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A RE-EVALUATION OF THE EUROTIALES

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The Ascomycota classified in the Eurotiales, Gymnoascales, and Onygenales are considered to belong to a single order Eurotiales, which includes 4 families, based on the shape, size, and symmetry of the ascospores. The Eurotiaceae and Gymnoascaceae have dorsiventrally flattened ascospores, the Onygenaceae have elongated ascospores, and those of the Amauroascaceae are spherical or nearly so. Spherical or obovate-saccate, thin-walled, unitunicate asci, aseptate, hyaline, or pale ascospores without germ pores, and the absence of ostiolate or discoid ascomata are characteristic of all Eurotiales (and the Erysiphales and Dipodascaceae). Anamorphs are often predominant; the conidia develop from meristematic hyphae, are often catenate and separate from each other or from the supporting hypha by two septa, usually with disjunctives. Terms such as phialide, separating cell, schizolytic, or rhexolytic are considered to be misleading and superfluous.

In a synopsis of the orders and families of Plectomycetes, Benny & Kimbrough (1980) accepted 6 orders, the Elaphomycetales, Onygenales, Eurotiales, Ascosphaerales, Microascales, and Ophiostomatales, which were separated from each other mainly by the structure of the centre of the ascomata (the arrangement of the asci within the cavity). All orders exclusively contain species with spherical or ovate, evanescent asci, and aseptate ascospores. The size, shape, symmetry, and pigmentation of the ascospores was neglected. The Erysiphales, which are also characterized by non-ostiolate ascomata, spherical or obovate asci, and aseptate ascospores, were excluded. The Eurotiales and Onygenales (incl. Gymnoascales) are characterized by spherical asci borne throughout the ascomatal cavity and are distinguished from each other mainly by the structure of the ascomatal wall and by the anamorphs, which are described as phialo-conidial for the first order and for the second order as arthro- or aleurio-conidial.

Von Arx (1971, 1974, 1977b) paid particular attention to the size and shape of the ascospores when he delimited the genera of the Gymnoascaceae. Three groups of genera were distinguished, one with dorsiventrally flattened, another with elongate, and a third with spherical or nearly spherical, often reticulate ascospores. Von Arx & van der Walt (1986) showed that the conidiogenesis of species of both Eurotiales and Onygenales (Gymnoascales) is similar: the conidia develop in basipetal sequence or at random from meristematic (or conidiogenous) hyphae by the formation of two usually adjacent septa. Occasionally an empty part of the conidiogenous hypha is present between the two

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septa. This is often described as a separating cell, even though contents and cell walls are lacking. The conidia are arranged in 'true', dry chains and separate by disjunctive structures (disjunctors) and by rupture or lysis of the hyphal wall. The seccession is termed 'schizolytic', when the two septa are adjacent. It is often considered to be a single, splitting septum. TEM micrographs, however, show, that the septa never have a central pore, but are often thickened and include disjunctives at an early state (von Arx & van der Walt, 1986). The seccession is termed 'rhexolytic', when the two septa are separated by shorter or longer, empty parts of the conidiogenous hypha. Both 'schizolytic' and 'rhexolytic' seccession have been observed within a single conidiogenous hypha, e.g. in the anamorphs of *Byssoascus stratisporus* (Barron & Booth) v. Arx and *Xylogone sphaerospora* v. Arx & Nilsson, in several species classified in the genera *Chrysosporium, Coremiella*, and *Oidiodendron*, in *Malbranchea arcuata* Sigler & Carmichael and in *Hormographis ramirezii* Guarro & al. (Martinez & al., 1986; Guarro & al., 1986). In species of *Aspergillus, Paecilomyces*, and their relatives, it is difficult to determine the 'rhexolytic' or 'schizolytic' nature of the conidial seccession, because the narrow septa become swollen.

It also may be noted that unthickened hyphal septa with central pores have never been observed to split. A true 'schizolytic' seccession apparently does not occur within the Eurotiales.

The 'phialide' in *Aspergillus, Paecilomyces*, and related genera in fact forms a meristematic filament, in which 'arthroconidia' are delimited in basipetal sequence by the formation of double septa with disjunctives. The ampulliform cells of *Aspergillus* or the subuloid cells of *Paecilomyces* therefore should not be compared with the 'phialides' of *Trichoderma, Gliocladium, Verticillium*, or *Fusarium*. Species of these genera form conidia at or in the apex of the conidiogenous cells by budding in basipetal or sympodial sequence. The conidia are usually mucoid and never have disjunctives. Species of *Chalara* form conidia inside a tube-like cell from a basal meristematic zone by the formation of endogenous, cylindrical cells.

The heterogeneity (diversity) of the structures called 'phialides' has been recognized by Subramanian (1979) and by Minter & al. (1983). These authors compared also the 'true' chains of conidia in *Aspergillus* and other members of the Eurotiales with the catenate conidia of *Oidium* (Erysiphales), *Geotrichum candidum* (Endomycetales), and *Oidiodendron*, which are formed from meristematic hyphae and also separate by disjunctives.

Both the Onygenales and Eurotiales sensu Benny & Kimbrough (1980) include genera characterized either by elongated (ellipsoidal, fusiform, or cylindrical), spherical, or dorsiventrally flattened (bivalvate, Saturn-shaped, discoid, or lenticular) ascospores. Von Arx & van der Walt (1986) therefore suggested that the Eurotiales and Onygenales should not be separated. They considered the Eurotiales (incl. Onygenales) to be related to the Endomycetales (the ascomycetous yeasts), and to the Erysiphales (powdery mildews). The latter also have non-ostiolate ascomata, spherical or obovate asci, aseptate ascospores and also form aseptate conidia from meristematic hyphae.

Currah (1985) restricted the Onygenales to Ascomycetes with 'rhexolytic' separation of the conidia. He distinguished four families, the Onygenaceae, Gymnoascaceae, Myxo-

trichaceae, and Arthrodermataceae, of which the two last mentioned are new. Currah placed relatively little emphasis on characters such as symmetry and pigmentation of ascospores, and the structure of the ascomatal initials and asci.

In the following treatment, the subdivision of the Eurotiales is based mainly on the shape and structure of the ascospores. All Eurotiales with ellipsoidal, fusiform or cylindrical ascospores are classified in the Onygenaceae. The Eurotiaceae are characterized by equally bivalvate, often Saturn-shaped and ornamented ascospores and by ascomata with a well-developed peridium. They include taxa with *Aspergillus* or *Penicillium* anamorphs and some taxa without known anamorphs. The Gymnoascaceae are characterized by discoid, lenticular, or unequally bivalvate, smooth ascospores. The family Amauroascaceae is erected for taxa with spherical, occasionally ovate-oblate (apparently bilaterally flattened) ascospores with an ornamented, often reticulate or pitted wall. Dorsiventrally flattened, aseptate ascospores occur only in Eurotiales and Endomycetales. Both are considered to have common ancestors, because such peculiar ascospores are likely to have evolved only once. Some members of the Pezizales may have the same ancestors, from which the Erysiphales also evolved (Müller & von Arx, 1962; von Arx & van der Walt, 1986). Some members of the Onygenaceae have also been linked with the Dipodascaceae by Redhead & Malloch (1977): they classified *Dipodascus geotrichum* (Butler & Peterson) v. Arx in a separate genus *Galactomyces* of the Onygenaceae. In its *Geotrichum* anamorph, the catenate conidia separate by double septa with several disjunctives. Hyphal Endomycetales do not form hyphae with simple, centrally perforated septa, but all septa are double and have one or several disjunctives, which in the past have been considered to be micropores, plasmodesmata, or closure lines of the septum. Hyphae are separated sooner or later into single cells in nearly all Endomycetales.

KEY TO THE FAMILIES OF THE EUROTIALES

1 a. Ascospores dorsiventrally flattened, not reticulate or pitted 2
b. Ascospores spherical, ellipsoidal, fusiform or cylindrical, occasionally oblate-ovate or flattened, then reticulate or pitted 3
2 a. Ascospores Saturn-shaped or equally bivalvate, often ornamented; ascomata usually with a distinct peridium . . . . . Eurotiaceae
b. Ascospores discoid, lenticular or unequally bivalvate, mostly smooth; ascomata without a wall of flattened cells . . . . . Gymnoascaceae
3 a. Ascospores usually ellipsoidal, fusiform or cylindrical, often spinulose, striate or punctulate (pitted) . . . . . Onygenaceae
b. Ascospores usually spherical or nearly so, occasionally ovate-oblate or bilaterally flattened, then with a pitted or reticulate-alveolate wall . . . . . Amauroascaceae

Eurotiaceae Clem. & Shear, 1931

Ascomata superficial, often embedded in aerial mycelium or immersed in a stroma or a sclerotium-like body, occasionally reduced to clusters of asci; asci irregularly disposed, spherical or obovoid, often catenate, rarely formed from croziers; ascospores dorsiven-

trally flattened, mostly bivalvate or Saturn-shaped, often with equatorial frills and spinulose, aseptate, hyaline, or pale.

