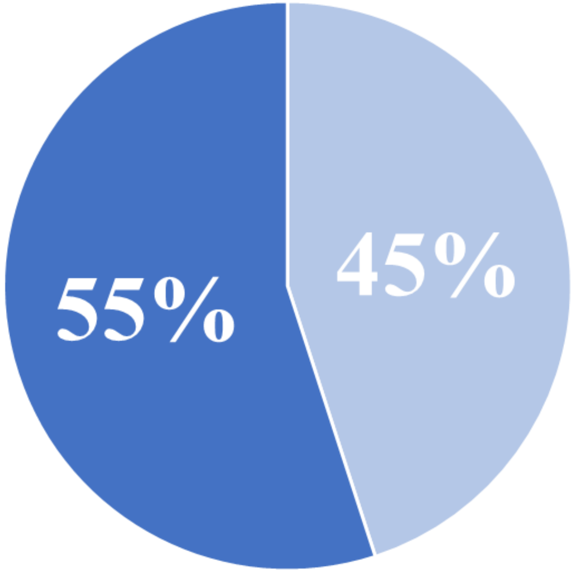


Desaint H, Aoun N *et al.* (2020)

Temperature elevation compromises plant defenses

- Reviewing temperature impact on plant defense response
  - **45** studies
  - **36** pathosystems **(21** plant species **/ 27** pathogen species**)**
  - **142** pathogen resistance responses evaluated

Impaired defense response



Defense response remaining efficient

- **All crops species**
- **All pathogen species**
- **All defense responses**
- **Descriptive**

Crucial to identify or promote robust resistance

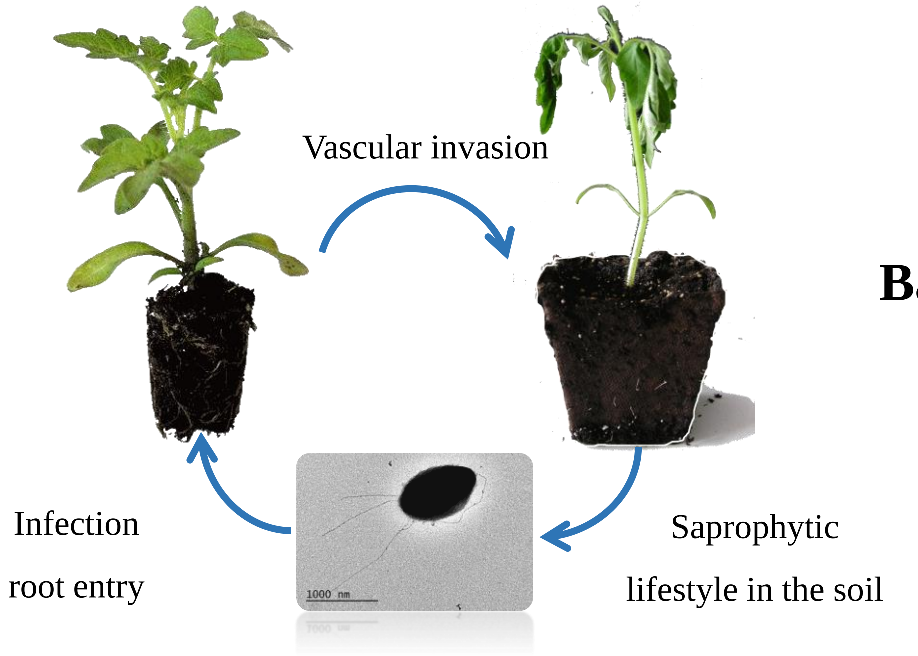
Desaint H, Aoun N *et al.* (2020)

