

## Chapter 19

### Animal Parasites

**Dinoflagellates:** classed as protozoa or algae; appear to be a bridge between prokaryotes and eukaryotes; most with 2 flagella; most marine; some produce powerful respiratory toxins; create 'red tides'

**Alexandrium:** 'indigenous' to ballast and sea water; causes paralytic shellfish poisoning

**Dinophysis:** causes diarrhoeal shellfish poisoning

**Gambierdiscus toxicus:** 'indigenous' to sea water; causes ciguatera fish poisoning; treatment: supportive, i.v. mannitol, tocainide, amitriptyline, nifedipine

**Gymnodinium breve:** 'indigenous' to ballast and sea water; causes neurotoxic shellfish poisoning; treatment: supportive

**Gonyaulax tamarensis:** causes paralytic shellfish poisoning; treatment: supportive

**Pfiesteria piscicida:** responsible for killing enormous numbers of fish in Chesapeake Bay on US Atlantic seacoast, and for memory loss and skin problems in fishermen

**Pseudonitzschia pungens:** causes amnesic shellfish poisoning

#### Kingdom Protista

#### Subkingdom Protozoa

#### Phylum Sarcomastigophora

#### Subphylum Sarcodina

#### Class Rhizopoda

**Order Amoebida:** amoebae; naked protoplasts during trophic stage, which characteristically form lobose pseudopodia that constitute locomotor organelles

#### FAMILY ENTAMOEBAE

**Entamoeba:** endoparasitic amoebae which have a more or less distinct nucleus (generally 1 nucleus in trophozoite), a relatively small spherical karyosome at or near centre of nucleus, peripheral layer of fine chromatin beads or granules lining distinct nuclear membrane; human-human transmission by ingestion of cysts; growth stimulated by excess iron

**E.coli:** trophozoites 15-50  $\mu$ m (usual range 20-25  $\mu$ m), motility sluggish, nonprogressive, with blunt pseudopods, 1 nucleus, often visible in unstained preparations, peripheral chromatin coarse granules, irregular in size and distribution, karyosomal chromatin large, discrete, usually eccentrically located, cytoplasm coarse, often vacuolated, contains bacteria; ripe cyst

10-35  $\mu$ m (usual range 15-25  $\mu$ m), usually spherical, occasionally oval, triangular or another shape, with 8 nuclei, occasionally supernucleate cysts with 16 or more, immature cysts with 2 or more occasionally, peripheral chromatin present, coarse granules irregular in size and distribution but appear more uniform than in trophozoites, karyosomal chromatin large, discrete, usually eccentric but occasionally central, glycogen in early stages only, large chromatids occasionally present but often absent, usually splinterlike with pointed ends; prevalence +++ (12% of travellers from tropics, 14% of homosexual men, 5% of Haitian entrants to USA); commensal (colonisation ? no disease) lumen parasite of large bowel; viable cysts passed in faeces transmitted to new host by contaminated food or drink or by fingers or fomites contaminated with faeces; diagnosis: demonstration of trophozoites or cysts in faeces

**E. dispar:** morphologically identical to *E.histolytica* but does not cause invasive disease

**E.gingivalis:** normal flora of mouth; found in gingival tissues; more common in the presence of inflammation

**E.hartmanni:** trophozoites 5-12  $\mu$ m (usual range 8-10  $\mu$ m), usually nonprogressive motility but may be progressive occasionally, 1 nucleus, not visible in unstained preparations, peripheral chromatin similar to *E.histolytica*, karyosomal chromatin small, discrete, often eccentrically located, cytoplasm finely granular, contains bacteria; cysts 5-10  $\mu$ m (usual range 6-8  $\mu$ m), usually spherical, 4 nuclei in mature cyst, immature cysts with 1 or 2 often seen, chromatin

similar to *E.histolytica*, chromatid bodies present, elongated bars with bluntly rounded ends, glycogen similar to *E.histolytica*; prevalence + (0.3% of travellers from tropics, 2% of homosexual men, 1% of Haitian entrants to USA); commensal in lumen of large intestine; diagnosis: demonstration of trophozoites or cysts in faeces

***E.histolytica***: trophozoites 10-60  $\mu$ m (usual range > 20  $\mu$ m), motility progressive with hyaline, fingerlike pseudopods, 1 nucleus, not visible in unstained preparations, peripheral chromatin fine granules, usually evenly distributed and uniform in size, karyosomal chromatin small, discrete, usually central but occasionally eccentric, cytoplasm finely granular, may contain erythrocytes; ripe cysts 10-20  $\mu$ m (usual range 12-15  $\mu$ m), usually spherical, with 4 nuclei, immature cysts with 1 or 2 occasionally, peripheral chromatin present, fine uniform granules, evenly distributed, karyosomal chromatin small, discrete, usually central, glycogen diffuse, concentrated mass often present in young cysts, stains reddish-brown with iodine, large chromatids generally present, elongated bars with bluntly rounded ends; prevalence high; global mortality 75 000/y (74 000 in developing world); case-fatality rate up to 47%; impact on nutrition with symptomatic clinical disease; causes amoebiasis (amebiasis, amoebosis, entamoebiasis), brain abscess, colitis, acute diarrhoea and/or vomiting, amoebic dysentery (1% of infective diarrhoea in adults), appendicitis, adult hepatitis, hepatic 'abscess' (bacteriologically sterile necrotic foci filled with proteinaceous debris rather than pus; most frequent in adult males), hepatic granuloma, pulmonary abscess, traveller's diarrhoea, urethritis in homosexual males, cutaneous amoebiasis; transmission by ingestion of cysts; attaches to and penetrates epithelium of large intestine, causing disease by killing epithelial cells and inducing diarrhoea by mucosal damage and inflammation; rarely invades subepithelial tissues and subsequently spreads through body (especially to liver); trophozoites in brain parenchyma, in tissue of genitourinary system (vagina, cervix, penis), in ulcers in large intestine, in liver and lung parenchyma, in wall of skin ulcer; cysts free in lumen of large intestine; shows leucotoxicity; diagnosis: combination of MIF staining and formalin-ethyl acetate concentration, direct smear of fresh stool to observe amoeboid motility, iron-haematoxylin or trichrome stain, serology (commonly available— indirect haemagglutination and counterimmunoelectrophoresis (most sensitive and specific), latex agglutination, immunodiffusion (agar gel diffusion), ELISA; evaluated— bentonite flocculation, indirect immunofluorescence, immunoelectrophoresis); treatment: metronidazole, tinidazole, emetine, dihydroemetine, chloroquine, iodoquinol, diloxanide furoate, paromomycin, iodoquinol; prevention and control by water and sanitation moderately feasible, moderate priority; health education, adequate diagnosis and correct treatment of invasive amoebiasis, implementation of surveillance and control programs also important

***E.polecki***: trophozoites 10-25  $\mu$ m (usual range 15-20  $\mu$ m), usually sluggish motility, occasionally progressive in diarrhoeic specimens, 1 nucleus, may be slightly visible in unstained preparations, occasionally distorted by pressure from vacuoles in cytoplasm, peripheral chromatin usually fine granules evenly distributed, occasionally irregularly arranged, sometimes in plaques or crescents, karyosomal chromatin small, discrete, eccentric, occasionally large, diffuse or irregular, cytoplasm granular, with numerous vacuoles, contains bacteria and yeasts; cysts 9-18  $\mu$ m (usual range 11-15  $\mu$ m), spherical or oval, 1 (rarely 2) nucleus, occasionally visible in unstained preparations, peripheral chromatin usually fine granules evenly distributed, karyosomal chromatin usually small and eccentric, chromatoid bodies present, many small bodies with angular or pointed ends or few large ones, may be oval, rodlike or irregular, glycogen usually small, diffuse masses, stains reddish-brown with iodine, dark inclusion mass often present, does not stain with iodine; usually considered rare but multiple cases found in SE Asian refugees; probably widely distributed; primarily parasite of hogs and monkeys; usually considered nonpathogenic but found in patients with loose stools or diarrhoea; diagnosis: demonstration of trophozoites or cysts in faeces; treatment: diloxanide furoate 500 mg three times daily for 10 d

***Endolimax***: parasitic amoeba of small size, having a vesicular nucleus; generally 1 nucleus in trophozoite, with a comparatively large, irregular, eccentric karyosome attached by several achromatic threads to a delicate nuclear membrane; no peripheral chromatin granules; forms cysts

***E.nana***: trophozoite 6-12  $\mu$ m (usual range 8-10  $\mu$ m), sluggish, usually nonprogressive, with blunt pseudopodia, 1 nucleus, occasionally visible in unstained preparations, no peripheral chromatin, karyosomal chromatin large, irregularly shaped, blotlike, cytoplasm granular, vacuolated, contains bacteria; ripe cyst 5-10  $\mu$ m (usual range 6-8  $\mu$ m), spherical, ovoid or ellipsoidal, with 4 nuclei, immature cysts with < 4 rare, no peripheral chromatin, karyosomal chromatin large, blotlike, usually central, occasionally chromatid granules or small oval masses, glycogen rarely present, usually diffuse, concentrated mass occasionally in young cysts, stains reddish-brown with iodine, chromatoids absent;

frequently inhabits lumen of large intestine; cosmopolitan (14% of travellers from tropics, 16% of homosexual men, 4% in male Haitian entrants to USA); nonpathogenic; diagnosis: demonstration of trophozoites or cysts in faeces

***Iodamoeba***: generally 1 nucleus in trophozoite; large, central, spherical karyosome rich in chromatin, surrounded by layers of achromatic granules or globules and anchored to the nuclear membrane by achromatic filaments; in endoplasm, 1, or at times 2, well-circumscribed glycogen vacuole, invariably present in cyst, occasionally seen in trophozoite; no peripheral chromatin

***I. bütschlii***: trophozoites 8-20  $\mu$ m (usual range 12-15  $\mu$ m), motility sluggish, usually nonprogressive, 1 nucleus, usually not visible in unstained preparations, no peripheral chromatin, karyosomal chromatin large, usually central, surrounded by refractile, achromatic granules (often not distinct), cytoplasm coarse, granular, vacuolated, contains bacteria, yeasts, other material; ripe cysts 5-20  $\mu$ m (usual range 10-12  $\mu$ m), ovoid, ellipsoidal, triangular or other shape, with 1 nucleus, no peripheral chromatin, karyosomal chromatin large, usually eccentric, refractile, achromatic granules on one side of karyosome (indistinct in iodine preparations), glycogen in a dense mass, stains dark brown with iodine, no chromatoids; inhabits lumen of large intestine; cosmopolitan (2% of male Haitian entrants to USA, 3% of travellers from tropics, 13% of homosexual men); no evidence of pathogenicity for man; diagnosis: demonstration of trophozoites or cysts in faeces

**Subphylum Mastigophora**: move by means of specialised structures known as flagella

**Class Zoomastigophora**: intestinal flagellates; lack chromosome

**Order Protomastigophora**: small forms with 1 or 2 flagella and relatively plastic body

**Family Retortamonadidae**: 2 flagella, 1 of which is directed anteriorly, a second posteriorly and trailing, both arising from a blepharoplast immediately in front of an anteriorly situated nucleus

***Retortamonas intestinalis***: relatively plastic body which is pyriform, ovoid or fusiform and is attenuated posteriorly; rare; probably nonpathogenic

***R. sinensis***: rare; probably nonpathogenic

#### **Family Acanthamoebidae**

***Acanthamoeba***: causes acanthamoebiasis (granulomatous amoebic meningoencephalitis; insidious neurologic changes in debilitated or immunosuppressed patients who usually have no history of recent exposure to fresh water; CNS infection secondary to some other focus; death after a more chronic course), nonpurulent conjunctivitis, keratitis and iritis, anterior uveitis, pneumonitis, sinusitis and disseminated infection in AIDS; diagnostic stage in CNS and eye; treatment: amphotericin B + miconazole + rifampicin, propanidine isethionate, bibromopropanidine isethionate, clotrimazole + neomycin or gentamicin

***A. astromyxis***: isolated from human CNS

***A. castellani***: isolated from human CNS, eye (keratitis and iritis)

***A. comedoni***: not isolated from human infections

***A. culbertsoni***: isolated from human CNS, eye (keratitis and iritis)

***A. griffini***: not isolated from human infections

***A. hatchetti***: isolated from human eye (keratitis and iritis)

***A. lenticulata***: not isolated from human infections

***A. palestinensis***: isolated from human CNS

***A. polyphaga***: isolated from human CNS, eye (keratitis and iritis)

***A. rhysoides***: isolated from human CNS, eye (keratitis and iritis)

***A. soyreba***: not isolated from human infections

***A. tubiashi***: not isolated from human infections

#### **Family Vahlkampfiidae**

***Naegleria***: causes amoebic meningoencephalitis, nonpyogenic meningitis; enters by penetration of mucous membranes; growth stimulated by excess iron

