



UNIVERSITY OF
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Plant resistance to insect pests

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Jasmonic Acid Pathway

- Farmer and Ryan (1990) discovered that jasmonic acid volatilized from sagebrush could trigger defense gene expression in adjacent tomatoes
- Jasmonic acid volatiles act as attractants for beneficial insects
- Jasmonic acid induces the production of disease and insect defense compounds.
 - Defense Proteins
 - Phytochemicals

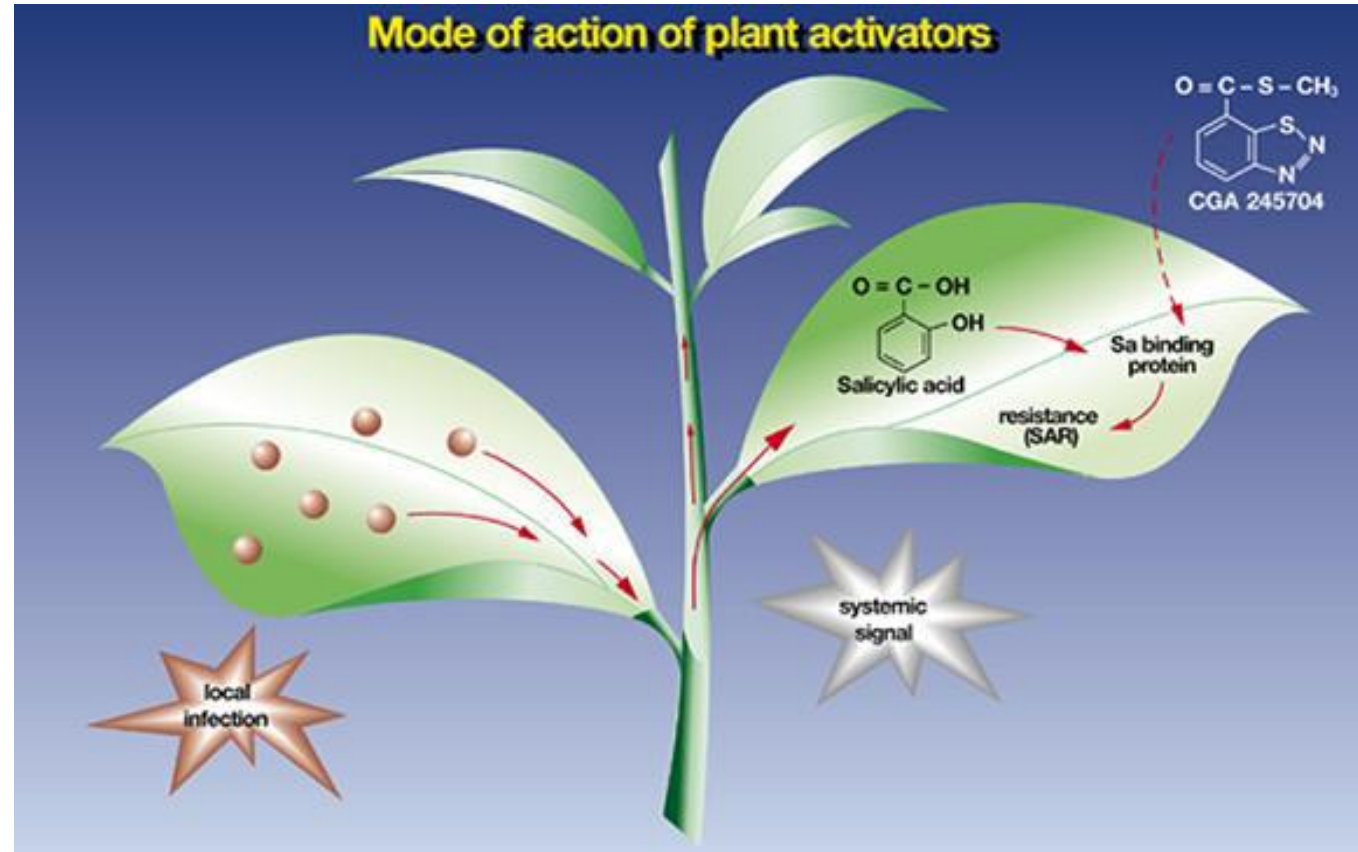
Phytochemicals

- phytochemicals are induced by wounding.
 - Phenolics
 - Furanocoumarins, Coumarins, Tannins, Lignin, other phenolics
 - Terpenoids
 - Alkaloids

Examples of plant activators

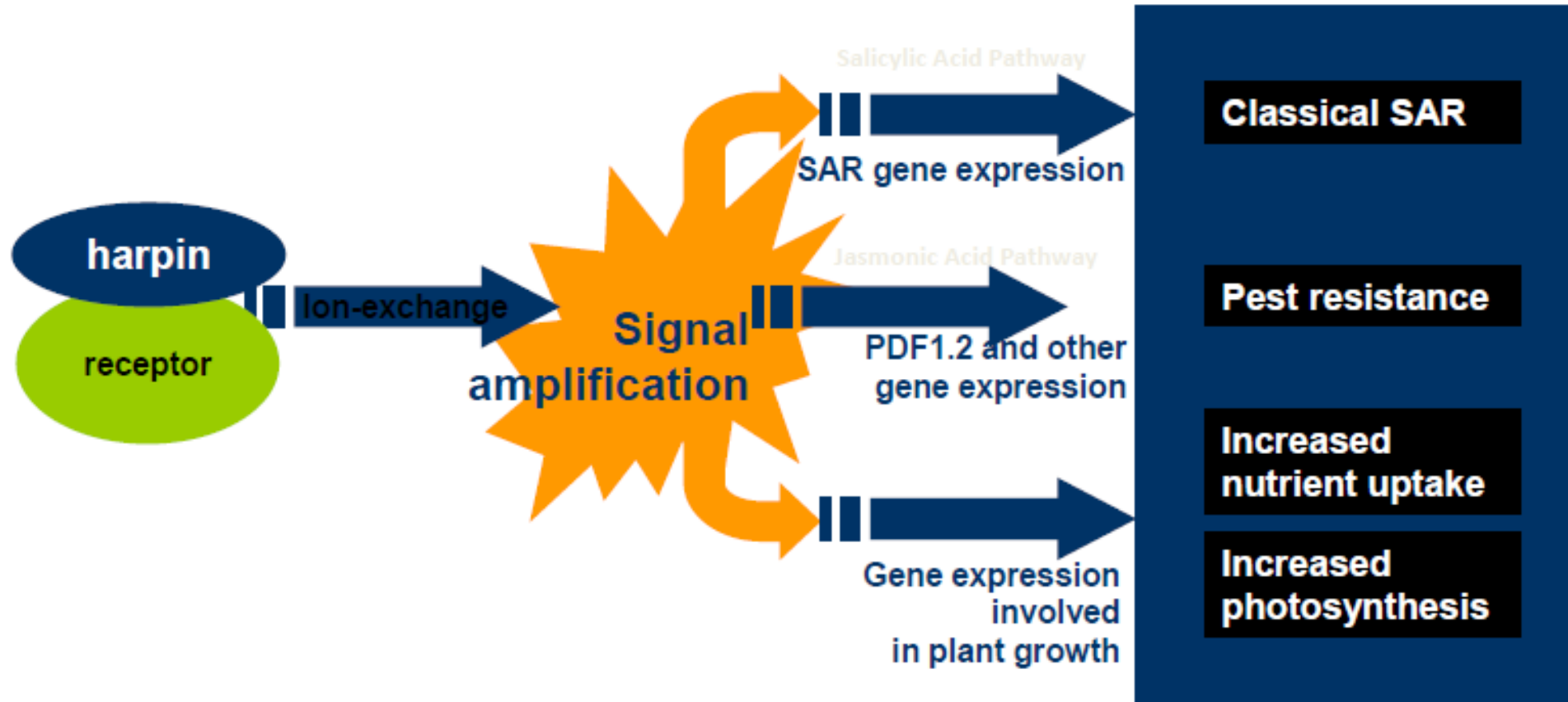
- Acibenzolar (Actigard)
- Harpin (Messenger)
 - Harpin is a natural protein found in many common pathogenic microorganisms;
 - *Erwinia amylovora*
 - *E. chrysanthemi*
 - *Pseudomonas syringae*
 - *Pseudomonas solanecarum*
 - *Xanthomonas campestris*.
- Biological control organisms

Mode of action - Actigard



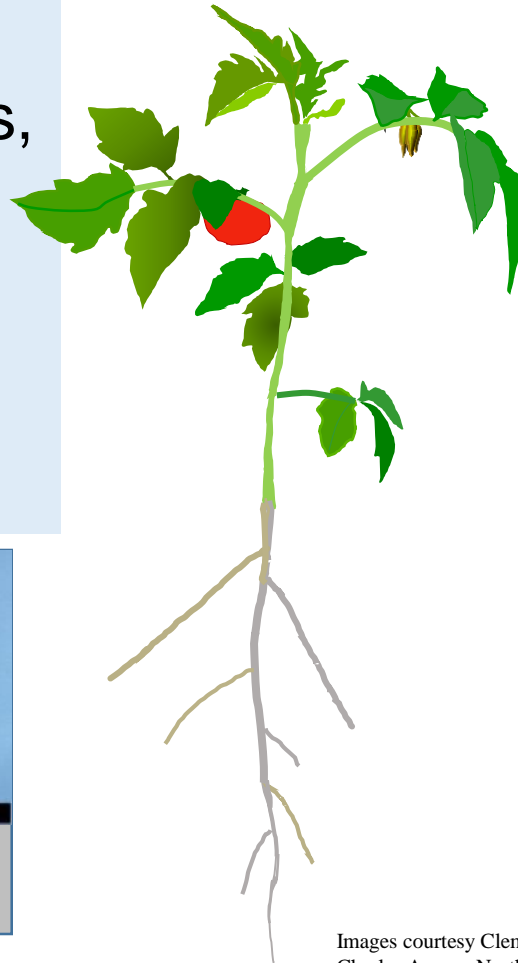
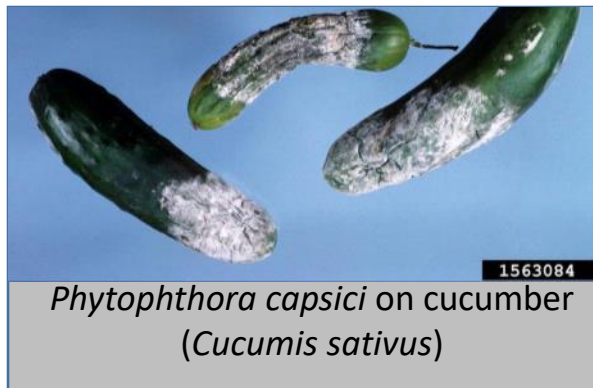
Induction of Systemic Acquired Resistance

Mode of action - Messenger



Pathogens and pests cause significant crop losses

Most plants are resistant to most pests, but a few organisms cause tremendous damage. 25% or more of potential harvests can be lost to insects and disease!

