

Chapter 18

Fungi

Phylum Eumycophyta: true fungi containing no chlorophyll; mycelium nonseptate

Class Phycomycetes (ZYGOMYCETES): cause encephalitis, urinary infections, superinfection in chronic pulmonary disease, diabetes mellitus (especially in acidosis), renal acidosis, severe malnutrition, therapy with deferoxamine, i.v. drug abuse, neutropenia; major host defence mechanisms phagocytes (+++), basophil-mast cell (+); diagnosis: wet preparation, Grocott's methenamine silver stain, culture; treatment: amphotericin B (MIC 0.78-1.56 mg/L)

Order Mucorales: spores borne in closed sac; uncommonly cause cellulitis (fulminant necrotising or indolent); treatment: amphotericin B

Family Mucoraceae: cause enterocolitis, infections in patients with interrupted integument, neutrophil dysfunction

Mucor: phycomycete; dust, soil; causes mucormycosis (zygomycosis)— bagassosis and farmer's lung, brain and epidural abscess in neutropenics, adult hepatitis, nonpyogenic meningitis (infrequent in neutropenics and impaired cell-mediated immunity), pneumonia (including diffuse interstitial in granulocytopenics), localised skin lesions, 1% of fungal peritonitis in continuous ambulatory peritoneal dialysis, postseptal cellulitis in immunosuppressed, systemic infections in abnormal host (interrupted integument, neutrophil dysfunction); altered normal flora, deficiencies in neutrophils, mononuclear phagocytes, integument, ? humoral factors in infection; immunity due to phagocytes (+++); diagnosis: immunodiffusion, wet preparation, Grocott's methenamine silver stain, culture; treatment: amphotericin B, flucytosine, ketoconazole

M.amphibiorum: causes skin ulceration in platypuses

Rhizomucor pusillus: causes pneumonia (especially in leukemics)

Rhizopus: phycomycete; causes zygomycosis— brain and epidural abscess in neutropenics, infections in abnormal host (interrupted integument, neutrophil dysfunction), localised skin lesions, nonpyogenic meningitis (infrequent in impaired cell-mediated immunity), pneumonia (including diffuse interstitial); growth stimulated by excess iron; immunity due to phagocytes; diagnosis: histology and culture of infected tissue; treatment: amphotericin B

R.arhizus sensu Ellis: causes rhinocerebral mucormycosis, systemic infections in abnormal host

R.microsporus var rhizopodiformis: causes skin infections associated with contaminated Elastoplast bandages, systemic infections in abnormal host

Absidia: causes zygomycosis— brain and epidural abscess in neutropenics, infection in abnormal host (interrupted integument, neutrophil dysfunction), nonpyogenic meningitis (infrequent in neutropenics and impaired cell-mediated immunity), pneumonia (including diffuse interstitial), rhinocerebral mucormycosis; immunity due to phagocytes (+++); diagnosis: histology and culture of infected tissue; treatment: amphotericin B

A.corymbifera: grows at 45°C; causes systemic infections in abnormal host

Saksenaea vasiformis: causes infection in abnormal host (interrupted integument, neutrophil dysfunction), subcutaneous zygomycosis

Cunninghamella bertholletiae: causes zygomycosis; diagnosis: histology and culture of infected tissue; treatment: amphotericin B

C.elegans: causes zygomycosis (rare)— systemic infections in abnormal host (interrupted integument, neutrophil dysfunction), pneumonia in disseminated infections; diagnosis: histology and culture of infected tissue; treatment: amphotericin B

Mortierella: causes systemic infections in abnormal host (interrupted integument, neutrophil dysfunction)

Basidiobolus haptosporus: causes zygomycosis (rare); diagnosis: histology and culture of infected tissue; treatment: amphotericin B

B.ranarum: tropical regions of eastern and western Africa, southeast Asia, South America, rare cases in USA; causes painless subcutaneous nodules on lower extremities and buttocks, gastrointestinal infection, systemic infection in

abnormal host (interrupted integument, neutrophil dysfunction); diagnosis: culture of clinical or surgical specimens, histopathology; treatment: surgery + itraconazole

Class Deuteromycetes: 'fungi imperfecti'; no sexual spores

Cryptococcus: unicellular budding cells only, reproduces by blastospores pinched off mother cell, cells surrounded by capsule; most urease positive; growth stimulated by excess iron; starch-like substance produced, no carotenoid pigment, utilises inositol; susceptible to miconazole, ketoconazole, fluconazole, itraconazole

C. albidus: rarely causes cryptococcosis

C. laurentii: rarely causes cryptococcosis

C. neoformans: brown colonies on caffeic acid agar; occurs in soil and pigeon faeces; causes cryptococcosis—nonpyogenic meningitis most usual infection, occasionally gives also chronic and subacute fever, encephalitis, hepatic granuloma, skin lesions (rare), pneumonia (diffuse interstitial in T cell deficiency), chronic pneumonitis, chorioretinitis (associated with meningitis), endocarditis, enterocolitis, endophthalmitis (rare, bloodborne), 2% of lymph gland infections, osteomyelitis and osteochondritis, pancreatitis (18% of cases in AIDS), urinary infection, systemic disease in abnormal host (in adrenal hyperplasia, Hodgkin's disease, immunosuppressive therapy, sarcoidosis, T helper lymphocyte dysfunction, chemotactic defect, ? corticosteroid therapy, ? diabetes mellitus); enters across respiratory tract epithelial surface and subsequently spreads through body; ? dissemination to CNS by reactivation; deficiencies in mononuclear phagocytes, integument, ? humoral factors in infection; polysaccharide capsule (polymer containing uronic acid) resists phagocytosis (virulence factor); multiplies in macrophages; produces proteinases (possible virulence factor); melanin synthesis, growth at 37°C, myristoylation and urease other virulence factors (possibly also mat?, mannitol synthesis, phospholipase, signal transduction via calcineurin); immunity cell mediated (delayed type hypersensitivity-activated macrophage +++), phagocytes (++) , alternative complement (+), antibody-dependent cellular cytotoxicity (+++); susceptible to macrophage colony stimulatory factor-stimulated macrophages; interferon-? active in experimental infections; diagnosis: latex agglutination (antipolysaccharide capsular antigen; negative if *C. albidus* infection), tube agglutination, charcoal particle agglutination, indirect fluorescent antibody titre, complement fixation test, India ink preparation, mucicarmine stain, culture; treatment: amphotericin B (MIC 0.05-0.78 mg/L), flucytosine, miconazole, itraconazole, fluconazole; also susceptible to ketoconazole

