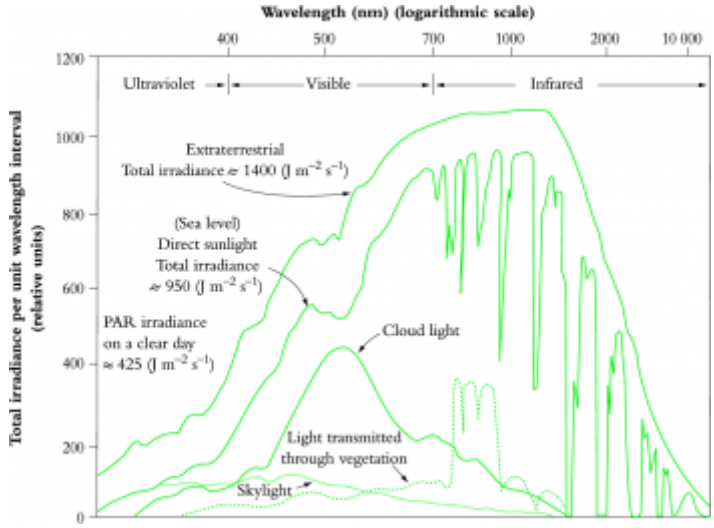
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Introduction

Terrestrial ecosystems are both *sustained* and *regulated* by sunlight: sustained in massive ways by photosynthetically active radiation, but regulated in subtle ways by photo-morphogenically active radiation. Wavelengths most effective for photosynthesis occupy a band between about 380 and 720nm. A closely matching band from about 350 to 800nm spans the action spectra for crucial responses in plant growth and reproductive development that are also light regulated. These include seed germination, tropisms, photomorphogenesis, pigmentation and photoperiodic responses such as floral initiation (Chapter 8).

These two categories of light-dependent outcomes differ by many orders of magnitude in terms of energy flow within a plant community. In one case, a flow of radiant energy is converted into chemical energy and stored as biomass; in the other, miniscule levels of radiant energy provide a trigger for a shift in gene expression and consequent developmental response. Nevertheless, each category is mediated by pigment systems that transduce solar energy into highly ordered chemical forms: synthetic systems in photosynthesis, triggering systems in photo-morphogenesis.



[1]

Figure 12.1 Sunlight passing through the earth's atmosphere is altered in both quantity and spectral composition. Attenuation of descrete wavebands of infrared radiation by water vapour is especially noticeable (right side of figure), while absorption of ultraviolet by stratospheric ozone is also of special significance for terrestrial organisms. Cloud light is especially rich in visible wavelenghts with a peak around 500µm which coincides

with the maximum spectral sensitivity of our eyes. Plants have also evolved with spectral properties that match biological necessities. Vegetation shows strong attenuation of visible wavelengths that drive photosynthesis, but transmit near-infrared radiation that would otherwise heat leaves.

A note on units: **Visible wavelengths of sunlight can be represented as either a quantum flux or a radiant energy flux. Quantum flux is regarded here as synonymous with 'photon irradiance' *(Q)* and has units of µmol quanta m^{-2} s^{-1} ('µmol quanta' rather than 'µmol photons' because the quantum energy derived from photons drives photosynthesis). For the sake of making a clear distinction from quantum flux, radiant energy flux is simplified to 'irradiance', and for present purposes, irradiance coincides with photosynthetically active radiation (PAR). Irradiance is then expressed as joules (J) per square metere per unit time. Depending on the application, time can span seconds, days or years, and is then coupled with either joules, megajoules (MJ) or gigajoules (GJ)**

(Based on Gates 1965)

The earth's atmosphere attenuates solar radiation in highly selective ways (Figure 12.1). Substantial amounts of infrared energy (between about 850 and 1300nm) are absorbed by CO_2, ozone and especially by water vapour, while ozone is principally responsible for a cut-off in ultraviolet radiation below about 300nm. Our atmosphere thus represents a 'window' through which visible wavelengths pour onto the earth's surface, and terrestrial life forms have evolved with attributes that are a direct consequence of this spectral composition.

Selective ?ltering of wavelengths either side of the visible spectrum is crucial. Ultraviolet radiation is absorbed comprehensively by biological ingredients, especially proteins, RNA and DNA and contain pigments; and because energy per quantum increases with decrease in wavelength, ultraviolet radiation would impose a heavy load of energy on biological components with attendant disruption. Similarly, wavelengths beyond the visible spectrum, though less energetic, are still damaging because tissue water absorbs infrared radiation. All life processes operate within an aqueous millieu, so that the absorption properties of water molecules would put cellular function at risk if sunlight was not also attenuated with respect to infrared radiation.

Between these two extremes stands the visible spectrum, and it is no coincidence that all manner of biological systems have evolved with devices that make effective use of this narrow band of solar radiation. Vascular plants are a case in point where canopy, leaf and chloroplast have all adapted to light climate with a range of features that optimise their use of sunlight including mechanisms to deal with excess radiation.

Photosynthetic ef?ciency in low light confers a selective advantage on shade-adapted plants, but also renders them especially vulnerable to full sun. Accordingly, such species have evolved with remarkable features for photoprotection. Their acclimation to sun and shade, together with properties of sun-loving plants, thus reveal an extraordinary plasticity in the photosynthetic apparatus of vascular plants (Section 12.1). Even increased UV-B radiation, commonly associated with global change, and especially formation of an 'ozone hole' over Antarctica, elicits responses that offer photoprotection to plants so adapted (Section 12.2).

Notwithstanding biological hazards from extreme wave-lengths of solar radiation, sunlight obviously sustains global photosynthesis, and close quantitative relationships exist between energy absorption and biomass production. Such relationships are especially well de?ned for managed communities, with

plantation forests providing clear examples (Section 12.3). Recognising canopy architecture as a major determinant of sunlight interception, and hence biomass production, canopy manipulations in horticulture are cited as examples of enhanced productivity (Section 12.4). In that case, light-dependent regulation of plant development assumes prominence because tree and vine canopies are shaped for both overall interception as well as maximum fruitfulness.

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