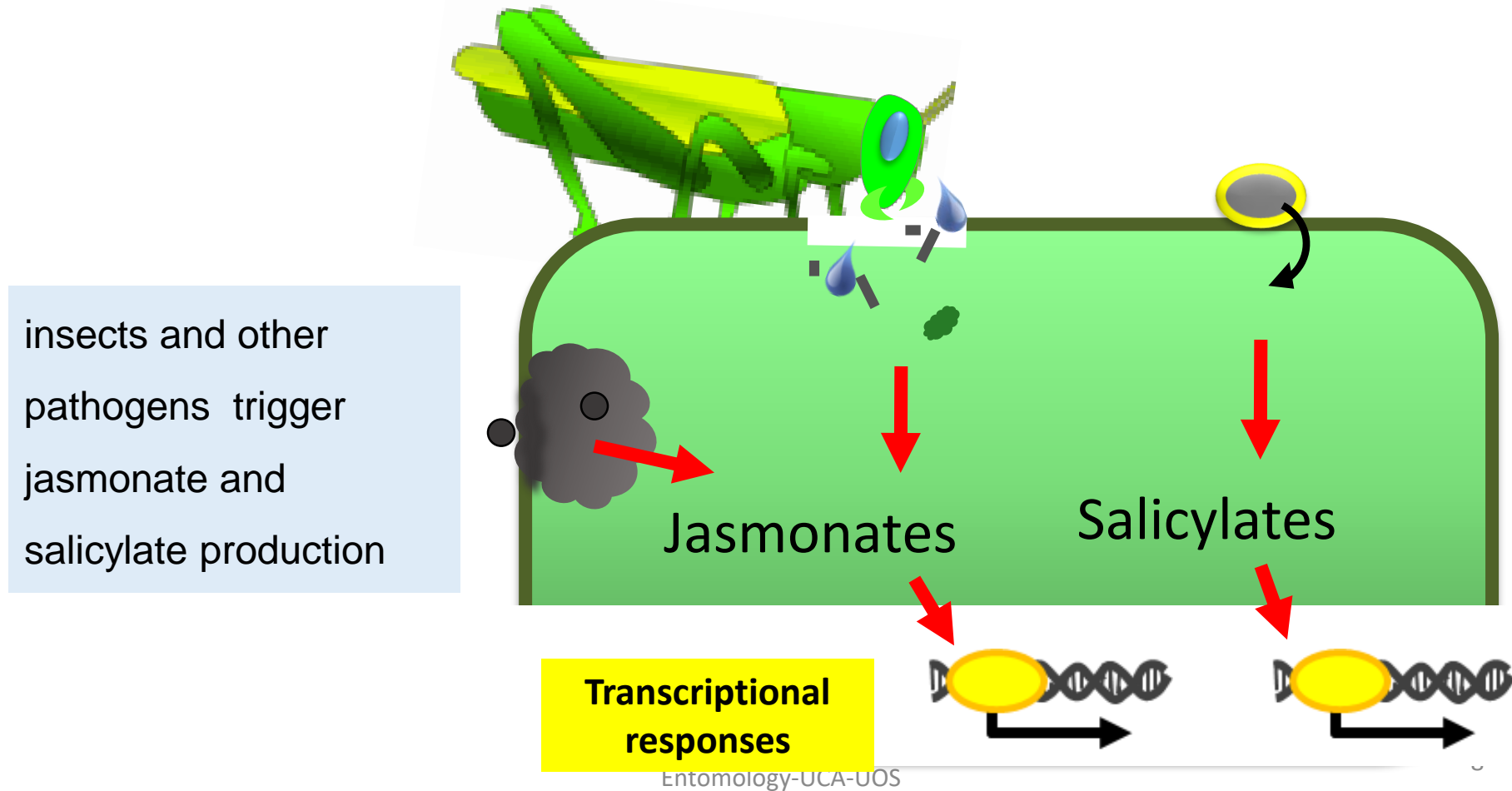


Jasmonates and salicylates are hormones that participate in plant defense responses



Images courtesy Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org; Charles Averre, North Carolina State University, Bugwood.org

Jasmonates participate in plant defenses to insects and necrotrophs



Jasmonates also contribute to developmental and growth controls

Flower development

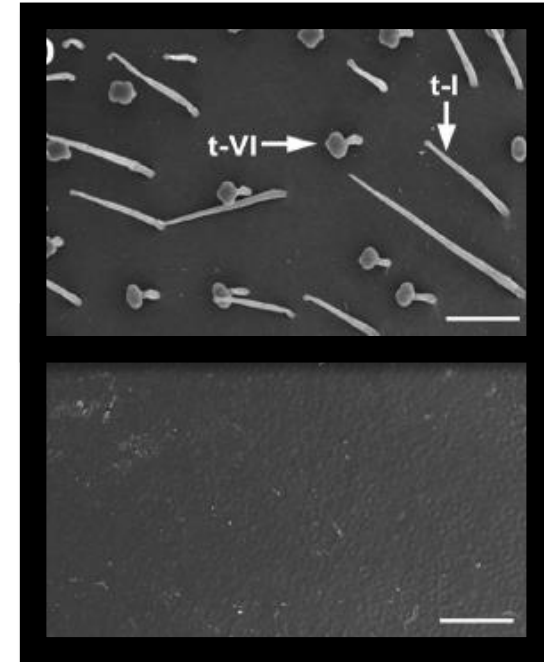


Seed development



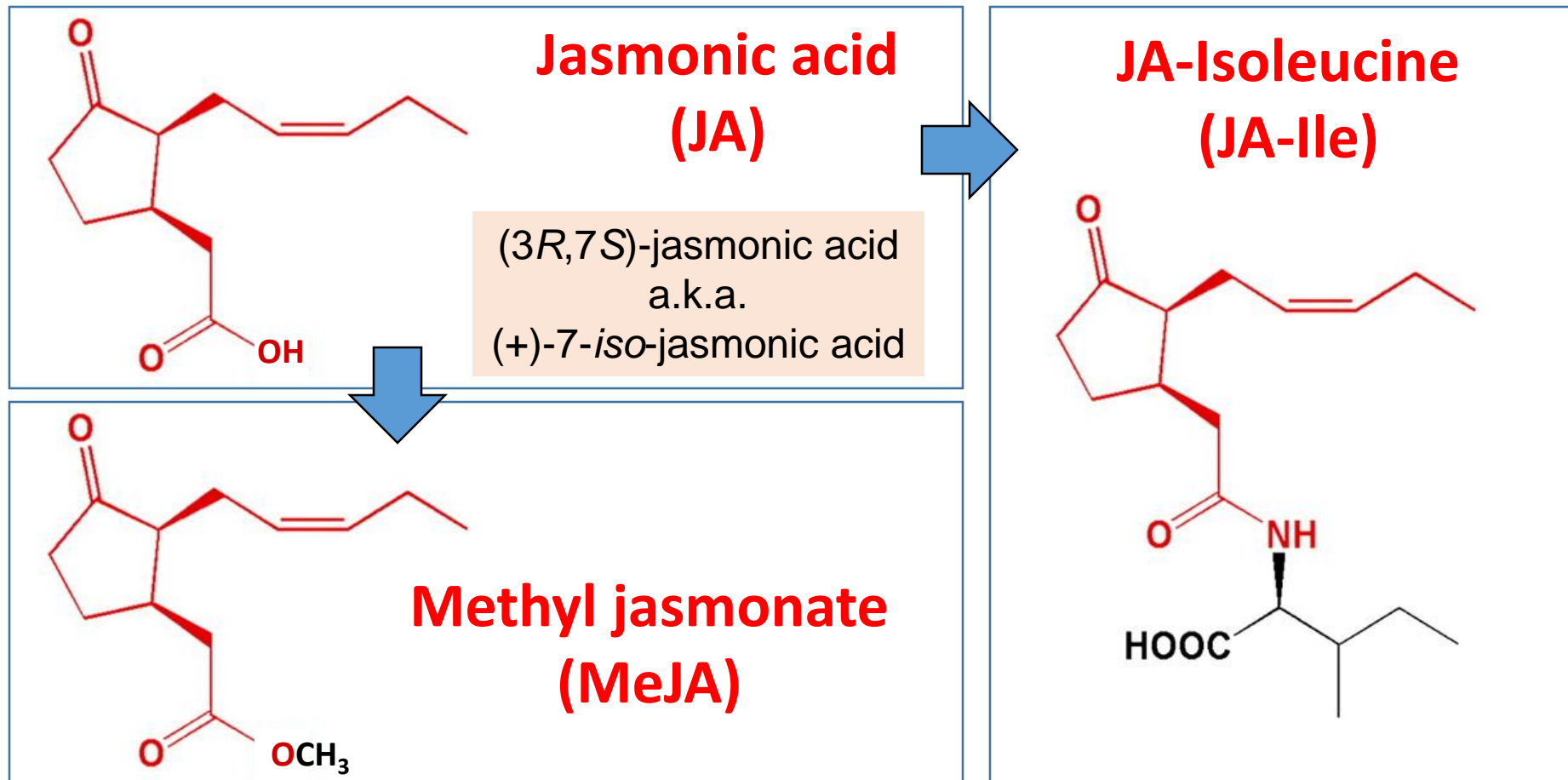
JA also controls: cell cycle, root extension, leaf senescence, stomata closure, and mutualistic interactions....