Pathosystems studied

Ralstonia solanacearum

- Widespread species complex
- Equatorial, tropical and warm temperate regions

- Soil-borne bacterium
- Vascular pathogen
- Hemibiotroph
- 250 plants species



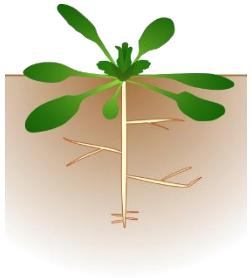
Bacterial wilt

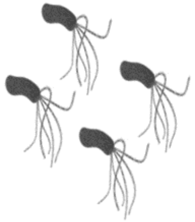
Plants

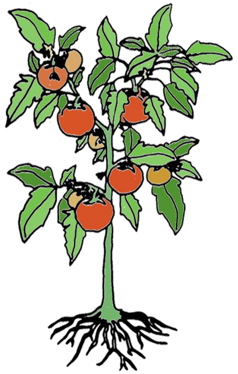
Model plant:
Arabidopis thaliana

Model crop:
Solanum lycopersicum

Few sources of resistance known in *A. thaliana* and tomato







A. thaliana: 2 major resistance mechanisms

- *ERECTA*
- *RPS4/RRS1-R*

Deslandes *et al*. (2002)
Sarris *et al*. (2015)
Le Roux *et al*. (2015)
Godiard *et al*. (2003)

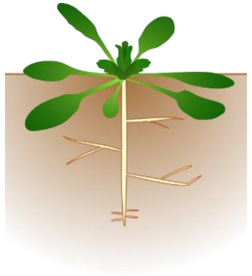
S. lycopersicum L.: 2 major QTLs

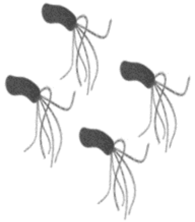
- *Bwr-6*
- *Bwr-12*

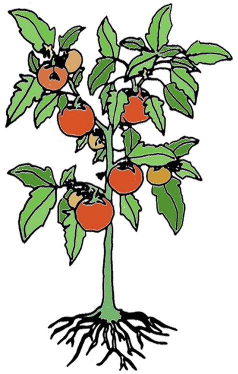
Carried by a major tolerant cultivar **'Hawaii 7996'**

Carmeille *et al*. (2006)
Wang *et al*. (2013)