C. neoformans var gattii: causes 12% of cryptococcosis in Australia; associated with Red Gum trees; most cases in normal hosts

C. neoformans var neoformans: causes 84% of cryptococcosis in Australia; 70% of cases in immunodeficient

C. uniguttulatus: single report of ventriculitis; susceptible to amphotericin B (MIC 0.25 mg/L), itraconazole (1 mg/L)

Candida: reproduction by pinched blastospores, may form pseudomycelium or true mycelium, no capsule or carotenoid pigment; urea usually negative, does not utilise inositol; normal flora of vagina (13%), skin, upper respiratory tract; causes candidiasis (worldwide; mucocutaneous— predisposing conditions diabetes mellitus, oral contraceptives, broad spectrum antibiotics— and systemic— predisposing conditions neutropenia, parenteral nutrition, ambulatory peritoneal dialysis, heroin addiction, corticosteroids), septic arthritis, balanitis, bagassosis and farmer's lung, cholangitis and cholecystitis (uncommon; in AIDS), chorioretinitis, purulent conjunctivitis, acute empyema, endocarditis, enterocolitis, adult hepatitis, hepatic granuloma, localised skin lesions in disseminated infections, postneonatal pyogenic and nonpyogenic meningitis, myocarditis and pericarditis (cardiac surgery, impaired host defences, severe debilitating disease), oesophagitis, osteomyelitis (drug abusers, periprosthetic), parametritis, pelvic abscess, pelvic inflammatory disease (associated with suture, IUD), peritonitis in chronic peritoneal dialysis, pneumonia (including diffuse interstitial), prenatal generalised disease, prostatic abscess (catheterised diabetics receiving broad spectrum antibiotics), 1-4% of septicemia, 8% of thrombophlebitis, thyroiditis, urethritis (uncommon in male), vaginitis, infections in abnormal host (interrupted integument, infusion infection, surgical procedure, neutrophil dysfunction, T helper lymphocyte dysfunction), superinfection in DiGeorge's syndrome, haematological malignancy during therapy, hypoadrenalism, hypoparathyroidism, hypothyroidism and thymic dysplasia, 72% of nosocomial fungal infections (traumatised skin, i.v. drug abuse, malnutrition, neutropenia, impaired cell-mediated immunity), systemic infection in chemotaxis defect, granulocytopenia, microbial abnormality; intravenous and bladder catheters, altered normal flora by antibiotics, deficiencies in integument, neutrophils, mononuclear phagocytes, ? humoral factors in infection; immunity due to

phagocytes (++), alternative complement (+), immune adherence (phagocytosis; ++), basophil (+) in systemic infection, cell-mediated (delayed type hypersensitivity-activated macrophage +++) in chronic mucocutaneous; recovery from primary infection due to antibody, ? cell-mediated immunity; diagnosis: precipitation test, agglutination (? 1:16; anti-yeast cell antigen), immunodiffusion (antimannan antigen), counterimmunoelectrophoresis (anti-non-mannan antigen), indirect fluorescent antibody (titre ? 1:66), ELISA (antigen, antibody), latex agglutination, radioimmunoassay, indirect haemagglutination assay, wet preparation, tissue stains (Grocott's methenamine silver, periodic acid-Schiff), culture; treatment: amphotericin B (MIC 0.2-1.56 mg/L), clotrimazole, fluconazole, itraconazole, ketoconazole, miconazole, nystatin, candicidin, flucytosine

C.albicans: germ tube positive; normal flora of mouth, throat, colon, lower ileum, external genitalia (adherence to labium majus +), anterior urethra, vagina, skin; causes candidiasis (moniliasis)— 51% of fungemia and fungal septicemia, balanoposthitis, bronchitis, mucopurulent cervicitis, purulent conjunctivitis, acute cystitis, chronic dacryocystitis, adenitis and canaliculitis, dermatitis, endocarditis, endophthalmitis, chronic eye infections, chronic and subacute fever, local and generalised sepsis, meningitis, 58% of fungal nosocomial infections, 3% of otitis externa, paronychia, perianal and perirectal abscess in patients with malignant disease, perinatal generalised disease, perinephric abscess, 42% of fungal peritonitis in chronic peritoneal dialysis, nonexudative pharyngitis and tonsillitis, pneumonitis, postoperative complications, prostatitis and seminal vesiculitis (uncommon), pulmonary infections, septic arthritis, systemic infections in abnormal host (all organs; common; chronic granulomatous disease), thrush, 5% of tinea pedis, vaginitis (common), vulvitis, vulvovaginitis; can be sexually transmitted; infection generally confined to epithelial surface of respiratory tract, conjunctiva and urogenital tract; produces endotoxin, proteinases, phospholipases, lysophospholipases; growth stimulated by excess iron; primary bodily defence mechanism cellular immune responses, leucocyte bactericidal function; susceptible to interleukin-3, interleukin-4, granulocyte macrophage colony stimulatory factor and macrophage stimulatory factor-stimulated macrophages; interleukin-1, granulocyte colony stimulatory factor and tissue necrosis factor also induce antimicrobial activity; interferon-? active in experimental infections; mean doubling time 30 minutes in vitro at 37°C; treatment: amphotericin B (MIC 0.2-0.78 mg/L), nystatin, natamycin, gentian violet, clotrimazole, ketoconazole (0.008 mg/L), itraconazole (0.02 mg/L), miconazole (0.17 mg/L), fluconazole (0.39 mg/L), flucytosine, econazole