Trichome formation



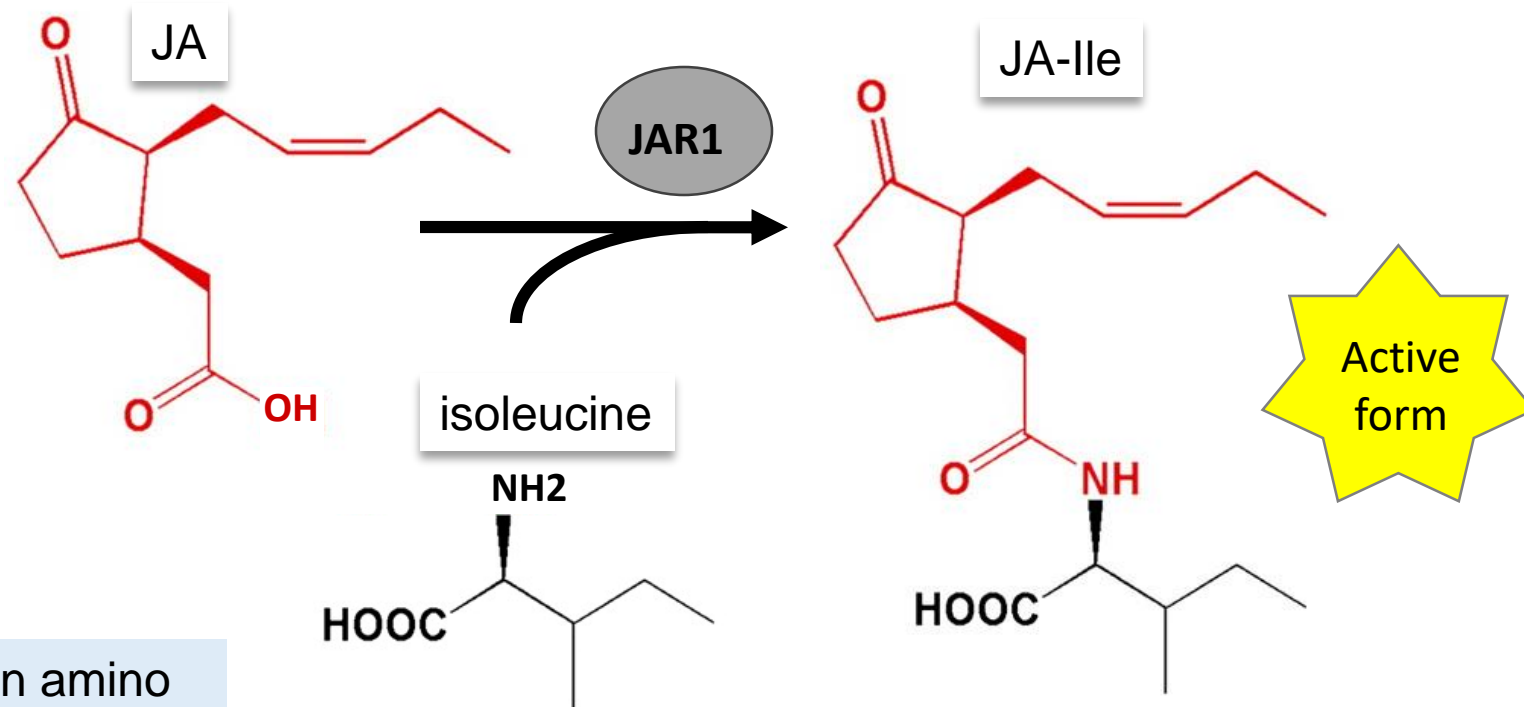
Li, L., Zhao, Y., McCaig, B.C., Wingerd, B.A., Wang, J., Whalon, M.E., Pichersky, E., and Howe, G.A. (2004). The tomato homolog of CORONATINE-INSENSITIVE1 is required for the maternal control of seed maturation, jasmonate-signaled defense responses, and glandular trichome development. *Plant Cell* 16: [126-143](#); Reprinted by permission from Macmillan Publishers Ltd. Thines, B., Katsir, L., Melotto, M., Niu, Y., Mandaokar, A., Liu, G., Nomura, K., He, S.Y., Howe, G.A., and Browse, J. (2007). JAZ repressor proteins are targets of the SCFCOI1 complex during jasmonate signalling. *Nature* 448: [661-665](#).

Jasmonates include jasmonic acid (JA) and derivatives



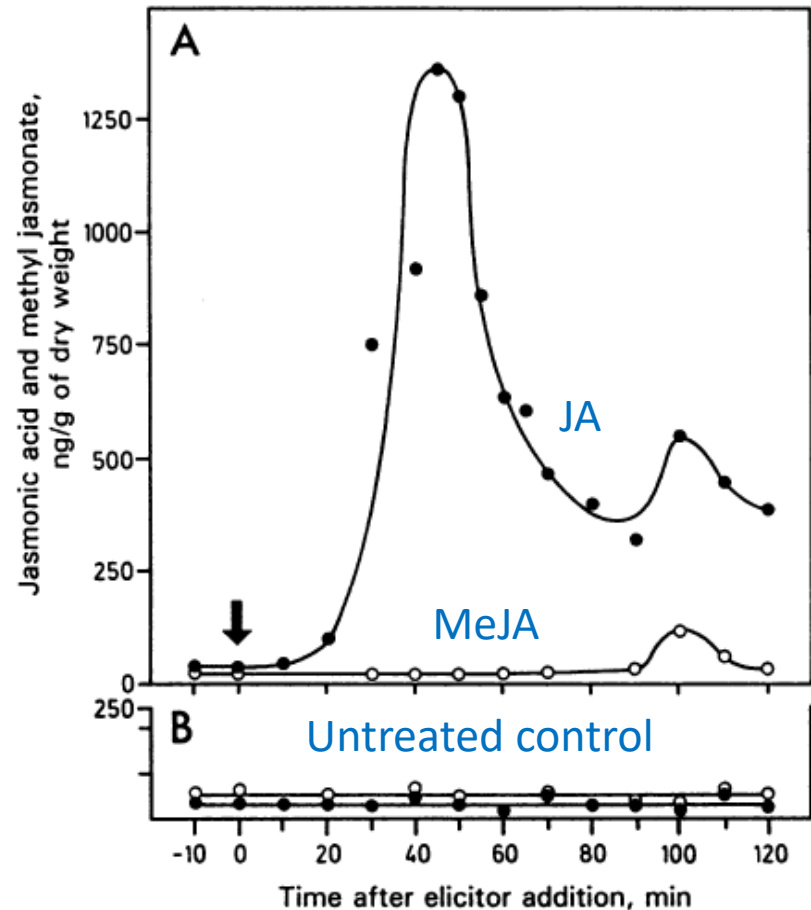
Yan, J., Zhang, C., Gu, M., Bai, Z., Zhang, W., Qi, T., Cheng, Z., Peng, W., Luo, H., Nan, F., Wang, Z., and Xie, D. (2009). The Arabidopsis CORONATINE INSENSITIVE1 protein is a jasmonate receptor. *Plant Cell* 21: [2220-2236](https://doi.org/10.1105/PC.107000).

Jasmonic acid can be conjugated to amino acids by JAR1



JAR1 is an amino acid conjugase

Jasmonates are produced preventively in flowers and induced as a defense response in other tissues



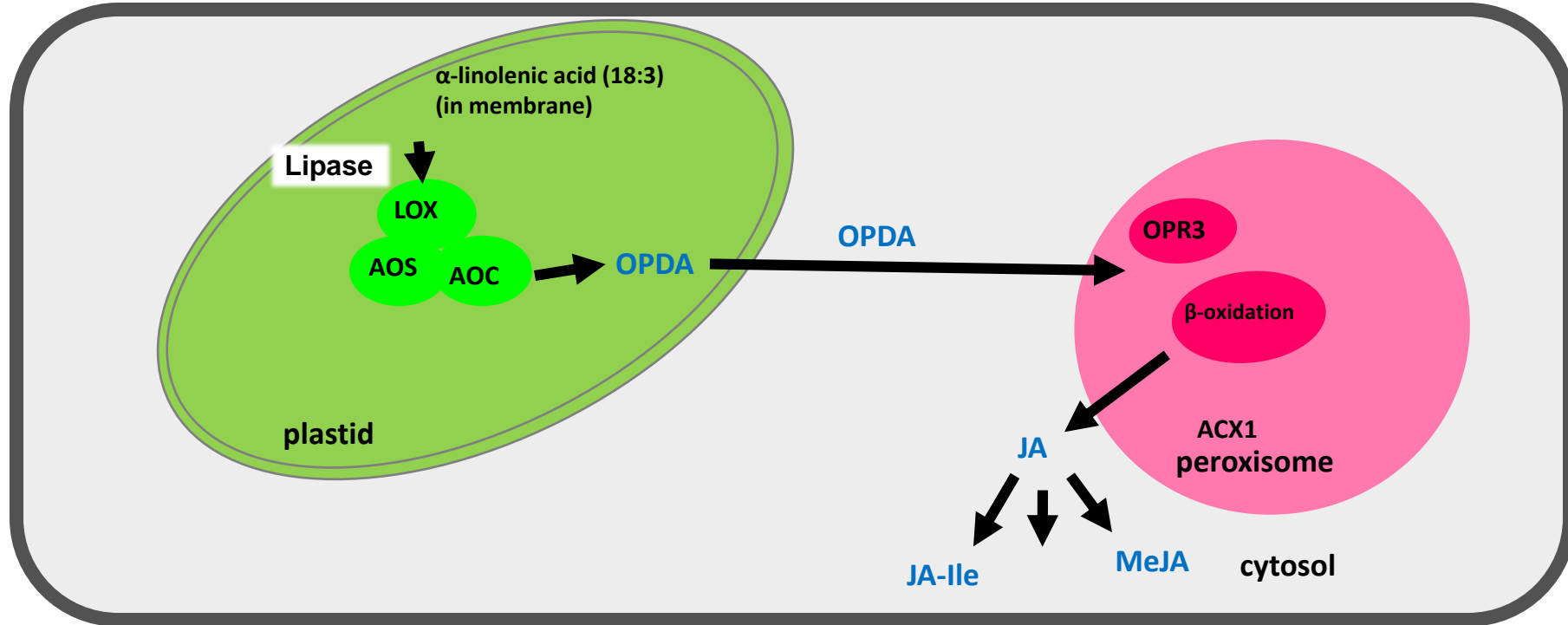
Wounding, pathogens or herbivores (or molecules derived from them) trigger very rapid accumulation of jasmonates