Few sources of resistance known in *A. thaliana* and tomato







A. thaliana: **2** major resistance mechanisms

S. lycopersicum L.: **2** major QTLs

- *ERECTA*
- *RPS4/RRS1-R*

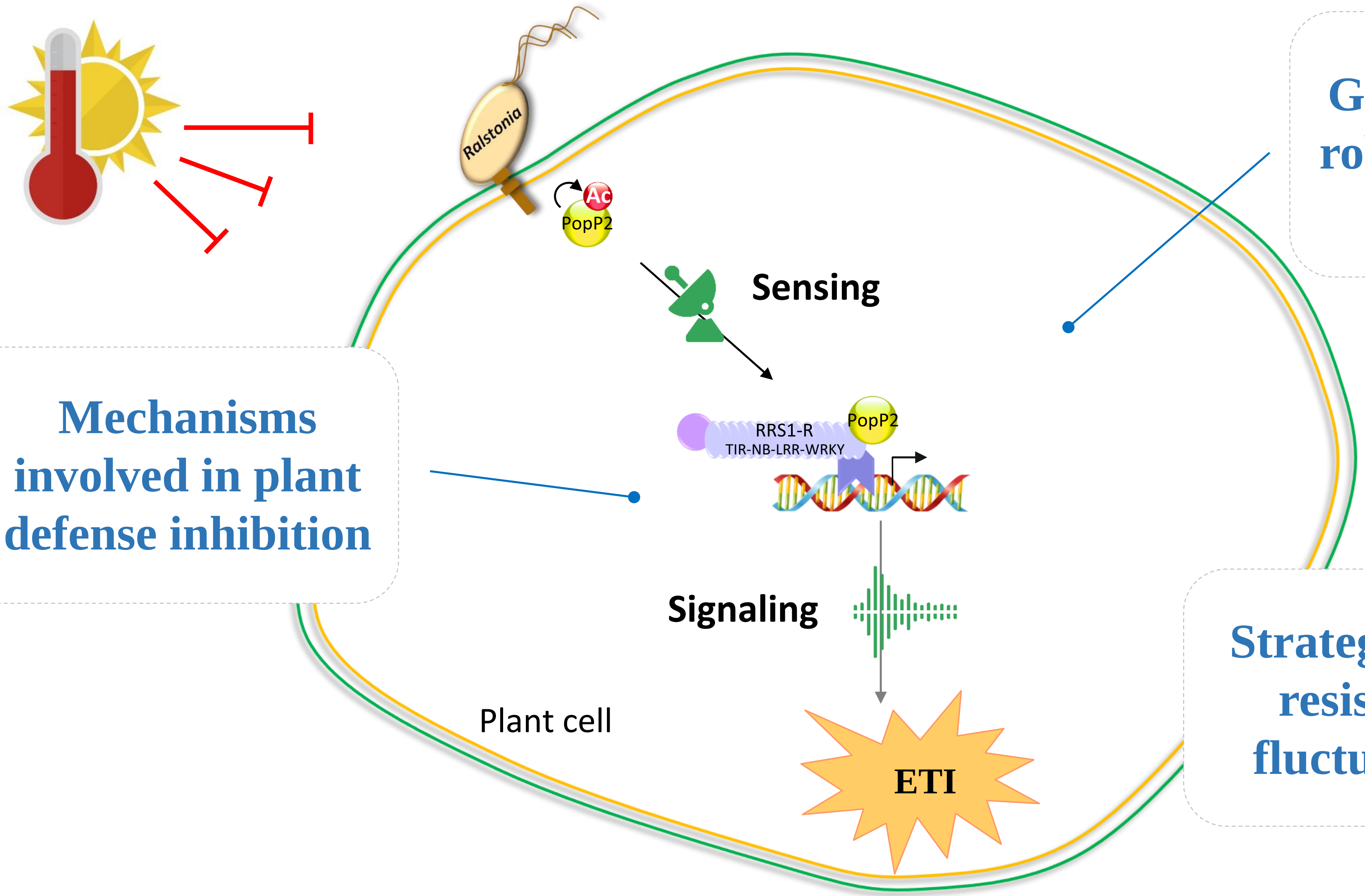
- *Bwr-6*
- *Bwr-12*

Carried by a major tolerant cultivar **'Hawaii 7996'**

Impaired at elevated temperature

Aoun *et al.* (2017); Kunwar *et al.* (2019)

Plant immunity under heat stress
(Objectives)



