

Chapter 17

Bacteria

Kingdom Procaryotae

Division Gracilicutes

Class Scotobacteria: nonphotosynthetic Gram negative bacteria

Order Spirochaetales: thin spirals, flexuous, motile but no flagella, Gram negative

Spirochaetaceae: no muramic acid in cell wall, inactivated by antibody, anaerobic; spirochaetosis is a general term for a disease caused by any bacterium of this family

Treponemataceae: filamentous spiral organisms that may or may not stain with usual laboratory stains; require complex media or animal host for growth

Treponema: helically coiled with axial filaments, very thin, motile, obligately anaerobic, nonsporeforming Gram negative rods; treponematoses is a general term for any disease caused by a bacterium of this genus; ? role in causing necrotising ulcerative gingivostomatitis, balanitis

T. carateum: causes pinta; treatment: penicillin

T. denticola: ? involved in periodontitis

T. pallidum biotype pallidum: obligate human parasite; sexual transmission, transmission in blood; worldwide distribution; related nonvenereal human bacteria; causes venereal syphilis, anterior uveitis (in secondary syphilis), acute epididymitis and epididymoorchitis, hepatic granuloma, adult and prenatal hepatitis, non-pyogenic meningitis (uncommon), prenatal generalised disease, proctitis in AIDS, maculopapular rash, stillbirth; warm, moist skin is more susceptible; attaches to mucopolysaccharide on cell surface or in tissue; mucopolysaccharidase associated with virulence; enters across epithelial surface of urogenital tract and subsequently spreads through body; facultative intracellular; polysaccharide capsular material resists phagocytosis; antibody of poor specificity or affinity fails to neutralise or opsonise; kidney deposits of circulating immune complexes cause glomerulonephritis (nephrotic syndrome in secondary syphilis); persists in disseminated sites (may be infectious, not shed to exterior), causing chronic disease; mean doubling time 30 h in vivo in rabbit; treatment: penicillin (extremely susceptible), tetracycline, erythromycin, doxycycline

T. pallidum biotype endemicum: causes nonvenereal syphilis

T. pallidum biotype pertunue: causes yaws; warm, moist skin is more susceptible; nonvenereal; restricted to tropical areas; extremely susceptible to penicillin

T. refringens: normal flora in mouth

'T. vincentii' (invalid): ? role in causing necrotising ulcerative gingivostomatitis, tropical ulcer; treatment: metronidazole

Serpulina hyodysenteria: causes swine dysentery, linked to long-standing diarrhoea in humans

S. pilosicoli: causes diarrhoea in pigs, dogs, birds and humans (especially in developing countries and in HIV patients and homosexual males); also bacteraemia in debilitated patients

Borrelia: flagellate spirochaete transmitted to humans by ticks; causes borreliosis; transmission by bite of ticks (worldwide, with major centres in N Africa, Northern India, Russia, Central Asia, S America), lice (Ethiopia major endemic area; also N Africa, W Africa, Namibia, eastern Europe, India, southern USA), infected insect faeces, infected rodents; undergoes antigenic shift during infection; infection usually diagnosed by examination of Wright- or Giemsa-stained peripheral blood

B. americana: vector *Ornithodoros alactogalis*; reservoir rodents; America

B. anserina: causes avian borreliosis; vector *Argas*, ? mites; reservoir fowl; worldwide

B. brasiliensis: vector *Ornithodoros brasiliensis*; Brazil

B. burgdorferi: causes Lyme disease and related disorders (acrodermatitis chronica atrophicans, erythema chronicum migrans, 11% of carpal tunnel syndrome); vector *Ixodes dammini* in Eastern United States, *Ixodes pacificus* in Western

United States, *Ixodes ricinus* in Europe, *Ixodes persulcatus* in Asiatic former Soviet Union, China, Japan, ? *Ixodes holocyclus* in Australia, possibly other arthropods worldwide; reservoir rodents, possibly deer and birds; diagnosis: microscopy, isolation, indirect immunofluorescent antibody, ELISA, haemagglutination, immunoblotting; treatment: tetracycline, penicillin, erythromycin, doxycycline, amoxicillin, ceftriaxone

B. caucasica: causes Caucasian tick-borne relapsing fever (usually mild endemic); vector *Ornithodoros verrucosus*; reservoir rodents; Caucasus to Iraq; treatment: tetracycline, doxycycline

B. coriaceae: causes epizootic bovine abortion; vector *Ornithodoros coriacei*; reservoir rodents, ? deer; Western United States; susceptible to ceftriaxone (MIC 0.01-1 mg/L), erythromycin (0.01-1 mg/L), minocycline (0.09-0.17 mg/L), ampicillin (0.25-1 mg/L)

B. crocidurae: causes North African tick-borne relapsing fever (mild); vector *Ornithodoros erraticus* (small variety); reservoir rodents; Morocco, Libya, Egypt, Iran, Turkey, Senegal, Kenya; treatment: tetracycline, doxycycline

B. dipodilli: as for *B. crocidurae*

B. duttoni: causes East African tick-borne relapsing fever (often severe); vector *Ornithodoros moubatai*; reservoir humans; Central, Eastern, Southern Africa; treatment: tetracycline, doxycycline

B. graingeri: vector *Ornithodoros graingeri*; Kenya

B. hermsii: causes American tick-borne relapsing fever (often severe); vector *Ornithodoros hermsii*; reservoir rodents, chipmunks, tree squirrels; Western United States; treatment: tetracycline, doxycycline

B. herveyi: causes tick-borne relapsing fever; treatment: tetracycline, doxycycline

B. hispanica: causes Hispano-African tick-borne relapsing fever (endemic); vector *Ornithodoros erraticus* (large variety); reservoir rodents; Spain, Portugal, Morocco, Algeria, Tunisia; treatment: tetracycline, doxycycline

B. latysschewii: causes Caucasian tick-borne relapsing fever (usually mild endemic); vector *Ornithodoros tartakovskyi*; reservoir rodents; Iran, Central Asia

B. mazzottii: causes American tick-borne relapsing fever; vector *Ornithodoros talaje*, ? *Ornithodoros dugesi*; reservoir rodents; Southern United States, Mexico, Central and S America; treatment: tetracycline, doxycycline

B. merionesi: as for *B. crocidurae*

B. microti: as for *B. crocidurae*

B. parkeri: causes American tick-borne relapsing fever (endemic); vector *Ornithodoros parkeri*; reservoir rodents; Western USA, Canada; treatment: tetracycline, doxycycline

B. persica: causes Asiatic-African tick-borne relapsing fever (endemic); vector *Ornithodoros tholozani*; reservoir rodents; from W China and Kashmir to Iraq and Egypt, former Soviet Union, India; treatment: tetracycline, doxycycline

B. queenslandica: vector *Ornithodoros gurreyi*; reservoir rodents; Australia

B. recurrentis: causes louse-borne epidemic relapsing fever (vector *Pediculus humanus*, reservoir humans; worldwide, especially Ethiopia, Sudan, S America; ? ¼ children; females > males; 40% case-fatality rate untreated, ? 5% treated; primary attack duration 6 d, afebrile interval 9 d, 1 relapse), adult hepatitis; carried in blood free in plasma; microbial antigens vary within individual host; treatment: penicillin, tetracycline, erythromycin, chloramphenicol

B. theileri: causes bovine borreliosis; vector *Rhipicephalus*, *Boophilus*; reservoir cattle, humans, ? sheep; worldwide

B. tillae: vector *Ornithodoros zumpti*; reservoir rodents; S Africa

B. turicatae: causes American tick-borne relapsing fever (usually mild endemic; most cases young adults and older children; males > females; case-fatality rate < 5%; primary attack duration 4 d, afebrile interval 7 d, 3 relapses); vector *Ornithodoros turicata*; reservoir rodents; Southwestern United States, Central and S America; treatment: tetracycline, doxycycline

B. venezuelensis: causes tick-borne relapsing fever; treatment: tetracycline, doxycycline

Family Leptospiraceae

Leptospira: aerobic, flagellated spirochaete; mostly pathogen of animals; causes leptospirosis (Weil's disease), abortion, adult hepatitis, anterior uveitis, erythema nodosum, non-pyogenic meningitis, rhabdomyolysis; diphasic illness due to disappearance from blood and spinal fluid and appearance of antibody; transmission by contact with water contaminated with urine from infected animals (rats, etc); most important site of survival in epidemiological spread is lumen of convoluted tubules in mammals; carried in blood free in plasma; can be seen by dark field microscopy or antigen stains; treatment: oxytetracycline

L. interrogans: causes leptospirosis; numerous serogroups— icterohaemorrhagicae (30% of total), canicola (25% of total), autumnalis (15% of total), pomona (10% of total), ballina, bataviae, grippityphosa; diagnosis: phase examination and culture of blood (first week of infection), urine (second and third weeks), serology (complement fixation test for group + microscopic agglutination test for serovars; ELISA); treatment: amoxycillin, penicillin, tetracycline

Family Spirillaceae: contains 2 genera— *Spirillum* and *Campylobacter*— whose species may cause disease in man

Spirillum minus: causes spirillosis (sodoka, sokoshio, spirillar fever, spirillary fever; one type of rat bite fever); diagnosis: isolation by animal inoculation, specific serology not available; treatment: penicillin, tetracycline, erythromycin

Campylobacter: microaerophilic, vibrioid, slender, spirally coiled Gram negative rod; appears S-shaped and gull-winged when 2 cells form short chains; asporogenous; motile with a characteristic corkscrew-like motion by means of a single polar flagellum or a polar tuft of flagella at 1 or both ends; requires an oxygen concentration of 3-15% and a CO₂ concentration of 3-5%; serum or blood not required for growth; selective media required for isolation from mixed flora; optimum temperature usually 35°C; indophenol oxidase produced; carbohydrates neither fermented nor oxidised; nitrate reduced by most species; negative test reactions for urease (usually), gelatine and lipase; taxonomic problems exist at species level; normal flora of large intestine, reproductive organs and oral cavity of humans and animals; possibly the most prevalent bacterial pathogen; causes enteritis and enterocolitis (worldwide; often bloody diarrhoea and severe abdominal pain; 40% of faecal enteric pathogen isolates), 0.1% of bacteraemia and septicemia, cholangitis and cholecystitis (rare), endocarditis, urinary tract infections including acute pyelonephritis, reactive arthritis (hips and lower back), Guillain-Barré syndrome, stroke, subarachnoid haemorrhage, brain abscess, subdural empyema, nosocomial meningitis; zoonosis from poultry (gut organism in birds; sporadic disease) and milk (contamination by cow's faeces; outbreaks); also found in cats, dogs, goats, rabbits and a wide range of wild birds; attaches to intact epithelium; growth stimulated by excess iron; invasive infection plus enterotoxin; involves small intestine, colon and rectum; incubation period ? 3-5 d; treatment: erythromycin, cotrimoxazole, ciprofloxacin (MIC 0.03-0.5 mg/L); also susceptible to ofloxacin (1 mg/L), enoxacin (1 mg/L), imipenem (100%)

C. butzleri: causes diarrhoea, enterocolitis, bacteraemia and septicemia, appendicitis; treatment: ciprofloxacin

C. coli: characteristics as for *C. jejuni* but hippurate not hydrolysed; found in healthy pigs; causes diarrhoea, enterocolitis, abortion, fever, septic shock, stillbirth in humans

C. cryaerophila: growth at 6°C and 25°C but not at 42°C; grows in 2% sodium chloride and 0.1% glycine, but not in 1% glycine; hippurate not hydrolysed; H₂S not detected in triple sugar iron agar; susceptible to nalidixic acid; cause of abortions in pigs, cattle, horses and sheep; found in the faeces of a single patient with enteritis; occasionally isolated from human blood infections

C. faecalis: 2% NaCl and H₂S (TSI) positive, mean inhibitory zone size cephalothin > 40 mm, light growth in GasPak with catalyst at 37°C and 42°C; causes diarrhoea in cattle

C. fetus: causes abortion, abscesses, bacteraemia, intravascular infections, meningitis, prenatal generalised disease, stillbirth; inhibits phagocytic attachment and ingestion; transmission has been linked to tank water; treatment: gentamicin; also susceptible to pefloxacin (MIC 0.125-1 mg/L), amoxycillin-clavulanate (0.25-1 mg/L)

C. fetus subsp fetus: growth at 25°C, but usually not at 42°C; grows in 1% glycine, but not 3.5% NaCl; H₂S detected with lead acetate paper but not TSI agar; hippurate not hydrolysed; resistant to nalidixic acid; isolated from blood, CSF and pleural fluid of patients with various debilitating conditions; common cause of abortion in sheep and cattle, bacteraemia and septicemia, diarrhoea and enterocolitis in humans (usually compromised hosts); uncommon cause of septic abortion, septic arthritis, abscesses, endocarditis, neonatal and postneonatal purulent meningitis, mycotic aneurism, peritonitis, prenatal generalised disease, salpingitis and thrombophlebitis in humans; treatment: gentamicin, erythromycin, amoxycillin-clavulanate, piperacillin, cotrimoxazole, rifampicin, fluoroquinolone

C. fetus subsp venerealis: growth at 25°C, but not at 42°C; no growth in 1% glycine or in 3.5% NaCl; H₂S not detected with lead acetate paper or TSI agar; hippurate not hydrolysed; usually resistant to nalidixic acid; isolated from bovines; causes abortion and infertility in cattle; clinical significance in humans uncertain

C. hyointestinalis: growth at 42°C, variable growth at 25°C; grows in 1% glycine, but not in 3.5% NaCl; H₂S detected with both lead acetate paper and TSI agar; hippurate not hydrolysed; colonies yellow pigmented; resistant to

nalidixic acid; causes proliferative ileitis in swine; occasionally found in faeces of patients with enteritis (watery diarrhoea) and enterocolitis; associated with proctitis

C. intestinalis: causes enterocolitis, toxic shock syndrome; treatment: erythromycin

C. jejuni: grows only microaerophilically at 42°C, not at 25°C; mean inhibitory zone size nalidixic acid 32-36 mm, catalase and oxidase positive, H₂S detected with lead acetate paper but not TSI, darting/tumbling motility, growth in 1% glycine, no growth in 3.5% NaCl, hippurate hydrolysed; isolated from human stool and occasionally from blood and CSF; causes abortion in sheep, enteritis in cattle; common cause of colitis, diarrhoea, enteritis, enterocolitis, gastroenteritis in humans; uncommon cause of appendicitis, bacteraemia and septicemia (in conjunction with gastroenteritis in people at extremes of age or with cirrhosis, diabetes, renal failure, cancer, HIV; 8% of septicemia associated with female genital tract infection), female genital tract infection (3%), fever, Guillain-Barré syndrome adult hepatitis, myocarditis, prenatal generalised disease, proctitis, reactive arthritis; rare cause of meningitis; found in 9% of adults and 19% of children with diarrhoea, 9% of asymptomatic children, absent in asymptomatic adults; attack rate (diarrhoea) 20-50% in day care centres; 6% of waterborne disease outbreaks (source human faeces; survival in water poor); 60% of cattle infected; transmitted in raw milk, chicken, salad vegetables, bottled water; replicates in intestinal epithelium, producing mucosal damage, inflammation and diarrhoea; toxin not demonstrated; susceptible to amoxicillin, ampicillin, azithromycin, clarithromycin, erythromycin (96% susceptible), roxithromycin, ciprofloxacin (MIC 0.25-1 mg/L), norfloxacin, nalidixic acid (100%), amikacin, gentamicin (100%), tobramycin, chloramphenicol (96%), imipenem, meropenem, pefloxacin (MIC 0.125-1 mg/L), fleroxacin (0.25-1 mg/L); variably susceptible to cefepime, ceftazidime; subsp *doylei* and *jejuni*

C. lariis: growth at 42°C but not 25°C; grows in 1% glycine but not 3.5% NaCl; H₂S detected with lead acetate paper but not TSI agar; hippurate not hydrolysed; resistant to nalidixic acid; isolated from avian and mammalian species, most frequently from seagulls, occasionally from humans; causes diarrhoea and enteritis, bacteraemia and septicemia in humans; treatment: ciprofloxacin

C. sputorum: anaerobic, nonfermentative metabolism, succinic acid from fumarate; normal flora of nasopharynx, tooth surface, gingiva, saliva; associated with periodontal disease; causes abscesses; isolated from children with diarrhoea; susceptible to clindamycin, chloramphenicol, metronidazole, penicillin G, tetracycline, erythromycin; resistant to vancomycin, bacitracin, rifampicin

C. upsaliensis: growth at 42°C but not at 25°C; growth in 1% glycine; catalase reaction negative or weak; H₂S not detected with TSI agar; hippurate not hydrolysed; susceptible to cephalothin and nalidixic acid; isolated from dog, cat and human faeces; isolated from diarrhoeic and healthy hosts; clinical significance uncertain but considered an uncommon cause of diarrhoea, enterocolitis, bacteraemia and septicemia

Helicobacter cinaedi: intermediate resistance to 30 µg cephalothin disc, nitrate positive, no odour, no growth at 25°C or 42°C, grows in 1% glycine but not in 3.5% NaCl, hippurate not hydrolysed, H₂S detected with lead acetate paper but not TSI agar, susceptible to nalidixic acid; isolated from human blood and rectal swabs; causes bacteraemia and septicemia in AIDS, enteritis, enterocolitis, proctitis and proctocolitis in homosexual men

Helicobacter fennelliae: no growth at 25°C or 42°C; grows in 1% glycine but not in 3.5% NaCl; nitrate not reduced; hippurate not hydrolysed; H₂S detected with lead acetate paper but not TSI agar; distinctive hypochlorite odour; susceptible to nalidixic acid; sensitive to 30 µg cephalothin disc; nitrate negative; isolated from human blood and rectal swabs; associated with bacteraemia and septicemia, diarrhoea, enteritis, enterocolitis, proctitis and proctocolitis in homosexual men

Helicobacter pylori: curved Gram negative bacillus, rods sometimes 'oxbow' shaped, cells large compared with *Campylobacter*, polar flagella; requires CO₂, blood or serum and adequate surface moisture for growth; enriched medium, chocolate agar or selective enriched medium used for isolation from biopsy tissue; does not grow anaerobically; some strains grow poorly at 30°C and 40°C; 3.5% NaCl, glucose, indole and nitrate negative; 1% glycine, oxidase and catalase positive; produces urease, H₂S detected with lead acetate paper, hippurate not hydrolysed, resistant to nalidixic acid; causes antral gastritis, duodenal and peptic ulcers, mucosa-associated lymphoid tissue lymphoma, ? syndrome X (microvascular angina), primary migraine, primary Raynaud's phenomenon, ischaemic heart disease; reservoir in dental plaque; transmission person-to-person (oral-oral, fecal-oral), possibly water-borne in some locations; seroprevalence in Australia 30.6%, ? 50% in USA, ? 90% in developing countries; treatment: combinations of proton

pump inhibitors + bismuth salt + metronidazole or tinidazole or amoxicillin + clarithromycin or tetracycline; also susceptible to penicillin G, erythromycin, gentamicin, cephalothin

Family Spirosomaceae: non-motile Gram negative curved bacteria

Flectobacillus: oxidative, pale pink or rose pigment, highly curved rod, oxidase positive

Eubacteriales: Gram positive and Gram negative cocci or rods, some motile, some form endospores, not acid-fast; includes the majority of human pathogens

Pseudomonadaceae: Gram negative aerobic and facultatively anaerobic bacilli, motile, polar monotrichous or tuft of flagella, nonsporeforming, nonfermentative, oxidise carbohydrates to acid but not gas, catalase positive; water-borne; cause infections in patients with interrupted integument

Chryseomonas luteola: rods motile with a polar tuft of 1-6 or more flagella; asporogenous; obligately aerobic; catalase, but not indophenol oxidase, produced; indole not formed; oxidative in glucose and a wide range of other carbohydrates; colonies rough and/or smooth, with a water-insoluble pigment; distinguished from phenotypically similar *Flavimonas oryzihabitans* by positive test reactions for nitrate reduction (no gas) and hydrolysis of ONPG, esculin and arginine (variable); usually not found in general environment; saprophytes or commensals of humans; isolated from a variety of human clinical specimens, including nose, blood, throat, gallbladder, urine, CSF and penis; associated with septicemia, subdiaphragmatic abscess and prosthetic valve endocarditis in patients with predisposing diseases and peritonitis in continuous ambulatory peritoneal dialysis; cause of septicemia in an otherwise healthy patient with granulomatous hepatitis, bacteraemia and septicemia associated with prosthetic materials and corticosteroids

Flavimonas oryzihabitans: rods motile with a single polar flagellum; asporogenous; obligately aerobic; catalase, but not indophenol oxidase, produced; indole not formed; oxidative in glucose and a wide range of other carbohydrates; colonies smooth and/or rough with a yellow intracellular pigment; distinguished from phenotypically similar *Chryseomonas luteola* by negative test reactions for nitrate reduction and hydrolysis of ONPG, esculin and arginine; found in general environment; saprophytes of humans and other warm-blooded animals; isolated from rice paddies and rice flour, from respiratory therapy equipment and sink drains in the hospital, and from various human specimens, including pus, conjunctiva, pleural fluid, maxillary sinus washing, pleural aspirate, blood, ear, finger exudate, eye and breast drainage; associated with septicemia in a postneurosurgical patient, peritonitis in patients undergoing continuous ambulatory peritoneal dialysis, septicemia in a patient with severe digestive haemorrhage and isolated from a patient with metastatic gastric carcinoma; causes abscesses, bacteraemia and septicemia (prosthetic materials, corticosteroids), wound infections; susceptible to gentamicin (MIC ? 0.03-0.13 mg/L)

Pseudomonas: straight or slightly curved rods; asporogenous; obligately aerobic; motile with polar monotrichous or polar tuft of 1-6 or more flagella; growth on MacConkey, growth on SS, nitrate may be reduced to nitrite, lysine decarboxylase and ornithine decarboxylase negative, arginine dihydrolase positive, special growth factors not required, catalase produced, usually oxidase positive, nonfermentative metabolism (some species oxidative in carbohydrates, others non-oxidative), DNase negative, PHB variable, indole not formed, pigments variable (some species produce various fluorescent and nonfluorescent pigments, but no photosynthetic pigments); widely distributed in nature; causes abortional and puerperal infections, cellulitis, cerebrospinal fluid shunt infections, cholangitis and cholecystitis (rare), acute cystitis, 3% of primary endocarditis, endotoxic reactions associated with reuse of cardiac catheters, chronic eye infections, endophthalmitis (postoperative), human bite and clenched fist infections, neonatal meningitis, peritonitis (primary, secondary, peritoneal dialysis), pneumonia, localised skin lesions in septicemia and endocarditis, local and generalised sepsis, symbiotic gangrene, transfusion reactions due to bacterial contamination of blood and blood products, water-related infections, systemic infections in microbicidal abnormality, 9% of nosocomial infection (interrupted integument); growth stimulated by excess iron; treatment; ticarcillin + gentamicin, ciprofloxacin; also susceptible to norfloxacin (MIC 1 mg/L), imipenem (< 5% resistance in Australia); 100% intrinsic resistance to penicillin, flucloxacillin, clindamycin, erythromycin

P.aeruginosa: produces water-soluble, yellow-green (pyoverdin), yellow-brown or colourless fluorescent pigments; grows at 42°C, not at 4°C; motile with a single polar flagellum; nitrate reduced to nitrite and nitrogen gas; glucose oxidised; maltose, sucrose, lactose, starch, lysine decarboxylase, ornithine decarboxylase and H₂S negative; gluconate oxidation, gelatinase, and indophenol oxidase positive; methionine not required, alkaline phosphatase heat resistant, arginine dihydrolase synthesised, citrate positive; identified on basis of the characteristic grapelike odour of

aminoacetophenone, the structure of colonies on agar medium and production of pyocyanin (a water-soluble, blue, nonfluorescent phenazine pigment); water-soluble, nonfluorescent red (pyorubin) and brown (pyomelanin) pigments occasionally produced; number of colonial variants (smooth, coliform-type, rough, mucoid, gelatinous) arising by dissociation of a single strain gives the false impression of different bacterial species present; most strains grow on ceftrimide; widely distributed in soil, water, sewage and plants; common human intestinal bacterium (large intestine, lower ileum); adherence to nasal mucosa +++, labium majus ++; cause of disease in humans, as well as in certain animals, insects and plants; associated with 5% of all community-acquired infections, but infection usually restricted to hospitalised patients with predisposing conditions (14% of nosocomial infections (25% of Gram negative bacilli); important cause of fatal bacteraemia in neutropenic patients; causes bacteraemia and septicemia (especially associated with haemodialysis), severe epidemic diarrhoea of infants, burn infections, cellulitis, cranial parameningeal deep fascial space infections (immunocompromised and otogenic), acute empyema, ecthyma gangrenosa, endocarditis (14% of cases in drug addicts, 4% in children), endotoxemia, acute epididymitis and epididymo-orchitis, eye infection (iridocyclitis, keratitis and iritis, corneal ulcer, purulent conjunctivitis, panophthalmitis), folliculitis (polymorphous rash associated with spas and whirlpools), gastroenteritis, local and generalised sepsis, neonatal and postneonatal purulent meningitis, mycotic aneurism, myocarditis and pericarditis, nasal septic abscess, 3% of necrotising fasciitis, 3% of osteomyelitis and osteochondritis, 35-70% of otitis externa ('swimmer's ear' and malignant), otitis media (malignant, chronic and complicating endotracheal intubation and mechanical ventilation), dermatitis, paronychia, perianal and perirectal abscess in patients with malignant disease, primary and secondary pneumonia, chronic pulmonary infection in cystic fibrosis (especially mucoid strains), postoperative complications, septic arthritis (complicating foot puncture wounds in children; in i.v. drug abusers), septicaemic adrenal haemorrhage syndrome, acute sinusitis, pulmonary abscess, 8% of thrombophlebitis, typhlitis, thyroiditis, wound infections including 5% of surgical wound infections (summer peak), urinary tract infections (pyelonephritis, cystitis, urethritis), infections in abnormal host (granulocytopenia, opsonophagocytic antibodies, local immunity (eg., cystic fibrosis), depressed/defective cell-mediated immunity, interrupted integument, surgical procedure), systemic infections in granulocytopenia; endotoxin A and cell-bound leucocidin kill macrophages; inhibits phagocytic chemotaxis; 'surface slime' (polysaccharide) resists phagocytosis (unless antibody present) and digestion (associated with invasiveness; virulence factor); collagenase (virulence factor) causes spread of infection; elastase (virulence factor) causes necrotising vasculitis; other virulence factors pili, exotoxin A, haemolysin, lecithinase and lipase; potential virulence factors exotoxins B and C, protease; primary bodily defence mechanism humoral immune responses (immune adherence (phagocytosis) +++, phagocytes +, alternative complement (natural antibody) +, ? interference with adherence +); diagnosis: culture, counterimmunoelectrophoresis (serum; sensitivity 100%); susceptible to ticarcillin (13% resistance in Australia), tobramycin (5% resistance in Australia), gentamicin (17% resistance in Australia), ciprofloxacin (13% resistance in Australia, 38% in USA), norfloxacin (8% resistance in Australia, 37% in USA), ceftazidime (10% resistance in Australia), azlocillin (commonly susceptible), amikacin (13% resistance in Australia), colistin, neomycin (topical), piperacillin (9% resistance in Australia), imipenem (17% resistance in Australia), meropenem, ofloxacin, piperacillin-tazobactam (9% resistance in hospitals in Australia), ticarcillin-clavulanate; variably susceptible to gatifloxacin, moxifloxacin; resists many antibiotics— uniform resistance to penicillin results from exclusion by cell membrane and chromosomally mediated penicillinase; 100% intrinsic resistance to ampicillin, amoxicillin, amoxicillin-clavulanate, cephalosporins except cefepime, ceftazidime and ceftipime, cotrimoxazole and trimethoprim; possesses a Class I chromosomal β -lactamase but low mutation rate to resistance (10^{-9}) and not likely to give rise to mutants except in a sequestered site (cystic fibrosis, osteomyelitis)

P. alcaligenes: motile with a single polar flagellum, wavelength of the flagellum ? 1.6 μ m; indophenol oxidase produced; nitrate reduction (no gas) strain variable; urease not produced; non-oxidative in carbohydrates; alkali accumulates in O-F fructose, which distinguishes *P. alcaligenes* from related *P. pseudoalcaligenes*, which oxidises fructose; isolated from water and a variety of clinical specimens, primarily urine, blood and sputum; occasionally, an opportunistic agent; cause of empyema, neonatal septicemia, intrauterine infection, chronic pulmonary infection in cystic fibrosis, endocarditis in bone marrow transplant recipients

P. delafieldii: motile with a polar flagellum; indophenol oxidase produced; oxidative in glucose, xylose and mannitol, but not lactose, sucrose or maltose; produces positive test reactions for nitrate reduction (no gas), arginine dihydrolase,

urease, DNase and gelatinase; isolated from soil by enrichment procedures, pus from cement in femur, joint aspiration and trachea; no information concerning clinical significance

P. diminuta: very tightly coiled monotrichous flagellum, with a wavelength that varies from 0.62-0.98 μ m, a distinctive characteristic of *P. diminuta* and *P. vesicularis* (wavelength of most polar monotrichous *Pseudomonas* ? 2 ? μ m); colonies usually chalk-white in colour; indophenol oxidase produced; most carbohydrates not oxidised, although a few strains produce weak acid from glucose; acid produced from primary alcohols by all strains that utilise alcohols; pellicle forms in broth cultures; rarely reduces nitrate; esculin not hydrolysed; panthothenate, biotin, cyanocobalamin and cystine required as growth factors; isolated from streams, ditch waters, contaminated cell culture, respiratory equipment and various clinical specimens, such as blood, CSF and urine; clinical significance uncertain

P. fluorescens: oxidase positive; produces water-soluble, yellow-green, yellow-brown or colourless fluorescent pigments (pyoverdins); arginine dihydrolase produced; gelatinase positive, gluconate variable, does not grow at 42°C, grows at 4°C; motile by polar tuft of 3 or more flagella; nitrate reduced to nitrite (few strains occasionally to nitrogen gas); oxidative in glucose and sucrose and certain other carbohydrates, maltose variable, lactose and starch negative; methionine not required; alkaline phosphatase heat resistant; proteolytic; failure to produce pyocanins and to grow at 42°C and possession of polar tuft of flagella distinguishes from closely related *P. aeruginosa*, isolated from soil, water, hospital environment and human clinical specimens, primarily from respiratory tract; causes bursitis, cat and dog bite infections, transfusion reactions due to bacterial contamination of blood and blood products, infections in abnormal host; susceptible to gentamicin (MIC ? 0.03-1 mg/L), ciprofloxacin (0.5-1 mg/L), norfloxacin (85%), enoxacin (85%); resistant to amoxicillin, amoxicillin-clavulanate, cefaclor, cefixime, cefuroxime, cephalexin

P. gladioli: motile with a single polar flagellum; produces acid from glucose, xylose and mannitol; ONPG positive; resistant to polymyxin; negative test reactions for indophenol oxidase, oxidation of lactose, sucrose and maltose and decarboxylases for lysine and ornithine and a positive test reaction for urease distinguishes from closely related *Burkholderia cepacia*; isolated from decayed onions and respiratory specimens of patients with cystic fibrosis; otherwise, rarely recovered from human clinical specimens

P. immobilis: non-motile, Gram negative coccobacilli, diplo forms; growth on MacConkey (may be sparse); growth at 25°C, sometimes at 35°C, not at 42°C; catalase, oxidase and Christensen's urea positive; indole, Simmon's citrate, esculin and gelatine negative; nitrate reduction to nitrite variable, nitrogen gas not produced, TSI alkaline/no change, acid from glucose, xylose, lactose, no acid from sucrose, maltose, growth in 0% NaCl and 6% NaCl, may have odour of rose

P. mallei: fluorescent pigment absent; colonies smooth and range from white to cream in colour; grows slowly compared with *P. aeruginosa* or *Burkholderia pseudomallei*; no growth on MacConkey; non-motile; slow and very weak or negative indophenol oxidase reaction; slowly oxidative in glucose and a wide range of other carbohydrates, including cellobiose and maltose, but not xylose or maltose; arginine dihydrolase produced; not susceptible to polymyxin; negative test reactions for nitrogen gas, gelatinase, Simmon's citrate, lysine decarboxylase and growth at 42°C; causes glanders (farcy) of equines (transmitted from equine hosts to humans by direct contact and transmitted from person to person; quite rare); only highly adapted parasite of animals in the genus; diagnosis: Gram stain and culture of swab of discharge from necrotic foci or skin or from enlarged lymph nodes, blood, sputum, nasopharyngeal discharge, complement fixation test, agglutinations; treatment: sulphonamides, cotrimoxazole

P. mendocina: colonies flat, smooth, butyrous and non-wrinkled; forms a brown-yellow intracellular carotenoid pigment; motile with a polar flagellum; indophenol oxidase produced; nitrate reduced to gas; oxidative in glucose and xylose, not maltose; arginine dihydrolase produced; starch not utilised; distinguished from similar strains of *P. stutzeri* by colonial morphology and reactions for maltose, starch and arginine; a polar monotrichous flagellum and growth at 42°C distinguishes from phenotypically similar denitrifying strains of *P. fluorescens*; isolated from soil, water and urine; association with infections in humans unknown

P. paucimobilis: colonies develop an intracellular, nondiffusible, yellow pigment; occasionally, only a few cells in a population motile (polar monotrichous); indophenol oxidase usually produced; oxidative in a wide variety of carbohydrates, but not mannitol; esculin and ONPG hydrolysed; negative test reactions for urease, nitrate, dihydrolases and decarboxylases; lack of urease distinguishes non-motile strains from phenotypically, but not genotypically, similar *Sphingobacterium multivorum*; isolated from water, hospital environment, including distilled water, respirator, humidifier

and dialysis fluid, and from human vaginal and cervical swabs, blood, CSF, urine, wound, splenic abscess, post-operative and post-traumatic wound infections and septicemia; cause of a community-acquired septicemia in a patient on chronic corticosteroid therapy; causes acute skin ulcers; treatment: ciprofloxacin (MIC < 0.5 mg/L); also susceptible to minocycline (MIC ? 0.03-0.13 mg/L), norfloxacin (< 0.5 mg/L)

P. pertucinogena: motile with a polar flagellum; grey colonies on Bordet-Gengou medium mimic colonies of rough phase IV strain of *Bordetella pertussis*; colonies on trypticase soy agar semitranslucent, entire and glistening; nonoxidative in carbohydrates; produces indophenol oxidase, phenylalanine deaminase and pertucin, a bacteriocin that inhibits growth of *Bordetella pertussis*; susceptible to most antimicrobials except novobiocin; source not recorded, probably human respiratory tract; clinical significance unknown

P. pickettii: growth of nonpigmented colonies on blood agar and other media characteristically slow; motile with a polar flagellum; indophenol oxidase produced; development of oxidative activity in O-F media and reduction of nitrate to gas characteristically slow, usually requiring 48 h of incubation to detect; urease produced; dihydrolase and decarboxylases not produced; not susceptible to polymyxin; alkali produced from malonate; mannitol, sucrose and ethanol not oxidised; several biovars differentiated by acidification of specific carbohydrates; isolated from environmental sources, such as water from an artificial kidney machine, chlorhexidine solution, autoclave-cooling water, intravenous fluid, umbilical catheter tip, i.v. catheter, respiratory therapy saline solution, paper mill effluent and teething ring; isolated from human sources, including urine, nasopharynx, abscess, wound, blood and CSF; part of increased flora during myelosuppressive chemotherapy; primarily opportunistic; associated with a case of acute, non-fatal meningitis, infections of urinary and respiratory tracts and a number of cases of septicemia

P. pseudoalcaligenes: motile with a single polar flagellum; indophenol oxidase produced; nitrate usually reduced (no gas); urease usually not produced; weak oxidation of fructose in O-F medium differentiates from closely related *P. alcaligenes*, most other carbohydrates not utilised; isolated from various water sources and human blood, urine, throat, sputum and abscess; occasionally an opportunistic agent; associated with meningitis, postoperative knee infection, pneumonitis, septicemia and intrauterine infection

P. putida: produces water-soluble, yellow-green, yellow-brown or colourless fluorescent pigments (pyoverdins); indophenol oxidase and arginine dihydrolase produced; nitrate not reduced; glucose positive, maltose variable, gelatine negative; nonproteolytic activity distinguishes from proteolytic *P. fluorescens*; failure to produce pyocyanin and to grow at 42°C and possession of a polar tuft of 3 or more flagella distinguishes from closely related *P. aeruginosa*; isolated from soil, water, hospital environment and human clinical specimens, primarily from respiratory tract; rarely opportunistic; associated with infections of extremities, bacteraemia, septic arthritis and septicemia following blood transfusion; newly recognised as pathogen in cancer patients; susceptible to gentamicin (MIC ? 0.03-1 mg/L), enoxacin (85%), norfloxacin (85%); resistant to amoxicillin, amoxicillin-clavulanate, cefaclor, cefixime, cefuroxime, cephalexin

P. stutzeri: most freshly isolated strains produce dry, wrinkled, tough and adherent colonies, smooth colonies and various intermediate colony types; colonies usually buff to yellow to light brown due to high concentration of cytochrome c in cells; fluorescent pigment absent; motile with a single polar flagellum; usually growth at 42°C, no growth at 4°C, nitrate reduced to nitrite and nitrogen gas; grows under anaerobic conditions in nitrate-containing media accompanied by nitrogen gas production; oxidation in glucose, maltose and certain other carbohydrates, but not lactose; starch usually hydrolysed; oxidase positive; salt tolerant and non-halophilic but requires sodium cation for growth; methionine not required for growth; alkaline phosphatase heat sensitive; arginine dihydrolase and gelatinase not produced; susceptible to polymyxin; isolated from soil, water, hospital environment such as deionised water and aqueous green soap, and numerous clinical specimens including wound, ear, blood and CSF; part of increased flora during myelosuppressive chemotherapy; occasionally associated with infections in humans, including postoperative and posttraumatic infection of extremities, otitis media, conjunctivitis, septic arthritis, pneumonia, osteomyelitis and septicemia; susceptible to sisomicin (MIC 0.06-0.5 mg/L), ciprofloxacin (0.5 mg/L), gentamicin (0.13-1 mg/L), pefloxacin (1 mg/L), cefotetan (1 mg/L), cefoperazone (1 mg/L), ceftriaxone (1 mg/L), enoxacin (85%), norfloxacin (85%), amoxicillin, amoxicillin-clavulanate; resistant to cefaclor, cefuroxime, cephalexin

P. vesicularis: very tightly coiled monotrichous flagellum, with a wavelength that varies from 0.62-0.98 ? m— a distinctive characteristic of this species (and *P. diminuta*); indophenol oxidase produced; variable oxidation of glucose, xylose and maltose; nitrate usually not reduced; requires pantothenate, biotin and cyanocobalamin as growth factors;

distinguished from closely related *P. diminuta* by esculin hydrolysis, production of an orange intracellular pigment (variable) and failure to produce a pellicle in broth culture; isolated from urinary bladder epithelium of a medicinal leech, whooping cough plate, tap water aerator, hospital sink, and human sources, such as cervical specimens, CSF, blood and urine; susceptible to doxycycline (MIC ? 0.03-0.25 mg/L)

***Pseudomonas* species group 1:** motile with a single polar flagellum; no acidification of carbohydrates in O-F medium; indophenol oxidase produced; reduction of both nitrate and nitrite to gas distinguishes from phenotypically similar *P. alcaligenes*; isolated from environmental sources and human urine, CSF, blood and throat; cause of bacteraemia and meningitis

***Pseudomonas*-like group 2:** polar tuft of flagella with a mean wavelength of 3.1 ?m, similar to that found in *Comamonas*; indophenol oxidase produced; urea and ONPG hydrolysed; oxidative in glucose, xylose, mannitol and lactose (variable), not sucrose or maltose; negative test reactions for nitrate, dihydrolase and decarboxylases; usually resistant to polymyxin; human respiratory isolates; possibly associated with acute or chronic respiratory distress

***Burkholderia cepacia*:** some strains produce a green-yellow, water-soluble, nonfluorescent phenazine pigment; pigment occurs in bacterial cell and usually diffuses into surrounding agar medium; many strains non-pigmented; motile with a polar tuft (3-many) of flagella; oxidative activity from a wide range of carbohydrates, including glucose, lactose, maltose and mannitol; most strains hydrolyse ONPG and produce decarboxylases of lysine and ornithine; nitrate not reduced to gas; occasionally, a very weak or negative indophenol oxidase reaction; not susceptible to polymyxin or colistin; isolated from rotten onions, as a phytopathogen, from soil from a variety of geographical regions, hospital environment, and various clinical specimens, including urine, blood, CSF, bronchial washing, sputum, abscess and wound; part of increased flora during myelosuppressive therapy; an opportunistic organism associated with various types of human infections of community-acquired and nosocomial origins, including septicemia, meningitis, endocarditis, pneumonia, chronic pulmonary infection in cystic fibrosis, post-operation wound infection, urinary tract infection, septic arthritis, chronic granulomatous disease, cervical osteomyelitis, endophthalmitis, endotoxic reactions associated with reuse of cardiac catheters, nosocomial infection from cryoprecipitate contaminated in water bath, pseudobacteremia due to contaminated povidone iodine solution; variably susceptible to imipenem, meropenem; resistant to gentamicin, amikacin, ampicillin, amoxycillin, amoxycillin-clavulanate, cephalothin, cefaclor, cefixime, cefuroxime, cephalixin, ciprofloxacin and many others

***Burkholderia pseudomallei*:** colonies vary from mucoid and smooth to rough and wrinkled in texture and from bright orange to cream colour; fluorescent pigment absent; characteristic musty, earthy odour; Gram negative rods, bipolar staining (safety pin appearance); motile with a polar tuft of 3 or more flagella; growth at 42°C, no growth at 4°C; nitrate reduced to nitrite and nitrogen gas; grows anaerobically in a nitrate-containing medium accompanied by gas production; oxidative in glucose, lactose, maltose, sucrose, cellobiose, starch and a wide variety of other carbohydrates; slow and very weak indophenol oxidase reaction; catalase positive; arginine dihydrolase produced; proteolytic; not susceptible to polymyxin, colistin or aminoglycosides; Simmon's citrate positive, lysine decarboxylase negative, methionine not required; alkaline phosphatase heat resistant; free-living organism isolated from soil or water in restricted geographical regions (endemic between 20°N and 20°S latitudes); causes melioidosis (an endemic glanders-like disease of humans and animals in SE Asia and Northern Australia; rarely occurs in Western hemisphere), bacteraemia and septicemia (common in S E Asia in rice farmers or their families; associated with diabetes and renal failure; 85-95% mortality), hepatic abscess, adult hepatitis, hepatic granuloma, parotitis and sialadenitis, pneumonitis; diagnosis: culture of pus swab from ulcers and abscesses, sputum, urine, blood, indirect haemagglutination antibody titre, enzyme immunoassay IgG and IgM, immunofluorescence IgG and IgM; susceptible to trimethoprim, cotrimoxazole, doxycycline, ceftazidime, meropenem (MIC 0.78 mg/L), chloramphenicol, tetracycline, minocycline, amoxycillin-clavulanate, imipenem, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate; resistant to ampicillin

***Comamonas*:** curved or straight rods; asporogenous; motile by means of a polar tuft of flagella with a mean wavelength of 3.1 ?m, a distinctive characteristic; number of flagella at one or both poles varies from 1 to 6; obligately aerobic; indophenol oxidase and catalase produced; nitrate reduced (no gas); alkali produced in O-F carbohydrates except for weak acidification of fructose and mannitol by *C. acidovorans*; indole not produced; some strains require growth factors; growth not pigmented; soil and water saprophytes

C. acidovorans: no growth at 42°C; oxidation of fructose and mannitol and production of anthranilic acid and kynurenine in tryptone broth, which causes Kovacs reagent to turn orange, distinguishes this species from *C. terrigena* and *C. testosteroni*; isolated from soil, water, rat kidney, hospital environment and human urine, blood, sputum, eye, tracheal washing, suprapubic tap, pleural fluid, abdominal drainage and wound; rarely aetiologically significant; susceptible to oxolinic acid (MIC ? 0.25 mg/L), meropenem (0.25 mg/L), cefoxitin (0.5 mg/L), moxalactam (0.5 mg/L), ceftriaxone (0.5 mg/L), cefixime (0.5 mg/L), enoxacin (1 mg/L)

C. terrigena: nonoxidative; differentiated from *C. testosteroni* in requiring growth factors (methionine and nicotinamide) in a mineral base medium for growth; utilises ?-alanine, not histidine and phenylalanine; isolated from soil, water, hospital environment and human blood and faeces; clinical significance unknown

C. testosteroni: nonoxidative; distinguished from *C. terrigena* in having no growth factor requirements and by utilisation of histidine and phenylalanine, but not ?-alanine, as sole source of carbon; isolated from soil, water, hospital environment and human blood, sputum and urine; rarely clinically significant

Shewanella putrefaciens: colonies slightly viscous or mucoid and usually red-brown or pink in colour; motile with a single polar flagellum; produces abundant H₂S in Kligler iron agar; indophenol oxidase produced; reduces nitrate (no gas); highly proteolytic; ornithine decarboxylase and DNase tests positive; distinguished from phenotypically similar strains of *Alteromonas putrefaciens* by failure to produce oxidative acidity from sucrose and maltose and ability to grow in high salt concentration (6.5%); few environmental isolates; primarily isolated from human blood, ear, urine, faeces, sputum, pus, wound exudate and throat; an occasional opportunist associated with otitis media, meningitis following head injury, lower limb cellulitis, bacteraemia and septicemia in patients with chronic infection of lower extremity and in association with severe underlying debility, liver disease, malignancy; usually susceptible to gentamicin, neomycin, nitrofurantoin, kanamycin, nalidixic acid, erythromycin, polymyxin B, tetracycline, chloramphenicol, cotrimoxazole

Stenotrophomonas maltophilia: colonies develop a characteristic lavender-green colour on blood agar; growth accompanied by a strong smell of ammonia; obligately aerobic; asporogenous; rods, motile by a polar tuft of 1-6 or more flagella; hydrolyses DNA; oxidative (delayed) in glucose, maltose, sucrose, lactose and certain other carbohydrates; positive test reactions for catalase, lysine decarboxylase and for hydrolysis of esculin and gelatine; usually no growth at 42°C or 4°C; nitrate and nitrite reduction negative; starch negative; usually oxidase negative; indole not formed; either methionine or cystine + glycine required for growth; alkaline phosphatase heat sensitive; wide geographic distribution; isolated from water, soil, animal sources, plant material and all varieties of human clinical specimens; occasionally an opportunist associated with urinary tract (acute pyelonephritis associated with hospitalisation and antimicrobial therapy) and respiratory tract infections (pneumonia following hospitalisation and antimicrobial therapy), postoperative and posttraumatic wound infections, endocarditis (associated with i.v. drug abuse and prosthetic valve surgery), bacteraemia and septicemia (nosocomial infections in immunocompromised patients receiving broad spectrum antimicrobials), meningitis, mastoiditis, conjunctivitis, ecthyma gangrenosum, pseudobacteremia; 2% of nosocomial infections (3% of Gram negative bacilli); high incidence of infections in patients with malignant solid tumours, leukemia and lymphoma; susceptible to ticarcillin-clavulanate (98%), cotrimoxazole (2% resistance in hospitals in Australia); 100% intrinsic resistance to ampicillin, amoxicillin, amoxicillin-clavulanate, cephalosporins except ceftazidime (92% susceptible), imipenem and meropenem; 79% intrinsic resistance to aminoglycosides (possibly all resistant in clinical practice), commonly resistant to ticarcillin, piperacillin, azlocillin

Family Acetobacteriaceae

Acetobacter: rare opportunistic invader

Family Legionellaceae

Legionella: rods of variable length; asporogenous; motile by 1 or more polar or lateral flagella; obligately aerobic; carbohydrates neither fermented nor oxidised; fastidious; no growth on standard blood agar or other commonly employed laboratory media; requires L-cystine and iron salts; charcoal yeast extract agar and buffered charcoal yeast agar used for isolation; slow growing (2-3 d); grows best in humidified air; some species require 2-5% CO₂ for optimal growth; at least 9 species recognised from clinical specimens; some reactions useful in distinguishing between species include indophenol oxidase activity, gelatinase production, blue-white fluorescence of growth on charcoal yeast extract agar under a Wood's lamp, ?-lactamase detection by rapid chromogenic cephalosporin technique, browning of

appropriate agar medium containing tyrosine, analysis of isoprenoid quinones; indirect fluorescent antibody test standard serological test to diagnose legionellosis; few laboratories expected to undertake separation of species; isolated from surface water, mud, moist soil adjacent to a body of water, from thermally polluted lakes and streams, from water collected from air conditioning cooling towers and evaporative condensers, and from hospital showers and nebulisers; not isolated from dry soil or animals; isolated from human lung, trachea, pleural fluid, sputum, blood and bronchial washing; causes pneumonia in humans (legionellosis, legionnaire's disease, Pittsburgh pneumonia; especially in T helper lymphocyte deficiency), nonpneumonic Pontiac fever, rhabdomyolysis, bacteraemia and septicemia (uncommon in neutropenics), endocarditis, systemic infections in cell-mediated immunity disorders; growth stimulated by excess iron; treatment: erythromycin or ciprofloxacin (MIC 0.125 mg/L) + rifampicin (0.015-0.5 mg/L); also susceptible to gatifloxacin, moxifloxacin, difloxacin (? 0.06-1 mg/L), ofloxacin (0.06 mg/L), azithromycin, clarithromycin, roxithromycin, doxycycline, tetracycline, minocycline, rifabutin

L.bozemanii: includes WIGA; recognised from clinical specimens

L.dumoffii: includes TEX-L; recognised from clinical specimens; susceptible to rifampicin (MIC 0.03 mg/L), imipenem (0.12 mg/L), erythromycin (0.25 mg/L), cefotaxime (0.5 mg/L)

L.gormanii: recognised from clinical specimens

L.jordanis: recognised from clinical specimens

L.longbeachae: causes legionnaires' disease; associated with potting soil

L.micdadei: does not produce β -lactamase; includes TATLOCK and HEBA; Pittsburgh pneumonia agent; nosocomial pneumonia, particularly in renal transplant and bone marrow transplant recipients; stains weakly acid fast in clinical specimens and when grown in liquid culture media; susceptible to rifampicin (MIC ? 0.008 mg/L), imipenem (? 0.015-0.06 mg/L), erythromycin (? 0.06-0.5 mg/L), cefotaxime (? 0.12-0.25 mg/L), amoxycillin (0.12-1 mg/L)