***N. australiensis***: not isolated from human infections

***N. fowleri***: causes naegleriasis (acute, fulminant, usually rapidly fatal meningoencephalitis usually affecting children and young adults exposed to water harbouring amoebae ('indigenous' to warm water); gains access to brain via olfactory epithelium); treatment: amphotericin B + miconazole + rifampicin

***N. gruberi***: not isolated from human infections

***N. jadini***: not isolated from human infections

***N. lovaniensis***: not isolated from human infections

***Vahlkampfia***: associated with corneal infections

#### **Family Hartmanellidae**

***Hartmanella***: associated with corneal infections

#### **Family Monocencomonadidae**

***Dientamoeba***: minute; generally 2 nuclei present; central particulate karyosome with several distinct granules; no peripheral chromatin; no cystic stage

***D. fragilis***: trophozoites 5-15  $\mu$ m (usual range 9-12  $\mu$ m), pseudopodia angular, serrated or broad-lobed and hyaline, almost transparent, 2 nuclei (only 1 present in ? 20%), invisible in unstained preparations, central granular karyosomes (large cluster of 4-8 granules) and no peripheral chromatin, cytoplasm finely granular, vacuolated, contains bacteria; cysts unknown; prevalence + (14% of immigrant children, 3% of travellers from tropics, 0.9% of homosexual men); pathogenicity ? (noninvasive, but has been associated with low grade superficial irritation of bowel mucosa, excess mucus and recurrent episodes of diarrhoea in 43-58% of cases (10-23% bloody, mucoid or loose stool), abdominal discomfort and pain in 46-54%, flatulence in 6-20%, fatigue and weakness in 6-13%, nausea or vomiting in 4-20%, alternating diarrhoea and constipation in 4-14%, weight loss in 3-10%); chief cause of parasitic gastrointestinal disease in Canada and Great Britain; faecal-oral transmission; trophozoites free in lumen of large intestine, possibly in tissue, found most commonly in mucous secretions within glandular crypts; diagnosis: stained trophozoites: high percentage of binucleate trophozoites, nuclei with peripheral chromatin, 4-8 chromatin granules in central mass; treatment: iodoquinol 650 mg 3 times a day (child: 40 mg/kg daily) for 10 d, tetracycline 250 mg four times a day for 7 d, paromomycin 500 mg 3 times a day for 5-7 d

**Family Hexamitidae**: 2 nuclei lying side by side in transverse plane; 6-8 flagella in 3 or 4 pairs; in some genera, paired axonemes; generally show bilateral symmetry

***Giardia***: trophozoites rounded anteriorly and tapered posteriorly, have convex dorsal surface and flattened ventral side with a shallow sucking disc in its anterior portion and 4 pairs of flagella arising from a complicated system of axonemes; cysts are ovoid to ellipsoidal and have thin, tough wall from which cytoplasm is characteristically separated

***G. intestinalis (G. lamblia)***: flagellate; high global prevalence (cosmopolitan; worldwide 200 M); most frequently identified organism in stools; 2-15% of immigrants, 27% of immigrant children, 19% of Guatemalan children, 6% of SE Asian refugees, 5% of travellers from tropics, 2% of homosexual men, 7% in USA, 3% in temperate climates (up to 20% in children), 25% in tropical areas; half of all instances of diarrhoea in primary hypogammaglobulinemia); causes giardiasis (giardosis, lambliaosis, lamblosis; low grade intestinal disease of upper small intestine and gall bladder; most frequently asymptomatic but acute or chronic disease— acute diarrhoea (incubation period 15 d; lasts > 5 d; recurrent and mucoid; 1% of infective diarrhoea in adults; up to 2% of traveller's diarrhoea) and/or vomiting, nursery infection, chronic diarrhoea and failure to thrive in children in tropical areas, chronic intestinal malabsorption— may result; predisposing factors blood group A, primary hypogammaglobulinemia, protein-energy malnutrition (in association with hypochlorhydria and pancreatitis), in children in developing countries, 25% of waterborne disease outbreaks (derived from animal and human faeces), infection in abnormal host (?-globulin dysfunction); faecal-oral transmission (human-human) by ingestion of viable cysts in contaminated food or drink; oral infectious dose in man 10-100 cysts; also direct transmission in day care centres and between sexual partners in homosexual males; attack rate 17-90% in day care centres, 12-50% in family members; incubation period 12-19 d; attaches to intestinal epithelium by mechanical sucker; replicates attached to intestinal epithelium; infection generally confined to epithelial surface of intestinal tract; diarrhoea not always produced, mechanism not understood; probable impact on nutrition (achlorhydria/hypochlorhydria, impaired protein digestion, bacterial overgrowth, local irritation and damage to microvilli underlying trophozoites, malabsorption of D-xylose and vitamin B<sub>12</sub> in 55-60%, steatorrhoea in 25-50%); recovery from primary infection due to antibody (interference with adherence +++), cell-mediated (+); diagnosis: demonstration of trophozoites in diarrhoeic, and cysts in formed, stools by modified Ritchie formalin-ether concentration, demonstration of trophozoites in duodenal or jejunal aspirate or by use of duodenal 'capsule'; counterimmunoelectrophoresis reported as sensitive and reliable in combined examination of faeces and duodenal fluid, ELISA (92% sensitivity, 98% specificity) reported; treatment:

metronidazole (> 99% cure rate with 15 mg/kg/d to 250 mg 3 times a day for 5-10 d), quinacrine, furazolidone, tinidazole, albendazole, paromomycin; prevention and control by intermittent treatment of those infected, improved water supply and sanitation, education high feasibility and priority

**Order Trichomonadida:** axostyle, 1 or 2 blepharoplasts and 3-6 flagella, 1 of which is a trailing flagellum

**Family Trichomonadidae:** cyclostome, 3-5 free flagella and an additional flagellum on the margin of an undulating membrane, and an axostyle which usually protrudes through posterior end of the body

**Trichomonas:** trophozoites with 4 free flagella and fifth along outer margin of an undulating membrane, costa at base of undulating membrane, conspicuous axostyle; causes trichomoniasis (trichomonosis, tricomoniasis), meningitis (associated with surgery)

**T.hominis:** cosmopolitan; prevalence + (0.1% of travellers from tropics); causes infection in abnormal host; trophozoites free in lumen of large intestine (trichomoniasis, cercomoniasis, intestinal trichomoniasis, intestinal tricomoniasis; no specific signs or symptoms and no conclusive evidence of pathogenicity); diagnosis: unstained trophozoites characteristic motility, undulating membrane, axostyle protruding through posterior part of body, stained trophozoites costa and axostyle, no cysts

**T.tenax:** normal flora of oral cavity of persons with poor oral hygiene; causes an extremely rare disease of mouth, gums and, occasionally, respiratory tract; has been associated with lung or thoracic abscesses

**T.vaginalis:** flagellate; normal flora of anterior urethra, vagina; prevalence +++; causes trichomoniasis (genital infection in both sexes; trichomonal vaginitis, urogenital *Trichomonas* infection, urogenital trichomoniasis, urogenital *Trichomonas* infection, urogenital tricomoniasis, vaginal trichomoniasis, vaginal tricomoniasis; leucorrhoea, prostatitis, urethritis, vaginitis, vulvovaginitis); sexually (usually) and nonsexually transmitted; often asymptomatic; disease worse in female; infection generally confined to epithelial surface of urogenital tract (trophozoites on surface of vaginal mucosa, in prostatic and seminal fluid in male, in urine of male and female); treatment: metronidazole, clotrimazole, tinidazole, nimorazole, natamycin, crystal violet

**Family Chilomastigidae:** trophozoites have 3 anteriorly directed free flagella, a delicate fourth flagellum lying within a cytostomal cleft and pear-shaped cysts in which a cytostome is clearly visible

**Chilomastix:** trophozoites rounded anteriorly and attenuated posteriorly, 3 anteriorly directed free flagella and a more delicate one within a prominent cytostome; cysts pear or lemon shaped, with rather thick wall, show clearly a large cytostome

**Chilomastix mesnili:** cosmopolitan; frequently found in caecal region of large intestine and in stools (2% of travellers from tropics, 0.9% of homosexual men); unlikely to be pathogenic; normally no signs or symptoms but some authors have reported diarrhoea associated with very large numbers of organisms (chilomastixiosis, chilomastixiasis, chilomastosis); infection from ingestion of viable cysts in contaminated food or drink; diagnosis: unstained trophozoites anterior flagellum and spiral groove, stained trophozoites single anterior nucleus, cyclostome with a curved, shepherd's crook fibril, no costa or undulating membrane, unstained cysts protuberance at one end of lemon-shaped cyst, stained cysts single, large nucleus and curved cytostomal fibril

**Order Polymastigida:** relatively small forms having 3-8 flagella and 1, 2, or rarely several, nuclei

**Family Enteromonadidae:** 3 anterior flagella and a fourth trailing flagellum, lack axostyle and other axial organelles

**Enteromonas hominis:** fairly frequently found in large intestine and stool specimens, especially from patients with diarrhoea, but unlikely to be pathogenic; probably enters body through ingestion of viable cysts in contaminated food or drink; diagnosis: unstained trophozoites anterior flagella, trailing flagellum, no undulating membrane, stained trophozoites absence of a costa, axostyle or cytostomal fibrils, single nucleus with large anterior karyosome, small size, stained cysts oval shape, 1-4 nuclei with preponderance of binucleate forms, small size

**Family Trypanosomatidae**

**Leishmania:** flagellate; causes leishmaniasis (leishmaniosis), adult hepatitis, kala azar, oriental sore, infections in T helper lymphocyte dysfunction; reservoir in canines such as wild dogs, foxes, genets and hyrax, additionally on occasion in rats; transmission from animal host to man via sandflies (*Phlebotomus*) by inoculation of promastigotes, and from man to man by direct contact; multiplies in macrophages; carried in blood associated with mononuclear cells; antigenic depletion by capping and shedding of surface antigens; polyclonal activation ?; growth stimulated by excess iron; primary immune defence activation of phagocytes, by T cell-generated lymphokines, rendering them resistant to

infection; killing of infected phagocyte (delayed hypersensitivity), complement-fixing, neutralising, agglutinating and opsonising cytotoxic antibodies also important; diagnostic stage in skin; treatment: chloroquine, hydroxychloroquine, amodiaquine, mepacrine, quinine, primaquine, proguanil, pyrimethamine

***L. braziliensis* complex:** *L. braziliensis braziliensis*, *L. braziliensis guayanensis*, *L. braziliensis panamensis*, *L. braziliensis peruviana*; high global prevalence; cause New World cutaneous and mucocutaneous leishmaniasis; treatment: sodium stibogluconate, amphotericin B, metronidazole, ketoconazole, pentamidine isethionate, allopurinol, interleukin 2

***L. braziliensis braziliensis*:** causes espundia

***L. donovani* complex:** *L. donovani chagasi*, *L. donovani donovani*, *L. donovani infantum* and possibly other undescribed subspecies; India, Mediterranean, E Africa, Middle East, S Africa, China, Latin America; high global prevalence; cause cutaneous (rare) and visceral leishmaniasis; sandfly vector; human, dog, fox, rodent, jackal reservoirs; intracellular survival within macrophages by resistance to microbicidal events; susceptible to granulocyte-macrophage colony stimulatory factor-stimulated macrophages; interleukin-1 and interleukin-2 also induce antimicrobial activity; interferon- $\gamma$  and tissue necrosis factor also active in experimental infections; diagnosis: examination of bone marrow smears, splenic pulp smears, liver biopsy, thin smears of buffy coat of blood, lymph node aspirate or biopsy, culture of tissue or blood, ELISA, indirect haemagglutination test, direct agglutination titre, complement fixation test, latex agglutination, Montenegro skin test; treatment: sodium stibogluconate,  $\gamma$ -interferon, allopurinol, pentamidine isethionate, metronidazole

***L. mexicana* complex:** *L. mexicana amazonensis*, *L. mexicana garnhami*, *L. mexicana mexicana*, *L. mexicana pifanoi*, *L. mexicana venezuelensis*; high global prevalence; cause New World cutaneous leishmaniasis, nasopharyngeal and oronasal leishmaniasis (rare); resists lysosomal enzymes; treatment: sodium stibogluconate, amphotericin B, metronidazole, ketoconazole, pentamidine isethionate, allopurinol, interleukin 2

***L. tropica* complex:** *L. aethiopica*, *L. major*, *L. tropica*; high global prevalence; cause Old World cutaneous leishmaniasis, visceral leishmaniasis (rare); sterilising immunity (invasion ? disease ? cure); susceptible to tissue necrosis factor-stimulated macrophages; treatment: sodium stibogluconate, paromomycin, methylbenzethonium

***Trypanosoma*:** flagellate; transmission by biting insects (African: tse tse fly; American: reduviid); animal reservoir; 2 species pathogenic for man, causing trypanosomiasis; metacyclic trypomastigotes enter across skin epithelial surface and subsequently spread through body; multiplies within macrophages (American, some African) and outside cells (African); carried in blood free in plasma; growth stimulated by excess iron; microbial antigens vary within individual host (sequential adoptive phenotypic variation); causes immunodepression and polyclonal activation; primary immune defence activation of phagocytes by T cell-generated lymphokines, rendering them resistant to infection, and killing of microbe extracellularly by complement-mediated lysis or intracellularly by opsonised phagocytosis and killing; killing of infected phagocyte and neutralisation of microbial toxins also important; diagnostic stage in plasma, gastrointestinal tract, lymph node, muscle, heart; diagnosis: thick and thin blood films and buffy coat examination (febrile stage)