Anamorphs: *Aspergillus, Penicillium, Polypaecilum*, or absent.

KEY TO THE GENERA

1 a. Anamorphs absent, ascospores spiny or with crests 2
b. Anamorphs present 3
2 a. Asci formed singly or in naked clusters from conjugating hyphal tips or croziers . . *Mallochia*
b. Ascomata with a wall of flattened cells present . . . . . *Cristaspora*
3 a. Anamorph *Penicillium*; ascomata usually immersed in a sclerotium-like stroma, slowly maturing . . . . . *Eupenicillium*
b. Anamorph *Aspergillus* or *Polypaecilum* 4
4 a. Anamorph *Polypaecilum*: conidiogenous cells apically branched; ascomata white; asci catenate . . . . . *Dichotomomyces*
b. Above characters not combined, anamorph *Aspergillus* 5
5 a. Ascomata surrounded by thick-walled 'Hülle cells' 6
b. 'Hülle cells' absent 7
6 a. Ascomata purplish; ascospores red or blue-violet . . . . . *Emericella*
b. Ascomata greenish or yellow; ascospores pale . . . . . *Fennellia*
7 a. Ascomata with a thin wall composed of a single layer of flattened cells, occasionally without wall when old; conidia 4–10 µm long . . . . . *Eurotium*
b. Ascomata with a thicker, often tomentose wall or immersed in a stroma 8
8 a. Ascomata discrete, with a wall composed of small cells or hyphae 9
b. Ascomata immersed in a crustose or spherical-pulvinate stroma 10
9 a. Conidia spherical, small . . . . . *Neosartorya*
b. Conidia clavate or obovoid . . . . . *Chaetosartorya*
10 a. Ascomata immersed in a crustose stroma . . . . . *Dichlaena*
b. Ascomata immersed in a spherical-pulvinate stroma 11
11 a. Conidia spherical, spiny, small . . . . . *Saitoa*
b. Conidia clavate or obovoid . . . . . *Hemicarpenteles*

Eurotium Link in Mag. Ges. naturf. Fr. Berl. 3: 31. 1809. — Type species: *E. herbariorum* (Pers.) Link. — Synonyms: *Edyuillia* Subram., *Gymnoeurotium* Malloch & Cain.

Anamorphs: *Aspergillus glaucus* group sensu Raper & Fennell (1965).

Eurotium was treated by Raper & Fennell (1965, as *Aspergillus*), Blaser (1976), and Pitt (1985). About twenty species have been accepted, but their delimitation is not satisfactory. *Eurotium athecium* (Raper & Fennell) v. Arx has been classified in the separate genera *Edyuillia* and *Gymnoeurotium*, because the ascomata are considered to have no peridium. A delicate, but distinct peridium of flattened cells was observed in young ascomata, when a subculture of the type was studied in 1970 in cooperation with Miss A.C. Stolk.

Emericella Berk. & Br. apud Berk., Introd. crypt. Bot.: 340. 1857. — Type species: *E. variecolor* Berk. & Br. — Synonyms: *Diplostephanus* Langeron, *Inzengaea* Borzi.

Anamorph: *Aspergillus nidulans* and its relatives.

About 25 species have been delimited by the ornamentation of the ascospores (Raper & Fennell, 1965; Samson & Mouchacca, 1974; Udagawa & Horie, 1976; Christensen &

Raper, 1978). Horie (1980) published beautiful SEM micrographs of the ascospores of all accepted species.

Fennellia Wiley & Simmons in Mycologia 65: 936. 1973. — Type species: *F. flavipes* Wiley & Simmons, the teleomorph of *Aspergillus flavipes* (Bainier & Sartory) Thom & Church.

Second species: *F. nivea* (Wiley & Simmons) Samson, the teleomorph of *Aspergillus niveus* Blochwitz (Samson, 1979).

Neosartorya Malloch & Cain in Can. J. Bot. 50: 2620. 1972. — Type species: *N. fischeri* (Wehmer) Malloch & Cain. — Synonyms: *Hemisartorya* Rai & Chowdhery, *Sartorya* auct.

Raper & Fennell (1965) treated seven species under the name *Aspergillus*. In all species the ascomata have a white or pale wall composed of filaments.

Chaetosartorya Subram. in Curr. Sci. 41: 761. 1972. — Type species: *C. chrysellus* (Kwon & Fennell) Subram., based on *Aspergillus chrysellus* Kwon & Fennell. — Synonym: *Harpezomyces* Malloch & Cain.

Second species: *C. cremea* (Kwon & Fennell) Subram., based on *Aspergillus cremeus* Kwon & Fennell (Raper & Fennell, 1965).

Hemicarpenteles Sarbhoy & Elphick in Trans. Br. mycol. Soc. 51: 156. 1968. — Type species: *H. paradoxus* Sarbhoy & Elphick (= *Aspergillus acanthosporus* Udagawa & Takada). — Synonym: *Sclerocleista* Subram.

Further species: *H. ornata* (Raper & al.) v. Arx, based on *Aspergillus ornatus* Raper & al.; *H. thaxteri* (Subram.) v. Arx (= *Sclerocleista thaxteri* Subram.).

Anamorph: *Aspergillus citrisporus* Höhnel (von Arx, 1974).

Saitoa Rajendran & Muthappa in Proc. Indian Acad. Sci., Plant Sci. 89: 185. 1980. — Type species: *S. japonica* Rajendran & Muthappa, the teleomorph of an *Aspergillus*, similar to *A. japonicus* (*Aspergillus niger* group).

The apical swelling of the conidiophore is covered with ampulliform cells, forming meristematic hyphae which are converted into chains of echinulate conidia.

Dichlaena Dur. & Mont., Fl. Alg.: 405. 1849. — Type species: *D. lentisci* Dur. & Mont.

Dichlaena lentisci was redescribed by Malloch & Cain (1972). They introduced a new genus *Petromyces* for a similar ascomycete described as *Aspergillus alliaceus* Thom & Church (Raper & Fennell, 1965). No ascomata could be found on subcultures of the type. The name *Syncleistostroma* Subram. was introduced for the same species.

Eupenicillium Ludwig, Lehrb. nied. Kryptog.: 263. 1882. — Type species: *E. crustaceum* Ludwig. — Synonym: *Carpenteles* Langeron.

Anamorph: *Penicillium*.

Eupenicillium was monographed by Stolk & Samson (1983). They accepted twenty species and some varieties and added several 'related' *Penicillium* species forming stromatic bodies (sclerotia).

Dichotomomyces Saito ex Scott in Trans. Br. mycol. Soc. 55: 314. 1970. — Type species: *D. cejpii* (Milko) Scott.

Anamorph: *Polypaecilum insolitum* G. Smith (conidiogenous cells apically branched, forming aseptate, smooth, hyaline conidia in a basipetal sequence from meristematic branches).

Cristaspora Fort & Guarro in Mycologia 76: 1115. 1984. — Type species: *C. arxii* Fort & Guarro.

The fungus is known from a single strain. No anamorph is present.

Mallochia v. Arx & Samson in Persoonia 13: 185. 1986. — Type species: *M. echinulata* (Dutta & Ghosh) v. Arx & Samson.

The genus is based on *Pseudoarachniotus echinulatus* Dutta & Ghosh. Ascomata are absent; the asci develop in clusters in the aerial mycelium from croziers or from conjugating hyphal tips. No anamorph is present.

Gymnoascaceae Baranetzky, 1872 (incl. Arthrodermataceae Currah, 1985)

Ascomata superficial, with a peridium composed of a net-work of hyphae or absent, often with appendages (setae); asci spherical or obovate, not catenate, usually clustered and irregularly disposed, 8-spored; ascospores dorsiventrally flattened, lenticular, discoid, or unequally bivalvate, aseptate, hyaline, yellow or reddish brown, usually smooth, but often with equatorial thickenings or furrows, never reticulate, alveolate, or pitted.

Anamorphs: *Chrysosporium, Trichophyton, Microsporon, Malbranchea*, or absent.

KEY TO THE GENERA

1 a. Ascospores hyaline or pale yellowish, bivalvate or discoid 2
b. Ascospores pigmented, lenticular or discoid 7
2 a. Ascomata without peridium and without appendages, often stipitate or sporodochial and larger than 0.3 mm; not keratinolytic . . . . . *Narasimhella*
b. Ascomata with a peridium or with appendages, often keratinolytic 3
3 a. Ascomatal appendages comb-like, pigmented . . . . . *Ctenomyces*
b. Comb-like appendages absent 4
4 a. Ascomatal appendages spirally coiled, pale 5
b. Ascomata often tomentose, without coiled appendages 6
5 a. Anamorph *Microsporum* (conidia fusiform, septate) . . . . . *Nannizzia*
b. Anamorph *Trichophyton* or *Chrysosporium* (conidia cylindric-clavate, septate or aseptate) *Arthroderma*

6 a. Ascospores bivalvate-lenticular, smooth; ascomata with a white peridium . . . . *Leucothecium*
b. Ascospores discoid, finely punctulate; ascomata with a pale brown peridium of flattened cells, embedded in the aerial mycelium . . . . . *Xynophila*
7 a. Ascomata with long and thick, apically circinate appendages; keratinolytic . . . *Uncinocarpus*
b. Ascomata without such appendages, without peridium or with a peridium of often stiff hyphae with short or no appendages; usually not keratinolytic . . . . . *Gymnoascus*

Gymnoascus Baranetzky in Bot. Ztg 30: 158. 1872. — Type species: *G. reessii* Baranetzky. — Synonyms: *Gymnascella* Peck, *Arachniotus* J. Schröt., *Petalosporus* Ghosh & al., *Pseudoarachniotus* Kuehn, *Waldemaria* Batista & al., *Plunkettomyces* Orr, *Gymnoascoides* Orr, *Disarticulatus* Orr, *Acitheca* Currah.

