

Cutin monomers (see Chapter 3) and the carbohydrates of cell walls also lack the extended double bond systems and, hence, cannot effectively absorb natural UV radiation. However, isolated cuticles of some plant species exhibit conspicuously high UV-B absorption (Krauss *et al.*, 1997; Baur *et al.*, 1998), suggesting the presence of UV-absorbing substances. Similarly, UV-absorbing compounds have been located in wax layers and cell walls of some species but are also present in vacuoles (see later). Furthermore, substances affecting optical characteristics and absorbing in the visible range occur in plant surfaces. In this chapter, we divide all compounds which contribute to surface optics by absorption of UV and visible radiation into three groups: (1) phenolics, including hydroxycinnamic acids, colourless flavonoids and anthocyanins, (2) betalains and (3) carotenoids.

Compounds of all groups are not only involved in absorption of radiation but also exhibit free-radical scavenging functions which is outside the scope of this chapter. Information on the latter properties have been summarised for hydroxycinnamic acids (Chen and Ho, 1997; Foley *et al.*, 1999; Son and Lewis, 2002), for colourless flavonoids (Pietta 2000; Cotellet 2001; Amić *et al.*, 2003; Williams *et al.*, 2004), for anthocyanins (Wang *et al.*, 1997; Neill and Gould, 2003), for betalains (Pedreño and Escribano, 2000; Kanner *et al.*, 2001; Cai *et al.*, 2003), and for carotenoids (Di Mascio *et al.*, 1991; Pfündel and Bilger, 1994; Young and Lowe, 2001). Also, consistent with the title and focus of this chapter, we will not discuss the occurrence and function of absorbing compounds located in the interior of plant organs.

6.3.1 Phenolics

Plant phenolics include hydroxycinnamic acids and flavonols and are products of general phenylpropanoid metabolism, in which the initial step is the elimination of ammonia from the aromatic amino acid phenylalanine to form cinnamic acid. This acid can be hydroxylated in the presence of O₂ by a mono-oxygenase to 4-hydroxycinnamic acid (i.e. *p*-coumaric acid) which has a C₆-C₃ structure. Coumaric acid may also be formed directly by elimination of ammonia from tyrosine (Hahlbrock and Scheel, 1989; Rosler *et al.*, 1997). There are a multitude of flavonoids but the first committed step in their synthesis, catalysed by chalcone synthase, is the condensation of 4-coumaroyl-CoA with three molecules of malonyl-CoA forming three molecules of CO₂ and the simplest flavonoid, chalcone, with a C₆-C₃-C₆ skeleton (Forkmann and Heller, 1999).

4-Hydroxycinnamic acids. Hydroxycinnamic acids (see Figure 6.3) and their simple derivatives, absorb mainly in the UV-B and the short-wavelength UV-A range (Lichtenthaler and Schweiger, 1998; Kolb *et al.*, 2001; Meyer *et al.*, 2003; Kolb and Pfündel 2005). Consequently, high concentrations of peripherally located hydroxycinnamic acids can efficiently protect plants from the known deleterious effects of UV-B radiation (Hollósy, 2002). In fact, hydroxycinnamic acids have been shown to screen the leaf mesophyll in *Arabidopsis thaliana* from UV-B radiation (Li *et al.*, 1993; Landry *et al.*, 1995; Sheahan, 1996).