C.dubliniensis: germ tube and chlamydospore positive, ?-glucosidase negative, very weak growth at 42°C, no growth at 45°C; causes oral candidiasis and candidemia

C.guilliermondii: causes 6% of fungemia and fungal septicemia (1% of catheter associated), 3% of fungal peritonitis in chronic peritoneal dialysis, systemic infections in abnormal host (endocarditis, joint infections); treatment: amphotericin B ? flucytosine, fluconazole

C.kefyr: causes disseminated candidiasis (rare)

C.krusei: causes 9% of fungemia and fungal septicemia, endocarditis (rare), 1% of fungal peritonitis in chronic peritoneal dialysis; treatment: amphotericin B ? flucytosine; also susceptible to miconazole, ketoconazole, itraconazole; resistant to fluconazole

C.lusitaniae: cellobiose fermented, rhamnose assimilated; causes 1% of catheter associated fungemia and fungal septicemia, chronic and subacute fever in immunocompromised, urinary tract infection in diabetics, vasculitis in immunocompromised; treatment: amphotericin B + flucytosine, fluconazole

C.parapsilosis: trehalose not fermented; causes 6% of fungemia and fungal septicemia, onychomycosis (rare), 8% of fungal peritonitis in continuous ambulatory peritoneal dialysis, purulent conjunctivitis (infrequent to rare), septic arthritis in prostheses, systemic infections in abnormal host (endocarditis (in i.v. drug addicts, invasive procedure, prosthetic devices, hyperalimentation), fungemia); produces proteinases; susceptible to interferon-?-activated macrophages; treatment: amphotericin B ? flucytosine, fluconazole, ketoconazole, miconazole

C.pseudotropicalis: causes 1% of catheter associated fungemia and fungal septicemia; treatment: amphotericin B ? flucytosine, fluconazole

C.stellatoideae: causes purulent conjunctivitis (infrequent to rare); treatment: amphotericin B + flucytosine

C.tropicalis: soluble starch assimilated, maltose fermented; causes 13% of fungemia and fungal septicemia, 14% of fungal peritonitis in continuous ambulatory peritoneal dialysis, psoas abscess, purulent conjunctivitis (infrequent to

rare), septic arthritis, systemic infections in abnormal host (endocarditis, peritonitis), vaginitis (rare); produces proteinases; treatment: amphotericin B ? flucytosine, fluconazole, itraconazole; resistant to ketoconazole

Rhodotorula: unicellular budding forms that may be encapsulated or produce pseudomycelium; carotenoid pigments present; causes infections in abnormal host (interrupted integument)

R.rubra: causes 3% of fungal peritonitis in chronic peritoneal dialysis, systemic infections (fungemia) in abnormal host (cancer patients); treatment: amphotericin B ? flucytosine, fluconazole

Pichia: causes fungemia in cancer patients; treatment: amphotericin B ? flucytosine, fluconazole

Saccharomyces cerevisiae: 6000 genes; raffinose assimilated; 1% of catheter associated fungemia in cancer patients, invasive infections, vaginitis (rare); treatment: clotrimazole, boric acid, ketoconazole, amphotericin B ? flucytosine, fluconazole

S.cerevisiae boulardii: prevents antimicrobial-associated colitis; may cause fungemia in critically ill patients

Torulopsis: no capsule or starch-like polysaccharide produced; causes pneumonia in cancer patients, hepatic granuloma; treatment: amphotericin B; also susceptible to itraconazole; resistant to miconazole, ketoconazole, fluconazole

T.glabrata: normal flora of mouth, female genital tract (low numbers); causes septic arthritis in prostheses, purulent conjunctivitis (infrequent to rare), 7% of nosocomial fungal infections, 2% of fungal peritonitis in continuous ambulatory peritoneal dialysis, psoas abscess, systemic infections (fungemia (13% of fungal isolates), urinary tract infections) in abnormal host (in diabetes mellitus, haematological malignancy during therapy, traumatised skin, chronic granulomatous disease, solid tumours), vaginitis (rare); diagnosis: agglutination, immunodiffusion (cross-reaction with *Candida*), wet preparation, Grocott's methenamine silver stain, culture; treatment: amphotericin B (MIC 0.1-0.4 mg/L), clotrimazole, boric acid, flucytosine

Geotrichum: reproduction by arthrospores only, forms a true mycelium; causes chronic sinusitis in immunocompromised, disseminated infections in cancer patients, pneumonia in disseminated infections

G.candidum: causes systemic infections in abnormal host; diagnosis: micro and culture of sputum, pus from oral lesions, faeces; treatment: amphotericin B

Blastomyces: soil fungus in the Americas; causes blastomycosis (systemic infection in man); susceptible to miconazole, ketoconazole, itraconazole

B.dermatitidis: perfect stage *Ajellomyces dermatitidis*, yeast forms 2-5 μ m (small form) or 8-15 μ m, broad-based buds; spherical or oval forms immature spherules, free endospores, nonbudding cells; white, beige, greyish-white colonies; hyphae ? small lateral conidia, conversion to broad-based budding yeasts at 37°C; causes blastomycosis, endophthalmitis (bloodborne), enterocolitis, hepatic granuloma, localised skin lesions, 3% of lymph gland infections, splenic abscess (rare), systemic infections in abnormal host (rare cases in haematological malignancy during therapy, impaired cell-mediated immunity, T cell deficiency); enters across epithelial surface of intestinal tract and subsequently spreads through body; produces endotoxin; diagnosis: immunodiffusion (1 band or (more specific) 2 bands), complement fixation test (= 1:8; limited value), wet preparation, tissue stains (Grocott's methenamine silver, periodic acid-Schiff), culture, DNA probe, skin tests, ELISA, radioimmunoassay; treatment: amphotericin B (MIC 0.05-0.2 mg/L), ketoconazole, hydroxystilbamidine isethionate, miconazole, fluconazole, itraconazole