The genus was revised by von Arx (1986b). It includes fourteen species, all with ascomatal structures embedded in the aerial mycelium, sessile, spherical asci and lenticular or discoid, pigmented ascospores. Only a few species include unnamed anamorphs.

Uncinocarpus Sigler & Orr in Mycotaxon 4: 461. 1976. — Type species: *U. reesii* Sigler & Orr.

Anamorph: *Malbranchea*.

Second species: *U. uncinatus* (Eidam) Currah (syn. *Gymnoascus uncinatus* Eidam).

Both species are keratinolytic. In culture on agar media, *U. reesii* shows a poor growth and develops only the *Malbranchea* anamorph. Ascomata may be observed from hairs mixed with soil grown in moist chambers. The fungus is common in soil and is responsible for the degradation of keratinous material. *Uncinocarpus uncinatus* has been illustrated by Benjamin (1956) under the name *Myxotrichum uncinatum* (Eidam) J. Schröt.

Ctenomyces Eidam in Cohn in Beitr. Biol. Pfl. 3: 274. 1880. — Type species: *C. serratus* Eidam.

Ctenomyces serratus occurs on feathers of birds, occasionally on hairs and is often isolated from soil. It includes an anamorph described as *Chrysosporium serratum* Dominik. The ascospores are unequally bivalvate and remain hyaline.

Leucothecium v. Arx & Samson in Persoonia 7: 378. 1973. — Type species: *L. emdenii* v. Arx & Samson.

The genus is monotypic and is known from a single strain. It forms hyaline arthroconidia which are separated by adjacent septa with disjunctives.

Arthroderma Berk., Outl. Brit. Fungol.: 357. 1860. — Type species: *A. curreyi* Berk.

Anamorphs: *Trichophyton, Chrysosporium.*

Arthroderma has been monographed by Padhye & Carmichael (1971). They accepted thirteen species, all keratinolytic and often causing dermatomycoses.

Nannizzia Stockdale in Sabouraudia 1: 45. 1961. — Type species: *N. gypsea* (Nannizzia) Stockdale.

Nannizzia is closely related to *Arthroderma* and can be distinguished mainly by the *Microsporum* anamorph with large, fusiform, ornamented and multi-septate conidia. The conidia of *Arthroderma* species are cylindric-clavate, either aseptate or with several transverse septa. Eleven species have been described, some of which are morphologically similar. All species are keratinolytic and cause dermatomycoses. Weitzman & al. (1986) synonymized *Nannizzia* with *Arthroderma.*

Narasimhella Thirumalachar & Mathur in Sydowia 19: 184. 1966. — Type species: *N. poonensis* Thirumalachar & Mathur.

Three species will have to be accepted, all of which are closely related, and some intermediates exist. *Narasimhella poonensis* has ascospores with a distinct equatorial brim, and those of *N. marginospora* (Kuehn & Orr) v. Arx have a narrow, indistinct brim. The ascospores of *N. hyalinospora* (Kuehn & al.) v. Arx have no visible brim. In all species the ascospores are unequally bivalvate and hyaline (von Arx, 1986a). Stalked, synnema-like ascomatal structures have been observed in *N. poonensis* and some strains of *N. hyalinospora*. The colonies of *N. marginospora* are usually green. All species are coprophilous or soil-borne and *N. hyalinospora* is rather common.

Xynophila Malloch & Cain in Can. J. Bot. 49: 845. 1971. — Type species: *X. mephitialis* Malloch & Cain.

The genus is monotypic. *Aphanoascus canadensis* Currah is apparently identical with *X. mephitialis* (J. Guarro, pers. comm.). *Xynophila* shows affinities to the Amauroascaceae. It is tentatively classified in the Gymnoascaceae, because the ascospores are distinctly discoid and their wall is not reticulate.

Onygenaceae Fr., 1849

Synonyms: Monascaceae J. Schröt., 1894; Trichocomaceae Fischer, 1897; Cephalothecaceae Höhnel, 1917; Eremascaceae Zender, 1923; Thermoascaceae Apinis, 1967; Myxotrichaceae Currah, 1985.

Ascomata or ascogenous structures superficial, embedded in the aerial mycelium, occasionally large, pulvinate, spherical, or stipitate, with or without peridium; asci spherical or obovate, often with a cylindrical base, usually not catenate (except in *Talaromyces*); ascospores elongate, ellipsoidal, cylindrical, or fusiform, occasionally nearly spherical, often rather thick-walled, smooth, striate, furrowed, punctulate, or spinulose, hyaline or pale brown.

Anamorphs: *Paecilomyces* (incl. *Penicillium* sect. *Biverticillata* and sect. *Sagenomella*), *Raperia, Coremiella, Oidiodendron, Geomyces, Basipetospora*, or absent.

KEY TO THE GENERA

1 a. Ascomata 1–5 mm, sometimes larger, stromatic, stipitate or columnar 2
b. Ascomata smaller or absent 5

2a. Ascomata clustered at the apex of short stalks; ascospores with longitudinal flanges; growing on seeds of tropical plants . . . . . *Penicilliopsis*
b. Above characters not combined 3
3a. Ascomata brush-like, columnar, with a discoid base . . . . . *Trichocoma*
b. Ascomata not brush-like 4
4a. Ascomata head-like, with a distinct stipe . . . . . *Onygena*
b. Ascomata tuberous, pulvinate, or spherical, sessile . . . . . *Ascocalvatia*
5a. Thermophilic; ascomata pulvinate or crustose, reddish . . . . . *Thermoascus*
b. Not thermophilic, occasionally thermotolerant; ascomata not crustose 6
6a. Ascomata spherical, 300–500 µm, with a tomentose wall with sutures (cephalothecoid) *Cephalotheca*
b. Above characters not combined 7
7a. Ascomata covered with seta-like, often circinate or branched appendages; ascospores often finely striate due to numerous longitudinal crests . . . . . *Myxotrichum*
b. Ascomatal appendages absent, or not seta-like when present 8
8a. Asci catenate; ascomata usually spherical and with a wall of pale hyphae . . . . . *Talaromyces*
b. Asci not catenate 9
9a. Ascomata with a peridium composed of a network of stiff hyphae; ascospores smooth or with longitudinal crests . . . . . *Pseudogymnoascus*
b. Ascomata without such a peridium 10
10a. Osmophilic; ascomata absent; asci formed from two conjugating hyphal tips . . . . *Eremascus*
b. Asci not formed from two conjugating hyphal tips 11
11a. Ascospores fusiform, with longitudinal furrows (stellate in transverse section); colonies green due to the anamorph forming branched chains of conidia . . . . . *Byssoascus*
b. Above characters not combined 12
12a. Asci obovate or clavate, clustered; anamorph absent . . . . . *Monascella*
b. Asci spherical or obovate; anamorphs usually present 13
13a. Asci obovate or obpyriform, borne from croziers; conidiophores coarse, apically inflated *Hamigera*
b. Asci spherical or obovate 14
14a. Ascomata small, with a distinct peridium when young . . . . . *Monascus*
b. Ascomata without a distinct peridium or absent 15
15a. Conidia relatively small, elongate, smooth, with disjunctives . . . . . *Byssochlamys*
b. Conidia spherical, spiny, relatively large . . . . . *Renispora*

Onygena Pers., Syn. Fung.: 203. 1801. — Type species: *O. equina* (Willd.) Pers. Second species: *O. corvina* Alb. & Schw.

Onygena equina occurs on hooves, horn, and similar substrates. Its ascospores are broadly elliptical, smooth, pale brown and measure 7–9 × 4–6 µm. *Onygena corvina* has been collected on pellets of carnivores, feathers, wool (old socks), and similar substrates. Its ascospores are cylindrical, often curved and measure 6–8 × 2.5–3.5 µm. Both species form white colonies and arthroconidia with disjunctors in culture.

Ascocalvatia Malloch & Cain in Can. J. Bot. 49: 840. 1971. — Type species: *A. dura* (Zukal) v. Arx (*A. alveolata* Malloch & Cain).

The description of *A. alveolata* agrees with that of *Gymnoascus durus* Zukal (von Arx, 1986b).

Cephalotheca Fuckel in Jb. nassau. Ver. Naturk. 25–26: 297. 1871. — Type species: *C. sulphurea* Fuckel.