***T. brucei*:** causes African trypanosomiasis, sleeping sickness; natural resistance (no invasion); transmitted in blood; diagnosis: Giemsa stained smears of fluid aspirated from enlarged lymph gland, bone marrow aspirate, CSF, ELISA; treatment: suramin, melarsopol, nitrofurazone, difluoromethylornithine hydrochloride monohydrate

***T. brucei gambiense*:** high global prevalence; causes West African trypanosomiasis; transmitted by *Glossina palpalis*, *Glossina fusciceps* and *Glossina tachinoides*; trypomastigote free in blood, in parenchyma and blood in brain, in fluid in lymph nodes; treatment: as for *Trypanosoma brucei* + pentamidine isethionate

***T. brucei rhodesiense*:** high global prevalence; causes East African trypanosomiasis, haemorrhagic fever; transmitted by *Glossina morsitans*, *Glossina pallidipes*, *Glossina swynnertoni* and (around Lake Victoria) *Glossina fusciceps*; trypomastigote free in blood, in parenchyma and blood in brain, in fluid in lymph nodes; treatment: as for *Trypanosoma brucei*

***T. cruzi*:** high global prevalence; causes American trypanosomiasis (Chaga's disease), achalasia, infusion infections; transmitted by Reduviidae; transmitted in blood; persists in blood (trypomastigote free in blood) and macrophage (intracellular survival due to escape from lysosomes; may be infectious, not shed to exterior), causing chronic disease; amastigote in neuroglia cells in brain, in Kupfer cells in liver, intracellular in lymph nodes and cardiac muscle and in reticuloendothelial cells of spleen; ineffective immunity (invasion ? disease response ? no resistance or cure); ? antigenic mimicry by coating of parasite by immunoglobulin fractions (fabulation); diagnosis: Machado-Geurrein test,

indirect fluorescent antibody titre, haemagglutination inhibition test, culture of blood and bone marrow aspirate on biphasic blood agar medium, xenodiagnosis; treatment: nifurtimox

***T.rangeli***: found in human blood but causes no specific signs or symptoms and is not believed to be pathogenic for man; believed to be transmitted by bite of insects of genus *Rhodinus*

**Phylum Apicomplexa**: sporozoans

### **Order Eucoccidiida**

**Suborder Eimerina**: human coccidia; complex life cycle in which both sexual and asexual reproduction may occur and intermediate hosts may or may not be used

**Family Eimeriidae**: coccidia in which entire growth period (asexual and sexual through development of unsporulated oocyst) is passed within host cell

***Eimeria***: causes coccidiosis in domestic animals (may cause diarrhoea and blood loss); attaches to and penetrates epithelium of large intestine, causing disease by killing epithelial cells and inducing diarrhoea; found in stools in man but believed ingested and passed as unaltered oocysts; no real evidence of pathogenicity in man

***Isoospora***: causes isosporiasis (coccidial colitis, coccidial diarrhoea, coccidial dysentery, intestinal coccidiosis, isosporosis); usually acquired through ingestion of mature (viable) oocysts, eg. in contaminated food or drink; oocysts produce 2 sporoblasts mating into 2 sporocysts, each of which develops 4 sporozoites

***I.belli***: cosmopolitan but uncommon (0.2% of patients with AIDS in USA, 15% of patients with AIDS in Haiti); causes acute diarrhoea and/or vomiting in AIDS, enteritis, infections in T helper lymphocyte dysfunction; diagnosis: finding immature or mature oocysts in fresh stool or concentrate (multiple examinations may be required), Charcot-Leyden crystals common; treatment: cotrimoxazole

***I.hominis (Sarcocystis hominis)***: found in 0.3% of homosexual men; causes enteritis; local irritation and damage and nutrient malabsorption

***I.natalensis***: reported in human faeces

***Cyclospora cayetanensis***: infections reported from Americas, Africa, Indian subcontinent, South-East Asia, New Guinea; acquired from water and contaminated food (basil, lettuce, raspberries); causes enteritis; diagnosis: unsporulated oocysts in wet film or modified acid-fast stain; treatment: cotrimoxazole

### **Family Sarcocystidae**

***Sarcocystis***: cosmopolitan but rare; wide range of hosts including humans; obligatory 2 host (predator-prey) life cycle; causes sarcocystosis (*Sarcocystis*-induced coccidiosis, sarcosporidiosis)—intestinal sarcocystosis caused by number of species for which dogs, cattle and other animals serve as intermediate hosts and diagnosed by finding mature oocysts containing sporocysts and/or free sporocysts each containing 4 sporozoites in fresh stool or concentrate, and muscle sarcosporidiosis in which humans are dead-end intermediate host for many species and infection is detected by histologic demonstration of cysts in muscle tissue; acquired by ingestion of raw or partly cooked meat containing cysts

***S.lindemanni***: incertae sedis; oocysts not known; may be several species; causes sarcocystosis

***S.suihominis***: causes sarcocystosis

### **Family Toxoplasmatidae**

***Toxoplasma***: causes toxoplasmosis, adult hepatitis, hepatic granuloma, pneumonia, erythema nodosum, systemic infections in cell-mediated immunity disorders; multiplies in macrophages; growth stimulated by excess iron; ? antigenic change, immunodepression, polyclonal activation; immunity due to delayed type hypersensitivity, complement-fixing, neutralising, agglutinating and opsonising cytotoxic antibodies, ? blocking antibodies; treatment: sulphadiazine + pyrimethamine, cotrimoxazole

***T.gondii***: causes toxoplasmosis, anterior uveitis, brain abscess in impaired cell-mediated immunity, encephalitis (3-40% of AIDS patients), adult hepatitis, hydrocephalus, lymph gland infection (localised or general), nonpyogenic meningitis in immunosuppressed, mental retardation, diffuse interstitial pneumonia, pancreatitis (7% of cases in AIDS), stillbirth, prenatal meningitis, retinochoroiditis, infection in abnormal host (infusion infection, T helper lymphocyte dysfunction); widely distributed in animals and birds; transmitted by blood transfusion or transplacental infection of foetus during initial infection of mother (tachyzoite), ingestion of cyst (spherical, 100-200 ?m diameter; dormant form, resistant to chemotherapeutic agents, drying, gastric acid) in uncooked, undercooked or unfrozen meat, or of oocysts

(spherical, 10-12  $\mu$ m diameter; shed in faeces of members of cat family after cysts ingested in raw meat; highly resistant to desiccation in cat faeces), subsequently spreads through body; cysts and tachyzoites (crescentic, 2-4x4-8  $\mu$ m; rapidly proliferating form that causes tissue injury and disease; susceptible to chemotherapy) intracellular in eye, tachyzoites intracellular in spleen; inhibits attachment to polymorph, lysosome-phagosome fusion and degranulation; carried in blood associated with mononuclear cells; persists in lymphoid tissue, muscle (cysts and tachyzoites intracellular in cardiac and skeletal muscle) and brain (cysts and tachyzoites in cells and interstitial fluid; may be infectious, not shed to exterior), activation causing neurological disease; immunity cell-mediated (delayed type hypersensitivity-activated macrophage +++); susceptible to interferon- $\gamma$  and interferon- $\gamma$ -stimulated macrophages; interleukin-2, interleukin-12 and tissue necrosis factor also induce antimicrobial activity; diagnosis: indirect haemagglutination (? 1:1024), direct fluorescent antibody (tissue for antigen), indirect fluorescent antibody (titre ? 1:1024 = recent infection; IgM = recent or congenital infection), immunodiffusion, complement fixation test (? 1:8), ELISA, Sabin-Feldman dye test (? 1:1024), latex agglutination, IgG avidity, mouse inoculation; treatment: sulphadiazine or trisulphapyrimidine + pyrimethamine, cotrimoxazole, spiramycin, 5-fluorouracil, clindamycin

### **Family Cryptosporidiidae**

***Cryptosporidium***: coccidia that grow and reproduce within epithelial cells of respiratory and digestive organs of vertebrates; zoonosis; lacks host specificity; transmission faecal-oral (water, unpasteurised cow's milk); prevalence 0.5-3% in USA, 32% in Mexico, 50% in patients with AIDS in Haiti and Africa; incidence in Australia 1-17%; incidence highest during summer and autumn; age range 3 d to 95 years but children < 2 y greatest prevalence; causes acute diarrhoea and/or vomiting, traveller's diarrhoea, enteritis, appendicitis, cholangitis and cholecystitis; diagnosis: oocysts in fresh warm stools or duodenal aspirate (Sheather's sucrose-phenol microscopy within 2-4 minutes or immunofluorescence); treatment: discontinue immunosuppressive drugs, spiramycin, erythromycin, paromomycin, immune bovine dialyzable leucocyte extract

***C. felis***: human pathogen

***C. hominis***: primarily infects humans, but infections in dugong, lamb, cattle reported

***C. meleagridis***: human pathogen

***C. muris***: possible human pathogen

***C. parvum***: genotype 1 = *C. hominis*, genotype type 2 affects rodents, calves, lambs and other mammals as well as humans; causes cryptosporidiosis (self-limiting gastroenteritis (watery diarrhoea and fever) in persons with immune response, chronic diarrhoea, potentially fatal, in those with impaired immune response (T helper lymphocyte dysfunction); attack rate 50-66% in day care centres, 14% in family members); transmitted in water (source animal and human faeces); cause of largest water-borne outbreak in history (Milwaukee, 1993): 400 000 affected, with 85 deaths; interferon- $\gamma$  active in experimental infections

### **Family Plasmodiidae**

***Plasmodium***: very high world prevalence; causes malaria, periodic fevers, adult hepatitis, hepatic granuloma, infections in abnormal host (infusion infection, splenic dysfunction); transmitted by bite from infected mosquito (mainly *Anopheles stephensi* in urban areas), transmitted in blood; sporozoites enter across skin epithelial surface and subsequently spread through body; carried in blood associated with erythrocytes, multiplying within them; failure to display microbial antigen on infected erythrocyte surface; polyclonal B cell activation; antigenic change; immunodepression; kidney deposits of circulating immune complexes; high overall morbidity with symptomatic clinical disease; impact on nutrition; possible clinical antagonism by malnutrition; growth stimulated by excess iron; cell-mediated immunity important in host defence (delayed hypersensitivity), also complement-fixing, neutralising, agglutinating, blocking and opsonising cytotoxic antibodies; concomitant immunity (invasion ? disease ? no cure ? resistance to infection); diagnosis: indirect haemagglutination (? 1:16), direct fluorescent antibody (tissue for antigen), indirect fluorescent antibody (titre ? 1:16), ELISA, thick and thin blood smears collected between chills; treatment: chloroquine, primaquine, hydroxychloroquine, amodiaquine, mepacrine, quinine, proguanil, pyrimethamine; vector control low to moderate feasibility, high priority

***Plasmodium (Laverania) falciparum***: multiple rings in erythrocytes; usually stages beyond ring forms, with exception of gametocytes, are not seen in thin smears of peripheral blood, rest of stages being thought to develop in visceral capillaries; double chromatin dots, accolé forms (forms that appear on the smear to be flattened against the

margin of the erythrocytes); crescent-shaped gametocytes; 8-24 merozoites; causes 22% of malaria, postneonatal pyogenic meningitis in therapy for nutritional deficiency, haemorrhagic fever; high global prevalence (44% in Chad); treatment: chloroquine, quinine, quinidine, doxycycline, tetracycline, pyrazinamide-sulphadoxine, mefloquine, halofantrine, artemisate, artemether

***Plasmodium (Plasmodium) brasilianum***: very rare human infections

***P. (P.) cynomolgi***: very rare human infections

***P. (P.) cynomolgi bastianelli***: very rare human infections

***P. (P.) eylesi***: very rare human infections

***P. (P.) inui***: very rare human infections

***P. (P.) inui shortti***: very rare human infections

***P. (P.) knowlesi***: very rare human infections

***P. (P.) malariae***: all forms of parasite in peripheral blood; band forms; 8-12 merozoites; causes 2% of malaria, quartan malarial nephropathy (relatively rare), postneonatal pyogenic meningitis (infrequent in asplensism); 44% prevalence in Chad; treatment: chloroquine

***P. (P.) ovale***: all forms of parasite in peripheral blood; 8-12 merozoites; enlarged erythrocytes; Schuffner's dots; fimbriated and oval erythrocytes; causes 3% of malaria

***P. (P.) schwetzi***: very rare human infections

***P. (P.) simium***: very rare human infections

***P. (P.) vivax***: rare multiple rings in erythrocytes; all forms of parasite in peripheral blood; 12-24 merozoites; enlarged erythrocytes; Schuffner's dots; causes 73% of malaria; high global prevalence

