12 Etiological and Laboratory Diagnostic Summaries in Tabular Form

FH Kayser, J Eckert, and KA Bienz

Table 12.**1** Upper Respiratory Tract

Infection	Most important pathogens*	Laboratory diagnosis
Rhinitis (common cold)	**Rhinoviruses** Coronaviruses Influenzaviruses Adenoviruses	Laboratory diagnosis not recommended
Sinusitis	*Streptococcus pneumoniae* *Haemophilus influenzae* *Staphylococcus aureus* *Moraxella catarrhalis* (children) *Streptococcus pyogenes* rarely: anaerobes	Microscopy and culturing from sinus secretion/pus (punctate) or sinus lavage
	Influenzaviruses Adenoviruses	Serology
	Rhinoviruses Coronaviruses	Laboratory diagnosis not recommended
Pharyngitis/tonsillitis/ gingivitis/stomatitis *Viruses*	**Adenoviruses** Influenzaviruses RS virus Rhinoviruses Coronaviruses	Isolation, if required, or direct detection in pharyngeal lavage or nasal secretion; serology
Herpangina	Coxsackie viruses, group A	Isolation if required
Gingivitis/stomatitis	Herpes simplex virus	Isolation Serology

Table 12.1 *Continued: Upper Respiratory Tract*

Infection	Most important pathogens*	Laboratory diagnosis
Infectious mononucleosis	**Epstein-Barr virus (EBV)**	Serology
	Cytomegalovirus (CMV)	Culture from pharyngeal lavage and urine; serology
Bacteria	***Streptococcus pyogenes,*** rarely: streptococci of groups B, C, or G	Culture from swab; rapid antigen detection test for A-streptocci in swab material if required
Plaut-Vincent angina	***Treponema vincentii*** + mixed anaerobic flora	Microscopy from swab
Acute necrotic ulcerous gingivostomatitis	***Treponema vincentii*** + mixed anaerobic flora	Microscopy from swab
Diphtheria	***Corynebacterium diphtheriae***	Culture from swab
Laryngotracheobronchitis (croup)	**Parainfluenza viruses** **Influenza viruses** **Respiratory syncytial virus** **Adenoviruses** Enteroviruses	Isolation from pharyngeal lavage or bronchial secretion, combined with serology
	Rhinoviruses	Laboratory diagnosis not recommended
Epiglottitis	***Haemophilus influenzae*** (usually serovar "b") More rarely: *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes*	Blood culture. Culture from swab (caution: respiratory arrest possible in taking the swab)

* The pathogens that occur most frequently are in bold type.

Table 12.**2** Lower Respiratory Tract

Infection	Most important pathogens	Laboratory diagnosis
Acute bronchitis. Acute bronchiolitis (small children)	**Respiratory syncytial virus** **Parainfluenza viruses** **Type A influenza viruses** Adenoviruses	Serology, combined with isolation from pharyngeal lavage or bronchial secretion
	Rhinoviruses	Not recommended
	Mycoplasma pneumoniae	Serology
	Chlamydia pneumoniae	Serology if required
Pertussis	*Bordetella pertussis*	Culture; special material sampling and transport requirements
		Direct immunofluorescence in smear
Acute exacerbation of "chronic obstructive pulmonary disease" (COPD)	***Streptococcus pneumoniae*** *Haemophilus influenzae* *Moraxella catarrhalis*	Culture from sputum or bronchial secretion
Tuberculosis	***Mycobacterium tuberculosis*** other mycobacteria	Microscopy and culture (time requirement: 3–6–8 weeks)
Pneumonia *Viruses* (15–20%) (usually community-acquired)	**Parainfluenza viruses** (children) **Respiratory syncytial virus** (children) **Influenza viruses** **Adenoviruses**	Serology, combined with isolation from pharyngeal lavage or bronchial secretion or antigen detection in nasal secretion
	Epstein-Barr virus (EBV)	Serology
	Cytomegalovirus (CMV) (in transplant patients) Measles virus	Serology, combined with isolation from pharyngeal lavage or bronchial secretion; cell culture if CMV pneumonia suspected. Antigen or DNA assay. Serology