Induction of jasmonate production in cell suspension culture (*Rauvolfia canescens*, a medicinal plant) by adding yeast cell wall elicitor

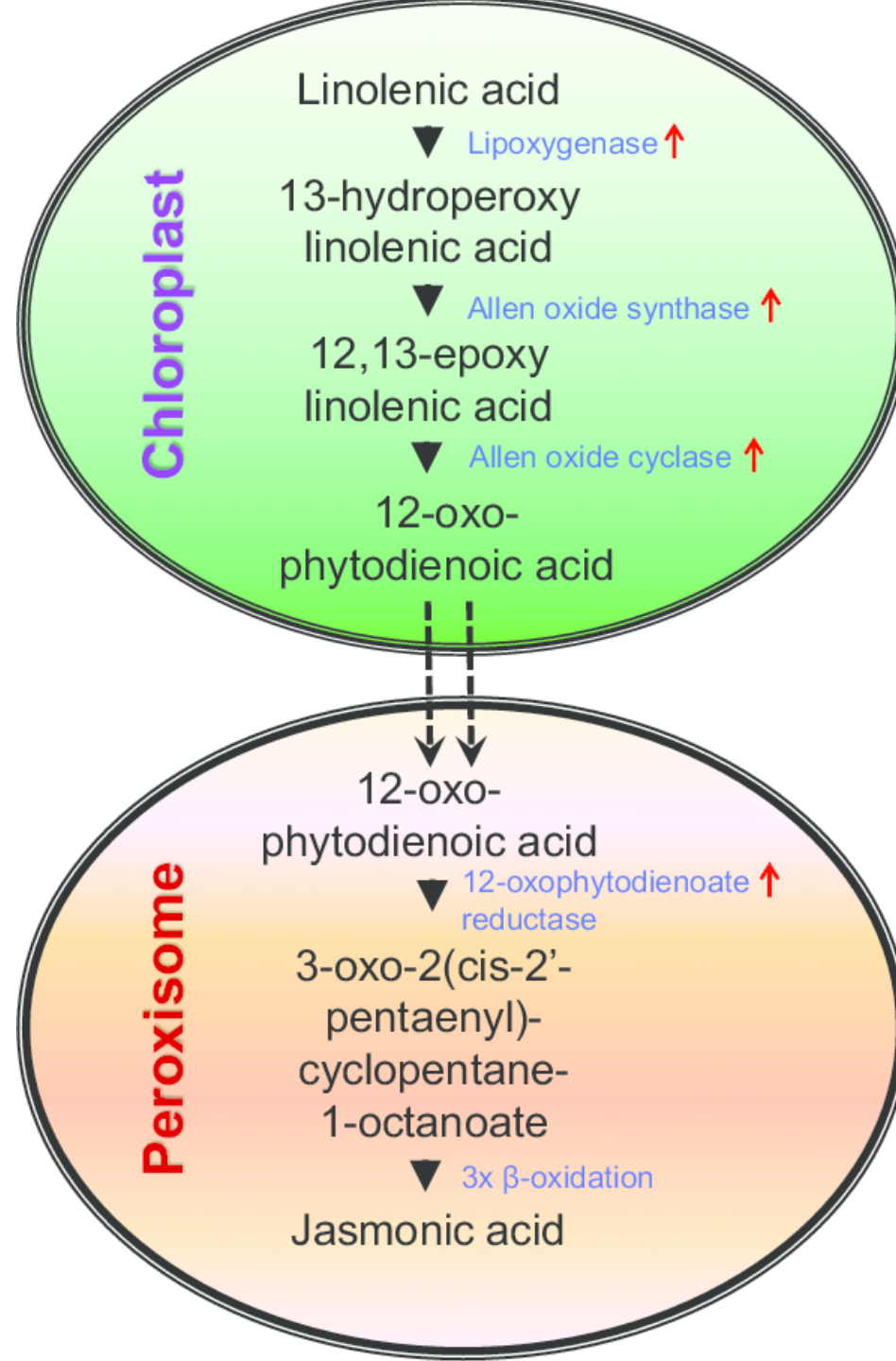
Rauvolfia canescens



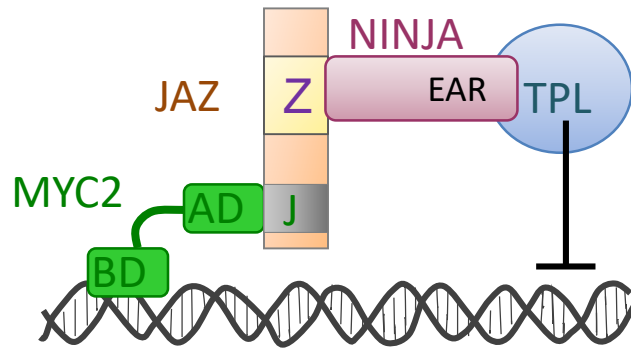
Jasmonate synthesis occurs in the plastid, peroxisome and cytosol



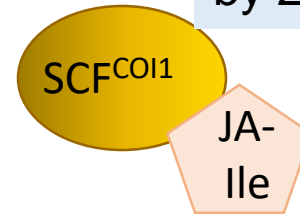
- Synthesis is initiated with the conversion of linolenic acid to **12-oxo-phytodienoic acid (OPDA)**, (conversion of **linolenic acid to OPDA** occurs in the **chloroplast**)
- OPDA undergoes a reduction and three rounds of oxidation to form (+)-**7-iso-JA, jasmonic acid**. occur in the **peroxisome**. (abbreviation in next slide)



The **jasmonate** signaling pathway



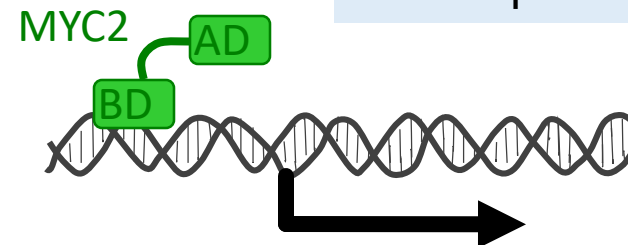
2. JAZ ubiquitinated (small protein called ubiquitin attach to JAZ and take it to proteasome for degradation) and degraded by 26S proteasome



JA-Ile

1. JA-Ile binds to SCF^{COI1} and JAZ protein

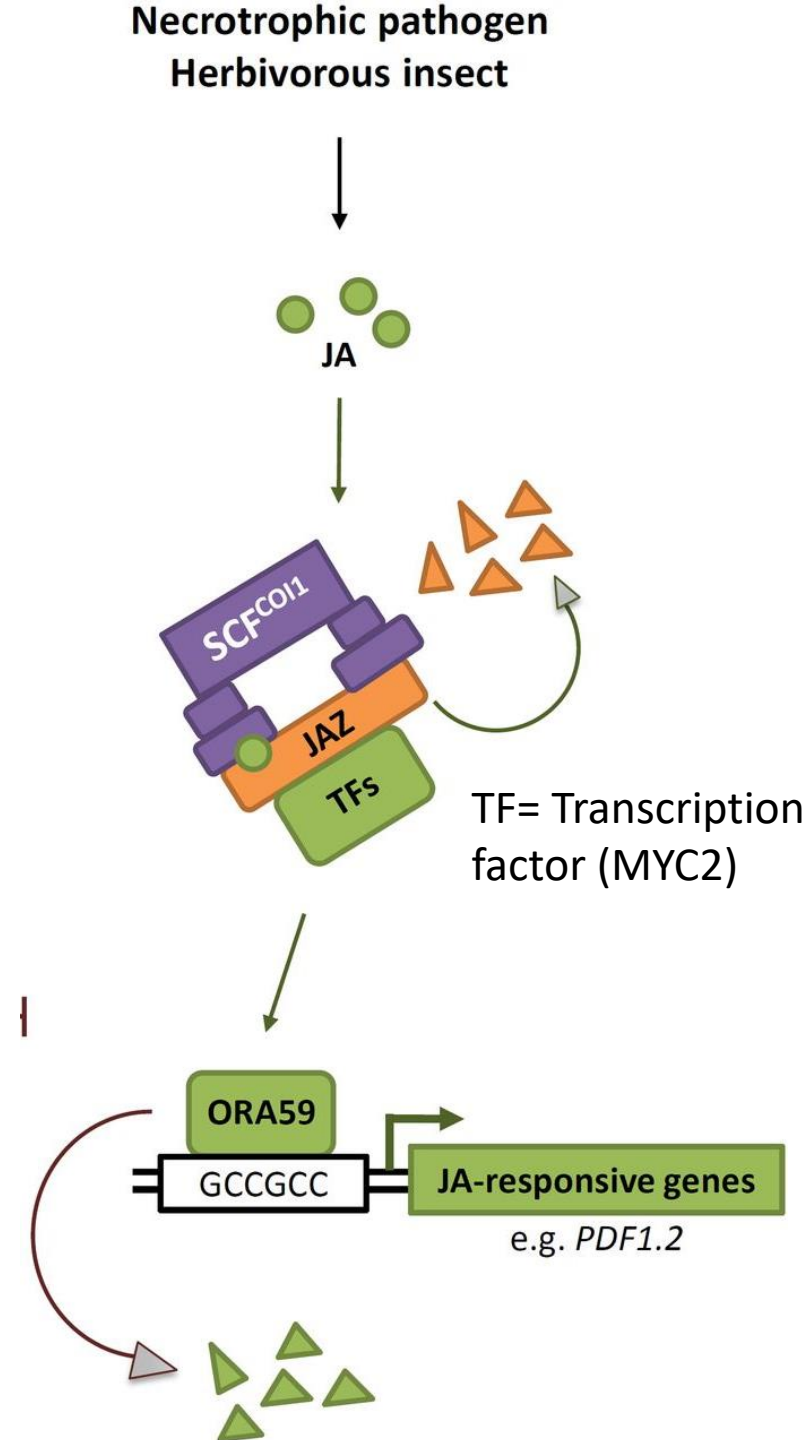
3. Degradation of repressor permits transcriptional activation by MYC2 transcription factors