Paracoccidioides brasiliensis: causes paracoccidioidosis, enterocolitis, systemic infections in abnormal host (impaired cell-mediated immunity); growth stimulated by excess iron; treatment: ketoconazole, sulphonamides, amphotericin B, miconazole, fluconazole, itraconazole

Histoplasma: causes adult hepatitis; growth stimulated by excess iron; diagnosis: microscopy and culture, immunodiffusion, complement fixation test, latex agglutination, radioimmunoassay; treatment: amphotericin B; also susceptible to miconazole, ketoconazole, fluconazole, itraconazole

H.capsulatum var capsulatum: yeast form 2-5 μ m; spherical or oval forms immature spherules, free endospores, nonbudding cells; white, beige, greyish-white colonies; hyphae ? microconidia and/or tuberculate macroconidia, conversion to small yeasts at 37°C; soil fungus in the Americas, especially Mississippi River Valley in United States; can give lung lesions and systemic illness in man; causes adult hepatitis, anterior uveitis, bone marrow infection, 5% of carpal tunnel syndrome, chorioretinitis, chronic and subacute fever, cutaneous lesions, encephalitis, endocarditis, endophthalmitis (bloodborne), enterocolitis, hepatic granuloma, 27% of lymph gland infections, nonpyogenic meningitis, oronasopharyngeal lesions, pneumonia (including diffuse interstitial), pulmonary histoplasmosis with exanthem, systemic

infections in abnormal host (infrequent cases in haematological malignancy, T helper lymphocyte dysfunction); enters across respiratory tract epithelial surface and subsequently spreads through body; inhibits lysosome-phagosome fusion; primary bodily defence mechanism cellular immune responses (delayed type hypersensitivity activated macrophage +++); dissemination often by reactivation; deficiencies in mononuclear phagocytes, ? humoral factors in infection; interferon- γ , tissue necrosis factor active in experimental infections; diagnosis: latex agglutination (? 1:16; anti-histoplasmin antigen), immunodiffusion (‘h’ band = active histoplasmosis; ‘m’ band = acute or chronic histoplasmosis or normal skin test positive individual), complement fixation test (anti-whole yeast antigen, anti-histoplasmin; ? 1:8), Giemsa stain, tissue stains (Grocott’s methenamine silver, periodic acid-Schiff), culture, DNA probe; treatment: amphotericin B, flucytosine, ketoconazole, fluconazole, miconazole, itraconazole, cotrimoxazole

H. capsulatum var duboisii: yeast forms 8-15 μ m, narrow-based buds; causes histoplasmosis, systemic infections in abnormal host

Sporothrix schenckii: mycelial form on standard media at 25°C, yeast forms on blood glucose cysteine agar or in brain heart infusion broth; causes sporotrichosis (cutaneous lymphatic, fixed cutaneous, localised extracutaneous, disseminated), 5% of carpal tunnel syndrome, endophthalmitis (bloodborne), enterocolitis, 1% of lymph gland infection, pneumonia, systemic infections in abnormal host (rare cases in haematological malignancy during therapy); treatment: amphotericin B, ketoconazole, itraconazole, potassium iodide

Pseudallescheria boydii: perfect stage of *Scedosporium apiospermum*, causes brain and epididymal abscess in malignant lymphoma and immunosuppression, chronic eye infections, chronic sinusitis, endocarditis in prosthetic valves and in AIDS, endophthalmitis in immunosuppressed, local and generalised sepsis in cancer patients, meningitis (uncommon), mycetoma, pneumonia in disseminated infections, systemic infections in abnormal host (in chronic pulmonary disease, haematological malignancy during therapy, neutrophil dysfunction); diagnosis: immunodiffusion (4-5 bands), wet preparation, Grocott’s methenamine silver stain, culture; treatment: ketoconazole, fluconazole, flucytosine; also susceptible to miconazole; resistant to amphotericin B

Coccidioides immitis: spherical or oval forms immature spherules, free endospores, nonbudding cells; white, beige, greyish-white colonies; hyphae ? alternate, doliiform arthroconidia, conversion to endosporulating spherules in vivo; Southwest North America, Central America, northern South America; 40% of infections symptomatic; 85% of these mild, influenza-like illness, 8% severe pulmonary disease, 7% disseminated extrapulmonary disease; causes encephalitis, endophthalmitis (bloodborne), enterocolitis, erythema nodosum, hepatic granuloma, 2% of lymph gland infections, nonpyogenic meningitis, pneumonia (including diffuse interstitial) with exanthem, systemic infections in abnormal host (< 1% of total cases; infrequent cases in haematological malignancy during therapy, T helper lymphocyte dysfunction, second half of pregnancy and postpartum, steroid use, HIV infection); produces proteinases; immunity cell-mediated (delayed type hypersensitivity-activated macrophage +++), basophil-mast cell (+); dissemination often by reactivation; deficiencies in mononuclear phagocytes, ? humoral factors in infection; susceptible to interferon- γ and tissue necrosis factor-stimulated macrophages; diagnosis: latex agglutination (anti-culture filtrate antigen; IgM), immunodiffusion tube precipitin (IgM), immunodiffusion complement fixation test (IgG), counterimmunoelectrophoresis, complement fixation test (? 1:8; limited value), coccidioidin skin test, wet preparation, tissue stains (Grocott’s methenamine silver, periodic acid-Schiff), culture (may be pigmented, may fail to produce arthroconidia, identify by exoantigen test (F, HL, HS) or spherule production in guinea pig testis) of appropriate specimens from affected tissues or fluid from these tissues, DNA probe; treatment: amphotericin B, miconazole, ketoconazole, fluconazole, itraconazole; also susceptible to clotrimazole (MIC 0.05-0.1 mg/L)

