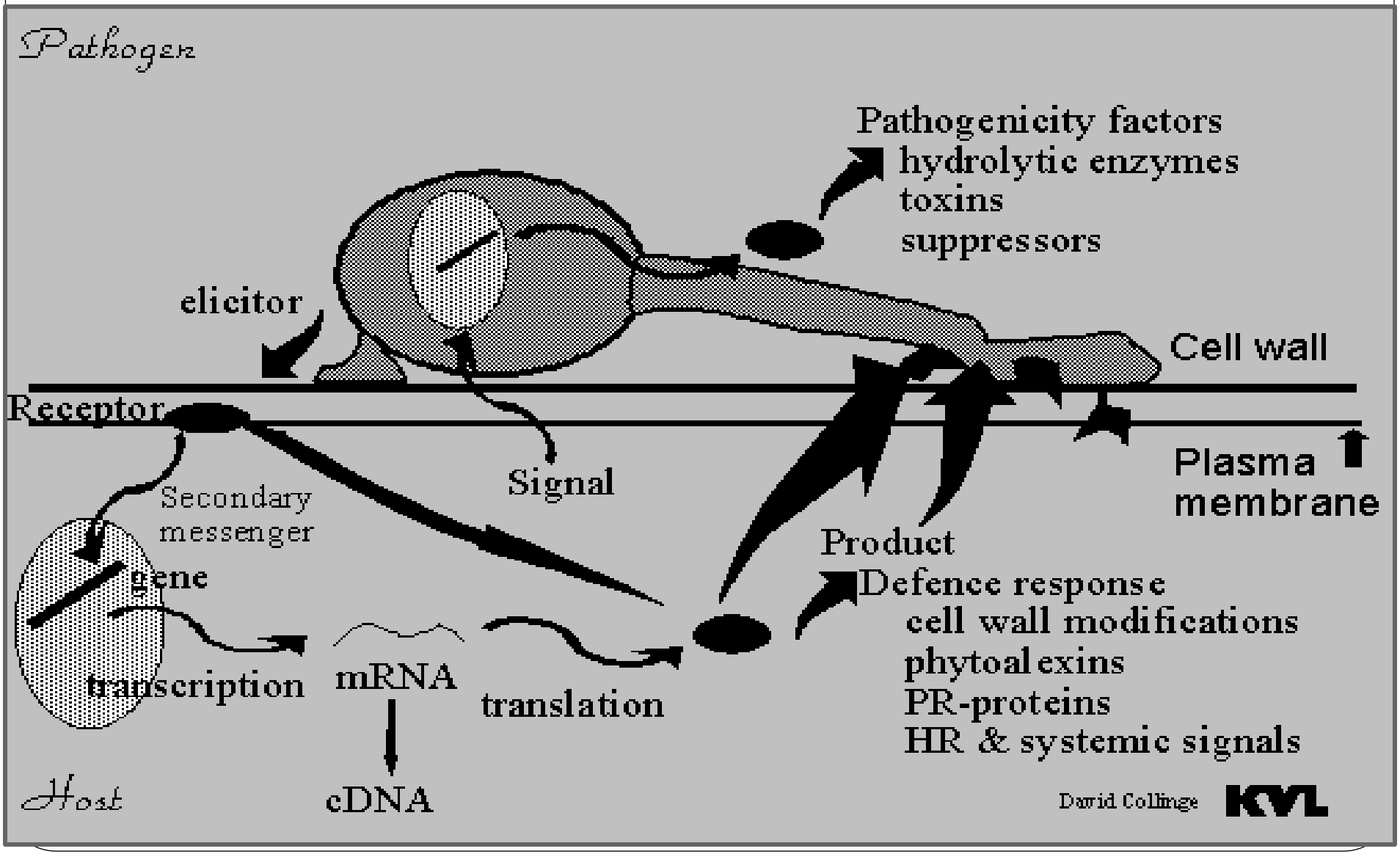
MAMPs, elicitors and their perception by host plants

PLANT- PATHOGEN INTERACTION



Elicitors

Molecules released during microbial entry into the plants which acts as chemical cues for plant active defense response

I. SPECIFIC ELICITORS

- Avr Gene products
- Hrp Gene products

III. DAMPs

II. NON SPECIFIC ELICITORS

Perception occurs via specific receptors and signals

Conceptually, referred as PAMP → MAMP

- Phytotoxins
- Extra cellular microbial enzymes
- Peptic enzymes
- Proteases
- Glycoproteins
- Proteins
- Peptides
- Fatty acids

- **PAMPs**– are molecules associated with groups of pathogens, that are recognized by cells of the innate immune system. These molecules can be referred to as small molecular motifs conserved within a class of microbes. They are recognized by Toll-like receptors (TLRs) and other pattern recognition receptors (PRRs) in both plants and animals.

The term "PAMP" has been criticized on the grounds that most microbes, not only pathogens, express the molecules detected; the term microbe-associated molecular pattern, or MAMP, has therefore been proposed.

A virulence signal capable of binding to a pathogen receptor, in combination with a MAMP, has been proposed as one way to constitute a (pathogen-specific) PAMP. Plant immunology frequently treats the terms "PAMP" and "MAMP" interchangeably, considering them to be the first step in plant immunity, PTI (PAMP-triggered immunity).

