Plant responses to attack by plant pathogens

Plants have evolved a range of defence strategies to protect themselves from attack by different plant pathogens. All are designed to either keep the disease causing organism out, or more typically to stop it spreading within the plant. These responses may be broadly distinguished as '*physical defence responses*' or '*chemical defence responses'*

The physical barriers include structural characteristics of the plant, while (bio)chemical barriers describe those reactions and substances within a plant cell that create conditions that inhibit pathogen growth or are toxic to invading pathogens.

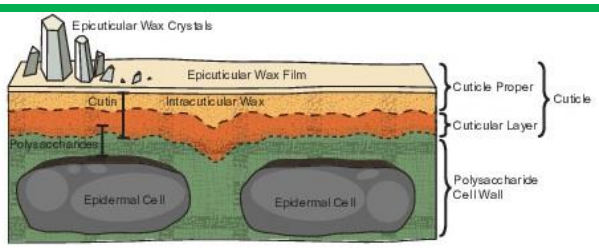

Figure 1. Schematic of the plant cuticle. Reproduced with permission from Jocelyn Rose and ASPB (published in Plant Physiology, 2013)

Physical Defence Responses

The first barrier encountered by any pathogen attacking the aerial parts of a plant is the **plant cuticle.** The cuticle coats the outer surface of epidermal cells and protects against water loss & irradiation as well as pathogen attack. It consists of a mixture of cutin (a polyester) and polysaccharides that is covered and mixed with waxes (Figs. 1 & 2).

The cuticle wax varies in thickness between 0.1 and 5 µm (1 µm is thousandth of a mm, a human hair being about 100 µm) and is closely associated with the next main physical barrier, the **epidermal cell wall** (ECW). The ECW can thicken in response to pathogen attack, making it harder for pathogens to enter a plant cell. ECWs may be reinforced by cross-links with proteins.

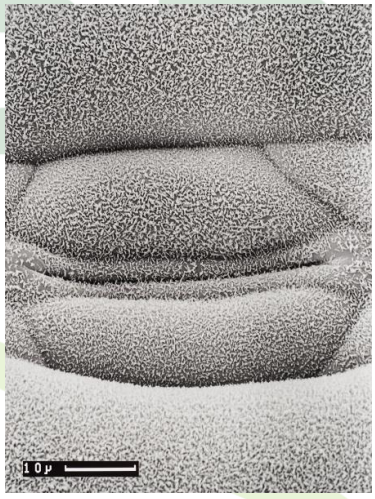

Figure 2. Scanning Electron Micrograph (SEM) of a plant leaf surface showing coverage of cuticular waxes.

There are many other examples of physical defence structures once the pathogen has gained entry into the plant – see overleaf

Physical Defence Responses

Pathogen invasion may stimulate the plant to form layers of **cork** beyond the point of infection. These layers stop further spread of the pathogen and any toxic substances produced by the pathogen. **Abscission layers** may form in which infected tissues die and fall away. **Tyloses** may form in xylem vessels, ahead of the pathogen. Depending on their size and number they may 'clog' xylem vessels again preventing pathogen spread (Figure 3).

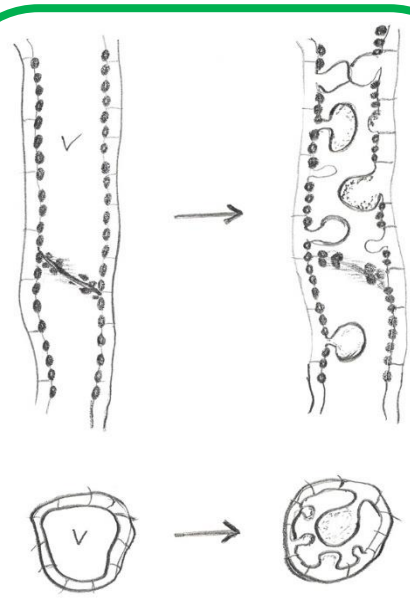

Figure 3 (after Agrios, 3rd ed). Sketch of tyloses in xylem vessels, v - overgrowths of parenchyma cells.

A common response against biotrophic fungi (such as powdery mildew) is the formation of papillae, made of callose, deposited on the inner side of the ECW, again providing a physical barrier to the invading pathogen (Figure 4).

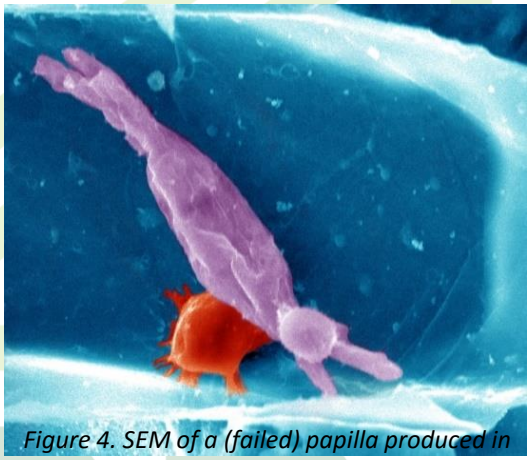

Figure 4. SEM of a (failed) papilla produced in barley in response to powdery mildew infection (reproduced with permission of Alan Little, University of Adelaide)

Chemical Defence Response

Once inside the plant, a wealth of chemical reactions and existing chemicals provide unfavourable conditions for pathogen survival and spread.

Many are the result of secondary metabolism. Some plants produce essential oils (monoterpenoids), and phenolic compounds may also be produced. Humans have found some of these to be anti-microbial and used them to treat diseases or act as medicines (eg. Mint and Witch Hazel). Interestingly, despite this, mint is still affected by many fungal plant diseases because the pathogens have developed immunity to the effect of menthol.

Papillae (physical barrier) are also sites where some of these anti-microbial chemicals are formed or accumulate. These are studied further at A-level.

GLOSSARY

Pathogen – organism that causes disease.
Cork – non-living, secondary tissue, cell walls made of waxy substance called suberin, impermeable to water & gases.
Abscission – cut away, to shed cells or tissues
Tyloses – balloon-like outgrowths of a parenchyma cell into adjacent xylem vessels.
Xylem Vessels – involved in movement of water through plants from roots to leaves.
Parenchyma – thin-walled, non-specialised plant cells. Found in non-woody plant parts.
Callose – a plant polysaccharide.
Secondary Metabolism - chemicals produced by plants for which no role has yet been found in growth, photosynthesis, reproduction, or other "primary" functions.