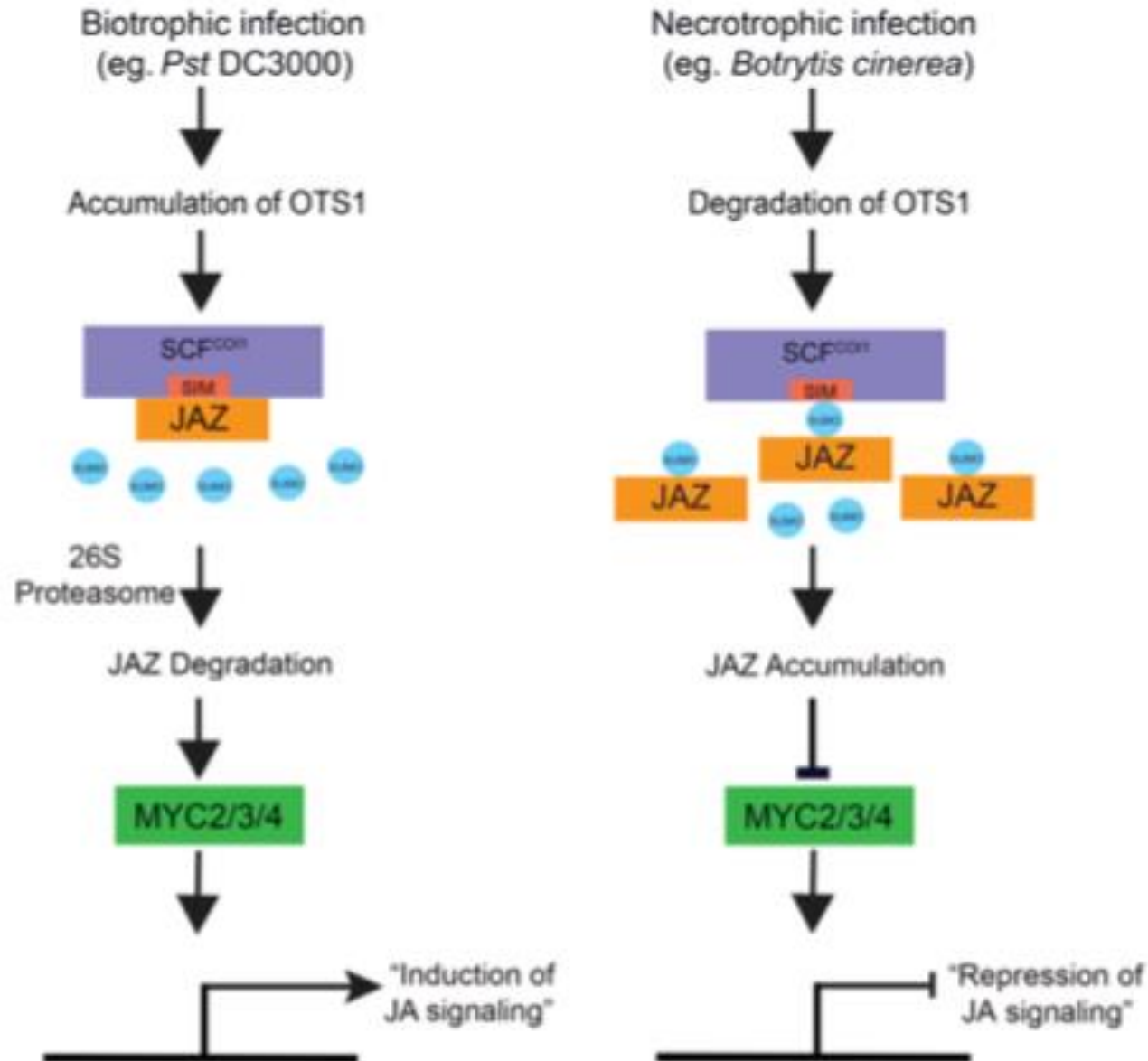
JAZ works as repressor protein, mean stop transcription or signaling.

What is the Role of TF?

Plant lost one **MYC** becomes more susceptible to insect herbivory than a normal plant.

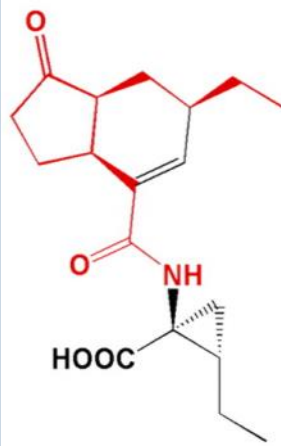


Role of repressor protein (JAZ)

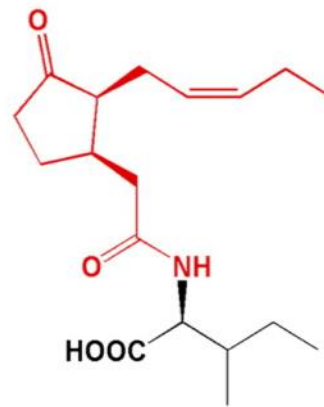


Coronatine is a bacterial compound and powerful jasmonate mimic

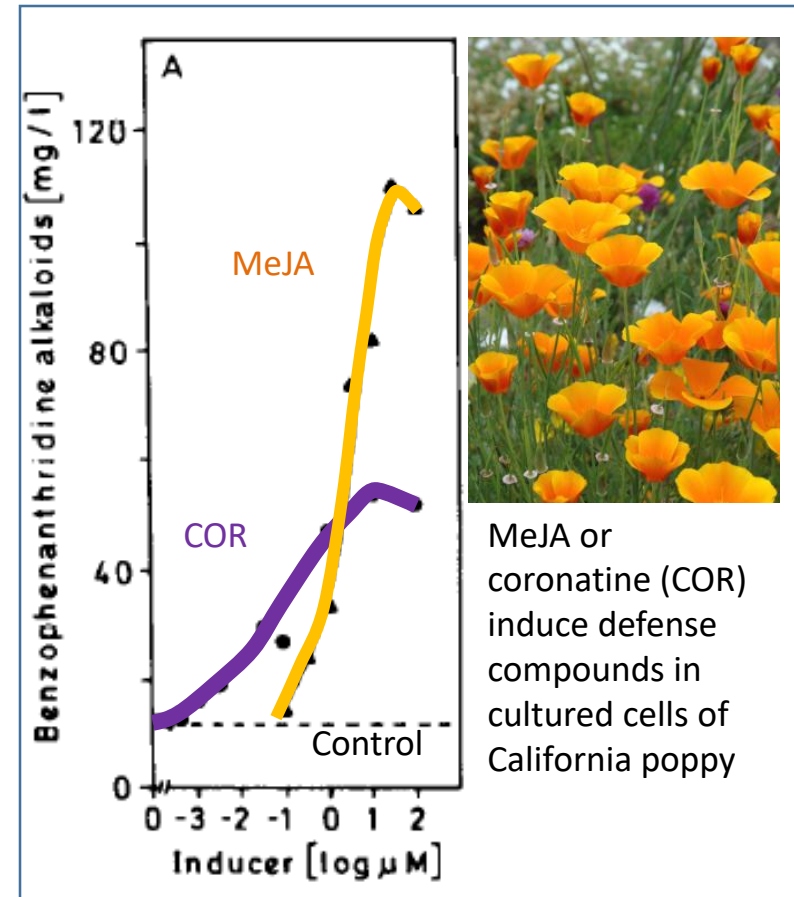
Coronatine is a toxin produced by some pathogenic bacteria that mimics jasmonate action and structurally resembles JA-Ile



Coronatine

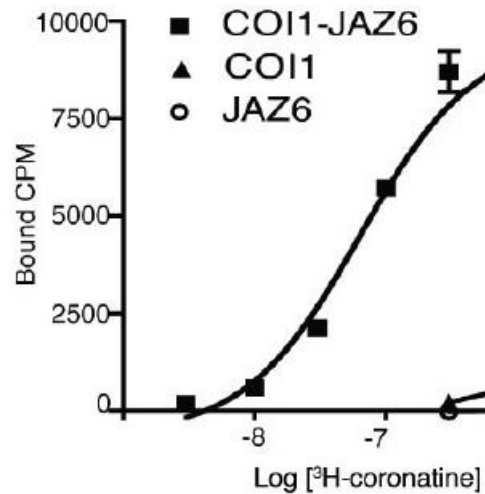
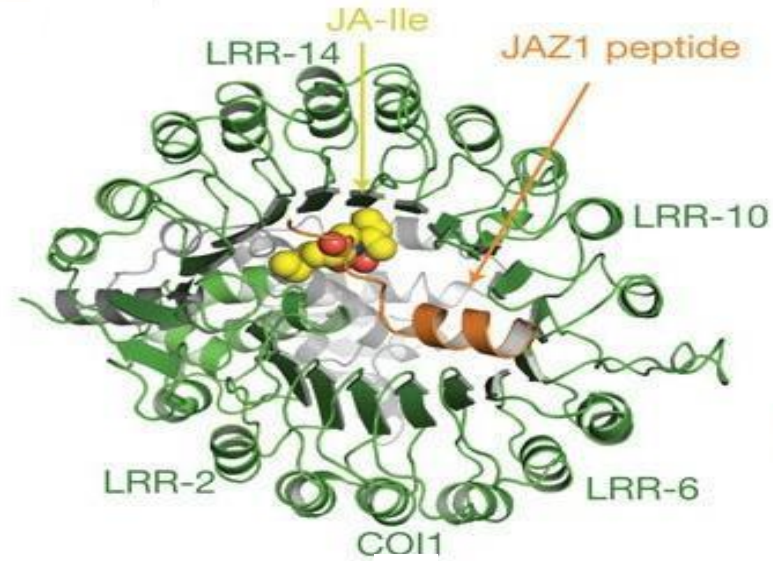
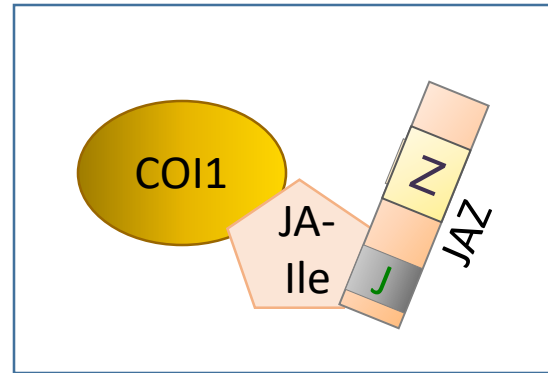


