Experiment 5: Examining the Effect of Light Wavelengths on Photosynthesis

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The discovery of C4 photosynthesis in the 1960s and awareness of the high photosynthetic capacity of C4, as compared with C3, plants created an upsurge of interest in the impact of photorespiration on the carbon economy of C3 plants, its origins in the Rubisco oxygenase reaction, and in the ecophysiological relationships between C3 and C4 plants. This was recorded strikingly in the proceedings of a conference held in Canberra in 1970 ([Hatch *et al*., 1971](javascript:;)). Later, Burris and Black wrote, ‘A continuing interest in plant productivity has been quickened in recent years primarily by a growing concern for feeding a rapid expanding world population and by the discovery of the C4 pathway of photosynthetic carbon assimilation. Population growth has served as a goad to research, and the low photorespiration and high efficiency of the C4 pathway have suggested a promising route to aid in achieving increased plant yields’ ([Burris and Black, 1976](javascript:;)). At the time, attempts were made to transfer the advantages of C4 photosynthesis (reduced photorespiration, and increased nitrogen, water efficiency and, under certain conditions, increased light use efficiency) into C3 plants by breeding. Although C3 and C4 species of *Atriplex* were hybridized, the independent inheritance of the genes conferring C4 characteristics, such as Kranz anatomy, elevated PEP carboxylase and low CO2 compensation point, indicated that plant breeding was unlikely to be a successful route ([Björkman *et al*., 1971](javascript:;); [Björkman, 1976](javascript:;)). However, the advent of genetic engineering in crop plants has recently resulted in attempts to introduce C4 characteristics into C3 plants, such as tobacco, potato and rice, by genetic manipulation ([Matsuoka *et al*., 2001](javascript:;)). Clearly, it is easier to over‐express enzymes of the C4 pathway either individually or in concert, than it is to introduce the complex Kranz leaf anatomy of C4 photosynthesis, with its division of labour between thin‐walled mesophyll cells surrounding the thick‐walled chlorenchymatous bundle‐sheath. For this reason, considerable interest has focused on engineering single‐celled C4‐type CO2‐concentrating mechanisms, such as that found in the aquatic plant, *Hydrilla verticillata*. The aim of this review is to discuss the requirements of a CO2‐mechanism as found in C4 plants, and thus to indicate the minimum requirements of any genetically‐engineered system.