PAMPs (Pathogen Associated Molecular Patterns)

- **Pathogen derived general elicitors.**
- Evolutionary conserved structures (not subjected to frequent mutations) which are functionally important.
- Examples are:
- Flagellin subunit of bacterial flagellum
- Lipopolysaccharides found in cell walls of G-ve bacteria
- Chitin, ergosterol, and a transglutaminase enzyme from fungi
- Translation elongation factor EF-Tu

In plants recognition of PAMPs triggers nonspecific basal defense, while recognition of pathogens avirulence gene product initiates gene specific resistance.

- **Microbe-associated molecular patterns (MAMPs)** are molecular signatures typical of whole classes of microbes, and their recognition plays a key role in innate immunity.
- Egs. - Flagellin (subunit of bacterial flagellum), Lippopolysacchride (cell wall of Gram-ve bacteria), chitin, ergesterol, and a transglutaminase enzyme from fungi, Translation elongation factor EF-Tu
- Because of the damage caused by microbes, signals may arise from the plant itself in the form of ENDOGENOUS ELICITORS are recognized as **Damage-associated molecular patterns (DAMPs)**.

Perception of MAMPs or DAMPs by the PRRs initiates an active defense response, called basal immunity in plants and innate immunity in animals, which is thought to hold nonadapted pathogens in check.

Well-adapted microbial pathogens, however, have found ways to breach this first line of active defense.

In a sort of ongoing arms race, plants and animals have evolved a second line of defense—acquired or adaptive immunity in the case of higher vertebrates and R-gene-based resistance in the case of plants.

DAMAGE-ASSOCIATED MOLECULAR PATTERNS

- **Many plant pathogens produce lytic enzymes to breach the structural barriers of plant tissues. The products generated by these enzymes may function as endogenous elicitors or DAMPs.**

- **DAMPs typically appear in the apoplast and, as in the case of MAMPs, can serve as danger signals to induce innate immunity.**

- **Perception system for most of the DAMPs remain unknown.**
- **Cell Wall Fragments, Cutin Monomers, Peptides like Systemin (The receptor for systemin is probably a LRR-RK), AtPEP1 and PEPR1, HypSys and RALF**

- **Pattern recognition receptors, or PRRs, are proteins expressed by cells of the innate immune system to identify pathogen-associated molecular patterns, or PAMPs, which are associated with microbial pathogens or cellular stress. They may also be referred to as pathogen recognition receptors or primitive pattern recognition receptors in light of the fact that these methods of immune surveillance have existed long before adaptive immunity evolved as an immune mechanism.**
- **Two types of PRRs are found in mammals : signalling and endocytosis PRRs.**

- The first PRR identified in plants was the **Xa21 protein**, conferring resistance to the Gram-negative bacterial pathogen *Xanthomonas oryzae pv. oryzae*.

- Two other plants PRRs, Arabidopsis FLS2 (flagellin) and EFR (elongation factor Tu receptor)have been isolated.

- The corresponding PAMPs for XA21, FLS2 and EFR have all been identified. Upon ligand recognition, the plant PRRs transduce "PAMP-triggered immunity" (PTI).

Other MAMPs binding proteins are **The Glucan Receptor of Soybean** (*Phytophthora megasperma*), **The Xylanase Receptor of Tomato** (*EIX2, a* LRR plasma membrane protein, required endocytosis to operate), **The Chitin Receptor of Rice (**CEBiP**).**

Plant immune systems also encode resistance proteins that resemble NOD-like receptors, that feature NBS and LRR domains and can also carry other conserved interaction domains such as the TIR cytoplasmic domain found in Toll and Interleukin Receptors. The NBS-LRR proteins are required for effector triggered immunity (ETI).

Class	Pattern recognition receptor (PRR)	Plant species	Predicted features of MAMPs protein	Molecule/protein recognized	Pathogen species
1	LeEix1, LeEix2	Tomato	LZ-eLRR-TM-ECS	EIX ah ethylene induced xylanase	*Trichoderma viride*
2	FLS2	Arabidopsis	eLRR-TM-kinase	flg22 a22 amino acid peptide derived from the N-terminal fragment of the flagellin protein	Multiple bacteria species
3	EFR	Arabidopsis	eLRR-TM-kinase	EF-Tu acetylated N terminus of the elongation factor Tu	Bacteria
4	GBP 75-kDa b-glucan binding protein	Soybean and Fabaceae species	Soluble, cell wall located protein with intrinsic endo--glucanase activity	HG hepta -glucoside	Phytophthora cell-wall derived
5	N-glycoproteins of 162 and 50 kDa	Tobacco, Arabidopsis and Acer pseudoplatanus	Plasma membrane localized	Lipid-transfer proteinselicitins which bind sterols	Oomycetes (Phytophthoraspeciesand Pythiumspecies)
6	CEBiP	Rice	Plasma membrane localized glycoprotein with two extracellular LysM motifs	Chitin oligomers (chitooligosaccharide)	Fungi
7	100-kDa Pep-13 binding protein	Parsley	Plasma membrane localized	Pep13 asurface exposed 13 amino acid sequence present within a cell wall transglutaminase	*Phytophthora sojae* and other *Phytophthora* species
8	Not known	Tobacco	Plasma membrane localized	RNP-1 cold shock inducible RNA-binding protein	Gram-negative and Gram-positive bacteria