(3R,7S)-JA-Ile



Induction of **alkaloids** in poppy by **Coronatine and MeJA**

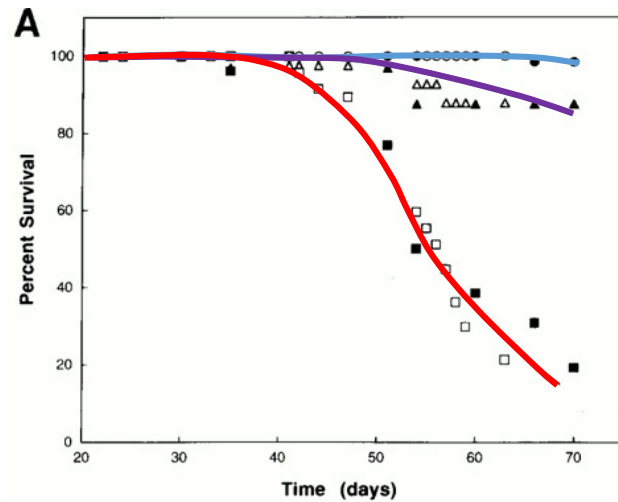
The jasmonate receptor consists of COI1 and JAZ co-receptors



JA-ile binds with SCF-COI1-JAZ complex only.
•The COI1-JAZ co-receptor has > 100 fold greater affinity for the ligand than either COI1 or JAZ alone

Reprinted by permission from Macmillan Publishers Ltd. Nature: Sheard, L.B., Tan, X., Mao, H., Withers, J., Ben-Nissan, G., Hinds, T.R., Kobayashi, Y., Hsu, F.-F., Sharon, M., Browse, J., He, S.Y., Rizo, J., Howe, G.A., and Zheng, N. (2010) Jasmonate perception by inositol-phosphate-potiated COI1-JAZ co-receptor. Nature 468: [400-405](#) copyright 2010.

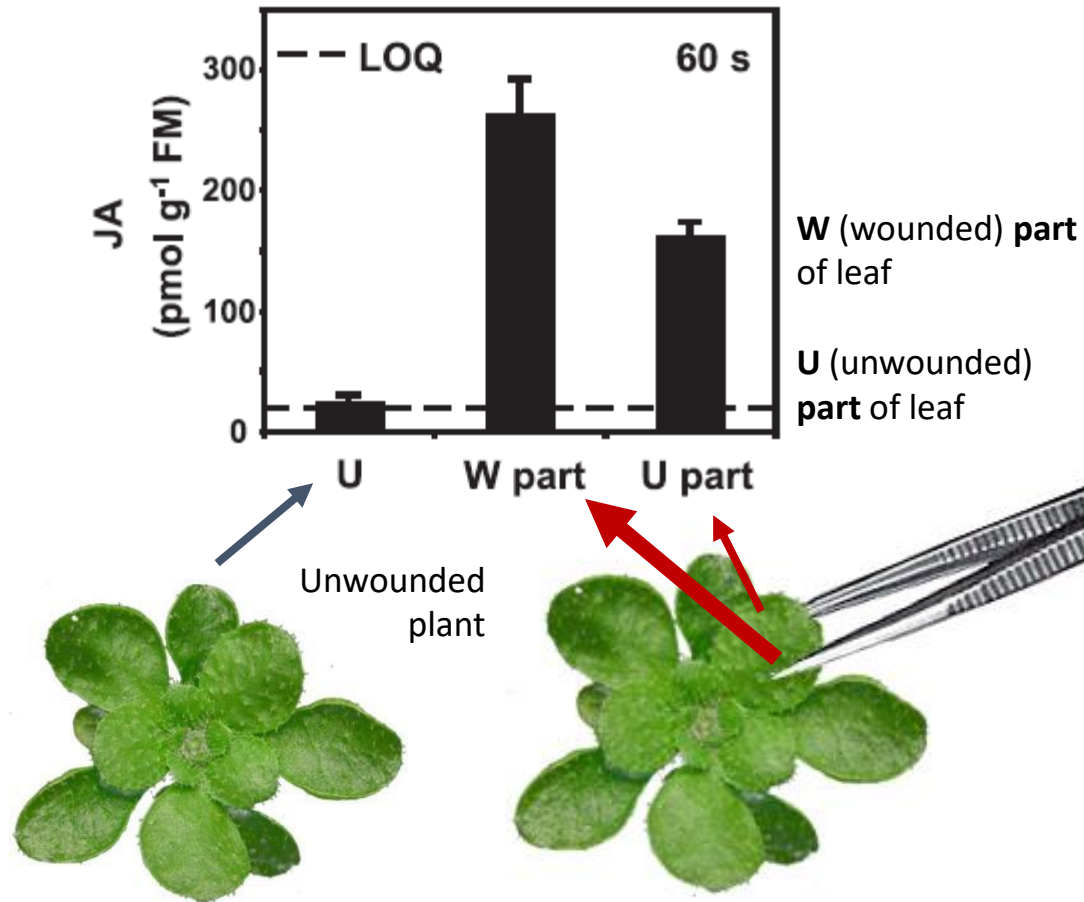
Jamunate signaling contributes to defenses against herbivory on Arabidopsis



When **Mutant without JA** Arabidopsis were exposed to hungry fly larvae, plants have low rates of survival. Wild Type Arabidopsis had higher survival rate. Because of What ??????? Jasmonate signaling

McConn, M., Creelman, R.A., Bell, E., Mullet, J.E., and Browse, J. (1997). Jasmonate is essential for insect defense in Arabidopsis. Proc. Natl. Acad. Sci. USA 94: [5473-5477](#).

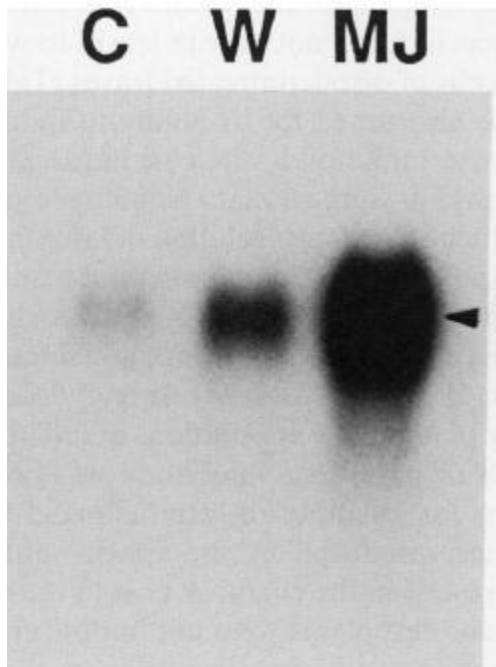
Jasmonates accumulate extremely quickly after wounding



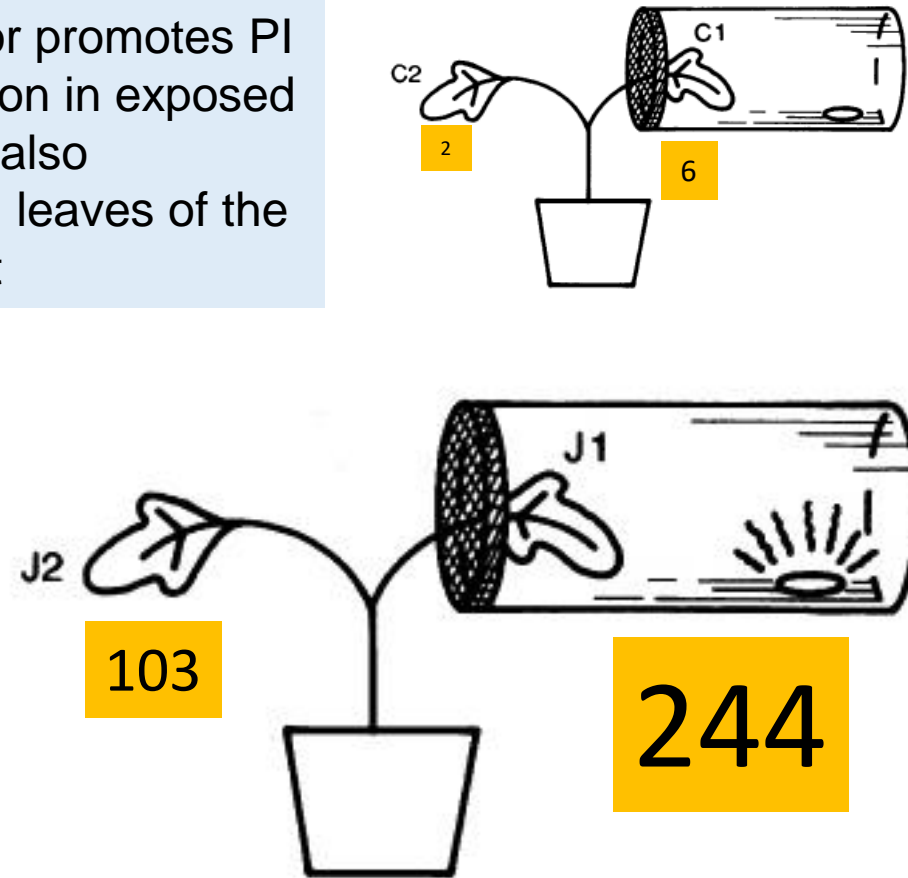
When a leaf is crushed with forceps, the level of JA in the wounded and unwounded part of the leaf increases within a minute

PI (Proteinase Inhibitor) genes are induced by jasmonate treatment, locally and systemically