## Family Babesidae

**Babesia:** causes babesiosis in cattle and man (rare), infection in abnormal host (infusion infection, splenic dysfunction); transmitted by bite of Ixodid ticks that have fed on infected domestic or wild animals, and by blood transfusion; organism binds complement and attaches to C3b receptor on erythrocyte; carried in blood associated with erythrocytes; diagnosis: indirect haemagglutination (? 1:32), indirect fluorescent antibody (titre ? 1:256), thick and thin blood smears; treatment: chloroquine phosphate or clindamycin + quinine or pentamidine isethionate, exchange transfusion

**B.bovis:** causes babesiosis in splenectomised persons (usually fatal)

**B.divergens:** causes babesiosis in splenectomised persons (usually fatal)

**B.microti:** causes babesiosis in persons with intact spleens (usually self-limited)

**Nuttalia:** causes intraerythrocytic parasitosis

**Entopolooides:** causes intraerythrocytic parasitosis in association with hepatic dysfunction and serum factors blocking lymphocyte reactivity

**Theileria parva:** tick-borne protozoal parasite causing East Coast fever (important cattle disease in East Africa); infects lymphocytes

**Family Nosematidae:** microsporidia; cause acute diarrhoea and/or vomiting in AIDS; diagnosis: examination of stool by technique of Weber et al, Giemsa stained smear of small intestine biopsy

**Encephalitozoon cuniculi:** microsporidium; causes chronic diarrhoea in AIDS; renal disease; sinusitis; treatment: albendazole

**E.hellum:** causes ocular and sinus infections

**Enterocytozoon biveusi:** microsporidium; causes chronic diarrhoea and malabsorption in AIDS; diagnosis: modified trichrome stain, fluorescent stain, examination of duodenal or jejunal biopsy by light or electron microscopy; treatment: albendazole

**Septata intestinalis:** causes malabsorption and diarrhoea; diagnosis: modified trichrome stain, fluorescent stain, examination of duodenal or jejunal biopsy by light or electron microscopy; treatment: albendazole

**Microsporidium ceylonicus:** causes enteritis in immunocompromised

**Nosema connori:** microsporidium; causes enteritis in immunocompromised; report of wide distribution in body of child with *Pneumocystis pneumonia*

**Pleistophora:** microsporidium

## Class Blastocystea

### Order Blastocystida

**Blastocystis hominis:** may be present in 20% or more of population; lacks a cell wall but contains mitochondria, Golgi apparatus and smooth and rough endoplasmic reticulum typical of protozoa; strictly anaerobic; pathogenicity doubtful; diagnosis: characteristic organisms in unstained, Gram stained or trichrome stained faecal smears; treatment: metronidazole, furazolidone (probably unwarranted)

## Phylum Ciliophora

**Class Ciliata:** ciliates; locomotion by cilia, relatively short threads of cytoplasm arising from small basal granules; cilia found during all stages of development

### Family Balantidiidae

**Balantidium:** more or less ovoid shape, conspicuous cytostome, ciliated covering over entire body, contractile vacuoles, conspicuous, slightly curved macronucleus and minute micronucleus

**B.coli:** ciliate; common parasite of large intestine of pig; rare in humans but wide distribution in temperate and warm climates and endemic among pig farmers in Papua New Guinea; causes balantidiasis (80-85% asymptomatic; dysentery, enteritis, peritonitis (very rare), vaginitis (very rare), appendicitis (exceedingly rare)); infection of man from pigs by ingestion of cysts; trophozoites in ulcers and free in lumen of large intestine; diagnosis: demonstration by direct microscopic examination of trophozoites (size and characteristic morphology) in more diarrhoeic stool or scraping of colonic mucosa or cysts (may be intermittent) in formed stool; treatment: metronidazole, tetracycline, paromomycin, diodohydroxyquine, chloroquine, resection of affected portions of gastrointestinal tract in invasive infections

**Metazoa:** triploblastic; possess a skin; possess a mouth of sorts; body systems mainly alimentary and reproductive; possess primitive nervous and excretory systems; sexes may be separate, hermaphroditism frequent

**Platyhelminthes:** flat worms; flattened, segmented or unsegmented; gut may or may not be present; no body cavity, viscera in gelatinous matrix

**Trematoda:** flukes; unsegmented; leaf-like or cylindrical; generally hermaphroditic; digenetic reproduction oviparous or multiplication within larval forms; infection mainly by larval stages entering intestinal tract, sometimes through skin; cause trematodiasis

### **Family Schistosomatidae**

**Schistosoma:** blood flukes; most parts of Africa, N and N E S America, Caribbean, Middle East; causes schistosomiasis (bilharziasis, haemic distomiasis, snail fever; 200 M infected worldwide; 75 000 deaths/y worldwide), adult hepatitis, hepatic abscess, 25 of hepatic granuloma; causes diarrhoea by mucosal inflammation, ? hypersensitivity, erosion, ulceration, fibrosis, altered motility of colon; loss of trace elements or vitamins, especially albumin-bound ones (eg, zinc, vitamin A), low D-xylose excretion, elevated faecal fat, glucose intolerance and subnormal levels of serum carnitine occur with heavy infection; transmission from snail by penetration of cercariae through skin; cercariae in papular lesions of skin; inhibits phagocytic recognition; diagnosis: ova in faeces, urine, aspirate, puncture, rectal or colonic granulomas, bentonite flocculation test, complement fixation test, counterimmunoelectrophoresis, fluorescent antibody staining of serum, indirect haemagglutination titre, FAST-ELISA; treatment: niridazole, sodium stibogluconate, praziquantel

**S.bovis:** causes cercarial dermatitis

**S.haematobium:** high global prevalence (8% in Chad); Africa, Middle East; causes schistosomiasis (bilharziasis tropical haematuria, bilharziasis of the bladder, bladder schistosomiasis, endemic haematuria, Egyptian haematuria, genitourinary bilharziasis, genitourinary tract schistosomiasis, urinary bilharziasis, urinary schistosomiasis, vesical bilharziasis, vesical schistosomiasis, pulmonary schistosomiasis (very rare), Katayama syndrome (primary; rare)); daily blood loss from bladder 23 mL, daily iron loss 7 mg; cercariae penetrate skin or mucous membranes and migrate via bloodstream to veins of bladder; adults attached to walls of vesical, pelvic and portal blood vessels, eggs discharged in bladder and, less frequently, rectum, genital organs and lungs; also found in liver and spleen parenchyma; treatment: trichlorofon, niridazole, sodium stibogluconate, bicanthone, metrifonate ? praziquantel

**S.intercalatum:** causes schistosomiasis (enteritis; similar to, but milder than *S.mansoni*); worms and eggs in mesenteric portal system, vesical system not involved, mainly colonic and rectal involvement

**S.japonicum:** high global prevalence; Japan, China, Philippines; causes acute or chronic schistosomiasis (Asiatic bilharziasis, Asiatic schistosomiasis, eastern schistosomiasis, Hankow fever, hepatic schistosomiasis, Japanese schistosomiasis, Katayama disease, Katayama fever, Kinkiang fever, oriental bilharziasis, oriental intestinal schistosomiasis, oriental schistosomiasis, schistosomiasis japonicum, urticarial fever, Yangtze Valley fever; primarily of intestinal tract (enteritis) and liver, also CNS, Katayama syndrome (primary and secondary), very rarely pulmonary schistosomiasis); adults attached to walls of mesenteric and intrahepatic portal blood vessels and in submucosal blood vessels of large intestine, eggs in liver and spleen parenchyma and, rarely, in brain parenchyma, myocardium and pulmonary arteries; treatment: praziquantel, niridazole

**S.mansoni:** moderately high global prevalence (36% in Chad, 2% of African refugees, 0.2% of travellers from tropics); Africa, Middle East, S America, Caribbean; causes acute or chronic schistosomiasis (bilharzial dysentery, colon schistosomiasis, Egyptian splenomegaly, intestinal bilharziasis, intestinal schistosomiasis, Manson disease, Manson intestinal schistosomiasis, schistosomal dysentery, schistosomiasis mansoni, visceral schistosomiasis, appendicitis, CNS schistosomiasis, enteritis, Katayama syndrome (primary and secondary), pulmonary schistosomiasis); low overall morbidity; impact on nutrition with symptomatic clinical disease (obstruction of intestinal lymphatics; daily blood loss from gastrointestinal tract 13 mL, daily iron loss 4 mg, daily albumin loss 2.2 g); possible clinical antagonism by malnutrition (severe protein-calorie deficiency depresses egg production, impairs egg maturation and diminishes egg viability; severe protein deficiency exacerbates anaemia and ascites; severe calorie deficiency exacerbates chronic phase low serum albumin, damage to hepatocyte, hepatomegaly, splenomegaly, ascites and portal hypertension, but ameliorates acute phase low serum albumin, damage to hepatocyte, hepatomegaly, splenomegaly and portal hypertension and reduces mortality in chronic phase; calorie, protein, vitamin C, riboflavin, thiamine and pyridoxine deficiency all inhibit granuloma formation); adults attached to walls of intrahepatic portal and mesenteric blood vessels and in submucosal blood vessels of large intestine, eggs in wall of large intestine, in liver, lung and spleen parenchyma and, rarely, present in brain parenchyma; antigenic mimicry by incorporation of host 'self' antigens into

parasite surface; antigenic depletion by shedding of integument; humoral and cellular immunosuppression; targeted chemotherapy moderately feasible, moderate to high priority; treatment: oxamniquine, praziquantel

***S.mattheei***: causes schistosomiasis (cercarial dermatitis, enteritis)

***S.mekongi***: causes schistosomiasis (acute or chronic; primarily of intestinal tract and liver; acquired only in Mekong River basin); treatment: praziquantel

***S.spindale***: causes cercarial dermatitis

***Austroilharzia***: causes cercarial dermatitis

***Bilharzia japonica***: causes cercarial dermatitis

***Gigantobilharzia***: causes cercarial dermatitis

***Heterobilharzia americana***: causes cercarial dermatitis

***Microbilharzia***: causes cercarial dermatitis

***Orientobilharzia***: causes cercarial dermatitis

***Schistosomatium douthitti***: causes cercarial dermatitis

***Trichobilharzia***: causes cercarial dermatitis

### **Family Diplostomidae**

***Fibricola seoulensis***: 1 case of disease, characterised by epigastric pain and fever, and a number of asymptomatic infections, from Republic of Korea

### **Family Paramphistomatidae**

***Watsonia watsoni***: parasite of certain monkeys and, possibly, other primates; causes watsoniasis, a rare disease characterised by severe toxic diarrhoea and emaciation

### **Family Gastrodiscidae**

***Gastrodiscoides hominis***: causes gastrodiscoidiasis (gastrodisciasis); fluke attaches itself to caecum and ascending colon; manifested by mucosal inflammation and diarrhoea

### **Family Fasciolidae**

***Fasciola***: causes fascioliasis, hepatic granuloma; worldwide; parasite of herbivores, man being infected occasionally from watercress infected by sheep and buffalo; treatment: bithionol

***F.gigantica***: giant liver fluke; causes fascioliasis (rare), biliary cirrhosis

***F.hepatica***: sheep liver fluke; 0.04% in travellers from tropics; causes fascioliasis (sheep liver fluke disease (usually acquired by eating raw infected watercress; mainly Latin America, Portugal, Spain; also France, North Africa, UK), adult hepatitis, enteritis, biliary cirrhosis, ? also pharyngeal fascioliasis ('halzoun) following ingestion of raw or poorly cooked infected animal liver); diagnosis: ova in faeces, biliary drainage, duodenal drainage

***F.indica***: causes fascioliasis (rare)

***Fasciolopsis buski***: giant intestinal fluke; causes fasciolopsiasis (Busk's fluke infection, giant intestine fluke infection, intestinal distoma, intestinal distomatosis, intestinal distomiasis; enteritis acquired by eating certain aquatic plants bearing encysted metacercariae; 2 M infected worldwide); diagnosis: ova and sometimes adults in faeces, ELISA; treatment: hexylresorcinol, bithionol

### **Family Echinostomatidae**

***Echinostoma***: causes echinostomiasis (Garrison's fluke infection); acquired by eating raw or inadequately cooked infected molluscs (second intermediate host); usually asymptomatic but intestinal colic and diarrhoea in heavy infection

***E.cinetorchis***: causes echinostomiasis

***E.ilocanum***: most common cause of echinostomiasis

***E.lindoense***: causes echinostomiasis

***E.malayanum***: causes echinostomiasis which may be serious, resembling fasciolopsiasis

***E.melis***: causes echinostomiasis

***E.revolutum***: causes echinostomiasis

***Hypodraeum conoideum***: a parasite of birds recovered from man (especially in Thailand) but pathogenicity uncertain

***Himasthla muehlensi***: found in man but pathogenicity uncertain

***Echinoparapyphium paraulum***: parasite of birds found once in man but pathogenicity uncertain

***Echinochasmus perfoliatus***: found in man on very rare occasions but pathogenicity uncertain

***Episthmium***: recovered, on 1 occasion, from stools of a patient in Bangkok undergoing treatment for opisthorchiasis

### **Family Psilostomatidae**

***Psilorchis hominis***: reported from a Japanese patient

### **Family Lecithodendriidae**

***Prostheodendricum molenkampi***: recovered from stools of patients in Bangkok undergoing treatment for opisthorchiasis