Chrysosporium: causes chronic sinusitis in immunocompromised, endocarditis associated with prostheses, 1% of peritonitis in continuous ambulatory peritoneal dialysis

Dactylaria constricta: causes brain and epidural abscess

Fusarium: causes chronic eye infections, fungemia, keratitis and iritis, 5% of fungal peritonitis in continuous ambulatory peritoneal dialysis, systemic infections in abnormal host (rare cases in burns, haematological malignancy, interrupted integument, neutropenia); diagnosis: histology and culture; treatment: natamycin, granulocyte infusions, GM-CSF

F. anthropilum: causes fusariosis

F. chlamydosporum: causes fusariosis

F.graminearum: produces trichothecenes and zearalenone (mycotoxins) on wheat and corn

F.moniliforme: causes fusariosis; produces fumonisins (mycotoxins) on maize

F.oxysporum: causes fusariosis; produces moniliformin (mycotoxin) on processed foods

F.proliferatum: causes fusariosis

F.solani: causes fusariosis

Hansenula: causes systemic infections in immunosuppression, use of intravenous devices, previous treatment with antibacterial drugs; diagnosis: blood cultures, histology and culture of biopsy specimens; treatment: amphotericin B

H.anomala: causes 92% of systemic *Hansenula* infections

H.polymorpha: causes 8% of systemic *Hansenula* infections

Helminthosporium: causes systemic infections in abnormal host

H.spiciferum: causes mycetoma

Leptosphaeria senegalensis: causes mycetoma

Pyrenochaeta romeroi: causes mycetoma

Dreschlera: causes endocarditis postsurgery for ventricular septal defect, granulomatous encephalitis, keratitis and iritis, localised skin lesions in neutropenics, nonpyogenic meningitis associated with lymphoma, osteomyelitis and osteochondritis associated with prior surgery

D.bisepta: causes pneumonia in disseminated infections

Acromonium: causes chronic sinusitis in immunocompromised, peritonitis in continuous ambulatory peritoneal dialysis, systemic infections in abnormal host

A.falciforme: causes mycetoma

A.recifei: causes mycetoma

Exophiala dermatitidis: causes systemic infection (pneumonia, brain abscess in chronic granulomatous disease); diagnosis: micro and culture of biopsy; treatment: amphotericin B, flucytosine, ketoconazole, fluconazole

Exophiala jeanselmei: causes mycetoma, 1% of fungal peritonitis in continuous ambulatory peritoneal dialysis, phaeohyphomycosis

E.moniliae: causes phaeohyphomycosis

E.pisiphila: causes phaeohyphomycosis

E.spicifera: causes phaeohyphomycosis, 2% of fungal peritonitis in continuous ambulatory peritoneal dialysis

E.werneckii: causes tinea nigra; treatment: amphotericin B

Exserohilum rostratum: causes chronic sinusitis in immunocompromised, phaeohyphomycosis

Wangiella dermatitidis: causes brain and epidural abscess, phaeohyphomycosis

Aspergillus: ascomycete; dust, soil; most common laboratory contaminant; causes adult hepatitis, arteritis, brain and epidural abscess in neutropenics, chorioretinitis, encephalitis, endocarditis (coronary artery surgery, liver transplantation), endophthalmitis (rare, bloodborne), enterocolitis, hepatic granuloma, keratitis and iritis, localised skin lesions, local and generalised sepsis, lymph gland infections (rare), mycotic aneurism, nonpyogenic meningitis (infrequent in neutropenics and impaired cell-mediated immunity), 1% of nosocomial fungal infections, osteomyelitis (predisposing factors), pericarditis (in 4% of disseminated cases), pneumonia, postseptal cellulitis in immunosuppressed, prostatitis and seminal vesiculitis (uncommon), upper airways infection, urinary infection, vascular graft infection (rare), superinfection in anti-tumour therapy, chronic granulomatous disease, corticosteroid therapy, leukemia during therapy, rheumatoid lung, interrupted integument, neutrophil dysfunction, systemic infection in granulocytopenia, microbicidal abnormality; primary bodily defence mechanism humoral immune responses (phagocytes +++, basophil-mast cell +); deficiencies in neutrophils, mononuclear phagocytes, integument, ? altered normal flora, ? humoral factors in infection; diagnosis: latex agglutination (? 1+; anti-culture filtrate antigen), counterimmunoelectrophoresis, immunodiffusion (1-2 bands in aspergilloma/allergy, ? 3 bands in aspergilloma/invasive aspergillosis), complement fixation test (? 1:8; limited value), ELISA, indirect fluorescent antibody (titre ? 1:66), radioimmunoassay, precipitin, wet preparation, tissue stains (Grocott's methenamine silver, periodic acid-Schiff), culture; treatment: amphotericin B (MIC 0.05-8 mg/L), flucytosine (0.2-1.56 mg/L), itraconazole, natamycin, rifampicin; resistant to miconazole, ketoconazole, fluconazole

A.carbonarius: some isolates produce ochratoxin (grapes and grape products, peanuts)

A. clavatus: causes bagassosis and farmer's lung

A. flavus: uni- or biserrate, conidiophore length 400-850 μ m, rough-walled, hyphae colourless, vesicle elongate, becoming subspherical to spherical, conidial head radiate, becoming columnar with age, conidia spherical, echinulate, 3-6 μ m; colonies yellow to yellowish-green; produces aflatoxin B (potent hepatocarcinogen), cyclopiazonic acid (nuts, oilseeds, spices, stored commodities; worldwide); causes aspergillosis, endocarditis, otitis externa, 1% of peritonitis in continuous ambulatory peritoneal dialysis, pneumonia (especially in leukemia), chronic sinusitis, thyroiditis, systemic infections in abnormal host; treatment: amphotericin B ? flucytosine or rifampicin, itraconazole