L.oakridgensis: recognised from clinical specimens

L.pneumophila: respiratory pathogen in man; causes legionnaire's disease, pneumonia, acute sinusitis in AIDS, cellulitis (single case associated with pneumonia), infections in abnormal host (T cell deficiency); serogroups 1-6, group 1 most important; transmitted in water (aerosols, cooling towers, evaporative condensers), often acquired from contaminated air conditioning units; toxin inhibits phagocyte oxidative response; multiplies in macrophages; toxin damages cells, ? contributing to extrapulmonary disturbances in legionnaire's disease; interferon ?, tumour necrosis factor induce antimicrobial activity; diagnosis: microagglutination (significant titre ? 1:880), direct fluorescent antibody (lung tissue, pleural fluid), indirect fluorescent antibody (significant titre ? 1:256), ELISA (significant titre ? 1:40), radioimmunoassay, Dieterle silver stain, culture on charcoal yeast extract agar, guinea pig inoculation; treatment: erythromycin (MIC ? 0.6-1 mg/L), doxycycline, rifampicin (0.008-0.06 mg/L), imipenem (0.015-0.06 mg/L), cefotaxime (? 0.12-0.25 mg/L), amoxycillin (0.12-1 mg/L), ampicillin (0.5-0.8 mg/L)

L.wadsworthii: recognised from clinical specimens

Fluorobacter: causes non-pneumonic legionnaire's disease; diagnosis: serology; treatment: erythromycin

Tatlockia: causes non-pneumonic legionnaire's disease; diagnosis: serology; treatment: erythromycin

Family Neisseriaceae

Neisseria: Gram negative aerobic (but strains of some species grow weakly under anaerobic conditions) cocci, single, but more often in pairs with adjacent sides flattened, or distinct short rods arranged as diplobacilli and in short chains (*N.elongata*, *N.parelongata*); tendency to resist Gram decolourisation; asporogenous; noncapsulated; nonmotile; some species fastidious; some species produce a yellow-green carotenoid pigment; oxidase positive, catalase produced (except *N.elongata*); most species reduce nitrite, some species oxidise carbohydrates; DNase not produced; may be β -haemolytic; normal flora of mouth, nasopharynx, nose, external genitalia, anterior urethra, vagina (13%), eye, skin; causes pyogenic arthritis, bacteraemia and septicemia, human bite and clenched fist infections, meningitis, pyogenic osteomyelitis, otitis media (in infants), acute sinusitis; multiplies outside cells, but attachment to body surface necessary for invasion; growth stimulated by excess iron; infection increased by C5, C6, C7, C8 complement deficiency, sex hormones (menstrual cycle), absent serum bactericidal activity; primary immune defence prevention of attachment by coating microbial surface with specific antibody (mainly secretory IgA); neutralisation of microbial toxins also important; treatment: amoxycillin-clavulanate, cotrimoxazole, cefaclor; also susceptible to imipenem (100%), ciprofloxacin

(MIC 0.07-0.015 mg/L), lomefloxacin (0.12 mg/L), enoxacin (0.12 mg/L), cefotaxime (0.12 mg/L), cefuroxime (1 mg/L), piperacillin (1 mg/L)

N. canis: cocci single and in pairs with adjacent sides flattened; CO₂ not required; no acid produced from carbohydrates; nitrate, but not nitrite, reduced; grows on nutrient agar at both 35°C and 25°C; no growth on Thayer-Martin medium; colonies smooth, butyrous and usually yellow pigmented; isolated from throats of cats and cat-bite wounds in humans

N. cinerea: cocci single and in pairs with adjacent sides flattened, CO₂ not required; acid from glucose, fructose and sucrose (may be negative in all), but not maltose or lactose; reduces nitrite (with gas), but not nitrate; grows on nutrient agar, trypticase soy agar, sheep blood agar and Muller-Hinton agar at both 35°C and 25°C and may grow on Thayer-Martin medium; isolated from throats of guinea pigs; causes bacteraemia and septicemia (uncommon in neutropenics and other immunodeficient), reported to cause proctitis in an 8 year old boy

N. elongata: short rods arranged as diplococci or in short chains; usually no acid produced from carbohydrates but some strains form weak acid in glucose; catalase usually negative; reduces both nitrate and nitrite (with gas); phenylalanine not deaminated; no growth on MacConkey agar; grows on nutrient agar at 35°C and 25°C; sparse growth on Thayer-Martin medium; weak yellow pigmented colonies occasionally show granular spreading zones; growth coherent, when collected lumpy and difficult to disperse; natural habitat nasopharynx of humans; isolated from bronchial aspirates, pus from perimandibular abscess and urine; considered a largely harmless parasite; cause of endocarditis and osteomyelitis

N. flavescens: cocci single but more often in pairs with adjacent sides flattened; CO₂ not required; no growth on Thayer-Martin medium or New York City medium, growth on brain heart infusion, usually slight growth at 22°C; usually grows on nutrient agar at both 35°C and 25°C; colonies smooth, opaque and usually yellow pigmented; no acid produced from carbohydrates; polysaccharides synthesised; reduces nitrite (with gas) but not nitrate; isolated from human trachea, lymph node and throat; a rare isolate; cause of meningitis, infective endocarditis (i.v. drug abusers with AIDS) and septicemia

N. gonorrhoeae: Gram negative, oval-shaped cocci single but more often in pairs with adjacent sides flattened and long axes parallel; oxidase and glucose positive; maltose, sucrose, fructose, mannitol, ONPG and ?-glutamyl aminopeptidase negative; nitrite, but not nitrate, occasionally reduced (no gas); growth on Thayer-Martin medium and New York City medium (most strains); no growth on brain heart infusion, trypticase soy agar or Mueller-Hinton agar; usually no growth on sheep blood agar; no growth at 22°C, no growth on nutrient agar at 35°C or 25°C; colonies opaque, grey-white, raised, granular, glistening and convex; gonococcal coagglutination and monoclonal antibody tests positive; obligate human parasite; isolated from human cervix, vagina, blood, urethra, joint fluid, eye, urine, throat, CSF and rectum; causes gonorrhoea, anterior uveitis, septic arthritis (50% of total adult cases), bacteraemia and septicemia, balanitis, 3% of carpal tunnel syndrome, mucopurulent cervicitis, purulent conjunctivitis, dermatitis, disseminated infection (dermatitis-polyarthritis syndrome with fever, sterile polyarthritis, tenosynovitis, pustular rash and bacteraemia; monoarticular syndrome with fever and suppurative monoarticular arthritis; intermediate forms), dysuria-frequency (urethral) syndrome, endocarditis, endometritis, acute epididymitis and epididymoorchitis, perinatal and prenatal generalised disease, neonatal and post-neonatal pyogenic meningitis, mycotic aneurism, oophoritis, parametritis, perihepatitis, peritonitis (primary), acute nonexudative pharyngitis and tonsillitis, proctitis, prostatitis and seminal vesiculitis, salpingitis, localised skin lesions, polymorphous rash, tenosynovitis, tubo-ovarian abscess, urethritis (acute and more severe in male), vaginitis, vulvovaginitis, infections in abnormal host, systemic infections in C5, 6, 7, 8 deficiency; sexually transmitted; defined peptide fragment on bacterial fimbriae (pili) attaches to carbohydrate polymer on urethral epithelium cell; infection generally confined to epithelial surface of urogenital tract; in disseminated gonorrhoea, ? ineffective antibody bound to microbe blocks action of 'good' antibody or immune cells; gonococcal bacteraemia usually caused by strains resistant to complement; inhibits phagocytic chemotaxis, attachment and ingestion, ingestion despite attachment, lysosome-phagosome fusion; IgA proteases interfere with IgA1; colony type 1 or 2, pili, lipopolysaccharide, capsule, IgA protease, AHU auxotype, ? LA factor associated with infection; colony types 3 and 4, no pili; persists in urogenital tract (infectious and shed to exterior), recovered or asymptomatic patient remaining infectious; 1000 genes; diagnosis: counterimmunoelectrophoresis (antigen and antibody), direct fluorescent antibody (skin lesion), culture on Transgrow, New York City medium (avoid cold, heat, lack of CO₂), coagglutination,

PCR; susceptible to penicillin (in Australia, 6% resistance due to β -lactamase, 10% chromosomal resistance; significant geographic variation; total resistance up to 98% in Vietnam), ceftriaxone (resistance not yet reported), cefotaxime (MIC < 1 mg/L), erythromycin (1 mg/L), azithromycin, clarithromycin, roxithromycin, amoxicillin (β -lactamase negative), amoxicillin-clavulanate, tetracycline (5% high level resistance in Australia), cotrimoxazole, doxycycline, tetracycline, minocycline, chloramphenicol, spectinomycin (resistance not yet reported in Australia), ciprofloxacin (in Australia, 2% less susceptible, 2% resistant), gatifloxacin, moxifloxacin, norfloxacin (< 0.0125-0.12 mg/L), cefuroxime axetil, cefepime, ceftazidime (< 1 mg/L), cefotetan, ceftazidime (? 0.125-1mg/L), ofloxacin (0.015-0.03 mg/L), rosoxacin (0.025 mg/L), enoxacin (? 0.06-0.12 mg/L), piperacillin (β -lactamase negative; 0.06mg/L), piperacillin-tazobactam, ticarcillin-clavulanate, mupirocin (0.06 mg/L), ampicillin (β -lactamase negative; 0.15 mg/L), apalcillin (β -lactamase negative; ? 0.5 mg/L), temocillin (β -lactamase negative; 0.5 mg/L), ticarcillin (β -lactamase negative; 0.5 mg/L), imipenem (100% susceptible at ? 1 mg/L), meropenem, cefoperazone (< 1 mg/L), moxalactam (< 1 mg/L), ceftazidime (< 1 mg/L), neomycin (1mg/L), cefixime

N.lactamica: cocci single, but more often in pairs with adjacent sides flattened; requires CO₂; growth on Thayer-Martin medium and New York City medium and on brain heart infusion, usually grows on nutrient agar at 35°C, few strains grow at 25°C, no growth at 22°C; colonies smooth, translucent, butyrous and usually yellow pigmented; glucose, maltose, lactose and ONPG positive; sucrose and fructose negative; reduces nitrite (with gas), but not nitrate; commonly found in nasopharynx of infants and children; isolated from human throat, nasopharynx, trachea, lung, sputum and vagina; rarely clinically significant; causes bacteraemia and septicemia (uncommon in neutropenics and other immunodeficient), postneonatal purulent meningitis following skull trauma; treatment: penicillin, cefotaxime, ceftriaxone

N.meningitidis: Gram negative, oval-shaped cocci single and in pairs with adjacent sides flattened and long axes parallel; requires CO₂; growth on New York City medium and on brain heart infusion, no growth at 22°C, no growth on nutrient agar at 25°C but a few strains grow at 35°C; colonies smooth, round and glistening; older cultures butyrous and rubbery; oxidase, glucose, maltose and β -glutamyl aminopeptidase positive; lactose, sucrose, fructose, mannitol and ONPG negative; nitrite reduced by some strains (no gas), but not nitrate; obligate human parasite; increased respiratory carriage in epidemics; inapparent infections of pharynx or nasopharynx common; occasionally, mild inflammation causing pharyngitis and nasopharyngitis; isolated from human CSF, blood, petechiae, joints, throat, sputum, nasopharynx, eye and trachea; causes purulent conjunctivitis (rare), acute epididymitis and epididymoorchitis, gonorrhoea-like disease, post-neonatal meningitis

(? 1000 cases/y in USA, 27% of bacterial meningitis cases, incidence 0.7/100 000 overall, 13/100 000 at age 3-8 mo; case-fatality rate 14%), meningococemia (transient bacteraemia, chronic intermittent bacteraemia, acute bacteraemia and septicemia with or without meningitis, septicaemic adrenal haemorrhage syndrome, haemorrhagic fever; ? 300 cases/y in USA; incidence 0.2/100 000 overall, 5/100 000 at age 6-8 mo; case-fatality rate 25%), myocarditis and pericarditis, osteomyelitis and osteochondritis, peritonitis, septic arthritis, polymorphous rash, localised skin lesions, spotted fever, pneumonia with exanthem, infections in abnormal host (β -globulin dysfunction, complement dysfunction, splenic dysfunction), systemic infections in agammaglobulinemia, complement deficiency, hyposplenism/splenectomy; total incidence in Australia ? 2/100 000 (15/100 000 in 0-4 y.o.); in carrier state, attaches to respiratory epithelial cell by pili; inhibits phagocytic chemotaxis, attachment and ingestion; capsular polysaccharides virulence factor associated with invasiveness (Group A: N-acetyl-O-acetyl-mannosamine phosphate; Group B: N-acetyl-neuraminic acid; Group C: N-acetyl-O-acetyl-neuraminic acid); IgA proteases interfere with IgA1 (virulence factor); lipopolysaccharide (endotoxin) also associated with infection; primary bodily defence mechanism humoral immune responses (phagocytes +, alternative complement +, bactericidal activity +++, immune adherence (phagocytosis) +); recovery from primary infection due to antibody; diagnosis: counterimmunoelectrophoresis (antigen and antibody), direct fluorescent antibody (CSF), culture on Transgrow, Thayer-Martin medium, New York City medium (avoid cold, heat, lack of CO₂); susceptible to penicillin (in Australia, < 5% MIC > 1 mg/L), cefotaxime (? 0.06 mg/L), ceftriaxone (resistance not yet reported), cefepime, ceftazidime, cefotetan, ceftazidime, amoxicillin (100% susceptible at 0.25 mg/L), doxycycline, tetracycline (0.5-1 mg/L), minocycline, ciprofloxacin (< 5% resistance in Australia), gatifloxacin, moxifloxacin, moxalactam (0.008-0.06 mg/L), ceferazone (0.008-0.12 mg/L), ofloxacin (0.15 mg/L), mupirocin (0.03 mg/L), pefloxacin (0.03 mg/L), cefixime (100% susceptible at ? 0.06 mg/L), cefuroxime (100% susceptible at ? 0.06 mg/L), ceftazidime

(? 0.06 mg/L), ceftizoxime (0.06 mg/L), enoxacin (100% susceptible at < 0.12 mg/L), amoxicillin-clavulanate (100% susceptible at 0.12 mg/L), cefaclor (100% susceptible at 0.12 mg/L), rosoxacin (< 0.125 mg/L), ampicillin (0.2 mg/L), novobiocin (0.3 mg/L), hydroxynalidixic acid (0.5 mg/L), chloramphenicol (< 5% resistance in Australia), rifampicin (< 5% resistance in Australia), cephalothin (< 5% resistance in Australia), imipenem, meropenem

N.mucosa: cocci single and in pairs with adjacent sides flattened; CO₂ not required; colonies nonpigmented to yellowish, mucoid, adherent; glucose, maltose, sucrose and fructose positive; lactose negative; polysaccharides synthesised; reduces both nitrate and nitrite (with gas); usually grows on nutrient agar at both 35°C and 25°C; usually no growth on Thayer-Martin medium; natural habitat nasopharynx of humans; isolated from human blood, eye, CSF, wound, urine and sputum; occasionally pathogenic for humans; cause of pneumonia, ocular infection in a newborn, endocarditis (i.v. drug abuser), cellulitis, septic arthritis, abscess of Bartholin's gland, postneonatal purulent meningitis in female infants and children with predisposing conditions; treatment: penicillin, cefotaxime, ceftriaxone, amoxicillin, gentamicin, netilmicin

N.parelongata: thin rods; variable growth on MacConkey; weak yellow pigmented colonies; carbohydrates not utilised; nitrite reduced (variable), but not nitrate; catalase produced; phenylalanine deaminated by most strains; associated with animal bite wounds of humans, pneumonia in an immunocompromised patient and osteomyelitis

N.polysaccharea: cocci arranged in pairs and tetrads with adjacent sides flattened; CO₂ not required; grows at 37°C but not 22°C; colonies yellow pigmented; acid produced from glucose and maltose, rarely from sucrose, but not from fructose or lactose; polysaccharides produced; ONPG not hydrolysed; nitrite, but not nitrate, reduced; nonhaemolytic; isolated from pharynx of infants and children; clinical significance unknown

N.sicca: cocci single and in pairs with adjacent sides flattened; CO₂ not required; colonies nonpigmented (occasionally yellow pigmented), dry, wrinkled, adherent; growth at 22°C; usually grows on nutrient agar at both 35°C and 25°C; generally no growth on Thayer-Martin medium; glucose, maltose, sucrose and fructose positive; lactose, mannitol and ONPG negative; reduces nitrite (with gas), but not nitrate; natural habitat human nasopharynx, saliva and sputum; isolated from human throat, sputum, urine, blood and eye; rarely clinically significant; cause of pneumonia in immunodeficient patient, osteomyelitis following a back injury, endocarditis; treatment: penicillin

N.subflava: cocci single and in pairs with adjacent sides flattened; CO₂ not required; colonies usually greenish yellow, smooth, transparent or opaque, often adherent; no growth on Thayer-Martin medium or New York City medium, growth on brain heart infusion; slight growth at 22°C, usually grows on nutrient agar at both 35°C and 25°C; glucose and maltose positive; lactose, mannitol and ONPG negative; sucrose and fructose variable; reduces nitrite (with gas), but not nitrate; agglutination in normal rabbit serum; natural habitat human nasopharynx; isolated from human throat, blood, CSF, sputum, nasopharynx, urogenital swab and eye; cause of bacteraemia and septicemia (neutropenics and other immunodeficient), endocarditis (i.v. drug abusers with AIDS) and postneonatal purulent meningitis; treatment: penicillin

Moraxella (Branhamella) catarrhalis: Gram negative coccus, single or in pairs with adjacent sides flattened; tendency to resist Gram decolourisation; non-motile; asporogenous; usually aerobic but some strains facultatively anaerobic; growth on media devoid of blood, no growth on Thayer-Martin medium; colonies nonpigmented or grey; growth at 22°C; catalase, indophenol oxidase and DNase produced; most strains reduce both nitrate (distinguishes from *Neisseria*) and nitrite (no gas); agglutination in saline; natural habitat nasal cavity of humans; isolated from human eye, sputum, blood, ear, throat and nose; causes bacteraemia and septicemia in immunodeficient (rare), bronchopulmonary infection, bronchitis, respiratory infections in compromised host, acute otitis media in infants and children, acute maxillary sinusitis, tracheitis, pneumonia, postneonatal purulent meningitis, endocarditis, conjunctivitis, endophthalmitis (postoperative), urethritis, septic arthritis (rare) and, occasionally, systemic infections; growth stimulated by excess iron; susceptible to amoxicillin-clavulanate (resistance not yet confirmed in Australia), piperacillin-tazobactam, ticarcillin-clavulanate, erythromycin (3% resistance in Australia), cefaclor, cefuroxime, cefepime, cefpirome, doxycycline, tetracycline (0.8% resistance in Australia), minocycline, aztreonam, chloramphenicol, cotrimoxazole (7% resistance in Australia), cefotaxime (resistance not yet confirmed in Australia), ceftriaxone (resistance not yet confirmed in Australia), cefotetan, ciprofloxacin (100% at 0.03 mg/L), gatifloxacin, moxifloxacin, enoxacin (100%), norfloxacin (100%), ceftazidime (resistance not yet confirmed in Australia), pefloxacin (MIC 0.015-0.25

mg/L), cefoxitin (< 0.06-0.25 mg/L), difloxacin (0.12 mg/L), fleroxacin (0.125-0.5 mg/L), cefuroxime (0.125-1 mg/L), ofloxacin

(0.13 mg/L), cefixime (? 0.25 mg/L), chloramphenicol (0.25-0.5 mg/L), rifampicin, amikacin, gentamicin, tobramycin, kanamycin, mezlocillin, imipenem, meropenem, azithromycin, clarithromycin, erythromycin, roxithromycin; 94% acquired resistance (via β -lactamase) to penicillin, ampicillin and amoxycillin (possibly all resistant in clinical practice); 98% intrinsic resistance to trimethoprim (possibly all resistant in clinical practice)

M (B) caviae: associated with animals; no carbohydrates fermented; growth at 22°C

M (B) cuniculi: associated with animals

M (B) ovis: associated with animals

Moraxella (Moraxella): rods very short and plump approaching coccus shape, usually in pairs and short chains; tendency to resist Gram decolourisation; nonmotile; asporogenous; obligately aerobic; growth on MacConkey scant or negative; most strains fastidious in growth requirements, some require serum supplementation; colonies not yellow; oxidase positive; citrate negative; some isolates produce urease, phenylalanine deaminase and liquify serum, but majority lack extracellular hydrolytic enzymes; catalase produced except for some strains of *Matlantae* and *Mbovis*; a few strains reduce nitrate to nitrite; normal flora of nasopharynx, nose, vagina, eye; causes transient bacteraemia, conjunctivitis, eye disease, rarely postpartum, postoperative and neonatal complications; growth stimulated by excess iron; usually susceptible to penicillin and most other antimicrobials, including gentamicin (MIC ? 0.03-0.25 mg/L), tetracycline (0.25 mg/L), neomycin (0.5 mg/L), ciprofloxacin (0.5 mg/L), norfloxacin (1 mg/L), imipenem (96% sensitive)

M (M) atlantae: serum required (variable) for growth on agar media; usually grows on MacConkey agar (may be delayed), but not in O-F basal medium; colonies small, semi-opaque, slightly pink, occasionally corroding and spreading; 1/3 of strains catalase positive; phenylalanine, urease, nitrate and gelatine negative; natural habitat unknown; isolated primarily from human blood and CSF, also lung tissue, sputum, urine, ear, nose and throat, wound, eye; clinical significance unknown

M (M) bovis: produces β -haemolysis on human blood agar and rabbit blood agar; growth on MacConkey agar; colonies either small, flat, corroding or larger, convex, butyrous, noncorroding and nonspreading; liquefies coagulated serum (Loeffler slant); nitrate reduction variable; 1/3 of strains catalase positive; phenylalanine positive; urease negative; hydrolyses gelatine; isolated from bovine eyes, both from unaffected eyes and cases of keratoconjunctivitis

M (M) lacunata: Gram negative, coccobacillary, does not require X or V factors, may not grow on media not containing blood or serum (counteracts toxic effect of certain components of peptone); no growth in O-F basal medium or on MacConkey agar; colonies small to large, translucent to semi-opaque, and occasionally ? pitting; catalase and oxidase positive; urease negative; phenylalanine deaminase variable; reduces nitrate (no gas); gelatine hydrolysis variable; liquefies coagulated serum (Loeffler slope); natural habitat upper respiratory tract and eyes of humans; rarely isolated; isolated from eye, blood, sputum, ear, nose, throat, CSF; causes purulent conjunctivitis, keratitis and iritis, meningitis, otitis media, sinusitis, infections in abnormal host

M (M) nonliquefaciens: coagulated serum not liquefied, otherwise similar to *Mlacunata*; some strains require addition of serum to peptone media; reduces nitrate (no gas); no growth in O-F basal medium or on MacConkey agar; colonies small to large, translucent to semi-opaque, occasionally mucoid and occasionally corroding and spreading; natural habitat human nasal cavity; a well-established parasite of humans and rarely causes disease; associated with endophthalmitis and pneumonitis with pulmonary abscess; isolated from ear, nose, throat, eye, sputum, blood, urine, CSF, wound

M (M) osloensis: utilisation of acetate in a mineral base medium without growth factor supplement distinguishes this species from other *Moraxella*; most strains grow in O-F basal medium and on MacConkey agar; colonies semi-opaque; alkalis sodium acetate slant; catalase positive; urease and gelatinase negative; phenylalanine deaminase variable; some strains reduce nitrate (no gas); natural habitat human pharynx; isolated from such clinical specimens as blood, genital swab, throat, CSF, urine, wound swab, pyogenic lesion, sputum, chest cavity, eye, nasopharyngeal swab and rectal swab; usually a harmless parasite but causes osteomyelitis, endocarditis, septicemia, meningitis, stomatitis and septic arthritis

M. (M) phenylpurvica: production of urease distinguishes this species from other *Moraxella*; catalase and phenylalanine deaminase positive; gelatine hydrolysis negative; most strains reduce nitrate (no gas); growth occurs in O-F basal medium and usually on MacConkey agar; colonies relatively small, often semi-opaque and slightly pink; natural habitat probably animals; isolated from human urine, urogenital tract, blood, CSF, skin, superficial lesion, pyogenic lesion, peritoneal fluid, ear, joint, sputum; clinical significance uncertain

Acinetobacter: rods very short and plump, approaching coccus shape in stationary phase, predominantly in pairs; asporogenous; nonmotile; catalase produced; obligately aerobic; some strains oxidise glucose and other carbohydrates; nitrate usually not reduced; lysine decarboxylase, arginine dihydrolase, ornithine decarboxylase and oxidase negative; most strains good growth on MacConkey; some strains α -haemolytic, proteolytic and grow on SS agar; occurs naturally in soil, water and sewage; normal flora of nasopharynx, colon, anterior urethra, vagina; causes bacteraemia and septicemia, burn infections, endocarditis (rare), nosocomial postneonatal purulent meningitis, pneumonia, urethritis; predisposing factors tracheostomy, ventilator therapy, broad-spectrum antimicrobial therapy, multiple indwelling catheters, old age, underlying chronic disease; growth stimulated by excess iron; susceptible to piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, amikacin, gentamicin, tobramycin, imipenem, meropenem, ciprofloxacin, gatifloxacin, moxifloxacin, cotrimoxazole; variably susceptible to cefotaxime, ceftriaxone, cefipime; 98% intrinsic resistance (due to β -lactamase) to amoxicillin, ampicillin, amoxicillin-clavulanate, cephalothin, cephalixin (possibly all resistant in clinical practice)

A. calcoaceticus: coccobacillary; oxidase negative; grows on MacConkey agar and brain heart infusions; many biovars (or species) based on growth temperature, acid production from glucose, gelatinase activity and substrate utilisations (at least 6 genospecies, including *A.baumannii*, *A.calcoaceticus*, *A.haemolyticus*, *A.johnsonii*, *A.junii*, *A.lwoffii*); most laboratories refer to 2 biovars— glucose-oxidising biovar *anitratu*s and nonoxidative biovar *lwoffii*; free-living and widely distributed in nature; isolated from almost every conceivable source on or within the human body, usually as contaminants; normal flora of large intestine, ileum, female genitals (adherence to labium majus +), skin; opportunistic pathogen implicated in a number of community-acquired, but primarily nosocomial, infections, causing bacteraemia and septicemia (*A.baumannii* nosocomial; *A. johnsonii* vascular catheter related), complications of instrumentation, surgery and burns, purulent conjunctivitis, disease of newborn, acute empyema, community pneumonia, urethritis, endotoxic reactions associated with reuse of cardiac catheters, meningitis, miscellaneous local septic infections, abscess, endocarditis, cellulitis, synovitis, osteomyelitis, ventriculitis, tracheitis, infections in abnormal host (various complications in immunocompromised individuals), nosocomial infections (incidence 4/10 000 patients; 42% biovar *anitratu*s, 6% biovar *lwoffii*, 52% not speciated; 1/10 000 patients pneumonia, 0.8/10 000 urinary tract infection, 0.7/10 000 surgical wounds; 8% of infections with secondary bacteraemia, 15% bacteraemia overall); treatment: imipenem (MIC 0.25-0.5 mg/L), ciprofloxacin, gentamicin, tobramycin; also susceptible to cotrimoxazole (0.25 mg/L), amifloxacin (1 mg/L); resistant strains of *A.baumannii* reported susceptible only to polymyxin and sulbactam
NO-1: similar to asaccharolytic strains of *Acinetobacter* but different cellular morphology and cellular fatty acid profile; isolated from animal bites (77% dog, 18% cat, 5% unknown); susceptible to aminoglycosides, β -lactams, tetracycline, quinolones and sulphonamides

Psychrobacter immobilis: coccobacilli or short to long rods; asporogenous; obligately aerobic; chiefly psychrotrophic and unable to grow at 35°C or 37°C; nonmotile; many strains oxidise glucose and several other carbohydrates, but not sucrose or mannitol; positive test reactions for catalase, indophenol oxidase, urease, nitrate and phenylalanine deaminase; indole and gelatinase not produced; an odour resembling that of a phenylethyl alcohol blood agar plate usually present; a few strains with an optimal growth temperature of 35°C similar to CDC group EO-2 strains; transformation studies required to identify such strains definitively; isolated from sea water, fish, fish slime, sausage, ground beef, poultry and air-contaminated agar media; a few strains with an optimal growth temperature of 35°C isolated from pathological specimens derived from both animals and humans; human sources include blood, brain tissue, urethra, wound, CSF, vagina and eye; no conclusion as to clinical significance; susceptible to penicillin

Kingella: presently assigned to family Neisseriaceae but taxonomic position uncertain; plump rods or coccobacilli occurring in pairs or short chains; tendency to retain crystal violet of Gram stain; asporogenous; nonmotile; facultatively anaerobic; fastidious; little or no growth in unsupplemented peptone media; spreading and corroding or smooth and convex colony types on blood agar; indophenol oxidase, but not catalase, produced; urease not formed;

glucose and a limited number of other carbohydrates fermented with acid production (no gas; delayed); growth on MacConkey scant or negative; distinguished from *Moraxella* by ?-haemolytic and catalase negative; occurs in human mucous membranes of upper respiratory tract; susceptible to penicillin and most other antimicrobials

K. denitrificans: ferments glucose but not maltose or sucrose; usually reduces nitrate and nitrite (with gas); no growth on MacConkey but grows on Thayer-Martin selective agar; may pit agar surface; indole not produced; natural habitat the mucous membranes of the respiratory tract of humans; also isolated from human urogenital tract, mandibular abscess and blood; pathogenicity uncertain

K. indologenes: rods more regular, longer in shape and evenly stained compared with other *Kingella* species; ferments glucose, maltose and sucrose; indole produced; negative test reactions for growth on MacConkey, nitrate and nitrite reduction; may pit agar surface; rare mannitol negative strains of *Cardiobacterium hominis* distinguished from strains of *K. indologenes* on basis of casein hydrolysis, phosphatase production and Tween 40 hydrolysis by the latter; natural habitat mucous membranes of respiratory tract of humans; causes endocarditis (rare), conjunctivitis, corneal abscess

K. kingae: ferments glucose and maltose but not sucrose; growth on MacConkey variable; usually ?-haemolytic; negative test reactions for indole and usually both nitrate and nitrite reduction; normal flora of nasopharynx; isolated from human blood, bone, joint fluid, pustule, wound and urine; causes septic arthritis (mainly infants and young children), endocarditis in children (especially prosthetic valve patients), intervertebral disc infection in children, osteomyelitis and osteochondritis (mainly infants and young children), acute meningitis in sickle cell anaemia, bacteraemia and septicemia in alcoholic liver disease and in children; treatment: penicillin

TAXONOMIC POSITION UNCERTAIN OR UNKNOWN

Moraxella (Pasteurella) anatipestifer: rods, frequently pleomorphic; produces a brown, water-soluble pigment; aerobic; fastidious; oxidative in glucose and maltose (weakly); catalase and indophenol oxidase produced; positive test reactions for arginine dihydrolase, urease and gelatinase (late); negative test reactions for growth on MacConkey, nitrate and indole; agent of septicemia in ducks, geese and turkeys

Oligella: small Gram negative rods often occurring in pairs; asporogenous; obligately aerobic; no acid production from carbohydrates; slowly developing colonies on blood agar similar to colonies of *Moraxella*; nonpigmented; indophenol oxidase, catalase and phenylalanine deaminase, but not indole, produced; utilises acetate in a mineral base medium; usually isolated from genitourinary tract of humans

O. ureolytica: nonmotile or motile with peritrichous flagella, often with 1 polar, and only a few lateral, flagella; most strains reduce both nitrate and nitrite (with gas); produces urease (rapid); no growth at 42°C; saprophytes from human urine; susceptible to netilmicin (MIC ? 0.03-0.25 mg/L); resistant to penicillin

O. urethralis: nonmotile; nitrate not reduced; nitrite reduction to gas strain variable; urease not produced; grows at 42°C; 1/3 catalase positive; growth on MacConkey; gelatine negative; natural habitat the human genitourinary tract; isolated as a saprophyte from urine and from the female genital tract, also wound, ear, nose, throat, blood; pathogenicity unknown; susceptible to penicillin

CDC Group IVC-2: rods motile by peritrichous flagella; asporogenous; obligately aerobic; indophenol oxidase and catalase produced; rapid urea hydrolysis (not as rapid as *Bordetella bronchiseptica*); no acid produced from carbohydrates; indole not formed; negative reactions for nitrate reduction and growth on SS agar differentiate from phenotypically similar strains of *Bordetella bronchiseptica*; environmental isolates, primarily from water; isolated from human blood, eye, sputum, urine, throat and peritoneal fluid; clinical significance probably low; cause of nosocomial septicemia in a patient with peripheral vascular disease and in a patient with plasma cell leukemia; susceptible to doxycycline (MIC 0.13-0.5 mg/L)

CDC Group EO-2: coccobacilli, usually vacuolated; asporogenous; obligately aerobic; oxidative in glucose, xylose and lactose and usually fructose and mannitol but not sucrose; nonmotile; indophenol oxidase and catalase produced; nitrate and urea reactions strain variable; indole not produced; difficult to distinguish from animal strains of *Psychrobacter* that oxidise carbohydrates and grow at 35°C; some EO-2 strains, but not *Psychrobacter* strains, grow at 42°C and produce acid from mannitol; isolated from horse blood, haemodialysis water and human clinical sources, including wound, eye, vagina, blood and others; clinical significance unknown

Cytophagaceae

Flavobacterium: simple rod, non-motile, asporogenous; obligately aerobic; some species produce brilliant yellow colonies; water-insoluble yellow or orange carotenoid pigment, very pale and not easily detectable in many species; pigment production variable on media that support growth; glutamate and undetermined vitamins required as organic growth factors; growth on MacConkey poor or negative; growth optimal at 30°C, no growth at 42°C; growth on SS usually negative; oxidative (delayed) or nonreactive; non-agar or cellulose digester; actively proteolytic, hydrolysing gelatine and casein; oxidase positive; catalase produced; indole formed by all but 1 species; some species weakly indole positive; lysine decarboxylase, arginine dihydrolase and ornithine decarboxylase negative; nitrate reduction and glucose variable; widely distributed in soil and water; also found in hospital environment and in human clinical material; normal flora of large intestine and lower ileum; causes bacteraemia, meningitis, infections in abnormal host; susceptible to ciprofloxacin (MIC 0.5 mg/L); strains of most species resistant to penicillin and polymyxin

F. breve: colonies yellow with green edges; proteolytic; indole and DNase produced; fails to hydrolyse ONPG, urea, esculin and starch; oxidises only a few carbohydrates (maltose and glucose); isolated from canal water and human clinical specimens, including urine, eye swab, bronchial secretion and blood; clinical significance unknown

F. gleum: colonies viscous to mucoid and difficult to remove from surface of agar media; other phenotypic properties similar to *F. indologenes*; most strains isolated from human clinical specimens; vaginal specimens most common source; also recovered from abdominal tap, dialysis fluid, CSF, wound swab and peritoneal swab; clinical significance uncertain

F. indologenes: colonies produce an intracellular bright yellow pigment; oxidative in maltose and other carbohydrates, but usually not lactose or mannitol; proteolytic; indole produced; tests for ONPG and extracellular DNase usually negative; esculin and starch hydrolysed; occasional strains reduce nitrate (no gas) and produce urease; natural habitat soil and water; frequently recovered from wet surfaces and water in hospital environment, as well as numerous clinical specimens, such as blood, sputum, throat, urine, lung, CSF, brain, nose and trachea; rarely clinically significant; associated with septicemia and meningitis in hospitalised patients

F. meningosepticum: pale yellow or nonpigmented colonies on blood agar in 24 h; oxidase positive; indole produced; ONPG, esculin, DNA and gelatine hydrolysed; oxidative in maltose and other carbohydrates, including lactose and mannitol; nitrate not reduced; urease and amylase usually not produced; other phenotypic properties similar to *F. indologenes*; isolated from soil, water, hospital environment and human CSF, blood, urine, trachea, sputum, eye and nose; highly virulent for prematures; occasionally causes bacteraemia and septicemia in leukemia, endocarditis in rheumatic heart disease, open heart surgery and i.v. drug abuse, endophthalmitis (postoperative), meningitis in neonates and adult immunocompromised, acute skin ulcers, burn infections, nosocomial infections; treatment: rifampicin, sulphadiazine, clindamycin, ciprofloxacin

F. odoratum: colonies large, with a tendency to spread on agar surface, yellowish-green in colour; non-oxidative; urea, DNA and gelatine hydrolysed; nitrite reduced (variable) to gas, but not nitrate; ONPG, esculin and starch not hydrolysed; indole not produced; usually exhibits a fruity odour; isolated from environment and human clinical specimens, especially urine, but also wound swab, ulcer, ear, blood and sputum; rarely clinically significant; associated with post-operative and post-traumatic foot infection and infant ventriculitis

Flavobacterium species Group IIe: *Flavobacterium*-like phenotypic properties; indole produced; unlike other *Flavobacterium*, gelatinase not produced; ONPG, urea, esculin and DNA not hydrolysed; growth fails in O-F medium, test oxidative activity produced from glucose and maltose in a modified O-F base medium; isolated from human blood, urine and genital sites; cause of meningitis; susceptible to penicillin and polymyxin

Flavobacterium species Group IIh: *Flavobacterium*-like phenotypic properties; indole produced; oxidative in a limited number of carbohydrates, usually maltose and xylose only; esculin, starch, gelatine and DNA hydrolysed; ONPG and urea not hydrolysed; susceptible to penicillin, but not polymyxin; isolated primarily from respiratory tract of animals; recovered from human CSF and ear as a saprophyte

Flavobacterium species group IIi: *Flavobacterium*-like phenotypic properties; indole produced; unlike other *Flavobacterium*, gelatinase not produced; oxidative in a wide range of carbohydrates, but not mannitol; ONPG and esculin hydrolysed; urea and DNA not hydrolysed; indole production and lack of urease activity usually distinguish this species from phenotypically similar, but unrelated, *Sphingobacterium multivorum*, isolated as a saprophyte from human blood, urine and wound

Sphingobacterium: small straight rods; nonmotile; asporogenous; nonflagellated, but exhibit gliding movement on agar surface; pale to bright yellow pigment produced by most species; obligately aerobic; indophenol oxidase and

catalase produced; oxidative in glucose and a wide range of other carbohydrates; ONPG, urea and esculin hydrolysed; failure to produce indole and, usually, gelatinase distinguishes this genus from *Flavobacterium*, primarily isolated from human clinical materials

S. mizutaii: oxidative activity from rhamnose; urea hydrolysis and nitrite reduction to gas strain variable; otherwise similar to *S. multivorum*, isolated from human ventricular fluid, synovial fluid and urine; cause of meningitis in prematures

S. multivorum: rhamnose and mannitol not oxidised; nitrate and nitrite not reduced; no growth at 42°C; otherwise similar to other species of this genus; isolated from soil, turnip and various clinical specimens, such as lung, eye, semen, throat, peritoneal fluid, blood, abdominal fluid, urine, skin, serous cavity fluid, CSF, spleen, wound and eye discharge; rarely clinically significant; associated with spontaneous peritonitis, septicemia in a haemodialysed patient and septicemia in a patient with lymphoma; susceptible to minocycline (MIC 0.5-1 mg/L)

S. spiritovorum: oxidises rhamnose and mannitol; otherwise similar to *S. multivorum*, isolated from human blood, wound swab, peritoneal fluid, urine, sputum, bone marrow, vaginal swab and intrauterine specimen, as well as from sink tap and humidifier sponge; clinical significance not known

S. thalophilum: reduces nitrate (no gas) and grows at 42°C; otherwise similar to *S. multivorum*, isolated from human clinical sources, including blood, abscess and wound swab; clinical significance not known

Weeksella: rod-shaped; asporogenous; obligately aerobic; indophenol oxidase and catalase produced; nonmotile; indole formed; actively proteolytic; nitrate and nitrite not reduced; no acid produced from carbohydrates; yellow pigment usually not produced; susceptible to penicillin; apparently not isolated from general environment; commensal of humans and other warm-blooded animals

W. virosa: colonies very mucoid, moist, with a tendency to stick to the agar surface; usually grows at 42°C; urea not hydrolysed; growth occurs in O-F basal medium (alkaline reaction); susceptible to penicillin and polymyxin; strict parasite or saprophyte; recovered primarily from human urine, vaginal and cervical specimens; rarely clinically significant; cause of postsurgical septicemia; susceptible to clindamycin (MIC ? 0.03 mg/L)

W. zoohelcum: colonies butyrous, sticky and difficult to remove from agar surface; distinguished from *W. virosa* by rapid urea hydrolysis, failure to grow in O-F basal medium and at 42°C and susceptibility to penicillin but not polymyxin; strict parasite or saprophyte; recovered from oral cavity of dogs and cats; isolated from infected human wounds from dog and cat bites and scratches; cause of meningitis

Capnocytophaga: Gram negative thin, filamentous rods with tapered ends; asporogenous; some strains motile with a single polar or lateral flagellum; gliding motility; frequently produces yellow to orange pigment; facultatively anaerobic; growth requires, or enhanced by, CO₂; fastidious; no growth on MacConkey; esculin hydrolysis variable; 5 species (*C. canimorsus*, *C. cynodegmi*, *C. gingivalis*, *C. ochracea*, *C. sputigena*) difficult to distinguish; catalase usually negative, oxidase usually negative; indole negative; ferments glucose (no gas), maltose, sucrose, usually lactose, not mannitol or xylose; ONPG positive; natural habitat periodontal pockets of humans; isolated from human sputum, throat, blood, urine, vagina, pleural fluid and CSF; a rare opportunist; cause of mediastinal abscess in a competent host, sepsis in granulocytopenic patients, periodontal disease and septic arthritis in infants, acute sinusitis, acute empyema (rare), pulmonary abscess, amnionitis, chorioamnionitis (rare), local and generalised sepsis, peritonitis (primary and secondary), 0.1% of bacteraemia and septicemia (especially with oral mucositis), osteomyelitis and osteochondritis, purulent conjunctivitis; growth stimulated by excess iron; treatment: penicillin; also susceptible to ciprofloxacin (MIC 0.05-0.12 mg/L), ofloxacin (0.25-0.5 mg/L), pefloxacin (0.5 mg/L)

C. canimorsus: moderate to long thin rods, frequently slightly tapered, and with occasional spindle forms; asporogenous; nonmotile; facultatively anaerobic; fastidious; growth requires, or enhanced by, CO₂; indophenol oxidase and catalase produced; ferments glucose (no gas), lactose and maltose (with serum); positive test reactions for esculin and arginine dihydrolase; negative test reactions for growth on MacConkey, urease, nitrate and indole; natural habitat oral mucosa of animals, particularly dogs; an opportunist, infecting mostly patients with underlying diseases and patients with impaired host defence after splenectomy; associated with bites of, or exposure to, dogs; causes cellulitis, bacteraemia and septicemia, meningitis (in splenectomised or alcoholics following dog or cat bite), endocarditis; susceptible to penicillin (95%), amoxicillin-clavulanate, cefoxitin, erythromycin, tetracycline, clindamycin

C. cynodegmi: associated with septicemia or meningitis following dog bite

UNNAMED

CDC Group DF-3 (Dysgonic Fermenter 3): small coccoid to short rods; asporogenous; nonmotile; facultatively anaerobic; fastidious; no growth on MacConkey; indophenol oxidase and catalase not produced; ferments glucose (no gas), xylose, lactose, sucrose and maltose (with serum); usually produces indole weakly; hydrolyses esculin; nitrate not reduced; isolated from human blood, wound, urine, peritoneal fluid, umbilicus, abscess, abdominal tap, stool and genital tract; associated with chronic diarrhoea in patients with common variable hypogammaglobulinemia

CDC Group EF-4a (Eugonic Fermenter 4): coccoid to short rods; asporogenous; nonmotile; facultatively anaerobic; fastidious; variable growth on MacConkey; ferments glucose only (no gas); indophenol oxidase and catalase produced; reduces nitrate and nitrite, frequently with gas; most strains hydrolyse arginine and gelatine; phenylalanine usually deaminated; negative test reactions for urease and indole; cultures smell like popcorn; recovered from respiratory tract of animals; mostly associated with dog bites of humans

CDC Group Ef-4b: coccoid to short rods; asporogenous; nonmotile; facultatively anaerobic; fastidious; variable growth on MacConkey; oxidises glucose only; indophenol oxidase and catalase produced; reduces nitrate and, sometimes, nitrite (no gas); phenylalanine usually deaminated; arginine and gelatine (usually) not hydrolysed; negative test reactions for urease and indole; cultures smell like popcorn; distinguished from group EF-4a by oxidation of glucose and negative test reactions for arginine dihydrolase, gelatinase and gas from nitrate; natural habitat respiratory tract of dogs and cats; isolated from animal bite and scratch wounds of humans, endophthalmitis associated with cat scratch

CDC Group HB-5: coccoid to bacillary rods; asporogenous; nonmotile; facultatively anaerobic; fastidious; growth enhanced by CO₂; growth on MacConkey variable; indophenol oxidase (variable) and catalase produced; ferments glucose (with small amounts of gas) and fructose; positive test reactions for indole and nitrate (no gas); urease not produced; natural habitat unknown; isolated from a variety of human specimens, primarily genitourinary tract of females; isolated from a purulent Bartholin abscess

Rhizobiaceae

Agrobacterium causes peritonitis in continuous ambulatory peritoneal dialysis

A. tumefaciens: rods motile by 1-6 peritrichous flagella; only 1 or 2 lateral flagella in some isolates; obligately aerobic; asporogenous; positive test reactions for indophenol oxidase, catalase, phenylalanine deaminase and hydrolysis of urea (rapid), esculin and ONPG; nitrate usually reduced (occasionally with gas); oxidises glucose, xylose, lactose, sucrose, maltose and mannitol; indole not produced; oxidative acidity from lactose and the production of 3-ketolactose (biovar 1, not biovar 2) separates biovar 1 of this species from phenotypically similar strains of *Achromobacter* species group Vd; some biovar 2 strains fail to grow at 35°C; primarily known as a phytopathogen; isolated from moist soil and from around roots of plants as well as from galls and tumours of diseased plants; isolated from human sputum, wound, blood, bronchial washing, tracheal aspirate, eye, urine, synovial fluid, ear, vagina, colon and endometrium; rarely clinically significant, usually contaminant; cause of bacteraemia and septicemia (intravascular catheter, artificial ventilation, adenocarcinoma), prosthetic valve endocarditis, urinary tract infection in a patient with nonfunctioning kidney, peritonitis in continuous ambulatory peritoneal dialysis; treatment: gentamicin, amoxycillin-clavulanate, piperacillin, cotrimoxazole, rifampicin, fluoroquinolone; also susceptible to ticarcillin, cefoxitin, cefuroxime, ceftriaxone, cefotaxime; resistant to aztreonam, tobramycin

Alcaligenaceae

Alcaligenes: rods or coccoid rods; motile with 1-8, occasionally up to 12, peritrichous flagella; asporogenous; good growth on MacConkey; simple nitrogenous growth requirements; growth on SS and at 42°C variable; colonies nonpigmented; obligately aerobic (some strains utilise nitrite instead of oxygen as final electron acceptor); catalase produced; nitrate reduction variable; indole not produced; usually negative tests for arginine dihydrolase, lysine decarboxylase, ornithine decarboxylase, phenylalanine deaminase, amylase, DNase, gelatinase; oxidase positive; oxidative (1 subspecies only) or nonreactive; occurs in water and soil; causes bacteraemia and septicemia (uncommon in neutropenics), swimmer's ear, other suppurative conditions; growth stimulated by excess iron; 100% susceptible to imipenem; resistant to ciprofloxacin (except *A.xylosoxidans*), ofloxacin, pefloxacin

A. faecalis: nonoxidiser; colonies large, umbonate with a spreading periphery, and granular; reduces nitrite with gas, but not nitrate; grows on cetrinide; hydrolyses acetamide; causes green discolouration of blood on blood agar media; produces a distinctive fruity odour; motile; normal flora of large intestine, ileum, cervix (3%); occurs in soil and water; isolated from nematodes, insects and numerous clinical specimens, such as faeces, urine, blood, sputum, wound and pleural fluid; rarely clinically significant; causes bacteraemia and septicemia, gastroenteritis (rare), nosocomial urinary tract infection, pneumonia (occasional), infections in abnormal host

'A. faecalis' types I and II: nonoxidiser; nitrite not reduced; type I strains reduce nitrate (no gas) and produce small, low convex, glistening colonies with a entire edge; type II strains fail to reduce nitrate and produce larger, umbonate, granular colonies with a spreading periphery; carbon substrate utilisation further distinguishes 2 types; isolated from soil, water and a number of human clinical specimens, primarily ear discharge, blood and sputum; rarely clinically significant; cause of endocarditis and septicemia

A. odorans: synonym for *A. faecalis*

A. piechaudii: nonoxidiser; reduces nitrate (no gas), but not nitrite; grows on cetrinide; utilises gluconate; no growth at 42°C; colonies circular, smooth, entire; isolated from soil and human pharyngeal swab, nose and blood; clinical significance not determined

A. xylosoxidans subspecies denitrificans: motile; nonoxidiser; reduces both nitrate and nitrite to gas; colonies low convex, glistening, entire; isolated from soil, water, hospital environment and a variety of clinical specimens, such as faeces, urine, blood, pleural fluid, ear discharge, prostatic secretion and throat swab; clinical significance unknown

A. xylosoxidans subspecies xylosoxidans: oxidises xylose; variable weak oxidation of monosaccharides; reduces both nitrate and nitrite with variable gas; grows on cetrinide; colonies convex, smooth, glistening, entire; negative tests for urease and phenylalanine deaminase distinguish this species from phenotypically similar *Achromobacter* species group Vd; natural habitat water; isolated from disinfectant solution, saline, deionised water, swimming pool, hospital sink and a wide range of human clinical material, including blood, sputum, wound, ear discharge, CSF, pleural fluid, tracheal aspirate, cerebral tissue, urine and faeces; infrequent but potentially serious nosocomial organism with a predilection for compromised patients; cause of catheter related endocarditis in bone marrow transplant recipients,

postoperative and posttraumatic wound infections, pneumonia, urinary tract infection, neonatal meningitis, peritonitis, biliary tract sepsis, both nosocomial and community-acquired chronic otitis media, chronic pulmonary infection in cystic fibrosis, bacteraemia and septicemia (rare catheter related and gastrointestinal, especially in cancer patients); treatment: cotrimoxazole, ciprofloxacin

TAXONOMIC POSITION UNCERTAIN OR UNKNOWN

Achromobacter: glucose negative; oxidase and motility positive; normal flora of large intestine, lower ileum; causes endophthalmitis (postoperative), postoperative and posttraumatic wound infectious complications