***Phaenopsolus bonnei***: recovered from stools of patients in Bangkok undergoing treatment for opisthorchiasis

### **Family Plagiorchiidae**

***Plagiorchis javensis***: reported once from intestinal disease in man

***P.muris***: reported once from intestinal disease in man

***P.philippinensis***: reported once from intestinal disease in man

### **Family Cathaemasidae**

***Cathaemasia cabrerai***: parasite of birds; 1 case of disease (epigastric pain and soft stools) reported from Philippines; infection attributed to eating raw snails

**Family Microphallidae**

***Spelotrema brevicaeca***: found, on very rare occasions, in lesions of heart, brain and spinal cord but pathogenicity uncertain

**Family Philophthalmidae**

***Philophthalmus***: reported once in Yugoslavia, once in Sri Lanka and once in Japan as causing trachoma-like condition

### **Family Dicrocoeliidae**

**Dicrocoelium:** lancet fluke; causes dicrocoeliasis (dicrocoeliiasis, lancet fluke infection); uncommon disease of bile ducts acquired by ingesting second intermediate host, ant of genus *Formica*; transient eggs without infection common in stools in endemic areas)

**D.dendriticum:** causes dicrocoeliasis, enteritis

**D.hospes:** causes dicrocoeliasis, enteritis

### **Family Troglotrematidae**

**Troglotrema salminicola:** parasite of salmon, causes 'salmon poisoning' in dogs and wild animals and, rarely, humans eating raw salmon

### **Family Paragonimidae**

**Paragonimus:** oriental lung fluke; Asia, W Africa and Central S America; causes paragonimiasis (endemic haemoptysis, lung fluke disease, parasitic haemoptysis, pulmonary distomiasis; pneumonia); larvae invade various organs of body, especially lungs, where granulomatous reaction with development of fibrotic encapsulation occurs; do not grow fully in human body but migrate, especially in chest region, and often cause spontaneous pneumothorax as a result of penetration through visceral pleura; some species localise preferentially in subcutaneous nodules or in CNS, in which case there are no pulmonary findings; treatment: praziquantel, bithionol

**P.africanus:** causes pulmonary paragonimiasis

**P.amazonicus:** causes pulmonary paragonimiasis

**P.caliensis:** causes paragonimiasis

**P.compactus:** causes pulmonary paragonimiasis

**P.congolensis:** causes pulmonary paragonimiasis

**P.ecuadoriensis:** causes pulmonary paragonimiasis

**P.heterotremus:** causes cutaneous paragonimiasis

**P.hueitungensis:** causes cutaneous paragonimiasis

**P.ilokatuenensis:** causes pulmonary paragonimiasis

**P.kellicotti:** causes pulmonary paragonimiasis

**P.mexicanus:** causes pulmonary paragonimiasis

**P.miyazakii:** causes pulmonary paragonimiasis

**P.okirai:** causes pulmonary paragonimiasis

**P.peruvianus:** causes pulmonary paragonimiasis

**P.philippinensis:** causes pulmonary paragonimiasis

**P.pulmonalis:** causes pulmonary paragonimiasis

**P.szechuanensis:** causes cutaneous paragonimiasis

**P.uterobilateralis:** causes pulmonary paragonimiasis

**P.westermani:** most frequent cause of pulmonary paragonimiasis, also causes enteritis; diagnosis: ova in faeces and sputum, complement fixation test

**Family Achillurbainiidae:** related to Paragonimidae; inhabit respiratory cavities, peritoneal cavity and tissues or live under skin of animals and humans in some parts of the world

**Achillurbainia nouveli:** infects man

**A.recondita:** infects man

**Poikilorchis congolensis:** infection of man reported from W and Central Africa

**Family Nanophyetidae:** small troglotrematid flukes related to Paragonimidae; infect members of Canidae and humans in N W USA and Siberia

**Nanophyetus salmincola salmincola:** USA; salmon-poisoning disease of canines on Pacific coast contracted by eating raw salmon; 10 cases in humans from eating raw, smoked or incompletely cooked salmon or steelhead trout; diagnosis: ova in faeces; treatment: niclosamide, bithionol

**Nanophyetus salmincola schikhobalowi:** Siberia; causes nanophyetiasis

### **Family Opisthorchidae**

**Opisthorchis:** causes opisthorchiasis (disease of bile ducts acquired by eating raw or inadequately cooked infected fresh-water fish; 1% of SE Asian refugees; diagnosis: ova in stools, biliary drainage, duodenal drainage; treatment: praziquantel, chloroquine phosphate)

**O.felineus:** causes opisthorchiasis (cat liver fluke fever), biliary cirrhosis, cholangitis and cholecystitis

**O.guayaquilensis:** causes opisthorchiasis

**O.noverca:** causes opisthorchiasis

**O.tenuicollis:** causes opisthorchiasis

**O.viverrini:** causes opisthorchiasis, biliary cirrhosis, cholangitis and cholecystitis

**Clonorchis sinensis:** causes clonorchiasis (Chinese liver fluke disease, clonorchiosis, *Clonorchis* liver infection, oriental liver fluke disease; chronic disease of bile ducts acquired from eating raw or inadequately cooked fresh-water fish), biliary cirrhosis, cholangitis and cholecystitis, enteritis; adults in bile ducts; in 2% of Indochinese refugees; diagnosis: ova in stools, bile or biliary drainage; treatment: praziquantel, chloroquine phosphate

### **Family Heterophyidae**

**Heterophyes:** causes heterophyiasis (dwarf fluke infection, heterophyiasis, heterophyidiasis; intestinal disease (enteritis) acquired from eating raw or inadequately cooked infected fresh-water fish; occasionally, eggs enter bloodstream and produce granulomatous foci in other tissues, especially brain and myocardium)

**H.brevicaeca:** causes heterophyiasis

**H.heterophyes:** most frequent cause of heterophyiasis

**H.katsuradai:** causes heterophyiasis

**H.taihokui:** causes heterophyiasis

**Metagonimus:** causes metagonimiasis (intestinal disease (enteritis) clinically resembling heterophyiasis, acquired from eating raw or inadequately cooked fresh-water fish)

**M.minutus:** rare cause of metagonimiasis

**M.yokogawai:** usual cause of metagonimiasis (Yokogawa's fluke infection)

**Centrocestus armatus:** found in intestine of man on rare occasions

**C.formosanus:** found in intestine of man on rare occasions

**Haplorchis microrchia:** causes intestinal disease in man on rare occasions

**H.pumilio:** causes intestinal disease in man on rare occasions

**H.taichui:** causes intestinal disease in man on rare occasions

**H.yokogawai:** causes intestinal disease in man on rare occasions

**Diorchitrema amplicaeale:** causes intestinal disease in man on rare occasions

**D.formosanum:** causes intestinal disease in man on rare occasions

**D.pseudocirratum:** causes intestinal disease in man on rare occasions

**Stellantchasmus falcatus:** causes intestinal disease in man on rare occasions

**Pygidiopsis summa:** 1 report of large numbers from small group of patients in Korea

### **Family Isoparorchidae**

**Isoparorchis hypselobagri:** found in human intestine on very rare occasions

**Cestoda:** tapeworms; segmented; possess scolex, neck and proglottids; hermaphroditic; reproduction oviparous, sometimes multiplication within larval forms; infection generally by encysted larvae; cause cestodiasis

### **Family Taeniidae**

**Taenia:** present in 1% of El Salvadorean refugees, 130 M infected worldwide; causes taeniasis; cysticerci enter orally; treatment: niclosamide, praziquantel, paromomycin

**T.africana:** less frequent cause of taeniasis

**T.confusa:** less frequent cause of taeniasis

**T.crassiceps:** 1 report of disease similar to cysticercosis

**T.saginata:** beef tapeworm; prevalence in humans from 0.02% in USA to 30% in some areas of W Africa; 0.1% in travellers from tropics; prevalence in cattle from 0.06% in USA to 10% in E Africa; common cause of taeniasis (beef tapeworm infection, taeniasis saginata; enteritis, appendicitis, cholangitis and cholecystitis); adults free in lumen of small intestine (scolex attached); transmission vertebrate-human by ingestion of cysticerci; diagnosis: gravid segments, ova, scolices in faeces; treatment: praziquantel, thiabendazole

***T. solium***: pork tapeworm; causes cysticercosis (cysticercal disease, cysticerciasis, cysticercus disease, *Taenia solium* cysticercosis; disease caused by larval form), enteritis (pork tapeworm infection, taeniasis solium; infection of intestine with adult tapeworm), eye infections, nonpyogenic meningitis (infrequent in impaired cell-mediated immunity), thyroiditis; cysticerci in brain parenchyma, in vitreous and anterior chamber of eye, in subcutaneous tissue and in skeletal and cardiac muscle; adults free in lumen of small intestine (scolex attached); transmission vertebrate-human by ingestion of embryonated eggs in contaminated food or water (source animal and human faeces), or autoinfection by ingestion of cysticerci; diagnosis: segments, ova, scolices in faeces or from perianal area, haemagglutination of serum and CSF, ELISA, enzyme-linked immunoelectrotransfer blot assay, indirect fluorescent antibody titre, histology of biopsied nodules; treatment: mebendazole, albendazole, praziquantel (+ dexamethasone or prednisone in neurocysticercosis)

***T. taeniaeformis***: less frequent cause of taeniasis

***Multiceps***: larval forms cause coenurosis (coenuriasis) in herbivorous animals, especially sheep (gid, staggers, sturdy) and, rarely, in man (cerebral or ocular (cysts usually beneath conjunctiva)); acquired by accidental ingestion of eggs

***M. brauni***: larval forms produce cysts in man

***M. glomeratus***: larval forms produce cysts in man

***M. multiceps***: 'gidworm'; most common cause of coenurosis

***M. serialis***: larval forms produce cysts in man

***Echinococcus***: tapeworm of animals; larval stage causes echinococcosis, adult hepatitis, thyroiditis; 1 of most important helminthiasis transmitted from animals to man; diagnostic stage in CNS, liver, spleen, lung; diagnosis: eosinophilia, identification of scolices, larval capsules or daughter cysts, complement fixation test, indirect haemagglutination titre, counterimmunoelectrophoresis, RAST, bentonite flocculation test, latex agglutination, indirect immunofluorescence, immunodiffusion, passive haemagglutination; treatment: thiabendazole, albendazole

***E. granulosus***: hydatid worm; causes echinococcosis (cystic echinococcosis, *Echinococcus* disease, unilocular echinococcosis, unilocular hydatid disease, unilocular hydatidosis; chronic disease, usually of liver or lungs, less frequently brain, bone or other organs; larvae become lodged in an organ and produce a well-defined, usually spherical, hydatid cyst, which may rupture and cause anaphylactic or allergic reactions and dissemination to other organs; acquired by ingestion of ova spread by infected dogs), enteritis, raised intracranial pressure; diagnosis: X-ray, serology; treatment: surgery

***E. multilocularis***: alveolar hydatid worm; causes echinococcosis (alveolar echinococcosis, alveolar hydatid, alveolar hydatid cyst, alveolar hydatid disease, alveolar hydatidosis, malignant hydatid, multilocular echinococcosis, multilocular hydatidosis; larvae produce tumour-like alveolar cysts that spread by direct tissue infiltration (as a rule, small vesicle develops initially and soon, through both exogenous and endogenous budding of germinative membrane, new small cysts are given off in every direction until they finally form a tight cluster of small vesicles); liver most frequently invaded organ; less common than echinococcosis due to *E. granulosus*, usually fatal if not treated; usually acquired by accidental ingestion of ova from excreta of infected foxes, dogs or cats), enteritis

***E. oligarthus***: causes echinococcosis (polycystic hydatid disease; most commonly in liver but cysts may spread to other sites; uncommon; acquired by accidental ingestion of ova from faeces of infected dogs)

***E. vogelsi***: uncommon cause of echinococcosis (polycystic hydatid disease; Central America and Northern S America; acquired by accidental ingestion of ova from faeces of infected dogs)

### **Family Hymenolepidae**

***Hymenolepis***: causes hymenolepiasis (hymenolepidosis; disease only results from heavy infection; mild infection usually asymptomatic); diagnosis: ova in faeces 30 d after infection; treatment: praziquantel, niclosamide, paromomycin

***H. diminuta***: rat tapeworm; ova spherical, 80-98  $\mu$ m, striated shell, yellow, polar filaments absent; of minor importance in human infections (hymenolepiasis due to *H. diminuta* (hymenolepiasis diminuta, rat tapeworm infection) is uncommon, clinically resembles that due to *H. nana*, and is acquired by ingestion of infected fleas or beetles)