A. fumigatus: uniseriate, conidiophores length up to 320 μ m, smooth-walled, greenish coloured hyphae, vesicle dome-shaped, conidial head compact and columnar, conidia spherical to subspherical, echinulate, 2.5-3 μ m diameter; colonies whitish green to grey-green; produces exotoxin, proteinases, oxidoreductases; causes 75% of aspergillosis, endocarditis, otitis externa (including rare malignant), 1% of peritonitis in continuous ambulatory peritoneal dialysis, pneumonia (especially in leukemia), thyroiditis, systemic infections in abnormal host; susceptible to interferon- γ and tissue necrosis factor-stimulated macrophages; treatment: amphotericin B ? flucytosine or rifampicin, itraconazole

A. glaucus Group: contains several species; causes aspergillosis, systemic infections in abnormal host

A. nidulans: causes mycetoma

A. niger: biserrate; conidiophore length 1.5-3 mm, smooth-walled, colourless or brownish, vesicle spherical, conidial head radiate, conidia spherical, brown/black, roughened, 4-5 μ m; colonies white/yellow, developing a black mat of conidia; causes otitis externa; some isolates produce ochratoxin (sun-dried fruit, peanuts)

A. ochraceous: produces ochratoxin in coffee beans

A. parasiticus: produces aflatoxins B and G in peanuts, corn and cottonseed (less widely distributed than *A. fumigatus*)

A. terreus: biserrate, conidiophore length 100-250 μ m, smooth-walled, colourless, vesicle hemispherical or dome shaped, conidial head long/columnar, conidia spherical to elliptical, smooth-walled, 2-2.5 μ m; causes aspergillosis

A. ustus: primary cutaneous aspergillosis following reduced intensity stem cell transplantation

Neosartorya: resembles *Aspergillus fumigatus* in conidial state but colonies may remain white

N. fischeri: 2 cases of systemic infection in transplant patients, single case of mixed pulmonary infection in patient with myeloma

N. hiratsukae: reticulated ascospores growing restrictedly on Czapek agar; isolated from air, pasteurised aloe juice and cerebral infection; resistant to amphotericin B, flucytosine; susceptible to itraconazole

N. pseudofischeri: ascospore walls ornamented with raised flaps of tissue resembling triangular projections or long ridge lines; causes localised and invasive infections

Penicillium: causes bagassosis and farmer's lung, pneumonia in cancer patients, systemic infections in abnormal host; diagnosis: Grocott methenamine silver, PAS and Wright's stain and culture; treatment: amphotericin B, itraconazole, flucytosine, ketoconazole

P. citreum: causes urinary infections

P. citrinum: most widespread species in tropics; most common species in flour; produces citrinin (mycotoxin)

P. commune: produces cyclopiazonic acid (mycotoxin) in cheese

P. crustosum: produces penitrem A (mycotoxin) in wide range of processed foods

P. expansum: produces patulin and citrinin (mycotoxins) in pome fruits, grapes, tomatoes, refrigerated foods

P. marneffeii: causes infections in T helper lymphocyte deficiency, penicilliosis in AIDS in S E Asia

P. verrucosum: produces ochratoxin A in processed meats and stored grains

Micropolyspora faeni (Thermosporopolyspora vulgaris): causes bagassosis and farmer's lung

Paecilomyces lilacinus: causes chronic sinusitis in immunocompromised

Trichoderma: resistant to most antifungal agents

T. longibrachiatum: causes peritonitis in continuous ambulatory peritoneal dialysis, invasive infections in immunocompromised patients

T. viride: causes peritonitis in continuous ambulatory peritoneal dialysis

Fonsecaea: causes chromoblastomycosis; diagnosis: micro and culture, complement fixation test; treatment: surgery, flucytosine + thiabendazole or amphotericin B, ketoconazole ? flucytosine, itraconazole

F.compacta: causes chromoblastomycosis (Far East)

F.pedrosoi: causes brain and epidural abscess, chromoblastomycosis (Far East)

Alternaria: causes chronic eye infections, chronic sinusitis in immunocompromised, keratitis and iritis, local and generalised sepsis, mucosal and visceral infections; treatment: itraconazole, natamycin

A.alternata: causes phaeohyphomycosis; produces tenuazonic acid, alternanol and alternanolmonomethyl ether (mycotoxins) in tomatoes, capsicums, eggplants, sorghum, wheat and related grains

Cladophialophora bantiana: causes brain and epidural abscess, phaeohyphomycosis, systemic infections in abnormal host; susceptible to clotrimazole (MIC 0.4 mg/L)

C.carrionii: causes chromoblastomycosis (Australia, S Africa, Venezuela)

C.cladosporiodes: causes systemic infections in abnormal host

Madurella grisea: causes mycetoma

Madurella mycetomatis: causes mycetoma

Curvularia: saprobic dematiaceous mould residing primarily in soil; causes keratitis and iritis, peritonitis in continuous ambulatory peritoneal dialysis (rare); treatment: natamycin

C.geniculata: causes mycetoma, phaeohyphomycosis

C.lunata: causes rare cases of endocarditis, brain abscess, skin infections, onychomycosis, keratitis, pneumonia, disseminated disease, mycetoma, allergic bronchopulmonary disease, chronic sinusitis; treatment: debridement, surgery

C.pallescens: causes brain and epidural abscess

Bipolaris: causes chronic sinusitis in immunocompromised, systemic infections in multiple myeloma, 2 cases of meningencephalitis in cancer patients; diagnosis: histology and culture of biopsy specimens; treatment: itraconazole, amphotericin B

B.australiensis: causes peritonitis in continuous ambulatory peritoneal dialysis

B.hawaiiensis: causes brain and epidural abscess, phaeohyphomycosis

B.spicifera: causes brain and epidural abscess, peritonitis in continuous ambulatory peritoneal dialysis