Ochrobacterium antropi: rods motile by peritrichous flagella; only 1 or 2 polar or lateral flagella found in some isolates; obligately aerobic; asporogenous; indophenol oxidase and catalase produced; oxidises xylose as well as other carbohydrates, excluding lactose; reduces nitrate to gas; hydrolyses urea (rapid); phenylalanine deaminated; indole not produced; distinguished from phenotypically similar *Agrobacterium* strains by failure to oxidise lactose and negative test for ONPG; natural habitat water; recovered from human wound, urine, sputum and blood; rarely clinically significant; cause of pancreatic abscess, septicemia in an immunocompromised host (catheter related) and puncture wound osteochondritis; treatment: cotrimoxazole

Alteromonas putrefaciens: straight or curved rods, asporogenous; motile by a single polar flagellum; obligately aerobic; indophenol oxidase and catalase produced; indole not formed; oxidative in carbohydrates; colonies slightly viscous or mucoid and usually red-brown or pink in colour; produces abundant H₂S in Kligler iron agar; highly proteolytic; ornithine decarboxylase and DNase tests positive; nitrate reduced (no gas); no PHB; distinguished from phenotypically similar strains of *Shewanella putrefaciens* on basis of oxidation of sucrose and maltose and failure to grow in high salt concentration (6.5%); however, sodium ion required for growth (no growth in 0% NaCl medium); found primarily in dairy, fishery and other environmental sources; isolated from eggs, butter, cuttlefish, haddock, cod, cutting oil, frog liver, ground beef, poultry, ditch water, tap water, sea water and sewage; causes spoilage of protein foods stored at refrigerator temperature, including butter, fish, meat and poultry; isolated from human pleural fluid, CSF, nose, throat, sputum, urine and blood; rarely clinically significant; associated with an intraabdominal abscess in a patient with colonic carcinoma; isolated from bile of a patient with biliary tract disease

Brucella: Gram negative coccobacillus; asporogenous; nonmotile; obligately aerobic; slow growing and fastidious; most strains require complex media; growth improved by serum or blood, but not X or V factors; many strains require CO₂; growth on MacConkey strain variable; growth on agar plate after 18-24 h incubation scant and usually occurs only in areas of heavy inoculum; discrete colonies usually develop after further incubation; catalase, and usually indophenol oxidase, positive; nitrate reduced to gas by some species; indole not produced; does not liquify gelatine; urease positive (except *B.ovis*); criteria for identification of species and biovars: production of H₂S detected with lead acetate paper, requirement for CO₂, tolerance to dyes, urease activity and agglutination in monospecific sera; recognised major species *abortus*, *canis*, *melitensis* and *suis*; additional minor species *neotomae*, *ovis*; other strains not coinciding with descriptions of major or minor species; DNA hybridisation indicates genus consists of single species (*B.melitensis*); facultative intracellular parasite; transmitted to a wide range of animal species, including humans; pathogen of goats, cattle and pigs with secondary human infection; risk of laboratory infections as dangerous as with *Francisella tularensis*; causes brucellosis (> 100 cases/10 000/y in Longreach district), anterior uveitis, septic arthritis (in 9-37% of infections), bone marrow infection, endocarditis, acute epididymitis and epididymo-orchitis (in 9% of infections), erythema nodosum, adult hepatitis, 2% of hepatic granuloma, lymph gland infection (in 50% of infections: most common physical finding in brucellosis), nonpyogenic meningitis (in < 5% of infections), osteomyelitis and osteochondritis, pneumonia, undulant fever; multiplies in macrophages; pathogenesis characterised by granuloma formation and delayed hypersensitivity; carried in blood associated with mononuclear cells; diagnosis: bone marrow culture, blood culture, direct immunofluorescence after incubation in nutrient broth, standard tube agglutination, dithiothreitol test (IgG), antihuman globulin test, complement fixation test (IgG), ELISA (IgG), lymphocyte proliferation assay; treatment: doxycycline, rifampicin (MIC 0.06-1 mg/L), streptomycin, cotrimoxazole (? 0.25-1 mg/L), oxytetracycline, gentamicin, ampicillin, chloramphenicol, tetracycline (? 0.13-0.25 mg/L); also susceptible to ciprofloxacin (0.5-1 mg/L)

B.abortus: usually susceptible to 1:100 000 thionine, usually resistant to 1:50 000 basic fuchsin, 1:400 crystal violet and

1: 8000 pyronine; CO₂ required on primary isolation (strain variable); indophenol oxidase produced; oxidises xylose and usually glucose; no gas from nitrate; slow hydrolysis of urea (1-2 h, rarely 24 h); H₂S variable; lysed by phage TB5; L-glutamic acid and D-ribose positive; DL-ornithine and L-lysine negative; cell wall substance resists killing by phagocytes; inhibits phagocytic oxidative burst and microbicidal activity by resistance to oxidative attack; natural hosts cattle and other bovidae, but also horses, camels, sheep, deer, dogs and humans; isolated from human blood, bone marrow and abscess; causes brucellosis (abortus fever), bursitis in humans, abortion in animals

B. canis: CO₂ not required; oxidises xylose and glucose; indophenol oxidase production variable; variable gas from nitrate; urease activity within 30 min; H₂S not produced; usually susceptible to basic fuchsin and resistant to thionine dyes; biochemically similar to *B. suis*; natural host dogs; causes orchitis and prostatitis in males and placentitis and abortion in females; isolated from human blood; infection occasionally transmitted to humans (brucellosis)

B. melitensis: resistant to 1:100 000 thionine, 1:50 000 basic fuchsin, 1:400 crystal violet and 1:8000 pyronine; CO₂ not required; hydrolysis of urea immediate or delayed (2 h, rarely 24 h); L-glutamic acid positive; H₂S, DL-ornithine, L-lysine and D-ribose negative; not lysed by phage; oxidises xylose and usually glucose; indophenol oxidase produced; no gas from nitrate; natural hosts usually sheep and goats, but also cattle, pigs and humans; isolated from human blood, bone marrow, bile and spleen; causes abortion in animals, brucellosis (Bruce septicemia, country fever of Constantinople, Cyprus fever, febris melitensis, Gibraltar fever, goat-milk fever, Malta fever, Mediterranean fever, melitensis septicemia, mountain fever, Neapolitan fever, new fever (Crete), Rio Grande fever, Rock fever (Gibraltar)), brain and epidural abscess (rare); treatment: cotrimoxazole; also susceptible to ciprofloxacin (MIC 0.5-0.8 mg/L), ofloxacin (0.8 mg/L)

B. neotomae: CO₂ not required; positive urease in 15 min; H₂S positive; no growth on media containing 1:50 000 thionine or fuchsin

B. ovis: CO₂ required; positive urease in ? 7 d; H₂S negative; resistant to 1:50 000 thionine, most strains susceptible to 1:50 000 fuchsin

B. suis: usually resistant to 1:100 000 thionine, usually susceptible to 1:50 000 basic fuchsin, 1:400 crystal violet and 1:8000 pyronine; CO₂ not required; rapid hydrolysis of urea (within 30 min); H₂S, L-glutamic acid and D-ribose variable; DL-ornithine and L-lysine positive; not lysed by phage; oxidises xylose and glucose; indophenol oxidase produced; gas from nitrate variable; natural hosts usually pigs, horses, rodents, reindeer, but also dogs and humans; isolated from human blood, bone marrow, lung tissue and spleen; causes brucellosis in humans, abortion in animals

Bordetella: minute Gram negative bacillus or coccobacillus; asporogenous; nonmotile or motile with usually 1-8 peritrichous flagella; obligately aerobic; some species fastidious and require modified media for isolation and primary growth; nicotinic acid, cystine and methionine required by some strains for growth; growth on MacConkey poor or negative; no acid produced from carbohydrates; catalase positive (except for some *B. pertussis* strains), oxidase positive (except for *B. parapertussis*); mammalian parasite; all species can produce infections of respiratory tract; susceptible to ciprofloxacin (MIC 0.5 mg/L)

B. avium: rods motile by peritrichous flagella; capsulated; somewhat fastidious; grows on cetrimide, MacConkey and SS agars; hydrolyses acetamide; urease and phenylalanine deaminase not produced; nitrate not reduced; 2 morphovars: type I colonies small, compact, pearl-like, entire edges, glistening surface; type II colonies larger, circular, convex, entire edges, smooth surface; probably misidentified as *Alcaligenes faecalis*; differentiated from latter on basis of requirement for undetermined amino acids and vitamins as growth factors in a mineral base medium; parasite of respiratory epithelium of birds; cause of respiratory disease in birds (turkeys); susceptible to penicillin, polymyxin and most other antimicrobials

B. brochiseptica: rods, motile by peritrichous flagella; nonfastidious; grows well on blood agar as hazily haemolytic colonies; utilises acetate in a mineral base medium without growth factors; grows on MacConkey agar; nitrate reduced (no gas); rapid urea hydrolysis distinguishes this species from similar strains of *Alcaligenes faecalis*; reduction of nitrate (no gas), growth on SS agar and failure to utilise gluconate distinguishes this species from similar group IVc-2 strains; commensal in respiratory tract of animals; humans serve as an accidental host; most infections occur in patients with close contact with animals, including dogs, cats, rabbits, turkeys, foxes, skunks; cause of human respiratory (acute tracheitis, bronchitis, tracheobronchitis, bronchopneumonia, pneumonia) and non-respiratory (endocarditis, posttraumatic meningitis, peritonitis) infections; susceptible to doxycycline (MIC 0.06-0.25 mg/L), imipenem (100%)

B. parapertussis: minute coccobacillus; nonmotile; requires complex growth factors; usually produces ?-haemolysis; growth more rapid on Bordet-Gengou medium than with *B. pertussis*; growth on peptone agar accompanied by a brown discolouration of medium; nitrate not reduced; distinguished from *B. pertussis* by growth on MacConkey agar, urease activity (24 h) and negative indophenol oxidase reaction; found only in respiratory tract of humans; multiplies among epithelial cilia of respiratory tract; causes human infections similar to whooping cough; susceptible to ciprofloxacin (MIC 0.06 mg/L), ofloxacin (0.5 mg/L)

B. pertussis: minute coccobacillus; nonmotile; more fastidious than other *Bordetella*; requires complex growth factors; no growth on usual laboratory media; Bordet-Gengou medium or charcoal agar preferred for primary isolation; usually produces ?-like haemolysis, but not as distinct as that produced by *B. parapertussis*; nitrate not reduced; distinguished from *B. parapertussis* by negative reactions for growth on MacConkey agar and urea hydrolysis and positive reactions for indophenol oxidase; found only in respiratory tract of humans; specialised human respiratory parasite; attaches to respiratory epithelium; multiplies among epithelial cilia of respiratory tract; infection generally confined to epithelial surface of respiratory tract; inhibits phagocyte function by bacterial adenylate cyclase; toxin causes ciliary damage; cell wall increases sensitivity to histamine, produces lymphocytosis, causes fasting hypoglycaemia and prevents hyperglycaemia; phase I and phase IV cultures are differentiated by vaccine effectiveness against infection, nutritional requirements and antigenic makeup; causes pertussis (whooping cough), catarrh; treatment: erythromycin, cotrimoxazole; also susceptible to rosoxacin (MIC 0.025 mg/L), ciprofloxacin (0.2 mg/L), ofloxacin (0.12-0.25 mg/L), norfloxacin (0.25 mg/L), enoxacin (0.15-0.5 mg/L)

Francisella novicida: rarely associated with human infection

F. tularensis: small Gram negative rods and ovals, bipolar staining (though takes stain poorly); asporogenous; nonmotile; nonencapsulated; obligate aerobe; fastidious; cysteine or cystine either required or stimulating for growth; usually not cultured on conventional laboratory media; glucose cystine agar with thiamine and blood, cystine heart agar with blood, cystine yeast extract agar with ?-ketoglutarate, chocolate agar with Isovitalex and Thayer-Martin medium support growth; catabolism of carbohydrates slow with production of acid (no gas); catalase (usually), but not indophenol oxidase, produced; identification confirmed by slide agglutination and/or direct fluorescent antibody tests; widely distributed in nature; found in all continents throughout world except Australia and Antarctica; isolated from approximately 100 types of wildlife; isolated from human blood, lymph node, pleural fluid, eye, lung and bone marrow; causes tularemia, bacteraemia and septicemia, meningitis (rare), pneumonitis, localised skin lesions, acute skin ulcers, cat and dog bite infections, hepatic granuloma, lymph gland infections (painful neck, axillary, epitrochlear) in humans; usually transmitted from wild animals (rabbits, hares, squirrels, moles, muskrats, beavers, deer, woodchucks), sheep, cattle, cats, birds, amphibians, fish, ticks, deerflies, mosquitoes to humans following handling of infected animals, insect bites or ingestion of contaminated meat or water; very infectious in laboratory; endotoxins present; diagnosis: culture of nodules, pustules, ulcers, lymph node aspirate, blood, pleural exudate or sputum on glycine-cystine agar, fluorescent antibody staining of exudates, microagglutination; treatment: streptomycin, tetracycline

Methylobacterium: pleomorphic, branched, vacuolated rods; cells contain large sudanophilic enclosures and volutin granules; tendency to resist Gram decolourisation; asporogenous; usually motile with a single polar flagellum; obligately aerobic; facultative methanol oxidiser; produces a pink to red pigment; grows poorly on media used for pseudomonads; growth occurs best on Saboraud's agar, buffered charcoal yeast extract agar or Middelbeek and Cohn 7H11 agar; growth may occur better at 30°C than 35°C; indophenol oxidase, catalase, urease and amylase reactions produced; nitrate reduction variable (no gas); indole not produced; 8 species recognised (*Mextorquens*, *Mfujisawense*, *Mmesophilum*, *Morganophilum*, *Mradiotolerans*, *Mrhodium*, *Mrhodierianum*, *Mzatmanii*), based on substrates utilised as sole carbon source; isolated from a wide range of habitats, such as soil, water (river, bay, lake, tap), air, rice grain, sewage, semen of cows, and hospital environment, but primarily from leaf surfaces and leaf nodules of plants (perennial rye grass, tobacco, soybean); occasionally isolated from clinical specimens, including blood, endocervix, throat, ulcer, ascitic fluid, skin lesion and bronchial washing; rarely clinically significant; source of nosocomial infection in a bone marrow transplant unit, bacteraemia in a patient with metastatic adenocarcinoma of the lung and probably associated with chronic skin ulcer infection

Mextorquens: causes bacteraemia and septicemia (catheter related); treatment: gentamicin, amoxicillin-clavulanate, piperacillin, cotrimoxazole, rifampicin, fluoroquinolone

CDC Pink Coccoid Group I: nonvacuolated; pale pink colonies

CDC Pink Coccoid Group II: O-F xylose negative

CDC Pink Coccoid Group III: O-F glucose and mannitol positive

CDC Pink Coccoid Group IV: nitrate and salicin positive

Enterobacteriaceae: facultatively anaerobic Gram negative bacteria; motile and nonmotile; nonsporeforming; indophenol oxidase negative; reduce nitrates to nitrites; ferment glucose, forming acid alone or acid and gas; growth on MacConkey, growth on SS; lysine decarboxylase, arginine dihydrolase and ornithine decarboxylase usually negative; normal flora of mouth, throat, large intestine, lower ileum, external genitalia, anterior urethra, vagina; cause abscesses, bacteraemia, bacteriuria, cystitis, diarrhoea, endocarditis, enteric fevers, intoxication, lung abscesses, meningitis, 15% of necrotising fasciitis, peritonitis, pneumonia, postoperative and posttraumatic complications, pyelonephritis, prostatitis and seminal vesiculitis, septicaemic adrenal syndrome, thyroiditis, infections in patients with interrupted integument, surgical procedure, neutrophil dysfunction; immunity due to phagocytes (+++), complement (+), antibody (+); synthesise lipopolysaccharides, not teichoic acid; form rough colonies on loss of O antigens; susceptible to carumonam (MIC ? 0.125 mg/L), aztreonam (? 0.125 mg/L), enoxacin (? 0.125-1 mg/L), norfloxacin (0.25-1 mg/L), imipenem (< 5% resistance in Australia), amikacin (< 5% resistance in Australia); 100% intrinsic resistance to penicillin, flucloxacillin, clindamycin, erythromycin

Escherichia: Gram negative rods; usually motile; indole, lactose and lysine decarboxylase positive; citrate negative; gas from glucose; normal flora of vagina (4%); growth stimulated by excess iron; susceptible to ciprofloxacin (MIC 0.015-0.5 mg/L)

E. coli: Gram negative, motile bacilli; indole, glucose, lactose, mannitol, arabinose and β -glucuronidase on 4-nitrophenyl- β -D-glucopyranosiduronic acid positive; acid and gas, but not hydrogen sulphide, produced on triple sugar iron agar slant; Simmon's citrate and potassium cyanide negative; ornithine decarboxylase, lysine decarboxylase, arginine dihydrolase, dulcitol, salicin, sorbitol, raffinose and rhamnose variable; normal flora of colon in man and animals, cervix (20%); many antigenic types; causes 12-29% of bacteraemia and septicemia, asymptomatic bacteriuria, acute bronchitis in newborn, bursitis, cholecystitis and cholangitis, purulent conjunctivitis, acute cystitis (72% of all cases), infantile and traveller's diarrhoea, acute empyema, endocarditis, endometritis, endophthalmitis (bloodborne), endotoxic reactions associated with reuse of cardiac catheters, acute epididymitis and epididymoorchitis, chronic eye infections, emphysematous gastritis, gastroenteritis, haemorrhagic colitis, haemolytic uraemic syndrome, adult hepatitis, human bite and clenched fist infections, intraabdominal abscess, mastitis and breast abscess, meningitis in neonates and adult immunocompromised, neonatal necrotising enterocolitis, nosocomial infections (13% of total, 34% of urinary tract infections, 17% of septicemia, 23% of Gram negative bacilli), osteomyelitis and osteochondritis, 2% of otitis externa, parametritis, pelvic abscess, pelvic inflammatory disease, perianal and perirectal abscess and cellulitis in patients with malignant disease, perinatal generalised disease, peritonitis (primary, secondary, spontaneous, peritoneal dialysis), primary and secondary pneumonia, prostatitis and seminal vesiculitis (older patients), acute pyelonephritis, rhabdomyolysis, salpingitis, septic arthritis, acute sinusitis, localised skin lesions in septicemia and endocarditis, local and generalised sepsis, 15% of surgical wound infections, symbiotic gangrene, nasal septic abscess, splenic abscess, 8% of thrombophlebitis, tubo-ovarian abscess, typhlitis, endogenous and nosocomial urinary tract infections, 16% of vascular graft infections, infections in abnormal host, systemic infections in granulocytopenia; attaches to intestinal epithelium (requires specific bacterial surface components on fimbriae (piglet: pilus K88 antigen; calves: K89 antigen; humans: ? K antigen), attaching to D-mannose receptor; infantile gastroenteritis strains (enteropathogenic *Escherichia coli* (632 M cases with 389 000 deaths (90% in children < 5 y) globally annually) express intimin protein that binds to host epithelium and stimulates an immunopathologic response favouring colonisation, cause diarrhoea by an unknown mechanism and show localised adherence to tissue culture cells by a plasmid-borne adhesin; traveller's diarrhoea strains (enterotoxigenic *Escherichia coli*; plasmid-borne tox gene; 744-1000 M episodes resulting in 4-6 M deaths in Africa, Latin America and Asia excluding China annually) attach to small intestine by colonisation factor antigen—sialic acid-specific lectin binding to tissue 2-8,N-acetyl-neuraminic acid, rarely penetrate, and cause diarrhoea by forming either heat-stable or heat-labile enterotoxin or both, which induce fluid loss from epithelial cells (disease-producing dose 10^6 - 10^9 ; food and water (source human faeces; survival 5h - 2 d) transmission; produce profuse watery diarrhoea, no blood in stool; in less developed countries and in travellers); coliform enteritis or dysentery (abdominal cramps, tenesmus, usually blood in stool) and piglet diarrhoea strains (enteroinvasive *Escherichia coli*) show ability to invade epithelial cell lines or conjunctiva of animals (plasmid-borne via genes), initially localise in small bowel, later attach to and penetrate epithelium of large intestine, multiplying intraepithelially and inducing mucosal inflammation, ulceration of mucosa and diarrhoea; calf enteritis strains attach to and penetrate epithelium of small intestine and invade subepithelial tissues; enterohaemorrhagic strains produce a toxin closely related to that produced by *Shigella dysenteriae* serotype 1 (verocytotoxin or Shiga-like toxin), encoded by a bacteriophage and causing haemorrhagic colitis, occasionally complicated by haemolytic uraemic syndrome; enteroaggregative strains cause nonspecific diarrhoea, traveller's diarrhoea and persistent diarrhoea, and show an aggregative pattern of adherence to cell cultures by a plasmid-borne adhesin, urinary tract epithelium (pili adhere to D-mannose receptor); multiplies outside cells but attachment to body surface necessary for invasion; selective adherence to small bowel, pharynx, buccal mucosa, urogenital tissue (low adherence to labium majus); inhibits phagocytic chemotaxis, attachment and ingestion, oxidative attack; capsular acid K antigens, cell wall O antigens and pilus protein K antigens associated with invasiveness; M antigens also present; K1 antigens, O antigens, pilus protein, endotoxin and haemolysin virulence factors; K1 antigen similar to group B *Neisseria meningitidis* antigen and similarly associated with meningitis; serogroups O26:NM, O55:NM, O55:H6, O55:H7, O86:NM, O86:H2, O86:H34, O111:NM, O111:H2, O111:H12, O111:H21, O114:NM, O114:H2, O119:H6, O125ac:H21, O126:H27, O127:NM, O127:H6, O127:H9, O127:H21, O128ab:H2, O142:H6, O158:H23 enteropathogenic; serogroups O6:H16, O8:NM, O8:H9, O11:H27, O15:H11, O20:NM, O25:NM, O25:H42, O27:H7, O27:H20, O63:H12, O78:H11, O78:H12, O85:H7, O114:H21, O115:H21, O115:H40, O126:H9, O128ac:H7, O128ac:H12, O128ac:H21, O148:H28, O149:H4, O159:H4, O159:H20, O166:H27, O167:H5 enterotoxigenic; serogroups O28ac:NM, O29:NM, O112ac:NM, O115ac:NM, O124:NM,

O124:H7, O124:H30, O135:NM, O135:NM, O143:NM, O144:NM, O144:H25, O152:NM, O165:NM, O167:NM enteroinvasive; serogroups O26:H11, O157:H7 enterohaemorrhagic; serogroups ONT:H33, O3:H2 enteroaggregative; primary immune defence immune adherence (phagocytosis) (+++), phagocytes (+), alternative complement (+), prevention of attachment by coating microbial surface with specific antibody (mainly secretory IgA) (+), bactericidal activity (+), neutralisation of microbial toxins also important; 4288 genes; mean doubling time 20 minutes in vitro; detection of toxin: ELISA; susceptible to ticarcillin-clavulanate, gentamicin (in Australia, 0.9% resistance), chloramphenicol, cephalixin, cefaclor, cefuroxime, cefotaxime and ceftriaxone (0.1% resistance), cefepime, ceftazidime (MIC 0.03-0.6 mg/L), cefotetan, ceftazidime, rosoxacin (0.05 mg/L), meropenem (? 0.06 mg/L), ofloxacin (96% susceptible at 0.06 mg/L), cefmenoxime (0.06-0.12 mg/L), aztreonam (1% resistance in hospitals), carumonam (0.06-0.12 mg/L), foramidocillin (0.12-0.5 mg/L), amifloxacin (0.125 mg/L), pefloxacin (0.125-0.25 mg/L), amdinocillin (0.13 mg/L), ciprofloxacin (0.3% resistance in Australia, 4% in USA), gatifloxacin, moxifloxacin, cefixime (? 0.25 mg/L), lomefloxacin (0.25 mg/L), ceftizoxime (100% susceptible at 1 mg/L), imipenem (0.1% resistance in Australia), enoxacin (99% susceptible at 1 mg/L), norfloxacin (0.3% resistance in Australia, 4% in USA), ceftazidime (1% resistance in hospitals), moxalactam

(< 1 mg/L), neomycin, soframycin, amikacin, tobramycin (1% resistance in hospitals), piperacillin-tazobactam (3% resistance in hospitals), levofloxacin (4% resistance in USA), nitrofurantoin (2% resistance in USA); 48% resistance (due to β -lactamase) to amoxicillin, ampicillin (39% in USA), ticarcillin, piperacillin, azlocillin, 19% resistance to cotrimoxazole, 19% resistance to trimethoprim, 32% resistance (due to β -lactamase) to cephalothin (30% in USA), 13% to cephalazolin and 7% to cephalixin, 27% resistance (due to β -lactamase) to amoxicillin-clavulanate (17% in USA)

Shigella: Gram negative rods; nonmotile; usually anaerogenic; glucose positive; lysine, oxidase, H₂S, citrate, sucrose, salicin, KCN, usually lactose negative; mannitol, dulcitol, sorbitol, arabinose, raffinose, rhamnose and indole variable; Kligler iron agar alkaline/acid; TSI agar slant acid, alkaline or neutral, with no gas (except some strains in a few serotypes) and no hydrogen sulphide; obligate parasite of man; local invasion only; causes profuse watery diarrhoea (no blood in stool), bacillary dysentery (303 M cases with 654 000 deaths (85% in children < 5 y) globally annually; abdominal cramps, tenesmus, usually blood in stool), bacteraemia and septicemia associated with severe dysentery (especially caused by *S.dysenteriae* serotype 1; uncommonly in neutropenics), 25% of waterborne disease outbreaks (source animal and human faeces; survival time < 15 - > 70 d), reactive arthritis, ? Reiter syndrome, adult hepatitis, symbiotic gangrene, infections in abnormal host; 4% of enteric pathogen isolates; disease-producing dose 10¹-10⁴; transmitted by food, water, contact, fomites; attack rate 33-73% in day care centres; initially localises in small bowel, later attaches to and penetrates epithelium of large intestine, replicates in intestinal epithelium of large intestine, causing disease by killing epithelial cells (exotoxin formed) and inducing diarrhoea by mucosal damage and inflammation; infection generally confined to epithelial surface of intestinal tract; growth stimulated by excess iron; susceptible to amikacin, gentamicin, tobramycin, imipenem, meropenem, cotrimoxazole (MIC 0.016-0.5 mg/L), sulphadimidine, tetracycline, ciprofloxacin (< 5% resistance in Australia), gatifloxacin, moxifloxacin, ofloxacin (0.032-0.25 mg/L), norfloxacin (0.032-0.5 mg/L), fleroxacin (0.125 mg/L), enoxacin (0.25-0.5 mg/L), pefloxacin (0.06-0.12 mg/L), aztreonam, cefotaxime (< 1 mg/L), ceftizoxime (< 1 mg/L), moxalactam (< 1 mg/L), ceftriaxone (< 1 mg/L), ceftazidime (< 1 mg/L), amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefuroxime, cefepime, ceftazidime, cefotetan/ceftazidime, chloramphenicol, trimethoprim, nalidixic acid

S.boydii: mannitol positive; lactose, dulcitol and ornithine decarboxylase (except type 13) negative; indole variable; serologic subgroup A; types 1-15; causes 2-3% of shigellosis cases, dysentery; susceptible to fleroxacin (MIC 0.25 mg/L)

S.dysenteriae: mannitol and ornithine decarboxylase negative; serologic subgroup A; types 1-10; causes 1% of shigellosis cases, dysentery; oral disease-producing dose in man 10 bacteria; enterotoxin induces fluid loss from intestine, causing diarrhoea; neurotoxin induces vascular endothelial damage in brain, causing neurological disturbances; susceptible to norfloxacin (MIC 0.05 mg/L), fleroxacin (? 0.06 mg/L), rosoxacin (0.2 mg/L)

S.flexneri: mannitol positive; lactose, dulcitol and ornithine decarboxylase negative; indole variable; some strains gas from glucose; serologic subgroup B; types 1-6; causes 29% of total shigellosis cases (46% due to types 2a and 3a; 58% of shigellosis cases on Indian reservations, 23% in general community, 7% in institutions), dysentery, rhabdomyolysis, splenic abscess (extremely rare); attaches to colonic epithelium; susceptible to meropenem (MIC 0.03 mg/L), fleroxacin (0.125 mg/L)

S. sonnei: mannitol, lactose (late), sucrose (late) and ornithine decarboxylase positive; sorbitol negative; serologic subgroup D; 1 type; causes 67% of shigellosis cases (93% of shigellosis in institutions, 74% in general community, 41% on Indian reservations; very mild infection), dysentery, rhabdomyolysis; susceptible to fleroxacin (MIC ? 0.06 mg/L), meropenem (0.06 mg/L)

Salmonella: Gram negative rods; motile; glucose, mannitol, sorbitol, arabinose (usually), rhamnose, arginine dihydrolase (may be delayed) and ornithine decarboxylase positive; indole, lactose, sucrose, salicin, adonitol, urea, malonate, gelatine and KCN negative; dulcitol, inositol and Simmon's citrate variable; aerogenic (gas produced on acid, alkaline or neutral TSI agar slant; except *S. typhi*); H₂S produced on TSI and LIA slants (except some strains of '*S. paratyphi A*'); lysine debarboxylase positive on LIA slant (except '*S. parathyphi A*'); causes enteric fever (typhoid, paratyphoid; continued fever, often without significant diarrhoea), gastroenteritis (food poisoning, salmonellosis), acute diarrhoea (0-25% of traveller's, 0-3% of nosocomial; 52% of enteric pathogen isolates) and/or vomiting, 13% of waterborne disease outbreaks (source animal and human faeces; survival time 12 h - 5 d), reactive arthritis, bacteraemia and septicemia, endocarditis (AIDS patients, oncology patients, elderly with previous valvular heart disease), asymptomatic bacteriuria in renal transplant recipients, brain and epidural abscess (uncommon), cellulitis (in renal transplant recipients), acute epididymitis and epididymoorchitis, 18-66% of mycotic aneurism, neonatal and postneonatal purulent meningitis, orchitis (in renal transplant recipients), osteomyelitis and osteochondritis (associated with haemoglobinopathies, particularly sickle cell disease; more likely in patients with lymphoma or connective tissue disorders), pneumonia (in renal transplant recipients), acute pyelonephritis (in renal transplant recipients), septic arthritis (< 20 y; related to sickle cell disease), acute sinusitis (in renal transplant recipients), local and generalised sepsis (in renal transplant recipients), splenic abscess, infections in abnormal host (infusion infection, T lymphocyte dysfunction); ? 2100 serotypes; primarily parasite of animals (pythons to elephants), great tendency to colonise domestic animals (pigs and poultry commonly affected); human disease usually follows consumption of contaminated meat (poultry, pork, ham, beef, meat pies, sausages) or eggs; also milk, unpasteurised orange juice; contaminates raw materials or food after cooking and is subsequently allowed to multiply; most species extracellular; causes profuse watery diarrhoea or dysentery (abdominal cramps, tenesmus, usually blood in stool); attaches to and penetrates epithelium of ileum, causing disease by killing epithelial cells (invasive infection with possible toxin involvement) and inducing diarrhoea; growth stimulated by excess iron; in certain species, infection is generally confined to epithelial surface of intestinal tract; certain species also invade subepithelial tissues of small bowel and colon, penetrating into submucosa and causing disease by inflammation of the lamina propria; disease-producing dose for most serotypes 10⁶-10⁸ organisms; most serotypes transmitted by food or water; Vi antigen, O antigens and endotoxin virulence factors; M antigens also present; immunity cell-mediated (delayed type hypersensitivity activated macrophages +++), bactericidal activity +, immune adherence (phagocytosis) ++; serotyped on basis of antigenic polysaccharides (O antigens) consisting of repeating units containing 3-5 sugars each in outermost regions of lipopolysaccharide; diagnosis: Widal agglutination (significant titre ? 1:80), indirect haemagglutination (4-fold rise in titre indicates active infection), ELISA, stool and blood cultures (preferred method), Wellcolex colour Salmonella test on culture in selenite broth (sensitivity 97.6%, specificity 99.7%); susceptible to cotrimoxazole (MIC 0.032-0.5 mg/L), chloramphenicol, cefotaxime (0.003-0.5 mg/L), ceftriaxone (0.01-0.2 mg/L), cefepime, ampicillin, amoxicillin, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, ofloxacin (0.032-0.06 mg/L), tetracycline, meropenem (? 0.06 mg/L), ceftazidime (0.06-0.5 mg/L), cefmenoxime (? 0.12 mg/L), cefuroxime, aztreonam (? 0.12 mg/L), carumonon (? 0.12 mg/L), ciprofloxacin (< 5% resistance in Australia), gatifloxacin, moxifloxacin, cefpirome (0.12 mg/L), pefloxacin (0.25 mg/L), fleroxacin (0.25 mg/L), norfloxacin (100% at 0.5 mg/L), enoxacin (100% at 0.5 mg/L), imipenem (100% at < 1 mg/L), amoxicillin-clavulanate, trimethoprim, nalidixic acid, azithromycin

serovar aberdeen: 0.3% of *Salmonella* CSF isolates

serovar adelaide: 1-3% of *Salmonella* isolates (29-62% from animal products)

serovar agona: 5% of total *Salmonella* isolates, 3% of poultry isolates, 3% of CSF isolates, 3% of urine, 3% of stool, 1% of blood; transmitted by non-fat powdered milk, raw milk, other food and water, contact, fomites; disease-producing dose 10² organisms

serovar anatum: 6-9% of total *Salmonella* isolates (70% from animal, 13% from human), 2% of urine isolates, 1% of stool, 0.5% of CSF; transmitted by non-fat powdered milk, unpasteurised orange juice

S. arizonae: H₂S, gelatine (delayed), lysine decarboxylase, arginine dihydrolase (may be delayed), ornithine decarboxylase, malonate, lactose, mannitol, sorbitol, arabinose, and rhamnose positive; gas from glucose; KCN and salicin negative

serovar bareilly: 1% of total *Salmonella* isolates (15% from animals), 0.8% of CSF isolates

serovar berta: 0.5% of *Salmonella* CSF isolates

serovar blockery: 2% of *Salmonella* stool isolates, 1% of *Salmonella* CSF isolates, 1% of *Salmonella* urine isolates, 0.5% of *Salmonella* blood isolates; causes rhabdomyolysis

serovar bovis-morbificans: 2-5% of total *Salmonella* isolates (44-75% from animal products), 0.3% of CSF isolates

serovar brandenburg: 0.5% of *Salmonella* CSF isolates

serovar bredeney: 3% of total *Salmonella* isolates (69% from animals), 0.8% of CSF isolates

serovar cerro: 1% of total *Salmonella* isolates (96% from animal products, especially raw milk)

serovar chester: 2-5% of total *Salmonella* isolates (35-57% from humans), 3% of clinical isolates, 0.8% of CSF isolates

serovar choleraesuis: *Salmonella* subgroup 1; arabinose negative; causes enteric fever, endocarditis (26% of *Salmonella* isolates), septic arthritis; 4% of *Salmonella* blood isolates, 1% of *Salmonella* CSF isolates; main host swine; treatment: chloramphenicol

serovar cubana: 0.3% of *Salmonella* CSF isolates; transmitted by non-fat powdered milk

serovar derby: 10-13% of total *Salmonella* isolates (69-81% from animal products), 2% of CSF isolates, 2% of urine, 2% of stool, 0.6% of blood

serovar dublin: causes 40% of gastroenteritis due to pasteurised milk, 34% of cases due to raw milk; 4% of *Salmonella* blood isolates, 2% of *Salmonella* CSF isolates; 44% of human isolates obtained from stool, 37% from blood, 6% from urine, 2% from gallbladder, 1% from wound; 10% of cattle infected

serovar eastbourne: disease-producing dose 10⁹ organisms; transmitted by food, water, contact, fomites

serovar enteritidis: *Salmonella* subgroup 1; 6% of *Salmonella* isolates (10% of blood, 9% of CSF, 7% of stool, 7% of urine); causes 13% of *Salmonella* endocarditis; main serovar transmitted by eggs; susceptible to fleroxacin (MIC 0.5 mg/L)

serovar gallinarum-pullorum: *Salmonella* subgroup 1; main host fowl

serovar hadar: 46% of gastroenteritis cases transmitted by turkey; 2-10% of *Salmonella* strains isolated from chickens

serovar havana: 3-4% of total *Salmonella* isolates (42-48% from animal products)

serovar heidelberg: causes gastroenteritis; 7% of total *Salmonella* isolates, 16% of CSF isolates, 9% of blood, 8% of urine, 7% of stool; disease-producing dose 10⁹ organisms; transmitted by food, water, contact, fomites

serovar infantis: 5% of total *Salmonella* isolates, 6% of urine isolates, 3% of blood, 2% of CSF

serovar java: 0.5% of *Salmonella* CSF isolates

serovar javiana: 2% of *Salmonella* urine isolates, 2% of *Salmonella* stool isolates, 1% of *Salmonella* CSF isolates, 0.7% of *Salmonella* blood isolates

serovar johannesburg: 1% of total *Salmonella* isolates (? 100% from animal products), 0.8% of CSF isolates

serovar kentucky: 0.3% of *Salmonella* CSF isolates; transmitted by raw milk

serovar kottbus: 2% of total *Salmonella* isolates (94% from animal products), 0.5% of CSF isolates

serovar lille: transmitted by raw milk

serovar manhattan: 2% of *Salmonella* urine isolates, 1% of *Salmonella* stool isolates, 0.5% of *Salmonella* CSF isolates

serovar marina: diarrhoea associated with pet iguanas

serovar mbdantaka: infectious dose in peanut butter < 5 organisms

serovar meleagridis: transmitted by raw milk

serovar miami: causes gastroenteritis

serovar minnesota: 0.5% of *Salmonella* CSF isolates; inhibits phagocytic microbicidal activity by resistance to granule substance

serovar montevideo: 2% of total *Salmonella* isolates, 2% of CSF isolates, 2% of urine, 2% of stool, 1% of blood; transmitted by raw milk

serovar muenchen: causes salmonellosis; transmitted by poultry, cattle, swine, marijuana, unpasteurised orange juice; 2-3% of total *Salmonella* isolates (58-62% from animal products)

serovar muenster: causes gastroenteritis; 0.3% of *Salmonella* CSF isolates; transmitted by undercooked turkey

serovar newington: 0.3% of *Salmonella* CSF isolates; transmitted by raw milk

serovar Newport: causes 20% of gastroenteritis due to pasteurised milk; 1-6% of total *Salmonella* isolates (80% from animals), 4% of clinical isolates, 7% of stool isolates, 5% of urine, 4% of CSF, 2% of blood; disease-producing dose 10^2 organisms; transmitted by food, water, contact, fomites

serovar ohio: 0.5% of *Salmonella* isolates from poultry

serovar onderstepoort: 1-2% of total *Salmonella* isolates (92-95% from animal products)

serovar oranienburg: causes gastroenteritis, soft tissue and cartilage infection; 2-3% of total *Salmonella* isolates (56-75% from animal products), 2% of CSF isolates, 2% of blood, 2% of urine, 2% of stool

serovar panama: 4% of *Salmonella* CSF isolates, 1% of *Salmonella* stool isolates, 1% of *Salmonella* blood isolates, 1% of *Salmonella* urine isolates

***S. paratyphi*:** causes enteric fever; *S. paratyphi* A 2% of *Salmonella* blood isolates, 0.3% of CSF isolates; *S. paratyphi* B 1% of blood isolates, causes hepatic granuloma; *S. paratyphi* C causes endocarditis, septic arthritis; attaches to and penetrates epithelium of small intestine and invades subepithelial tissues; facultative intracellular; main host man; treatment: chloramphenicol, ciprofloxacin, amoxicillin, ceftriaxone, ofloxacin

serovar pensacola: 0.3% of *Salmonella* CSF isolates

serovar poona: 1% of CSF isolates; cantaloupe

serovar reading: 0.3% of *Salmonella* CSF isolates

serovar saint-paul: causes salmonellosis; 3% of total *Salmonella* isolates, 5% of clinical isolates, 6% of CSF isolates, 4% of stool, 4% of urine, 3% of blood; transmitted by raw milk

serovar san-diego: 1% of *Salmonella* CSF isolates

serovar schottmuelleri: causes enteric fever

serovar schwarzengrund: 0.7% of *Salmonella* blood isolates

serovar sendai: main host man

serovar singapore: 5-10% of *Salmonella* isolates (32-34% from animals)

serovar sofia: 90% of *Salmonella* isolates from poultry

serovar stanley: 0.3% of *Salmonella* CSF isolates; transmitted by peanuts (infectious dose up to 200 organisms)

serovar tennessee: transmitted by non-fat milk

serovar thompson: 2% of *Salmonella* blood isolates, 2% of *Salmonella* urine isolates, 2% of *Salmonella* blood isolates, 1% of *Salmonella* CSF isolates

***S. typhi*:** *Salmonella* subgroup 1; natural host man; invasive; causes enteric fever (typhoid fever; 31 M cases with 581 000 deaths (94% < 5 y) globally annually), septic arthritis, bacteraemia and septicemia, bone marrow infection, adult hepatitis, hepatic granuloma, osteomyelitis, pancreatic abscess, rhabdomyolysis; 2% of total *Salmonella* isolates, 23% of blood isolates, 6% of CSF, 5% of urine, 2% of stool; oral disease-producing dose in man 10^4 - 10^6 bacteria; bacterial adhesin attaches to mannose-like receptor on epithelial cell of small intestine, invades subepithelial tissues, replicates in intestinal lymphoid tissue, liver, biliary tract, subsequently spreads through body; biliary excretion of bacteria into intestine; inhibits phagocytic chemotaxis and oxidative burst; Vi antigen (poly-N-acetyl-D-galactosaminouronic acid) resists phagocytosis (unless antibody present) and killing (associated with invasiveness); O antigens (polysaccharide-protein-phospholipid complex) inhibit phagocytosis, inhibit complement, modify fibrinogen and potentiate effects of epinephrine; facultative intracellular; recovery from primary infection due to cell-mediated immunity; antibodies to cells containing O antigen confer specific immunity; persists in gall bladder and urinary tract (infectious, intermittent shedding in urine and faeces); transmitted by food and water; treatment: chloramphenicol, cotrimoxazole, ciprofloxacin (MIC 0.02-0.1 mg/L), amoxicillin, ceftriaxone, ofloxacin (0.1 mg/L), amoxicillin-clavulanate; also susceptible to meropenem (? 0.06 mg/L) norfloxacin (0.2 mg/L), fleroxacin (0.25 mg/L), rosoxacin (0.4 mg/L)

serovar typhimurium: causes 20% of gastroenteritis due to pasteurised milk (also transmitted by non-fat powdered milk, raw milk, other food, water, contact, fomites), 21% of *Salmonella* endocarditis, septic arthritis in renal transplant recipients; most commonly isolated *Salmonella* (35-38% of total isolates (47-60% from animals), 3% of poultry isolates, 28% of clinical isolates, 30% of stool, 23% of urine, 22% of CSF, 20% of blood); multiple sources, including eggs, Turkish helva, wild birds; disease-producing dose from 10² organisms in halva to > 20 000 organisms in rice dish; mean doubling time 30 minutes in vitro, 5-12 h in mouse spleen; inhibits phagocytic microbicidal activity by resistance to granule (lysosomal enzymes); susceptible to macrophage colony stimulatory factor-activated macrophages; interferon γ , interferon α , interleukin 1, granulocyte macrophage colony stimulatory factor, tissue necrosis factor also induce antimicrobial activity; treatment: chloramphenicol

serovar typhimurium var copenhagen: causes 20% of gastroenteritis due to pasteurised milk

serovar urbana: 1% of *Salmonella* CSF isolates

serovar virchow: 6% of *Salmonella* clinical isolates

serovar welikade: 1% of *Salmonella* isolates (92% from animal products)

serovar weltevreden: 0.3% of *Salmonella* CSF isolates

serovar wien: disease-producing dose 10² organisms; transmitted by food, water, contact, fomites

serovar worthington: transmitted by raw milk

Citrobacter: glucose (with gas), H₂S, rhamnose, arabinose, sorbitol and citrate positive; indole, lysine decarboxylase and urea negative; lactose, malonate and dulcitol variable; causes bacteraemia, asymptomatic bacteriuria (frequently extraneous), urinary tract infection, perinatal generalised infection, wound infection, suppurative lesions; some strains appear to cause occasional outbreaks of enteritis; some strains Vi antigen positive; treatment: gentamicin, chloramphenicol; also susceptible to ciprofloxacin (MIC 0.015-0.25 mg/L), enoxacin (0.125-0.5 mg/L), amifloxacin (0.125-0.5 mg/L), ofloxacin (0.25 mg/L), pefloxacin (0.25 mg/L), lomefloxacin (0.5 mg/L), norfloxacin (1 mg/L); 98% intrinsic resistance (due to inducible Class I chromosomal β -lactamase) to amoxicillin, ampicillin, amoxicillin-clavulanate, cephalothin, cephalosporins, penicillins, cephamycins and aztreonam, but may be susceptible to imipenem

C.amalonicus: susceptible to ciprofloxacin (100%), norfloxacin (100%), enoxacin (100%), meropenem (MIC ? 0.06 mg/L)

C.diversus: adonitol, malonate, indole, arginine dihydrolase (may be delayed), ornithine decarboxylase, mannitol and salicin (may be delayed) positive; KCN, H₂S and lysine decarboxylase negative; urease variable; causes infections in abnormal host, neonatal nosocomial meningitis (brain abscess common); treatment: cefotaxime, ceftriaxone, chloramphenicol; also susceptible to ofloxacin (MIC ? 0.03-0.5 mg/L), pefloxacin (0.03-0.5 mg/L), meropenem (? 0.06 mg/L), ciprofloxacin (100% susceptible at 0.06 mg/L), enoxacin (0.25 mg/L), norfloxacin (0.25 mg/L), gentamicin (0.5 mg/L), usually susceptible to cotrimoxazole, trimethoprim, amikacin, tetracycline

C.freundii: KCN and mannitol positive; lysine decarboxylase negative; urease, ornithine decarboxylase, lactose, salicin and raffinose variable; isolated from water; species most commonly found in patients; causes infections in abnormal host, perianal and perirectal abscess and cellulitis in patients with malignant disease, peritonitis; susceptible to piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefuroxime, cefepime, cefpirome, ceftazidime, meropenem (0.13 mg/L), ciprofloxacin (100% at 0.25 mg/L), gatifloxacin, moxifloxacin, norfloxacin (99%), enoxacin (98% at 0.25 mg/L), ofloxacin (0.25 mg/L), difloxacin (0.5 mg/L), imipenem (100%), aztreonam, cotrimoxazole, trimethoprim, amikacin, gentamicin, tobramycin; 96% intrinsic resistance to amoxicillin and ampicillin, 92% to amoxicillin-clavulanate, 97% to cephalothin, cephalosporins and cephalixin (possibly all resistant in clinical practice)

C.koseri: may be associated with meningitis in newborn infants; susceptible to ciprofloxacin (MIC 0.008 mg/L), ofloxacin (0.06 mg/L), norfloxacin (0.06 mg/L), difloxacin (0.12 mg/L), enoxacin (0.12 mg/L), pefloxacin (0.12 mg/L), imipenem (100%), gentamicin (100%), tobramycin (100%)

Klebsiella: Gram negative rods, capsulated, nonmotile; indole negative (except *K.oxytoca*); lysine positive on lysine iron agar slant; gas, but not hydrogen sulphide, produced on acid TSI agar slant; present in vegetation, soil, sometimes faeces; normal flora of vagina (2%); pathogenic when host resistance lowered; causes ankylosing spondylitis, 4-8% of bacteraemia and septicemia, asymptomatic bacteriuria, acute cystitis, acute empyema, human bite and clenched fist infections, chronic eye infections, neonatal and post-neonatal pyogenic meningitis, mycotic aneurism, 8% of nosocomial

infections (15% of Gram negative bacilli), osteomyelitis and osteochondritis, otitis, peritonitis, pneumonia, pulmonary abscess, localised skin lesions in septicemia and endocarditis, septic arthritis, surgical wound infections (5% of total; summer peak), thrombophlebitis; extracellular; growth stimulated by excess iron; K (capsular) antigens, O antigens and endotoxin virulence factors; primary bodily defence mechanisms phagocytes (+), alternative complement (+), leucocyte bactericidal function (+), immune adherence (phagocytosis) (+++); susceptible to amoxicillin-clavulanate (in Australia, 10% acquired resistance in hospitals and 5% in private laboratories), piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefaclor, cefuroxime, cefotaxime and ceftriaxone (in Australia, 5% resistance in hospitals and 0.9% in private laboratories), cefepime, ceftazidime (MIC 1 mg/L), cefotetan, ceftazidime (UTI only; 4% resistance in Australia), gentamicin (in Australia, 8% resistance in hospitals and 5% in private laboratories), tobramycin, ciprofloxacin (4% resistance in Australia), pefloxacin (0.5 mg/L), gatifloxacin, moxifloxacin, colistin (0.5 mg/L), imipenem (in Australia, 0.8% resistance in hospitals, none so far in private laboratories), meropenem, ceftizoxime (97% at < 1 mg/L), moxalactam, (< 1 mg/L), amifloxacin (1 mg/L), lomefloxacin (1 mg/L), neomycin (1 mg/L), amikacin, aztreonam, chloramphenicol; variably susceptible to doxycycline, tetracycline, minocycline; 98% intrinsic resistance (due to ?-lactamase) to ampicillin, amoxicillin, azlocillin, carbenicillin, ticarcillin, piperacillin (possibly all resistant in clinical practice); in Australia, 12% acquired resistance to cotrimoxazole, 12% in hospitals and 16% in private laboratories to trimethoprim, 19% acquired resistance to cephalothin, cephazolin and cephalexin in hospitals and 10% in private laboratories

K. oxytoca: isolated from water and human wounds and respiratory and urinary infections; also causes cholangitis and cholecystitis, malignant otitis externa (rare), pyomyositis (uncommon); susceptible to meropenem (MIC 0.06 mg/L), ceftazidime (98% of hospital isolates), ceftriaxone (94% of hospital isolates), cefpiramide (0.1-0.5 mg/L), aztreonam (94% of hospital isolates), ceftazidime (0.12-0.25 mg/L), moxalactam (0.12-0.25 mg/L), carumonam (0.12-0.5 mg/L), cefmenoxime (0.12-1 mg/L), ceftizoxime (0.12-1 mg/L), pefloxacin (0.25-0.5 mg/L), foramidocillin (0.25-0.5 mg/L), ceftazidime (0.25-0.5 mg/L), cefbuperazone (0.25-1mg/L), ciprofloxacin (100%), ofloxacin (100%), imipenem (100%), enoxacin (99%), gentamicin (98% of hospital isolates), tobramycin (100%), cotrimoxazole (100%), cefotaxime (96% of hospital isolates)