***H. nana***: dwarf tapeworm; ova oval or spherical, 48-55X55-62  $\mu$ m, shell nonstriated, colourless, polar filaments present; present in 0.1% of travellers from tropics; hymenolepiasis due to *H. nana* (dwarf tapeworm infection, hymenolepiasis nana) is a result of heavy intestinal infection; infection is acquired by ingestion of ova or (in autoinfection) cysticercoids

***Dorepanidotaenia lanceolata***: common parasite of anseriform birds; 1 report of finding in man

#### **Family Anoplocephalidae**

***Bertiella mucronata***: recovered from human intestine on very rare occasions; no signs or symptoms

***B.studeri***: recovered from human intestine on very rare occasions; no signs or symptoms

#### **Family Davaineidae**

***Raillietina***: common parasites of chicken, pigeon and other birds

***R.asiatica***: found in man on rare occasions

***R.celebensis***: found in man on rare occasions

***R.demeraiensis***: found in man on rare occasions

***R.garrisoni***: found in man on rare occasions

***R.siriraji***: found in man on rare occasions

#### **Family Linstowiidae**

***Inermicapsifer arvicanthidis***: occasionally found in man; asymptomatic

***I.cubanensis***: occasionally found in man; asymptomatic

***I.madagascariensis***: occasionally found in man; asymptomatic

#### **Family Mesocestoididae**

***Mesocestoides lineatus***: recovered from man on rare occasions in Japan but pathogenicity uncertain

***M.variabilis***: recovered from man on rare occasions but pathogenicity uncertain

#### **Family Dilepididae**

***Dipylidium caninum***: dog tapeworm; common parasite of dogs and cats; of minor importance in human infections (causes dipylidiasis (dog tapeworm infection), mainly in children, acquired by ingestion of infected fleas); adults free in lumen of small intestine (scolex attached)

#### **Family Diphylobothriidae**

***Diphylobothrium***: causes diphylobothriasis (bothriocephaliasis, bothriocephalosis, broad tapeworm infection, dibothriocephaliasis, *Dibothriocephalus* anaemia, fish tapeworm infection, tapeworm anaemia; common intestinal infection (enteritis) acquired from eating raw or inadequately cooked fresh-water fish); diagnosis: ova or proglottids in faeces or vomitus; treatment: niclosamide, praziquantel, paromomycin

***D.cordatum***: occasional cause of diphylobothriasis

***D.latum***: fish tapeworm of man; most frequent cause of diphylobothriasis (enteritis, achlorhydria/hypochlorhydria, competition for nutrients); cysticerci enter orally; adults free in lumen of small intestine (scolex attached)

***D.minus***: occasional cause of diphylobothriasis

***D.pacificum***: occasional cause of diphylobothriasis

***D.parvum***: occasional cause of diphylobothriasis

***D.strictum***: occasional cause of diphylobothriasis

***D.tungussicum***: occasional cause of diphylobothriasis

***D.ursi***: occasional cause of diphylobothriasis

***D.yonagoensis***: occasional cause of diphylobothriasis

***Spirometra***: causes spirometrosis (larval diphylobothriasis, *Sparganum* infection, sparganosis; larvae migrate through subcutaneous tissue; almost any tissue may be invaded, including brain, breast, joints, muscle, spermatic cord); treatment: thiabendazole

***S.baxteri***: causes spirometrosis

***S.erinacei***: causes spirometrosis

***S.houghtoni***: causes spirometrosis

***S.mansoni***: Manson's tapeworm; causes spirometrosis

***S.mansonoides***: causes spirometrosis

***S.proliferum***: causes spirometrosis

***Diplogonoporus grandis***: tapeworm occasionally found in man, producing disease manifested by abdominal pain, alternating diarrhoea and constipation, and anaemia

***Digramma brauni***: twice found in man; believed to cause anaemia

***Ligula intestinalis***: found in man on rare occasions

***Braunia jasseyeensis***: found in man on rare occasions

**Nematoda**: roundworms; unsegmented; possess mouth, oesophagus and anus; in general, sexes separate; reproduction oviparous or larviparous; infection by ingestion of eggs or penetration of larvae through surfaces or arthropod vector or ingestion of encysted larvae; cause nematosis

#### **Family Trichinellidae**

***Trichinella pseudospiralis***: found in wild animals, not known to cause disease in man

***T. spiralis***: trichina worm; causes trichinellosis (trichuria worm infection, trichinellasis, trichuriasis, trichinosis, trichinous myositis, trichinous polymyositis), enteritis, nonpyogenic meningitis, encephalitis, maculopapular rash (in 75% of cases), myocarditis and pericarditis (rare); transmitted by ingestion of larvae in raw or inadequately cooked pork and also meat of other animals (wild boar, beaver, rat, horse, badger, bear); transmission of *T. spiralis nativa* in beans has been reported; encysted larvae enter orally, penetrate intestinal mucosa at level of duodenum and jejunum, enter glandular crypts and develop into adults; causes diarrhoea by hypersensitivity reaction in duodenum; adults embedded in mucosa of small intestine and mucus adherent to mucosa (for about 2 mo after inoculation); after mating, females deposit larvae; these reach venules or lymphatics, are distributed throughout body and encyst in striated muscle; 50 M infected worldwide; immunity due to lymphocytes, serum, inflammation, reaginic antibody; diagnosis: ELISA, latex agglutination, immunodiffusion, complement fixation test, indirect haemagglutination, indirect fluorescent antibody (titre ? 1:16), bentonite flocculation test (? +++), muscle biopsy; treatment: mebendazole, albendazole

#### **Family Trichuridae**

***Trichuris***: human-human transmission by ingestion of embryonated eggs; 500 M infected worldwide; treatment: mebendazole

***T. muris***: immunity due to lymphocytes and serum

***T. suis***: common parasite of pigs; may cause disease in man on rare occasions

***T. trichiura***: whipworm; causes trichuriasis (trichocephalosis, tricocephalosis, whipworm disease, whipworm infection; enteritis, appendicitis); causes diarrhoea by intense mucosal inflammation, hyperactivity in caecum and colon; high global prevalence (3% of Guatemalan children, 8% of immigrant children, 12% of Laotian immigrants, 1% of travellers from tropics, up to 94% in parts of India); faecal-soil (larval development)-oral (egg) transmission; adults anterior end embedded in mucosa of large intestine, posterior end free in lumen; diagnosis: ova in faeces; treatment: mebendazole

***T. vulpis***: common parasite of dogs; may cause disease in man on rare occasions

***Capillaria***: causes capillariasis, hepatic granuloma

***C. aereophila***: associated with acute bronchopulmonary symptoms (pulmonary capillariasis) on very rare occasions

***C. hepatica***: common parasite of rodents; causes hepatic capillariasis (*Capillaria hepatica* infection, liver-worm infection); rare disease of liver (adult hepatitis); also acts as occasional cause of visceral larva migrans; diagnosis: microscopy of biopsy or autopsy specimens for ova; no known treatment

***C. philippinensis***: causes intestinal capillariasis (*Capillaria philippinensis* infection; disease of small intestine with local irritation and damage and nutrient malabsorption, mucosal damage resulting in endogenous losses); diagnosis: microscopy of faeces for ova

***Anatrichosoma cutaneum***: associated with cutaneous larva migrans on very rare occasions

#### **Family Mermithidae**

***Agamomermis hominisoris***: recovered from man but pathogenicity doubtful

***A. restiformis***: recovered from man but pathogenicity doubtful

#### **Family Dioctophymatidae**

***Dioctophyma renalis***: causes pyelonephritis (*Dioctophyma renalis* infection, *Dioctophyma renalis* infestation, giant kidney-worm infection, kidney-worm infection; very rare)

#### **Family Strongyloididae**

***Eustrongyloides***: adults parasitic in gastrointestinal tract of fish-eating birds, larvae in connective tissue or body cavity of freshwater fish; only recorded human infections from swallowing live minnows

***Strongyloides***: causes strongyloidiasis (anguilliosis, anguilluliasis, anguillulosis, Cochinchina diarrhoea, strongyloidosis), acute diarrhoea and/or vomiting, hepatic granuloma, peritonitis (secondary); non-human species cause cutaneous larva migrans; diagnosis: microscopy for larvae and ova in faeces, serology by indirect fluorescent antibody titre; treatment: thiabendazole, albendazole, ivermectin

***S.fuelleborni***: causes strongyloidiasis; in infants, disease is more acute than that due to *S.stercoralis* and is often fatal

***S.myopotami***: filariform larvae in superficial layers of skin

***S.papillosus***: may cause cutaneous infections

***S.ransomi***: may cause cutaneous infections

***S.ratti***: immunity due to lymphocytes, serum, inflammation and reaginic antibody

***S.stercoralis***: threadworm; causes strongyloidiasis (enteritis— local irritation and damage and nutrient malabsorption, mucosal damage resulting in endogenous losses; diarrhoea caused by mucosal erosion and ulceration, altered motility, superimposed bacterial infections in small intestine and colon), appendicitis, cutaneous larva migrans, diffuse interstitial pneumonia and pneumonitis (due to migrating larvae), nonpyogenic meningitis, infection in abnormal host (including hyperinfection and disseminated infection in T helper lymphocyte dysfunction); high global prevalence (from 0.2% of US travellers from tropics to 5-50% of SE Asian refugees; 80 M infected worldwide); larval development in soil and intestine; infection by third stage filariform larvae through penetration of skin (often causing urticaria), migrate via bloodstream to lungs (eggs, larvae and adults occasionally in alveoli and bronchial epithelium), sometimes causing respiratory symptoms, then invade intestinal mucosa (parasitic adult females, embryonated eggs and rhabditiform larvae embedded in mucosa of small intestine (not below muscularis mucosae) and in mucus adherent to mucosa); immunity cell-mediated (delayed type hypersensitivity-activated macrophage +++), antibody-dependent cellular cytotoxicity +++, basophil-mast cell ++; if immune response is impaired (eg., in those with AIDS), massive autoinfection may occur, resulting in potentially fatal disseminated disease); diagnosis: indirect fluorescent antibody (titre ? 1:66), special stain of stool, duodenal aspirate and sputum for ova and parasites; treatment: thiabendazole, pyrantel embonate, mebendazole

***Rhabditis donbass***: found in faeces; pathogenicity uncertain

***R.gracilis***: found in faeces; pathogenicity uncertain

***R.hominis***: found in faeces; pathogenicity uncertain

***R.niellyi***: found in skin lesions; pathogenicity uncertain

***R.pellio***: found in the vagina; pathogenicity uncertain

***R.schachtliella***: found in faeces; pathogenicity uncertain

***Turbatrix aceti***: recovered from urine and vaginal exudates but pathogenicity uncertain

***Diploscapter coronata***: found in stomach and in urinary tract disease but pathogenicity uncertain

#### **Family Cephalosidae**

***Micronema***: may cause meningoencephalitis

#### **Family Strongylidae**

***Ternidens deminutus***: parasite of simian primates; may cause ternidensiasis (cystic nodules found in intestine; severe infections give rise to anaemia) in man

***Oesophagostomum***: causes oesophagostomiasis (nodular disease); larvae burrow into wall of large intestine and form conspicuous nodules, rupture of which may produce diarrhoea with blood-stained stools, dehydration and, at times, peritonitis

***O.apistomum***: nodular worm; causes oesophagostomiasis

***O.bifurium***: causes oesophagostomiasis

***O.stephanostomum var thomasi***: causes oesophagostomiasis

**Family Ancylostomatidae**: hookworms; cause enteritis, pneumonitis; high global prevalence (800 M infected worldwide; 3% of immigrant children, 16% of SE Asian refugees, 66% of Laotian immigrants, 0.2% of travellers from tropics, up to 92% in parts of India); 55 000 deaths/y worldwide; larval development in soil; human-human transmission by penetration of skin by, or ingestion of, third stage filariform larvae; pulmonary migration; moderate overall morbidity; impact on nutrition with symptomatic clinical disease (achlorhydria/hypochlorhydria, mucosal damage resulting in endogenous losses); iron supplementation intervention high feasibility and priority; diagnosis: ova and larvae in faeces by brine flotation; treatment: thiabendazole, pyrantel embonate, mebendazole, albendazole, bephenium hydroxynaphtoate, tetrachloroethylene

***Ancylostoma***: causes ancylostomiasis (Wakana disease; chronic disease; larvae penetrate skin (sometimes causing pruritus and itching (ground itch) and migrate via bloodstream through lungs (where may cause respiratory

symptoms) to small intestine; infection by oral route also possible; adult worm attaches itself to, and damages, intestinal mucosa), cutaneous larva migrans (creeping eruption, dermatitis linearis migrans, plumbers itch; larvae penetrate skin and wander for prolonged periods in epidermis, leaving a pruritic trail; larvae unable to complete life cycle as not in 'normal' host; when they die, lesions heal), hepatic granuloma