Genetic bases of robust resistance mechanisms

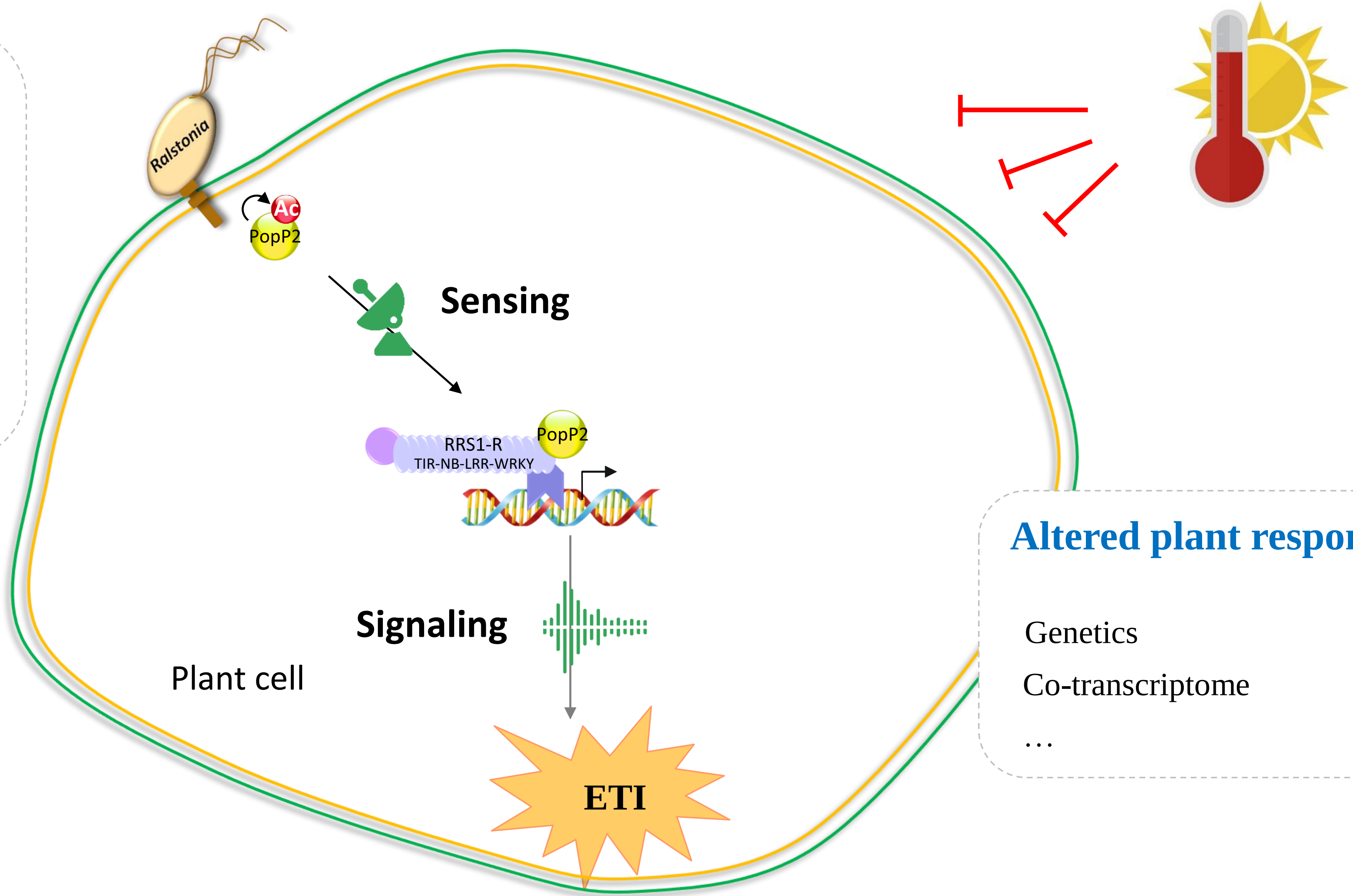
Mechanisms involved in plant defense inhibition

Strategies to maintain resistances under fluctuating climates

Mechanisms involved in plant defense inhibition

Enhanced virulence?

Growth-motility
Pathogenic determinants
Co-transcriptome
Metabolism
Modelization

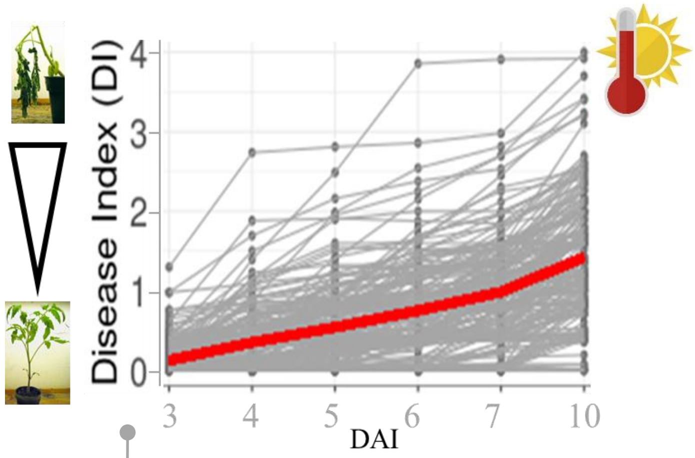


Altered plant response?