Anamorph: *Paecilomyces* (similar to *P. marquandii* (Massee) Hughes).

Several further species have been included in the genus, but are excluded by Malloch & Cain (1970b) (see also Chesters, 1934, Booth, 1961).

Hamigera Stolk & Samson in Persoonia 6: 342. 1971. — Type species: *H. avellanea* (Thom & Turesson) Stolk & Samson. — Synonyms: *Warcupiella* Subram., *Sporophormus* Malloch & Cain.

Anamorph: *Raperia* (von Arx, 1986a).

Hamigera avellanea is the teleomorph of *Raperia ingelheimense* (v. Beyma) v. Arx. *Hamigera spinulosa* (Warcup) v. Arx is based on *Aspergillus spinulosus*; its anamorph has been described as *Raperia spinulosa* Subram. & Rajendran (von Arx, 1986a).

Byssochlamys Westling in Svensk bot. Tidskr. 3: 134. 1909. — Type species: *B. nivea* Westling.

Anamorph: *Paecilomyces*.

Further species: *B. fulva* Olliver & Smith, *B. verrucosa* Samson & Tansey, *B. zollerniae* Ram, *B. striata* (Raper & Fennell) v. Arx (*Talaromyces striatus, Penicillium striatum*).

Talaromyces C. R. Benjamin in Mycologia 47: 681. 1955. — Type species: *T. flavus* (Klöcker) Stolk & Samson. — Synonym: *Sagenoma* Stolk & Orr.

Anamorph: *Paecilomyces* (incl. *Penicillium* sect. *Biverticillata, Sagenomella*).

The genus includes about twenty species, treated by Stolk & Samson (1972) and Pitt (1979). The following species have to be added: **Talaromyces viride** (Stolk & Orr) v. Arx, *comb. nov.* (basionym: *Sagenoma viride* Stolk & Orr in Mycologia 66: 676. 1974), and **Talaromyces ryukyensis** (Ueda & Udagawa) v. Arx, *comb. nov.* (basionym: *Sagenoma ryukyensis* Ueda & Udagawa in Mycotaxon 20: 499. 1984). The anamorph of this species is a typical *Paecilomyces* with conidiophores and chains of fusiform conidia with distinct disjunctives.

Byssoascus v. Arx in Persoonia 6: 376. 1971. — Type species: *B. striatisporus* (Barron & Booth) v. Arx.

Anamorph: unnamed, *Coremiella* or *Oidiodendron* like, forming branched chains of arthroconidia with disjunctives. The ascospores are distinctly furrowed and have five longitudinal rims (Barron & Booth, 1966).

Pseudogymnoascus Raillo in Zentbl. Bakt. ParasitKde 2, 38: 520. 1929. — Type species: *P. roseus* Raillo.

Anamorph: *Geomyces* or absent.

Geomyces pannorum is the anamorph of *P. roseus* (Samson, 1972). Species without anamorphs are *P. bhattii* Samson and *P. alpinus* Müller & v. Arx (ascospores with two or three longitudinal rims).

Myxotrichum Kunze in Mykol. Hefte 2: 109. 1823. — Type species: *M. chartarum* Kunze. — Synonyms: *Actinospora* Corda, *Eidamella* Matr. & Dassonv., *Toxotrichum* Orr & Kuehn.

Anamorphs: unnamed, *Geomyces*- or *Malbranchea*-like.

Currah (1985) accepted nine species, all closely related.

Monascus v. Tiegh. in Bull. Soc. bot. Fr. 31: 266. 1884. — Type species: *M. ruber* v. Tiegh. — Synonyms: *Allescheria* Sacc. & Syd., *Backusia* Thirumalachar & al., *Xeromyces* Fraser.

Anamorph: *Basipetospora*.

Hawksworth & Pitt (1983) accepted three species, among which was *M. purpureus* Went, but excluded *M. bisporus* (Fraser) v. Arx (as *Xeromyces bisporus* Fraser), a highly osmophilic species on dried fruits, tobacco and other substrates.

Monascella Guarro & v. Arx in Mycologia 78: 869. 1986. — Type species: *M. botryosa* Guarro & v. Arx, isolated from soil in Spain, without anamorph.

Eremascus Eidam in Cohn in Beitr. Biol. Pfl. 3: 385. 1883. — Type species: *E. albus* Eidam.

Second species: *E. fertilis* Stoppel.

Both species are highly osmophilic. The genus is related to *Monascus*. *Xeromyces* would be an intermediate, if it were to be accepted as a separate genus.

Renispora Sigler & Carmichael in Mycotaxon 10: 133. 1979. — Type species: *R. flavissima* Sigler & al.

Anamorph: *Chrysosporium*.

Thermoascus Miehe, Die Selbsterhitzung des Heues: 70. 1907. — Type species: *T. aurantiacus* Miehe. — Synonym: *Dactylomyces* Sopp.

Anamorphs: *Paecilomyces, Polypaecilum*, or absent.

Further species: *T. crustaceus* (Apinis & Chesters) Stolk and *T. thermophilus* (Sopp) v. Arx.

Trichocoma Jungh., Praemissa Fl. Crypt. Javae Ins. 1: 9. 1838. — Type species: *T. paradoxa* Jungh.

The fungus has been redescribed by Boedijn (1935), Kominami & al. (1952) and Malloch & Cain (1972). It includes a *Paecilomyces*-like anamorph.

Penicilliopsis Solms-Laubach in Ann. Jard. Bot. Buitenz. 6: 53. 1887. — Type species: *P. clavariaeformis* Solms-Laubach.

Anamorph: *Sarophorum, Stilbodendron* (conidiogenesis as in *Paecilomyces* or *Raperia*).

Second species: *P. africana* Samson & Seifert.

The genus has been discussed by Samson & Seifert (1985). Its species occur on the large seeds of *Araucaria, Diospyros*, and other plants in tropical areas. The ellipsoidal ascospores are flanged, which is uncommon in the Onygenaceae.

Amauroascaceae v. Arx, *fam. nov.*

Ascomata superficialia, globosa, non-ostiolata, hyalina vel pigmentata; asci globosi vel obovati, sessiles, plerumque octospori, tenui tunicati, evanescentes; ascosporae globosae, subglobosae vel oblatae, non septatae, hyalinae vel pigmentatae, ornamentatae (alveolatae vel punctatae) vel glabrae. — Genus typica: *Amauroascus* J. Schröt.

The Amauroascaceae include Eurotiales with spherical or nearly spherical, occasionally bilaterally flattened (oblate) ascospores with a relatively thick, often reticulate, alveolate, pitted, spinulose, crested, or sheathed wall. The ascomata are usually spherical and small or medium-sized (up to 0.5 mm in diameter). Most species are keratinolytic.

Similar asci and ascospores occur in the Pezizales, especially in the Tuberaceae and Ascodesmidiaceae. Some members of the Pezizaceae are also characterized by spherical, alveolate-reticulate ascospores, but these are formed in cylindrical asci with an operculum.

Several genera of the Endomycetales (yeasts) include species with spherical, smooth or ornamented, usually hyaline and small ascospores.

Anamorphs: *Chrysosporium, Malbranchea, Histoplasma, Zymonema, Geotrichum*-like, often unnamed.

KEY TO THE GENERA

1 a. Ascomata bearing densely coiled, pale appendages 2
b. Ascomata without coiled appendages 5
2 a. Ascomata dark, with a wall of angular cells . . . . . *Pleuroascus*
b. Ascomata pale and without such a wall 3
3 a. Conidia of the anamorph spherical and warty . . . . . *Emmonsiella*
b. Conidia of the anamorph smooth 4
4 a. Ascospores smooth, parasitic on man . . . . . *Ajellomyces*
b. Ascospores punctulate or pitted, saprophytic . . . . . *Apinisia*
5 a. Ascospores hyaline 6
b. Ascospores pigmented 8
6 a. Ascomata white or pale, with a wall of hyphal filaments . . . . . *Arachnotheca*
b. Ascomata with a dark wall 7
7 a. Ascospores sheathed when young, becoming reticulate . . . . . *Leiothecium*
b. Ascospores smooth or nearly so . . . . . *Xylogone*
8 a. Ascomata with some long, apically circinate hairs; ascospores oblate, smooth, pale brown *Arachnomyces*
b. Above characters not combined 9
9 a. Ascomata covered with stiff, often branched appendages or setae; ascospores reticulate-alveolate . . . . . *Auxarthron*
b. Ascomata without such appendages 10

10 a. Ascomata with a hyphal wall or without a wall; anamorphs absent; ascospores spherical, reticulate-alveolate . . . . . *Amauroascus*
b. Ascomata with a wall of angular or flattened cells; ascospores spherical-ovate or oblate . . 11
11 a. Ascospores 5–8 µm, reticulate-alveolate or crested . . . . . *Aphanoascus*
b. Ascospores 2–3 µm, punctulate or pitted . . . . . *Xanthothecium*

Amauroascus J. Schröt. in Krypt. Fl. Schles. (ed. Cohn) 3(2): 211. 1893. — Type species: *A. niger* J. Schröt.