**A. braziliense:** causes cutaneous larva migrans; larvae in serpiginous tunnels in stratum germinativum of skin

**A. caninum:** occasional cause of cutaneous larva migrans

**A. ceylanicum:** causes ancylostomiasis, cutaneous larva migrans, enteritis

**A. duodenale:** Old World hookworm; high global prevalence; causes ancylostomiasis (enteritis; adults attached to mucosa of small intestine) and, occasionally, cutaneous larva migrans

**A. malayanum:** reported in man but of uncertain pathogenicity

**Uncinaria stenocephala:** causes cutaneous larva migrans; treatment: thiabendazole

**Necator americanus:** tropical hookworm; high global prevalence; causes necatoriasis (resembles ancylostomiasis except initial dermatitis occurs more often and anaemia is usually less severe), enteritis, cutaneous larva migrans; treatment: thiabendazole

### Family Syngamidae

**Mammomonogamus laryngeus:** causes syngamiasis (syngamosis; rare disease in which adult worms attach themselves to laryngeal mucosa and cause coughing, haemoptysis and, sometimes, asthma; parasites removed through endoscope)

**Family Trichostrongylidae:** common parasites of herbivorous animals

**Trichostrongylus:** causes trichostrongyliasis (trichostrongylosis, *Trichostrongylus* infection; enteritis); larvae attach themselves to mucosa of small intestine; diagnosis: ova or adult worms in stool

**T. axei:** causes trichostrongyliasis

**T. brevis:** causes trichostrongyliasis

**T. columbriformis:** common cause of trichostrongyliasis

**T. extenuatus:** causes trichostrongyliasis

**T. instabilis:** causes trichostrongyliasis

**T. orientalis:** common cause of trichostrongyliasis

**T. probolurus:** causes trichostrongyliasis

**T. skjabini:** causes trichostrongyliasis

**T. vitrinus:** causes trichostrongyliasis

**Ostertagia circumcincta:** common parasite of herbivorous animals; reported from man but pathogenicity uncertain

**O. ostertagia:** common parasite of herbivorous animals; reported from man but pathogenicity uncertain

**Haemonchus contortus:** common parasite of sheep; causes haemonchiasis in man on rare occasions; blood-sucking larvae produce anaemia similar to that found in ancylostomiasis or necatoriasis

### Family Metastrongylidae

**Metastrongylus elongatus:** causes metastrongyliasis (a disease of pigs, reported in man on very rare occasions; affects respiratory tract)

### Family Angiostrongylidae

**Parastrongylus cantonensis:** rat lungworm; causes angiostrongyliasis (eosinophilic meningoencephalitis), eye infections; China, Far East, Hong Kong, Papua New Guinea; treatment: dexamethasone

**P. costaricensis:** causes angiostrongyliasis (abdominal angiostrongyliasis, abdominal angiostrongylosis, intestinal angiostrongyliasis, intestinal angiostrongylosis), appendicitis

**P. malayensis:** causes eosinophilic meningoencephalitis (Malaysia); treatment: dexamethasone + analgesics

### Family Oxyuridae

**Enterobius vermicularis:** pinworm, seatworm; causes appendicitis (rare), enteritis (relatively common; enterobiasis, enterobiosis, oxyuriasis, oxyuriasis vermicularis, pinworm infection, seatworm infection, threadworm infection), vulvovaginitis in infant girls; peritoneal granulomata reported; infection by ingestion of eggs; intestinal migration; larval development perianal; prevalence up to 20% in parts of India, 10% of travellers from tropics, 0.3% of homosexual men; 500 M infected worldwide; diagnosis: ova in perianal scrapings or sticky tape preparation, occasionally in faeces; treatment: pyrantel embonate, mebendazole, piperazine citrate, pyriminium pamoate or embonate

***Syphacia obvelata***: common parasite of rats and mice; found in stools of man but pathogenicity uncertain

### **Family Ascarididae**

***Ascaris***: causes ascariasis (ascariasis, ascariidiosis, ascariidosis, ascariidosis, roundworm infection); occurs in soil and water contaminated with animal or human faeces; human-human infection by ingestion of embryonated eggs; migrating larvae pass from small intestine to liver (heavy infection may cause hepatitis and hepatic granuloma) and thence to lungs (heavy infection may cause simple eosinophilic pneumonia— *Ascaris* pneumonia, *Ascaris* pneumonitis), rarely to urogenital tract; treatment: thiabendazole

***A. lumbricoides***: giant intestinal roundworm; most common helminthic infection worldwide (25% of world's population; 78% of Guatemalan children, 8-9% of immigrants, 3% of SE Asian refugees, 1% of travellers from tropics, up to 90% in parts of India); causes ascariasis— enteritis, appendicitis, cholangitis and cholecystitis, pneumonitis (due to migrating larvae) and, occasionally, visceral larva migrans; 20 000 deaths/y worldwide; faecal-soil (larval development)-oral (eggs) transmission; adults free in lumen of small intestine, larvae in lung parenchyma; low overall morbidity; probable impact on nutrition (biliary obstruction, pancreas obstruction, impaired protein digestion, local irritation and damage and nutrient malabsorption with heavy load); targeted chemotherapy moderate feasibility, low to moderate priority; treatment: pyrantel embonate, thiabendazole, mebendazole, albendazole, piperazine citrate, praziquantel, vipyrium embonate, diethylcarbamazine citrate

***A. suum***: common parasite of pigs; less common cause of ascariasis (enteritis) in man

***Toxocara***: causes hepatic abscess, hepatic granuloma, visceral larva migrans; diagnosis: ELISA, bentonite flocculation, indirect haemagglutination; treatment: thiabendazole, diethylcarbamazine citrate

***T. canis***: dog ascarid; principal causative organism of visceral larva migrans; also causes anterior uveitis and retinochoroiditis; larvae in brain, liver and lung parenchyma and eye tissue

***T. cati***: less frequent cause of visceral larva migrans

***Lagochilascaris minor***: recovered from subcutaneous abscesses in cervical, intramastoidal and intracranial regions, sometimes associated with irreversible damage to tissues (especially nervous tissues) but pathogenicity uncertain; treatment: levamisole

***Toxascaris leonina***: a possible cause of visceral larva migrans; treatment: thiabendazole, diethylcarbamazine

***Baylisascaris procyonis***: occasional cause of ocular, visceral and neural larva migrans, 1 case of eosinophilic meningoencephalitis; treatment: thiabendazole, diethylcarbamazine

**Family Anisakidae**: cause anisakiasis (enteritis); acquired from raw or undercooked infected saltwater fish (herring, cod, tuna, rockfish, salmon, many others) and squid; diagnosis: larvae in faeces and pharynx

***Anisakis marina***: causes anisakiasis

***A. simplex***: causes anisakiasis

***Contracaecum osculatum***: causes anisakiasis

***Phocanema***: causes anisakiasis

***Pseudoterranova decipiens***: causes anisakiasis

### **Family Spiruridae**

***Gongylonema pulchrum***: causes gongylonemiasis (very rare disease; adult worms migrate through mucosa and submucosa of buccal cavity and cause irritation of infected site; infection through ingestion of infected beetles)

### **Family Gnathostomatidae**

***Gnathostoma***: S E Asia and S America; causes gnathostomiasis (gnathostomiasis, wandering swelling, Yangtse oedema); larvae invade cutaneous and subcutaneous tissues; cited as occasional cause of visceral larval migrans

***G. hispidium***: causes infection

***G. spinigerum***: parasite of a number of carnivores; usual cause of visceral gnathostomiasis, eye infection

***G. vivarina***: causes eye infection

### **Family Physalopteridae**

***Physaloptera caucasica***: parasite of simian primates; causes physalopteriasis (enteritis)

### **Family Thelazidae**

***Thelazia***: causes thelaziasis (eye worm infection, thelaziosis)

***T. californiensis***: less frequent cause of thelaziasis

***T. callipaeda***: causes thelaziasis

## Family Acuariidae

**Cheilospirochaeta**: found once in conjunctiva of person suffering from chronic catarrhal conjunctivitis and keratitis

**Superfamily Filarioidea**: cause filariasis

**Wuchereria**: transmission by bite of mosquito (*Culex*, *Aedes*, *Anopheles*, *Manzonia*) by penetration of third stage larvae

**W.bancrofti**: Bancroft's filaria; high global prevalence (5% in Chad); causes filariasis (Bancroft filariasis, bancroftian filariasis, bancroftosis, elephantiasis, elephantiasis filariasis, elephantoid fever, wucheriasis; lymphangitis, tropical eosinophilic pneumonia); sheathed, nocturnal microfilaria free in peripheral blood, adult worms infect lymphatic system, most commonly inguinal area, upper arms, legs, spermatic cord; diagnosis: peripheral thick blood films (collected at midnight), histology of biopsy, ELISA, bentonite flocculation, indirect haemagglutination, indirect immunofluorescence; treatment: diethylcarbamazine, ivermectin, flubendazole

**Brugia beaveri**: ? pathogenic

**B.malayi**: Malayan filaria; causes filariasis (Brug filariasis, *Brugia* filariasis, brugiasis, filariasis malayi, Malayan filariasis; lymphangitis, tropical eosinophilic pneumonia); transmitted to man by bite of certain mosquitoes (*Mansonia*, *Aedes*, *Anopheles*); microfilaria free in blood, adults in vessels and tissue of lymph node; diagnosis: peripheral thick blood films collected at midnight, histology of biopsy, ELISA, bentonite flocculation, indirect haemagglutination, indirect immunofluorescence; treatment: diethylcarbamazine citrate, ivermectin, flubendazole

**B.pahangi**: has caused allergic symptoms and tropical eosinophilic pneumonia on rare occasions; treatment: diethylcarbamazine

**B.timori**: causes filariasis similar to, but often more severe than, that caused by *B.malayi*; transmitted by *Anopheles* mosquitoes in 1 small group of islands in Indonesia; diagnosis and treatment as for *B.malayi*

**Onchocerca volvulus**: convoluted filaria; causes onchocerciasis (blinding filariasis, coastal erysipelas, Guatemala nodules, onchocercosis, onchodermatitis, onchphthalmia, river blindness, river disease, river valley blindness, Robles disease; chronic disease of subcutaneous tissue, skin or eye); high global prevalence (92% in Chad); transmitted from blackfly (*Simulium*) vector by penetration of third stage larvae; unsheathed microfilaria in skin and eye, adult worms in subcutaneous tissues; diagnosis: biopsy of nodule, skin shavings, Mazzotti test, radioimmunoassay, patch test; treatment: ivermectin, diethylcarbamazine, suramin, flubendazole

**Mansonella**: causes mansonelliasis; transmitted to man by bite of *Culicoides* and, perhaps, *Simulium*; diagnosis: recovery of microfilariae from blood by Knott's concentration (night collection better than day for *M.perstans*); treatment: ivermectin, flubendazole

**M.ozzardi**: Ozzard's filaria; causes mansonelliasis (filariasis ozzardi, *Mansonella ozzardi* infection, mansonelliasis ozzardi, mansonellosis, Ozzard filariasis)

**M.perstans**: persistent filaria; causes mansonelliasis (acanthocheilonemiasis, dipetalonemiasis due to *Dipetalonema perstans*); 29% prevalence in Chad; microfilaria free in blood, adult worms in abdomen

**M.streptocerca**: crooked tail filaria; causes mansonelliasis (dipetalonemiasis due to *Dipetalonema streptocerca*); adults in subcutaneous tissue, microfilariae in skin of upper body; diagnosis: skin snips

**Meningonema peruzzi**: filarial parasite of monkeys; causes meningonemiasis (rare); treatment: ivermectin, flubendazole

**Dirofilaria**: causes dirofilariasis (rare visceral larva migrans); adults in blood vessels and in abscesses or nodules ('coin lesions') in heart, lungs, subcutaneous tissue and eye; treatment: ivermectin, flubendazole

**D.immitis**: 'cruel' filaria, dog heart worm; causes dirofilariasis (usually lung lesion ('coin lesions')); vectors *Aedes notoscriptus*, *Culex annulirostris*, *Aedes vigilax*, *Aedes camptorhynchus*, *Culex quinquefasciatus* and *Anopheles annulipes*

**D.repens**: causes dirofilariasis (may be found in subcutaneous nodules)

**D.striata**: reportedly found in man

**D.tenuis**: causes dirofilariasis

**D.ursi**: reportedly found in man

**Edesonfilaria malayensis**: peripheral microfilaremia decreases in response to increased body temperature

**Monnigofilaria setariosa**: peripheral microfilaremia decreases in response to increased body temperature

**Loa loa**: loa worm, 'eye worm' causes loiasis (eye worm, eyeworm disease of Africa, loaiasis, loasis, loa worm; eye infection in 5% of cases); 9% prevalence in Chad; vector tabanid flies (*Chrysops silacea* and *Chrysops dimidata*,

geographical distribution determines that of the disease); sheathed, diurnal microfilaria in peripheral blood; peripheral microfilaremia increases in response to elevated body temperature; adult worms migrate through subcutaneous tissue and, occasionally, across eye; diagnostic stage in eye and calabar swelling; diagnosis: peripheral thick blood films collected at noon, histology of biopsy, ELISA, bentonite flocculation, indirect haemagglutination, indirect immunofluorescence; treatment: diethylcarbamazine citrate