Table 12.**2** *Continued: Lower Respiratory Tract*

Infection	Most important pathogens	Laboratory diagnosis
	Pulmonary hantaviruses (USA)	Serology
	Enteroviruses	Isolation from pharyngeal lavage or bronchial secretion
	Rhinoviruses	Laboratory diagnosis not recommended
Bacteria (80–90%) "Community-acquired pneumonia"	*Streptococcus pneumoniae* (30%) *Haemophilus influenzae* (5%) *Staphylococcus aureus* (5%) *Klebsiella pneumoniae* *Legionella pneumophila* Mixed anaerobic flora (aspiration pneumonia)	Microscopy and culturing from expectorated sputum, or better yet from transtracheal or bronchial aspirate, from bronchoalveolar lavage or biopsy material. If anaerobes are suspected use special transport vessels
	Mycoplasma pneumoniae (10%)	Serology
	Coxiella burnetii *Chlamydia psittaci*	Serology Serology: CFT can detect only antibodies to genus. Microimmunofluorescence (MIF) species-specific
	Chlamydia pneumoniae	Serology: MIF
"Hospital-acquired pneumonia"	***Enterobacteriaceae*** ***Pseudomonas aeruginosa*** ***Staphylococcus aureus***	Laboratory procedures see above at "community-acquired pneumonia"
Fungi	*Aspergillus* spp. *Candida* spp. *Cryptococcus neoformans* *Histoplasma capsulatum* *Coccidioides immitis* *Blastomyces* spp. *Mucorales*	Microscopy and culture, preferably from transtracheal or bronchial aspirate, bronchoalveolar lavage or lung biopsy. Serology often possible (see Chapter 5)

Table 12.**2** *Continued: Lower Respiratory Tract*

Infection	Most important pathogens	Laboratory diagnosis
	Pneumocystis carinii (Pneumocystis carinii pneumonia (PCP) frequent in AIDS patients)	Pathogen detection in "induced" sputum or bronchial lavage by means of microscopy, immunofluorescence or DNA analysis
Protozoa	Microspora	As for *P. carinii*, DNA detection (PCR)
	Toxoplasma gondii	Serology
Helminths	*Echinococcus* spp.	Serology
	Schistosoma spp.	Serology; worm eggs in stool
	Toxocara canis (larvae)	Serology
	Ascaris lumbricoides (larvae)	Serology (specific IgE) (worm eggs in stool)
	Paragonimus spp.	Worm eggs in stool and sputum; serology
SARS (Severe Acute Respiratory Syndrome)	SARS Corona Virus	Reverse transcriptase PCR (RT-PCR) in respiratory tract specimens (swabs, lavage etc.). Serology (EIA).
Empyema	***Streptococcus pneumoniae*** ***Staphylococcus aureus*** ***Streptococcus pyogenes*** Numerous other bacteria are potential pathogens	Microscopy and culture from pleural pus specimen
Pulmonary abscess Necrotizing pneumonia	Usually endogenous infections with Gram-negative/Gram-positive mixed anaerobic flora Aerobes also possible	Microscopy and culture from transtracheal or bronchial aspirate, bronchoalveolar lavage or lung biopsy. Transport in medium for anaerobes
	Candida spp. *Aspergillus* spp. *Mucorales*	Microscopy and culture, serology as well if required

Table 12.3 Urogenital Tract

Infection	Most important pathogens	Laboratory diagnosis
Urethrocystitis Pyelonephritis	***Escherichia coli*** Other *Enterobacteriaceae* *Pseudomonas aeruginosa* Enterococci *Staphylococcus aureus* *Staphylococcus saprophyticus* (in women)	Microscopy and culture; test midstream urine for significant bacteriuria (p. 210)
Prostatitis	***Escherichia coli*** Other *Enterobacteriaceae* *Pseudomonas aeruginosa* Enterococci *Staphylococcus aureus* *Neisseria gonorrhoeae* *Chlamydia trachomatis*	Microscopy and culture. Specimens: prostate secretion and urine. Quantitative urine bacteriology (p. 210) required for evaluation. To confirm *C. trachomatis*, antigen detection by direct IF or EIA or cell culture or PCR.
Nonspecific urethritis	***Chlamydia trachomatis***	Microscopy (direct IF) or antigen detection with EIA, or cell culture or PCR
	Mycoplasma hominis *Ureaplasma urealyticum*	Culture (special mediums)
Urethral syndrome (women)	*Chlamydia trachomatis* (30%) *Escherichia coli* (30%) *Staphylococcus saprophyticus* (5–10%) Unknown pathogens (20%)	See above: nonspecific urethritis Culture from urine. Bacteriuria often $\leq 10^4$/ml
Microsporosis of the genitourinary tract	*Encephalitozoon* spp.	Microscopy of urine sediment, DNA detection (PCR)
Nephropathia epidemica	Hantaviruses/Puumala virus	Serology
Tuberculosis of the urinary tract	*Mycobacterium tuberculosis*	Microscopy and culture Three separate morning urine specimens, 30–50 ml each