Further species: *A. mutatus* (Quél.) Rammeloo (*A. verrucosus*), *A. aureus* (Eidam) v. Arx, *A. kuehnii* v. Arx (*Arachniotus reticulatus* Kuehn), *A. volatilis-patellis* (Orr & Kuehn) Currah. *Amauroascus aureus* may be pathogenic on man.

Auxarthron Orr & Kuehn in Can. J. Bot. 41: 1439. 1953. — Type species: *A. californiense* Orr & Kuehn. — Synonym: *Macronodus* Orr (Currah, 1985).

Currah (1985) accepted seven species, which are distinguished mainly by the structure of the ascomatal hairs.

Aphanoascus Zukal in Ber. dt. bot. Ges. 8: 296. 1890. — Type species: *A. cinnabarinus* Zukal (*A. fulvescens* (Cooke) Apinis). — Synonyms: *Anixiopsis* Hansen, *Keratinophyton* Randhawa & Sandhu.

Anamorph: *Chrysosporium.*

Anixiopsis Hansen, with *Anixiopsis fulvescens* (Cooke) de Vries as type species, may be an alternative generic name. The identity of *Aphanoascus cinnabarinus* and *Anixiopsis stercoraria* Hansen has been questioned by de Vries (1969), because the type specimen of *Aphanoascus cinnabarinus* does not exist. A further species might be *Keratinophyton terreum* Randhawa & Sandhu. The taxon described by Currah (1985) under the incorrect name *Keratinophyton durum* (Zukal) Currah represents an undescribed species with oblate ascospores with a reticulate wall (von Arx, 1986b).

Arachnotheca v. Arx in Persoonia 6: 376. 1971. — Type species: *A. glomerata* (Müller & Pacha-Aue) v. Arx. — Synonyms: *Kuehniella* Orr, *Nanniziopsis* Currah.

Anamorphs: *Chrysosporium, Malbranchea.*

Further species: *A. albicans* (Apinis) v. Arx; *A. vriesii* (Apinis) Samson apud v. Arx (1981).

Pleuroascus Massee & Salmon in Ann. Bot. 15: 330. 1901. — Type species: *P. nicholsonii* Mass & Salm.

The fungus was redescribed by Malloch & Benny (1973). The genus is monotypic.

Apinisia LaTouche in Trans. Br. mycol. Soc. 51: 283. 1968. — Type species: *A. graminicola* LaTouche.

The fungus is known from a single specimen. It includes a *Chrysosporium*-like anamorph.

Emmonsiella Kwon-Chung in Science 177: 368. 1972. — Type species: *E. capsulata* Kwon-Chung.

Emmonsiella capsulata is the rare teleomorph of *Histoplasma capsulatum* Darling. McGinnis & Katz (1979) synonymized *Emmonsiella* with *Ajellomyces*. Both can be distinguished mainly by the much more common anamorphs.

Ajellomyces McDonough & Lewis in Mycologia 60: 77. 1968. — Type species: *A. dermatitidis* McDonough & Lewis.

Anamorph: *Zymonema dermatitidis* (Gilchrist & Stokes) Dodge.

Xylogone v. Arx & Nilsson in Svensk bot. Tidskr. 63: 345. 1969. — Type species: *X. sphaerospora* v. Arx & Nilsson.

Anamorph: unnamed, with septate, hyaline arthroconidia with disjunctives.

Xanthothecium v. Arx & Samson in Persoonia 7: 377. 1973. — Type species: *X. peruvianum* (Cain) v. Arx & Samson, without anamorph.

Leiothecium Samson & Mouchacca in Can. J. Bot. 53: 1634. 1975. — Type species: *L. ellipsoideum* Samson & Mouchacca.

Arachnomyces Massee & Salmon in Ann. Bot. 16: 68. 1902. — Type species: *A. nitidus* Mass. & Salm.

Further species: *A. minimus* Malloch & Cain, *A. sulphureus* Mass. & Salm. (Malloch & Cain, 1970a).

THE ANAMORPHS OF THE EUROTIALES

The anamorphs of the Eurotiales are similar to those of the Erysiphaceae and the Dipodascaceae and can be recognized by the formation of 'arthroconidia' or acrogenous 'aleurioconidia'. Catenate conidia develop in basipetal sequence or at random and are separated from each other by two septa. Disjunctives between the two septa are usually present, but are often not visible by light microscopy. Acrogenous conidia separate from the supporting cell by two septa, which are often not adjacent, but separated by empty parts of the conidiogenous hypha. The conidia usually separate by elongation or swelling of the disjunctives and by cleavage or lysis of the hyphal wall.

In the anamorphs of the Microascaceae, the conidia are often also arranged in basipetal chains, but the conidiogenous cells elongate percurrently and often show annellations. Disjunctives between the conidia are absent (form genera *Scopulariopsis, Cephalotrichum, Gliomastix*, and *Memnoniella*).

In the anamorphs of the Xylariaceae the conidia also separate from the supporting cell by two septa. After release frills are visible at the base of the conidia and on the conidiogenous cells. In contrast to the anamorphs of the Eurotiales, the conidia are formed singly and successively on numerous loci of the conidiogenous cell, which may

elongate sympodially (form genera *Dicyma* (incl. *Hansfordia*), *Nodulisporium*, *Geniculisporium*, and *Dematophora*).

In the existing systems of the Hyphomycetes, the above-discussed relations have never been recognized. Consequently the anamorphs of the Eurotiales have been classified in the most divergent groups or families, mainly in the Aleuriosporae, Arthrosporae, and Phialosporae (compare in this respect Hawksworth & al., 1983).

Only genera known to the author from personal studies are included in the following key. Some anamorph genera of Sphaeriales and other Ascomycota are included, especially genera which often have been confused with anamorphs of Eurotiales.

KEY TO THE GENERA OF ANAMORPHS

1 a. Conidia catenate 2
b. Conidia not catenate 25
2 a. Conidiogenous filaments develop from ampulliform or lanceoloid cells, conidia in basipetal chains 3
b. Ampulliform or lanceoloid cells absent 10
3 a. Colonies restricted, reddish; conidia short cylindrical; osmophilic . . . . . *Wallemia*
b. Above characters not combined 4
4 a. Conidiogenous cells ampulliform; conidia spherical or ovate 5
b. Conidiogenous cells usually lanceolate or cylindrical, or with a narrow and elongate neck; conidia cylindrical, fusiform, ellipsoidal, or occasionally nearly spherical 7
5 a. Conidiophores with an apical swelling . . . . . *Aspergillus*
b. Conidiophores without apical swelling 6
6 a. Conidiogenous cells in an apical whorl; conidia dark, verrucose . . . . . *Memnoniella*
b. Conidiophores penicillately branched or absent; conidia hyaline or pale . . . . . *Penicillium*
7 a. Conidia broadly fusiform and longer than 20 µm . . . . . *Phialomyces*
b. Conidia shorter 8
8 a. Conidiophores apically inflated and coarse . . . . . *Raperia*
b. Conidiophores apically not inflated, often verticillately or penicillately branched, occasionally simple or absent 9
9 a. Conidiophores erect, pigmented, verrucose . . . . . *Acrophialophora*
b. Conidiophores pale, simple, branched, or absent . . . . . *Paecilomyces*
10 a. Conidia formed in basipetal sequence, hyaline, smooth, spherical or ellipsoidal 11
b. Conidia usually formed at random in unbranched or branched chains, usually cylindrical or barrel-shaped, or becoming spherical-oblate 12
11 a. Conidiogenous cells apically inflated or forked, often with several conidiogenous loci *Polypaecilum*
b. Conidiogenous cells not inflated, not forked . . . . . *Basipetospora*
12 a. Colonies unpigmented, all hyphae disarticulating by double, adjacent septa . . . *Geotrichum*
b. Colonies pigmented or unpigmented, vegetative hyphae usually not disarticulating 13
13 a. Conidial chains much branched; conidia 0- to 5-septate, hyaline; parasitic on palms, causing rot . . . . . *Mauginiella*
b. Above characters not combined 14
14 a. Conidiogenous hyphae in whorls on long, erect conidiophores 15
b. Above characters not combined 17
15 a. Conidia barrel-shaped, separated from each other by empty parts of the hypha *Amblyosporium*
b. Conidia short cylindrical, separated from each other by disjunctives 16