#### **Family Dracunculidae**

***Dracunculus medinensis***: dragon worm, medina worm, guinea worm; high global prevalence (20 M; mainly Africa); causes dracunculiasis (dracunculosis, dracontiasis, guinea worm disease, Medina infection, Medina worm infection), 0.8% of carpal tunnel syndrome; transmission from crustacean vector (water fleas or cyclops of many different genera) by ingestion of larvae; gravid female worms migrate to subcutaneous regions; adults in cutaneous lesion; treatment: metronidazole, niridazole, thiabendazole

#### **Family Gordiidae**

***Gordius aquaticus***: reportedly found in man but pathogenicity uncertain

***G. chilensis***: reportedly found in man but pathogenicity uncertain

***G. robustus***: reportedly found in man but pathogenicity uncertain

***G. setiger***: reportedly found in man but pathogenicity uncertain

#### **FAMILY CHORDODIDAE**

***Chordodes capensis***: recovered from man but pathogenicity uncertain

***Paragordius aerolatus***: found in man but pathogenicity uncertain

***P. cinctus***: found in man but pathogenicity uncertain

***P. tricuspidatus***: found in man but pathogenicity uncertain

***P. varius***: found in man but pathogenicity uncertain

***Parachordodes alpestris***: found in man but pathogenicity uncertain

***P. pustulosus***: found in man but pathogenicity uncertain

***P. tolosanus***: found in man but pathogenicity uncertain

***P. violaceus***: found in man but pathogenicity uncertain

***Neochordodes colombianus***: found in man but pathogenicity uncertain

***Pseudogordius tanganyikae***: found in man; pathogenicity uncertain

**Phylum Acanthocephala**: 'thorny-headed worms'; cause acanthocephaliasis (rare infections in man as a result of eating raw fish)

#### **Phylum Annelida**

##### **Order Gnathobdellida**

***Haemedipsa ceylanica***: leech; causes external hirudiniasis

***H. fallax***: leech; causes external hirudiniasis

***H. japonica***: leech; causes external hirudiniasis

***H. javanica***: leech; causes external hirudiniasis

***H. montana***: leech; causes external hirudiniasis

***H. morsitans***: leech; causes external hirudiniasis

***H. ornata***: leech; causes external hirudiniasis

***H. picta***: leech; causes external hirudiniasis

***H. sylvestris***: leech; causes external hirudiniasis

***H. vagans***: leech; causes external hirudiniasis

***Phytobdella catenifera***: leech; causes external hirudiniasis

***Dinobdella ferox***: leech; causes external and internal hirudiniasis

***Limnatis africana***: leech; causes internal hirudiniasis

***L. granulosa***: leech; causes internal hirudiniasis

***L. maculosa***: leech; causes internal hirudiniasis

***L. mysomelas***: leech; causes internal hirudiniasis

***L. nilotica***: leech; causes internal hirudiniasis, laryngeal and tracheal hirudiniasis (halzoun)

#### **Phylum Arthropoda**

## **Class Insecta**

**Order Anoplura:** sucking lice

### **Family Pediculidae**

***Pediculus:*** causes pediculosis

***P.humanus:*** causes blepharitis

**'*P.humanus capitis*' (nomen dubium):** causes pediculosis (head-lice infestation)

**'*P.humanus corporis*' (nomen dubium):** causes pediculosis (lice infestation); vector of typhus fever (*Rickettsia prowazekii*) and relapsing fever (*Borrelia recurrentis*)

***Phthirus pubis:*** causes phthiriasis (crab-lice infestation, phthiriasis, phthirosis), blepharitis

### **Order Coleoptera**

**Family Scarabaeidae:** cause scarabiasis (cantharidiasis; infestation, usually of gastrointestinal or urinary tract, by both larval and adult beetles; nose and eye also infested on rare occasions; may be severe irritation of organs involved)

**Order Siphonaptera:** fleas; may cause pruritic rash

### **Family Tungidae**

***Tunga penetrans:*** causes tungiasis (burrowing flea infestation, chigoe disease, jigger disease, nigua, sandflea infestation)

### **Order Diptera**

#### **Family Syrphidae**

***Eristalis tenax:*** causes intestinal myiasis

#### **Family Phoridae**

***Megaselia spiracularis:*** causes myiasis

#### **Family Muscidae**

***Fannia canicularis:*** causes intestinal myiasis

***F.scalaris:*** causes intestinal myiasis

***Musca domestica:*** causes intestinal and wound myiasis

***M.erythrocephala:*** causes myiasis

#### **Family Calliphoridae**

***Auchmeromyia senegalensis:*** causes myiasis

***Calliphora vicina:*** causes myiasis

***C.vomitorea:*** causes genitourinary and intestinal myiasis

***Chrysomya albiceps:*** causes myiasis

***C.bezziana:*** causes genitourinary, nasopharyngeal and ocular myiasis

***C.chloropyga:*** causes intestinal and genitourinary myiasis

***C.megacephala:*** causes nasopharyngeal, ocular and wound myiasis

***C.putoria:*** causes genitourinary and intestinal myiasis

***Cochliomyia hominivorax:*** causes cutaneous, nasopharyngeal, ocular and wound myiasis

***C.macellaria:*** causes cutaneous, nasopharyngeal and ocular myiasis

***Cordylobia anthropophaga:*** causes cutaneous myiasis

***C.rodhainii:*** causes myiasis

***Cynomya:*** causes myiasis

***Lucilia caesar:*** causes myiasis

***L.cuprina:*** causes myiasis

***L.sericata:*** causes wound myiasis

***Phaenicia cuprina:*** causes wound myiasis

***P.sericata:*** causes nasopharyngeal and wound myiasis

***Phormia regina:*** causes cutaneous and wound myiasis

#### **Family Sarcophagidae**

***Sarcophaga albiceps:*** causes wound myiasis

***S.bullata:*** causes intestinal and wound myiasis

***S. canaria***: causes wound myiasis  
***S. chrysostoma***: causes wound myiasis  
***S. crassipalpis***: causes wound myiasis  
***S. fertoni***: causes wound myiasis  
***S. fuscicauda***: causes wound myiasis  
***S. haemorrhoidalis***: causes wound myiasis  
***S. hirtipes***: causes intestinal myiasis  
***S. krameri***: causes cutaneous myiasis  
***S. lambens***: causes wound myiasis  
***S. lherminieri***: causes intestinal myiasis  
***S. misera***: causes wound myiasis  
***S. nodosa***: causes wound myiasis  
***S. peregrina***: causes intestinal and wound myiasis  
***S. placida***: causes wound myiasis  
***S. plinthopyga***: causes wound myiasis  
***S. ruficornis***: causes intestinal and wound myiasis  
***S. sarraceniae***: causes intestinal myiasis  
***S. striata***: causes intestinal and wound myiasis  
***S. tibialis***: causes wound myiasis  
***Wohlfahrtia magnifica***: causes genitourinary, nasopharyngeal, ocular and wound myiasis  
***W. meigeni***: causes cutaneous myiasis  
***W. nuba***: causes wound myiasis  
***W. opaca***: causes cutaneous myiasis  
***W. vigil***: causes cutaneous and wound myiasis

#### **Family Piophilidae**

***Piophila casei***: causes genitourinary and intestinal myiasis

#### **Family Psychodidae**

***Clogmia albipunctata***: causes intestinal myiasis

#### **Family Oestridae**

***Oestrus ovis***: causes nasopharyngeal and ocular myiasis

***Rhinoestrus purpureus***: causes nasopharyngeal and ocular myiasis

#### **Family Hypodermatidae**

***Hypoderma bovis***: causes creeping myiasis, ocular myiasis

***H. lineatum***: causes creeping myiasis, ocular myiasis

#### **Family Cuteridridae**

***Dermatobium cyaniventris***: causes myiasis

***D. hominis***: causes cutaneous myiasis

#### **Family Gasterophilidae**

***Gasterophilus haemorrhoidalis***: causes creeping and intestinal myiasis

***G. intestinalis* (nomen dubium)**: causes creeping, intestinal and ocular myiasis

***G. nasalis***: causes creeping and intestinal myiasis

#### **Class Arachnida**

**Order Acarina**: cause acarine dermatitis

#### **Family Dermanyssidae**

**'*Dermanyssus gallinae*' (nomen dubium)**: chicken mite, fowl mite; causes dermatitis closely resembling scabies

***D. hirudinis***: mite of cage birds, swallows; causes pruritic rash

***Liponyssoides (Allodermanyssus) sanguineus***: house mouse mite; attacks rodents but readily feeds on man and can cause dermatitis

***Ophoriassus matricis***: causes pruritic rash

### Family Macronyssidae

***Ornithonyssus bacoti***: tropical rat mite; causes dermatitis

***O. bursa***: bird mite, paper mite; causes dermatitis

***O. nagayoi***: causes dermatitis

***O. sylviarum***: Northern fowl mite; causes dermatitis

### Family Trombiculidae

***Leptotrombidium akamushi***: causes trombiculosis

***Trombicula alfreddugesi***: causes trombiculosis

***T. alfreddugesi uruguayensis***: causes trombiculosis

***T. autumnalis***: causes trombiculosis

***T. batatas***: causes trombiculosis

***T. hirsti***: causes trombiculosis

***T. lahillei***: causes trombiculosis

***T. samboni***: causes trombiculosis

***T. sarcina***: causes trombiculosis

***T. splendens***: causes trombiculosis

***T. wichmanni***: causes trombiculosis

***Schoengastia indica***: causes dermatitis

***S. nunezi***: causes dermatitis

***Acromatacarus australiensis***: causes severe dermatitis resembling trombiculosis

### Family Pyemotidae

***Pyemotes ventricosus***: burrows under the skin of man and causes dermatitis (grain itch)

### Family Demodicidae

***Demodex brevis***: reported to parasitise sebaceous glands; may cause blepharitis and dermatitis

***D. folliculorum***: causes blepharitis and dermatitis

### Family Sarcoptidae

***Sarcoptes siro scabei***: causes scabies; treatment: benzyl benzoate, lindane, permethrin

### Family Tyroglyphidae

***Tyrophagus***: from foods; causes pruritic rash

***T. longior***: causes dermatitis; also reported from urinary tract

***T. putrescentiae***: causes dermatitis (cheese itch, copra itch, grocer's itch); also reported from urinary tract

***T. siro***: causes dermatitis

### Family Glycyphagidae

**'*Glycyphagus domesticus*' (nomen dubium)**: burrows under skin of man and produces temporary pruritus (grocer's itch)

### Family Pyroglyphidae

***Dermatophagoides farinae***: house dust mite; causes pruritic rash and other allergic reactions

***D. pteronyssimus***: house dust mite; causes pruritic rash and other allergic reactions

### Family Ixodidae: hard ticks

***Amblyomma americanum***: Lone Star tick; southern and eastern USA; vector of ehrlichiosis, tularemia; causes tick paralysis

***Amblyomma ovale***: causes tick paralysis

***Dermacentor andersoni***: Rocky Mountain wood tick; southern and western USA; vector of tularemia; causes tick paralysis

***D. variabilis***: American dog tick; southern and eastern USA; vector of Rocky Mountains spotted fever, tularemia; causes tick paralysis

***Ixodes holocyclus***: Australian paralysis tick; Australia; causes tick paralysis

***Ixodes pacificus***: western black-legged tick; western USA; vector of Lyme disease, babesiosis; causes tick paralysis

***Ixodes ricinus***: sheep tick; Europe; vector of Lyme disease, babesiosis

***Ixodes scapularis***: black-legged tick; northeastern and eastern USA; vector of Lyme disease, babesiosis; causes tick paralysis

***Rhipicephalus sanguineus***: brown dog tick; Australia, Europe, USA

**Family Argasidae**: soft ticks

***Ornithodoros coriaceus***: Pajaroello tick; southern USA and Mexico

***Ornithodoros moubata***: African hut tick; eastern and southern Africa

**Phylum Pentastomida**

**Family Linguatulidae**

***Armillifer armillatus***: pentastome; Middle East; occasionally parasitises man (viscera and eye); usually asymptomatic

***A. grandis***: occasionally found in man but pathogenicity uncertain

***A. moniliformis***: occasionally found in man but pathogenicity uncertain

***Linguatula serrata***: tongue worm; Middle East; causes linguatulosis (intestine, lung, nasopharyngeal region (halzoun), eye (with visual damage), other organs; uncommon), hepatic granuloma; treatment: levamisole

***Pentastoma najae***: found once in man but pathogenicity uncertain

***Porocephalus crotali***: causes porocephalosis (porcephalosis, porocephalosis); infection of human viscera (usually lung or liver); larvae encyst and calcify without producing clinical symptoms but congestion has been noted in pulmonary disease

***P. moniliformis***: causes porocephalosis

**Phylum Chordata**

**Family Trichomycteridae**

***Vandellia cirrhosa***: vermiform spined fish ('candiru') of Amazon basin; invades rectum, urethra and vagina of bathers