SOME EXAMPLES OF WOOD DISCOLOURATIONS RELATED TO MECHANISMS FOR POTENTIAL PROTECTION OF LIVING TREES AGAINST FUNGAL ATTACK

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Discolourations in wood may arise from various causes. Most frequent and in general particularly intensive are colourations which indicate the activity of wood staining and wood destroying fungi. Such discolourations, however, also often appear specifically in those parts of the stem where the tree actively tries to prevent the penetration of air or microorganisms.

A well known example for this is represented by the resin cone formed at the base of dying or dead softwood branches at the beginning of branch growth regression which extends in all directions during the period of branch dying (Dietrích, 1973; Von Aufsess, 1975). At the moment of branch death the cone is completed and occupies the entire knot cross section (Fig. 1a). The cells in this region are strongly impregnated and often even totally blocked up with resin (Figs. 1b & c). In the withered bough this zone appears as a reddish brown coloured double zone.

As opposed to coniferous trees the dying hardwood branches are separated from the living stem timber not by resin impregnation but by a protection zone with a high accumulation of tyloses, wound gum and other inclusions in the cells (Gelinsky, 1933; Mayer-Wegelin, 1936; Von Aufsess, 1974). This protection zone, whose formation seems to be similar to that of heartwood, also distinctly contrasts with the surrounding wood on account of its darker colour (Fig. 2a). The discolouration is caused by compact inclusions in the parenchyma tissue and frequently the lumina of vessels and tracheids are full of dark substances (Figs. 2b & c). Their decomposition and subsequent transformation into brownish coloured inclusion substances has been observed in microscopic wood sections.

The formation of resin cones in conifer branches as well as the development of a protection zone at the base of hardwood knots require the presence of living parenchyma cells and are therefore only possible in the sapwood area. In older branches that had already grown pithy at their centre at the beginning of branch dying, resin cones or a protection zone can only be formed in the sap but never in the heartwood.

In response to injuries, those sections of the woody stem of soft- and hardwoods which are laid bare soon become darker to a certain, in most cases slight depth, and differ distinctly from the surrounding healthy wood (Fig. 3a). This darker zone, which Frank in 1884 already called 'protection wood', is characterised by a lower moisture content and is intended to prevent not only the entrance of water and air but also the spreading of fungal infections. Under the influence of oxygen an intensive formation of tyloses takes place in hardwoods, and in all species both the parenchyma tissue and also the fibre lumina were filled up with brown contents of wound gum or wound resins including various tannin derivates (Figs. 3b & c). The mode of protection wood formation corresponds in the main essentials to that of heartwood and appears to be especially stimulated by the penetration of fungal hyphae.

Another example of discoloration associated with mechanisms for the prevention of fungal decay in living trees is the transition zone between healthy wood and that attacked by fungi — in particular in spruce infected by *Fomes annosus* — described by Shain (1967, 1971) and others as 'reaction zone'. It is found, when fungal decay has taken place of the entire heartwood area and penetrates from there into the sapwood or when wound rot expands into the outer layers of stems, where the tree is still able to react actively to fungal infections. In most cases it is only distinguishable by a more or less intensive violet demarcation (Fig. 4a), followed, towards the rotted heartwood, by a light greenish coloured zone. Often a great amount of amorphous, grained or crystalline inclusions can be observed — varying in form and size — in the tracheid lumina (Fig. 4b). Moreover, it is characterised by a high content of dead, starchless parenchyma cells, high concentrations of potassium, calcium, and magnesium as well as a lignin concentration. In biotests the extracts from this zone showed a distinct antagonistic effect against the root rot fungus *Fomes annosus* (Alcubilla et al., 1974).
Fig. 1. Resin cones in softwood branches. – a. Double resin cone at the base of a spruce branch. – b. Spruce-wood tracheids strongly impregnated with resin; x 130. – c. Spruce-wood tracheids totally blocked up with resin; x 2450.