K. ozaenae: urease, VP and malonate negative; causes infections in abnormal host; susceptible to meropenem (MIC 0.25 mg/L)

K. pneumoniae: lysine decarboxylase, urease, VP, malonate, glucose (with gas) and lactose positive; ornithine decarboxylase and H₂S negative; methyl red variable; nonmotile, gas produced; causes acute empyema, cholangitis and cholecystitis, endotoxemia, acute epididymitis and epididymo-orchitis, neonatal necrotising enterocolitis, perianal and perirectal abscess and cellulitis in patients with malignant disease, perinatal generalised disease, peritonitis, primary and secondary pneumonia, pulmonary abscess, rhabdomyolysis, septicemia in haemodialysis, infections in abnormal host, systemic infections in granulocytopenia, hepatic abscess and endophthalmitis in diabetics; adherence to nasal mucosa ?; polysaccharide resists phagocytosis (unless antibody present) and digestion; capsular K antigens and cell wall O antigens associated with invasiveness; diagnosis: counterimmunoelectrophoresis, culture; treatment: cefotaxime (6% resistance (due to ?-lactamase) in Australia), gentamicin (11% resistance in Australia), amikacin, ceftazidime (6% resistance in hospitals), ciprofloxacin (4% resistance in Australia and USA), aztreonam (7% resistance in hospitals), chloramphenicol; also susceptible to meropenem (0.06 mg/L), ceftizoxime (? 0.12 mg/L), cefmenoxime (? 0.12 mg/L), ceftazidime (? 0.12 mg/L), carumonam (0.12-0.25 mg/L), cefixime (? 0.25 mg/L), ofloxacin (0.25 mg/L), cefbuperazone (0.25-0.5 mg/L), enoxacin (97% at 0.5 mg/L), oxolinic acid (0.5 mg/L), cefaclor (0.5 mg/L), pefloxacin (0.5 mg/L), foramidocillin (0.5-1 mg/L), rosoxacin (0.8 mg/L), imipenem (0.4% resistance in Australia), moxalactam, ceftriaxone (6% resistance in Australia), levofloxacin (3% resistance in USA); resistant to carbenicillin, azlocillin, piperacillin; in Australia, 15% resistance to cotrimoxazole (10% in USA), 21% resistance (due to ?-lactamase) to cephalothin (13% in USA), cephazolin, cephalexin, 11% resistance to amoxicillin-clavulanate (9% in USA), 7% resistance to tobramycin (15% in hospital isolates), 7% resistance to norfloxacin (5% in USA)

K. rhinoscleromatis: malonate, glucose and lactose positive; urease, VP, indole and H₂S negative; nonmotile, gas not produced; causes rhinoscleroma, infections in abnormal host

Enterobacter: arabinose, mannitol, rhamnose and citrate positive; malonate variable; causes 1-3% of bacteraemia and septicemia, cholangitis and cholecystitis, emphysematous gastritis, human bite and clenched fist infections,

endophthalmitis, mycotic aneurism, 4% of nosocomial infections, osteomyelitis and osteochondritis, pneumonia (mainly nosocomial), acute empyema, local and generalised sepsis, thrombophlebitis, urinary tract infections (acute cystitis); extracellular; growth stimulated by excess iron; K antigens, O antigens and endotoxin virulence factors; major host defence mechanisms phagocytes (+), alternative complement (+), bactericidal activity (+), immune adherence (phagocytosis) (+++); susceptible to ciprofloxacin (2% resistance in Australia), gatifloxacin, moxifloxacin, enoxacin (0.125-0.5 mg/L), amifloxacin (0.25 mg/L), norfloxacin (0.8% resistance in hospitals and 3% in private laboratories), ofloxacin (92% sensitive at 0.5 mg/L), lomefloxacin (0.5 mg/L), imipenem (2% resistance in hospitals, none so far in private laboratories), meropenem, pefloxacin (1 mg/L), mezlocillin, tobramycin, chloramphenicol, cotrimoxazole (5% resistance in hospitals and 7% in private laboratories), trimethoprim (8% resistance in hospitals and 12% in private laboratories), gentamicin (3% resistance in hospitals and 1% in private laboratories), amikacin, ticarcillin, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefepime, ceftazidime, azlocillin; 96% intrinsic resistance (due to β -lactamase) to amoxicillin and ampicillin, 92% to amoxicillin-clavulanate, 97% to cephalothin, cephazolin, and cephalexin (possibly all resistant in clinical practice); in Australia, 25% resistance to cefotaxime, ceftriaxone and ceftazidime in hospitals and 10% in private laboratories

E.aerogenes: VP, ornithine decarboxylase, sucrose, salicin, inositol, sorbitol, raffinose, lysine decarboxylase, mucate, glucose (with gas) and lactose positive; methyl red, urease, indole and H_2S negative; gelatine variable; motile; common in human intestinal tract; causes infections in abnormal host; on occasion, may be opportunistic pathogen and cause suppurative lesions at almost any site; primary bodily defence mechanism leucocyte bactericidal function; susceptible to carumonam (0.12-0.5 mg/L), meropenem (0.13 mg/L), oxolinic acid (? 0.25 mg/L), pefloxacin (0.25 mg/L), difloxacin (0.5 mg/L), ciprofloxacin (98% of hospital isolates), norfloxacin (100%), ofloxacin (100%), imipenem (96% of hospital isolates), enoxacin (94%), gentamicin (98% of hospital isolates), tobramycin (100%), amikacin, cotrimoxazole (98% of hospital isolates)

E.cloacae: VP, arginine dihydrolase, ornithine decarboxylase, mucate, glucose (with gas), lactose (may be delayed), sucrose, sorbitol, raffinose and salicin (may be delayed) positive; methyl red, indole and H_2S negative; gelatine, dulcitol and inositol variable; motile; isolated from water and human wounds; causes bursitis, infusion infections, perianal and perirectal abscess and cellulitis in patients with malignant disease, perinatal generalised disease, peritonitis; on occasion, may be opportunistic pathogen and cause suppurative lesions at almost any site; treatment: gentamicin (14% resistance in Australia), chloramphenicol; also susceptible to ciprofloxacin (5% resistance in Australia, 11% in USA), imipenem (2% resistance in Australia), ofloxacin (100% at 0.25 mg/L), meropenem (0.25 mg/L), rosoxacin (0.8 mg/L), norfloxacin (1% resistance in Australia, 14% in USA), enoxacin (98%), tobramycin (95% of hospital isolates), cotrimoxazole (12% resistance in Australia, 17% in USA), trimethoprim (23% resistance in Australia); possesses an inducible Class I chromosomal β -lactamase and should be considered resistant to all cephalosporins, penicillins, cephamycins and aztreonam but may be susceptible to imipenem

E.sakazakii: isolated from water and human wounds; rare invasive infections with high death rate in neonates; DNase positive at 25°C at 24-48 h; susceptible to ciprofloxacin (MIC ? 0.06 mg/L), meropenem (0.13 mg/L), enoxacin (0.25 mg/L), norfloxacin (0.25 mg/L)

E.taylorae: isolated from water and human wounds; causes typhlitis

Pantoea agglomerans: rhamnose positive (may be delayed); indole, methyl red, VP, Simmon's citrate, urease, KCN, motility, phenylalanine deaminase, gas from glucose, lactose, sucrose, dulcitol, inositol and raffinose variable; causes endotoxemia, infusion infection; susceptible to ceftriaxone (MIC 0.03 mg/L), cotrimoxazole (? 0.06-0.12 mg/L), meropenem (0.13 mg/L), moxalactam (0.25 mg/L), cefotaxime (0.25-0.5 mg/L), imipenem (0.5 mg/L), gentamicin (0.5 mg/L), ciprofloxacin (100%), enoxacin (94%), norfloxacin (94%)

Erwinia: causes rare opportunistic infections in abnormal host (including bacteraemia and septicemia in neutropenics), nosocomial infections

E.herbicola: causes septicemia, brain abscess, urinary tract infection, pneumonia with empyema, rhabdomyolysis

Serratia: gelatine (may be delayed), lysine decarboxylase (may be delayed), mannitol, sucrose, salicin (may be delayed) positive; widely distributed opportunistic pathogen; causes 2% of bacteraemia and septicemia, neonatal meningitis, osteomyelitis and osteochondritis (spine, sacroiliac joint, sternoclavicular joint, symphysis pubis, as well as usual large joints, in drug addicts), primary and secondary pneumonia, 2% of nosocomial infection, systemic infections

in microbicidal abnormality; inhibits phagocyte chemotaxis; K antigens, O antigens and endotoxin virulence factors; major host defence mechanisms phagocytes (+), alternative complement (+), bactericidal activity (+), immune adherence (phagocytosis) (+++); susceptible to cefotaxime, ceftriaxone, cefepime, ceftazidime, foramidocillin (MIC 0.25-0.5 mg/L), ofloxacin

(0.5 mg/L), lomefloxacin (0.5 mg/L), enoxacin (95% at 0.5 mg/L), pefloxacin (1 mg/L), imipenem (100%), meropenem, ceftizoxime (96%), norfloxacin (93% at 0.5 mg/L), cefoperazone, moxalactam, mezlocillin, amikacin, usually susceptible to cotrimoxazole, trimethoprim, gentamicin, tobramycin, ciprofloxacin, gatifloxacin, moxifloxacin, aztreonam, ticarcillin, piperacillin, azlocillin, piperacillin-tazobactam, ticarcillin-clavulanate; 96% intrinsic resistance (due to β -lactamase) to amoxicillin and ampicillin, 92% to amoxicillin-clavulanate, 97% to cephalothin, cephalozin and cephalexin (possibly all resistant in clinical practice)

S. liquefaciens: inositol (may be delayed), sorbitol, arabinose, raffinose, ornithine decarboxylase, gelatine and lysine decarboxylase positive; mucate negative; methyl red, VP, gas from glucose, lactose and urease variable; causes infections in abnormal host (infusion infections); susceptible to imipenem (100%), meropenem (MIC 0.13 mg/L)

S. marcescens: VP, gelatine (may be delayed), sorbitol, ornithine decarboxylase, glucose (with gas) and sucrose positive; mannose, rhamnose, lactose, H₂S, indole and arabinose negative; motile; water-borne; causes variety of infections (especially urinary and respiratory tract infections (including acute empyema) and septicemia (sometimes with localised skin lesions)), chiefly in abnormal host (interrupted integument) and hospital patients, also perinatal generalised disease, psoas abscess, rare pyomyositis; extracellular; primary bodily defence mechanism leucocyte bactericidal function; treatment: gentamicin (100% susceptible), chloramphenicol, tobramycin; also susceptible to oxolinic acid (0.25 mg/L), enoxacin (0.25 mg/L), meropenem (0.25 mg/L), rosoxacin (0.4 mg/L), amifloxacin (0.5 mg/L), norfloxacin (0.8 mg/L), ciprofloxacin (100% at 1 mg/L), pefloxacin (1 mg/L), imipenem (100%), piperacillin/tazobactam (100%); resistant to tetracycline, nitrofurantoin; possesses an inducible Class I chromosomal β -lactamase and should be considered resistant to all cephalosporins, penicillins, cephamycins and aztreonam but may be susceptible to imipenem

S. rubidaea: methyl red, VP, gelatine (may be delayed), arabinose, raffinose, lactose, adonitol (may be delayed) and inositol positive; ornithine decarboxylase and sorbitol negative; rhamnose, KCN, motility, malonate, gas from glucose and urease variable; isolated from water and human wounds; causes infections in abnormal host

Hafnia alvei: lysine decarboxylase, ornithine decarboxylase and gas from glucose positive; gelatine and mucate negative; methyl red, VP, Simmon's citrate, arginine dihydrolase, lactose and sucrose variable; found in human intestinal tract but is not enteropathogenic; on very rare occasions, causes infections in abnormal host (including bacteraemia and septicemia in neutropenics), nosocomial infections, perinatal generalised disease; treatment: gentamicin, chloramphenicol; also susceptible to ciprofloxacin (MIC \approx 0.06 mg/L), norfloxacin (\approx 0.06 mg/L), meropenem (0.06 mg/L), enoxacin (0.13 mg/L), imipenem

(0.5 mg/L), cefoperazone, mezlocillin, piperacillin, carbenicillin, gentamicin, tobramycin

Edwardsiella tarda: lysine decarboxylase, ornithine decarboxylase, glucose (with gas), H₂S and indole positive; Simmon's citrate, KCN, lactose, urease, sucrose, mannitol, dulcitol, salicin, adonitol, inositol, sorbitol, raffinose and rhamnose negative; arabinose variable; isolated from water and human wounds; causes bacteraemia and septicemia, cellulitis associated with trauma to mucosal surfaces, infection in abnormal host, intestinal and extraintestinal infections similar to those caused by *Salmonella*, wound infections and necrosis (60% after exposure to marine environment), felon, tubo-ovarian abscess, Bartholin abscess, perirectal abscess, cholecystitis; risk factors include exposure to aquatic environments or exotic animals, preexisting liver disease, iron overload, raw fish ingestion; > 90% of phenotypes show invasion of HeLa and Hep-2 cells and complement-mediated resistance and produce α -haemolysis and chondroitinase, 50% have non-fimbrial adhesins, 10% produce enterotoxin and some produce dermatonecrotic toxin; treatment: ciprofloxacin

Proteus: Gram negative rods, motile; urease and phenylalanine deaminase positive; lysine decarboxylase negative; normal flora of colon; common in soil, faeces; occasionally pathogenic; causes 1-3% of bacteraemia and septicemia, acute cystitis, acute pyelonephritis, asymptomatic bacteriuria, chronic bacteriuria (endogenous; associated with infected bladder or renal stones, bladder diverticulum, renal abscess, indwelling catheter), urethritis, enterotoxaemia and gastroenteritis (rare), chronic eye infections, foot and leg sores in diabetics, Fournier's gangrene of scrotum, human bite and clenched fist infections, intraabdominal abscess, local and generalised sepsis, mastitis and breast abscess,

neonatal and postneonatal purulent meningitis, acute empyema, mycotic aneurism, osteomyelitis and osteochondritis, 2% of otitis externa, septic arthritis, 7% of surgical wound infections, other wound infections, 7% of nosocomial infection, 8% of vascular graft infections; extracellular; growth stimulated by excess iron; treatment: gentamicin (100% susceptible), chloramphenicol; also susceptible to ciprofloxacin (MIC 0.03-0.12 mg/L), ofloxacin (0.12-0.25 mg/L), lomefloxacin (0.25 mg/L), norfloxacin (0.5 mg/L), enoxacin (0.5 mg/L), ceftozoxime, moxalactam, mezlocillin, carbenicillin, tobramycin (100%), amikacin, aztreonam (100%)

P.mirabilis: ornithine decarboxylase, citrate (may be delayed), H₂S, glucose (with gas), urease, phenylalanine deaminase and gelatine positive; indole and lactose negative; VP, sucrose and salicin variable; spreading on blood agar; normal flora of cervix (10%); causes asymptomatic bacteriuria, acute empyema, endocarditis, endophthalmitis, malignant otitis externa (rare), 3% of nosocomial infections (5% of Gram negative bacilli), perianal and perirectal abscess and cellulitis in patients with malignant disease, infections in abnormal host; susceptible to amoxicillin-clavulanate (9% resistance due to β -lactamase in Australia, 4% in USA), piperacillin-tazobactam, ticarcillin-clavulanate, cefaclor, cefmenoxime (MIC \approx 0.01 mg/L), cefpirome

(\approx 0.01 mg/L), aztreonam (100%), carumonam (\approx 0.01 mg/L), meropenem (0.13 mg/L), ciprofloxacin (0.4% resistance in Australia, 14% in USA), ofloxacin (100% at 0.25 mg/L), norfloxacin (0.4% resistance in Australia, 15% in USA), gatifloxacin, moxifloxacin, cefixime (\approx 0.25 mg/L), amifloxacin (0.25 mg/L), foramidocillin (0.25-0.5 mg/L), enoxacin (0.25-0.5 mg/L), carbenicillin (\approx 0.5 mg/L), pefloxacin (0.5-1 mg/L), cefotetan/cefotixin (0.5-1 mg/L), cefotaxime/ceftriaxone (0.5% resistance in Australia), cefepime, ceftizoxime (100% at $<$ 1 mg/L), mezlocillin ($<$ 1 mg/L), apalcillin ($<$ 1 mg/L), moxalactam (1 mg/L), cefuroxime (1 mg/L), gentamicin (2% resistance in Australia), ceftazidime (100%), tobramycin (3% resistance in hospitals in Australia), amikacin, levofloxacin (13% resistance in USA), chloramphenicol, rifampicin/rifabutin; 95% intrinsic resistance to nitrofurantoin (98% in USA) and 98% to tetracycline (possibly all resistant in clinical practice); in Australia, 18% resistance (due to β -lactamase) to amoxicillin/ampicillin (15% in USA), ticarcillin, piperacillin, azlocillin, 18% resistance to cotrimoxazole (16% in USA), 28% resistance to trimethoprim, 10% resistance (due to β -lactamase) to cephalothin (13% in USA), cephalozin and cephalixin, 18% resistance to imipenem

P.vulgaris: phenylalanine deaminase, gelatine, glucose, sucrose, indole, H₂S and urease positive; ornithine decarboxylase and lactose negative; gas from glucose and citrate variable; spreading on blood agar; causes asymptomatic bacteriuria (frequently extraneous), infections in abnormal host; susceptible to ciprofloxacin (100% at 0.06 mg/L), gatifloxacin, moxifloxacin, carumonam (\approx 0.12 mg/L), pefloxacin (0.25 mg/L), cotrimoxazole (100% at 0.5 mg/L), norfloxacin (100%), enoxacin (100%), trimethoprim, gentamicin (100%), amikacin, tobramycin (100%), aztreonam, chloramphenicol; 96% intrinsic resistance (due to β -lactamase) to amoxicillin and ampicillin, 92% to amoxicillin-clavulanate, 97% to cephalothin, cephalozin, cefaclor, cefuroxime, and cephalixin (possibly all resistant in clinical practice); possesses an inducible Class I chromosomal β -lactamase and should be considered resistant to all cephalosporins, penicillins, cephamycins and aztreonam but may be susceptible to imipenem, meropenem; commonly resistant to tetracyclines

Providencia: phenylalanine deaminase and indole positive; normal inhabitant of intestinal tract; causes 0.1% of bacteraemia and septicemia, nosocomial infections, osteomyelitis, 20% of thrombophlebitis, urinary tract infections (chronic bacteriuria); susceptible to pefloxacin (MIC 0.25 mg/L), ciprofloxacin (0.5 mg/L), gatifloxacin, moxifloxacin, ofloxacin (1 mg/L), lomefloxacin (1 mg/L), aztreonam, chloramphenicol, cotrimoxazole, trimethoprim, gentamicin, tobramycin, amikacin; 96% intrinsic resistance (due to β -lactamase) to amoxicillin and ampicillin, 92% to amoxicillin-clavulanate, 97% to cephalothin, cephalozin and cephalixin (possibly all resistant in clinical practice); possesses an inducible Class I chromosomal β -lactamase and should be considered resistant to all cephalosporins, penicillins, cephamycins and aztreonam but may be susceptible to imipenem, meropenem; usually resistant to tetracycline

P.alcalifaciens: glucose, phenylalanine and adonitol positive; ornithine decarboxylase, inositol, sorbitol, lactose, H₂S and urease negative; sucrose and gas from glucose variable; motile; causes infections in abnormal host; susceptible to meropenem (MIC 0.13 mg/L)

P.rettgeri: phenylalanine deaminase, urease, citrate, indole, and glucose positive; ornithine decarboxylase, H₂S and lactose negative; sucrose, mannitol, salicin, sorbitol and rhamnose variable; gas usually not produced; causes 0.5-1% of bacteraemia and septicemia in long term care patients, infections in abnormal host; susceptible to ceftriaxone (MIC

0.008 mg/L), aztreonam (0.125 mg/L), cefixime (? 0.25 mg/L), meropenem (MIC 0.25 mg/L), pefloxacin (0.5 mg/L), cefuroxime (1 mg/L), ciprofloxacin (100%), enoxacin (100%), norfloxacin (93%), ofloxacin (92%), cefoperazone, ceftizoxime

P. stuartii: indole, phenylalanine deaminase, inositol and sucrose (may be delayed) positive; urease, ornithine decarboxylase and gas from glucose negative; adonitol and mannitol variable; causes 13% of bacteraemia and septicemia in long term care patients, chronic bacteriuria in indwelling catheter; susceptible to cefotaxime (MIC 0.06-0.5 mg/L), ceftizoxime (0.06-1 mg/L), cefmenoxime (0.06-1 mg/L), ceftriaxone (0.06-1 mg/L), ceftazidime (0.06-1 mg/L), ceftiprome (0.06-1 mg/L), aztreonam

(< 0.12 mg/L), carumonam (< 0.12 mg/L), cefixime (? 0.25 mg/L), meropenem (0.5 mg/L), moxalactam (0.5-1 mg/L), imipenem (100%); resistant to amoxicillin-clavulanate

Morganella morganii: phenylalanine deaminase, ornithine decarboxylase, indole, glucose and urease positive; citrate, H₂S and lactose negative; motility and gas from glucose variable; not spreading on blood agar; causes bacteraemia and septicemia in neutropenics and long term care, infections in abnormal host, nosocomial infections, typhlitis, urinary tract infections (chronic bacteriuria); susceptible to ciprofloxacin (100% at 0.03 mg/L), gatifloxacin, moxifloxacin, carumonam (0.12 mg/L), ofloxacin (100% at 0.25 mg/L), lomefloxacin (0.5 mg/L), norfloxacin (100% at 0.5 mg/L), enoxacin (0.5 mg/L), pefloxacin (0.5 mg/L), aztreonam, chloramphenicol, cotrimoxazole (100% at 1 mg/L), gentamicin (100%), amikacin, trimethoprim, tobramycin (100%); 98% resistance (due to ?-lactamase) to amoxicillin, ampicillin, amoxicillin-clavulanate, cephalothin, cephalosporins, cephalosporins, cephamycins and aztreonam but may be susceptible to imipenem, meropenem

Yersinia: Gram negative rods and ovals, bipolar staining; colonies < 1 mm on nutrient agar after 24 h at 37°C; growth on MacConkey, growth on SS variable; fermentative, nitrate reduced to nitrite; mannitol and arabinose positive; oxidase, lysine decarboxylase and arginine dihydrolase negative; ornithine decarboxylase variable; primarily animal parasite; causes yersiniosis, reactive arthritis, enterocolitis (acute diarrhoea and/or vomiting, 4% of enteric pathogen isolates), erythema nodosum, mesenteric adenitis, plague; facultative intracellular; endotoxins present; susceptible to amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, ciprofloxacin (MIC 0.015-0.12 mg/L), gatifloxacin, moxifloxacin, norfloxacin, ceftriaxone (0.06-0.12 mg/L), cefotaxime (0.06-0.25 mg/L), ceftozoxime (0.06-0.25 mg/L), cefmenoxime (0.06-0.25 mg/L), ceftiprome (0.06-0.25 mg/L), ceftazidime (0.12-0.5 mg/L), moxalactam (0.25 mg/L), cefepime, amikacin, gentamicin, tobramycin, carumonam (0.25-1 mg/L), imipenem (100%), meropenem, cotrimoxazole, doxycycline/tetracycline, minocycline, aztreonam, chloramphenicol, trimethoprim

Y. enterocolitica: motile at 20°C but not at 35°C; growth on MacConkey agar and Tergitol 7; ornithine decarboxylase, sorbitol, urease, salicin and D-galactosidase positive; grows at refrigeration temperatures; lysine decarboxylase, arginine dihydrolase, phenylalanine deaminase, gas from glucose, lactose, rhamnose, oxidase and Simmon's citrate negative; VP, inositol, indole and sucrose variable; cross-reacts serologically with *Brucella abortus*; isolated from water (source animal and human faeces; survival time days - weeks) and human infections; 86% of infections gastroenteritis (profuse watery diarrhoea with no blood in faeces or dysentery with abdominal cramps, tenesmus and usually blood in stool; primary attack rate 7-76%, secondary cases rare; incubation period 1-11 d; unpasteurised milk most common vehicle or source in outbreaks, pork in sporadic cases; O3, O9, O8 and O5,27 predominant serotypes; 36-86% diarrhoea, 62-100% abdominal pain, 50-100% fever, 44-56% vomiting, 24-67% nausea, 18-60% headache, 22-31% pharyngitis, 11-38% rash, 15-38% joint pain, laparotomy in up to 17% of cases), 14% extraintestinal (throat, blood, urinary tract, central nervous system, wounds); causes bacteraemia and septicemia in iron overload, endocarditis, traveller's diarrhoea, enteritis, enterocolitis, gastroenteritis, terminal ileitis, erysipelas-like condition, erythema nodosum, maculopapular rash, mesenteric lymphadenitis, mycotic aneurism, myocarditis and pericarditis, reactive arthritis, infections in abnormal host; virulent strains bind congo red, bear plasmids of 40-50 MD, autoagglutinate, show reduced growth on magnesium oxalate agar, serum resistance, lethality for iron-stressed mice; transmitted in blood; treatment: cotrimoxazole, pefloxacin (MIC 0.25 mg/L), tobramycin, tetracycline; also susceptible to ciprofloxacin (0.03 mg/L), ofloxacin (< 0.06-0.12 mg/L), meropenem (0.06 mg/L), norfloxacin (0.1-0.5 mg/L), enoxacin (0.25-0.5 mg/L), imipenem (100%), cefamandole, cefoperazone, cefotaxime, ceftizoxime, mezlocillin, piperacillin,

gentamicin, tobramycin, amikacin, chloramphenicol, amoxicillin-clavulanate, trimethoprim, nalidixic acid; usually resistant to ampicillin

Y. fredericksonii: VP, rhamnose and sucrose positive; isolated from water and human wounds; susceptible to fleroxacin (MIC 0.125-0.25 mg/L)

Y. intermedia: citrate, VP, rhamnose, sucrose, melibiose, ?-methyl D-glucoside and raffinose positive; isolated from water and human wounds

Y. kristensenii: VP negative; susceptible to fleroxacin (MIC ? 0.06 mg/L)

Y. pestis: salicin, ?-glucosidase, ?-D-galactosidase and maltose positive; VP, lysine decarboxylase, arginine dihydrolase, ornithine decarboxylase, phenylalanine, gas from glucose, lactose, inositol, rhamnose, Simmon's citrate, ?-glutamyl transferase, cellobiose, sorbitol, oxidase and H₂S negative; urease and sorbitol variable; causes plague, bacteraemia and septicemia, postneonatal pyogenic meningitis (rare complication of plague), pneumonitis, local and generalised sepsis, lymph gland infections (pea-sized to orange-sized inguinal, axillary), haemorrhagic fever; transmitted by bite from infected rodent flea; primarily pathogen of rodents; transfer to man caused greatest epidemic in human history (75 M deaths); envelope or capsular antigen (fraction I, carbohydrate-protein complex) and VW antigen complex inhibit phagocytic attachment and ingestion; fraction I evokes protective antibodies under some conditions; antibodies to VW antigen are protective against strains that lack envelope antigen; extracellular protein toxin damages phagocytes; diagnosis: Gram stain, fluorescent antibody stain and culture of lymph node and bubo aspirate, blood cultures, sputum, CSF, urine, serum passive haemagglutination titres, ELISA; treatment: streptomycin, tetracycline

Y. pseudotuberculosis: motile at 20°C, nonmotile at 35°C; growth on MacConkey agar and Tergitol 7; salicin, arabinose (may be delayed), ?-xylosidase, urease, rhamnose, ?-D-galactosidase, H₂S, maltose and melibiose positive; VP, lysine decarboxylase, arginine dihydrolase, ornithine decarboxylase, phenylalanine deaminase, gas from glucose, lactose, inositol, sorbitol, oxidase, indole, sucrose, cellobiose and sorbose negative; Simmon's citrate variable; causes pseudotuberculosis, adult hepatitis, hepatic abscess, maculopapular rash, mesenteric lymphadenitis, reactive arthritis, infections in abnormal host; diagnosis: culture of appropriate specimen; treatment: cotrimoxazole, tetracycline, streptomycin; also susceptible to fleroxacin (MIC ? 0.06-0.125 mg/L), imipenem (100%), chloramphenicol, kanamycin

Y. ruckeri: lysine decarboxylase, melibiose, gelatinase, citrate, H₂S and maltose positive; urease, cellobiose, indole, sorbose and sorbitol negative

Kluyvera ascorbata: isolated from water and human wounds; infrequently causes peritonitis

Rahnella aquatilis: isolated from water and human wounds

Family Vibrionaceae: flagellated at poles only

Vibrio: Gram negative straight or curved rods, motile by monotrichous or multitrichous polar flagella; on solid media, lateral flagellum in some species; sheath on flagellum; facultatively anaerobic (capable of both respiratory and fermentative metabolism); colonies convex, smooth, creamy white with entire edges; growth on MacConkey, usually no growth on SS; most species grow on a wide range of commonly used laboratory media provided they contain 0.5-1% NaCl; lysine decarboxylase, ornithine decarboxylase, indole, PHB and HB positive; arginine dihydrolase negative; ferments glucose to acid (generally no gas); all species growth stimulated by, and most require, sodium ion; susceptible to O/129 vibriostatic compound; variable amylase and pigment; most species oxidase positive and reduce nitrate (no gas); found in aquatic habitats throughout the world, including marine and estuarine environments, fresh water habitats and on surface and in intestinal contents of marine animals; pathogenic for marine vertebrates and invertebrates as well as for humans; causes profuse watery diarrhoea (no blood in stool), cellulitis, septicemia, otitis externa, thrombophlebitis, water-related wound infections; treatment: tetracycline; also susceptible to ciprofloxacin (< 5% resistance in Australia)

V. alginolyticus: motile with a single polar flagellum; requires NaCl for growth, grows in 10% NaCl; swarming on solid complex media; grows on MacConkey and TCBS agars; ferments glucose (no gas), sucrose, maltose and mannitol, not lactose; indophenol oxidase produced; positive test reactions for indole and decarboxylases for lysine and ornithine; VP reaction usually positive; ONPG and arginine not hydrolysed; inositol, sorbitol, rhamnose and melibiose negative; partially susceptible to O/129; causes cellulitis, otitis externa, marine-associated wound infections (71% of infections), local and generalised sepsis, gastroenteritis (12% of infections), conjunctivitis, intracranial infections; treatment: ciprofloxacin, tetracycline, chloramphenicol; also susceptible to fleroxacin (MIC ? 0.06-0.125 mg/L)

V. anguillarum: motile with a single polar flagellum; requires NaCl for growth (tolerance of 6% NaCl strain variable); grows on MacConkey (slow) and TCBS agars; ferments glucose (no gas), sucrose, maltose and mannitol, but not lactose; indophenol oxidase produced; positive test reactions for ONPG, indole, arginine dihydrolase and VP; lysine and ornithine not decarboxylated; O/129 susceptible; causes disease of marine fish and eels

V. campbellii: O/129 partially susceptible

V. cholerae: motile with a single polar flagellum; grows on MacConkey and TCBS; ferments maltose, mannitol; does not require NaCl (tolerates 3% NaCl); indophenol oxidase produced; positive test reactions for ONPG, lysine decarboxylase and ornithine decarboxylase; arginine dihydrolase not produced; gelatinase, glucose (no gas), indole, sucrose and mannitol positive; phenylalanine deaminase, salicin, inositol, sorbitol, rhamnose, melibiose, arabinose, lactose (occasionally positive) and urease negative; VP variable; causes epidemic Asiatic cholera (O1 strains; 8M cases with 122 000 deaths (31% in children < 5 y) globally annually), gastroenteritis (non-O1 strains), traveller's diarrhoea (O1 and non-O1), wound and soft tissue infections (non-O1), local and generalised sepsis (non-O1), bacteraemia and septicemia (non-O1 strains in cirrhosis and leukemia), fulminating systemic infection (non-O1 strains); obligate parasite of man; noninvasive intestinal infection; O1 strains cause epidemics; epidemic strains divided into classical and eltor biovars on basis of haemolysis of sheep erythrocytes, VP reaction, haemagglutination of chicken erythrocytes, susceptibility to polymyxin and phage typing; subdivision into biovars not supported by hybridisation studies; eltor biovar causes less explosive outbreaks and is more resistant to environmental conditions; oral disease-producing dose in man 10^9 bacteria, 10^4 + bicarbonate; attaches to epithelium of small intestine (receptor is fucose and mannose), rarely penetrates, and causes diarrhoea by forming an enterotoxin (cholera toxin) which activates adenyl cyclase, raising CAMP level in intestinal epithelial cells, causing water and electrolyte loss from epithelial cells into intestine; transmitted by food and water (viability from 1 d in beer, cola drinks and carbonated water to 60 d in sea water at 5-10°C); short-lived immunity to infection following attack of cholera is most likely mediated by antitoxin; treatment: rehydration and electrolyte replacement, doxycycline, tetracycline (usually susceptible), cotrimoxazole (usually susceptible), norfloxacin (usually susceptible), erythromycin, furazolidone, chloramphenicol (usually susceptible); also susceptible to fleroxacin (MIC ? 0.06 mg/L), usually susceptible to ampicillin, amoxicillin-clavulanate, trimethoprim, ciprofloxacin, nalidixic acid

V. cincinnatiensis: motile with a single polar flagellum; requires NaCl for growth (tolerates 6% NaCl); grows on TCBS agar; ferments glucose (no gas) and sucrose; positive test reactions for lysine decarboxylase and ONPG; indophenol oxidase produced; VP reaction positive; negative test reactions for indole, ornithine decarboxylase, arginine dihydrolase and urease; cause of meningitis and septicemia in 1 patient; treatment: moxalactam

V. fluvialis: motile with a single polar flagellum; requires NaCl for growth (tolerant to 6-7% NaCl); grows on MacConkey and TCBS agars; ferments glucose (no gas), sucrose, maltose and mannitol; indophenol oxidase produced; positive test reactions for ONPG and arginine dihydrolase; indole production strain variable; isolated from human wound; causes diarrhoea, gastroenteritis and ileitis following consumption of seafood, rarely wound infections, primary septicemia

V. fumissii: biochemically similar to *V. fluvialis* except for gas production from glucose; causes gastroenteritis

V. harveyi: O/129 partially susceptible

V. hollisae: motile with a single polar flagellum or nonmotile; requires NaCl for growth (tolerates 6% NaCl); variable growth on MacConkey, no growth on TCBS agar; ferments glucose (no gas), not lactose or sucrose; indophenol oxidase produced; positive test reactions for indole and ONPG; negative test reactions for lysine decarboxylase and ornithine decarboxylase, arginine dihydrolase (usually) and urease; nitrate reduced to nitrite; citrate, VP, gelatine, mannitol, inositol, sorbitol, rhamnose, melibiose and amygdalin negative; causes gastroenteritis (diarrhoea) and bacteraemia (rare) following ingestion of seafood, rare wound infections

V. metschnikovii: motile with a single polar flagellum; requirement for NaCl strain variable (tolerance to 8% NaCl strain variable); grows on TCBS; ferments glucose (no gas) and sucrose; positive test reactions for arginine dihydrolase, lysine decarboxylase (usually) and VP; ONPG and indole production strain variable; negative test reactions for nitrate and ornithine decarboxylase; gelatine and mannitol positive; urease, melibiose, amygdalin, arabinose and oxidase negative; O/129 susceptible; cause of cholecystitis and associated bacteraemia in 1 patient, isolated from 5 infants with diarrhoea

V.mimicus: motile by a single polar flagellum; NaCl not required for growth (tolerates 3% NaCl); grows on TCBS; ferments glucose (no gas), maltose, lactose (slow) and mannitol, but not sucrose; indophenol oxidase produced; positive test reactions for ONPG, indole, lysine decarboxylase and ornithine decarboxylase; urease, inositol, sorbitol, rhamnose, melibiose and arabinose negative; causes diarrhoea, gastroenteritis and ileitis following consumption of seafood (85% of infections), wound infections, local and generalised sepsis and acute otitis after exposure to sea water; treatment: tetracycline, chloramphenicol

V.natriengens: 0/129 partially susceptible

V.parahaemolyticus: motile with a single polar flagellum; requires NaCl for growth (tolerates 8% NaCl); grows on MacConkey and TCBS; ferments glucose (no gas), maltose and mannitol, but not lactose or sucrose (usually); indophenol oxidase produced; positive test reactions for indole, lysine decarboxylase, ornithine decarboxylase and L-arabinose; negative test reactions for ONPG, arginine dihydrolase, inositol, sorbitol, melibiose; 0/129 partially susceptible; causes eye infections (panophthalmitis, purulent conjunctivitis), gastroenteritis (food poisoning; acquired from fish, shellfish and processed seafoods (especially from tropical waters, notably East Asia); disease-producing dose 10^5 - 10^7 organisms; multiplication in intestine; cholera-like enterotoxin; nausea and vomiting, severe abdominal pain and acute watery diarrhoea; incubation period 2-48 h; 59% of infections), puncture wound infections (34% of infections), cellulitis, local and generalised sepsis, primary septicemia (5% of infections; erythema multiforme, haemolytic anaemia, hypotension), localised skin lesions in septicemia and endocarditis, reactive arthritis; treatment: doxycycline + ceftazidime or ciprofloxacin or gentamicin (not required in gastrointestinal infections)

V.pelagia: 0/129 susceptible

V.sputorum: normal flora of mouth

V.succinogenes: anaerobic, polar flagella, nonfermentative, produces succinic acid from fumarate

V.vulnificus: motile with a single polar flagellum; requires NaCl for growth (tolerates 6% NaCl); grows on MacConkey and TCBS; ferments glucose (no gas) and lactose (weak or delayed), but not sucrose (usually); indophenol oxidase produced; positive test reactions for ONPG, indole, lysine decarboxylase, ornithine decarboxylase, cellibiose and salicin; arginine dihydrolase not produced; urease, inositol, sorbitol, rhamnose and melibiose; cause of endometritis (woman engaging in sex in sea water), osteomyelitis and osteochondritis (trauma in seawater), pneumonia (in drowning victim), septicemia after ingestion of raw shellfish (major danger for persons with chronic liver disease), soft tissue and wound infections, cellulitis, local and generalised sepsis, rhabdomyolysis after contact with marine environment or handling shellfish; treatment: doxycycline + ceftazidime or ciprofloxacin or gentamicin

Photobacterium: no sheath on flagellum; PHB positive; HB and amylase negative; no pigment; variable oxidase

P.damsela: motile with a single polar flagellum; requires NaCl for growth (tolerates 8% NaCl); grows on MacConkey; ferments glucose (no gas) and maltose, but not lactose; indophenol oxidase, arginine dihydrolase and urease produced; lysine decarboxylase strain variable; negative reactions for indole, ornithine decarboxylase and ONPG; nitrate reduced to nitrite; citrate, mannitol, inositol, sorbitol, rhamnose, melibiose, amygdalin and arabinose negative; causes wound infection, local and generalised sepsis following exposure of wounds to brackish water or injury by saltwater animals; mortality rate 25%; treatment: tetracycline, chloramphenicol

Aeromonas: straight rods; asporogenous; motile by a single polar flagellum; facultatively anaerobic (metabolism of glucose both respiratory and fermentative); grows at 35°C; most routine laboratory media, including MacConkey and SS agar, support growth; colonies round, raised, with an entire edge, smooth surface, white to buff; oxidase positive; catalase produced; resistant to vibriostatic agent 2,4-diamino-6,7-diisopropylpteridine (0/129); acid or acid and gas produced from glucose, maltose, mannitol and other carbohydrates, but not xylose; positive test reactions for indole, nitrate (no gas), lecithinase, amylase, gelatinase, deoxyribonuclease, arginine dihydrolase, O-nitrophenyl-?-D-galactopyranoside hydrolysis and growth in broth without NaCl; negative test results for H₂S, urease, phenylalanine deaminase and growth in broth with 6.5% NaCl; variable test reactions for lysine decarboxylase and ornithine decarboxylase; psychrotrophic, nonmotile aeromonads not recovered from humans differ from mesomorphic, motile aeromonads in a number of additional phenotypic properties; routine identification of mesophilic, motile aeromonads to species level is not recommended; mesophilic, motile aeromonads occur widely in water, sludge and sewage; causal agent of 'red-leg' disease in amphibians, diseases in reptiles, fish, snails, cows and humans; opportunistic for immunologically compromised patients suffering from chronic disease; occasionally primary agents of disease; normal

flora of large intestine, lower ileum; causes diarrhoea (enterotoxigenic strains (predominantly *A. hydrophila* and *A. veronii* biotype sobria) watery to cholera-like diarrhoea by possession of adhesins and action of cytotoxic and/or cytotoxic enterotoxins on small intestine; enteroadherent strains (*A. caviae*) watery diarrhoea especially in infants < 1 mo by possession of adhesins and ? action of enterotoxins on small and large intestine; enteroinvasive strains (*A. veronii* biotype sobria > *A. hydrophila*) severe diarrhoea and dysentery to colitis, fever, faecal leucocytes by possession of adhesins and invasins and action of cytotoxic enterotoxins on large intestine), abortional infection, bacteraemia and septicemia (uncommon in neutropenics), endocarditis, localised skin lesions in septicemia and endocarditis (often fatal), endophthalmitis (foreign body trauma), infection of skin, soft tissue, muscle and bone associated with traumatic exposure to water, local and generalised sepsis (cellulitis, myonecrosis with or without gas gangrene, ecthyma gangrenosum), neonatal meningitis, 0.1% of nosocomial infections (0.3% of Gram negative bacilli), osteomyelitis and osteochondritis, otitis, peritonitis (nosocomial), postoperative complications, thrombophlebitis, urinary tract infection (occasional); 48% of clinical isolates from gastrointestinal tract, 19% from wounds, 13% from blood; growth stimulated by excess iron; susceptible to amikacin, gentamicin, tobramycin, ciprofloxacin (< 5% resistance in Australia), fleroxacin (MIC ? 0.06-0.12 mg/L), gatifloxacin, moxifloxacin, ofloxacin (0.1 mg/L), norfloxacin (0.1- 0.5 mg/L), enoxacin (0.13-0.5 mg/L), usually susceptible to chloramphenicol, cotrimoxazole, trimethoprim, doxycycline, tetracycline, minocycline, aztreonam, trimethoprim; all isolates produce an inducible penicillinase and mutate at a relatively high frequency to produce this enzyme constitutively, resulting in high level resistance to all penicillins, and should be regarded as resistant to all penicillins; 95% of strains mutate at a high rate to resistance to imipenem; many strains also produce an inducible cephalosporinase and can mutate to produce this enzyme constitutively, resulting in high level resistance to all ?-lactams except imipenem

A. caviae: not ?-haemolytic; oxidase, esculin, KCN, salicin, arabinose and arginine dihydrolase positive; ferments glucose (no gas) and mannitol; gluconate, ornithine decarboxylase, urease, lecithinase and elastase negative; found in fresh water and sewage and on fish; isolated from human stool, blood, wound and respiratory tract; causes gastroenteritis (particularly paediatric); susceptible to meropenem (MIC ? 0.06 mg/L), cotrimoxazole, tetracycline, gentamicin; resistant to ampicillin, cephalothin

A. eucrenophila: new species

A. hydrophila: facultatively anaerobic motile Gram negative bacillus; ?-haemolytic; non-lactose fermenting on MacConkey with cloudy pink halo; growth on SS; oxidase, catalase, H₂S, esculin, glucose (no gas), mannitol, maltose, sucrose, salicin, arabinose, VP, gluconate, arginine dihydrolase, indole, nitrate, lecithinase and elastase positive; inositol, sorbitol, rhamnose, melibiose, ornithine decarboxylase and urease negative; KCN, lactose and lysine decarboxylase variable; 'indigenous' to freshwater; occasionally pathogenic for frogs, fish and mammals, including humans; isolated from human stool, blood, wound and respiratory tract; causes bacteraemia and septicemia (? 50% case-fatality rate in immunocompromised), traumatic and aquatic wound infections, skin and soft tissue infections (water-related), cellulitis (? bullae, abscesses and crepitant, necrotising myonecrosis), multiple abscesses in immunodeficient persons, traveller's diarrhoea, enteritis, gastroenteritis, pneumonia, infections in abnormal host; treatment: gentamicin (100% susceptible), ciprofloxacin (100% susceptible at 0.015 mg/L); also susceptible to ofloxacin (100% at 0.015 mg/L), enoxacin (0.015-0.12 mg/L), pefloxacin (0.06 mg/L), norfloxacin (100%), cotrimoxazole (90%), tobramycin, amikacin, chloramphenicol, tetracycline; should be regarded as resistant to all ?-lactams and imipenem

A. jandaei: causes gastroenteritis, septicemia, wound infections

A. media: psychrotrophic; nonmotile; esculin, KCN, salicin, arabinose and arginine dihydrolase positive; no gas from glucose; VP, gluconate, lysine decarboxylase, lecithinase and elastase negative; not recovered from humans

A. salmonicida: psychrotrophic; nonmotile; no growth at 37°C; brown pigment; methyl red and gelatine positive; VP, Simmon's citrate, inositol and urease negative; causes fish furunculosis, ulcer disease; not recovered from humans

A. schubertii: causes traumatic aquatic wound infections

A. veronii* biovar *sobria: ?-haemolytic; H₂S, gas from glucose, gluconate, arginine dihydrolase, lysine decarboxylase, lecithinase and elastase positive; esculin, KCN, salicin, arabinose, urease and ornithine decarboxylase negative; VP reaction strain variable; found in fresh water and sewage and on fish; isolated from human stool, blood, wound and respiratory tract; causes gastroenteritis (? invasive), postneonatal pyogenic meningitis in chronic alcoholic

liver disease (rare), septicemia, wound infections; 30% of clinical isolates; susceptible to meropenem (MIC 1 mg/L), cotrimoxazole, gentamicin; resistant to ampicillin

A. veronii biovar veronii: gas from glucose, salicin fermented, VP reaction positive, growth in KCN broth strain variable, esculin hydrolysed, ornithine decarboxylated; isolated from human stool, sputum, wound, maxillary sinus, endotrachea and leg; causes gastroenteritis and septicemia

Plesiomonas: inositol and ornithine decarboxylase positive; mannitol and gelatinase negative; O/129 susceptible; one case of postoperative pancreatic abscess; susceptible to ciprofloxacin (< 5% resistance in Australia), norfloxacin (MIC 0.06-0.5 mg/L), enoxacin (0.125-0.5 mg/L), nalidixic acid (0.5 mg/L)

P.shigelloides: straight, variable length rods; asporogenous; motile by a tuft of polar flagella; facultatively anaerobic (both respiratory and fermentative type of metabolism); growth at 37°C; NaCl not required; colonies greyish, shiny, opaque, slightly raised centre, smooth entire edge, no brown pigment; not ?-haemolytic on blood agar; grows on MacConkey and SS; lysine decarboxylase, ornithine decarboxylase, arginine dihydrolase, oxidase, catalase, indole, nitrate (no gas), and methyl red positive; VP, Simmon's citrate and gelatine negative; acid from glucose (no gas), maltose, lactose and inositol but not mannitol, sorbitol, rhamnose, melibiose, amygdalin, arabinose; negative reactions for urease, amylase, lipase and proteinase; most strains susceptible to O/129; occurs in fish and other aquatic animals and in a variety of mammals; isolated from human stool, CSF, knee, wound, urine, abscess, blood, leg and paracentesis fluid; causes cholecystitis, gastroenteritis (occasional outbreaks and sporadic cases, chiefly in tropical areas), infections in abnormal host, osteomyelitis, meningitis, proctitis with fatal septicemia, bacteraemia secondary to cellulitis; susceptible to ciprofloxacin (MIC 0.008 mg/L), ofloxacin (0.015 mg/L), meropenem (? 0.06 mg/L), pefloxacin (0.06 mg/L), fleroxacin (0.06-0.25 mg/L), imipenem (100%)

Allomonas enterica: straight or slightly curved rods; motile with a single polar flagellum, occasionally nonmotile; asporogenous; facultatively anaerobic (metabolism both respiratory and fermentative); no growth in media without NaCl (tolerates 5% NaCl); brown, nondiffusing pigment after growth at room temperature; indophenol oxidase and catalase produced; acid from glucose (no gas) and sucrose, but not lactose; positive test reactions for indole, amylase, gelatinase and ornithine decarboxylase (usually); negative test reactions for lysine decarboxylase, phenylalanine deaminase and urease; isolated from faeces of healthy humans, river water and sewage

Pasteurellaceae

Pasteurella: small Gram negative rods and ovals occurring singly, in pairs or short chains, bipolar staining; nonmotile; nonsporeforming; usually no growth on MacConkey, no growth on SS; aerobic to microaerophilic or facultatively anaerobic; fastidious; occasional V factor-requiring species or strain; optimum temperature 35-37°C; colonies round, greyish or yellowish; colonies of some species rough; no haemolysis on sheep blood agar; oxidase and indole positive; ornithine decarboxylase usually negative; catalase usually produced; ferments glucose, fructose, galactose, mannose and sucrose but not sorbitol, rhamnose, m-inositol, salicin or adonitol; nitrate reduced (no gas); no hydrolysis of starch or esculin; arginine dihydrolase, lysine decarboxylase and gelatinase (except *P.dagmatis*) negative; urease negative (except *P.dagmatis*); parasite in vertebrates, particularly mammals (rarely humans) and birds; causes pasteurellosis (cat and dog bite infections, erythema nodosum, local and generalised sepsis); growth stimulated by excess iron; treatment: penicillin (resistance not yet confirmed in Australia)

P.aerogenes: taxonomic position uncertain; not related to genus *Pasteurella*; coccobacilli, filamentous; nonmotile; obligately anaerobic; fastidious; growth on MacConkey; indophenol oxidase and catalase produced; ferments glucose (with gas), xylose, sucrose and maltose; positive test reactions for urease, nitrate (no gas) and ornithine decarboxylase (usually); indole not produced; natural habitat intestine of pigs; associated with pig bite and leg ulcers of humans

P.anatis: no V factor requirement; ferments trehalose, D-xylose and mannitol; negative test reactions for ornithine decarboxylase, indole and urease; isolated from intestinal tract of ducks

P.avium: some strains require V factor; ferments trehalose and D-xylose (strain variable); negative test reactions for ornithine decarboxylase, indole and urease; isolated from chicken and calves

P.caballi: Gram negative, oxidase positive, non-motile, fermentative, aerogenic, catalase negative coccobacillus; causes equine endocarditis; treatment: oxytetracycline, ampicillin, ceftiofur

P. canis: no V factor requirement; variable acid from trehalose and D-xylose; ornithine decarboxylase, but not urease, produced; indole production variable (biotype 1 indole positive, biotype 2 indole negative); found in oral cavities of dogs and calves and in dog-bite wounds of humans