16 a. Conidiophores and conidia hyaline, colonies pigmented . . . . . *Botryomonilia*
b. Conidiophores and conidia pigmented . . . . . *Staheliella*
17 a. Conidiogenous hyphae formed successively in sympodulae, conidia cylindrical, hyaline *Sympodiella*
b. Conidiogenous hyphae not in sympodulae 18
18 a. Conidiogenous hyphae much branched, forming orange, pustulate sporodochia; colonies much expanding . . . . . *Chrysonilia*
b. Conidia not in orange, pustulate sporodochia 19
19 a. Pigmented, erect conidiophores usually present 20
b. Pigmented, erect conidiophores absent 21
20 a. Conidia spherical-oblate, with a darker girdle . . . . . *Stephanosporium*
b. Conidia without such a girdle . . . . . *Oidiodendron*
21 a. Conidia short cylindrical, not or only slightly swollen 22
b. Conidia swollen or septate, with truncate ends or a truncate base 24
22 a. Conidiogenous hyphae and conidia 4–9 µm broad . . . . . *Sporendonema*
b. Conidiogenous hyphae and conidia 1.5–4 µm broad 23
23 a. Conidia usually separated from each other by empty parts of the hypha . . . . . *Malbranchea*
b. Conidia separated from each other by two adjacent septa, often with disjunctives. *Coremiella*
24 a. Conidia thick-walled or ornamented, in short chains, separated from each other by empty parts of the hypha 25
b. Conidia thin-walled, aseptate or septate, smooth, in often branched chains; usually separated from each other by adjacent septa 32
25 a. (from 1 and 24) At least some conidia large and many-septate 26
b. Conidia aseptate (occasionally 1-septate) 29
26 a. Macroconidia fusiform 27
b. Macroconidia cylindrical or clavate-obovate 28
27 a. Macroconidia broadly fusiform. ornamented; microconidia usually present . . *Microsporum*
b. Macroconidia narrowly fusiform and smooth; microconidia absent . . . . . *Keratinomyces*
28 a. Macroconidia clavate-obovate, microconidia absent . . . . . *Epidermophyton*
b. Macroconidia cylindrical or ellipsoidal, microconidia present, often predominant *Trichophyton*
29 a. Conidia spherical, relatively large (more than 10 µm) and warty; parasitic on man *Histoplasma*
b. Above characters not combined 30
30 a. Conidia spherical or nearly so, relatively large, smooth; parasitic on man . . . . . *Zymonema*
b. Above characters not combined, conidia when spherical smaller 31
31 a. Indistinct conidiophores often present, conidia mainly intercalary . . . . . *Geomyces*
b. Erect conidiophores absent, conidia intercalary and lateral . . . . . *Chrysosporium*
32 a. Conidia swollen, aseptate . . . . . *Arthrographis*
b. Conidia not or only slightly swollen, septate . . . . . *Hormographis*

Aspergillus Mich. ex Link in Mag. Ges. Naturf. Berlin 3: 16. 1809. — Type species: *A. glaucus* (Mich.) Link. — Synonyms: *Sterigmatomyces* Cramer, *Raedellia* Cif., *Cladosarum* Yuill.

About 150 species have been accepted by Raper & Fennell (1965) and Samson (1979). Many more are described.

Penicillium Link in Mag. Ges. Naturf. Berlin 3: 16. 1809. — Type species: *P. expansum* Link. — Synonyms: *Coremium* Link, *Citromyces* Wehmer, *Eladia* G. Smith, *Rhodocephalus* Corda, *Torulomyces* Delitsch.

About 150 species will have to be accepted, but many more are described. *Penicillium* sensu Raper & Thom (1949) and sensu Pitt (1979) is polyphyletic; the species of the section *Biverticillata* should be transferred to *Paecilomyces*. The type species of the former genus *Torulomyces* has no distinct conidiophores. *Geosmithia* Pitt is closely related to *Penicillium*.

Wallemia Johan-Olson in Forh. Christiana Vid. Selsk. 12: 6. 1887. — Type species: *W. sebi* (Fr.) v. Arx. — Synonyms: *Bargellinia* Borzi, *Hemispora* Vuill.

Paecilomyces Bainier in Bull. Soc. mycol. Fr. 23: 26. 1907. — Type species: *P. variotii* Bainier. — Synonyms: *Phialotubus* Roy & Leelavathy, *Septofusidium* W. Gams, *Sagenomella* W. Gams, *Penicillium* sect. *Biverticillata* sensu Raper & Thom (1949), *Spicaria* auct.

About 25 species will have to be accepted. The entomogenous species with swollen conidiogenous cells and conidia without disjunctors belong to *Nomuraea* Maubl. sensu Samson (1974) and represent anamorphs of Clavicipitaceae. *Mariannaea* Arnaud ex Samson (1974) is unrelated to *Paecilomyces*, but may be indistinguishable from *Clonostachys* Corda. The conidia have no disjunctors, but are arranged obliquely in 'false' chains. This genus includes anamorphs of the Hypocreaceae.

Raperia Subramanian & Rajendran in Kavaka 3: 129. 1975. — Type species: *R. spinulosa* Subramanian & Rajendran. — Synonym: *Merimbla* Pitt (von Arx, 1986a).

Second species: *R. ingelheimensis* (v. Beyma) v. Arx.

Memnoniella Höhnel in Zentbl. Bact. ParasitKde 2, 60: 16. 1923. — Type species: *M. echinata* (Riv.) Galloway.

Further species: *M. subsimplex* (Cooke) Deighton.

Teleomorphs are absent. The genus is reminiscent of *Penicillium*, but is a relative of *Scopulariopsis* (anamorphous Microascaceae). The spherical and echinulate, dark conidia have an indistinctly truncate base without disjunctors (Jong & Davis, 1976).

Phialomyces Misra & Talbot in Can. J. Bot. 42: 1287. 1967. — Type species: *P. macrosporus* Misra & Talbot.

Acrophialophora Edward in Mycologia 51: 789. 1959. — Type species: *A. nainiana* Edward.

Further species: *A. fusispora* (Saksena) Samson, *A. levis* Samson & Tariq Mahmood.

Basipetospora Cole & Kendr. in Can. J. Bot. 46: 991. 1968. — Type species: *B. rubra* Cole & Kendr.

Further species: *B. chlamydosporis* Matsushima, *B. variabilis* Matsushima.

Polypaecilum G. Smith in Trans. Br. mycol. Soc. 44: 437. 1961. — Type species: *P. insolitum* G. Smith.

Further species: *P. botryoides* (Brooks & Hansf.) Rao & Hoog.

Stephanosporium Dal Vesco in Allionia 7: 182. 1961. — Type species: *S. cerealis* (Thüm.) Swart.

Oidiodendron Robak in Nyt. Mag. Naturvid. 71: 243. 1932. — Type species: *O. tenuissimum* (Peck) Hughes.

About twelve species are described (Barron, 1962). Teleomorphs are unknown.

Coremiella Bubak & Krieger in Annls Mycol. 10: 52. 1912. — Type species: *C. cubispora* (Berk. & Curt.) M. B. Ellis.

Further species: *C. cuboidea* (Sacc. & Ellis) Cif. & Caretta.

Briosia may be an older generic name, but the type specimen of the type species is no longer adequate for study. Sigler & Carmichael (1976, 1983) and Sigler & al. (1982) classified some similar fungi in *Arthrographis* and in the new genera *Arthrocristula* and *Arthropsis.*

Geomyces Traaen in Nyt. Mag. Naturvid. 52: 28. 1914. — Type species: *G. pannorum* (Link) Hughes.

The genus can be distinguished from *Chrysosporium* only with difficulty.

Chrysosporium Corda in Sturm, Dtl. Fl., Pilze 3, 13: 85. 1833. — Type species: *C. merdarium* (Link) Carmichael.

Carmichael (1962) delimited about twenty species, some of which were transferred by van Oorschot (1980) to *Geomyces* and *Myceliophthora*. The latter genus is polyphyletic and preferably should be restricted to anamorphs of *Corynascus* (Sordariaceae). Several teleomorphs of Eurotiales include undescribed *Chrysosporium* anamorphs.

Malbranchea Sacc. in Michelia 2: 638. 1882. — Type species: *M. pulchella* Sacc.

Sigler and Carmichael accepted about fifteen species, among which the thermophilic *M. cinnamomea* (Lib.) Oorschot & Hoog (as *M. sulphurea* (Miehe) Sigler & Carmichael). The genus is similar to *Sporendonema* and its separation from the *Chrysosporium/Geomyces* complex is artificial and difficult.

Sporendonema Desm. in Fr., Syst. Mycol. 3: 434. 1832. — Type species: *S. casei* Desm.

Second species: *S. purpurascens* (Bon.) Mason & Hughes. Teleomorphs are unknown.

Zymonema Beurm. & Gougerot in Tribune Méd. 42: 503. 1909. — Type species: *Z. dermatitidis* (Gilchrist & Stokes) Dodge (*Blastomyces dermatitidis, Z. gilchristii*) (van Oorschot, 1980).

Histoplasma Darling in J. Am. med. Ass. 46: 1283. 1906. — Type species: *H. capsulatum* Darling.

Microsporum Gruby in C.r. hebd. Séance Acad. Sci. Paris 17: 301. 1836. — Type species: *M. audouinii* Gruby.

About twelve species are distinguished.

Keratinomyces Vanbreus. in Bull. Acad. R. méd. Belg. 38: 1068. 1952. — Type species: *K. ajelloi* Vanbreus. (*Trichophyton ajelloi*), a keratinolytic, apparently saprophytic soil fungus. Two further species are described (Punsola & Guarro, 1984).