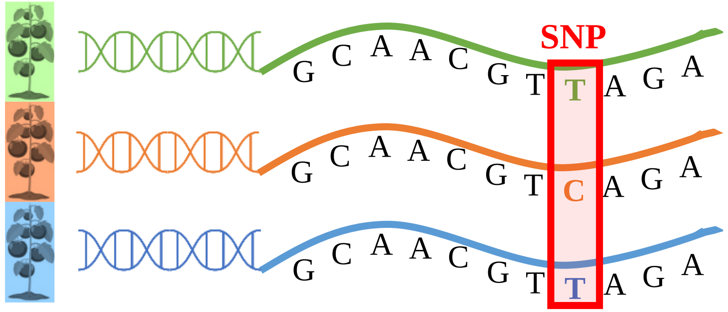
Genetics
Co-transcriptome
…

Identify robust resistances: genome wide association mapping approach (GWA)

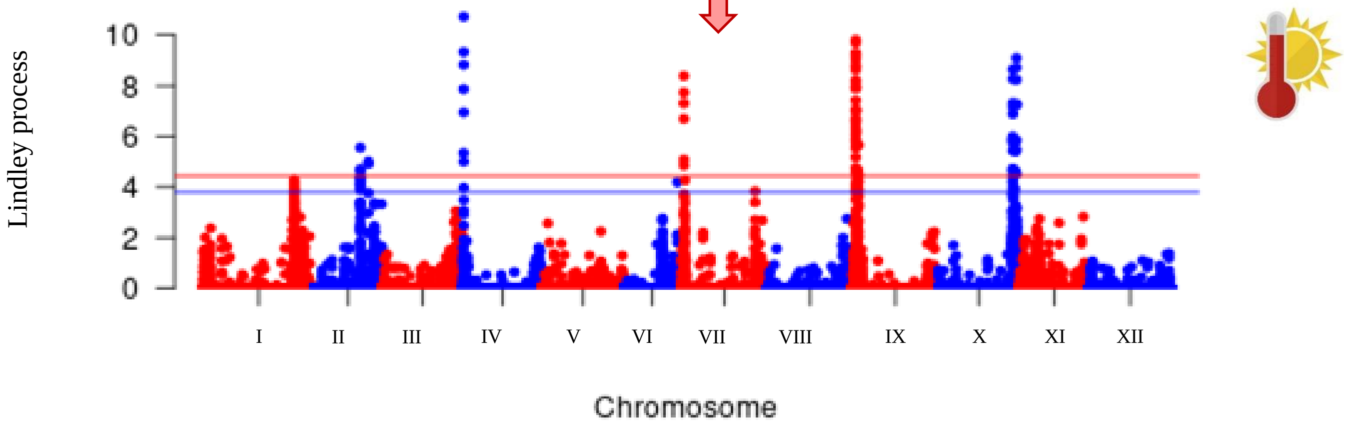
Phenotypic diversity of response of 200 accessions of tomato to *R. solanacearum*



Genetic diversity

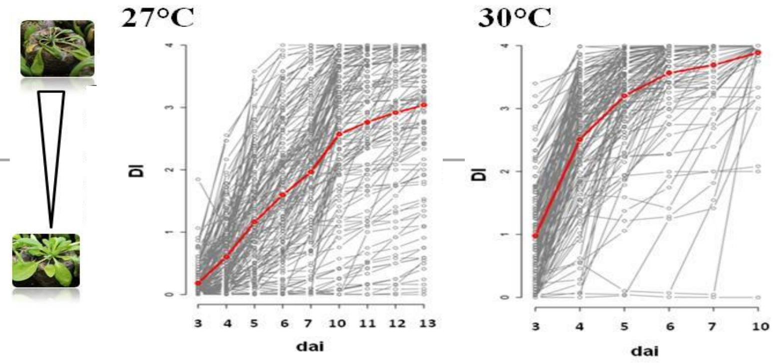


Phenotype ~ Genotype



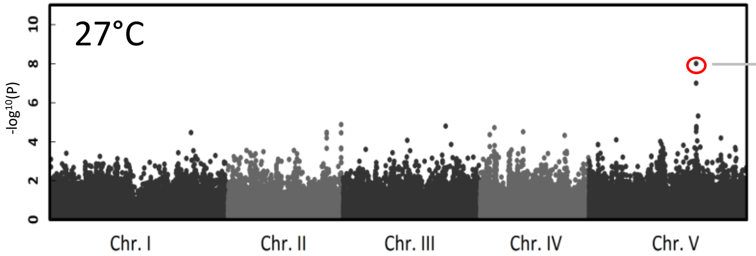
Genetic bases of robust resistance to *R. solanacearum* under heat stress