P. dagmatis: no V factor requirement; ferments trehalose and maltose; positive test reactions for urease and indole; ornithine not decarboxylated; gelatine slowly liquefied (after 14 d); isolated from dogs and cats, as well as from human local and systemic infections resulting from animal bites; also causes endocarditis

P. gallinarum: no V factor requirement; ferments trehalose and maltose; negative test reactions for ornithine decarboxylase, indole and urease; isolated from chickens; commensal of poultry and occasionally sheep and cattle

P. haemolytica: taxonomic position uncertain; closely related to genus *Actinobacillus*; rods and coccoid forms; nonmotile; asporogenous; facultatively anaerobic; fastidious; usually ?-haemolytic on primary isolation; usually grows on MacConkey agar; indophenol oxidase and catalase (variable) produced; ferments glucose, mannitol, maltose and other carbohydrates according to biovar; nitrate reduced; H₂S positive; negative test reactions for urease, arginine dihydrolase, lysine decarboxylase and indole; rarely pathogenic for humans; causes fowl cholera, pneumonia in cattle, sheep, goats, lambs and birds, septicemia in lambs

P. lingua: no V factor requirement; ferments mannitol; negative tests for ornithine decarboxylase, indole and urease; isolated from respiratory tract of healthy chickens

P. multocida: no V factor requirement; no growth on MacConkey agar or Tergitol 7; indole, ornithine decarboxylase, mannitol, sucrose and H₂S positive; urease, ?-D-galactosidase and maltose negative; fermentation of sorbitol and dulcitol differentiate 3 subspecies: subspecies *multocida* ferments sorbitol, not dulcitol; subspecies *septica* ferments neither carbohydrate; subspecies *galliarta* ferments both sorbitol and dulcitol; isolated from most mammals, including humans, and birds; causes infections in cat and dog bites, endophthalmitis (cat scratch), infant meningitis (rare; animal contact; case-fatality rate 30%), infant appendicial peritonitis, sinusitis, head surgery infection, psoas muscle abscess, polyarticular septic arthritis, infant and adult brain abscesses, osteomyelitis, infections in abnormal host, chronic pulmonary infections and septicemia in humans, acute septicemia and chronic infections in cats and dogs, haemorrhagic septicemia in cattle; inhibits phagocytic attachment and ingestion; susceptible to penicillins (95%) except flucloxacillin/dicloxacillin, amoxicillin-clavulanate (100%), cephalosporins, aminoglycosides, carbapenems, fluoroquinolones (95%), tetracyclines (95% susceptible), trimethoprim, cotrimoxazole (90% susceptible), aztreonam, chloramphenicol, rifampicin, rifabutin

P. pneumotropica: taxonomic position uncertain; closely related to genus *Actinobacillus*; nonmotile rods; asporogenous; facultatively anaerobic; fastidious; growth on MacConkey variable; indophenol oxidase and catalase produced; ferments glucose (no gas), xylose, sucrose, maltose, lactose (occasionally) and mannitol (rarely); positive test reactions for urease, indole (usually), nitrate (no gas) and ornithine decarboxylase; isolated from mice, rats and other small animals; rarely pathogenic for humans; isolated from human cellulitis, rabbit bite, throat, pleural fluid and lymph node; causes abscess, conjunctivitis, peritonitis, pneumonia, septicemia in laboratory rats, mice and guinea pigs and in cats and dogs, human septic arthritis and osteomyelitis and other infections resulting from dog and cat bites or exposure

P. stomatis: no V factor requirement; ferments trehalose; indole produced; urease and ornithine decarboxylase not produced; normal habitat throat, gum and tonsil of mammals; isolated from respiratory tracts of cats and dogs

P. ureae: rarely pathogenic for humans

P. volantium: V factor required; ferments trehalose, maltose, mannitol, D-xylose (strain variable) and sorbitol (strain variable); ornithine decarboxylated by some strains; indole and urease not produced; isolated from fowl and humans (no site indicated)

Pasteurella species A: V factor required; ferments trehalose and L-arabinose with variable acid production from maltose, D-xylose and mannitol; negative test reactions for ornithine decarboxylase, indole and urease; isolated from chickens and pigeons

Pasteurella species B: V factor not required; ferments trehalose, maltose, D-xylose and dulcitol; ornithine decarboxylase and indole, but not urease, produced; isolated from cat and dog-bite wounds of humans

Haemophilus: Gram negative minute to medium-sized coccobacilli or rods of variable morphology, sometimes forming threads or filaments and showing marked pleomorphism; nonmotile; nonsporeforming; aerobic or facultatively

anaerobic; often bipolar staining; polysaccharide capsules in many strains; fastidious, requiring preformed growth factors present in blood (X factor— protoporphyrin IX or protopene) and/or V factor— nicotinamide adenine dinucleotide); grows best on complex media, such as chocolate agar, supplemented with these growth factors; colonies usually nonpigmented or slightly yellowish, flat, convex and usually smooth; optimum temperature 35-37°C; may be α -haemolytic; indophenol oxidase strain variable; ferments carbohydrates; nitrate reduced to nitrite; normal flora of mouth, nasopharynx, throat; obligate parasite on mucous membranes of humans and a variety of animal species; causes arthritis, bacteraemia, brain abscess, purulent conjunctivitis, endocarditis (1% of primary), epiglottitis, laryngotracheobronchitis, meningitis, osteomyelitis, otitis media, pharyngitis, pneumonitis, sinusitis, venereal infections; predisposing factors age, sickle cell disease, splenectomy, agammaglobulinemia, treated Hodgkin's disease, alcoholism; treatment: amoxicillin/ampicillin (resistance noted; > 95% due to β -lactamase), cotrimoxazole; most strains susceptible to most antimicrobials except erythromycin and clindamycin; ciprofloxacin (MIC 0.015 mg/L), cefotaxime (resistance not yet reported), lomefloxacin (0.06 mg/L), enoxacin (0.25 mg/L), amoxicillin/clavulanate (< 5% resistance in Australia), chloramphenicol (< 5% resistance in Australia), cefaclor (< 5% resistance in Australia)

H.aegyptius: long, slender rods, sometimes filamentous; nonencapsulated; may take 2-4 d to grow on chocolate agar; requires X and V factors but no growth on tryptic soy agar with X and V factors added; growth not enhanced by CO₂; non-haemolytic; porphyrin test negative; ferments glucose (slow), but not xylose or lactose; urease produced; catalase and indophenol oxidase formed; indole and ornithine decarboxylase not produced; natural habitat unknown (? soil); causes acute or subacute purulent conjunctivitis and other eye disease, Brazilian purpuric fever, endocarditis; treatment: rifampicin

H.aprophilus: genus affiliation uncertain; small rods or filaments; granular growth in broth, with colonies adhering to side of tube; colonies roughened surface with a centrally situated stellate imprint; X factor required both aerobically and anaerobically for primary isolation (some strains) or neither X nor V factor required; requires, or growth stimulated by, CO₂; nonhaemolytic; oxidase usually negative; H₂S negative; ferments glucose (with slight gas), raffinose, lactose, melibiose, melizitose and sorbose, but not xylose or galactose; negative tests for catalase, indole, urease and ornithine decarboxylase; porphyrin reaction weakly positive; isolated from mucous membranes and dental plaque of humans; pathogenic for humans (endocarditis, sinusitis, soft tissue wounds, septicemia, brain abscess, pneumonia, osteomyelitis and osteochondritis, crystalline keratopathy, cholecystitis, perinatal generalised disease, cat and dog bite infections); treatment: ampicillin + gentamicin

H.canis: requires X factor; nonhaemolytic

H.ducreyi: small, slender, Gram negative bacilli in pairs, chains, filaments or 'fish shoals'; growth very poor on most laboratory media, satisfactory on chocolate agar enriched with Isovitalex, very sparse on blood agar; growth enhanced by moisture and CO₂; requires X, but not V, factor; porphyrin reaction negative; slight haemolysis; colonies usually difficult to remove from agar surface; indophenol oxidase, but not catalase, produced; negative test reactions for urease, indole and ornithine decarboxylase; usually no acid from carbohydrates; causes chancroid (soft chancre; genital sore, lymph node suppuration; sexually transmitted; commoner in tropics and subtropics); diagnosis: microscopy and culture; treatment: ceftriaxone (MIC < 0.0005-0.03 mg/L), ciprofloxacin (0.0005-0.08 mg/L), cotrimoxazole (93-95% cure rate), erythromycin, tetracycline, sulphisoxazole, amoxicillin-clavulanate; also susceptible to rosoxacin (0.001-0.1 mg/L), norfloxacin (< 0.003-0.5 mg/L), pefloxacin (< 0.003-1 mg/L), ofloxacin (0.015-0.06 mg/L), fleroxacin (0.015-0.125 mg/L), enoxacin (0.015-0.25 mg/L)

H.equigenitalis: glucose negative

H.haemoglobinophilus: small pleomorphic rods, sometimes with filaments; requires X factor only; porphyrin reaction negative; growth not enhanced by CO₂; grows as well on blood agar as on chocolate agar; ferments glucose and xylose, but not lactose; indophenol oxidase and catalase produced; indole formed; urease and ornithine decarboxylase tests negative; normal flora of dog's preputial sac and vagina; cause of human otitis media and osteomyelitis

H.haemolyticus: small coccobacilli or short rods, sometimes with filaments; X and V factors required; growth not enhanced by CO₂; α -haemolysis on horse and rabbit blood agar; porphyrin reaction negative; ferments glucose (usually with gas) and xylose (occasionally), but not lactose; urease, catalase and indophenol oxidase usually produced; indole

production variable; ornithine decarboxylase not produced; natural habitat the nasopharynx of some healthy humans; clinical significance unknown

H. influenzae: Gram negative, slender coccobacilli or small rods; pleomorphic, sometimes with filaments; some strains encapsulated; X and V factors required; no haemolysis on blood agar; no growth on blood-free media; growth not enhanced by CO₂; porphyrin production negative; ferments glucose and usually xylose, but not lactose; catalase and usually indophenol oxidase produced; 6 biovars based on urease, indole and ornithine decarboxylase reactions; human commensal (present in human nasopharynx), invades damaged lung; causes abortion, abortional and puerperal infection, acute obstructive laryngotracheal infection, amnionitis, septic arthritis (in infants, young children and debilitated adults; type b), bacteraemia and septicemia (0.7-4% overall; 1.6-8% of neonatal (50-86% mortality); 90% nontypeable in neonates, mainly type b in older patients), bronchiectasis, acute bronchitis (non-type b and nontypeable strains), bursitis, cellulitis (type b; buccal associated with otitis media; cervical cellulitis in adults), cerebrospinal fluid shunt infections, chorioamnionitis, purulent conjunctivitis, acute endocarditis, IUD-related endometritis, empyema (type b), acute epididymitis and epididymoorchitis (mainly homosexual men and children), acute epiglottitis (type b; children), endophthalmitis (postoperative and conjunctival filtering-bleb associated), human bite and clenched fist infections, infections in abnormal host (?-globulin dysfunction, splenic dysfunction), liver abscess in adults, mastoiditis, nasal septal abscess, perinatal generalised disease, post-neonatal pyogenic meningitis (children; usually type b; ? 2000 cases/y in USA; 46% of bacterial meningitis; incidence 1/100 000 (59/100 000 at age 6-8 months); case-fatality rate 7%), nasopharyngitis, osteomyelitis and osteochondritis (type b), otitis media (non-type b and nontypeable), pancreatic abscess, parametritis, pelvic abscess and pelvic inflammatory disease (IUD-related and maternal), pericarditis in adults (type b), peritonitis, peritonsillar abscess, pharyngitis, preseptal and postseptal cellulitis (< 5 y; following upper respiratory infection; usually type b), primary and secondary pneumonia (all types), chronic pulmonary infection in cystic fibrosis, pneumonitis, pulmonary abscess, pyomyositis (rare), septicaemic adrenal haemorrhage syndrome, acute and chronic maxillary sinusitis (non-type b and nontypeable), thyroiditis, tissue abscesses (type b), acute tracheitis, dysuria-frequency (acute urethral) syndrome, urethritis, urinary tract infection (non-type b and nontypeable), uvulitis (children), vaginitis, systemic infections in agammaglobulinemia, chemotactic defect, C1, 2, 3, 4, factor B deficiency, hyposplenism/splenectomy; probably a secondary role in chronic infection of upper and lower respiratory tract, paranasal sinuses, middle ears and conjunctivae; invasive infections in older children and adults most common in male Caucasians with ethanol abuse, bacteraemic infections most commonly presenting as pneumonia and non-bacteremic as cutaneous abscess/cellulitis; 80% of nosocomial isolates from lower respiratory tract; extracellular; attaches to respiratory epithelium; polysaccharide capsule resists phagocytosis (unless antibody present; antibody confers specific immunity) and digestion; type-specific capsular polyribophosphate associated with invasiveness; role of endotoxic factors unknown; primary bodily defence mechanism humoral immune responses (phagocytes +, alternative complement +, bactericidal activity +, immune adherence (phagocytosis) ++++); recovery from primary infection due to antibody; diagnosis: latex agglutination, counterimmunoelectrophoresis (antigen), Gram stain, culture, Quellung reaction, coagglutination; susceptible to amoxycillin/ampicillin (28% resistance (due to ?-lactamase) in Australia), amoxycillin-clavulanate (2% resistance in Australia), piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefaclor (6% resistance in Australia), cefuroxime, trimethoprim (10% resistance in Australia), cotrimoxazole (5% resistance in Australia), doxycycline (5% resistance in Australia), cephamandole, cefotaxime/ceftriaxone (0.6% resistance in Australia), cefepime, cefpirome, rifampicin, rifabutin, ceftazidime (0.06-0.125 mg/L), cefotetan, cefoxitin, aztreonam, amikacin, chloramphenicol (3% resistance in Australia), amifloxacin (? 0.004 mg/L), ofloxacin (0.015-0.03 mg/L), pefloxacin (0.015-0.06 mg/L), fleroxacin (0.03-0.06 mg/L), rosoxacin (0.05 mg/L), ciprofloxacin (100% at < 0.06 mg/L), gatifloxacin, moxifloxacin, tetracycline (5% resistance in Australia), minocycline, oxolinic acid (? 0.06 mg/L), mupirocin (0.06 mg/L), foramidocillin (0.06-0.12 mg/L), enoxacin (0.06-0.5 mg/L), norfloxacin (100% at < 0.12 mg/L), cefixime (? 0.25 mg/L), colistin (0.25 mg/L), temocillin (0.25-0.5 mg/L), imipenem (0.5 mg/L), meropenem, gentamicin (0.5 mg/L), ceftizoxime (< 1 mg/L), cefperazone (< 1 mg/L), moxalactam (< 1 mg/L), tobramycin (1 mg/L); variably susceptible to azithromycin, clarithromycin, roxithromycin

H. paracolicus: arginine dihydrolase positive

H. parahaemolyticus: small rods, pleomorphic, usually filamentous; growth not enhanced by CO₂; distinct ?-haemolysis on horse or sheep blood agar; V factor required; synthesises porphyrins; ferments glucose (sometimes with

gas) but not xylose or lactose; urease and indophenol oxidase produced; ornithine decarboxylase and catalase reactions variable; indole not produced; similar to *H.parainfluenzae*; natural habitat human oral cavity and pharynx; associated with acute pharyngitis, purulent oral infection, endocarditis, gallbladder empyema and periorbital cellulitis

H.parainfluenzae: small pleomorphic rods, usually with long filaments; granular growth in broth by some strains; non-haemolytic; growth not enhanced by CO₂; V factor required; porphyrin test positive; ferments glucose (often with gas), but not lactose, xylose, ribose or trehalose; indophenol oxidase produced; catalase reaction variable; indole not formed; 3 biovars based on urease and ornithine decarboxylase reactions; natural habitat human oral cavity and pharynx; causes localised abscesses (brain (rare), skin, joints, liver), purulent arthritis, endocarditis, acute epiglottitis, meningitis, vertebral osteomyelitis, pneumonia, prostatitis, rhabdomyolysis, urethritis, infections in abnormal host; treatment: amoxicillin, amoxicillin-clavulanate, erythromycin, ampicillin, gentamicin; also susceptible to cotrimoxazole (MIC 0.03-1 mg/L), ofloxacin (0.25 mg/L), ciprofloxacin (100%), norfloxacin (100%), enoxacin (100%), gentamicin (100%), kanamycin (100%), colistin (100%), carbenicillin (100%), cephalothin (100%)

H.paraphrohaemolyticus: short to medium length rods with occasional filaments; requires V factor and increased CO₂; catalase produced; ornithine decarboxylase not produced; no gas from glucose; otherwise, identical to *H.parahaemolyticus*; isolated from human sore throat, ulcer of mouth, sputum and urethral discharge of adult males; associated with liver abscess

H.paraprophilus: small rods or filaments; granular growth in broth; V factor and CO₂ required; porphyrin test positive; indophenol oxidase produced; otherwise, identical to *H.aprophilus*; occurs in human oral cavity and pharynx; pathogenic for humans (arthritis, brain abscess, endocarditis, endophthalmitis (in association with endocarditis), epiglottitis, osteomyelitis, paronychia, sinusitis); susceptible to ciprofloxacin (MIC ? 0.03 mg/L), norfloxacin (0.03 mg/L), ofloxacin (0.03 mg/L), cotrimoxazole (0.03-1 mg/L), enoxacin (0.06 mg/L)

H.segnis: rods pleomorphic with filamentous forms; requires V factor only; growth not enhanced by CO₂; porphyrin test positive; ferments glucose (weakly), but not xylose or lactose; catalase reaction variable; urease, indole, indophenol oxidase and ornithine decarboxylase tests negative; natural habitat human oral flora, particularly in dental plaque; isolated from pancreatic abscess; a cause of appendicitis and endocarditis

H.suis: requires X and V factors; non-haemolytic; growth not enhanced by CO₂

Actinobacillus: Gram negative coccobacillary to rod-shaped; asporogenous; nonmotile; facultatively anaerobic; fastidious; grows only on complex media; growth requires, or enhanced by, increased moisture, serum and/or CO₂; colonies sticky on primary isolation and occasionally difficult to remove from agar surface; ferments glucose, fructose and mannitol; positive for ONPG; nitrate reduction (no gas); indole not produced; parasites of mammals (including humans) and birds; causes bacteraemia and septicemia (uncommon in neutropenics)

A.actinomycetemcomitans: growth requires, or enhanced by, increased moisture and CO₂; growth in broth granular, with colonies adhering to sides of tubes; star-like colonies observed in older agar plate cultures; no growth on MacConkey; ferments glucose (with serum added), sometimes with gas; biotypes based on acid from xylose, maltose and mannitol; catalase produced; variable indophenol oxidase reaction; urease negative; natural habitat mucous membranes of humans; isolated from human blood, mandibular and submandibular abscesses and rib, neck and facial sinus; causes bacteraemia and septicemia (associated with oral infection), cat and dog bite infections, cerebral abscess (uncommon), empyema, endarteritis, endocarditis (associated with periodontitis and prosthetic valves), endophthalmitis (in association with endocarditis), acute cystitis (in association with endocarditis), meningitis, vertebral osteomyelitis (uncommon), parotitis and submandibular sialadenitis (uncommon), myocarditis and pericarditis (rare), periodontal infection (dominant organism in juvenile periodontitis), pneumonia, skin and soft tissue infections (localised granulomatous lesions and abscesses; may be associated with infection due to *Actinomyces*), synovitis, thyroiditis; treatment: chloramphenicol (usually susceptible), tetracycline (usually susceptible), ampicillin, gentamicin (usually susceptible); also usually susceptible to carbenicillin, mezlocillin, cefazolin, cefotaxime, ceftriaxone, tobramycin, rifampicin

A.capsulatus: capsules present; growth enhanced by CO₂; ferments glucose (no gas), xylose, lactose, maltose, sucrose and mannitol; positive test reactions for indophenol oxidase, catalase, urease and esculin; etiological agent of arthritis in rabbits

A.equuli: colonies extremely sticky; usually grows on MacConkey; ferments glucose (no gas), xylose, lactose, sucrose, maltose, mannitol, trehalose and melibiose; ONPG and urease only positive reactions in API; positive test reactions for

indophenol oxidase and urease; catalase usually produced; esculin not hydrolysed; distinguished from *A.lignieresii* on basis of fermentation of trehalose and melibiose; natural habitat rumens of cattle and sheep; mostly of veterinary significance (arthritis, septicemia, nephritis in foals and pigs); isolated from animal-bite wounds and joint fluid of humans

A.lignieresii: usually grows on MacConkey; ferments glucose (no gas), xylose, lactose (slow), sucrose, maltose and mannitol, but not trehalose or melibiose; positive test reactions for indophenol oxidase and urease; usually produces catalase; esculin not hydrolysed; distinguished from *A.aequuli* on basis of failure to ferment trehalose and melibiose; natural habitat rumens of cattle and sheep and oral mucosa of normal horses; mostly of veterinary significance; isolated from animal-bite wounds of humans

A.pleuropneumoniae: most strains require V factor (biovar 1), some do not (biovar 2); ?-haemolytic on sheep blood agar; no growth on unsupplemented MacConkey; lactose not fermented; CAMP reaction positive; closely related to, and additional phenotypic properties the same as for, *A.lignieresii*; isolated from pigs, lambs and cattle; of veterinary significance

A.ureae: no growth on MacConkey; ferments glucose (no gas), sucrose, maltose and mannitol, but not xylose; indophenol oxidase and urease produced; variable test reactions for catalase; esculin not hydrolysed; normal habitat human respiratory tract; isolated from human sputum, bronchi, throat, trachea, nasal swab, sinus, blood, exudate, CSF, eye and in otitis media; associated infrequently with bronchiectasis and chronic bronchitis; occasionally associated with pneumonia, meningitis, septicemia, peritonitis, sinusitis and ozaena

Actinobaculum massiliae: isolated from urine of woman with recurrent cystitis

A.suis: usually grows on MacConkey; a clear zone of haemolysis produced by most strains; ferments glucose (no gas), xylose, lactose, sucrose, maltose and mannitol (variable); positive test reactions for indophenol oxidase, urease and esculin; usually produces catalase; commensal and pathogen of pigs, hamsters, donkeys, horses, cattle and zebras; isolated from animal-bite wounds of humans

Zymomonas: causes bacteraemia and septicemia (uncommon in neutropenics)

Simonsiellaceae

Simonsiella: filamentous bacteria (6-8 ? m long, 2-3 ? m wide); consists of segmented groups of cells aligned face to face with their short axis coinciding with the long axis of the filament; asporogenous; obligately aerobic; grows on sheep blood agar and serum-enriched agar medium (BSTSY agar) at 37°C; no growth on MacConkey; narrow zone of haemolysis on blood agar; microcolonies detected after 6-10 h of incubation by scanning agar surface microscopically with a X10 objective lens and colonies subcultured at this time to prevent overgrowth by other flora; demonstrates gliding motility; catalase and indophenol oxidase produced; saprophyte in oral cavity of humans and a variety of warm-blooded vertebrates; causes erosive lesions of oral mucosa; susceptible to penicillin

TAXONOMIC POSITION UNCERTAIN OR UNKNOWN

Chromobacterium violaceum: Gram negative rods motile by means of both a single polar flagellum and usually 1-4 lateral flagella; asporogenous; facultatively anaerobic; produces butyrous, violet colonies (nonpigmented colonies frequently produced); nonfastidious; grows on most ordinary media, including MacConkey and SS; attack on glucose and, rarely, sucrose usually fermentative, sometimes oxidative; nitrate and nitrite reduced (often with gas); oxidase positive; catalase and arginine dihydrolase produced; negative test reactions for lysine decarboxylase, ornithine decarboxylase and indole; common occurrence in soil and water in tropical regions (between 35°N and 35°S); isolated from human blood, wound, skin lesion, urine and ear; occasionally causes bacteraemia and septicemia (associated with abscesses in multiple organs), hepatic abscess, local pyogenic skin abscess, generalised fine rash, maculopapular rash, acute skin ulcers (in 11% of infections), local and generalised sepsis, pneumonia, pulmonary abscess, infections in abnormal host; high mortality in humans and domestic animals; treatment: chloramphenicol, tetracycline, gentamicin

Cardiobacterium hominis: pleomorphic rods; variable rosette clusters; tendency to retain crystal violet stain; asporogenous; nonmotile; facultatively anaerobic; fastidious; no growth on MacConkey; growth enhanced by increased moisture and CO₂; colonies intertwining network of bacilli comprising colony core with peripheral streaming of filamentous bacilli, frequently pit agar surface; ferments glucose (no gas), mannitol, sucrose and maltose, but not xylose or lactose; indophenol oxidase, but not catalase, produced; indole (weak) formed; negative test reactions for urease and nitrate; rare mannitol negative strains distinguished from phenotypically similar *Kingella indologenes* strains by

positive tests for caseinase, phosphatase and Tween 40 hydrolysis by the latter; found in nasopharynx and sputum of apparently healthy persons; also occurs in faeces; causes bacteraemia, endocarditis, meningitis; treatment: penicillin, cephalosporins, tetracycline

Calymmatobacterium granulomatis: pleomorphic rods; cells exhibit single or bipolar condensation of chromatin or 'safety pin' forms; capsule present; exudate from infected tissues, when stained by Wright's stain or Giemsa stain, demonstrate characteristic intracellular blue to purple pleomorphic rods surrounded by pink capsules in cytoplasm of large mononuclear phagocytes; cultured in vitro on special egg yolk-containing media; optimum temperature 37°C; pathogenic for humans, causing granuloma inguinale (ulcerative lesions; commoner in tropics; sexually transmitted), hepatic granuloma; treatment: streptomycin, tetracycline, doxycycline, cotrimoxazole, chloramphenicol, gentamicin, erythromycin

Eikenella corrodens: slender straight rods or small Gram negative coccobacilli with regular morphology, nonbranching, nonencapsulated, occasionally filamentous; asporogenous; nonmotile; facultatively anaerobic; fastidious; growth enhanced by CO₂ and X factor (required aerobically, not anaerobically); variable slightly yellow pigment; usually pitting or corroding of colonies, with spreading edges, on blood agar; no growth on MacConkey; distinctive odour (bleach-like); no acid formed from carbohydrates; catalase not produced; positive test reactions for oxidase, nitrate (no gas), lysine decarboxylase and ornithine decarboxylase; negative test reactions for indole and urease; natural habitat normal adult human mouth and intestine; isolated from human wound, abscess, peritoneal fluid, blood, pleural fluid, sinus, pus, eye and bronchi; opportunistic pathogen; rarely sole isolate to initiate infection in host with normal immune status; in immunocompromised host, usually sole isolate; causes deep abscesses (usually in sites where there has been mucous membrane flora contamination), infections in abnormal host, bacteraemia and septicemia following dental extraction, cervical fascial space infections, clenched fist injury and human bite infections, dental infections, cutaneous, wound and burn infections, other suppurative lesions, local and generalised sepsis, persisting empyema (rare), pneumonia, paronychia, abdominal abscess, pancreatic abscess, meningitis, osteomyelitis and osteochondritis (in 50% of infections related to human bite or fist fight injuries), septic arthritis (in 50% of infections relating to human bites or fist fight injuries), endocarditis; treatment: cefotaxime, ceftriaxone, amoxicillin-clavulanate (always susceptible) chloramphenicol (generally susceptible), ampicillin (generally susceptible); also always susceptible to quinolones, generally susceptible to penicillin, tetracycline; always resistant to clindamycin, methicillin, flucloxacillin, metronidazole, most resistant to aminoglycosides

Streptobacillus moniliformis: pleomorphic rods, frequently in wavy chains or tangled filaments with thickenings along the filaments, resulting in a 'string of pearls' or 'monilia-like' appearance; asporogenous; facultatively anaerobic; grows in serum broth producing discrete 'fluff ball-like' colonies; nonmotile; fastidious; no growth on MacConkey; usually requires a moist environment and blood, serum or ascitic fluid; indophenol oxidase and catalase not produced; ferments glucose (no gas) and maltose (weakly); negative test reactions for indole and nitrate; characteristic spontaneous appearance of defective cell walls; natural habitat nasopharynx of rats, mice and other rodents; cause of epizootics among animals; causes streptobacillosis; human infection following rat bite causes one form of rat-bite fever; human infection following consumption of contaminated milk referred to as haverhill fever; infection also follows drinking contaminated water; complications, usually in compromised patients, include endocarditis (rare), brain abscess, amnionitis, bronchitis, pneumonia and persistent septic arthritis; diagnosis: isolation in artificial medium, serology; treatment: penicillin, tetracycline, erythromycin

Family Bacteroidiaceae: never form spores; opportunistic pathogens causing wound and burn infections, septicemia, abscesses, other suppurative lesions; lack oxidative mechanism for active transport of aminoglycosides into cell; grow on blood media containing vitamin K and kanamycin

Bacteroides: strictly anaerobic Gram negative rods and filaments; nonsporeforming; motile by peritrichous flagella or nonmotile; does not produce butyric acid or only lactic acid or acetic acid and H₂S; normal flora of mouth (large numbers), tonsils (usually present), colon (predominant organism), lower ileum (predominant organism), female external genitalia (usually present), vagina (usually present), urethra (usually present), cervix (usually present); anaerobic Gram negative bacilli most frequently isolated in pure culture (antibiotics in medium help in isolation); causes abdominal abscess (40% of isolates), abortion and puerperal infection, abscesses, balanoposthitis, 2-6% of bacteraemia and septicemia, cellulitis, cervical fascial space infections, cholecystitis, complications of surgical procedures (especially in females), cranial parameningeal deep fascial space infections, acute empyema, endocarditis, endometritis, enteritis,

enterocolitis, ischio-rectal abscess, local and generalised sepsis, lung abscess, lung gangrene, chronic mastitis and breast abscess, post-neonatal pyogenic meningitis (associated with surgery), urethritis, parametritis, pelvic abscess, pelvic inflammatory disease, peritonitis, tubo-ovarian abscess, vaginosis, chronic otitis externa; predisposing factors trauma or surgery, alcoholic liver disease, diabetes mellitus, malignancy (solid tumours), atherosclerosis, prematurity, end stage renal disease; KDO and heptose absent from lipopolysaccharide, very low toxicity; treatment: metronidazole, chloramphenicol, erythromycin, clindamycin; resistant to ciprofloxacin, ofloxacin, pefloxacin, lomefloxacin, enoxacin, cefuroxime, piperacillin, gentamicin

B. amylophilus: normal flora of gastrointestinal tract

B. capillosus: normal flora of gastrointestinal tract, cervix, vagina, urethra; causes bone and soft tissue infection, female genital tract infection (3% of cases; acute salpingitis), intraabdominal abscess, lung abscess, peritonitis, postoperative wound infection (abdominal, head and neck), septicemia (8% of septicemia associated with infections of female genital tract), submandibular abscess; elaborates collagenase; susceptible to chloramphenicol, metronidazole, doxycycline

B. coagulans: normal flora of gastrointestinal tract, cervix, vagina; causes bone and soft tissue infection; susceptible to penicillin (MIC ? 0.062 mg/L), ampicillin (? 0.062 mg/L)

B. distasonis: *B. fragilis* group; normal flora of large intestine and female genital tract; causes infections in abnormal host; susceptible to clindamycin (100% at 0.03 mg/L), metronidazole (100% at 0.5 mg/L), imipenem (100% at 1 mg/L), meropenem (1 mg/L)

B. eggerthii: *B. fragilis* group; normal flora of gastrointestinal tract; causes abdominal wound infection, intraabdominal abscess, peritonitis

B. foisythus: ? involved in periodontitis

B. fragilis: small Gram negative rod often showing irregular staining and moderate pleomorphism, encapsulated; grey, entire colonies; catalase positive, inhibited by 0.1% deoxycholate, not inhibited by 20% bile + 0.1% deoxycholate, bile-esculin positive, no butyric acid from glucose or amino acids, end pH glucose 5.0-5.4, no formic acid from threonine, resistant to penicillin G (zone of inhibition < 20 mm with 2U disc), relatively susceptible to erythromycin (17-45 mm zone with 60 ?g disc), usually resistant to colistin (no zone with 10 ?g disc), no zone with 1000 ?g kanamycin disc, resistant to vancomycin (5?g disc), sensitive to rifampicin (15 ?g disc), resistant to penicillin (2 U disc); normal flora of large intestine and female genital tract; anaerobe most frequently isolated from clinical material (77% of *Bacteroides* isolated from blood, 67% from urine, 51% from surgical wounds, 50% from respiratory tract, 37% from body fluids); causes 3% of surgical wound infections, female genital tract and pelvic infection (79%), infections in abnormal host (surgical procedure), intraabdominal abscess (54% of anaerobic infections), local and generalised sepsis, meningitis, pleuropulmonary infections (including pulmonary abscess), bacteraemia and septicemia (70% of anaerobic, 50% of septicemia associated with infections of female genital tract), 68% of anaerobic perirectal abscess (including perianal and perirectal abscess and cellulitis in patients with malignant disease), 50% of anaerobic decubitus ulcers, 35% of anaerobic miscellaneous soft tissue infections below waist, 30% of anaerobic foot ulcers, 12% of anaerobic osteomyelitis and osteochondritis, acute diarrhoea and/or vomiting, acute cystitis, tubo-ovarian abscess, perinatal generalised disease, psoas abscess; extracellular; capsule inhibits phagocytic attachment and ingestion, promotes abscess formation, ? adhesin; elaborates collagenase, hyaluronidase, chondroitin sulphatase, fibrinolysin, neuraminidase, heparinase, DNase, gelatinase, superoxide dismutase; susceptible to metronidazole/tinidazole (< 5% resistance), clindamycin, lincomycin, chloramphenicol, minocycline (MIC < 0.03 mg/L), imipenem, meropenem (0.5 mg/L), thienamycin (100%), amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, gatifloxacin, moxifloxacin; 100% intrinsic resistance (due to ?-lactamase) to penicillin, amoxicillin, ampicillin, cephalosporins except cefoxitin and cefotetan

B. gracilis: related to *Campylobacter*; pitting colonies; vancomycin resistant, kanamycin susceptible, colistin susceptible, urease negative

B. hypermegas: normal flora of gastrointestinal tract

B. levii: related to *Porphyromonas*

B. merdae: *B. fragilis* group

B.ovatus: *B.fragilis* group; mannitol fermented; normal flora of large intestine and female genital tract; 25% of *Bacteroides* isolates from respiratory tract, 11% from body fluids, 7% from surgical wounds, 5% from blood; causes infections in abnormal host; susceptible to imipenem (100% at 0.5 mg/L), meropenem (0.5 mg/L), metronidazole (100% at 1 mg/L); 99% resistant to penicillin, 22% resistant to clindamycin, 46% resistant to cefoxitin

B.pneumosintes: bacilli ? 0.3 ? m length; normal flora of nasopharynx and oropharynx, gastrointestinal tract, cervix, vagina; causes chronic disease of meninges and other organs (rare), pneumonia; treatment: metronidazole; also susceptible to ampicillin (MIC 0.25 mg/L)

B.putredinis: inhibited by 0.1% deoxycholate, not inhibited by 20% bile + 0.1% deoxycholate, no butyric acid from glucose or amino acids, carbohydrates not fermented, no pitting of agar, gas from glucose, indole positive, most catalase positive; normal flora of gastrointestinal tract; causes acute salpingitis, bone and soft tissue infection, intraabdominal abscess, peritonitis; susceptible to cefoxitin, chloramphenicol, clindamycin, erythromycin, metronidazole

B.ruminicola: normal flora of vagina; elaborates DNase

B.ruminicola subspecies ruminicola: normal flora of gastrointestinal tract; causes bone and soft tissue infection, pneumonia; susceptible to clindamycin (MIC ? 0.062 mg/L)

B.splanchnicus: normal flora of gastrointestinal tract, vagina; causes abdominal wound infection, intraabdominal abscess, liver abscess, peritonitis; susceptible to penicillin, ampicillin, carbenicillin, cephazolin, cefoxitin, cefoperazone, chloramphenicol, clindamycin, erythromycin, metronidazole; resistant to cephalothin, cefaclor

B.stereois: *B.fragilis* group

B.tectum: possibly related to *B.fragilis* group

B.thetaiotaomicron: *B.fragilis* group; normal flora of large intestine and female genital tract; 33% of *Bacteroides* isolates from urine, 25% from body fluids, 19% from surgical wounds, 15% from blood, 32% of anaerobes from perirectal abscess, 30% of anaerobes from intraabdominal infection, 26% of anaerobes from decubitus ulcers, 15% of anaerobes from miscellaneous soft tissue infections below waist; causes infections in abnormal host; susceptible to imipenem (100% at

0.5 mg/L), meropenem (0.5 mg/L); 100% resistant to penicillin, 16% resistant to clindamycin, 5% resistant to cefoxitin

B.uniformis: *B.fragilis* group; 8% of *Bacteroides* isolates from body fluids, 6% from surgical wound, 1% from blood; susceptible to meropenem (0.5 mg/L); 98% resistant to penicillin, 20% resistant to clindamycin, 14% resistant to cefoxitin

B.ureolyticus: related to *Campylobacter*; pits surface of solid media; growth in broth containing 20% bile; vancomycin resistant, kanamycin susceptible, colistin susceptible; urease positive, esculin positive, indole negative, oxidase positive; normal flora of oropharynx, gastrointestinal tract, cervix, vagina, urethra; causes abdominal wound infection, severe erosive balanoposthitis, empyema, infections of abdomen, blood, bone and soft tissue, head and neck, lungs and pleural space, intraabdominal abscess, lung abscess, non-specific urethritis, peritonitis, pneumonia, postoperative wound infection, submandibular abscess; 12% of anaerobes from perirectal abscess; susceptible to ciprofloxacin (MIC 0.06 mg/L), ofloxacin (0.12 mg/L), meropenem (0.13 mg/L), penicillin (0.25 mg/L), enoxacin (0.25 mg/L), norfloxacin (0.25 mg/L), difloxacin

(0.5 mg/L), pefloxacin (0.5 mg/L), chloramphenicol, metronidazole

B.vulgatus: *B.fragilis* group; normal flora of large intestine and female genital tract; 25% of *Bacteroides* isolates from respiratory tract, 9% from surgical wounds, 7% from body fluids; causes infections in abnormal host; susceptible to meropenem (0.5 mg/L), metronidazole (100% at 1 mg/L), 92% susceptible to cefoxitin; 92% resistant to penicillin, 18% resistant to clindamycin

Fusobacterium: strictly anaerobic Gram negative long thin cells with tapered ends, nonsporeforming, motile by peritrichous flagella or nonmotile; produces butyric acid without much isobutyric or isovaleric acids; vancomycin resistant, kanamycin susceptible, colistin susceptible; normal flora of mouth (large numbers), tonsils (usually present), large intestine (irregular), lower ileum (irregular), external genitalia (usually present), urethra (usually present), vagina (irregular); causes abscesses, 0.3% of bacteraemia and septicemia, complication of cat and dog and human bite and clenched fist injuries, acute empyema, lung abscesses, intraabdominal abscess, peritonsillar abscess, cranial parameningeal deep fascial space infections; susceptible to metronidazole/tinidazole (100% at < 1 mg/L), chloramphenicol (100%), penicillin (100%), cefoxitin (99%), ampicillin-sulbactam (97%), ticarcillin-clavulanate (97%),

ceftizoxime (94-100%), clindamycin/lincomycin (92%), cefotaxime/ceftriaxone (90-100%), piperacillin (85-99%), amoxy/ampicillin, amoxicillin-clavulanate, piperacillin-tazobactam, ticarcillin-clavulanate, cephalixin, cephalothin, cephalozin, cefaclor, cefuroxime, cefepime, ceftazidime, cefotetan, imipenem, meropenem, azithromycin, clarithromycin, erythromycin, roxithromycin; resistant to fluoroquinolones

F. cloacis: new species

F. gonidiaformans: gas, indole and threonine positive; esculin and lactate negative

F. mortiferum: gas, bile-esculin and threonine positive; indole, lactate and lipase negative; erythromycin and rifampicin resistant

F. naviforme: gas and indole positive; esculin, threonine and lactate negative

F. necrophorum: usually ?-haemolytic, sometimes ?; ? 20 mm zone of inhibition with 2U penicillin disc, ? 15 mm zone with 15 ?g rifampicin disc, usually shows large zone with 1000 ?g kanamycin disc, 6-25 mm zone with 1000 ?g neomycin disc, usually inhibited by bile, indole and lipase positive, esculin negative; terminal pH glucose 6.0-6.9, propionic acid from lactate; oral; causes bacteraemia and septicemia, cervical fascial space infections, endocarditis, infections in abnormal host, 22% of anaerobic dental infections, chronic otitis externa; produces phospholipase A, lysophospholipase; treatment: metronidazole (100% susceptible), tetracycline, lincomycin; susceptible to ticarcillin (MIC ? 1 mg/L), ticarcillin-clavulanate (? 1 mg/L), clindamycin (100%)

F. necrophorum subspecies funduliforme: new subspecies

F. necrophorum subspecies necrophorum: new subspecies

F. nucleatum: variable length and width; inhibited by 0.1% deoxycholate, usually inhibited by bile, butyric acid from glucose or amino acids, does not produce gas, indole positive; esculin and lipase negative; susceptible to erythromycin, rifampicin, colistin, penicillin, kanamycin; resistant to vancomycin; lytic reaction on egg yolk agar; most commonly isolated *Fusobacterium* species; oral; causes endocarditis, infections in abnormal host, 40% of anaerobic head and neck infections, 32% of anaerobic CNS infections, necrotising pneumonia and pulmonary abscess (29% of transtracheal aspirates and pleural fluids growing anaerobes), 28% of anaerobic human bite infections, 22% of miscellaneous soft tissue infections above waist, 15% of anaerobic animal bite infections, 13% of anaerobic intraabdominal infections; adheres to epithelial cells, Gram positive and Gram negative bacteria, red blood cells; treatment: metronidazole (100% susceptible), tetracycline, lincomycin; also susceptible to ticarcillin (MIC ? 1 mg/L), ticarcillin-clavulanate (? 1 mg/L), clindamycin (100%)

F. nucleatum subspecies fusiforme: new subspecies

F. nucleatum subspecies nucleatum: new subspecies

F. nucleatum subspecies polymorphum: new subspecies

F. periodonticum: new species

F. russii: gas produced; indole, esculin, threonine and lactate negative

F. sulci: new species

F. ulcerans: new species

F. varium: indole positive; esculin and lipase negative; propionic acid from threonine, butyric acid from glucose, not inhibited by 20% bile, weak or no action on carbohydrates; ? 20 mg zone of inhibition with 2U penicillin disc, small or no zone with 15 ?g rifampicin disc or 60?g erythromycin disc; susceptible to chloramphenicol, metronidazole

Porphyromonas asaccharolytica: brown or black pigment, brick-red fluorescence with UV light; ?-fucosidase positive; normal flora of female genital tract and oral cavity; causes gingivitis and periodontitis, chronic otitis externa, severe erosive balanoposthitis, urethritis; 26% of anaerobes isolated from perirectal abscess, 17% of anaerobes isolated from decubitus ulcers, 10% of anaerobes isolated from foot ulcers, 10% of anaerobes isolated from miscellaneous soft tissue infections above the waist; susceptible to meropenem (MIC 0.06 mg/L)

P. endodontalis: does not produce ?-fucosidase, trypsin-like enzyme or phenylacetic acid, does not agglutinate sheep erythrocytes

P. gingivalis: produces trypsin-like enzyme, phenylacetic acid, agglutinates sheep erythrocytes; dominant organism in rapidly progressive periodontitis; adheres to crevicular epithelium, Gram positive bacteria, red blood cells; capsule antiphagocytic; elaborates collagenase, IgA protease, IgG protease

Prevotella bivia: normal flora of oropharynx, vagina; causes acute salpingitis, Bartholin cyst infection, breast abscess, infections in blood, bone and soft tissue, head and neck, lungs and pleural space, urogenital tract, pneumonia, postoperative wound infection, postpartum endometritis; elaborates neuraminidase; susceptible to clindamycin (MIC ? 0.25 mg/L), meropenem (0.5 mg/L), carbenicillin, cefamandole, ceftioxin, cefoperazone, moxalactam, chloramphenicol, erythromycin, metronidazole

P. buccae: normal flora of oropharynx, gastrointestinal tract; causes abdominal wound infections, brain abscess, cellulitis, empyema, infections of abdomen, blood, bone and soft tissue, central nervous system, head and neck, lungs and pleural space, intraabdominal abscess, lung abscess, peritonitis, pneumonia, postoperative wound infection, submandibular abscess; susceptible to ceftioxin, chloramphenicol, clindamycin, metronidazole

P. disiens: normal flora of oropharynx, vagina; causes acute salpingitis, breast abscess, infections of blood, bone and soft tissue, head and neck, lungs and pleural space, urogenital tract, perinatal generalised disease, pneumonia, postoperative wound infection; treatment: metronidazole; also susceptible to meropenem (MIC 0.25 mg/L), carbenicillin, clindamycin, erythromycin

P. intermedia: causes gingivitis and periodontitis, chronic otitis externa

P. melaninogenica: encapsulated, often coccobacillary; characteristically produces a black pigment on blood agar (may be nonpigmented or pigment very slowly), red fluorescence of young colonies on blood agar under UV light; inhibited by bile and 0.1% deoxycholate, fermentation patterns variable, ? 20 mm zone of inhibition with 2U penicillin disc, ? 15 mm zone of inhibition with 15 ?g rifampicin disc, usually little or no zone with 1000 g kanamycin disc, 30-74 mm zone with 60 ?g erythromycin disc, kanamycin resistant, colistin variable; normal flora of female genital tract and oral cavity; causes balanoposthitis, female genital tract infection (24%), infections in abnormal host, non-specific urethritis, orodental infections (gingivitis and periodontitis; 11% of anaerobic infections), pleuropneumonia infections (including pulmonary abscess; in 23% of transtracheal aspirates and pleural fluid specimens growing anaerobes), septicemia (8% of septicemia associated with female genital tract infection), endocarditis (polymicrobial), 40% of anaerobic head and neck infections, 20% of anaerobic human bite infections; adheres to crevicular epithelium, Gram positive bacteria, vaginal epithelium; capsule antiphagocytic, inhibits macrophage migration, promotes abscess formation; elaborates collagenase, IgA protease, IgG protease, neuraminidase, DNase, phospholipase A, hyaluronidase, fibrinolysin; susceptible to metronidazole, tinidazole, lincomycin, cephalixin, cephalothin, cephalozin, cefaclor, cefuroxime (0.1 mg/L), cefotaxime, ceftriaxone, cefepime, ceftazidime, cefotetan, ceftioxin, erythromycin (0.1 mg/L), clindamycin (0.1-0.25 mg/L), meropenem (0.5 mg/L), imipenem (99%), amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, azithromycin, clarithromycin, erythromycin, roxithromycin, chloramphenicol

P. nigrescens: new species

P. oralis: no red fluorescence of young colonies on blood agar under UV or brown or black pigment on blood agar, may have granular growth in broth; lack of growth in bile, inhibited by 0.1% deoxycholate, no butyric acid from glucose or amino acids, no propionic acid from threonine, mannitol fermented, no or slight gas from glucose; susceptible to penicillin

(? 20 mm zone of inhibition with 2 U disc), ? 15 mm zone with 15 ?g rifampicin disc, usually little or no zone with 1000 ?g kanamycin, 37-70 mm zone with 60 ?g erythromycin disc; normal flora of oropharynx; causes infections in abnormal host, orodental infections, necrotising pneumonia; elaborates collagenase, neuraminidase; susceptible to meropenem (MIC 0.25 mg/L)

Anaerorhabdus furcosus: pleomorphic bifurcated cells; normal flora of gastrointestinal tract

Dichelobacter nodosus: large pleomorphic cells; Gram negative; obligate anaerobe; causes footrot in sheep

Tissierella praeacuta: normal flora of gastrointestinal tract; causes bone and soft tissue infection, intraabdominal abscess, peritonitis; susceptible to cefamandole (MIC ? 0.062 mg/L), ceftioxin (? 0.062 mg/L), moxalactam (? 0.062 mg/L), clindamycin (? 0.062 mg/L), erythromycin (? 0.062 mg/L)

Mobiluncus: currently included with Bacteroidaceae but possibly belongs in Order Actinomycetales; motile, anaerobic vibrio-shaped Gram negative bacillus; found in vagina of 0-22% of women with vaginal discharge; ? causes vaginosis; treatment: metronidazole, tinidazole, nimorazole, clindamycin, Aci-Jel?

