

How DAMPs Act as Signaling Molecules?

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SUMMARY

As sessile organisms, plants have evolved effective mechanisms to protect themselves from environmental stresses. Damaged (i.e., wounded) plants recognize a variety of endogenous molecules as danger signals, referred to as damage-associated molecular patterns (DAMPs). Plants require sophisticated surveillance systems to detect a variety of danger signals. Plants have evolved a large number of receptor, most of which are likely involved in response to different stresses.

INTRODUCTION

Plants are the target of a variety of pathogens and pests that cause disease, via both their above-ground and underground structures. Pathogens/pests shed microbe associated molecular pattern (MAMPs) or generate damage associated molecular pattern (DAMPs) that can be received by receptors to initiate cell-surface immunity. Pathogens/pests can deliver effectors to the outside or inside of cells, where they can act on host systems to their benefit, including the suppression of signaling pathways downstream of cell-surface receptors. Effectors or their activities can be sensed by intracellular immune receptors (NLRs) to initiate intracellular immunity (Bentham *et al.*, 2020) (Fig. 1).

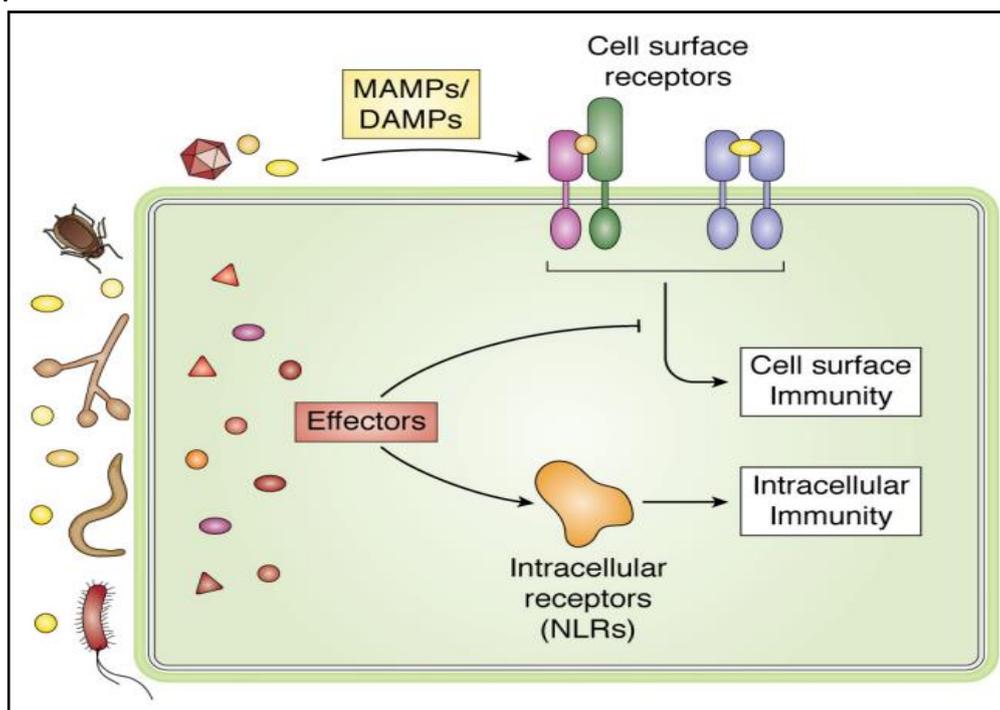


Fig. 1: Immunity in plants

What are DAMP molecules?

The immune system is concerned more with danger than foreignness, that is, damage means danger. Cells around a wound site must initiate regeneration and prepare for upcoming infections. These responses require a recognition of the damaged self, independently of an identification of a damaging agent. Damage is sensed via endogenous danger signals, so-called damage-associated molecular patterns (DAMPs). Ubiquitous self-molecules such as ATP and DNA are sensed as DAMPs upon their appearance in the extracellular space as an indication of damaged or dying cells (Tanaka and Heil, 2021). Numerous host tissue-derived molecules released in pathological conditions such as tissue injury, trauma, or non-apoptotic cell death have shown to trigger immune responses very similar to those activated upon PAMP recognition. Such patterns are inconsistently referred to as DAMPs, danger signals, alarmins, or self-antigens (Fig. 2).