Trichophyton Malmsten in Arch. Anat. Phys. Wiss., Med. 1: 1838. — Type species: *T. tonsurans* Malmsten.

About forty species are described; common on man are *T. mentagrophytes* (Robin) Blanchard, *T. rubrum* (Castellani) Sabouraud and *T. violaceum* Sabouraud.

Epidermophyton Sabour., Les maladies du Cuir Chevalu 3: 420. 1910. — Type species: *E. floccosum* (Harz) Langeron & Milochevitch.

Sympodiella Kendr. In Trans. Br. mycol. Soc. 41: 519. 1958. — Type species: *S. acicola* Kendr.

Further species are added by Matsushima (1975). Teleomorphs are unknown.

Staheliella Emden in Acta bot. Neerl. 23: 251. 1974. — Type species: *S. nodosa* Emden, without teleomorph.

Botryomonilia Goos & Piroz. in Can. J. Bot. 53: 2927. 1975. — Type species: *B. scheeleae* Goos & Piroz., without teleomorph.

Amblyosporium Fres. in Beitr. Mykol. 3: 99. 1863. — Type species: *A. spongiosum* (Pers.) Hughes.

Pirozynski (1969) delimited three further species. Teleomorphs are unknown. The cultural states are reminiscent to those of Sclerotiniaceae.

Arthrographis Cochet ex Sigler & Carmichael in Mycotaxon 4: 359. 1976. — Type species: *A. kalrai* (Tewari & Macpherson) Sigler & Carmichael.

The teleomorph has been described by von Arx (1978) as *Pithoascus langeronii* (Pithoascaceae or Microascaceae). Sigler & Carmichael (1983) classified further species in *Arthrographis*, which have to be excluded, because they form dematiaceous and more expanding colonies, and the conidia develop in unbranched chains and are short cylindrical and unswollen.

Hormographis Guarro & al. in Mycologia 78: 969. 1986. — Type species: *H. ramirezii* Guarro & al., without teleomorph, keratinolytic.

Chrysonilia v. Arx in Sydowia 34: 16. 1981. — Type species: *C. sitophila* (Mont.) v. Arx (*Monilia sitophila* Mont.).

The genus includes anamorphs of *Neurospora* species (Sordariaceae). The catenate conidia develop at random or in basipetal or acropetal sequence and separate by double septa and extending disjunctors. *Melanocarpus albomyces* (Cooney & Emerson) v. Arx has a similar anamorph with relatively large, long cylindrical conidia. This fungus is thermophilic and should also be classified in the Sordariaceae.

Mauginiella Cav. in Boll. Orto bot. Napoli 8: 207. 1926. — Type species: *M. scaettae* Cav.

A teleomorph is unknown. The fungus causes rot on date palms and apparently represents an anamorph of the Sclerotiniaceae, related to *Septotis* (teleomorph: *Septotinia*, similar to *Sclerotinia*). The septa of the vegetative hyphae have central pores, in which plasmatic strands and migrating nuclei have been observed by von Arx & al. (1981).

Geotrichum Link in Mag. Ges. Naturf. Berlin 3: 17. 1809. — Type species: *G. candidum* Link. — Synonyms: *Oosporidea* Sumstine, *Polymorphomyces* Coupin, *Blastoschizomyces* Salkin & al.

Teleomorph: *Dipodascus* Lagerh. (and *Galactomyces* Redhead & Malloch) (Dipodascaceae, Endomycetales).

Several Eurotiales include unnamed, *Geotrichum*-like anamorphs. The colonies, however, are usually pigmented and the vegetative hyphae are persistent and have septa with central pores. In *Geotrichum* species the colonies are unpigmented and all hyphae form double, adjacent septa with disjunctives and disarticulate earlier or later into single cells.

Several species of *Geotrichum* are dimorphic or even trimorphic. *Geotrichum armillariae* v. Arx for example forms arthroconidia and acrogenous, aseptate, hyaline aleurioconidia (chlamydospores), which are often predominant. *Geotrichum capitatum* (Diddens & Lodder) v. Arx forms arthroconidia and supplementary conidia with a truncate base from sympodially elongating conidiogenous cells or hyphae. Erect conidiophores may be present. A separate genus *Blastoschizomyces* Salkin & al. (type species: *B. pseudotrichosporon* Salkin & al.) has been introduced for this species. Other dimorphic *Geotrichum* species are *G. eriense* (Hedrick & Dupont) Weijman and *G. terrestre* (v. d. Walt & Johannson) Weijman.

Von Arx (1977a) delimited fourteen species; eight of which include *Dipodascus* teleomorphs. The asci develop from conjugating hyphae or hyphal tips, which arise from arthroconidia or from aerial hyphae. *Dipodascus magnusii* (Ludwig) v. Arx forms erect ascophores, on which the gametangial hyphae develop. All *Dipodascus* species have rather persistent asci and the ascospores are often extruded through an apical opening. *Dipodascus geotrichum* (Butler & Peterson) v. Arx and *D. reessii* (v. d. Walt) v. Arx have 1- or 2-spored asci with rather thick-walled ascospores. These species therefore have been classified in a separate genus *Galactomyces* of the Onygenaceae by Redhead & Malloch (1977). *Galactomyces* was synonymized with *Dipodascus* by von Arx (1977a).

The ascospores of *Dipodascus* species are reminiscent of those of the species of the yeast genera *Yarrowia* v. d. Walt & v. Arx and *Schwanniomyces* Klöcker, and of those of the Onygenaceae.

TAXA EXCLUDED FROM THE EUROTIALES

A. THE PSEUDEUROTIACEAE

The Pseudeurotiaceae are described and delimited by Malloch & Cain (1970b). They are characterized by relatively large, spherical ascomata with a distinct peridium, by spherical, oblate, or reniform, often pigmented ascospores, and by *Cephalosporium*- or *Sporothrix*-like anamorphs with aseptate, hyaline blastoconidia. One species has a *Chalara*-like anamorph with cylindrical conidia formed in a tube in basipetal sequence from a meristematic zone.

The Pseudeurotiaceae sensu Malloch & Cain (1970b) are probably polyphyletic, but all show affinities to the Sphaeriales, especially to the Ophiostomataceae, Microascaceae, and Sordariaceae.

KEY TO THE GENERA OF PSEUDEUROTIACEAE

1 a.	Ascomata with a pale, fleshy wall; ascospores with a sheath or with winged appendages	2
b.	Ascomata with a dark, usually black wall; ascospores smooth, occasionally reticulate	3
2 a.	Ascospores ellipsoidal, with a sheath	*Leucosphaerina*
b.	Ascospores ellipsoidal or fusiform, with winged appendages	*Emericellopsis*
3 a.	Ascomata spherical, not cephalothecoid; ascomatal wall without sutures	4
b.	Ascomata cephalothecoid; ascomatal wall with sutures (lines of dehiscence)	8
4 a.	Ascospores with a reticulate wall, spherical or nearly so	*Hapsidospora*
b.	Ascospores with a smooth wall	5
5 a.	Ascospores hyaline	6
b.	Ascospores pigmented when mature	7
6 a.	Ascospores reniform in lateral view	*Connersia*
b.	Ascospores spherical or nearly so	*Nigrosabulum*
7 a.	Ascospores triangular in lateral view	*Pidoplichkoviella*
b.	Ascospores ovate or nearly spherical	*Pseudeurotium*
8 a.	Ascospores hyaline, short cylindrical	*Cryptendoxyla*
b.	Ascospores not cylindrical, pigmented when mature	9
9 a.	Parasitic on Polyporales; ascospores often bilaterally flattened	*Albertiniella*
b.	Saprophytic; ascospores reniform or hemispherical	*Fragosphaeria*

Albertiniella Kirschst. in Annls Mycol. 34: 183. 1936. — Types species: *A. polyporicola* (Jacz.) Malloch & Cain.

The fungus occurs on pores of members of the Polyporales. It was first described as *Cephalotheca polyporicola* Jacz., and since as *Albertiniella reticulata* Kirschst. and as *Cephalotheca splendens* Udagawa & Horie (1971). The latter authors discovered a *Cephalosporium*-like anamorph. The ascospores are slightly oblate (bilaterally flattened?) and brown when mature.

Connersia Malloch in Fungi Canadensis no. 32. 1974. — Type species: *C. rilstonii* (Booth) Malloch.

Connersia rilstonii is based on *Pseudeurotium rilstonii* Booth, which differs from typical *Pseudeurotium* species by hyaline, ellipsoidal-reniform, unilaterally flattened ascospores. Those of *Pseudeurotium* species are spherical-ovate and slightly pigmented when mature.

Cryptendoxyla Malloch & Cain in Can. J. Bot. 48: 1816. 1970. — Type species: *C. hypophloia* Malloch & Cain.

This fungus includes a *Chalara*-like anamorph with conidia formed in tube-like cells endogenously in basipetal sequence. This anamorph is similar to that of *Ceratocystis* species (Ophiostomataceae).