M. curtsii: new genus and species

M. curtsii subspecies curtsii: new subspecies

M. curtsii subspecies holmesii: new subspecies

M. mulieris: new species

Leptotrichia buccalis: obligately anaerobic Gram negative rods, nonsporeforming, peritrichous flagella or nonmotile, produces only lactic acid; normal flora of mouth, tooth surface; believed to play a role in causation of necrotising ulcerative gingivostomatitis, necrotising ulcerative pharyngitis and necrotising ulcer of the skin surface (tropical ulcer); causes bacteraemia and septicemia in cancer patients, cat and dog bite infections; susceptible to ? - lactams, clindamycin, tetracycline, metronidazole

Mitsuokella dentalis: new species

M. multiacida: normal flora of gastrointestinal tract

Butyrivibrio fibrosolvens: anaerobic, Gram negative bacillus, nonsporeforming, motile by polar flagella, fermentative, butyric acid produced; normal flora of large intestine; single case of endophthalmitis following penetrating injury; susceptible to penicillin, chloramphenicol, erythromycin, tetracycline; resistant to bacitracin, streptomycin, kanamycin, lincomycin, sulphonamides

Succinimonas amyolytica: motile by polar flagella, anaerobic, Gram negative bacillus, ovoid cells, succinic acid produced, fermentative; single case of groin cellulitis and abscess; susceptible to bacitracin, oxytetracycline, penicillin; resistant to kanamycin, streptomycin, erythromycin

Succinivibrio: obligately anaerobic Gram negative rods, spiral-shaped cells, nonsporeforming, motile by polar flagella, fermentative, produces succinic acid

S. dextrinosolvens: motile, anaerobic, Gram negative bacillus, spiral cells, succinic acid produced; normal flora of oral cavity, colon; rare cases of septicemia (associated with gastrointestinal or oesophageal sepsis); susceptible to penicillin, tetracycline, erythromycin, chloramphenicol

Anaerobiospirillum succiniciproducens: bipolar tufts of flagella; causes septicemia, diarrhoea; treatment: cephamandole; also susceptible to cephalothin, chloramphenicol, tetracycline, rifampicin; resistant to vancomycin, trimethoprim, penicillin

Bilophila wadsworthia: new genus and species

Centipodia periodontii: new genus and species

Campylobacter: motile, anaerobic, Gram negative bacillus, nonfermentative metabolism, succinic acid from fumarate; normal flora of oral cavity, colon, vagina; causes abscesses (brain, chest wall, alveolar), susceptible to imipenem (MIC ? 1 mg/L), ciprofloxacin (1 mg/L), metronidazole, clindamycin, chloramphenicol, tetracycline, erythromycin; resistant to vancomycin, bacitracin, nalidixic acid

C. concisus: anaerobic, nonfermentative metabolism, succinic acid from fumarate; normal flora of oral cavity; associated with periodontal disease, single case of infected foot ulcer, uncommon cause of diarrhoea, enterocolitis; susceptible to imipenem (MIC ? 1 mg/L), ciprofloxacin (? 1 mg/L), clindamycin, chloramphenicol, metronidazole, penicillin, tetracycline, erythromycin; resistant to vancomycin, bacitracin, rifampicin

Selenomonas sputigena: obligately anaerobic, Gram negative rods, motile by tuft of flagella on concave side of crescent-shaped cells, fermentative metabolism; normal flora of nasopharynx, oral cavity; causes sepsis (in alcoholism), lung abscess; susceptible to clindamycin, chloramphenicol, metronidazole; resistant to vancomycin, colistin

Anaerovibrio: motile by polar flagella, anaerobic, Gram negative bacillus, fermentative, propionic and acetic acids produced

Desulfomonas pigra: dissimilating sulphate-reducing bacteria

Desulphovibrio desulfuricans: motile, anaerobic, Gram negative bacillus, respiratory metabolism, sulphur compounds reduced to sulphur; normal flora of colon; causes sepsis, cholecystitis, intraabdominal abscess; susceptible to penicillin, clindamycin, chloramphenicol, tetracycline, erythromycin; resistant to vancomycin, colistin

Veillonaceae: Gram negative cocci

Veillonella: anaerobic Gram negative cocci resembling *Neisseria*; pink to red fluorescence under ultraviolet light (360 nm); produces propionic acid; nitrate positive; susceptible to erythromycin, rifampicin, colistin, penicillin, kanamycin; resistant to vancomycin; normal flora of cervix (27%), vagina, mouth, tonsils, large intestine; causes bacteraemia and septicemia, endocarditis (polymicrobial), cranial parameningeal deep fascial space infections, infections in abnormal host, 44% of anaerobic human bite infections, 33% of anaerobic head and neck infections, 33% of

anaerobic dental infections, 26% of transtracheal aspirates and pleural fluids growing anaerobes, 12% of perirectal abscess, 11% of anaerobic miscellaneous soft tissue infections above waist; usually found with other aerobes and anaerobes, role in infection remains uncertain; 100% susceptible to imipenem

V. parvula: found in mouths of many healthy persons; may on rare occasions act as opportunistic pathogen, causing abscesses, cat and dog bite infections, osteomyelitis and osteochondritis, wound infections and respiratory tract disease (pneumonia), endocarditis (polymicrobial); treatment: chloramphenicol, clindamycin

Acidaminococcus fermentans: obligately anaerobic Gram negative cocci, produces butyric and acetic acids; nitrate negative; normal flora of large intestine; rarely isolated from clinical specimens

Megasphaera elsdenii: nitrate negative; colon; rarely isolated from clinical specimens

Order Rickettsiales: not deficient in basic energy metabolic functions; rigid cell envelope; no growth on cell-free media (few exceptions); cell wall or cell wall peptidoglycan present; do not require sterols; usually arthropod parasites

Family Rickettsiaceae: only group of bacteria that are obligate intracellular parasites transmitted by arthropods

Rickettsia: no growth in nonliving media; causes rickettsioses, scrub typhus, spotted fevers, typhus, encephalitis, localised skin lesions, haemorrhagic rash, macular rash, maculopapular rash; transmitted by infestation with infected arthropod; enters across skin epithelial surface and subsequently spreads through body; carried in blood free in plasma; multiplies inside tissue cells; primary immune defence prevention of entry into cells by coating microbial surface with specific antibody (IgG, IgA, IgM), killing of infected cell also important; treatment: tetracycline, chloramphenicol, doxycycline, cotrimoxazole

R. akari: causes rickettsialpox; urban localities in NE USA, former Soviet Union, Korea, Southern Africa, Mediterranean; mite vector; house mice, rat reservoir; typhus⁺⁺⁺, RMSF⁺⁺⁺; OX19, OX2 and OXK negative; treatment: tetracycline, doxycycline

R. australis: causes North Queensland tick typhus; Australia; vector tick; reservoir ? rat, ? marsupial; OX19⁺, OX2⁺; OXK negative; treatment: tetracycline, doxycycline

R. canada: susceptible to tetracycline, chloramphenicol

R. conorii: causes Boutonneuse (Marseilles, Mediterranean) fever (Mediterranean, Caspian and Black Sea littoral, Middle East), Indian tick typhus (India), Kenya tick typhus (E Africa), adult hepatitis, nonpurulent conjunctivitis (in 32% of cases); vector tick (*Rhipicephalus sanguineus*); reservoir dog, rodents; OX19⁺, OX2⁺; OXK negative; diagnosis: microimmunofluorescence, latex agglutination of serum, immunofluorescence of skin biopsy, Western blot, isolation from blood culture with shell vial cell culture; treatment: tetracycline, doxycycline

R. honei: causes Flinders Island spotted fever; tick (*Ixodes holocyclus* and *Ixodes tasmani*) vector

R. pijperii: causes tick bite fever (haemorrhagic fever); S Africa; reservoir ? rodents; OX19⁺, OX2⁺; OXK negative; treatment: tetracycline, doxycycline

R. prowazekii: causes epidemic (classic, European, louseborne) typhus (fever, encephalitis, haemorrhagic rash); worldwide (Europe, Asia, America); human louse (*Pediculus humanus corporis*) vector (infected louse faeces rubbed into broken skin or as aerosol to mucous membranes); reservoir man, squirrel; typhus⁺⁺⁺, RMSF[?], OX19⁺⁺⁺⁺, OX2⁺; OXK negative; multiplies in macrophages; transmitted in blood; persists in lymph node (? infectious, shed to exterior), activation months or years after primary attack giving Brill-Zinsser disease (typhus⁺⁺⁺, RMSF[?], OX19[?]; OX2 negative); 1000 genes; treatment: tetracycline, chloramphenicol, doxycycline

R. rickettsii: Western hemisphere; causes Rocky Mountain spotted fever (N America), Sao Paulo typhus (Brazil), Tolia fever (Colombia), adult hepatitis, anterior uveitis, myocarditis and pericarditis (in 5% of infections), nonpurulent conjunctivitis (in 30% of infections), haemorrhagic fever; ticks vector; rabbits, small rodents, dog, opossum reservoir; typhus[?], RMSF⁺⁺⁺, OX19⁺⁺⁺, OX2⁺⁺⁺; multiplies in macrophages; treatment: tetracycline, chloramphenicol, doxycycline; also susceptible to erythromycin, rifampicin, streptomycin, thiomycetin

R. siberica: causes Siberian tick typhus; Central Asia; tick vector; rodents, dog reservoir; typhus[?], RMSF⁺⁺⁺, OX19⁺⁺⁺, OX2⁺⁺⁺; OXK negative; treatment: tetracycline, doxycycline

***R. typhi* (*R. mooseri*)**: causes murine (endemic, fleaborne) typhus; scattered pockets worldwide; flea (*Xanopsylla cheopsis*) and rat louse vectors; wild rats and field mice reservoir; typhus⁺⁺⁺, RMSF[?], OX19⁺⁺⁺⁺, OX2⁺; OXK negative; treatment: tetracycline, chloramphenicol, erythromycin, rifampicin, streptomycin

Orientia tsutsugamushi: causes scrub typhus (tsutsugamushi disease, Japanese river fever, Kadani fever, rural typhus; fever, eschar, rash); Japan, Korea, China, Philippines, SE Asia, Indian subcontinent, Indonesia, N Australia, Pacific Islands; vector trombiculid mites; reservoir native rodents, bandicoots, ? birds; typhus, RMSF, OX19 and OX2 negative; OXK⁺⁺⁺; escapes from phagosome; treatment: tetracycline, doxycycline, chloramphenicol

Grahamella: causes grahamellosis in certain mammals, especially rodents; found within erythrocytes of, but not known to cause disease in, man

Coxiella burnetii: causes Q fever (endocarditis, chronic hepatitis, low platelets, acute respiratory illness, pneumonia, encephalitis, meningoencephalitis, myocarditis and pericarditis, haemorrhagic fever, abortion, premature delivery, stillbirth); worldwide; vector ticks but does not require arthropod vector for transmission; reservoir bandicoot, sheep, cattle, goats, ? birds; human infections from direct or indirect contact with infected sheep, cattle, goats; Q fever⁺⁺⁺; typhus, RMSF, OX19, OX2 and OXK negative; enters across epithelial surfaces of respiratory tract, conjunctiva and ? intestinal tract; diagnosis: indirect fluorescent antibody titre, complement fixation test, ELISA; treatment: doxycycline, tetracycline, erythromycin, rifampicin, clindamycin, cotrimoxazole, lincomycin; also susceptible to trimethoprim

Afipia felis: motile; no growth on MacConkey; oxidase and urease positive; NaCl, carbohydrate fermentation, citrate, indole, gelatine, esculin, H₂S, decarboxylases and cetrimide negative; 11-methyloctadec-12-enoic acid present

Family Ehrlichiaaceae

Ehrlichia: causes ehrlichiosis, ? mucocutaneous lymph node syndrome; growth stimulated by excess iron; diagnosis: serology, immunohistologic examination of acute phase bone marrow and liver biopsy; treatment: doxycycline, tetracycline

E. canis: causes monocytic ehrlichiosis

E. chaffeensis: causes human monocytic ehrlichiosis

E. ewingii: causes human and canine granulocytic ehrlichiosis

E. phagocytophila: causes granulocytic ehrlichiosis (may be reclassified as *Anaplasma*)

E. sennetsu: causes monocytic ehrlichiosis, Hyuga fever; treatment: doxycycline, tetracycline

Family Bartonellaceae

Bartonella bacilliformis: Gram negative bacilli, flagella; causes bartonellosis (Oroya fever; invasion of vascular endothelial cells and haemolytic anaemia); carried in blood associated with erythrocytes; immunologically characterised by recurrent attacks of verruga peruana and selective suppression of resistance to *Salmonella*; diagnosis: stained smears of material from skin lesions, blood cultures; treatment: tetracycline

B. elizabethae: single report of endocarditis

B. henselae: small gram negative bacillus, often slightly curved; no flagella but produces twitching motion when suspended in saline; aerobic, highly fastidious, grows in presence of 5% CO₂ after 7 or more days; no acid from carbohydrates, catalase, oxidase, indole and urease negative, nitrates not reduced; causes bacillary angiomatosis, bacillary peliosis, cat scratch disease, hepatitis, prolonged or relapsing fever with persistent bacteraemia and constitutional symptoms; louse vector; reservoir man; diagnosis: Warthin-Starry stain and culture of biopsy, PCR; treatment: erythromycin, doxycycline, tetracycline, minocycline

B. quintana: causes trench fever (recurrent episodes of fever), bacillary angiomatosis, bacillary peliosis; treatment: erythromycin, doxycycline, tetracycline, minocycline, rifampicin, ciprofloxacin

B. vinsoni* subsp *berkhoffii: single report of endocarditis

Chlamydiales: small cellular forms, possibly degenerate Gram negatives, highly evolved to an intracellular parasitic life mode with concurrent loss of certain important energy-yielding metabolic functions; no growth outside host cell; independent protein synthesis; variable rigid cell envelope; susceptible to antibiotics; reproduction by fission; DNA and RNA; cell wall or cell wall peptidoglycan present; do not require sterols

Chlamydia: no growth in nonliving media; Gram negative with cell wall similar to other Gram negative bacteria; possesses both RNA and DNA; reproduces by binary fission; possesses ribosomes; susceptible to antibiotics; elementary body (? 0.3? m) rigid cell wall, relatively resistant to sonication, resistant to trypsin, subunit in cell envelope, RNA:DNA content = 1:1, toxic for mice, isolated organisms infectious, adapted for extracellular survival; reticulate body (0.5-1 ? m) fragile cell wall, sensitive to sonication, lysed by trypsin, no subunit in envelope, RNA:DNA = 3:1, nontoxic for mice, isolated organisms not infectious, adapted for intracellular growth; causes reactive arthritis, Bartholinitis,

purulent cervicitis, conjunctivitis, acute dacryocystitis, adenitis and canaliculitis, encephalitis, hepatic granuloma, pneumonia, 35-50% of non-gonococcal urethritis, ? sweating disease; ? 7000 total notified cases/y in Australia; attaches to conjunctival or urethral epithelium (? sialic acid-containing receptors on epithelial cell); infection generally confined to epithelial surface of conjunctiva (trachoma, inclusion conjunctivitis) or urogenital tract (TRIC agents in nonspecific urethritis); growth stimulated by excess iron; susceptible to gatifloxacin, moxifloxacin, tetracycline, doxycycline, minocycline, azithromycin, clarithromycin, erythromycin, roxithromycin; resistant to ciprofloxacin

C. psittaci: not inhibited by neuraminidase, not pathogenic for monkeys or mouse brains, resistant to sulphonamides, more diffuse inclusion, no glycogen in inclusion, G+C ? 41%; principal hosts birds and mammals; causes ornithosis (psittacosis), splotchy rash with pulmonary involvement, many clinical and subclinical diseases of mammals and birds; enters across epithelial surface of respiratory tract and subsequently spreads through body; inhibits lysosome-phagosome fusion; persists in lung (rarely in man; ? infectious, not shed to exterior) and spleen of bird (may be infectious, shed to exterior, activation occurs); penicillin inhibits conversion of reticulate bodies to elementary bodies; diagnosis: complement fixation test (*C. trachomatis* antigen); treatment: doxycycline, erythromycin, tetracycline, rifampicin

C. trachomatis: more compact inclusion, glycogen present in inclusion, G+C ? 44%, susceptible to sulphonamides; principal host humans; serotypes A-K (trachoma, inclusion conjunctivitis, urethritis, etc) inhibited by neuraminidase; serotype L (LGV) not inhibited by neuraminidase, pathogenic for mouse brains; causes chlamydial lymphogranuloma (LGV biovar), dysuria-frequency (urethral) syndrome, mucopurulent cervicitis, endometritis, acute epididymitis and epididymo-orchitis (mainly heterosexual men), orchitis, parametritis, pelvic abscess, pelvic inflammatory disease, perihepatitis, peritonitis, primary pneumonia in infants and in AIDS, proctitis, salpingitis, trachoma, 35-50% of nongonococcal urethritis, vaginitis; increased infectiousness in abnormal host; LGV strain enters across epithelial surface of urogenital tract and subsequently spreads through body; TRIC strain persists in conjunctiva (infectious, ? shed to exterior), causing chronic disease and blindness; 500 genes; diagnosis: culture, PCR, direct immunofluorescence, enzyme immunoassay, DNA probe; treatment: tetracycline (MIC 0.5 mg/L), erythromycin (0.5 mg/L), doxycycline, sulphamethoxazole, sulphisoxazole, chlortetracycline, oxytetracycline, sulphadiazine

Chlamydophila pneumoniae: causes bronchitis, nonexudative pharyngitis and tonsillitis, pneumonia, acute sinusitis, endocarditis, ? chronic asthma, ? atherosclerosis, ? multiple sclerosis; growth strongly suppressed by iron restriction; detection: isolation, microimmunofluorescent antibody; treatment: tetracycline

Division Firmicutes: intracellular osmotic pressure of Gram positive bacteria is 2 or more times that of Gram negatives

Class Firmibacteria: simple Gram positive bacteria

Family Micrococcaceae: Gram positive, may be encapsulated, form chains in liquid media, possess catalase, produce penicillinase

Micrococcus: Gram positive cocci, cells round, single and in irregular clusters and tetrads, no capsule; no cell wall teichoic acid, no pentaglycine cross bridge in peptidoglycan; usually no anaerobic growth in glucose, growth in 5% NaCl, growth on furoxone-Tween 80-oil red agar; yellow pigmented strains, non-adherent to blood agar, nonhaemolytic, large colonies; glucose oxidised; no anaerobic acid production from glycerol in presence of erythromycin; susceptible to 0.04 U bacitracin, susceptible to lysozyme (50? g), resistant to lysostaphin; DNA base composition 66-75% G+C; normal flora of skin, mouth, tonsils; normal habitat water; causes cat and dog bite infections, rare cause of endocarditis; treatment: vancomycin (< 5% resistance in Australia)

M. kristinae: anaerobic acid production from glucose

M. luteus: adherence to nasal mucosa+

M. varians: anaerobic acid production from glucose

Stomatococcus: capsule present; cells in clusters; large colonies, adheres to blood agar, nonhaemolytic; no growth in 5% NaCl, anaerobic growth in glucose; catalase variable

S. mucilaginosus: normal flora of mouth and upper respiratory tract; causes bacteraemia and septicemia and endocarditis (i.v. drug abuse, cardiac valve disease, vascular catheters, immunocompromised), peritonitis in chronic ambulatory peritoneal dialysis; treatment: vancomycin (100% susceptible), gentamicin (100% susceptible), penicillin (71% susceptible)

Staphylococcus: Gram positive cocci, cells round, single and in groups, especially tetrads and botryoidal clusters; may be capsulated; cell wall teichoic acid, pentaglycine bridge in peptidoglycan; anaerobic growth in glucose, growth in 6.5% NaCl; may be β -haemolytic; nonadherent, large colonies; no growth on furoxone-Tween 80-red O agar; catalase positive, glucose fermented, bile esculin negative; aerobic acid production from glycerol in presence of erythromycin; usually resistant to 0.04 U bacitracin, resistant to lysozyme, usually susceptible to lysostaphin; DNA base composition 30-40% G+C; among most ubiquitous of bacteria; normal flora of skin, vagina (62%); frequently causes pyogenic and suppurative conditions, including appendicitis, boils, cholangitis and cholecystitis, discitis, endocarditis, post-neonatal pyogenic meningitis, perinephric abscess, postnatal infection, pulmonary abscess, septic arthritis, septicemia (including haemorrhagic fever), septicemia adrenal haemorrhage syndrome, thyroiditis, water-related infections; commonest skin invader; infection usually confined to epithelial surface of skin; extracellular; growth stimulated by excess iron; leucocidins (deoxyribonuclease, diphosphopyridine nucleotidase, nicotinamide adenine dinucleotidase) induce lysosomal discharge into cell cytoplasm killing phagocyte (both neutrophils and macrophages disrupted), protein A blocks Fc portion of antibody inhibiting opsonised phagocytosis, polysaccharide capsule in some strains, cell wall mucopeptide resists killing by phagocytes, β catalase resists killing, hyaluronidase causes spread of infection; also produces large amounts of exotoxin, which may cause intoxication; primary bodily defence mechanism leucocyte bactericidal function; recovery from primary infection due to antibody; mean doubling time 20 minutes in vitro; treatment: cloxacillin, flucloxacillin, gentamicin, vancomycin, rifampicin, amoxicillin-clavulanate, cephalothin, sodium fusidate, clindamycin; also susceptible to irloxacin (MIC 0.5 mg/L), cephalixin, penicillin (β -lactamase negative), ampicillin (β -lactamase negative), methicillin; resistant to cefixime

S. arlettae: found in animals and animal products; novobiocin resistant

S. aureus: ribitol-N-acetylglucosamine cell wall teichoic acid; Gram positive cocci in clusters; colonies may be golden; anaerobic growth; catalase positive; glucose fermented, mannitol fermented, phosphatase, heat-resistant endonucleases, Staphylase and tube coagulase positive (clumping factor reacts with fibrinogen, protein A reacts with Fc portion of human IgG; small colony variant methicillin resistant strains lack clumping factor); novobiocin susceptible; normal flora of skin, mouth, nasopharynx, tonsils, nose (adherence to nasal mucosa ++), large intestine, lower ileum, external genitalia (adherence to labium majus ++), anterior urethra (rare), vagina, cervix (3-17%), ear, eye (rare); phage typing identifies virulent strains; causes abortifacient and puerperal infections, abscesses, appendicitis, septic arthritis, 10-30% of bacteraemia and septicemia, balanitis, blepharitis, boils, 60% of brain and epidural abscess (common after trauma or surgery), acute bronchitis, burn infections, bursitis, carbuncles, 1% of carpal tunnel syndrome (+ 3% due to toxic shock syndrome), cat and dog bite infections, cellulitis, cerebrospinal fluid shunt infections, cervical fascial deep space infections, cholangitis and cholecystitis, chondritis, complication of pseudomembranous enterocolitis, compound fractures infections, purulent conjunctivitis, cranial parameningeal deep fascial space infections (immunocompromised and others), croup, acute cystitis, acute empyema, 10-32% of endocarditis (45% of *S. aureus* infections in drug addicts), endophthalmitis (postoperative, posttraumatic, septicemia), enteritis, enterotoxemia (food poisoning; organisms spread from nose, hands or septic lesion of food handler, multiply in poultry, pork, ham, beef, meat pies, sausages, custard, trifle, etc), post-antibiotic diarrhoea and enterocolitis (profuse watery diarrhoea, with dehydration, resulting from production of enterotoxins by antibiotic-resistant strains in gut lumen following administration of antibiotics), acute epididymitis and epididymo-orchitis, 83% of false aneurism, folliculitis, furunculosis, adult hepatitis (in toxic shock syndrome), hepatic abscess, hidradenitis, hordeolum, human bite and clenched fist infections, impetigo and bullous impetigo, ischio-rectal abscess, keratitis and iritis, laryngotracheitis, local and generalised sepsis, 3% of lymph gland infection, acute mastitis and breast abscess, mastoiditis, meningitis (0.5% of neonatal (late), 1-9% of postneonatal pyogenic), mycotic aneurism (3% of *S. aureus* infections in heroin addicts), nasal septal abscess, 1% of necrotising fasciitis, 55% of osteomyelitis and osteochondritis (+ 22% in combination with anaerobes), 16% of otitis externa (including rare malignant), otitis media, pancreatic abscess, paronychia, parotitis and submandibular sialadenitis, myocarditis and pericarditis (in granulocytopenia), perichondritis, perinatal generalised disease, peritonitis (primary and continuous ambulatory peritoneal dialysis), primary and secondary pneumonia (including diffuse interstitial, chronic pulmonary infection in cystic fibrosis), pulmonary abscess, postseptal cellulitis, prostatic abscess (younger patients), psoas abscess, pustulosis, acute pyelonephritis, pyoderma, erythematous rash (staphylococcal scalding¹), rhabdomyolysis, 12% of septic thrombophlebitis (associated with local trauma; 7% of *S. aureus* infections in heroin addicts), acute and

chronic sinusitis, localised skin lesions, splenic abscess, sty, 15% of surgical wound infections (summer peak), sycosis barbae, symbiotic gangrene, thyroiditis, toxic epidermal neurolysis, toxic shock syndrome, acute tracheitis, chronic ulcers, urethritis, vaginitis in prepubertal girls and elderly women, 10% of nosocomial infection, infections in abnormal host (interrupted integument, surgical procedure, neutrophil dysfunction), systemic infections in chemotactic defect, C1, 2, 3, 4, factor B deficiency, granulocytopenia, microbicidal abnormality; α -toxin is cytotoxic and acts on cell membranes, causing necrosis at site of infection and systemic toxicity; leucocidin kills phagocytes (virulence factor); enterotoxin absorbed from intestine acts on vomiting centre in brain, causing nausea, vomiting, diarrhoea (food poisoning; incubation period 0.5-6 h); haemolysins and exfoliatin other toxins produced; inhibits phagocytic attachment and ingestion; cell wall N-acetylglucosamine linked to polyribitol phosphate (mucopeptide) associated with invasiveness (virulence factor); coagulase provides protection by fibrin deposition (virulence factor); fibronectin binding important in endocarditis; catalase, lipase, lysozyme, lactic acid dehydrogenase, acid phosphatase, protease, hyaluronidase, fibrinolysin, deoxyribonuclease, penicillinase other enzymes produced; teichoic acid and protein A significant factors; major host defence mechanisms α -lysin (+), phagocytes (+++), immune adherence (phagocytosis) (+); ultrastructure in vivo comparable to that if grown on a solid support medium and different from that if grown in a liquid medium; diagnosis: counterimmunoelectrophoresis (teichoic acid antibody α 1:4; pleural fluid, sensitivity 86%), culture; non-MRSA susceptible to di/flucloxacillin, amoxicillin-clavulanate, piperacillin-tazobactam, ticarcillin-clavulanate, cephalexin, cefuroxime, cefotetan, cefoxitin, cephalothin (MIC 0.06-0.5 mg/L), cephazolin, cefaclor, ceftazidime, cefepime, ceftazidime, thienamycin

(α 0.06 mg/L), mupirocin (0.06-0.12 mg/L), amikacin, gentamicin, tobramycin (0.25 mg/L), imipenem, meropenem (0.25 mg/L), teicoplanin (0.25-1 mg/L), gatifloxacin, moxifloxacin, doxycycline, tetracycline, minocycline, chloramphenicol, clindamycin, lincomycin, sodium fusidate, linezolid, synergid, rifampicin/rifabutin, vancomycin/teicoplanin, neomycin, bacitracin, resistant to cefixime, nalidixic acid, piperidic acid; methicillin resistant 100% resistant to all penicillins, all cephalosporins, susceptible to vancomycin/teicoplanin (resistance not yet confirmed in Australia), linezolid, synergid, usually susceptible to novobiocin; in Australia, 85% of methicillin susceptible strains resistant (acquired resistance due to β -lactamase) to penicillin, amoxicillin, ampicillin, ticarcillin, piperacillin and azlocillin, 34% of all strains (13% of methicillin susceptible) resistant to erythromycin and other macrolides, 25% of all strains resistant to methicillin, dicloxacillin, cloxacillin, oxacillin, flucloxacillin and cephalosporins (significant geographic variation), 26% of all strains (3% of methicillin susceptible) resistant to cotrimoxazole, 23% of all strains (5% of methicillin susceptible) resistant to tetracycline, 12% of MRSA resistant to rifampicin, 4% of MRSA resistant to fusidic acid, 12% of all strains (60% of MRSA) resistant to ciprofloxacin, 27% of all strains resistant to trimethoprim

S. auricularis: novobiocin susceptible; pathogenicity rare/undetermined

S. capitis: novobiocin susceptible, maltose negative; 1-44% of coagulase negative staphylococcal colonisers; uncommon pathogen; susceptible to meropenem (MIC 0.25 mg/L)

S. caseolyticus: novobiocin susceptible; found in animals and animal products

S. cohnii: novobiocin resistant; sucrose and xylose negative; no colonisers, 2% of coagulase negative staphylococcal disease isolates; susceptible to meropenem (MIC 1 mg/L)

S. epidermidis: glucose cell wall teichoic acid; yellow pigmented strains; anaerobic growth; glucose, maltose and phosphatase positive; mannitol, trehalose, glycerol and heat-resistant endonucleases negative; novobiocin susceptible; 57% of coagulase negative staphylococcal colonisers, 45-66% of disease isolates; normal flora of mouth, nose (adherence to nasal mucosa ++), tonsils, throat, external genitalia, anterior urethra (rare), vagina (57%); causes acne, pimples, catheter-induced bacteraemia in neutropenics (74% of bacteraemia and septicemia due to coagulase negative staphylococci), blepharitis, 2% of brain abscess, cerebrospinal fluid shunt infections, complication of cardiac surgery, acute cystitis, endocarditis, endometritis, catheter-induced septic arthritis in neutropenics, 5% of surgical wound infections, thrombophlebitis, 3% of nosocomial infection, 12% of vascular graft infection, infections in abnormal host (interrupted integument); slime production important in endocarditis; susceptible to sodium fusidate, linezolid, synergid, vancomycin (MIC 0.5-1 mg/L; resistance reported from Slovak Republic), rifampicin; variably susceptible to di/flucloxacillin, amoxicillin-clavulanate, piperacillin-tazobactam, ticarcillin-clavulanate, imipenem, meropenem, clindamycin, lincomycin

S. equorum: novobiocin resistant; found in animals and animal products

S. felis: novobiocin susceptible; found in animals and animal products

S. gallinarum: novobiocin resistant; found in animals and animal products

S. haemolyticus: novobiocin susceptible; maltose and mannitol positive; 8% of coagulase negative staphylococcal colonisers, 10-38% of disease isolates; susceptible to ofloxacin (MIC 0.5 mg/L), pefloxacin (0.5 mg/L), ciprofloxacin (0.5-1 mg/L), enoxacin (1mg/L), amifloxacin (1mg/L)

S. hominis: novobiocin susceptible; maltose and trehalose positive; mannitol negative; 35% of coagulase negative staphylococcal colonisers, 4-15% of disease isolates, 14% of isolates from bacteraemia and septicemia; susceptible to ofloxacin (MIC 0.5 mg/L), ciprofloxacin (1 mg/L), amifloxacin (1mg/L), pefloxacin (1 mg/L)

S. hyicus: coagulase variable, novobiocin susceptible; found in animals and animal products

S. intermedius: 27% coagulase positive; causes dog bite wound infections; 100% susceptible to dicloxacillin, amoxicillin-clavulanate

S. klivosii: novobiocin resistant; found in animals and animal products

S. lentus: found predominantly in animal products

S. lugdunensis: tube coagulase negative, clumping factor usually positive, usually weak positive thermostable DNase reaction; novobiocin susceptible, nitrofurantoin susceptible; urease, ornithine decarboxylase, PYR, glucose, fructose, sucrose, maltose, lactose, trehalose, N-acetylglucosamine positive; arginine dihydrolase, ?-galactosidase, ?-glucosidase, esculin, mannitol and raffinose negative; causes endocarditis (mainly community acquired, usually preexisting cardiac abnormality), venous catheter infection, peritonitis, endophthalmitis, wound infection, septic arthritis; susceptible to cotrimoxazole (MIC

? 0.03-0.06 mg/L), gentamicin (? 0.06 mg/L), tobramycin (? 0.06 mg/L), erythromycin (? 0.06 mg/L), pristinamycin (? 0.06 mg/L), minocycline (? 0.06 mg/L), fusidic acid (? 0.06 mg/L), rifampicin (? 0.06 mg/L), penicillin (? 0.06-1 mg/L), lincomycin (0.25 mg/L), teicoplanin (0.25-0.5 mg/L), kanamycin (0.25-0.5 mg/L), oxacillin (0.25-1 mg/L), pefloxacin (0.5 mg/L), meropenem (0.5 mg/L), vancomycin (0.5-1 mg/L)

S. saccharolyticus: resistant to novobiocin and SPS; susceptibility to metronidazole variable; produces formic and acetic acids

S. saprophyticus: ribitol-N-acetylglucosamine and glycerol-N-diacetylglucosamine cell wall teichoic acids; weak anaerobic growth; coagulase and Staphyslide negative (typically, reaction in both test and control); novobiocin resistant; weak glucose and sucrose fermentation; xylose, phosphatase and heat-resistant endonucleases negative; 2% of coagulase negative staphylococcal colonisers, 2-4% of disease isolates; causes chronic bacteriuria related to infected bladder or renal stones, acute cystitis and pyelonephritis in otherwise healthy young women, bacteraemia and septicemia (rare cases associated with sexual intercourse and/or urinary obstruction), endocarditis, prostatitis and vesiculitis, infections in abnormal host; susceptible to nitrofurantoin (100%), all penicillins, all cephalosporins, imipenem, meropenem (MIC 0.5 mg/L), chloramphenicol, clindamycin, lincomycin, macrolides, tetracyclines, linezolid, synergid, cotrimoxazole (5% resistance in USA), trimethoprim, vancomycin, teicoplanin, rifampicin/rifabutin, sodium fusidate

S. schleiferi subsp coagulans: coagulase positive; novobiocin susceptible; maltose and sucrose negative; uncommon pathogen in dog bite wounds

S. sciurii: 2% of coagulase negative staphylococcal colonisers, no disease isolates

S. simulans: novobiocin susceptible; maltose negative; uncommon pathogen

S. warneri: novobiocin susceptible; maltose and mannitol positive; occasional colonisers, 3% of coagulase negative staphylococci disease isolates, 6% of coagulase negative staphylococci isolated from bacteraemia and septicemia

S. xylosus: novobiocin resistant; xylose positive; sucrose negative; no colonisers, 2% of coagulase negative staphylococcal disease isolates

'Coagulase Negative Staphylococci': Gram positive cocci in clusters; catalase positive; coagulase negative; cause 5% of bacteraemia and septicemia, blepharitis, bursitis, cat and dog bite infections, 0.5% of carpal tunnel syndrome, endophthalmitis (postoperative, posttraumatic), generalised infections in patients in whom inanimate objects have been inserted into vascular system (valve prostheses, ventricular shunt devices, intravenous cannulae), human bite and clenched fist injury infections, local abscesses related to foreign bodies in tissues (joint prostheses), chronic mastitis and breast abscess, 1% of necrotising fasciitis, osteomyelitis and osteochondritis, 7% of otitis externa (including rare malignant), peritonitis (primary and associated with continuous peritoneal dialysis), pyelonephritis only

after instrumentation (except *S.saprophyticus*), systemic infections in granulocytopenics; usually susceptible to vancomycin (< 5% resistance in Australia), rifampicin, fucidin; commonly susceptible to penicillin, methicillin, oxacillin, erythromycin, cotrimoxazole, trimethoprim

Family Deinococcaceae

Streptococcus: Gram positive, cells round to slightly elongated, single and in short to long chains in liquid culture, may be encapsulated; adherence to blood agar and haemolysis variable; colonies small; growth in 5% NaCl, no growth in 6.5% NaCl, anaerobic growth in glucose variable; catalase negative; no gas from glucose; have no cytochromes; normal flora of vagina (25%), upper respiratory tract; causes abortional and puerperal infections, 15-20% of septic arthritis, 8% of brain and epidural abscess, acute bronchitis, bursitis, 2% of carpal tunnel syndrome, cat and dog bite infections, cholangitis and cholecystitis, purulent conjunctivitis, croup, dental caries (endogenous), 31-46% of endocarditis, acute epididymitis and epididymo-orchitis, erysipelas, erythema nodosum, 22% of false aneurism, subacute febrile disease, emphysematous gastritis, impetigo, laryngotracheitis, local and generalised sepsis, mastitis and breast abscess, post-neonatal pyogenic meningitis, mycotic aneurism, 30% of necrotising fasciitis, osteomyelitis and osteochondritis, paronychia, perinatal generalised disease, peritonitis, pneumonia, pulmonary abscess, rhabdomyolysis, septicemia (in haemorrhagic fever), sore throat, symbiotic gangrene, symmetric peripheral gangrene, thyroiditis, tubo-ovarian abscess, vaginitis in prepubertal girls and elderly women, 2% of nosocomial infection, infections in abnormal host (neutrophil dysfunction); infection generally confined to epithelial surfaces; haemolysins (streptolysin O and S) induce lysosomal discharge into cell cytoplasm killing phagocyte, cause cell membrane lysis and also inhibit polymorph chemotaxis; M substance on fimbriae resists phagocytosis and digestion; C carboprotein protects from lysozyme; microbial antigens vary within host population; multiplies outside cells, but attachment to body surface necessary for invasion; fibrinolysin (streptokinase) and hyaluronidase cause spread of infection; growth stimulated by excess iron; primary immune defence prevention of attachment by coating microbial surface with specific antibody (mainly secretory IgA); neutralisation of microbial toxins also important; recovery from primary infection due to antibody; mean doubling time 20 minutes in vitro; treatment: penicillin (< 5% resistance in Australia), amoxycillin, ampicillin, clindamycin, erythromycin, roxithromycin, vancomycin (resistance not yet reported), amoxycillin-clavulanate; usually susceptible to oxacillin, cotrimoxazole, trimethoprim, chloramphenicol, cefotaxime, ceftriaxone, commonly susceptible to tetracycline; 100% intrinsic resistance to aminoglycosides because of thick peptidoglycan

S.agalactiae: ?-haemolytic (also ?, ?); group B; PYR negative; may be bacitracin susceptible; esculinase positive; normal flora of vagina, nasopharynx; causes amnionitis, bacteraemia and septicemia (in neonates and hospitalised patients with underlying disease), asymptomatic bacteriuria, acute cystitis, cellulitis and pyomyositis (rare in diabetics), endocarditis (rarely), perinatal generalised disease, various diseases of neonate (abscess, endocarditis, meningitis, myocarditis, 40% of neonatal osteomyelitis, septicemia), neonatal and postneonatal pyogenic meningitis (? 100 cases/y in USA; 3-6% of bacterial meningitis; incidence 0.09/100 000 (42/100 000 at age < 1 mo); case-fatality rate 12-24%), peritonitis (primary and secondary), acute pharyngitis and exudative tonsillitis (mild and self-limiting), pneumonia, pyelonephritis, important cause of reproductive tract infections in women (chorioamnionitis, endometritis), local and generalised sepsis, septic abortion, septic arthritis (stage III prosthetic infection), 2% of surgical wound infections, toxic shock syndrome, urinary tract infections, infections in abnormal host; mastitis in cow (attaches to duct epithelium); selective adherence to urogenital tissue; diagnosis: culture, coagglutination; treatment: penicillin (< 5% resistance in Australia), cefotaxime (? 0.06-0.25 mg/L), ceftriaxone; also susceptible to cefamandole (0.06 mg/L), erythromycin (0.06 mg/L), clindamycin (0.06 mg/L), meropenem (0.06 mg/L), ampicillin (0.12 mg/L), cefuroxime (? 0.25 mg/L), cotrimoxazole (100% susceptible at 0.25 mg/L), cefixime (? 0.25-1 mg/L), cefaclor (0.5 mg/L), ceftazidime (0.5 mg/L), mupirocin (0.5 mg/L), imipenem (100%), cefoxitin (100%), ampicillin (100%), amoxycillin, amoxycillin-clavulanate, vancomycin (resistance not yet reported), levofloxacin (2% resistance in USA); resistant to enoxacin, norfloxacin, amikacin, nalidixic acid, pefloxacin, gentamicin, tobramycin, neomycin, chloramphenicol, colistin, sulphamethoxazole; in Australia, 79% acquired resistance to tetracycline

S.anginosus: part of *S.milleri* group; ?-, ?- or ?-haemolytic, minute colony; group C or F; trehalose and VP positive; sorbitol negative; oral flora; pathogenicity uncommon in animals, rare in humans; causes endocarditis

S.bovis: ?- or ?-haemolytic (rarely ?); no growth at 50°C; group D (non-enterococcus); lactose and starch positive, bile tolerant; causes bacteraemia (possible indicator of colonic carcinoma), endocarditis, infections in abnormal host,

urinary tract infections; treatment: penicillin or amoxycillin + gentamicin, netilmicin or streptomycin; may be tolerant to penicillin, oxacillin, ampicillin, cephalothin, vancomycin; also susceptible to amoxycillin-clavulanate (100% at 0.12 mg/L), cefaclor (100% at 0.25 mg/L), meropenem (0.25 mg/L), cotrimoxazole (100% at 0.5 mg/L), ciprofloxacin (1 mg/L), cefixime (1 mg/L)

S. canis: ?-haemolytic (also ?, ?); group G; PYR negative; normal habitat nasopharynx, skin; causes acute glomerulonephritis (occasional), bacteraemia and septicemia (from cellulitis or abscess in patients with malignancies), cellulitis, endocarditis (rare), empyema, meningitis, osteomyelitis and osteochondritis (sacroilitis), otitis media, acute pharyngitis and exudative tonsillitis (mild and self-limiting), local and generalised sepsis, ulcers (rare), wound infections (rare); diagnosis: culture, coagglutination; susceptible to ceftizoxime (100% at ? 0.015 mg/L), imipenem (100% at ? 0.015 mg/L), penicillin (< 5% resistance in Australia), rifampicin (100% at 0.03 mg/L), ampicillin (100% at 0.06 mg/L), clindamycin (0.12 mg/L), azlocillin (100% at 0.125 mg/L), ceftazidime (0.125 mg/L), daptomycin (100% at 0.25 mg/L), cefotaxime (100% at 0.5 mg/L), ceftriaxone (100% at 0.5 mg/L), cefuroxime (100% at 0.5 mg/L), mezlocillin (100% at 0.5 mg/L), flucloxacillin (100% at 0.5 mg/L), cefazolin (100% at 1 mg/L), vancomycin (resistance not yet reported), cefoxitin (1 mg/L), netilmicin (1mg/L); resistant to enoxacin, norfloxacin

S. constellatus: part of *S. milleri* group; microaerophilic; susceptible to novobiocin; resistant to metronidazole and SPS; produces lactic and acetic acids; oral flora; causes 2% of bacteraemia and septicemia due to '*S. viridans*', endocarditis

S. crista: viridans group

S. dysgalactiae: ? or ? haemolysis, large colonies; group C; trehalose positive; VP negative; sorbitol variable; causes mastitis in cow

S. equi: ?-haemolytic, large colonies; group C; VP, hippurate, trehalose and sorbitol negative; normal habitat nasopharynx, skin; causes bacteraemia and septicemia, infections in abnormal host, skin and wound infections (rare), endocarditis (rare), strangles in horse; susceptible to meropenem (MIC 0.03 mg/L)

S. equinus: group D (non-enterococcus); lactose negative; causes infections in abnormal host

S. equisimilis: ?-haemolytic, large colonies; group C; trehalose positive; VP, hippurate, and sorbitol negative; produces streptokinase or streptolysin O; commonly pathogenic in humans (bacteraemia and septicemia, endocarditis, rare cases of pneumonia secondary to tonsillitis and bronchitis), uncommonly in animals

S. gordonii: *S. sanguis* group; oral; causes endocarditis

S. hansenii: taxonomic position uncertain; related to *Clostridium aminovalericum* and *Clostridium sphenoides*

S. iniae: causes invasive disease in fish grown in aquaculture and hand cellulitis and endocarditis in humans handling such fish

S. intermedius: part of *S. milleri* group; microaerophilic; susceptible to novobiocin; resistant to metronidazole and SPS; produces lactic and acetic acids; oral; causes 7% of bacteraemia and septicemia due to '*S. viridans*', endocarditis

S. milleri: *S. anginosus*, *S. constellatus*, *S. intermedius*; group A, C, F, G or non-groupable; normal flora of teeth (28%), throat (31%), intestinal tract (15%), vagina (18%); causes abscesses, appendicitis, bacteraemia and septicemia (possible indicator of hidden abscess), brain abscess, cellulitis, cholangitis and cholecystitis, empyema, endocarditis, hepatic abscess, mouth abscess, osteomyelitis, pneumonia, parametritis, pelvic abscess, pelvic inflammatory disease, perinatal generalised disease, peritonitis (primary and secondary), sinusitis, surgical infections, wound infections; treatment: penicillin (< 5% resistance in Australia) or amoxycillin + surgery; also susceptible to meropenem (MIC 0.06 mg/L), vancomycin (resistance not yet reported)

S. mitis: *S. sanguis* group; lactose positive; starch negative; not bile tolerant; oral; selective adherence to buccal mucosa; adherence to nasal mucosa +; causes 41% of bacteraemia and septicemia due to '*S. viridans*', acute cystitis, endocarditis, perinatal generalised disease; susceptible to meropenem (MIC 1 mg/L)

S. morbillorum: microaerophilic; susceptible to novobiocin; resistant to metronidazole and SPS; produces lactic and acetic acids; causes 13% of bacteraemia and septicemia due to '*S. viridans*'

S. mutans: viridans group; non-grouping; regular inhabitant of mouth; low adherence to nasal mucosa; causes 2% of bacteraemia and septicemia due to '*S. viridans*', dental caries, endocarditis; initiates plaque on tooth by binding to glycosyltransferase, linked to glucan 'glue' (bacterial product), and attached to teeth

S. oralis: *S. sanguis* group; oral; causes endocarditis

S. parasanguis: *S. sanguis* group; causes endocarditis

S. parvulus: taxonomic position uncertain; related to *Peptostreptococcus*; susceptible to metronidazole and novobiocin; resistant to SPS; lactic and acetic acids produced

S. pleomorphus: taxonomic position uncertain; related to *Clostridium innocuum*; colon

S. pneumoniae: Gram positive, oval-shaped cocci in pairs or short chains; ? - (rarely ?-) haemolytic; catalase negative; non-grouping; optochin susceptible; bile soluble; bile-esculin, NaCl and PYR negative; normal upper respiratory tract (mouth, nose, throat, tonsils) commensal (6% of adults without children to 38% of children 0-5 y), can spread to infected or damaged lungs; causes septic arthritis (52% of community acquired infections), 4-8% of bacteraemia and septicemia, brain abscess (occasional), bronchiectasis, acute bronchitis, acute bronchiolitis and bronchopneumonia, cellulitis (children, chronic illness, alcoholics, i.v. drug users), cervical fascial space infections, purulent conjunctivitis, croup, dacryocystitis, adenitis and canaliculitis, acute empyema, acute endocarditis, endometritis, endophthalmitis (septicemia), acute epiglottitis (10% of adult cases), haemolytic uraemic syndrome, keratitis and iritis, laryngotracheitis, mastoiditis, early neonatal and post-neonatal meningitis (? 500 cases/y in USA; 11-18% of bacterial meningitis; incidence 0.3/100 000 (8/100 000 at age 3-5 mo); case-fatality rate 19-28%), mycotic aneurism, nasal septal abscess, nasopharyngitis, 2% of osteomyelitis and osteochondritis, otitis media, pancreatic abscess, parametritis, pelvic abscess, pelvic inflammatory disease (IUD, recent birth, gynecologic surgery), pericarditis, perinatal generalised disease, peritonitis (primary and spontaneous), peritonsillar abscess, acute lobar pneumonia, pulmonary abscess, preseptal and postseptal cellulitis, local and generalised sepsis (associated with connective tissue disorders), rhabdomyolysis, septicaemic adrenal haemorrhage syndrome, acute and chronic sinusitis, splenic abscess (rare), thyroiditis, vaginitis in infant girls, 0.6% of nosocomial infections (80% lower respiratory tract), infections in abnormal host (?-globulin dysfunction, splenic dysfunction), systemic infection in agammaglobulinemia, C1, 2, 3, 4, factor B deficiency, hyposplenism/splenectomy; case-fatality rate from 3% in bacteremic pneumococcal pneumonia in patients 14-29 y to 75% in extrapulmonary pneumococcal infection ? pneumonia in patients 70+ y; extracellular; polysaccharide capsule resists phagocytosis (unless antibody present) and digestion; type-specific polysaccharides associated with invasiveness (virulence factor); shows leucotoxicity; carried in blood free in plasma; microbial surface antigens in extracellular fluids combine with and 'divert' antibodies; hyaluronidase causes spread of infection; primary bodily defence mechanism humoral immune responses (?-lysin+, phagocytosis +, alternative complement +, immune adherence (phagocytosis) + + +); diagnosis: counterimmunoelectrophoresis (antigen; type 14 not applicable due to neutral charge), smear and culture (CSF, sputum, body fluids), Quellung reaction, coagglutination, ELISA (sputum; sensitivity 96%, specificity 93%); susceptible to amoxy/ampicillin (in Australia, 6% resistance in hospitals and 2% in private laboratories), amoxicillin-clavulanate, cefaclor (MIC 0.5 mg/L), erythromycin (12% resistance in Australia), doxycycline/tetracycline (13% resistance in Australia), minocycline, roxithromycin (12% resistance in Australia), azithromycin, clarithromycin, penicillin (in Australia, 9% MIC ? 0.5 mg/L), cefotaxime (resistance not yet confirmed in Australia), ceftriaxone (< 1 mg/L), cefepime, vancomycin/teicoplanin (resistance not yet reported), cefmenoxime (0.01-0.06 mg/L), apalcillin (? 0.02 mg/L), azlocillin (? 0.02 mg/L), mezlocillin (< 0.02-0.25 mg/L), cefpiramide (0.02-0.25 mg/L), cefpirome (0.02-0.25 mg/L), clindamycin/lincomycin (< 0.06 mg/L), meropenem (0.06-1 mg/L), carbenicillin (? 0.25 mg/L), ticarcillin (? 0.25-1 mg/L), cefuroxime (0.5 mg/L), imipenem (100% at < 1 mg/L), meropenem, ceftizoxime (< 1 mg/L), cephalothin, cephazolin (< 1 mg/L), cefoperazone (< 1 mg/L), ceftazidime (< 1 mg/L), cefamandole (< 1 mg/L), piperacillin (1 mg/L), piperacillin-tazobactam, ticarcillin-clavulanate, mupirocin (1 mg/L), ofloxacin (1 mg/L), cefotetan, cefoxitin (100%), cephalexin, gatifloxacin, moxifloxacin, chloramphenicol (3% resistance in Australia), linezolid, synercid; in Australia, 80% resistance to cotrimoxazole, 52% resistant to trimethoprim

