Differentiation of pathogenic species of *Candida* by their recovery characteristics following ultraviolet irradiation

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Each of seven pathogenic species of *Candida* exhibits a unique pattern of light and dark recovery responses to ultraviolet irradiation. *C. guilliermondii, C. parapsilosis* and *C. pseudotropicalis* photoreactivate whereas *C. albicans, C. krusei, C. stellatoidea* and *C. tropicalis* do not. Within each of these groups, individual species are distinguishable by whether or not they express differential dark recovery during postirradiation growth at 25°C or 37°C on oxidative vs fermentative carbon sources, on inorganic vs amino acid nitrogen sources or in the presence rather than absence of ergosterol. Equivalent recovery patterns are obtained for species of *Candida* and the ascosporogenous species which are their corresponding perfect forms. These observations indicate strongly that the post-irradiation recovery is a reliable, species-specific characteristic of yeasts.

**INTRODUCTION**

Cellular recovery from ultraviolet irradiation (UV) depends on the activities of light-dependent and light-independent metabolic processes for repair or circumvention of primary photochemical damage. Light-dependent recovery (i.e., photoreactivation) results from the splitting of UV-induced pyrimidine dimers in DNA by means of a specific light-activated enzyme (Setlow, Boling and Bol lum, 1965). Light-independent (dark) recovery is attributable principally to the actions of separate enzyme complexes for exising pyrimidine dimers from DNA or for repairing discontinuities in DNA strands resulting from post-UV replication of dimer-containing molecules (Howard-Flanders, 1973); in addition, certain, as yet poorly characterized, dark-recovery processes have been identified which appear to moderate UV damage to non-genetic cellular targets (Game and Cox, 1969; Sarachek and Pettriess, 1974).

Each of the systematically well-defined genera of yeasts have been found to consist solely or predominantly of either photoreactivable or non-photoreac-
tivable species (Saracheck and Ireland, 1970). Species belonging to the same genus or to closely related genera show comparable action spectra for photoreactivation whereas species of unrelated genera have dissimilar spectra (Saracheck and Bish, 1975). Moreover, differences in the magnitudes of the photoreactivable sectors of species of the genera *Hansenula* and *Pichia* (i.e., proportions of lethal UV-induced damage subject to photorepair) correlate well with the known phylogenetic relationships within and between the two genera (Saracheck and Ireland, 1971; 1973). Collectively, these observations imply that loss or retention of photoreactivability has been a significant feature of the evolutionary divergence of yeasts.

Although various kinds of modifications in postirradiation growth conditions have been reported to influence dark recovery by particular species of yeasts, little is known of the systematic occurrence of such effects among yeasts in general. Dark recovery of *Candida albicans* is enhanced by post-UV growth (1) in the presence of sterols or long chain fatty acids, (2) at 25°C rather than 37°C and (3) on minimal medium containing an inorganic nitrogen source rather than medium enriched with amino acids (Busbee and Sarachek, 1969; Sarachek and Higgins, 1972); recovery by irradiated *Saccharomyces* is promoted by growth on media containing oxidatively respired alcohols or organic acids rather than fermentable carbohydrates as carbon sources (Sarachek, 1958). Depression of recovery by elevated postirradiation growth temperatures has been found to be usual among a broad spectrum of both ascomycetous and basidiomycetous yeasts (Saracheck and Ireland, 1970). Our unpublished observations on species of *Hansenula* and *Pichia* have indicated that modifications of post-UV survival due to carbon, nitrogen or lipid nutrition are temperature-dependent and species-specific occurrences which, unlike photoreactivation, do not correlate with the known systematic relationships between species. The present report examines post-UV reactions to these nutritional conditions, to growth temperatures and to photoreactivating light of seven species of *Candida*, commonly associated with human disease, and certain ascosporogenous yeasts accepted as perfect stages of the *Candida* species. The genus *Candida* is an arbitrary, phylogenetically heterogenous grouping of yeasts consisting of asporogenous organisms which can form hyphae or pseudohyphae, have ascomycetous affinities and for which a perfect stage was unrecognized at the time of initial classification. The work was undertaken to determine whether profiles of post-UV recovery responses are sufficiently species-specific to be useful in (1) differentiating the pathogenic species of *Candida* and (2) identifying perfect forms of *Candida* among yeasts consigned to ascosporogenous genera.

**MATERIALS AND METHODS**

Test organisms were obtained from the American Type Culture Collection,