Table 12.**3** *Continued: Urogenital Tract*

Infection	Most important pathogens	Laboratory diagnosis
Listeriosis (pregnancy)	*Listeria monocytogenes*	Microscopy and culture from cervical and vaginal secretion, lochia. Blood culture if required
Schistosomosis of the urinary tract	*Schistosoma haematobium*	Microscopy of urine sediment; serology
Vulvovaginitis	Herpes simplex virus	Isolation or antigen detection in secretion
	Candida spp.	Microscopy, culture if required
	Trichomonas vaginalis	Microscopy (native). Submit two slides with air-dried secretion (for Giemsa staining or immunofluorescence), culture from vaginal secretion
Nonspecific vaginitis (vaginosis)	Several bacterial spp. often contribute to infection: *Gardnerella vaginalis* *Mycoplasma hominis* *Mobiluncus mulieri* *Mobiluncus curtisii* Gram-negative anaerobes	Attempt microscopy and culture of vaginal secretion. Look for "clue cells" in microscopy. Interpretation of many findings is problematic because the bacteria are part of the normal flora
Cervicitis Endometritis Oophoritis Salpingitis Pelveoperitonitis	***Neisseria gonorrheae*** ***Chlamydia trachomatis*** ***Mixed anaerobic flora*** Less frequently: *Enterobacteriaceae* *Streptococcus* spp. *Gardnerella vaginalis* *Mycoplasma hominis* *Mycobacterium tuberculosis*	Microscopy and culture from swab material. Use transport mediums. For detection of chlamydiae: direct IF microscopy, EIA antigen detection, cell culture or PCR. PCR kit available to detect gonococci simultaneously.

Table 12.**4** Genital Tract (venereal diseases)

Infection	Most important pathogens	Laboratory diagnosis
Gonorrhea	*Neisseria gonorrhoeae*	Microscopy (send two slides to the laboratory, for gram staining and IF); culture (swab in special transport medium); rapid antigen detection with antibodies in swab material; PCR (kit available to detect *C. trachomatis* simultaneously)
Syphilis (lues)	*Treponema pallidum* (ssp. *pallidum*)	Microscopy (dark field) of material from stage I and II lesions. **Serology** (see p. 321 for basic diagnostics)
Lymphogranuloma venereum	*Chlamydia trachomatis* (L serovars)	Microscopy (direct IF) of pus; cell culture or PCR
Ulcus molle (soft chancre)	*Haemophilus ducreyi*	Microscopy of pus. Culture (very difficult)
Granuloma inguinale	*Calymmatobacterium granulomatis*	Microscopy of scrapings or biopsy material (look for Donovan bodies); culture (embryonated hen's egg or special mediums)

Table 12.**5** Gastrointestinal Tract

Infection	Most important pathogens	Laboratory diagnosis
Gastritis type B Gastric ulceration Duodenal ulceration Gastric adenocarcinoma Gastric lymphoma (MALT)	*Helicobacter pylori*	Direct fecal antigen detection Biopsy and histopathology Urea breath test Culture from biopsy Serology for screening
Gastroenteritis/enterocolitis		
Viruses	**Rotaviruses** Adenoviruses Rarely: enteroviruses, coronaviruses, astroviruses, caliciviruses, Norwalk virus	Direct virus detection with electron microscopy (reference laboratories) or direct detection with immunological methods (e.g., EIA)
Bacteria	*Staphylococcus aureus* intoxication (enterotoxins A-E)	Toxin detection (with antibodies) in food and stool
	Clostridium perfringens (foods)	Culture (quantitative) from food and stool
	Vibrio parahaemolyticus (food, marine animals)	Culture from stool
	E. coli (EPEC, ETEC, EIEC, EHEC, EAggEC)	No simple tests available; if necessary: culture from stool and identification of pathovars by means of DNA assay; serovar may provide evidence
	Campylobacter jejuni	Culture from stool
	Yersinia enterocolitica	Culture from stool
	Bacillus cereus	Culture from stool
Pseudomembranous colitis (often antibiotic-associated)	*Clostridium difficile*	Toxin detection (cell culture) in stool. DNA assay for toxin possible
Shigellosis (dysentery)	*Shigella* spp.	Culture from stool