S. pyogenes: Gram positive cocci in chains; nonmotile; ?-haemolytic (rarely ?); group A; bacitracin susceptible (0.04 ?g disc); resistant to 23.75 ?g sulphamethoxazole + 1.25 ?g trimethoprim disc; PYR, lactose, trehalose, glucose and salicin positive; hippurate, sorbitol, catalase, nitrate, esculin and mannitol negative; normal habitat nasopharynx (adherence to nasal mucosa + + +), skin, rectum, female genital tract (low numbers; adherence to labium majus + +); causes many human diseases, including abortifacient and puerperal infections, appendicitis, bacteraemia and septicemia, cellulitis (may be gangrenous or pyomyositis in diabetes), cervical adenitis, cranial fascial space infections, acute dacryocystitis, adenitis and canaliculitis, disseminated sepsis, acute empyema, endocarditis, endophthalmitis (septicaemic, posttraumatic), erysipelas, erythema marginatum (in 10% of cases of acute rheumatic fever), parametritis, pelvic abscess, pelvic inflammatory disease, perinatal generalised disease, glomerulonephritis (immunopathological basis; after

pharyngitis or impetigo), impetigo, localised skin lesions, mastitis and breast abscess, postneonatal pyogenic meningitis, nasopharyngitis, otitis media, peritonsillar abscess, primary and secondary pneumonia (rarely; including diffuse interstitial pneumonia), pulmonary abscess, preseptal and postseptal cellulitis (secondary to puncture wounds or lacerations), purulent conjunctivitis, pyoderma (occasional in association with *Staphylococcus aureus*), rhabdomyolysis, rheumatic fever (immunopathological basis; after infection of upper respiratory tract), scarlet fever (erythematous rash), local and generalised sepsis, septic arthritis (15% of total adult cases), septicaemic adrenal syndrome, acute and chronic sinusitis, sore throat, acute exudative tonsillitis, nonexudative pharyngitis and tonsillitis, acute tracheitis, 0.7% of surgical wound infections, chronic ulcers, vaginitis in prepubertal girls and elderly women, water-related infections (especially coral cuts), infections in abnormal host (interrupted integument, surgical procedure, neutrophil dysfunction), systemic infections in C1, 2, 3, 4, factor B deficiency, obsessive-compulsive disorder, attention deficit/hyperactivity disorder; 9600-9700 cases of invasive disease/y (1100-1200 deaths/y) in USA; binds to pharyngeal epithelium and skin via lipoteichoic acid on fimbriae (associated with invasiveness; virulence factor); adherence to nasal mucosa ++++; extracellular; erythrogenic toxin (3 antigenic types) causes vasodilation, producing scarlet fever rash (stimulates production of inhibitory antibody); leucocidin and streptolysins (streptolysin O, but not streptolysin S, stimulates production of inhibitory antibody) kill phagocytes; streptokinase lyses fibrin, ? promoting spread of bacteria in tissues (virulence factor; stimulates production of inhibitory antibody); hyaluronidase liquefies connective tissue matrix, ? promoting spread of bacteria in tissues (virulence factor; stimulates production of inhibitory antibody); also produces haemolysins, streptodornase, NADase, DPNase (stimulates production of inhibitory antibody), proteinase (may stimulate production of inhibitory antibody), amylase (stimulates production of inhibitory antibody), esterases (do not stimulate production of inhibitory antibody), DNase (stimulates production of inhibitory antibody); inhibits phagocytic attachment and ingestion; capsular hyaluronic acid and cell wall M (virulence factors, inhibit phagocytosis; anti-M protein antibodies confer specific immunity; hyaluronic acid not antigenic), T and R proteins and group-specific carbohydrates (A-rhamnose-N-acetylglucosamine) associated with invasiveness; acid shows leucotoxicity; kidney deposits of circulating immune complexes cause glomerulonephritis; major host defences ?-lysin (+), phagocytes (+), alternative complement (+), interference with adherence (+), immune adherence (phagocytosis) (+++); protection depends on antibody against M protein; antibodies to various toxins do not prevent infection but may mitigate effects (eg., antierythrogenic toxin prevents rash of scarlet fever, antistreptokinase inhibits digestion of fibrin by streptokinase-plasminogen-plasmin system); diagnosis: indirect haemagglutination (Streptozyme? ; ? 1:100), direct fluorescent antibody on throat swab, antistreptolysin O (? 166 Todd units, ? 170 IU), antideoxyribonuclease B (? 1:170), antihyaluronidase (? 1:256), throat swab culture, blood cultures, coagglutination, latex agglutination; susceptible to penicillin (resistance not yet reported), erythromycin (8% resistant in Australia), azithromycin, clarithromycin, roxithromycin, clindamycin, lincomycin, amoxicillin, cefotaxime (< 1 mg/L), ceftriaxone (< 1 mg/L), cefepime, di/flucloxacillin, cephalothin, vancomycin/teicoplanin (resistance not yet reported), cephalexin (0.5-1 mg/L), sulphadiazine, imipenem (0.008 mg/L), meropenem (? 0.01 mg/L), cefmenoxime (0.01-0.03 mg/L), apalcillin (? 0.02 mg/L), azlocillin (? 0.02 mg/L), mezlocillin (? 0.02-0.25 mg/L), piperacillin (? 0.02-0.25 mg/L), piperacillin-tazobactam, cefpiramide (0.02-0.25 mg/L), cefpirome (0.02-0.25 mg/L), amoxicillin-clavulanate (100% at ? 0.06 mg/L), cotrimoxazole (? 0.06-1 mg/L), cefotetan (? 0.12 mg/L), mupirocin (0.12 mg/L), oxacillin (? 0.25 mg/L), ampicillin (? 0.25 mg/L), cefuroxime (? 0.25 mg/L), carbenicillin (? 0.25-1 mg/L), ticarcillin (? 0.25-1 mg/L), ticarcillin-clavulanate, ceftazidime (0.25 mg/L), cefaclor (100% at 0.5 mg/L), cefixime (< 1 mg/L), ceftizoxime (< 1 g/L), ceftazidime (< 1 mg/L), cefoperazone (< 1 mg/L), cefoxitin (< 1 mg/L), cefamandole (< 1 mg/L), cephalosin (< 1 mg/L), tetracyclines (1 mg/L), trimethoprim, gatifloxacin, moxifloxacin, sodium fusidate, linezolid, synergid, rifampicin, rifabutin, trimethoprim, cotrimoxazole, usually susceptible to chloramphenicol

S. salivarius: viridans group; no growth at 50°C; group K; lactose positive; starch negative; not bile tolerant; oral; binds to buccal epithelium and tongue via ? lipoteichoic acid on fimbriae or ? lipoprotein fibrillar coat; adherence to nasal mucosa +; causes 2% of bacteraemia and septicemia due to *Streptococcus viridans*, endocarditis, infections in abnormal host

S. sanguis: viridans group; group H; oral; selective adherence to teeth; causes 22% of bacteraemia and septicemia due to *Streptococcus viridans*, brain abscess in intermittently treated jaw infections, endocarditis (fibronectin binding

important factor), infections in abnormal host; IgA proteases interfere with IgA1; treatment: penicillin; also susceptible to ciprofloxacin (MIC 0.25 mg/L), meropenem (1 mg/L)

S. sobrinus: viridans group

S. suis: groups R and S but cross-reacts with group D; causes postneonatal pyogenic meningitis in pig workers; treatment: penicillin, cefotaxime, ceftriaxone

S. uberis: group E; causes mastitis in cattle

S. vestibularis: viridans group

'*S. viridans*': ?-haemolytic; bile esculin, NaCl and PYR negative; normal flora of skin, mouth, throat, large intestine, lower ileum, external genitalia (adherence to labium majus +), anterior urethra (rare), vagina, eye; does not adhere to nasal mucosa; oral commensals settle on abnormal heart valves during bacteraemia (dextran important factor); causes appendicitis, 3-5% of bacteraemia and septicemia, cholangitis and cholecystitis, 50-70% of subacute bacterial endocarditis cases, endophthalmitis (conjunctival filtering-bleb associated, bloodborne), keratitis and iritis, osteomyelitis and osteochondritis, perinatal generalised disease, peritonitis in continuous ambulatory peritoneal dialysis, psoas abscess, acute and chronic sinusitis, subacute febrile disease; susceptible to penicillin, amoxy/ampicillin, amoxicillin-clavulanate, erythromycin

(MIC < 0.06 mg/L), azithromycin, clarithromycin, roxithromycin, clindamycin (< 0.06 mg/L), lincomycin, vancomycin/teicoplanin (resistance reported in USA and Europe), cefotaxime (0.5 mg/L), ceftriaxone, cefepime, cefpirome, ceftazidime, piperacillin (0.5 mg/L), piperacillin-tazobactam, ticarcillin-clavulanate, cephalexin, cephalothin, cephalosporin, cefazolin, cefaclor, cefuroxime, cefotetan, cefoxitin (100%), imipenem (100%), meropenem, gatifloxacin, moxifloxacin, chloramphenicol, linezolid, synergid

S. zooepidemicus: ?-haemolytic, large colonies; group C; sorbitol positive; hippurate and trehalose negative; causes infections in horses, bacteraemia and septicemia, endocarditis and rare foodborne outbreaks in humans

Group C *Streptococcus*: *S. dysgalactiae*, *S. equi*, *S. equisimilis* (also some *S. milleri* group); haemolysis variable; PYR negative; cause bacteraemia and septicemia in cardiovascular disease and malignancy, endocarditis, acute epiglottitis (1 case), acute pharyngitis, acute exudative tonsillitis, acute and chronic sinusitis, pneumonia (rare), local and generalised sepsis, cellulitis, impetigo, myocarditis and pericarditis (rare), perinatal generalised disease, post-streptococcal glomerulonephritis (occasional), neonatal meningitis, 0.8% of otitis externa, septic arthritis, osteomyelitis and osteochondritis, many animal diseases; most infections in man due to *S. equisimilis*; treatment: penicillin (< 5% resistance in Australia), flucloxacillin, erythromycin; 100% susceptible to vancomycin, ciprofloxacin, imipenem; resistant to enoxacin

Group D '*Streptococcus*': *Enterococcus*, *S. bovis*, *S. equinus*; haemolysis variable; bile esculin positive; dairy products, intestinal tract of man and animals; cause bacteraemia and septicemia, endocarditis, local and generalised sepsis, neonatal sepsis, nosocomial infection, perianal and perirectal abscess and cellulitis in patients with malignant disease, pelvic abscess, perinatal generalised disease, peritoneal abscess, septic endometritis, septic meningitis, septic thrombophlebitis, 10% of surgical wound infections, urogenital infection; diagnosis: culture, coagulability; treatment: penicillin or ampicillin + gentamicin

Group E *Streptococcus*: haemolytic; cause pharyngeal abscesses in swine

Group F *Streptococcus*: some *S. milleri* group; haemolytic; PYR negative; found in respiratory tract; susceptible to penicillin (< 5% resistance in Australia), vancomycin (resistance not yet reported)

Group G *Streptococcus*: *S. canis* and some *S. milleri* group; haemolytic; cause mild respiratory infections and occasional post-streptococcal glomerulonephritis in man, rare genital infections in dogs; susceptible to meropenem (MIC 0.03 mg/L)

Group H *Streptococcus*: haemolysis variable; found in respiratory tract of man

Group K *Streptococcus*: haemolysis variable; found in respiratory tract of man

Group L *Streptococcus*: haemolytic; cause more invasive vaginitis in dogs

Group M *Streptococcus*: haemolytic; non-pathogen in dog's vagina

Group N *Streptococcus*: non-haemolytic; dairy foods

Group O *Streptococcus*: haemolysis variable; carried in upper respiratory tract of man; cause endocarditis

Abiotrophia defectiva: nutritionally variant *Streptococcus* (requires pyridoxal); oral flora; causes endocarditis

Granulicatella adiacens: nutritionally variant *Streptococcus* (requires pyridoxal); oral flora; causes endocarditis

G. balaenopterae: nutritionally variant *Streptococcus* (requires pyridoxal); oral flora; causes endocarditis

G. elegans: nutritionally variant *Streptococcus* (requires pyridoxal); oral flora; causes endocarditis

Enterococcus: does not share close relationship with streptococci by DNA-RNA homology and differs from them in relative resistance to penicillin, high salt tolerance and cell wall antigens; Gram positive cocci in pairs or short chains; catalase negative; bile esculin, 6.5% NaCl and PYR positive; normal flora of mouth, tonsils, nose, large intestine, lower ileum, external genitalia, anterior urethra, vagina; causes bacteraemia and septicemia, asymptomatic bacteriuria, cerebrospinal fluid shunt infections, cholecystitis, acute cystitis, acute empyema, endocarditis, intraabdominal abscess, early neonatal meningitis, perinatal generalised disease, peritonitis (primary, secondary and continuous ambulatory peritoneal dialysis), pneumonia, postoperative complications, psoas abscess, pyelonephritis, 8% of nosocomial infections, infections in abnormal host (neutrophil dysfunction); selective adherence to endocardium; treatment: penicillin, amoxicillin or ampicillin (except in *E. faecium*, resistance not yet confirmed in Australia; 8% in USA) ? gentamicin or streptomycin, vancomycin; also susceptible to teicoplanin (0.06-0.5 mg/L), nitrofurantoin (2% resistance in USA); 100% intrinsic resistance to aminoglycosides, all cephalosporins, flucloxacillin, clindamycin; in Australia, 1% resistance to vancomycin (VanA: inducible by vancomycin or teicoplanin, vancomycin MIC > 256, teicoplanin MIC 16-256; VanB inducible by vancomycin only but exposure to vancomycin leads to teicoplanin resistance, vancomycin MIC 8-256, teicoplanin MIC 0.125-8; VanC constitutive, caused by chromosomally encoded genes (not transferable) found in all strains of *E. cassiloflavus*, *E. flavescens* and *E. gallinarum*, vancomycin MIC 4-16, teicoplanin MIC 0.125-8); < 5% ?-lactamase producers in Australia

E. avium: group D; causes bacteraemia and septicemia in gastrointestinal tract abnormalities, infections in abnormal host; susceptible to ciprofloxacin (MIC 1 mg/L)

E. durans: ?-haemolytic; group D; mannitol and sorbitol negative; causes infections in abnormal host; susceptible to amoxicillin-clavulanate (100% at 0.25 mg/L), cotrimoxazole (100% at 1 mg/L)

E. faecalis: ?- or ?-haemolytic (rarely ?); usually nonmotile; group D; bile esculin, 6.5% NaCl, glucose, salicin and mannitol positive; gelatine, catalase and nitrate negative; normal habitat gastrointestinal and genital tracts; causes abortional and puerperal infections, 0.5% of carpal tunnel syndrome, cholangitis and cholecystitis, endocarditis, gastroenteritis (rare), postneonatal pyogenic meningitis (infrequent in granulocyte disorders), peritonitis (rarely), acute pyelonephritis (rarely), septic arthritis, symbiotic gangrene, infections in abnormal host; treatment: vancomycin (0.4% resistance in Australia) or teicoplanin, penicillin or amoxy/ampicillin (0.7 % resistance in Australia) + gentamicin (12% high level resistance in Australia), amikacin, tobramycin or netilmicin; also susceptible to cotrimoxazole (MIC ? 0.06 mg/L), minocycline (0.2 mg/L), amoxicillin-clavulanate (100% at 0.5 mg/L), piperacillin, piperacillin-tazobactam, thienamycin (1 mg/L), imipenem, meropenem, linezolid, trimethoprim; variably susceptible to gatifloxacin, moxifloxacin; resistant to aminoglycosides (but synergy with cell wall active agent) and cephalosporins

E. faecium: group D; causes gastroenteritis (rare), infections in abnormal host; susceptible to cotrimoxazole (100% at ? 0.06 mg/L), amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, linezolid, synergic, trimethoprim; resistant to all cephalosporins, ciprofloxacin, enoxacin, norfloxacin; variably susceptible to gatifloxacin, moxifloxacin; in Australia, 69% resistant to ampicillin, 29% to gentamicin (high level), 7% to vancomycin; used as probiotic

Lactococcus: growth at 10°C; no gas from glucose; susceptible to vancomycin

Leuconostoc: catalase negative, produces gas from glucose, bile-esculin 90% positive, 6.5% NaCl variable; causes rare cases of bacteraemia and septicemia associated with parenteral nutrition, other catheters and previous antimicrobial therapy; treatment: penicillin (MIC 1 mg/L), clindamycin; also susceptible to erythromycin (< 0.25 mg/L), cephazolin; resistant to vancomycin

Pediococcus: bile esculin positive, 6.5% NaCl variable, no gas from glucose, PYR negative, 95% react with streptococcal group D antiserum; resistant to vancomycin

Aerococcus: no growth at 45°C or 10°C; catalase negative, bile esculin, NaCl and PYR positive, no gas from glucose; susceptible to vancomycin

A. viridans: causes pseudobacteremia and, rarely, endocarditis and meningitis

Gemella: no growth at 45°C or 10°C; catalase and bile esculin negative; no gas from glucose; may, on rare occasions, cause diseases of respiratory tract but no proof of causal role; susceptible to vancomycin

Microaerophilic Gram Positive Cocci: cause peritonsillar abscess, necrotising pneumonia, symbiotic gangrene, cranial parameningeal deep fascial space infections, mastitis and breast abscess, endocarditis; treatment: penicillin

Anaerobic Gram Positive Cocci: susceptible to erythromycin (60% g), rifampicin (15% g), penicillin (2 U), kanamycin (1000 ?g), vancomycin (5% g); resistant to colistin (10 ?g); normal flora of mouth, intestine and vagina (large numbers), skin, upper respiratory tract, external genitalia (usually present), urethra (irregular); cause balanoposthitis, endocarditis, peritonitis, urethritis; susceptible to piperacillin (100% at < 1 mg/L), imipenem (100% at < 1 mg/L), clindamycin (88-97% at < 1 mg/L), ciprofloxacin (1 mg/L), penicillin (100%), mezlocillin (100%), carbenicillin (100%), ticarcillin (100%), ampicillin-sulbactam (100%), cefotaxime (100%), ceftizoxime (100%), cefoperazone (100%), moxalactam (100%), cefotetan (100%), ticarcillin-clavulanate (100%), chloramphenicol (98-100%), metronidazole (98-99%), clindamycin (88-97%), cefoxitin (66-100%)

Anaerobic Streptococci: glucose positive, urease negative, produce lactic acid (only end-product of glucose fermentation); susceptible to metronidazole

Peptococcus: causes peritonsillar abscess, necrotising pneumonia, pulmonary abscess, tubo-ovarian abscess, endometritis, local and generalised sepsis, cellulitis, 0.4% of bacteraemia and septicemia (mainly obstetrical patients during peripartum period); treatment: chloramphenicol, metronidazole

P.niger: obligately anaerobic Gram positive coccus, cells singly or in clumps; susceptible to metronidazole; resistant to novobiocin and SPS; indole negative; butyric, caproic, isovaleric and acetic acids produced; normal flora of external genitalia, cervix (7-71%), vagina, skin (umbilicus), tonsils, throat, mouth, large intestine; only occasionally isolated from human clinical specimens; more commonly isolated from veterinary specimens; causes complications in compromised patients, infections in abnormal host, lung abscess (rare), myonecrosis, peritonitis, postpartum or postoperative complications, various abscesses; susceptible to metronidazole (MIC 1 mg/L), imipenem (100%)

Peptostreptococcus: obligately anaerobic Gram positive coccus, cells in chains, ?-haemolytic; normal flora of external genitalia, cervix (14-33%), vagina (19%), colon, lower ileum, mouth, tonsils, skin; causes abortional and puerperal infections, abscesses (including brain abscess, peritonsillar abscess, lung abscess; in pure culture or as part of mixed aerobic and anaerobic flora), 1% of bacteraemia and septicemia (8% of septicemia associated with female genital infection), cholecystitis, cervical fascial space infections, cranial parameningeal deep fascial space infection, empyema, gangrene (including Fournier's gangrene of scrotum and lung gangrene), chronic mastitis and breast abscess, osteomyelitis and osteochondritis, chronic otitis externa, pleuritis, necrotising pneumonia, sinusitis, tubo-ovarian abscess, infections in abnormal host, ? 100% of anaerobic dental infections, decubitus ulcers, foot ulcers and osteomyelitis, 98% of anaerobic miscellaneous soft tissue infections below waist, 68% of pancreatic abscess, 62% of miscellaneous soft tissue infections above waist, 51% of intraabdominal infections, 40% of human bite infections, 33% of transtracheal aspirates and pleural fluids growing anaerobes, 21% of anaerobic CNS infections, 21% of animal bite infections; treatment: benzylpenicillin (most reliable antimicrobial for treating bacteraemia), chloramphenicol, metronidazole/tinidazole (MIC 1 mg/L), clindamycin/lincomycin; also susceptible to phenoxymethylpenicillin, amoxy/ampicillin, amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cefaclor, cefuroxime, cefotaxime, ceftriaxone, cefepime, ceftiofime, cefepime, cefpirome, cefotetan (MIC 0.5 mg/L), cefoxitin, imipenem (100%), meropenem, gatifloxacin, moxifloxacin, azithromycin, clarithromycin, erythromycin, roxithromycin, vancomycin, teicoplanin

P.anaerobius: produces acetic and isocaproic acids, susceptible to sodium polyanethol sulphonate; vagina, colon; isolated from a wide variety of clinical specimens, including abscesses of brain, jaw, pleural cavity, ear, pelvic region, urogenital area and abdominal region; also from blood, spinal fluid, joint cultures and specimens from osteomyelitis, gingival crevice of persons with gingivitis or periodontal disease

P.asaccharolyticus: SPS resistant, indole positive, produces butyric acid; vagina; vaginal discharge, skin abscess, peritoneal abscess; susceptible to meropenem (MIC 0.03 mg/L), ticarcillin (? 1 mg/L), ticarcillin-clavulanate (? 1 mg/L)

P.hydrogenalis: new species; has been isolated from vaginal discharge

P.indolicus: most biochemical properties as for *P.asaccharolyticus*

P.lacrimalis: new species

P.lactolyticus: new species

P.magnus: large cocci; glucose and lactose negative, resistant to novobiocin, produces acetic acid; oral, genital tract, rare in colon or gingival crevice; causes endocarditis, wounds, abscesses of abdomen, peritoneal, appendiceal or gingival sites, perinatal generalised disease; more frequent in anatomic sites below diaphragm; treatment: penicillin; also susceptible to meropenem (MIC 0.13 mg/L)

P.micros: small cocci; glucose and lactose negative, susceptible to novobiocin; produces acetic acid; genital tract, frequently in healthy gingival crevice and intestinal tract; frequently isolated from clinical specimens, including brain, lung, jaw, head, neck and bite abscesses, spinal fluid, blood and abscesses at other body sites; often a major component of flora of gingival sulcus in periodontal disease; susceptible to meropenem (MIC 0.25 mg/L)

P.prevotii: indole negative, resistant to novobiocin, produces butyric and acetic acids; skin, vagina, tonsils; susceptible to ticarcillin (MIC ? 1 mg/L)

P.productus: glucose and lactose positive, produces acetic acid; colon (1 of more predominant members of faecal flora)

P.tetradius: glucose and urease positive; lactose negative; produces butyric and lactic acids; vagina, vaginal discharge and various purulent secretions

Ruminococcus bromii: normal flora of large intestine; 6 species isolated from faeces but not from clinical specimens

Coprococcus: 3 species isolated from faeces but not from clinical specimens

Sarcina: normal flora of large intestine, external genitalia, vagina (2%), skin; causes complications in compromised patients, postpartum or postoperative complications (rare); isolated from diseased stomach

S.lutea: inhibits phagocytic microbicidal activity by resistance to oxidative attack; susceptible to gentamicin

Family Bacillaceae

Bacillus: large, sporeforming bacillus, Gram positive but some species readily decolourised; heat-resistant endospores associated with uptake of calcium ions and synthesis of dipicolinic acid; germination requires injury to spore coat, water,

L-alanine and replenishment of nitrogen and carbon; aerobic ? anaerobic growth; catalase positive; normal flora of large intestine, skin; frequent laboratory contaminant; causes bacteraemia and septicemia in compromised patients, food poisoning, iridocyclitis, meningitis (infrequent in compromised patients, very rare in neonates), panophthalmitis, wound infection; growth stimulated by excess iron; treatment: vancomycin (< 5% resistance in Australia), clindamycin; also susceptible to irloxacin (MIC 0.06 mg/L), ciprofloxacin (0.2-1 mg/L), norfloxacin (1mg/L), enoxacin (1 mg/L), gentamicin

B.anthraxis: large (1-1.5 x 3-5 µm), Gram positive, square-ended bacillus with oval, central to subterminal, non-swelling spore (1 x 1.5 µm); single or in chains of 2-4 and encapsulated in clinical specimens but non-encapsulated and long chains from sheep blood agar; nonmotile; penicillin susceptible, producing spherical cells in vicinity of disc; colonies on sheep blood agar grey-white to white, generally smaller than *B.cereus*, nonhaemolytic, flat or slightly convex, irregularly round, with slightly undulate edges and ground glass appearance, often many comma-shaped outgrowths 'Medusa head' colony), tenacious consistency, standing up like egg white when teased with a loop; colonies on nutrient agar + 0.8% bicarbonate in 5% CO₂ raised and mucoid (virulent strains) and yield heavily encapsulated cells; no growth on MacConkey agar; litmus milk not peptonised, salicin negative, VP positive, gelatine liquefaction negative or slow, lecithinase weakly positive; lysed by ? phage; elaborates anthrax toxin; possesses plasmids pX01 and pX02; virulent in mice and guinea pig; M'Fadzean reaction in killed mice; fluorescent antibody to *B.anthraxis* positive; causes anthrax (? 5 cases (no deaths)/y in USA), bacteraemia and septicemia, haemorrhagic meningitis; pathogen of herbivorous animals, who ingest spores; occasional human infection; systemic disease following local lesion at inoculation site; inhibits phagocytic attachment and ingestion; toxic complex kills phagocytes; cell wall poly-D-glutamic acid resists killing by phagocytes and is associated with invasiveness; carried in blood free in plasma; 3 factors form a toxic complex and cause increased vascular permeability, causing oedema and haemorrhage (primary lesion), circulatory failure (systemic disease); characteristic appearance in chest X-ray of inhalation anthrax results from lymphadenopathy and mediastinal haemorrhage; antibodies to capsular material not protective; antibodies to toxin, or

possibly to spontaneously 'toxoided' derivatives, confer specific immunity; resistance can be induced by immunisation with whole toxin or spores; treatment: penicillin, streptomycin, tetracycline, erythromycin, vancomycin

B.cereus: ubiquitous organism; diameter of vegetative cells $\approx 0.9 \mu\text{m}$; motile; usually α -haemolytic on sheep blood agar, colonies slight green tinge, few or no comma-shaped outgrowths from colonies on blood agar; colonies on 0.7% bicarbonate agar in air or CO_2 rough, dull, grey, flat; anaerobic growth; litmus milk not peptonised; VP, catalase, lecithinase, nitrate, 6.5% NaCl, gelatine and lecithinase (strongly) positive; penicillin resistant; fluorescent antibody to *B.anthraxis* negative; not lysed by ϕ phage; nonpathogenic to mouse and guinea pig; causes endocarditis (infrequent in valvular heart disease, i.v. drug abuse), endophthalmitis (posttraumatic, bloodborne) gastroenteritis (emetic type due to preformed heat-resistant enterotoxin, incubation period 1-6 h, vomiting median 9 h, almost invariably associated with ingestion of contaminated fried or reheated rice dishes; diarrhoeal type caused by heat-labile enterotoxin, more common, incubation period 6-24 h, abdominal cramps and watery diarrhoea median 20 h, most commonly associated with meats and sauces), local and generalised sepsis (prime cause of traumatic wound infections in tropics), panophthalmitis in drug abusers, infections in abnormal host, bacteraemia and meningitis in immunocompromised; treatment: vancomycin + carbapenem; flucloxacillin, clindamycin; also susceptible to ciprofloxacin (MIC 0.125 mg/L), enoxacin (1 mg/L); resistant to ceftazidime

B.cereus var mycoides: spreading rhizoid colonies with marked tailing

B.megaterium: diameter of vegetative cells $\approx 0.9 \mu\text{m}$; motile; no haemolysis on sheep blood agar; no growth on 10 mg/L penicillin agar, no growth on 0.7% bicarbonate agar in air, colonies in CO_2 smooth, dull yellow, raised; salicin and VP negative; peptonisation of litmus milk variable; causes infections in abnormal host

B.sphaericus: spores spherical

B.subtilis: diameter of vegetative cells $< 0.9 \mu\text{m}$; grows at pH 6; VP, gelatine and starch positive; nitrate reduced to nitrite; common laboratory contaminant; causes conjunctivitis, infections in abnormal host

B.thuringiensis: crystalline parasporal inclusion; colonies slight green tinge

Clostridium: Gram positive sporebearing (sometimes difficult to demonstrate) bacillus, typically large straight rods, may be pleomorphic, can rapidly lose their Gram stain; motile; most species only anaerobic growth; catalase negative; normal flora of colon and lower ileum (large numbers), mouth, urethra and vagina (irregular); widely distributed in soil; causes abortional and puerperal infection, 1-2% of bacteraemia and septicemia, botulism, cellulitis, cholecystitis, choledochitis, complication of surgical procedures, food poisoning, gas gangrene (myonecrosis), intraabdominal abscess, ischiorectal abscess, postneonatal pyogenic meningitis (infrequent), peritonitis, pseudomembranous colitis, rhabdomyolysis, local and generalised sepsis, tetanus, wound infection; growth stimulated by excess iron; treatment: penicillin (100% susceptible), chloramphenicol (100% susceptible), metronidazole (99% susceptible), clindamycin (88-90% susceptible), cefoxitin, erythromycin; also susceptible to mezlocillin (100% at $\approx 1 \text{ mg/L}$), imipenem (100%), ampicillin-sulbactam (100%), piperacillin (100%), ticarcillin-clavulanate (100%), ticarcillin (100%), cefotetan (95-100%), cefoperazone (84-100%), ceftizoxime (75-100%), moxalactam (73-100%), carbenicillin; resistant to ciprofloxacin, ofloxacin, lomefloxacin, enoxacin, cefotaxime, cefmenoxime, gentamicin

C.bifermentans: spores subterminal; nonmotile; haemolytic, no aerobic growth; fructose, esculin, indole, lecithinase, gelatinase, glucose, maltose, indole positive; lactose and sucrose negative; milk clot and digestion; acetic, propionic, isobutyric, isovaleric, isocaproic acids by GLC; nontoxic to mice; susceptible to meropenem (MIC 0.13 mg/L)

C.botulinum: oval, subterminal spores, no capsule; nonmotile; no aerobic growth; glucose positive; lecithinase and indole negative; proteolysis, maltose, lactose, sucrose and milk reaction variable; exotoxin⁺⁺⁺; toxic to mice; toxin neutralisation for specific identification; causes botulism (food (enterotoxemia; 66% type A, 5% type B, 25% type E), infant, wound), localised skin lesions, local and generalised sepsis, pneumonia, osteomyelitis and osteochondritis (in wound botulism), sudden infant death syndrome; powerful neurotoxin (exotoxin protein) absorbed from intestine (incubation period 5-36 h) blocks release of acetylcholine, causing neurotoxic signs and paralyses; 6 types (A (USA, former Soviet Union; proteolytic; botulism of man, limberneck of chickens), B (USA, Northern Europe, former Soviet Union; some strains proteolytic; botulism of man, limberneck of chickens), C (nonproteolytic; paralytic disease of chickens, botulism of wild animals, forage poisoning of cattle in Australia), D (nonproteolytic; Lamzochte of cattle in Africa), E (Northern Europe, Canada, USA, Japan, former Soviet Union; nonproteolytic; botulism of man), F (Denmark, USA; proteolytic; botulism of man)) produce immunologically distinct toxins; diagnosis can be performed by

demonstrating toxin in blood; treatment: antitoxin (confers specific immunity and is of proven value in treatment), tetracycline, metronidazole, chloramphenicol, penicillin, clindamycin

C. butyricum: causes necrotising enterocolitis; susceptible to meropenem (MIC 0.5 mg/L)

C. chauvoei: causes blackleg in cattle, horses, pigs, sheep

C. difficile: spores subterminal; motile; no aerobic growth; yellow colonies (usually flat and dull) with spreading, irregular or rhizoid edge, fluorescing bright yellow under long wavelength UV light, on cycloserine cefoxitin egg yolk fructose agar; colonies on blood agar nonhaemolytic, fluoresce yellow-green under long wavelength UV light; very characteristic 'horse stable' odour; fructose, esculin and glucose positive; milk digestion, indole, lecithinase, lactose, maltose and sucrose negative; gelatinase variable; acetic, propionic, isobutyric, butyric, isovaleric, valeric, isocaproic acids by GLC; toxin neutralisation for specific identification; causes reactive arthritis, bacteraemia and septicemia in immunocompromised, acute diarrhoea and/or vomiting, pseudomembranous colitis (caused by necrotising action of toxin on colonic mucosa; complication of antimicrobial therapy (clindamycin and amoxicillin most frequent) causing overgrowth of *C. difficile*; 4% of faecal specimens (up to 44% in neonates), causes 11% of enteritis, 15-52% of nosocomial diarrhoea; attack rate 32% in day care centres), splenic abscess, ? ulcerative colitis; treatment: metronidazole/tinidazole (MIC < 1 mg/L), vancomycin/teicoplanin (oral), bacitracin (oral), cholestyramine

C. fallax: causes gas gangrene, cellulitis, myonecrosis; treatment: clindamycin, metronidazole, penicillin, erythromycin

C. histolyticum: oval, subterminal spore, no capsule; motile; aerobic and anaerobic growth; proteolytic, milk clot and digestion, gelatinase positive; glucose, lactose, maltose, sucrose, indole and lecithinase negative; acetic, lactic acids by GLC; exotoxin positive; toxicity to mice variable; causes 0.8% of carpal tunnel syndrome

C. innocuum: spores terminal; nonmotile; colonies on cycloserine cefoxitin fructose agar similar to *C. difficile* but slightly umbonate and glistening; colonies on blood agar not fluorescent; no odour

C. novyi: oval, subterminal spores; motile, no capsule; no aerobic growth; slight proteolysis; glucose⁺, lecithinase⁺ and gelatinase positive; lactose, sucrose and indole negative; maltose and milk variable; acetic, propionic, butyric acids by GLC; exotoxin ++++; toxicity to mice variable; toxin neutralisation for specific identification; causes cellulitis, myonecrosis with rapid progressive tissue death (sometimes associated with production of gas in tissues), black disease of cattle, horses, pigs and sheep; ? toxin (lethal, necrotising) produced by types A and B, ? toxin (haemolytic, necrotising, lecithinase), ? toxin (haemolytic, lecithinase), ? toxin (CO₂-labile haemolytic) and ? toxin (opalescence in lecithovitellin) by type A, ? toxin (haemolytic) by type B; treatment: clindamycin, metronidazole, penicillin, erythromycin

C. oedematiens: causes cellulitis, myonecrosis, gas gangrene, bacteraemia and septicemia in immunocompromised; treatment: clindamycin, metronidazole, penicillin, erythromycin

C. perfringens: large Gram positive bacillus with square ends, oval subterminal spores with no swelling, encapsulated; nonmotile; only anaerobic growth; complex nutritional requirements, optimal temperature 43-45°C; double zone of haemolysis; Nagler positive; liquefies gelatine, slight proteolysis; glucose, lactose, maltose, sucrose, and lecithinase positive; indole negative; milk clot and gas; acetic, butyric acids by GLC; exotoxin⁺⁺; toxicity to mice variable; normal flora of colon; causes abortional infection, 6% of anaerobic bacteraemia and septicemia, cellulitis, cholangitis and cholecystitis, compound fractures infections, acute empyema (rare), enterotoxemia (food poisoning: type A, ubiquitous organism, resists heat of cooking and multiplies in anaerobic conditions (eg., bulky meat and poultry dishes, pies and stews), limited multiplication and production of enterotoxin during spore formation, enterotoxin released in gut causing abdominal pain and diarrhoea, incubation period 9-24 h, disease-producing dose 10⁸ organisms, transmitted by food and water), Darmbrand and pigbel (type C oxygen-labile haemolysin, collagenase and hyaluronidase-producing strains), necrotising enterocolitis, gastroenteritis (uncommon), gas gangrene, myonecrosis with rapid progressive tissue death, postoperative gangrene (usually arising from intestine), parametritis, pelvic abscess, pelvic inflammatory disease, perinatal generalised disease, peritonitis, rhabdomyolysis, 15% of anaerobic intraabdominal infections in humans, necrotising enterocolitis and pulpy kidney disease in calves, piglets, foals and lambs (type D); all types produce ? toxin (lethal, lecithinase, necrotising, phospholipase; acts on cell membrane of muscle, causing cell necrosis, haemolysis, toxemia, capillary fragility), ? toxin (only some strains of type A; oxygen-labile haemolysin; inhibits chemotaxis, haemolytic, necrotising), ? toxin (collagenase; destroys collagen framework in intact muscle), ? toxin (hyaluronidase; depolymerises hyaluronic acid in intercellular ground substance), and ? toxin (deoxyribonuclease);

types B and C produce ? toxin (lethal, necrotising, may be neurotoxic), types B and D ? toxin (lethal, affects gut permeability, necrotising), type E ? (lethal, affects capillary permeability, necrotising); antibodies to phospholipase, but not collagenase and hyaluronidase, protective against infection; capsule resists phagocytosis; diagnosis: culture, ELISA (toxin); susceptible to benzylpenicillin (a few strains resistant), phenoxymethylpenicillin, amoxy/ampicillin, clindamycin (MIC

< 1 mg/L), lincomycin, metronidazole/tinidazole (99% susceptible), erythromycin, meropenem (? 0.06 mg/L), cephalixin, cephalothin, cephazolin, cefaclor, cefuroxime, cefotaxime, ceftriaxone, cefepime, ceftazidime, cefotetan

(? 0.12 mg/L), ceftiofloxacin, ciprofloxacin (? 0.13-0.5 mg/L), ofloxacin (? 0.25-0.5 mg/L), pefloxacin (? 0.25-1 mg/L), ticarcillin (? 1 mg/L), ticarcillin-clavulanate (? 1 mg/L), piperacillin (1 mg/L), piperacillin-tazobactam, ticarcillin-clavulanate, imipenem (99% at 1 mg/L), meropenem, chloramphenicol, vancomycin, teicoplanin, carbenicillin, gatifloxacin, moxifloxacin, azithromycin, clarithromycin, erythromycin, roxithromycin; antitoxin of no proven value in treatment

C.septicum: oval subterminal spores, no capsule; motile; no aerobic growth; heavy swarming; slight proteolysis; glucose, lactose, maltose, gelatinase positive; sucrose, indole and lecithinase negative; milk clot and gas; acetic, butyric acids by GLC; exotoxin⁺⁺; toxic to mice; toxin neutralisation for specific identification; causes 2% of anaerobic bacteraemia and septicemia, cellulitis, myonecrosis with rapid progressive tissue death (sometimes associated with production of gas in tissues), blackleg in cattle, horses, pigs and sheep; treatment: clindamycin, metronidazole, penicillin, erythromycin; also susceptible to meropenem (MIC 0.06 mg/L)

C.sordellii: haemolytic; urease, indole and lecithinase positive; esculin and milk digestion negative; infections following trauma, childbirth, routine gynecological procedures, medically induced abortions, injection drug use; overall case fatality rate 69%; susceptible to meropenem (MIC 0.06 mg/L)

C.sporogenes: spores subterminal; motile; no aerobic growth; milk clot and digestion; gelatinase and sucrose positive; lecithinase, lactose and indole negative; maltose variable; isovaleric acid by GLC; nontoxic to mice; susceptible to meropenem (MIC 0.25 mg/L)

C.tertium: Gram positive bacillus with oval terminal spore; motile; both aerobic and anaerobic growth; lactose, glucose, maltose and sucrose positive; lecithinase, gelatinase and indole negative; action on milk variable; acetic, butyric, lactic acids by GLC; nontoxic to mice; causes 13% of anaerobic bacteraemia and septicemia (neutropenics and aspiration pneumonia)

C.tetani: 'drum stick' appearance, with large terminal spherical spore; noncapsulated; motile; no aerobic growth; heavy swarming; nonproteolytic; milk no change; gelatinase positive; glucose, lactose, sucrose and lecithinase negative; indole variable; acetic, propionic, butyric acids by GLC; exotoxin⁺⁺⁺; toxic to mice; toxin neutralisation for specific identification; causes tetanus; non-invasive; toxin (exotoxin protein) is bound by ganglioside of nervous tissue and blocks action of inhibitory neurones, causing overaction of motor neurones, producing muscle spasm, lockjaw; antitoxin protective; treatment: immunoglobulin or antitoxin + penicillin or cephalosporin or erythromycin

Lactobacillus: Gram positive rods, no spores; nonmotile; facultative or obligate anaerobe; ? - or ?-haemolytic (never ?); growth at 10°C; glucose positive; H₂S not produced in triple sugar iron agar; catalase and nitrate negative; salicin, mannitol and bile esculin variable; lactic acid major or sole end-product of fermentation (propionic acid not produced); normal flora of mouth (usually present), saliva, colon and lower ileum (moderate to large numbers), urethra (irregular), vagina (large numbers), cervix (53-75%; sole or predominant organism in 46-66%); causes bacterial endocarditis (very rare; usually patients with preexisting structural heart disease and recent dental infection or manipulation), febrile disease (rare), lung abscess (extremely rare), 22% of anaerobic dental infections, 17% of anaerobic head and neck infections, 15% of transtracheal aspirates and pleural fluids growing anaerobes, 12% of anaerobic intraabdominal infections; treatment: penicillin ? gentamicin; 90% resistant to vancomycin

L.acidophilus: oral; causes endocarditis; used as probiotic

L.cateniforme: short rods in chains or singly; smooth colonies on blood agar, diffuse granular growth in enriched thioglycolate broth; obligate anaerobe; catalase and indole negative, glucose fermented (metabolic products acetic and lactic acids)

L.johnsonii: used as probiotic

L. paracasei: oral; causes endocarditis; used as probiotic

L. plantarum: oral; causes endocarditis; used as probiotic

L. reuterii: used as probiotic

L. rhamnosus: used as probiotic

L. rimae: new species; anaerobic

L. salivarius: oral; causes endocarditis

L. uli: anaerobic

Listeria: small Gram positive rods and filaments, no spores; motile at 25°C, motile or nonmotile at 35°C; catalase, VP and esculinase positive; PYR and oxidase negative; bacitracin resistant; normal flora of upper respiratory tract; carried in blood associated with mononuclear cells; causes systemic infections in cell-mediated immunity disorders; growth stimulated by excess iron; susceptible to penicillin, amoxy/ampicillin, piperacillin, piperacillin-tazobactam, meropenem, chloramphenicol, trimethoprim, cotrimoxazole, vancomycin, teicoplanin; synergy with aminoglycosides and cell wall active agent

L. innocua: nonhaemolytic, CAMP test negative

L. monocytogenes: motile; ?-haemolytic; catalase, glucose, maltose, sucrose, salicin and CAMP test positive; H₂S not produced in triple sugar iron agar, nitrate negative; starch variable; found in sewage, soil, faeces of healthy animals and man, widespread in foods of virtually all types, normal flora of upper respiratory tract; causes listeriosis (highest mortality in neonatal infection; in most cases, origin unknown), premature or nonviable termination of pregnancy, localised external or internal abscesses, localised skin lesions (rare), amnionitis, 0.2% of bacteraemia and septicemia (low grade in gravida ? influenza-like condition, case-fatality rate in perinatal period and in adults 11%), brain abscess (especially in leukemia and renal transplant recipients; case-fatality rate 57%), cervical adenitis, cholangitis and cholecystitis, endocarditis (in rheumatic fever, prosthetic heart valve, malignancy, immunosuppressed, following coronary artery bypass surgery; case-fatality rate 29%), endophthalmitis (oculoglandular listeriosis; uncommon), gastroenteritis, genital tract infection, prenatal and perinatal generalised disease, hepatitis (adult, neonatal and prenatal), hepatic abscess in diabetes, hepatic granuloma, infectious mononucleosis-like syndrome, keratoconjunctivitis, lymph gland infection, neonatal and postneonatal pyogenic and nonpyogenic meningitis and meningoencephalitis (2-3% of bacterial meningitis; incidence 0.04/100 000; case-fatality rate 30%; ? 50% nosocomial; 55% adult infections; most common in impaired cell-mediated immunity, neonates, immunosuppressed patients and those with underlying chronic disease), non-meningitic central nervous system infection (including rhombencephalitis in nonimmunosuppressed adults; mortality rate 42%), mycotic aneurism, myocarditis and pericarditis (cardiac transplantation and others), osteomyelitis and osteochondritis, peritonitis, pneumonia, purulent conjunctivitis, splenic abscess, stillbirth, vascular graft infection, infections in abnormal host (T-lymphocyte dysfunction); 56% of isolates from blood, 8% from CSF, 16% from blood and CSF; resists phagocytic oxidative attack; multiplies in macrophages; immunity cell-mediated (delayed type hypersensitivity activated macrophage +++); susceptible to interferon-?, interferon-?, interferon-?, interleukin-4, interleukin-6, interleukin-1 and macrophage colony stimulatory factor-activated macrophages; interleukin-2, interleukin-6, granulocyte macrophage colony stimulatory factor, granulocyte stimulatory factor and tissue necrosis factor also induce autoimmune activity; diagnosis: indirect haemagglutination (4-fold rise in titre indicates active infection), enrichment in broths based on trypticase ? peptones + acriflavine dyes + nalidixic acid as selective agents (? potassium thiocyanate, cycloheximide), culture on blood agar + cycloheximide, colistin, cefotetan, fosfomycin and acriflavine; treatment: ampicillin (resistance not yet confirmed in Australia), amoxicillin (100% susceptible at 0.25 mg/L) or penicillin (0.25 mg/L) ? gentamicin (1 mg/L), i.v. cotrimoxazole (0.025 mg/L) followed by oral trimethoprim (0.12 mg/L), chloramphenicol or erythromycin (0.25 mg/L); also susceptible to rifampicin (0.06 mg/L), imipenem (0.06-0.125 mg/L), tetracycline (0.5 mg/L), vancomycin (1m/L); resistant to all cephalosporins, enoxacin, pefloxacin

L. murrayi: nitrate positive

Erysipelothrix: resembles *Listeria* but catalase negative and filamentous; growth stimulated by excess iron

E. rhusiopathiae: diphtheroid-appearing rod; non-motile; ?-haemolytic (never ?-haemolytic) on blood agar, H₂S in triple sugar iron agar, glucose positive; catalase, nitrate, esculin, maltose, sucrose, salicin and mannitol negative; causes arthritis, cellulitis, conjunctivitis without keratitis, endocarditis (animal contact, alcohol abuse), erysipeloid and bacteraemia and septicemia in humans, and cutaneous disease (diamondback, diamond skin infection, swine erysipelas),

acute septicemia and arthritis in pigs; transmitted from animals to humans; treatment: penicillin (100% susceptible at 0.06 mg/L), erythromycin (100% susceptible at 0.25 mg/L); also susceptible to cloxacillin (100% at 0.025 mg/L), methicillin (100% at ? 0.12 mg/L), flucloxacillin (100% at ? 0.12 mg/L), tetracycline (MIC 0.2 mg/L; MBC 16-31 mg/L), ampicillin (100% at 0.25 mg/L), clindamycin (100% at 0.25 mg/L), cephalothin (100% at 1 mg/L); resistant to sulphonamides, cotrimoxazole, vancomycin, aminoglycosides

Kurthia bessonii: motile at 35°C and 25°C; catalase positive, no reaction in O-F medium; normal habitat water; human infections unknown or extremely rare

Coryneforms: nonsporulating, Gram positive; not branching, filamentous or acid-fast; frequently pleomorphic; usually relatively rapidly growing; adherence to nasal mucosa ++

Corynebacterium: presence of ester-linked ?-hydrogenated long chain fatty acids characteristic of group and of mycobacteria; Gram positive irregular rods in 'Chinese letters', some clubbed forms; few weakly acid-fast; usually nonmotile; aerobic and facultative anaerobic; ? or ? haemolysis; catalase positive; no H₂S produced in triple sugar iron agar; bile esculin, NaCl, PYR and salicin negative; nitrate, glucose and mannitol; normal flora of mouth, nose (adherence to nasal mucosa +), large intestine, lower ileum, external genitalia, anterior urethra, vagina (37%), cervix (20-66%), skin, ear, eye; also animal, soil, plants; causes bacteraemia and septicemia, complication of cardiac surgery, endophthalmitis (postoperative), lung abscesses, perinatal generalised disease, 2% of endocarditis, infection in abnormal host (interrupted integument), systemic infections in granulocytopenics; growth stimulated by excess iron; treatment: penicillin ? aminoglycoside, erythromycin, vancomycin (resistance not yet reported); also susceptible to ofloxacin (MIC ? 0.25-1 mg/L), ciprofloxacin (0.25-1 mg/L)

C. aquaticum: motile at 35°C and 25°C; catalase positive; VP negative; oxidative; reported from blood cultures, endocarditis and neonatal meningitis

C. bovis: ?-haemolytic, colonies white to cream, oxidase positive; causes infections in abnormal host, post-neonatal pyogenic meningitis (rare), otitis media (rare), chronic ulcers; treatment: erythromycin + rifampicin

C. diphtheriae: typical morphology in Gram stain (especially from Loeffler's slope); nonmotile; ?-haemolytic; optimal growth on Loeffler's or Tinsdale medium; gravis type short, uniformly staining, low, circular colony; intermedius long, pleomorphic, clubbed, small colony; mitis long, pleomorphic, prominent granules, 'poached egg' colony; catalase, glucose, maltose and nitrate positive; VP, lactose and urease negative; sucrose and starch variable; important identification test agar gel diffusion; causes diphtheria (infection of nose, external mucosa of respiratory, auditory and genital tracts and, occasionally, skin; toxæmic diphtheria only if lysogenic), bronchitis, purulent conjunctivitis (uncommon), croup, endocarditis (nontoxigenic strains), nonexudative pharyngitis and tonsillitis, laryngotracheitis, myocarditis and pericarditis (usually following pharyngeal diphtheria), otitis externa (very rare), septic arthritis; natural host man; attaches to mucosal epithelium; infection generally confined to epithelial surface of respiratory tract; necrotising toxin (exotoxin protein), inhibits cell protein synthesis and oxidative processes, possibly through interference with cytochrome b, causing heart damage and nerve paralysis; isolates should be tested for toxin production; treatment: antitoxin + penicillin or erythromycin (resistance not yet confirmed in Australia), cefotaxime

C. jeikeium: glucose, galactose and catalase positive; urease negative; causes bacteraemia and septicemia (90% catheter-related), cellulitis (biopsy sites in granulocytopenic patients, endocarditis, localised skin lesions and local sepsis at sites of biopsy or catheter insertion or perianal fissure in granulocytopenic patients, peritonitis in continuous ambulatory peritoneal dialysis; susceptible to vancomycin (MIC ? 0.25 mg/L), teicoplanin (0.12-0.25 mg/L), sodium fusidate, rifampicin/rifabutin; usually resistant to ?-lactams and aminoglycosides, erythromycin, clindamycin, imipenem; variable susceptibility to quinolones (susceptible to amifloxacin at 1 mg/L; resistant to ciprofloxacin)

C. kutscheri: causes chorioamnionitis, septic arthritis; treatment: ampicillin + gentamicin, cefotaxime, erythromycin

C. matruchotii: normal flora of tooth surface (dental plaque and calculus), gingiva; may possibly act as opportunistic pathogen

C. minutissimum: causes erythrasma (endogenous; scaly condition of axilla, groin and between toes; infection confined to stratum corneum); case of recurrent breast abscess described; treatment: erythromycin

C. pseudodiphthericum: does not show pleomorphism (cells regular, evenly stained except for transverse septum, frequently in parallel rows); nonmotile; nitrate, urease and catalase positive; inert towards carbohydrates; causes

endocarditis, pneumonia (trauma and immunodeficient), acute tracheitis (1 case); treatment: ampicillin + gentamicin, vancomycin ? tobramycin

C.pseudotuberculosis: grows poorly on most media but well on Loeffler's medium, yellowish friable colonies; catalase, urease, glucose and maltose positive; lactose negative; causes lymph gland infection, caseous lymphadenitis in sheep, local lymphadenitis and eosinophilic pneumonia in man; treatment: erythromycin (250-500 mg orally 4 times daily (child: 30 mg/kg daily in 4 divided doses) or penicillin + surgical drainage or excision

