Intelligence Gathering in the Plant Kingdom:

How Plants Perceive and Integrate Noisy Environmental Signals into a Coherent Stress Response

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Aspirin

Quinine

Taxol

Medicine

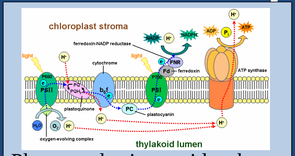
Morphine

Colchicine

Plants are essential

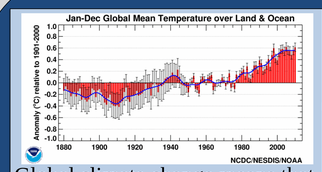
Plants give us food, clothing, shelter, medicine, and fuel.

Plants are the foundation of many food chains, including our own.



Photosynthesis provides the energy for carbon fixation and generates the O_2 we breathe.

Panel 1



Global climate change means that we must reduce CO_2 emissions.

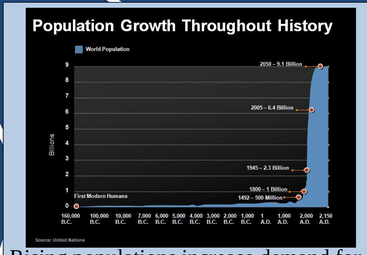
Plants are key sinks for CO_2

Use of biofuels reduces CO_2 emissions, but increases demand for plants.

We must produce more plant products than ever before. Developing stress tolerant plants can help meet this goal.

New farmland results in loss of biodiversity and important CO_2 sinks.

Improved stress tolerance can increase yield on existing farms.



Rising populations increase demand for plant products. We can meet this need by creating more farmland or increasing yield on existing farmland.

Panel 2

Fungi and Oomycetes

Cause of Irish potato famine

Bacteria

P. syringae causing tomato speck.

Herbivory

Consumption of plant tissue by insects and animals.

Biotic Stresses
Stresses caused by other organisms

Stress

A stress is an environmental factor that harms a plant. Stress is a key limiting factor in crop yield.

Water

Abiotic Stresses
Stresses induced by fluctuations in environmental conditions

Temperature

Nutrients

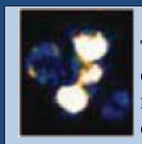
Cabbage with nitrogen deficiency

Panel 3

We identified 162 genes induced 5 minutes after wounding. These overlap significantly with genes rapidly induced by other stresses, validating them as general stress response genes.

Promoter RSRE Stress Response Gene

Analysis of the promoters (DNA that controls the expression of a gene) of stress response genes revealed the RSRE. This element causes genes to be induced rapidly by stresses.



RSRE::Luciferase
Transgenic plants were created containing luciferase (gene that makes fireflies glow) under the control of RSRE.

Mechanical Wounding
To identify genes that respond to these conserved signals, we used wounding as a model stress in *A. thaliana*.

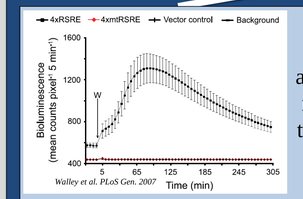
A. thaliana is a model plant with a fully sequenced genome. It is easy to genetically modify and has a short life cycle.

Diverse stresses have common effects on plant cells early in the stress event. These are characterized by a disruption of the plasma membrane, leading to disruption of osmotic and ionic homeostasis.

Rapid Stress Response

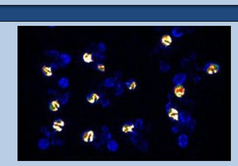
Our lab identified genes that respond rapidly to many stresses. They are controlled by the Rapid Stress Response Element (RSRE).

The RSRE is sufficient to induce gene expression in response to a diverse range of stresses and stimuli.

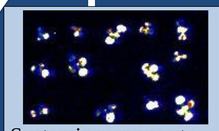


The rapid and transient response of the RSRE to wounding.

The response to wounding is local, while the response to certain elicitors is systemic.



Local response to wounding stimuli.



Systemic response to fragments of the plant cell wall that signal damage.

Panel 4

Research Goals:
Understand the mechanisms involved in the induction of the RSRE during stress events.

Identify signals that activate the RSRE

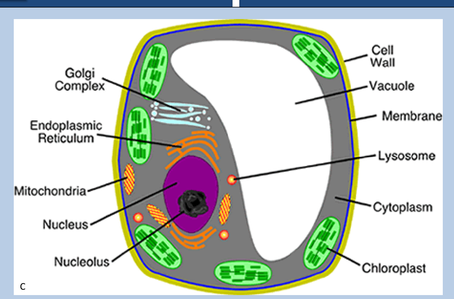
Identify proteins that regulate the RSRE

Understand process behind systemic induction

Completion of these goals will result in identification of targets that can be manipulated to create stress-tolerant plants.

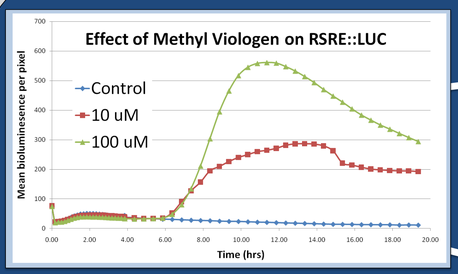
Panel 5

Calcium and reactive oxygen species are key signals in the induction of the RSRE.



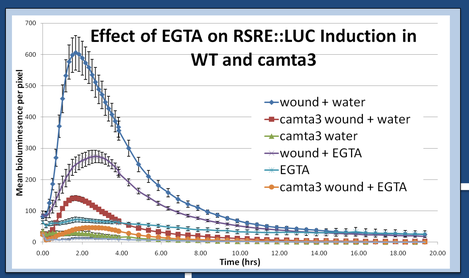
Background: Calcium is found in large quantities in the cell walls of plants. Controlled release of calcium into the cytoplasm acts as a signal during important growth and defense processes. Reactive oxygen species (ROS) also serve as signals and are produced at the plasma membrane and in the mitochondria and chloroplast.

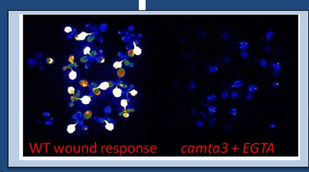
Reactive Oxygen Species



Methyl viologen induces the ROS superoxide. Additional experiments found that an inhibitor of superoxide production reduces the wound response.

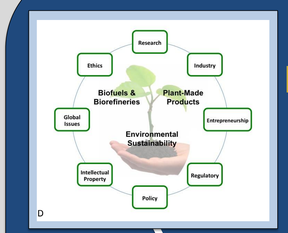
Calcium





CAMTA3 is calcium-regulated protein that is partially responsible for control of the RSRE. camta3 plants lack CAMTA3. EGTA captures calcium and prevents it from moving into the cell.

Panel 6



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Panel 7