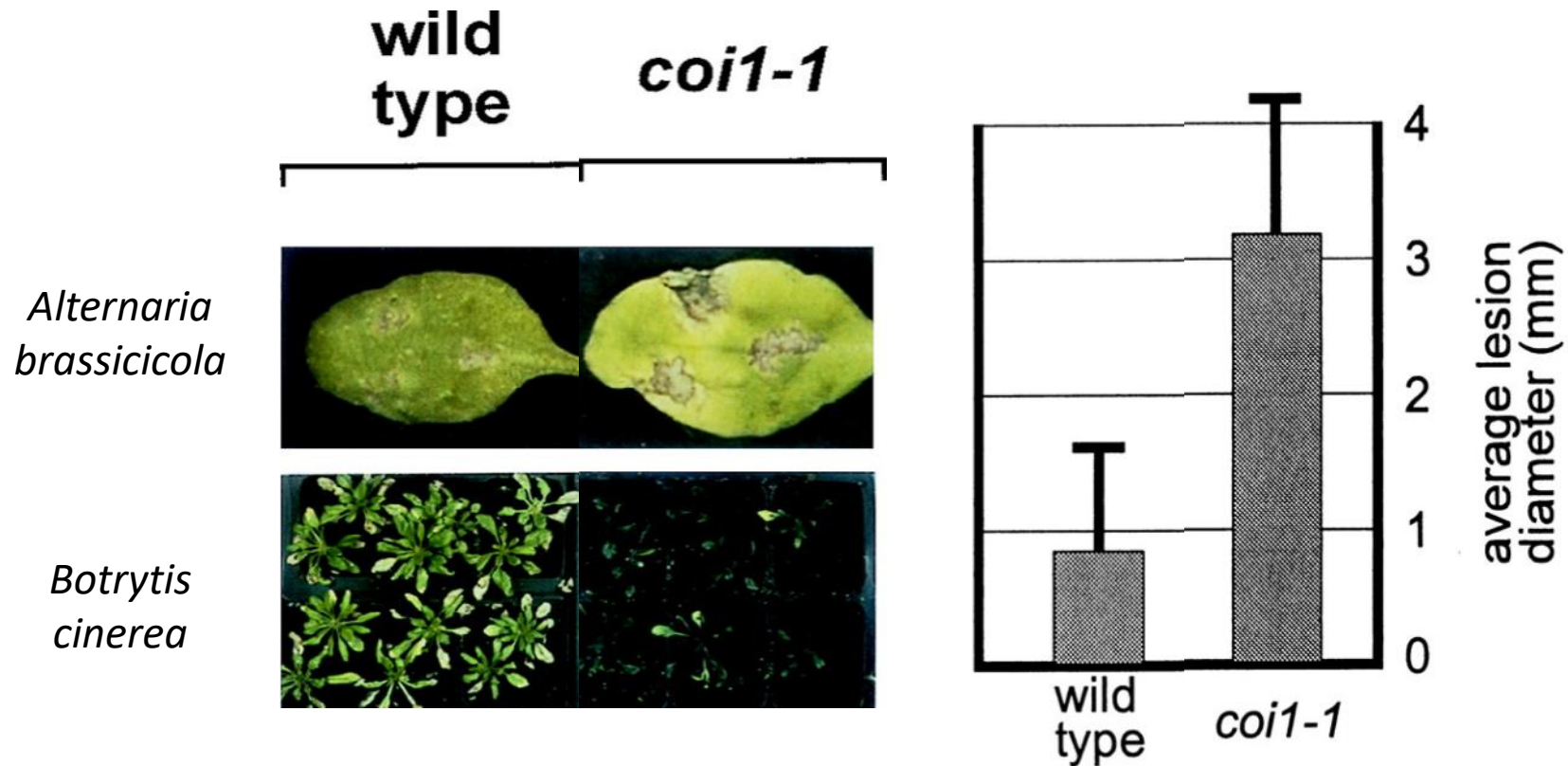
Proteinase inhibitor gene expression is induced by Wounding or Methyl Jasmonate.



MeJA vapor promotes PI accumulation in exposed leaves but also unexposed leaves of the same plant

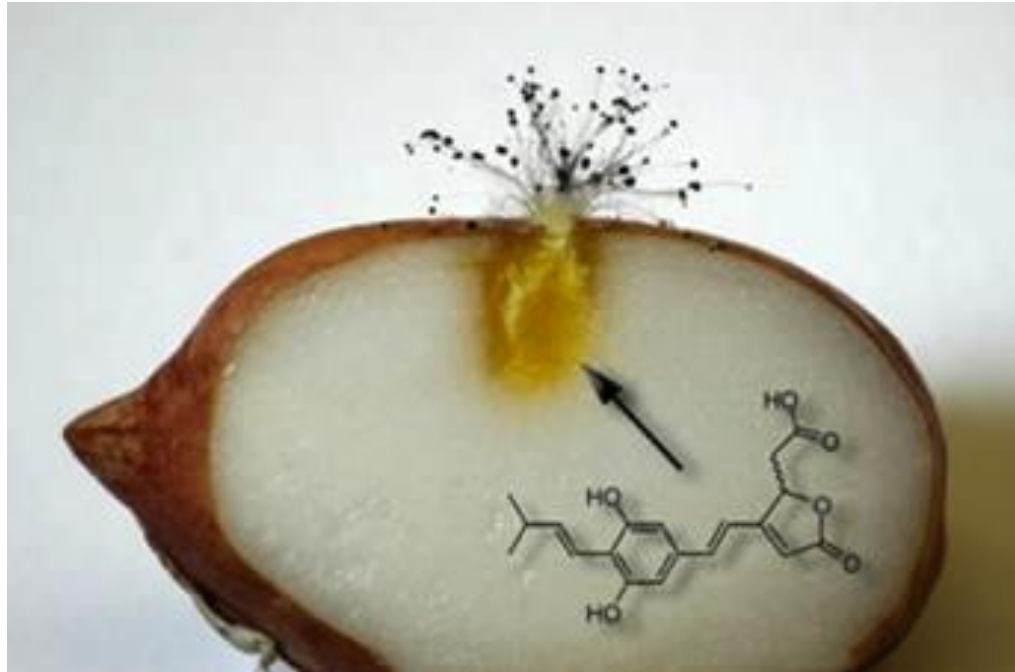


JA-insensitive plants are more susceptible to pathogens



Thomma, B.P.H.J., Eggermont, K., Penninckx, I.A.M.A., Mauch-Mani, B., Vogelsang, R., Cammue, B.P.A., and Broekaert, W.F. (1998). Separate jasmonate-dependent and salicylate-dependent defense-response pathways in Arabidopsis are essential for resistance to distinct microbial pathogens. Proc. Natl. Acad. Sci. USA 95: [15107-15111](#) copyright 1998 National Academy of Sciences USA.

JA-induces plant defenses against pathogens



JA-mediated responses to pathogens include production of **phytoalexins, and antimicrobial peptides or proteins**

Peanut kernel infected by a soil fungus (*Aspergillus niger*). Yellow-colored phytoalexin is locally produced by the kernel tissues (arrow)

Summary of JA signaling pathway

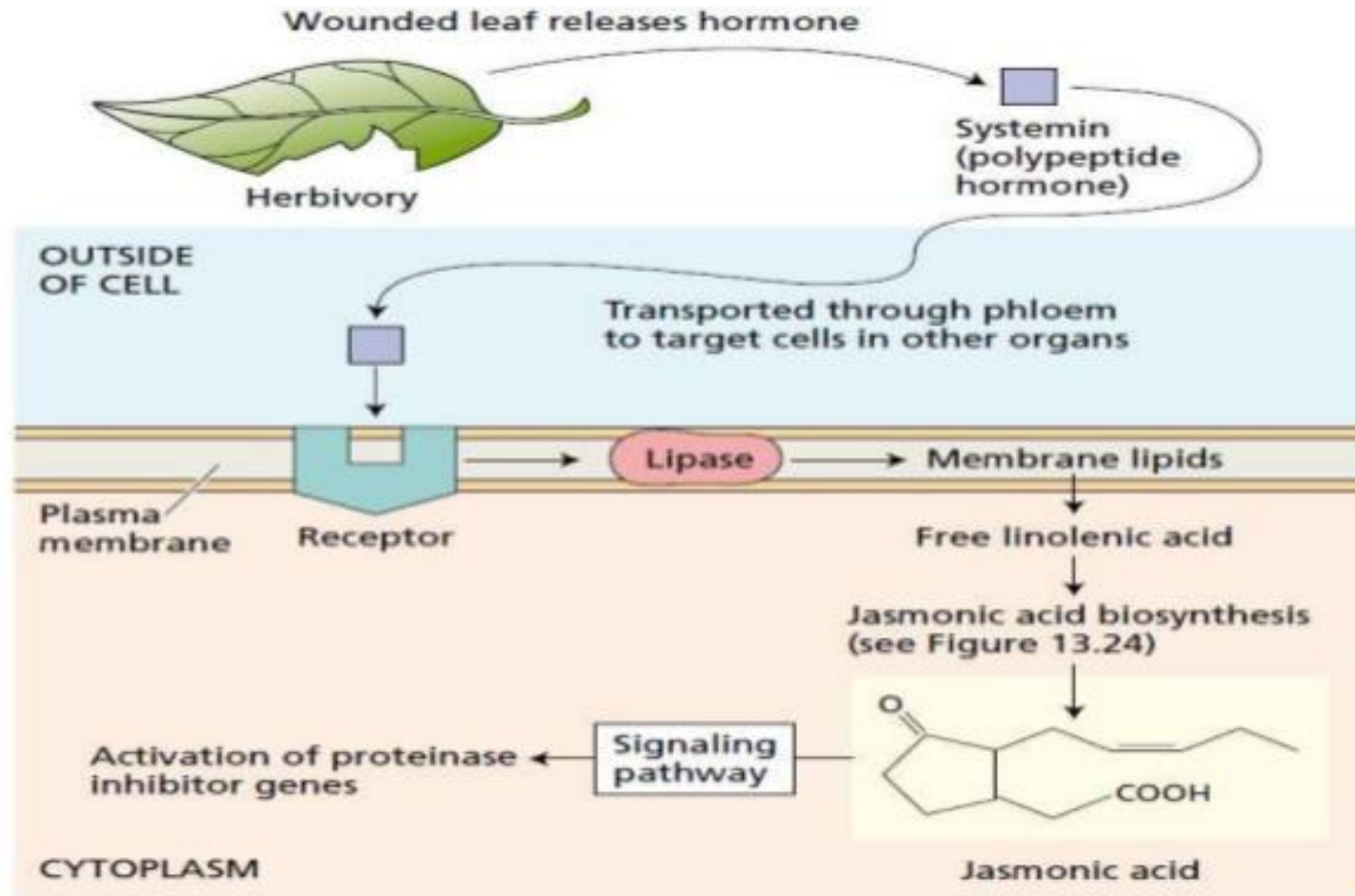
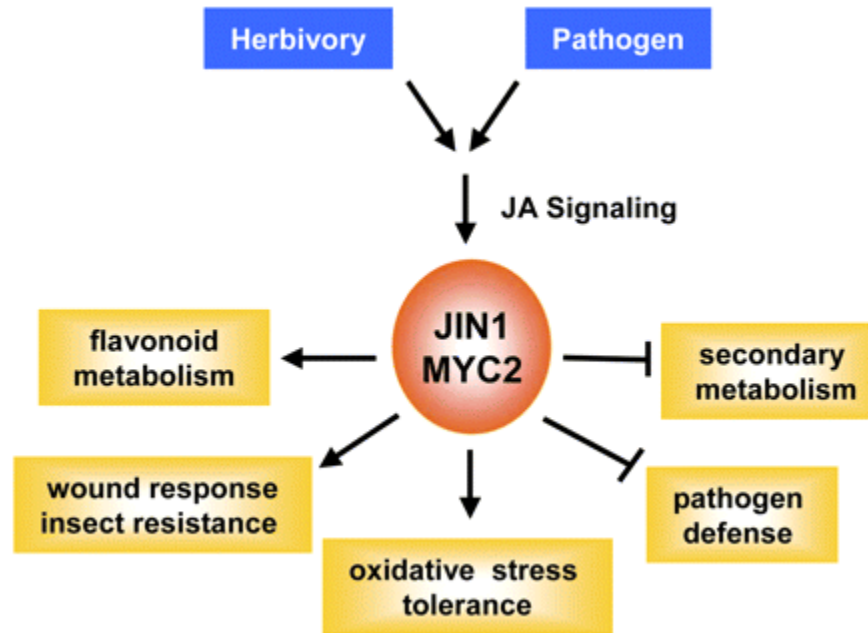