C.renale: cells large, pleomorphic, with pointed ends

C.striatum: cells characteristically striated on Gram stain; nitrate, glucose and sucrose positive; urease, maltose, mannitol and xylose negative; causes chorioamnionitis (rare), pleuropulmonary infections, bacteraemia, infection of exit sites of central venous catheters, thrombophlebitis associated with central venous catheters (rare), conjunctivitis; treatment: vancomycin (MIC ? 0.25 mg/L); also susceptible to rifampicin (? 0.008 mg/L), gentamicin (? 1 mg/L)

C.tenuis: causes trichomycosis axillaris; diagnosis: microscopy of hair; treatment: shaving, sulphur ointment

C.ulcerans: morphology similar to *C.diphtheriae*; urease positive; nitrate negative; causes acute nonexudative pharyngitis and tonsillitis resembling diphtheria, and peritonsillar abscess; usually self-limiting but isolates should be tested for toxin production; from unpasteurised milk

C.urealyticum: urease, hippurate and catalase positive; glucose, galactose, PYR and ribose negative; causes wound infections, local and generalised sepsis, acute cystitis, bacteraemia and septicemia in immunosuppressed; treatment: vancomycin (MIC 0.25-0.5 mg/L); also susceptible to teicoplanin (0.12-0.25 mg/L); usually resistant to ?-lactams and aminoglycosides, varying susceptibility to quinolones

C.xerosis: nonmotile; colonies small, yellow to tan; catalase, nitrate, glucose and sucrose positive; maltose and starch negative; normal flora of eye; causes endocarditis (children and i.v. drug abusers with AIDS), septic arthritis following vascular surgery, infections in abnormal host; treatment: cefotaxime, erythromycin

Arcanobacterium: facultatively anaerobic Gram positive short irregular rods, non acid-fast, nonmotile; usually catalase negative; human, animal

A.haemolyticum: ?-haemolytic; catalase negative; morphology and most reactions similar to *C.diphtheriae* but poor growth on Tinsdale agar, lactose and gelatine negative; causes acute nonexudative pharyngitis and tonsillitis, chronic ulcers, septic arthritis; treatment: penicillin, erythromycin, rifampicin

Tsukamurella: Gram positive bacilli; identification requires high performance liquid chromatography, 16S ribosomal gene sequencing and DNA-DNA dot blots; cause bacteraemia in immunosuppressed patients with indwelling central venous catheters

Brevibacterium casei: obligately aerobic gram positive bacilli associated with milk products and on human skin; causes bacteraemia and sepsis associated with Hickmann catheter in AIDS patients

TAXONOMIC POSITION UNCERTAIN OR UNKNOWN

Gardnerella vaginalis: Gram variable diphtheroid-like, irregular or pleomorphic rods, non-acid-fast, asporogenous; nonmotile; aerobic and facultatively anaerobic; CO₂ required; fastidious; ?-haemolytic on horse blood agar, ?-haemolytic on sheep blood agar (minute colonies), wide (sometimes double) zone of incomplete ?-like haemolysis on heart infusion agar with 5% rabbit or human blood; no growth on MacConkey; ferments glucose (no gas), maltose and certain other carbohydrates, but not mannitol (serum added); indophenol oxidase and catalase not produced; starch and hippurate hydrolysed; resistant to sulphonamides, susceptible to 10?g metronidazole disc; normal flora of female genital tract (moderate numbers; 12-47% of vaginal samples), urinary tract; world-wide distribution; cause of amnionitis, chorioamnionitis, endometritis, bacteraemia and septicemia (obstetric patients, rarely from prostate in males); assumed to be aetiologically significant in vaginosis (epithelial cells covered with masses of bacteria ('clue cells') seen in vaginal discharge), urethritis and acute cystitis; treatment: metronidazole, tinidazole, nimorazole, clindamycin, Acigel? ; 100% susceptible to imipenem; resistant to ciprofloxacin

Rothia: Gram positive filaments, rods, cocci, clubbed forms, non acid-fast; nonmotile; catalase positive; indole negative; oral cavity

R.dentocariosa: normal flora of mouth (dental plaque and calculus); may on occasion act as opportunistic pathogen, causing mouth abscesses, infections in abnormal host, subacute bacterial endocarditis (rare; i.v. drug abusers, poor dentition, congenital heart disease); treatment: penicillin, amoxicillin or vancomycin + gentamicin or netilmicin

Propionibacterium: Gram positive irregular rods, diphtheroids, branched, coccoid, non-acid-fast, nonsporeforming; nonmotile; microaerophilic or anaerobic; smooth colonies on blood agar; glucose fermented, propionic and acetic acids major end-products of fermentation; usually catalase positive; indole positive; normal flora of upper respiratory tract (usually present), mouth (irregular), skin (large numbers), colon (irregular), vagina (usually present); also dairy; causes brain abscess, cerebrospinal fluid shunt infections, endocarditis, chronic mastitis and breast abscess, osteomyelitis and osteochondritis, peritonsillar abscess, pulmonary abscess; susceptible to penicillin, amoxy/ampicillin, amoxicillin-clavulanate, piperacillin, piperacillin-tazobactam, ticarcillin-clavulanate, cephalexin, cephalothin, cephazolin, cefaclor, cefuroxime, cefotaxime, ceftriaxone, cefepime, cefpirome, ceftazidime, cefotetan, ceftoxitin, metronidazole, chloramphenicol, vancomycin, teicoplanin, clindamycin/lincomycin (100% susceptible), imipenem (100%), meropenem, azithromycin, clarithromycin, erythromycin, roxithromycin

P.acnes: obligate or facultative anaerobe; diffuse (granular) growth in enriched thioglycolate broth; catalase and indole variable; metabolic products acetic, propionic, lactic and succinic acids; normal flora of nose, skin, mouth; may contribute to lesions of acne vulgaris (endogenous); causes bacteraemia (colonising prostheses), endocarditis, infections in abnormal host, late infections after hip-joint surgery, chronic otitis externa, splenic abscess, 37% of anaerobic CNS infections, 33% of anaerobic animal bite infections, 16% of anaerobic osteomyelitis; treatment: penicillin; also susceptible to meropenem (MIC 0.25 mg/L), ticarcillin (? 1 mg/L), ticarcillin-clavulanate (? 1 mg/L), imipenem (100%), clindamycin (100%)

P.avidum: facultatively anaerobic; diffuse growth in enriched thioglycolate broth; catalase positive; indole negative; metabolic products acetic, propionic and succinic acids, with small amount of lactic acid; normal flora of skin, intestines; causes splenic abscess; treatment: penicillin; also susceptible to meropenem (MIC 0.25 mg/L)

P.granulosum: facultatively anaerobic; diffuse growth in enriched thioglycolate broth; catalase positive; indole negative; metabolic products acetic, propionic and succinic acids, with small amount of lactic acid; susceptible to meropenem (MIC 0.25 mg/L)

P.propionicum: cells branching filaments or diphtheroidal; microaerophilic or obligate anaerobe; rough colonies on blood agar; growth in enriched thioglycolate broth granular or diffuse; catalase and indole negative; glucose fermented; metabolic products acetic and propionic acids, with small amounts of lactic and succinic acids; normal flora of mouth (oral cavity, dental plaque), tonsillar crypts; on occasion, produces chronic abscesses and draining sinuses; causes actinomycosis, acute dacryocystitis, adenitis and canaliculitis and dacryocystitis (particularly older males); treatment: penicillin, tetracycline, erythromycin

Eubacterium: Gram positive rod, regular and irregular, nonsporeforming, non-acid fast; motility variable; smooth colonies on blood agar, diffuse growth in enriched thioglycolate broth; catalase and indole negative; normal flora of mouth (usually present) and upper respiratory tract (irregular), vagina (irregular), large intestine (large numbers), skin (irregular); also animal, soil; causes diverticulitis, chronic mastitis and breast abscess, peritonitis, 37% of anaerobic intraabdominal infections, 25% of head and neck infections, pulmonary abscess (23% of transtracheal aspirates and pleural fluids growing anaerobes), 18% of anaerobic animal bite infections, 18% of perirectal abscess, 16% of anaerobic miscellaneous soft tissue infections below waist, 13% of decubitus ulcers, 12% of foot ulcers, 11% of dental infections, 11% of anaerobic miscellaneous soft tissue infections above waist; often associated with necrotising pneumonia; treatment: penicillin, tetracycline; 100% susceptible to imipenem; resistant to ciprofloxacin

E.alactolyticum: thin rods, V forms, cross-stick arrangements; ferments glucose; produces acetic, butyric, caproic acids

E.lentum: short coccoidal rods, diphtheroidal; glucose not fermented; causes bacteraemia and septicemia; susceptible to meropenem (MIC 0.13 mg/L)

E.limosum: plump rods, bulbous and bifid forms; glucose fermented; metabolic products acetic, butyric acids

E.yunii: new species

E.yunii subspecies margaretiae: new subspecies

E.yunii subspecies schtetka: new subspecies

E.yunii subspecies yunii: new subspecies

Lachnospira: propionic acid not produced, ratio of lactic to acetic acid produced < 1:1, produces butyric acid and other acids or no major acid

Actinomycetales: Gram positive, some acid-fast, rods and filaments tending to branch; mostly nonmotile

Family Actinomycetaceae

Actinomyces: Gram positive irregular rods (some clubbed) and filaments, 0.5-2 μ m diameter, branching (not always apparent), non-acid-fast, no spore formation; nonmotile; anaerobic or microaerophilic, growing better when CO₂ added to medium; may take 2 w or longer to grow in supplemented thioglycolate broth or on solid media (blood agar + vitamin K, colistin nalidixic acid agar); requires rich media (eg., blood or brain heart infusion); poor growth below 37°C; grows on agar as white, spherical or lobulated colonies; end-products of fermentation succinic and lactic acids with small amounts of acetic or formic acids (propionic acid not produced); usually catalase and indole negative; glucose fermented; forms granules in tissue; normal flora of mouth (usually present; oral cavity, dental plaque and calculus), tonsils (usually present), irregularly present in intestine; also animal; causes actinomycosis, abscesses (including hepatic, brain and epidural), acute dacryocystitis, adenitis and canaliculitis, adult hepatitis, hepatic granuloma, mycetoma, myocarditis and pericarditis (rare), parotitis and submandibular sialadenitis, salivary calculi, 44% of anaerobic dental infections, 32% of anaerobic CNS infections, 21% of anaerobic animal bite infections, 14% of transtracheal aspirates and pleural fluids growing anaerobes, 10% of anaerobic osteomyelitis; extracellular; diagnosis: Gram stain, direct immunofluorescent stain and anaerobic culture of pus, curettings, biopsy from wall of abscess; susceptible to penicillin (80%), di-/flucloxacillin, amoxy-/ampicillin, tetracyclines, erythromycin (100%), azithromycin, clarithromycin, roxithromycin, clindamycin (85%), lincomycin, chloramphenicol (98%), azlocillin (100%), piperacillin (100%), piperacillin-tazobactam, mezlocillin (100%), carbenicillin (100%), imipenem (100%), meropenem, ticarcillin-clavulanate (100%), vancomycin, teicoplanin; resistant to ciprofloxacin

A. bovis: cell wall lysine and aspartic acid; causes actinomycosis

A. eriksonii: causes actinomycosis

A. israelii: cell wall lysine and ornithine; Gram positive branching filaments or diphtheroidal; microaerophilic or obligate anaerobe; requires rich media; rough colonies on blood agar, up to 1 mm diameter (often smaller), usually very raised or heaped in centre, usually whitish and either circular around to edge or irregular in outline (molar tooth colony), normally have glistening appearance under microscope; may appear dry but are usually moist when touched with a loop; granular or diffuse growth in enriched thioglycolate broth; usually associated with animals; normal flora of human mouth; causes actinomycosis (endogenous; progressive chronic inflammation with suppuration and formation of sinuses and sulphur granules; cervicofacial, abdominal, pulmonary, brain, bone, liver, kidney, female pelvic organs), bacteraemia and septicemia (usually in pulmonary actinomycosis), endometritis, infections in abnormal host, mycetoma, otitis externa (very rare), parametritis, pelvic abscess, pelvic inflammatory disease (almost exclusively associated with IUD), peritonitis, salpingitis; diagnosis: Gram stain and culture, direct immunofluorescence; treatment: penicillin + streptomycin, tetracycline, erythromycin, cephalosporins

A. meyeri: cells diphtheroidal, branching; obligate or facultative anaerobe; smooth colonies on blood agar; diffuse growth in enriched thioglycolate broth; causes actinomycosis

A. naeslundii: possibly homologous with *A. viscosus*; cells diphtheroidal, branching; facultative anaerobe; smooth colonies on blood agar; diffuse growth in enriched thioglycolate broth; causes actinomycosis

A. odontolyticus: cells diphtheroidal, branching; microaerophilic or obligate anaerobe; usually red pigment on blood agar; colonies up to 5 mm diameter, regular and smooth with entire edge, centre slightly raised; diffuse growth in enriched thioglycolate broth; causes actinomycosis

A. pyogenes: cells diphtheroidal, coccoidal; facultative anaerobe; smooth colonies on blood agar; diffuse growth in enriched thioglycolate broth; gelatine positive; catalase negative; causes subacute localised infections in cattle, pigs, sheep, brain abscess, empyema, peritonsillar abscess, pharyngitis, septic arthritis, vulvovaginitis, ulcer and wound infections in man

A. viscosus: possibly homologous with *A. naeslundii*; cells diphtheroidal, branching; facultative anaerobe; small colonies on blood agar; diffuse growth in enriched thioglycolate broth

Bifidobacterium: Gram positive rod, irregular, branching, nonsporeforming; nonmotile; obligately anaerobic; major end-products of fermentation acetic acid and lactic acids + formic acid (propionic and butyric acids not formed); catalase positive; normal flora of mouth (usually present), large intestine (large numbers), vagina (irregular); also sewage; causes actinomycosis, diverticulitis, peritonitis; treatment: tetracycline, penicillin, erythromycin; also susceptible to meropenem (MIC 1 mg/L)

B.adolescentis: normal flora of oral cavity, tonsils and intestinal tract; has caused lung abscesses and pleural fluid

B.animalis: used as probiotic

B.breve: used as probiotic

B.dentium: thin rods, bifid or bulbous ends; obligate anaerobe; smooth colonies on blood agar; diffuse growth in enriched thioglycolate broth; catalase and indole negative; glucose fermented, metabolic products acetic and lactic acids; has been isolated from human tissues but role as pathogen not clear

B.longum: used as probiotic

Mycobacteriaceae

Mycobacterium: cells rods of variable length (coccoid to filaments), weakly Gram positive, strongly acid fast and acid/alcohol fast, not branching; meso-diaminopimelic acid, arabinose and galactose in cell wall; nonmotile; catalase positive; normal flora of large intestine, lower ileum, external genitalia, anterior urethra, vagina, skin; also animal, environment; causes bone marrow infection, 40% of carpal tunnel syndrome, encephalitis, hepatic granuloma, 36% of lymph gland infection, skin mycobacteriosis (including chronic ulcers), otitis externa (very rare), diffuse interstitial pneumonia, pulmonary abscess, pulmonary tuberculosis, prostatic abscess (rare), infections in abnormal host (T lymphocyte dysfunction), systemic infections in cell-mediated immunity disorders; growth stimulated by excess iron; cell wall component resists killing and digestion by phagocytes, unknown factor inhibits lysosomal fusion; cell-mediated immunity important in host defence; material responsible for adjunct activity of mycobacterial waxes D is thought to be N-acetylmuramyl dipeptide; treatment: streptomycin, paraaminosalicylic acid, ethionamide, cycloserine, viomycin, ethambutol, rifampicin, isoniazid, dapson, pyrazinamide, capreomycin

M.abscessus: non-sterile water implicated in most outbreaks (following cardiac surgery, cosmetic surgery, podiatric procedures, invasive otologic procedure, dialysis, injection of unapproved alternative medication); in cystic fibrosis from unknown source

M.africanum: causes tuberculosis

M.asiaticum: photochromogen; slow growth rate; rarely causes disease in humans (disseminated mycobacteriosis in AIDS); 0.01% of *Mycobacterium* isolates; incidence 0.1/100 000

M.avium-intracellulare: Runyon group III (nonchromogen); slow growing; growth at 25°C and 42°C variable; some strains show light yellow pigment that intensifies with age; weak catalase positive at 25-37°C, positive at 68°C; nitrate, tween hydrolysis and urease negative; serotyping helpful; widely distributed in environment; often associated with disease; 17-30% of *Mycobacterium* isolates; 71% of isolates respiratory; incidence 3/100 000; causes acute diarrhoea and/or vomiting in AIDS, adult hepatitis, dissemination (frequent in AIDS), infections in abnormal host, 12% of lymph gland infection (frequent local lymphadenitis in children), musculoskeletal infections (bone and joint; infrequent), pancreatitis (14% of cases in AIDS), granulomatous prostatitis and seminal vesiculitis (rare), pulmonary tuberculosis (chronic cavitating lung disease in adults; frequent), skin and soft tissue infections (infrequent), urinary infection (rare cases in renal transplant recipients); diagnosis: Ziehl-Neelsen stain and culture of appropriate specimen; treatment: ethionamide, cycloserine, ethambutol, rifampicin, streptomycin, clofazimine, ansamycin, isoniazid, rifabutin, amikacin, ciprofloxacin, azithromycin, clarithromycin (4-6 in combination) ? surgery; resistant to ofloxacin

M.avium: pathogenic to rabbit and chick, sometimes mouse; causes mycobacteriosis (avian tuberculosis) clinically indistinguishable from pulmonary tuberculosis but primary focus lower gastrointestinal tract and acquired through gastrointestinal tract; extrapulmonary (including granulomatous synovitis) and disseminated forms reported; susceptible to interleukin-4, granulocyte macrophage colony stimulatory factor, macrophage colony stimulatory factor and tissue necrosis factor-activated macrophages; interferon- γ and interleukin-2 also induce autoimmune activity; treatment: isoniazid + rifampicin + pyrazinamide

M.avium subspp paratuberculosis: slow growth rate; causes Johne's disease in animals, ? Crohn's disease in humans; survives normal pasteurisation

M.bovis: *Mycobacterium tuberculosis* complex; niacin and nitrate negative, no growth on Lowenstein-Jensen medium containing 2-thiophene-carboxylic acid hydrazide; pathogenic for guinea pig, rabbit and mouse; often associated with disease; 0.07% of *Mycobacterium* isolates; incidence 0.01/100 000; causes tuberculosis (respiratory, genitourinary, lymphatic, skeletal; disseminated in AIDS); enteric infection via milk; also, uncommon zoonotic transmission from seals, rhinoceros and elk; inhibits phagocytic degranulation; escapes from phagosome; susceptible to interferon- γ and

interleukin-6 activated macrophages; tissue necrotic factor active in experimental infection; treatment: isoniazid + rifampicin + pyrazinamide ? ethambutol or streptomycin

M.chelonae: Runyon group IV (rapid grower; growth after 3 d); growth at 25°C and 37°C, no growth at 42°C; no pigment; strong catalase positive at 25-37°C, positive at 68°C; p-aminosalicylate and salicylate degraded; resistant to ethambutol; urease positive; nicotinamidase, tween hydrolysis and nitrate negative; glucose, mannose and trehalose used as carbon source; serine and ethanolamine used as source of both nitrogen and carbon; serotyping helpful; often associated with disease; 1% of *Mycobacterium* isolates; incidence 0.2/100 000; causes bacteraemia and septicemia (catheter related), disseminated disease (in AIDS and patients undergoing haemodialysis; infrequent), granulomatous synovitis, local infections after implantation of prosthetic devices (including endocarditis associated with prosthetic valve), infections in abnormal host, keratitis and iritis, lymphadenitis (infrequent), musculoskeletal infections (frequent), peritonitis in continuous ambulatory peritoneal dialysis, pulmonary tuberculosis (infrequent), skin and soft tissue infections including subcutaneous abscesses (following trauma; frequent), thyroiditis; treatment: clarithromycin, amikacin, erythromycin, sulphisoxazole, cefoxitin, tetracycline, cotrimoxazole, triple sulpha, sulphamethoxazole, doxycycline, sulphacetamide; resistant to ciprofloxacin, ofloxacin

M.chelonae subspecies chelonae: no growth on Sauton agar containing 0.2% picric acid, sodium citrate utilised, no growth in 5% NaCl

M.flavescens: intermediate growth rate; growth at 25°C and 37°C, no growth at 42°C; pigmented; strong catalase positive at 25-37°C, positive at 68°C; nitrate and tween hydrolysis positive; growth in 5% NaCl; urease negative; rarely associated with disease; 0.8% of *Mycobacterium* isolates; incidence 0.2/100 000

M.fortuitum subspecies fortuitum: Runyon group IV (rapid grower); growth at 25°C and 37°C, no growth at 42°C; no pigment; strong catalase positive at 25-37°C, positive at 68°C; urease, nitrate reduction and iron uptake positive; tween hydrolysis variable; serotyping helpful; 4-8% of *Mycobacterium* isolates; 40% of isolates from peritoneal fluid; incidence 0.7/100 000; cutaneous and ocular (keratitis and iritis) disease following trauma reported; causes local infections associated with implanted prosthetic devices, augmentation mammoplasty infection, bacteraemia and septicemia (catheter related), cellulitis, cervical lymphadenitis (infrequent), disseminated disease (infrequent; in AIDS and non-AIDS patients), infection in abnormal host, musculoskeletal infections (frequent), osteomyelitis and osteochondritis, peritonitis in continuous ambulatory peritoneal dialysis, prosthetic valve endocarditis, pulmonary tuberculosis (infrequent), skin and soft tissue infections (frequent), lupus vulgaris-like lesions; treatment: triple sulpha, amikacin (100% susceptible), cefoxitin (64% susceptible), tetracycline, erythromycin, cotrimoxazole, sulphamethoxazole (88% susceptible), doxycycline (91% susceptible), sulphisoxazole, sulphacetamide; also susceptible to ciprofloxacin (100% susceptible at 0.25 mg/L), ofloxacin (0.4 mg/L), norfloxacin (0.8 mg/L), clarithromycin (90% susceptible), imipenem (91% susceptible)

M.gastri: slow growth rate; growth at 25°C and 37°C, no growth at 42°C; no pigment; weak catalase positive at 25-37°C, negative at 68°C; tween hydrolysis and urease positive; nitrate negative; serotyping helpful; rarely associated with disease; 0.3% of *Mycobacterium* isolates; incidence 0.1/100 000

M.gordona: slow growth rate; scotochromogen; small yellow-orange colonies in 2-6 w; growth at 25°C and 37°C, no growth at 42°C; strong catalase positive at 25-37°C, positive at 68°C; tween hydrolysis positive; nitrate and urease negative; uses glucose and n-butanol as carbon source; normal inhabitant of tap water; rarely associated with disease; causes granulomatous synovitis, disseminated mycobacteriosis in non-AIDS patients, occasional infections of respiratory tract and spleen in AIDS; 5-15% of *Mycobacterium* isolates; 42% of isolates from urine; incidence 3/100 000; treatment: isoniazid + rifampicin + pyrazinamide

M.haemophilum: nonchromogen; slow growing; potentially pathogenic in humans; causes disseminated mycobacteriosis in AIDS, skin and soft tissue infections (frequent), local and generalised sepsis (in immunocompetent), lymphadenitis (infrequent); treatment: rifampicin, isoniazid, ethambutol ? surgery

M.intracellulare: causes chronic mycobacteriosis (Battley disease) clinically indistinguishable from pulmonary tuberculosis; acquired by respiratory route; rare instances of lymphadenitis, osteomyelitis, renal abscess, thyroiditis and disseminated disease reported; susceptible to interferon- γ -activated macrophages

M.kansasii: Runyon group I (photochromogen); growth at 25°C and 37°C, no growth at 42°C; strong catalase positive at 25-37°C, positive at 68°C; nitrate reduced, tween hydrolysis and urease positive; serotyping helpful;

pathogenicity for mouse variable; often associated with disease but not commonly found in environment; 3-5% of *Mycobacterium* isolates; 75% of isolates from respiratory; incidence 0.5/100 000; causes bone marrow infection, disseminated disease (infrequent; in AIDS), granulomatous synovitis, infections in abnormal host, lymph gland infection (local lymphadenitis in children; infrequent), musculoskeletal infection (bone, joint, bursitis; infrequent), pulmonary tuberculosis (chronic cavitating lung disease in adults; frequent), skin and soft tissue infection (sporotrichoidal, cutaneous 'tuberculosis', deep heel infection; infrequent); diagnosis: Ziehl-Neelsen stain and culture of appropriate specimen; treatment: rifampicin + isoniazid + pyrazinamide ? ethambutol, streptomycin, sulphamethoxazole, amikacin ? surgery; resistant to ciprofloxacin

M.leprae: obligate parasite of man but ? recoverable from soil, water, vegetation; attacks skin, nasal mucosa and nerves; causes leprosy (15 M lepers in world), adult hepatitis and hepatic granuloma (in 90% of lepromatous, and 20% of tuberculoid, cases); inhibits phagocytic microbicidal activity by resistance to granule substance; multiplies in macrophages; carried in blood associated with mononuclear cells; in lepromatous leprosy, immune complexes prominent in pathogenesis of clinical disease, cell-mediated immunity suppressed; recovery from infection and resistance to reinfection due to cell-mediated immunity; mean doubling time 2 w in vivo; diagnosis: modified Ziehl-Neelsen stain of scrapings from mucosal ulcers, fluid from nodules, biopsy of macule, muscle or nerve, histology of biopsy, ELISA; treatment: dapsone + isoniazid, sulphonamides, rifampicin, clofazimine, ethionamide, prothionamide

M.lepraemurium: inhibits phagocytic microbicidal activity by resistance to granule substance (lysosomal enzymes)

M.malmoense: nonchromogen; slow growing; strict or potential pathogen; 0.03% of *Mycobacterium* isolates; incidence

< 0.1/100 000; causes disseminated mycobacteriosis in AIDS and non-AIDS patients, lymphadenitis (infrequent), pulmonary infection (frequent); treatment: rifampicin, streptomycin, ethionamide, capreomycin, ethambutol, rifabutin, clofazimine, isoniazid ? surgery

M.marinum: Runyon group I (photochromogen); growth at 25°C, growth at 37°C variable, no growth at 42°C; weak catalase positive at 25-37°C, positive at 68°C; tween hydrolysis and urease positive; nitrate negative; does not use glucose or n-butanol as carbon source; pathogenic to mouse (local areas); 'indigenous' in sea water; often associated with disease; causes bursitis, granulomatous synovitis, musculoskeletal infections (frequent), skin and soft tissue infections (sporotrichoidal; frequent), swimming pool granuloma; 0.4% of *Mycobacterium* isolates; incidence 0.04/100 000; treatment: rifampicin, ethambutol, tetracycline, isoniazid, pyrazinamide ? surgery

M.microti: causes rodent tuberculosis; inhibits phagocytic degranulation

M.nonchromogenicum: growth at 42°C; slow growth rate (no growth after 3 d); p-aminosalicylate and salicylate not degraded; susceptible to ethambutol; nicotinamidase and tween hydrolysis positive; urease negative; glucose, mannose and trehalose not used as carbon source; serine and ethanolamine not used as source of both nitrogen and carbon; rarely causes disease in humans (chronic tenosynovitis of knee); treatment: ethambutol, sulphonamides, cotrimoxazole, erythromycin, streptomycin + surgical debridement

M.parafortuitum: rapid growth rate; usually non-pathogenic

M.phlei: rapid growth rate; rarely associated with disease

M.scrofulaceum: Runyon group II (scotochromogen); growth at 25°C and 37°C, no growth at 42°C; strong catalase positive at 25-37°C, positive at 68°C ; urease positive; tween hydrolysis and nitrate negative; serotyping helpful; not pathogenic to animals; often associated with disease; 2% of *Mycobacterium* isolates; 50% of isolates from respiratory, 50% from urine; incidence 0.4/100 000; causes bone disease (rare), cutaneous ulcers (rare), disseminated infection (infrequent; in AIDS), infection in abnormal host, cervical lymphadenitis (frequent in children), pulmonary infection (chronic cavitating lung disease in adults; infrequent); usually resistant to drugs, requiring combination of isoniazid, streptomycin and cycloserine + surgery

M.simiae: photochromogen; growth at 25-37°C, variable growth at 42°C; strong catalase positive at 25-37°C, positive at 68°C; urease positive; nitrate and tween hydrolysis negative; serotyping helpful; often associated with disease but not commonly found in environment; 0.2% of *Mycobacterium* isolates; incidence 0.02/100 000; causes disseminated disease (infrequent), osteomyelitis (infrequent), pulmonary infections (chronic cavitating lung disease in adults; frequent); usually resistant to drugs, requiring combination of isoniazid, ethambutol and rifampicin

M. smegmatis: rapid growth rate; growth at 25°C, 37°C and 43-45°C; late-developing yellow to orange pigment in 50%; low semiquantitative catalase test, strong catalase positive at 25-37°C, positive at 68°C; tween hydrolysis and urease positive; serotyping not helpful; causes skin and soft tissue infections (primary and post-surgical (especially cardiac), catheter tunnel), cellulitis, local and generalised sepsis, disseminated mycobacteriosis in AIDS; treatment: sulphamethoxazole, amikacin, cefoxitin, doxycycline + surgery

M. szulgai: growth at 25°C and 37°C, variable growth at 42°C; scotochromogenic at 37°C and variably photochromogenic at 25°C; strong catalase positive at 25-37°C, positive at 68°C; nitrate and urease positive; tween hydrolysis variable; serotyping helpful; often associated with disease but not commonly found in environment; 0.1% of *Mycobacterium* isolates; incidence 0.03/100 000; causes disseminated disease (infrequent; in AIDS), musculoskeletal infection (bursitis; infrequent), pulmonary tuberculosis (chronic cavitating lung disease in adults, pneumonitis; frequent); treatment: rifampicin + isoniazid + ethambutol + ethionamide or cycloserine or streptomycin

M. terrae*/*M. triviale: growth at 25°C and 37°C, no growth at 42°C; slow growth rate; no pigment; strong catalase positive at 25-37°C, negative at 68°C; nitrate and tween hydrolysis positive; urease negative; serotyping helpful; rarely associated with disease; 2% of *Mycobacterium* isolates; 67% of isolates from respiratory; incidence 0.4/100 000

M. thermoresistibile: rapid growth rate; rarely causes disease in humans (2 pulmonary cases, 1 cutaneous)

M. tuberculosis: niacin and nitrate positive; growth on Lowenstein-Jensen medium containing 2-thiophene-carboxylic acid hydrazide; pathogenic for guinea pig and mouse; often associated with disease; 52% of *Mycobacterium* isolates; causes tuberculosis, chronic respiratory infection in man (10-15 M active cases in world), anterior uveitis, septic arthritis, bone marrow infection, brain abscess, 21% of carpal tunnel syndrome, cholangitis and cholecystitis, chorioretinitis, purulent conjunctivitis, acute diarrhoea and vomiting in AIDS, acute epididymitis and epididymoorchitis, erythema nodosum, adult hepatitis, 20% of hepatic granuloma, 20% of lymph gland infection, non-pyogenic meningitis, mesenteric lymphadenitis, mouth lesions, mycotic aneurism, oesophagitis, 1% of osteomyelitis and osteochondritis, otitis externa (very rare), chronic draining otitis media, parotitis and submandibular sialadenitis, peritonitis (primary), pneumonia, psoas abscess, pulmonary abscess, septic arthritis, splenic abscess in AIDS, granulomatous synovitis, thyroiditis, infections in abnormal host, disseminated mycobacteriosis in AIDS; inhalation infectious dose in man 1-10 bacteria; exposure to ultraviolet light and particle size are responsible for secondary aerosols being less dangerous in transmission of tuberculosis than primary aerosols; enters across respiratory tract epithelial surface and subsequently spreads through body; inhibits phagocyte chemotaxis, lysosome-phagosome fusion (by bacterial sulphatide), degranulation, microbicidal activity (by resistance to granule substance); basic factors in pathogenesis of pulmonary tuberculosis include intracellular multiplication and delayed hypersensitivity; multiples in macrophages; cord factor virulence factor; primary immune defence activation of macrophages, by T cell-generated lymphokines (tissue necrosis factor, interferon- γ), rendering them resistant to infection (+++), killing of infected phagocyte also important; recovery from primary infection, resistance to reinfection and resistance to reactivation of latent infection due to cell-mediated immunity; cell-mediated immunity in tuberculosis has been called a 'double-edge sword' because it limits intracellular multiplication and mediates delayed hypersensitivity simultaneously; persists in lung or lymph node (infectious, shed to exterior), activation giving tuberculosis in middle aged; mean doubling time 24 h in vitro; diagnosis: auramine rhodamine stain of sputum or bone marrow, acid-fast smear, culture, tuberculin test, interferon gamma test, PCR (not faeces, synovial fluid or urine), DNA probe, gene amplification and hybridisation, ELISA; treatment: streptomycin (6.8% resistance in Australia), paraaminosalicylic acid, isoniazid (8.5% resistance in Australia), rifampicin (1.5% resistance in Australia), ethambutol (0.3% resistance in Australia), pyrazinamide, thiacetazone; susceptible to ciprofloxacin

(MIC 0.5-1 mg/L), ofloxacin (0.8-1 mg/L)

M. ulcerans: nonchromogen; slow growing; often associated with disease but not commonly found in environment; causes chronic ulcers (Bairnsdale (Buruli) ulcer); treatment: streptomycin, dapsone, ethambutol, rifampicin + surgery, local heat

M. vaccae: rapid growth rate; usually nonpathogenic

M. xenopi: Runyon group III (nonchromogen); slowly produces small yellow colonies; grows best at 42°C; no growth at 25°C, growth at 37°C; weak catalase positive at 25-37°C, positive at 68°C; nitrate, tween hydrolysis and urease negative; pathogenicity for mouse and chick variable; often associated with disease; 0.2% of *Mycobacterium* isolates;

causes disseminated disease (infrequent; in AIDS), pulmonary tuberculosis (chronic cavitating lung disease in adults, pneumonitis; frequent); incidence 0.03/100 000; treatment: isoniazid + rifampicin + pyrazinamide ? streptomycin or ethambutol ? surgery

Nocardioforms

Nocardia: cells branched filaments ? rods ? cocci, some forming conidia on aerial hyphae; weakly acid-fast, variably Gram positive; nonmotile; mycolic acids present; meso-diaminopimelic acid, arabinose and galactose in cell wall; grows only aerobically, appearing in 2-5 d on blood and chocolate blood agar as rough, dry, velvety colonies digging into the agar; optimum growth at 5-10% CO₂ and 37°C; grows on simple media and at wide temperature range; catalase and urease positive; causes abscesses (including silent brain abscesses), chorioretinitis, adult hepatitis, hepatic granuloma, postneonatal pyogenic meningitis, actinomycetoma, disseminated infection in cell-mediated immunity disorders; primary bodily defence mechanism leucocyte bactericidal function; diagnosis: Gram, Ziehl-Neelsen stain and culture of sputum, thoracentesis specimen, transtracheal aspirate, bronchial washings, lung biopsy, pus from abscess or draining sinus, biopsy from other affected sites, serology (immunodiffusion); susceptible to sulphonamides, trimethoprim, cotrimoxazole, minocycline, amikacin, imipenem

N. asteroides: Gram positive branching filaments, partially acid fast; starch not hydrolysed, casein, tyrosine, gelatine, acetamide and aryl negative; 36% of *Nocardia* isolates in Australia; causes abscesses without granules in mouse and guinea pig, frequently causes death; causes intense suppuration with minimal fibrosis; causes brain abscess in impaired cell-mediated immunity, postneonatal pyogenic and nonpyogenic meningitis (common in impaired cell-mediated immunity; case-fatality rate 57%), mycetoma, osteomyelitis and osteochondritis, diffuse interstitial pneumonia in T cell deficiency, pneumonitis in immunodeficient, infections in abnormal host (especially in alveolar proteinosis, Hodgkin's disease, immunosuppressive therapy, T lymphocyte dysfunction); immunity cell-mediated (delayed type hypersensitivity +++); diagnosis: immunodiffusion (antigen), Gram and acid-fast smears, culture (mycobacterial media, modified Thayer-Martin medium, paraffin-containing medium, BMPA?, MWY charcoal yeast extract agar); treatment: amikacin, sulphonamide, cotrimoxazole + streptomycin, minocycline, imipenem; also susceptible to tobramycin; resistant to erythromycin

N. brasiliensis: partially acid fast; starch not hydrolysed, casein, tyrosine and gelatine positive; abscesses with granules caused in mouse and guinea pig by some strains; causes 14% of nocardiosis in Australia (most common cause of lymphocutaneous), mycetoma, infections in abnormal host; treatment: cotrimoxazole or sulphamethoxazole + amikacin

N. brevicatena: acid-fast spores; trehalose positive, lysosome sensitive; relatively rare but generally associated with severe disease (pulmonary, brain, blood); treatment: cotrimoxazole, ciprofloxacin, cefotaxime, amikacin, minocycline, imipenem; also susceptible to tobramycin, sulphafurazole, cephmandole; resistant to erythromycin, augmentin

N. caviae: causes mycetoma; treatment: cotrimoxazole + amikacin

N. farcinica: growth at 45°C, acetamide and rhamnose positive, aryl negative; 17% of *Nocardia* isolates in Australia; sensitive to ciprofloxacin, augmentin; resistant to cefamandole, cefotaxime, erythromycin, ampicillin, tobramycin

N. nova: no growth at 45°C, aryl positive, acetamide and rhamnose negative; 25% of *Nocardia* isolates in Australia; causes peritonitis, abscesses; sensitive to cefamandole, cefotaxime, ampicillin, erythromycin; resistant to tobramycin, ciprofloxacin, augmentin

N. otitiscaviarum: 3% of *Nocardia* isolates in Australia

N. transvaliensis: 6% of *Nocardia* isolates in Australia

Nocardiosis dassomillei: has been isolated from clinical specimens but its role as a human pathogen is uncertain

Rhodococcus: Gram positive rods, cocci, filaments, weakly acid fast; mycolic acids present; nonmotile; conidia not formed; catalase positive; humans, soil; susceptible to ciprofloxacin (MIC 1 mg/L)

Rhodococcus equi: coryneform; grows well on ordinary media as large, irregular, highly mucoid, salmon-pink colonies; causes infections in abnormal host (opportunistic infection (diffuse interstitial pneumonia, pneumonitis, pulmonary abscess) associated with AIDS or T helper lymphocyte dysfunction and exposure to animals); treatment: rifampicin + erythromycin + surgery

Oerskovia: Gram positive, extensive branching ? rods due to fragmentation ? motile coccoid elements; facultative anaerobe; aerial mycelium not produced; non-acid fast; nitrate, gelatine, esculin, glucose, maltose and sucrose positive;

urea, mannitol and xylose negative; catalase positive on aerobic incubation, negative if grown anaerobically; soil, clinical; causes bacteraemia (catheter related), endocarditis (prosthetic valves); sometimes isolated from CSF but pathogenicity uncertain; treatment: ampicillin + cotrimoxazole; susceptible to metronidazole

Micropolyspora: fragmentation of mycelium in older cultures not marked

Intrasporangium: aerial mycelium not produced

Streptomyces: cells branching, filaments, Gram positive, non-acid fast, mycelium formed, little fragmentation, usually with conidia on aerial hyphae forming chains; arthrospores; L-diaminopimelic acid and glycine in cell wall; nonmotile; colonies tough; no anaerobic growth; urease, arabinose and xylose negative; causes mycetoma

S.griseus: isolated from sputum (36%), wound (32%), blood (25%), brain (7%); susceptible to amikacin

S.paraguayensis: causes mycetoma; treatment: cotrimoxazole + amikacin

S.somaliensis: causes mycetoma; treatment: cotrimoxazole + amikacin

Actinoplanes: meso-diaminopimelic acid and glycine in cell wall

Dermatophilus: Gram positive filaments, branch at right angles, produce motile coccoid forms; substrate mycelium; non-acid fast; catalase positive; causes human and animal skin lesions

D.congolensis: causes dermatophilosis; diagnosis: Giemsa stain and culture of scabs and exudates

Actinomadura: delicate, non-fragmenting, branched filaments, non-acid fast; meso-diaminopimelic acid in cell wall; aerobic; growth in simple media; usually found in soil

A.maduræ: not acid fast; arthrospores; arabinose and xylose positive, casein and starch hydrolysed; urease negative; not pathogenic to mice and guinea pig; causes mycetoma; treatment: cotrimoxazole + amikacin; also susceptible to ceftriaxone, imipenem

A.pelletierii: not acid fast; urease, arabinose and xylose negative; casein hydrolysed, starch not hydrolysed; not pathogenic to mice and guinea pig; causes mycetoma; treatment: cotrimoxazole + amikacin

Tropheryma whippelii: causes Whipple's disease, endocarditis; diagnosis: PCR on tissue, CSF, blood; small bowel biopsy

Division Tenericutes

Class Mollicutes: wall-less procaryotes

Order Mycoplasmatales: probably a group of degenerate bacterial forms lacking rigid cell walls (cell wall or cell wall peptidoglycans absent); Gram negative, pleomorphic; visible in optical microscope; filterable through 450 nm pore size filters; contain both RNA and DNA; grow on cell-free media; generate metabolic energy, do not depend on host cells for multiplication, can synthesise proteins by own enzymes, require sterols (except *Acholeplasma*); growth inhibited by antibody alone; growth inhibited by antimicrobials acting on protein synthesis; all resistant to penicillin

Mycoplasmataceae: genome size $\approx 5 \times 10^8$ D; NADH oxidase localised to cytoplasm; sterol required for growth

Mycoplasma: small, highly pleomorphic organisms that are difficult to observe with routine smears; cell wall does not contain muramic acid; requires complex medium including cholesterol for growth; does not hydrolyse urea; 88 currently recognised species; habitat man, animals, plants, insects; normal flora of mouth, large intestine, lower ileum, external genitalia, anterior urethra, vagina (13%); causes encephalitis, meningoencephalitis, pneumonia (including diffuse interstitial), ? nonspecific urethritis; inhibits phagocytic ingestion despite attachment; 650 genes; treatment: tetracycline, doxycycline

M.arginini: activates B lymphocyte

M.arthritis: activates T lymphocyte activation of B cells by superantigen bridge

M.buccale: arginine positive; glucose and urea negative; rare isolates from oro-respiratory tract

M.faucium: arginine positive; glucose and urea negative; rare isolates from oro-respiratory tract

M.fermentans: glucose and arginine positive; urea negative; rare isolates from lower urogenital tract and oropharynx; secondary colonisation/infection of leukemic bone marrow, arthritic joint, peripheral blood lymphocytes in AIDS, urine in AIDS; activates B and T lymphocytes

M.genitalium: has a flask-shaped appearance, with a specialised terminal portion; exhibits gliding motility; grows slowly, particularly in primary culture; on agar, grows optimally in N_2 -5% CO_2 and produces some 'fried egg' colonies; growth inhibited by thallium acetate, tetracycline, erythromycin and other antimicrobials; exhibits haemadsorption, reduced by treating erythrocytes with neuraminidase; attaches to cells in tissue and organ cultures and to glass and plastic; has specific proteins, some of which are shared with *M.pneumoniae*; protein of terminal 140 kD portion

different from that of *M.pneumoniae* but has considerable sequence homology; is serologically distinct from other *Mycoplasma* species but has some cross-reactivity with *M.pneumoniae* and *M.pirum*; guanine/cytosine ratio 32.4?1 mol%; arginine positive; glucose and urea negative; rare isolates from urogenital tract and oropharynx; secondary colonisation/infection of urethra, synovial fluid in arthritic joint

M.hominis: aerobic and anaerobic growth in vitro; arginine positive; glucose and urea negative; common inhabitant of oropharynx and lower urogenital tract; secondary colonisation/infection of lung and pleural effusion, blood in postpartum septicemia, prostheses, transplants, sites of trauma/surgery, malignancies, CSF, peritoneum, synovial fluid in arthritis, skin, pericardium, amniotic fluid, neonatal septicemia; rarely causes abortifacient and puerperal infection, 6% of neonatal bacteraemia and septicemia, cellulitis (postcaesarean and others), mucopurulent cervicitis, chorioamnionitis, endometritis, nonpyogenic meningitis, myocarditis and pericarditis, parametritis, pelvic abscess, pelvic inflammatory disease, peritonitis, acute pyelonephritis, salpingitis, septic arthritis associated with prostheses, septicemia in puerperium, ? vaginitis; diagnosis: direct immunofluorescence, culture (identification by growth inhibition, immunofluorescence test, growth agglutination (subspecies)), modified metabolic inhibition, mycoplasmacidal test, indirect haemagglutination; treatment: doxycycline, erythromycin, tetracycline, ciprofloxacin

M.hyorhinis: activates B lymphocytes

M.lipophilum: arginine positive; glucose and urea negative; rare isolates from oro-respiratory tract

M.neurolyticum: activates B lymphocytes

M. orale: arginine positive; glucose and urea negative; common inhabitant of oro-respiratory tract; secondary colonisation/infection of leukemic bone marrow and of lymph nodes and skin in sarcoidosis; activates B lymphocytes

M.penetrans: glucose and arginine positive; urea negative; coloniser of genital tract; secondary colonisation/infection of urine in male AIDS patients; associated with Kaposi's sarcoma in AIDS

M.pirum: glucose and arginine positive; urea negative; primary site of colonisation unknown; secondary colonisation/infection of peripheral blood lymphocytes

M.pneumoniae: aerobic and anaerobic growth in vitro; glucose positive; arginine and urea negative; haemagglutinates guinea pig red blood cells; rare isolates from oro-respiratory tract except during outbreaks of disease; does not colonise but produces acute or subacute infection; primary sites of infection oropharynx, lung, pleural fluid, bronchoalveolar fluid; secondary sites arthritic joints, skin lesions, middle ear fluid, CSF, tubo-ovarian abscess, vagina, pericardial fluid, cardiac blood, kidney, brain; causes acute respiratory illness— pharyngitis/tracheobronchitis (77% of infections; annual rate of 46/1000), acute exudative and nonexudative tonsillitis, acute bronchiolitis and bronchopneumonia, primary atypical pneumonia in children and young adults (usually interstitial; 3% of infections; annual rate 2/1000), pneumonitis in immunodeficient, coryza, bullous myringitis and pleural effusion, ? chronic asthma, also haemolytic anaemia (rare), thrombocytopenia, migratory polyarthritis (rare), hepatitis, myocarditis and/or pericarditis (rare), erythema multiforme, erythema nodosum, nonpyogenic meningitis, encephalitis and meningoencephalitis (rare), macular rash, maculopapular rash, generalised urticarial rash, varicella-like rash, petechial or purpuric rash (rare), ? inflammatory bowel disease; implicated in Stevens-Johnson syndrome and Guillain-Barré syndrome; 20% of infections asymptomatic; 'foot' on surface of organism attaches to neuraminic acid receptor on respiratory epithelial cell; infection generally confined to epithelial surface of respiratory tract; microbial antigens mimic host antigens, leading to poor antibody response; activates B and T lymphocytes; diagnosis: modified metabolic inhibition, cold agglutination (? 1:32; sensitivity 50%, specificity 50%), complement fixation test (? 1:66; sensitivity 54%, not completely specific), culture on A7B agar (identification by growth inhibition on agar, immunofluorescence); treatment: tetracycline, erythromycin, doxycycline, roxithromycin, minocycline, gatifloxacin, moxifloxacin, azithromycin, clarithromycin

M.primatum: arginine positive; glucose and urea negative; rare isolates from urogenital tract (female urethra); secondary colonisation/infection of umbilicus

M.pulmonis: activates B and T lymphocytes

M.salivarium: arginine positive; glucose and urea negative; common inhabitant of oro-respiratory tract; secondary colonisation/infection of cervix/vagina, arthritic joint

M.spermatophilum: arginine positive; glucose and urea negative; coloniser of genitourinary tract (cervix/sperm)

Ureaplasma: requires cholesterol; urease positive; 5 currently recognised species; habitat man and animals; normal flora of vagina (54%); ? causes diffuse interstitial pneumonia

U. urealyticum: isolation medium contains sterol and has a pH of 6; urea positive; glucose and arginine negative; serotype 3 haemabsorbs guinea pig red blood cells; isolated from genitourinary tract and oropharynx (rare); other sites of primary colonisation/infection bronchoalveolar fluid, placenta; causes 30-40% of nongonococcal urethritis, prostatitis, acute cystitis, urinary calculi, chorioamnionitis, endometritis, parametritis, pelvic abscess, pelvic inflammatory disease, pneumonia (including neonatal), septic arthritis in hypogammaglobulinemia, puerperal septicemia, 1% of neonatal bacteraemia and septicemia, myocarditis and pericarditis; sexually transmitted; importance not clear; treatment: erythromycin, minocycline, tetracycline, doxycycline; resistant to ciprofloxacin

Spiroplasmataceae: helical organisms during some phase of growth; genome size ? 10^9 D; NADH oxidase localised in cytoplasm; sterol required for growth

Spiroplasma: helical filaments; requires cholesterol; habitat arthropods (including insects) and plants; 11 currently recognised species

Acholeplasmatales

Acholeplasmataceae: genome size ? 10^8 D; NADH oxidase localised in membrane; sterol not required for growth; all nonpathogenic for man

Acholeplasma: does not require cholesterol; habitat animals, plants, insects; 12 currently recognised species

A. laidlawii: aerobic and anaerobic growth in vitro; glucose positive; arginine and urea negative; coloniser of oropharynx

A. oculi: glucose positive; arginine and urea negative; primary site of colonisation unknown; secondary colonisation/infection of antral fluid

Anaeroplanetales

Anaeroplanataceae

Anaeroplasmata: requires cholesterol; obligate anaerobe; habitat bovine and ovine rumen; 4 currently recognised species

Asteroplasmata: does not require cholesterol; oxygen sensitive; habitat bovine and ovine rumen; 1 currently recognised species

Division Mendosicutes

Class Archaeobacteria: procaryotes with unusual walls, membrane lipids, ribosomes and RNA sequences

Cyanobacteria: 'blue-green algae'

Anabaena: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (microcystin) and neurotoxicity (anatoxin and saxitoxin)

Aphanizomenon: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (cylindrospermopsin) and neurotoxicity (anatoxin and saxitoxin)

Cylindrospermopsis: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (cylindrospermopsin) and neurotoxicity (saxitoxin)

Lynghya: 'indigenous' in freshwater; forms blooms; causes neurotoxicity (anatoxin)

Microcystis: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (microcystin)

Nodularia: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (nodularin)

Nostoc: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (microcystin)

Oscillatoria: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (microcystin) and neurotoxicity (anatoxin)

Umezakia: 'indigenous' in freshwater; forms blooms; causes hepatotoxicity (cylindrospermopsin)