Chaetoconidium: causes chronic sinusitis in immunocompromised

Coniothyrium: causes chronic sinusitis in immunocompromised

Phialophora hoffmanii: causes phaeohyphomycosis

P.parasitica: causes phaeohyphomycosis

P.parasitici: causes phaeohyphomycosis

P.repens: causes phaeohyphomycosis

P.richardsiae: causes phaeohyphomycosis

P.spicifera: causes phaeohyphomycosis

P.verrucosa: causes chromoblastomycosis, phaeohyphomycosis

Phoma: causes phaeohyphomycosis

Pleurophoma: causes phaeohyphomycosis

Dermatophytes: skin fungi; *Microsporum*, *Epidermophyton*, *Trichophyton*, cause ringworm, infection of skin, hair and nails; some species acquired from animals; mean doubling time 1-24 h in vitro at 28°C

Microsporum: dermatophyte; produces fluorescence with Wood's UV light; causes infection of skin, hair and nails, ringworm; some species acquired from animals

M.audouinii: anthropophilic; 0.05% of dermatophytes identified in Australia (solely from body); causes childhood epidemic tinea capitis (not in Europe, declining importance in USA), systemic infections in abnormal host

M.canis var canis: zoophilic (dogs, cats); 7% of dermatophytes identified in Australia (mainly body, limb, scalp); large decline in relative importance over past 25 y; causes ringworm, nonepidemic scalp infections (ectothrix; uncommon in Europe, ? 50% in USA, 24% in Australia, 75% in Queensland)

M.cookei: perfect state *Arthroderma cajetana*; macroconidia abundant, oval to elliptical, thick-walled, verrucose, multi-septate; found in 55% of soils; 0.05% of dermatophytes identified in Australia (solely from foot); produces penicillin and other antibiotics

M.ferrugineum: causes ringworm of scalp and glabrous skin; Africa, India, China, Japan

M.fulvum: perfect state *Arthroderma fulva*; macroconidia longer and more clavate than those of *M.gypseum*, 3-6 septa; geophilic; causes sporadic tinea corporis, tinea capitis, tinea barbae

M.gallinae: zoophilic (birds); produces antibiotics

M.gypseum: perfect state *Arthroderma gypseum*, *Arthroderma incurvata*; macroconidia abundant, ellipsoidal, thin-walled, verrucose, 4-6 celled; found in 68% of soils; 2% of dermatophytes identified in Australia (mainly body and limb); slight decline in relative importance over past 25 y; causes ringworm of scalp (suppuration and kerion common; relatively rare in USA, common in S America, 11% in Queensland) and glabrous skin; produces fusidic acid-like antibiotic, penicillin and other antibiotics

M.nanum: perfect state *Arthroderma obtusa*; zoophilic (pigs) and geophilic; 0.05% of dermatophytes identified in Australia (solely body)

Epidermophyton: dermatophyte; causes ringworm, infection of skin and nails (never hair)

E.floccosum: normal flora of skin; anthropophilic; ubiquitous but more common in tropics; 9% of dermatophytes identified in Australia (mainly groin, body, foot, limb); causes athlete's foot, skin and nail infections, tinea corporis, tinea cruris (classic eczema marginata; 29% of isolations in Australia), tinea pedis (minority of cases); produces penicillin, actinomycin and other antibiotics

Trichophyton: normal flora of skin; causes athlete's foot, ringworm, skin diseases; infection restricted to skin, nails, hair; some species acquired from animals; produces 'antibacterial substances' (myosine, ? penicillin); susceptible to clotrimazole (MIC < 0.05-1.56 mg/L)

T.ajelloi: perfect state *Arthroderma uncinatum*; found in 30% of soils

T.concentricum: 0.05% of dermatophytes identified in Australia (body only)

T.equinum: some strains require nicotinic acid (not most Australian strains— *T.equinum* var *autotrophicus*); zoophilic (horses); 0.05% of dermatophytes identified in Australia

T.mentagrophytes: perfect state *Arthroderma benhameii*; urease positive in 2-5 d, red pigment not formed; found in 4% of soils; declining relative importance in Australia over past 25 y; produces penicillin and 6-aminopenicillanic acid

T.mentagrophytes var erinacei: 0.3% of dermatophytes identified in Australia (scalp, body)

T.mentagrophytes var granulare: 8% of dermatophytes identified in Australia (mainly foot, body, limb, hand, face); zoophilic (rodents); causes ringworm of smooth skin, suppurative folliculitis in scalp and beard

T.mentagrophytes var interdigitale: downy variety; 11% of dermatophytes identified in Australia (mainly foot, body, nail); anthropophilic; causes tinea pedis ('athlete's foot'; 39% of isolations in Australia), tinea unguium, tinea cruris (5% of isolations in Australia)

T.mentagrophytes var quintuarum: 0.1% of dermatophytes identified in Australia (groin and foot)

T.rubrum: produces red pigment on lactrimel and T1 medium in 2 w, urease negative at 1 w; anthropophilic; 53% of dermatophytes identified in Australia (all sites; most commonly body and foot, rarely scalp; large increase in relative importance over past 25 y); causes tinea cruris (63% of isolations in Australia), tinea pedis (53% of isolations in Australia), tinea unguium (most common cause in USA; 74% of isolations in Australia), psoriasis-like lesions of smooth skin (25% of tinea corporis), mild suppurative folliculitis in beard; produces penicillin and other antibiotics

T.schoenleini: anthropophilic; causes favus in scalp and smooth skin, scutulum and kerion; Europe, Far East, rare in USA

T.soudanense: 0.05% of dermatophytes identified in Australia (body only); causes more inflammatory types of tinea capitis and tinea corporis; Central and W Africa

T.terrestre: perfect state *Arthroderma quadrifolium*; geophilic; 0.7% of dermatophytes identified in Australia (all sites except scalp, face); produces penicillin and other antibiotics