Figure 5: Schematic presentation of mechanism of JA in response to Insect attack

Summary of JA signaling pathway



Examples of JA signaling

- in the **tomato**, wounding produces defense molecules that **inhibit leaf digestion** in the insect's gut.
- **MeJA (volatile emission)** on leaves can travel airborne to **nearby plants** and elevate levels of transcripts related to wound response
- this emission **upregulate JA synthesis** and signaling and induce nearby plants to produce defense compounds to stop herbivory

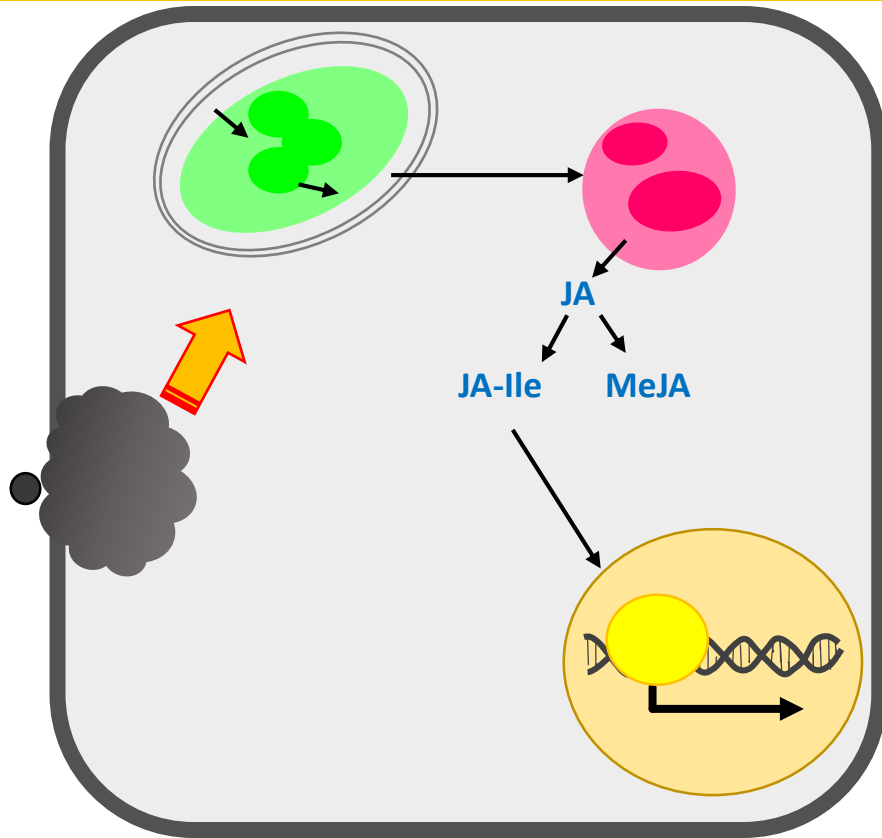
Role of JA in Defense

- JAs have also been implicated in **cell death and leaf senescence**.
- JA interact with many **kinases and transcription** factors associated with senescence.
- JA can also induce **mitochondrial death** by inducing the accumulation of **reactive oxygen species (ROSs)**.
- ROS **disrupt mitochondria membranes** and compromise the cell by causing **apoptosis**, or **programmed cell death**.
- JAs' roles in these processes suggest that **plant defends itself against biotic** challenges and limits the spread of infections.

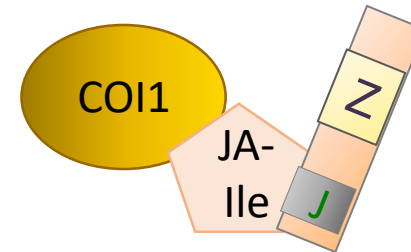
Assignments/Exams Question

❖ How does the plant discriminate between threats?

Ongoing questions



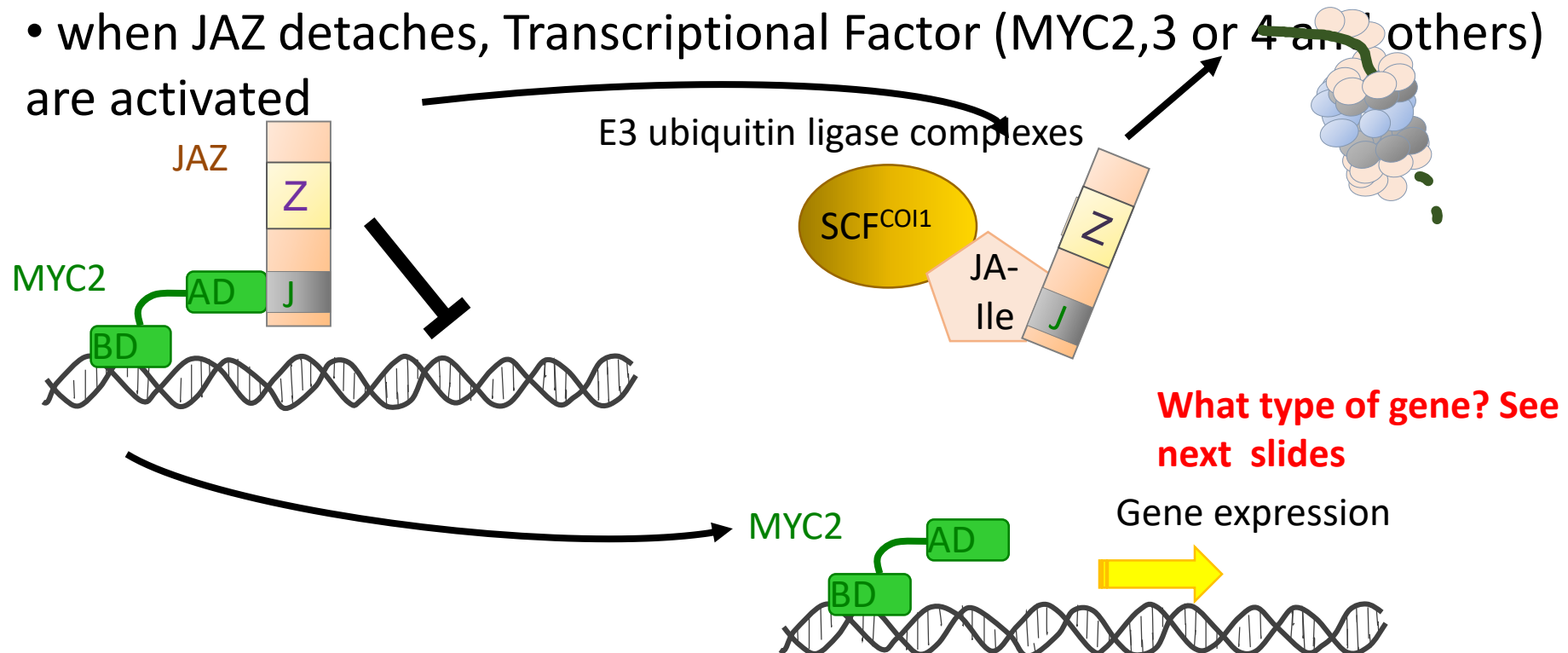
- ❖ What signals trigger JA synthesis and signaling pathways?
- ❖ How does the plant discriminate between threats?
- ❖ What is the systemic signal?



- ❖ What do the different JAZ proteins do?
- ❖ How is the diversity of JA responses controlled in specific organs and cell types?

Perception and signaling

- JA-Ile binding by the **SCF-COI1** (E3 ubiquitin ligase complexes) and JAZ coreceptor
- Ubiquitination (Attachment of **SCF-COI1** with JAZ) and degradation of JAZ
- when JAZ detaches, Transcriptional Factor (MYC2,3 or 4 and others) are activated



MYC2= transcription factor of light, abscisic acid (ABA), and jasmonic acid (JA) signaling pathways
JAZ=JASMONATE-ZIM DOMAIN (JAZ) repressor proteins. SCF=Skp1/Cullin/F-box
COI1= CORONATINE INSENSITIVE1