Natural variability

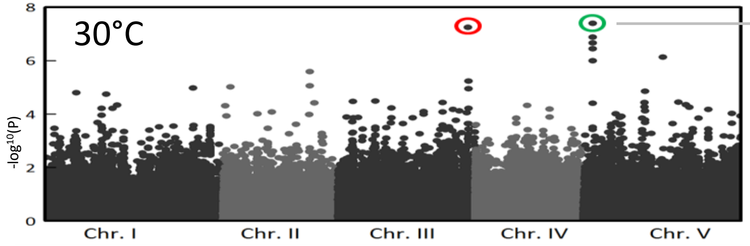


Drastic impact of temperature elevation (+3°C)

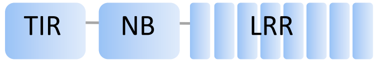
GWA mapping

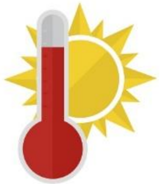


RPS4/RRS1 locus detected at 27°C (not at 30°C)



several QTL identified at 30°C and validated





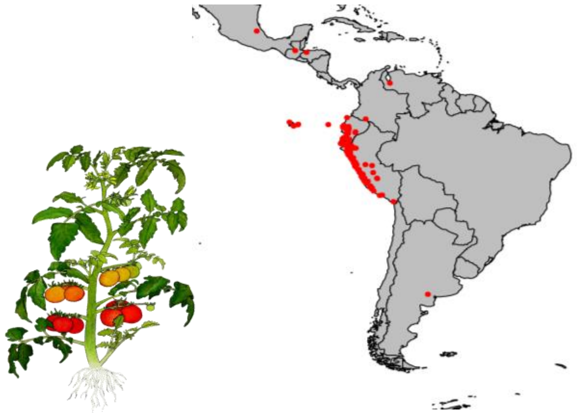
Identification of a thermotolerant NLR variant

Aoun *et al*. (2017, 2020)

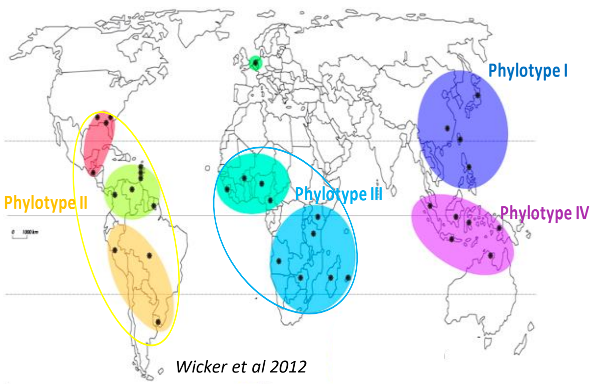
Robust resistance mechanisms to *Ralstonia* in tomato

1 - Creation of unique genomic ressources

- Genetic polymorphism
- Comparative genomics

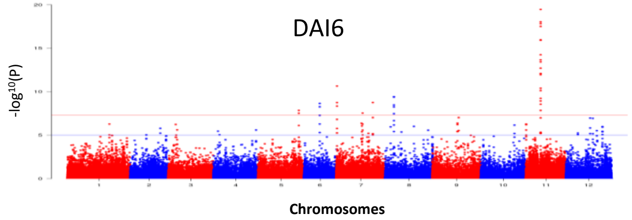


200 accessions of *S. pimpinellifolium*



96 strains of *R. solanacearum*

2 - Genetic bases of tomato immune response to *Ralstonia*



Controlled (28°C/32°C) / Field conditions (GWA analyses)