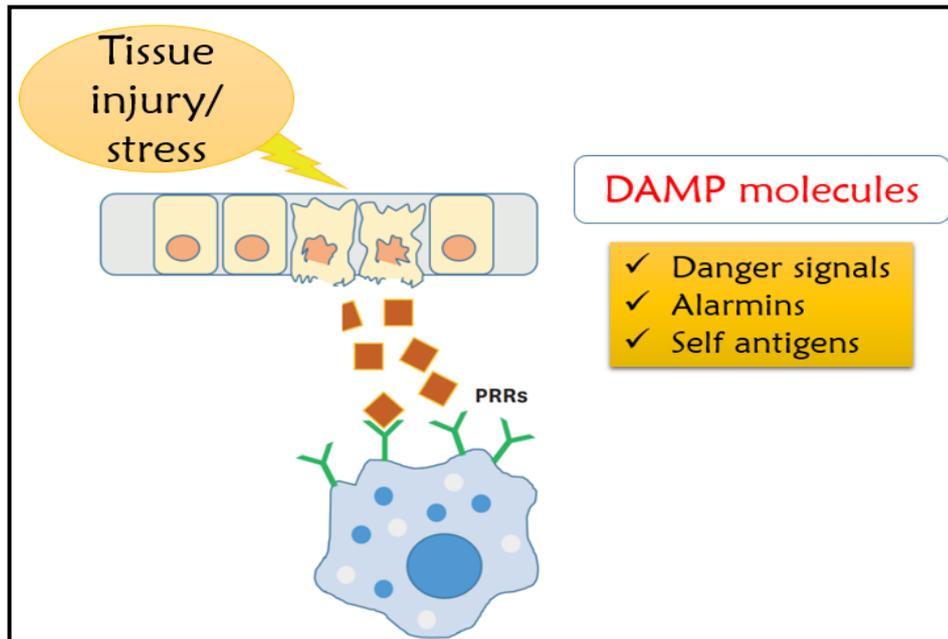


Fig. 2: DAMPs production

Key examples of such host-derived (endogenous) immunogens are ATP, heat-shock protein 70, hyaluronic acid, mitochondrial or nuclear DNA, and high mobility group box (HMBG) nuclear proteins. Notably, many of these patterns are recognized by the same classes of PRRs (e.g., TLRs) through which PAMPs are recognized, suggesting co-evolution of perception systems for either pattern type. Both endogenous DAMPs and microbe-derived PAMPs are considered to be danger signals (Gust *et al.*, 2017).

Classification of DAMP molecules:

Danger signals can be divided into exogenous signals derived from ‘non-self’ and endogenous signals originating from the host ‘self’. Exogenous danger signals include molecular patterns from pathogens/microbes (PAMPs or MAMPs), herbivores (HAMPs), nematodes (NAMPs), parasitic plants (ParAMPs), and possibly from viruses, as well as effectors from host adapted pathogens. In contrast to exogenous danger signals, endogenous danger signals originate from the organism itself and comprise primary and secondary signals. Primary danger signals can be regarded as the ‘classical’ damage-associated molecular patterns (DAMPs) because they are only released upon cellular damage. Secondary endogenous danger signals are processed peptides that act as immunity modifiers and should be termed ‘phyto cytokines’ (Fig. 3).

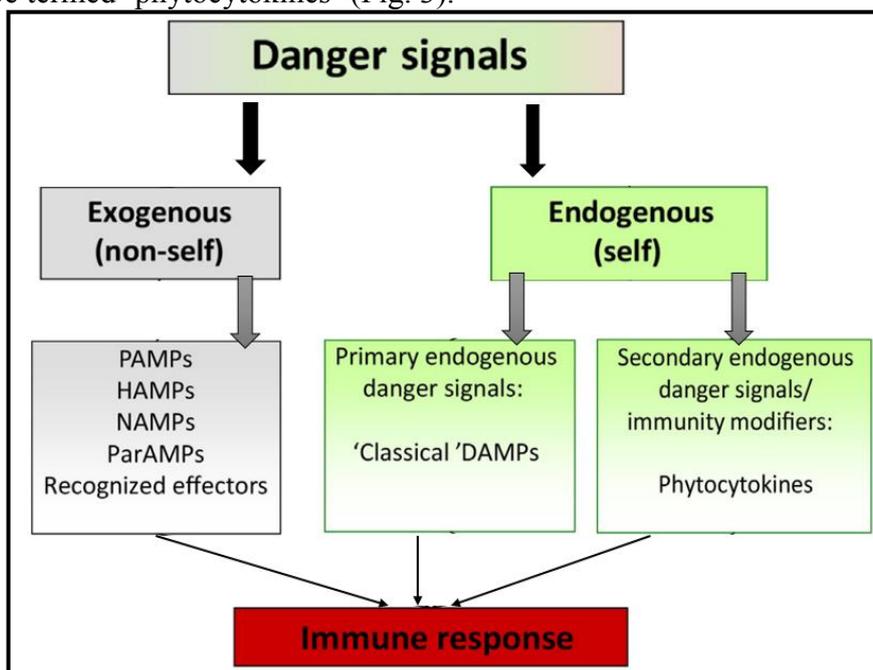


Fig. 3: Immunogenic Patterns Implicated in Danger Perception and Activation of Plant Immunity

CONCLUSION

Host-derived danger signals, DAMPs, have been discovered in many plant responses during physical damage and biological stress. Plants “use what is there” as a signal. The localization of the DAMPs into aberrant compartments (mostly apoplast) by cellular damage, they act as immunogenic signals. DAMPs and their receptors appear to evolve more dynamically, resulting in a considerable divergence of molecular structures of signals and their recognition mechanisms.

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