T.tonsurans: slow growing, growth enhanced by thiamine; anthropophilic; 7% of dermatophytes identified in Australia (mainly body, scalp (46% of isolations in Australia, 11% in Queensland), limb and face); causes black dot ringworm of scalp and smooth skin, sycosis, onychomycosis in all age groups; common in Aborigines and in slums; causes 95% of tinea capitis in USA

T.verrucosum: growth stimulated by inositol and (to much lesser extent) by thiamine; zoophilic (cattle); 0.9% of dermatophytes identified in Australia (limb, body, face, hand; slight decline in relative importance over past 25 y); causes nonepidemic ringworm of scalp and smooth skin, suppurative folliculitis in scalp and beard; produces penicillin and other antibiotics

T.violaceum: growth stimulated by thiamine; anthropophilic; 0.7% of dermatophytes identified in Australia (scalp, body, nail, groin, hand; slight decline in relative importance over past 25 years); causes black dot endothrix infections in scalp and smooth skin (kerion frequent), onychomycosis; common in Europe and Far East, rare in USA

Malassezia furfur: causes tinea versicolor (desquamating macular rash), fungemia in patients receiving i.v. fat emulsions; treatment selenium sulphide, sodium thiosulphate, ketoconazole, amphotericin B ? flucytosine, fluconazole

M.pachydermatis: causes fungemia in patients receiving i.v. fat emulsions; treatment: amphotericin B ? flucytosine, fluconazole

Pityosporum: mostly unicellular budding cells, reproduction by blastospores that cut off from mother cell by development of a cross wall, cell may adhere, forming short hyphal structures

P.ovale: normal flora of skin; ? causes dandruff; treatment: selenium sulphide shampoo

Piedraia hortae: causes black piedra; diagnosis: micro and culture of nodules on hair shafts; treatment: shaving, sulphur ointment

Rhinosporidium seeberi: causes rhinosporidiosis; treatment: natamycin

Trichosporon: reproduction by blastospores and arthrospores, mycelium and pseudomycelium formed; causes fungemia, infections in abnormal host (neutrophil dysfunction), pneumonia and disseminated infections in cancer patients; growth stimulated by excess iron; susceptible to amphotericin B (MIC 0.78-3.13 mg/L), ketoconazole, fluconazole, itraconazole

T.beigelii: causes peritonitis in continuous ambulatory peritoneal dialysis (rare), systemic infections in abnormal host; diagnosis: blood cultures, culture and histology of specimens; treatment: amphotericin B + flucytosine

T.cutaneum: causes white piedra, systemic infections in abnormal host (rare cases of endocarditis, fungemia)

Blastoschizomyces capitatus: causes systemic infections in leukemia; diagnosis: blood cultures, smear and culture of sputum, sinus, biopsy; treatment: amphotericin B + flucytosine

Rhinocladiella: causes chromoblastomycosis

R.atrovirens: 1 case of brain abscess in HIV infected i.v. drug abuser

Scedosporium: causes cellulitis (posttraumatic), osteomyelitis and osteochondritis (penetrating injury, surgery), otitis externa; diagnosis: micro and culture of appropriate specimen; treatment: debridement, itraconazole

S.apiospermum: asexual form of *Pseudallescheria boydii*; causes scedosporiosis

S.prolificans: causes chronic sinusitis in immunocompromised, pneumonia in disseminated infection; resistant to amphotericin B

Schizophyllum: causes chronic sinusitis in immunocompromised

Pneumocystis: previously classified as parasite; causes pneumonia (interstitial plasma cell pneumonia, plasma cell pneumonia of infants); growth stimulated by excess iron

P.jiroveci: causes acute diarrhoea and/or vomiting in AIDS, diffuse interstitial plasma cell pneumonia, disseminated infection (AIDS, haematological malignancy, lymphoreticular malignancy, immunosuppressive therapy), systemic infection in cell-mediated immunity disorders; primary bodily defence mechanism humoral immune responses (immune adherence (phagocytosis) +++); resistance to reactivation of latent infection due to cell-mediated immunity (delayed type hypersensitivity-activated macrophage +++); interferon- γ , tissue necrosis factor and interleukin-1 active in experimental infections; diagnostic stage in lung; diagnosis: indirect fluorescent antibody (titre ? 1:40), toluidine blue O stain of transtracheal aspirate, brush biopsy or open lung biopsy, Grocott's methenamine silver tissue stain, culture in Vero cells; treatment: miconazole, chloroquine, cotrimoxazole, pentamidine isethionate, carbutamide, trimethoprim + dapson, eflornithine, trimetrexate + calcium folinate + sulphadiazine, clindamycin + primaquine; prednisolone for hypoxia

Prototheca: achlorophyllic alga; large (8-20 ? m diameter), nonbudding, spherical, ovoid or elliptical cells (theca) with prominent wall and containing several thick-walled autospores; colonies yeast-like in appearance; causes cutaneous and subcutaneous infection, olecranon bursitis, systemic infections in abnormal host; diagnosis: stains poorly in haematoxylin and eosin, stains well in Grocott's silver stain, PAS useful for observing starch grains, immunofluorescent stains, culture; treatment: surgical excision, amphotericin B ? nystatin, pentamidine, ketoconazole

P.moniformis: oval or spherical cells > 9.5 ? m in long dimension; capsule always present; does not assimilate trehalose, does not assimilate galactose strongly

P. stagnora: spherical cells < 8.5 μ m diameter; capsule common; does not assimilate trehalose, does assimilate galactose

P. wickerhamii: spherical cells < 8.5 μ m diameter; does assimilate trehalose, does not assimilate 1-propanol or acetate (pH 5); causes systemic protothecosis

P. zopfii: oval or spherical cells > 8.5 μ m diameter in long dimension; no capsule; does not assimilate trehalose, does not assimilate galactose strongly, assimilates 1-propanol and acetate (pH 5); causes systemic protothecosis

***Pythium* (? Kingdom Protocista)**: causes arteritis in thalassemic farmers; growth stimulated by excess iron; treatment: surgery + i.v. sodium iodide