3 - Molecular actors involved under heat stress

Joint GWA analyses

24 tomato accessions *vs* 96 *Rasltonia* strains
28°C/32°C

Robust resistance mechanisms to *R. solanacearum* under heat stress

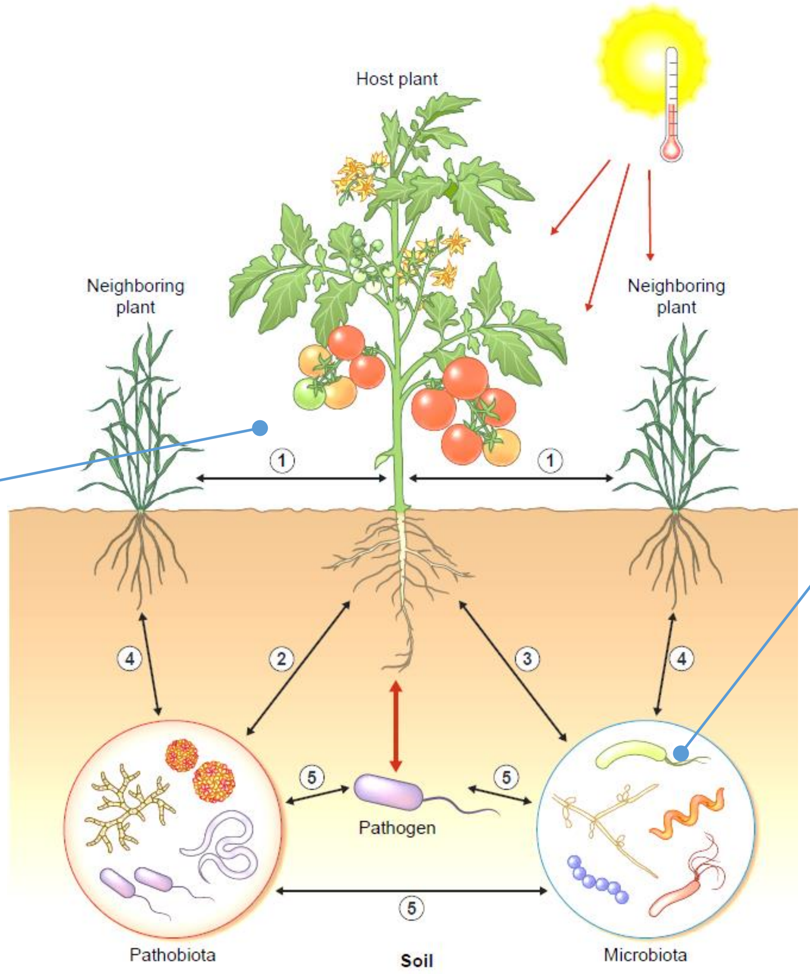
- **Genetic diversity + GWAs**
  - powerful to identify robust resistances to *R. solanacearum* under heat stress

- **Several QTLs corresponding to genes involved in QDR**
  - Not common defense related genes
    - Susceptibility genes,
    - functions: cell wall, DNA methylation, miRNA regulation, biotic and abiotic response
  - Functional validation
  - Functional characterization (Cell wall / epigenetic / thermostable *R* gene)
  - Applications: plant breeding → identification of markers, haplotypes, ideotypes

Integrate the complexity of the interactions in a natural context

Plant-Plant associations in the interaction with pathogen and environment?

- Effect on plant defenses under heat stress?
- Intra/inter species?
- Mechanisms?
- Link with microbiota?



Microbiota and immune response to *R. solanacearum* in fluctuating environment?

- Communities?
- Fluctuation?
  - -Resistant/susceptible plant
  - -Climate

→mechanisms
→biocontrol solutions
→cultivation practices

To maintain or promote resistance

Desaint H, Aoun N *et al.* (2020)

REACH team :
Plant **RE**sistance pathways dynamics and **A**daptation to climate **CH**ange

6 research scientists

IE TRE

PhD students, post-docs, M2R/M1 students…
and all former team members.

Collaborations

S. Genin
L. Noël
F. Roux
J. Gouzy (Bioinf. Platform)

local

L. Navarro (IBENS)
C. Raynaud/M. Benhamed (IPS2)
S. Vernhettes/T. Mary-Huard/ M. Causse (INRAE)
S. Poussier/C. Jourda/Y. Pecrix (PVBMT)

national

G. Coaker
J. E. Parker
B. Kobe/P. Dodds
Z. Zang
J. Duangjit

international

G. Bonnet
C. Labourey
C. Sauvage
P. Piamjit

Private partner