Emericellopsis v. Beyma in Antonie van Leeuwenhoek 6: 263. 1939. — Type species: *E. terricola* v. Beyma.

Gams (1971) accepted seven species, all with pale ascomata and ellipsoidal-fusiform, slightly pigmented ascospores with longitudinal wings and crests. All species include *Cephalosporium*-like anamorphs and are closely related, probably indistinguishable. The genus has been connected with the Hypocreaceae, but this may be questionable. The ascospores are reminiscent of those of *Penicilliopsis* species.

Fragosphaeria Shear in Mycologia 15: 124. 1923. — Type species: *F. purpurea* Shear, with a *Cephalosporium*-like anamorph.

Further species: *F. reniformis* (Sacc. & Therry) Malloch & Cain, with a *Sporothrix*-like anamorph, and **Fragosphaeria savoryi** (Booth) v. Arx, *comb. nov.* (basionym. *Cephalotheca savoryi* Booth in Mycol. Pap. 83: 12. 1961) with a *Tritirachium*-like anamorph.

Fragosphaeria may be related to *Microascus* and *Pithoascus.*

Hapsidospora Malloch & Cain in Can. J. Bot. 48: 1819. 1970. — Type species: *H. irregularis* Malloch & Cain, with a *Cephalosporium*-like anamorph.

Leucosphaerina v. Arx, *nom. nov.* (replaced synonym: *Leucosphaera* v. Arx & al. in Persoonia 10: 141. 1978; non *Leucosphaera* Gilg, 1897). — Type species: **Leucosphaerina indica** (v. Arx & al.) v. Arx, *comb. nov.* (basionym: *Leucosphaera indica* v. Arx & al. in Persoonia 10: 141. 1978).

Anamorph: *Sporothrix*- or *Cephalosporium*-like.

Nigrosabulum Malloch & Cain in Can. J. Bot. 48: 1822. 1970. — Type species: *N. globosum* Malloch & Cain.

This fungus includes a *Cephalosporium*-like anamorph. The hyaline ascospores are spherical or nearly so and often show a small lateral globule.

Pidoplichkoviella Kirilenko in Mykrobiol. Zh. 37: 603. 1975. — Type species: *P. terricola* Kirilenko.

The ascomata are spherical, smooth, dark and relatively small. The pigmented ascospores are triangular in lateral view and have no germ pore. No anamorphs could be observed in subcultures of the type. A relationship to the Pithoascaceae has to be considered. The ascospores, however, are not dextrinoid when young.

Pseudeurotium v. Beyma in Zentbl. Bakt. ParasitenKde. 2, 96: 415. 1937. — Type species: *P. zonatum* v. Beyma.

The genus includes two or three species with dark, spherical ascomata with a wall of angular cells. The ascospores are spherical or broadly ellipsoidal, smooth and pigmented when mature. All species include *Cephalosporium*-like or *Sporothrix*-like anamorphs with aseptate, hyaline blastoconidia. *Pseudeurotium ovalis* Stolk is a rather common soil fungus.

B. OTHER EXCLUDED AND DOUBTFUL TAXA

Amorphotheca Parbery in Austr. J. Bot. 17: 342. 1969. — Type species: *A. resinae* Parbery.

Amorphotheca resinae is the rarely encountered teleomorph of *Hormoconis resinae* (Lindau) v. Arx & Vries (*Cladosporium resinae*), the creosote fungus. The conidia are formed acropetally in branched chains with denticle-like, unthickened scars on erect conidiophores. The asci develop in obcampanulate or spherical ascomata with an amorphous wall, are clavate and contain ellipsoidal-reniform, aseptate, hyaline, smooth ascospores. Redhead & Malloch (1977) classified the Amorphothecaceae in the Endomycetaceae. It may be related to the Pithoascaceae and Microascaceae and consequently represent a family of the Sphaeriales.

Aporothielavia Malloch & Cain in Mycologia 65: 1074. 1973. — Type species: *A. leptoderma* (Booth) Malloch & Cain.

Aporothielavia leptoderma is known from a single isolate. It is a relative of *Zopfiella curvata* (Fuckel) Winter with aseptate ascospores without germ pores. The fungus should be classified in the Lasiosphaeriaceae (von Arx, 1975).

Eleutherascus v. Arx in Persoonia 6: 378. 1971. — Type species: *E. lectardii* (Nicot) v. Arx. — Synonym: *Hemiascosporium* Batra (1973).

Von Arx (1971) considered the fungus to be a relative of *Ascodesmis* (Pezizales) with spherical asci without operculum. Several members of the Pezizales have similar asci and ascospores, especially taxa classified in the Tuberaceae. *Eleutherascus* includes four species (van Emden, 1975; Huang, 1975; Samson & Luiten, 1975).

Ephemeroascus Emden in Trans. Br. mycol. Soc. 61: 599. 1973. — Type species: *E. verticillatus* Emden.

The fungus is known from a single isolate. It has been considered to be a relative of *Coniochaeta* with ascospores without germ slits. The ascomata are stromatic, black and a *Verticillium* anamorph with hyaline conidiophores and conidia is present.

Europhium Parker in Can. J. Bot. 35: 175. 1957. — Type species: *E. trinacriiforme* Parker.

The fungus has hat-shaped ascospores, very early-evanescent asci and includes a *Leptographium (Verticicladiella)* anamorph. It has to be classified in the Ophiostomataceae, but should not be synonymized with *Ceratocystis* or *Ophiostoma*. Robinson-Jeffrey & Davidson (1968) described supplementary species.

Faurelina Locquin-Linard in Rev. Mycol. 39: 125. 1975. — Type species: *F. fimigena* Locquin-Linard.

Further species are *F. elongata* (Udagawa & Furuya) Furuya and *F. indica* v. Arx & al. The latter species includes an anamorph with 1-septate arthroconidia. The genus has been connected with the Microascaceae, but its classification is debatable. The ascomata are hemispherical-pustulate and the ascospores are finely striate and pale brown when mature. The ascospore ornamentation and the anamorph suggest a relationship to *Neurospora* (Sordariaceae).

Leuconeurospora Malloch & Cain in Can. J. Bot. 48: 1820. 1970. — Type species: *L. pulcherrima* (Winter) Malloch & Cain.

This psychrophilic, soil-borne, or coprophilous fungus develops at temperatures of about 6 °C. It forms cephalothecoid ascomata and broadly fusiform, ridged or reticulate, pale brown ascospores. Von Arx (1978) suggested a relationship to *Sphaerodes* (Ceratostomataceae, Melanosporaceae), which differs by ascospores with two prominent and protuberant, apical germ pores and by ostiolate or non-ostiolate ascomata with a pale wall.

Neogymnomyces Orr in Can. J. Bot. 48: 1061. 1970. — Type species: *N. demonbreunii* (Ajello & Cheng) Orr.

The genus is based on *Gymnoascus demonbreunii* Ajello & Cheng, which is known by a single isolate. Currah (1985) redescribed the fungus and classified it in the Onygenaceae. Subcultures of the type are sterile. The value of the genus may be questioned.

Neoxenophila Apinis & Clark in Trans. Br. mycol. Soc. 63: 263. 1974. — Type species: *N. foetida* Apinis & Clark.

Currah (1985) classified the fungus tentatively in the Onygenaceae. It is known by a single specimen, which was not available. The description is rather inadequate.

Pectinotrichum Varsavsky & Orr in Mycopath. Mycol. appl. 43: 229. 1971. — Type species: *P. llanense* Varsavsky & Orr.

Currah (1985) classified the fungus in the Onygenaceae. It may be related to *Auxarthron*, but differs by smooth and apparently oblate ascospores, a character of the Gymnoascaceae. No cultures or specimens with asci and ascospores could be studied.

Pithoascus v. Arx in Proc. K. Ned. Akad. Wet. (C) 76: 295. 1973. — Type species: *P. nidicola* (Massee & Salmon) v. Arx.

The genus includes seven species, partly with ostiolate, partly with non-ostiolate ascomata (von Arx, 1973, 1978). It differs from *Microascus* by fusiform or narrowly navicular ascospores without germ pore. A few species include *Scopulariopsis*- or *Arthrographis*-like anamorphs. Benny & Kimbrough (1980) introduced a separate family Pithoascaceae for *Pithoascus* and *Faurelina*.

Shanorella Benjamin in Aliso 3: 319. 1956. — Type species: *S. spirotricha* Benjamin.

The fungus is characterized by ascomata with a peridium composed of disarticulating hyphae and with spirally coiled, pale appendages. The ascospores are lenticular and slightly pigmented. *Shanorella* may belong to the Gymnoascaceae. Subcultures of the type are sterile. Currah (1985) observed the fungus on dung of carnivores after a long period of incubation.

Spiromastix Kuehn & Orr in Mycologia 59: 160. 1962. — Type species: *S. warcupii* Kuehn & Orr.

The genus is characterized by ascomata surrounded by arcuate, pigmented appendages and small, lenticular, yellow ascospores. It may belong to the Gymnoascaceae. Subcultures of the type are sterile.

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