

the *Hypocreales* (Lindau, 1897). The most significant advance in circumscribing the *Hypocreales* was Luttrell's (1951) recognition of the distinctive *Nectria*-type centrum. This centrum type is characterized by apical paraphyses, developing from meristematic tissues in the upper part of the centrum, extending downwards to the base of the fruiting body, and dissolving at maturity. The *Nectria*-type centrum is correlated with other characteristics, the most conspicuous of which are generally light- to bright-colored, soft-textured, uniloculate, perithecial, rarely cleistothecial, ascomata, lack of interthecial elements at maturity, unitunicate asci, and phialidic anamorphs that have light- to bright-colored conidia, conidiophores, and cultures. In longitudinal sections of young ascomata the *Nectria*-type centrum is observed as apical paraphyses developing from an apical meristem. In mature *Nectria*-type ascomata, remnants of dissolving apical paraphyses may be evident in crush mounts but often the interthecial elements are lacking. The *Nectria*-type centrum development has been confirmed for numerous species in the *Hypocreales* including: *Bionectria ochroleuca* (as *Nectria gliocladioides*, Hanlin, 1961) and *Hydropisphaera peziza* (as *Neuronectria peziza*, Hanlin, 1963a) in the *Bionectriaceae*; *Hypocrea avellanea*, *H. citrina*, and *H. spinulosa* (Canham, 1969; Carey & Rogerson, 1977; Doguet, 1957), *Hypomyces aurantius*, *H. lactifluorum*, *H. polyporinus*, and *H. trichothecoides* (Carey & Rogerson, 1981; Hanlin, 1963b, 1964; Samuels, 1973c), and *Sarawakus lycogaloides* (Rifai, 1969b) in the *Hypocreaceae*; and *Cosmospora episphaeria* (as *Nectria episphaeria*, Strikmann, 1961), *Gibberella pulicaris* (Parguey-Leduc, 1964), *Nectria aurantiicola* (as *Sphaerostilbe aurantiicola*), and *N. austroamericana* (as *Thyronectria austroamericana*, Luttrell, 1944; Seeler, 1940), and *Neocosmospora vasinfecta* (Doguet, 1956) in the *Nectriaceae*.

The three families of hypocrealean fungi considered here, namely the *Bionectriaceae*, *Hypocreaceae*, and *Nectriaceae*, correspond to the three major phylogenetic clades revealed by Rehner & Samuels (1994, 1995) based on analyses of 28S rDNA gene sequences, and Ogawa *et al.* (1997) based on analyses of both 18S and 28S rDNA gene sequences. These major clades also correlate with morphological characteristics of both the sexual and asexual states. The clade referred to as the *Hypocrea* clade is herein regarded as the *Hypocreaceae*, and includes *Hypocrea*, *Hypomyces*, and related genera. Another clade referred to as the *Bionectria* clade is herein regarded as the *Bionectriaceae* and includes most of the nectrioid genera that have pallid, KOH-, superficial or immersed ascomata and non-, one- or multiseptate, non-apiculate, non-disarticulating ascospores. The third clade or *Nectria* clade encom-

passes the *Nectriaceae* and includes primarily genera having red to dark purple, KOH+ ascomata and non-, one-, multiseptate or muriform, non-apiculate, non-disarticulating ascospores.

One of the two remaining families in the *Hypocreales* is the *Niessliaceae* or black hypocrealean fungi. This family consists of genera that have small, soft-textured, brown to black ascomata and phialidic anamorphs. The dark pigments in the peridium neither change color nor diffuse in KOH or lactic acid, thus differentiating the *Niessliaceae* from members of the *Bionectriaceae* and *Nectriaceae* having brown ascomata. Although none of the members of the *Niessliaceae* have been critically studied to determine their centrum development, the structure of immature and mature ascomata indicates a *Nectria*-type centrum. The phialidic anamorphs of members of the *Niessliaceae* suggest hypocrealean affinities for these fungi as discussed by Samuels & Barr (1998). The other family, the *Clavicipitaceae*, recognized as the order *Clavicipitales* by Rogerson (1970) and others, has historically been placed near the *Hypocreales* based on the light- to bright-colored ascomata and unitunicate asci. Recent molecular data suggest that the *Clavicipitales* represent one or more lineages sharing a close common ancestor with or derived from the *Hypocreales* and should be recognized as a family within the *Hypocreales* (Gams *et al.*, 1998b; Glenn *et al.*, 1996; Spatafora & Blackwell, 1993, 1994). A fundamental incongruence exists between the molecular data and morphological studies concerning the type of centrum development of the *Clavicipitales* and *Hypocreales* as discussed by Rossman (1996). In the *Clavicipitaceae* ( $\equiv$  *Clavicipitales*) asci develop from a pseudoparenchymatous basal pad (White, 1997), while in the *Hypocreales* exclusive of the *Clavicipitaceae* asci develop from a broad region of ascogenous hyphae lining the centrum. Ascumatal wall structure and texture, ascal and ascospore characteristics, and habitat preferences all suggest that the *Clavicipitaceae* are distinct from other families in the *Hypocreales*. Definitive studies of clavicipitalean fungi are needed to reconcile the differences between the *Nectria*-type centrum development characteristic of the *Hypocreales* and that occurring in the clavicipitalean lineage.

## Excluded Genera

A number of genera initially placed in the *Hypocreales* because of their bright-colored, soft-textured ascomata have been previously or are herein removed from the order (Gams & Müller, 1980; Palm *et al.*, 1996; Rossman, 1987; Samuels & Hallett, 1983; Samuels & Ross-

man, 1992; Samuels *et al.*, 1993). Such misplaced genera are accounted for in the section on excluded genera. The genera excluded from the *Bionectriaceae*, *Hypocreaceae*, and *Nectriaceae* in this study are placed among 19 families in 12 orders of ascomycetes as well as one basidiomycetous genus, *Mycaureola* (Porter & Farnham, 1986). Two genera are uniloculate, discomycetous loculoascomycetes (Rossman, 1987), while a number of excluded genera have true apothecia and belong in the *Helotiales* and *Pezizales* or are lichenized fungi and placed in the *Lecanorales*. Many pyrenomycetes confused with hypocrealean fungi are herein placed in the *Diaporthales* and *Xylariales*, often in the *Hyponectriaceae* and *Thyridiaceae*. Genera for

which ordinal placement is most difficult are those having immersed ascomata. The immersed habit often results in a simplification of ascomatal morphology, thus careful observations must be made of centrum characteristics. Immersed non-hypocrealean genera include: *Charonectria* and *Hyponectria*, differentiated from the *Hypocreales* by the presence of apically free paraphyses, now placed in the *Hyponectriaceae*, *Xylariales*; and *Cryptoleptosphaeria*, *Cryptonectriella* and *Schizoparme* also having apically free paraphyses and asci with a conspicuous ascal ring, now placed in the *Diaporthales*. Several genera are placed in the *Niessliaceae* and *Clavicipitaceae* of the *Hypocreales*.