Table 12.**5** *Continued: Gastrointestinal Tract*

Infection	Most important pathogens	Laboratory diagnosis
Salmonellosis		
Enteric form	*Salmonella enterica* (enteric serovars)	Culture from stool
Typhoid form	*Salmonella enterica* (typhoid serovars) (or possibly enteric salmonellae in predisposed persons)	Culture from blood and stool; serology (Gruber-Widal results of limited significance)
Cholera	*Vibrio cholerae*	Culture from stool, possibly also from vomit
Whipple's disease	*Tropheryma whipplei*	Microscopy and DNA detection from small intestine biopsy. Culture not possible
Protozoa		
Amebosis	*Entamoeba histolytica*	Microscopy of stool, detection of coproantigen (or DNA); serology
Giardiosis	*Giardia intestinalis*	Microscopy of stool or duodenal fluid, coproantigen detection
Cryptosporidiosis	*Cryptosporidium* species	Microscopy of stool, coproantigen detection, DNA detection
Microsporosis	*Enterocytozoon bieneusi*	Microscopy of stool, DNA detection
Cyclosporosis	*Cyclospora cayetanensis*	Microscopy of stool
Sarcocystiosis	*Sarcocystis* spp.	Microscopy of stool
Isosporiosis	*Isospora belli*	Microscopy of stool
Blastocystosis	*Blastocystis hominis*	Microscopy of stool

Table 12.**5** *Continued: Gastrointestinal Tract*

Infection	Most important pathogens	Laboratory diagnosis
Helminths		
Trematode infections	*Schistosoma* spp.	Microscopical detection of worm eggs in stool; serology
	Fasciolopsis buski	Microscopical detection of worm eggs in stool
	Heterophyes heterophyes and others	Microscopical detection of worm eggs in stool
Cestode infections	*Taenia* spp. *Hymenolepis* spp. *Diphyllobothrium* spp.	Microscopical detection of worm eggs and/or proglottids in stool
Nematode infections	*Ascaris lumbricoides* *Trichuris trichiura* *Ancylostoma* and *Necator* spp.	Microscopical detection of worm eggs in stool
	Strongyloides stercoralis	Microscopy and culturing of larvae in stool (serology)
	Enterobius vermicularis	Microscopical detection of worm eggs (anal adhesive tape on slide) or worms in stool

Table 12.**6** Digestive Glands and Peritoneum

Infection	Most important pathogens	Laboratory diagnosis
Mumps (parotitis epidemica)	Mumps virus (paramyxovirus)	Serology
Infectious hepatitis	Hepatitis A virus	Serology (IgM)
	Hepatitis B and D virus	Antigen and antibody detection in blood, PCR
	Hepatitis C and G virus	Serology, PCR
	Hepatitis E virus	Serology (IgE, IgM), PCR
Yellow fever (liver)	Yellow fever virus (flavivirus)	Serology; isolation if required (use reference laboratory)
Cytomegalovirus infection (liver)	Cytomegalovirus (CMV)	Cell culture from saliva, urine and if required from biopsy material. Antigen assay or DNA test (PCR). Serology
Leptospirosis (liver)	*Leptospira interrogans* (serogroup ictero-haemorrhagiae)	Serology. Culture from urine and blood
Cholecystitis/Cholangitis	***E. coli*** Other *Enterobacteriaceae* Gram-negative anaerobes	Culture from bile
	Fasciola hepatica	Worm eggs in stool; serology
	Opisthorchis *Clonorchis* *Dicrocoelium*	
Pancreatitis Pancreatic abscess	*Enterobacteriaceae* *Staphylococcus aureus* *Streptococcus* spp. *Pseudomonas* spp. Anaerobes	Microscopy and culture from pus (punctate or biopsy, if specimen sampling feasible)

Table 12.**6** *Continued: Digestive Glands and Peritoneum*

Infection	Most important pathogens	Laboratory diagnosis
Liver abscess	Usually mixed bacterial flora: *E. coli* Other *Enterobacteriaceae* Gram-negative anaerobes Gram-positive anaerobes *Staphylococcus aureus* *Streptococcus pyogenes* *Streptococcus milleri* *Entamoeba histolytica*	Microscopy and culture from pus if specimen sampling feasible (punctate, biopsy, surgical material) Serology
Splenic abscess	*Staphylococcus* spp. (in endocarditis) *Streptococcus* spp. (in endocarditis) *Enterobacteriaceae* Gram-negative and Gram-positive anaerobes	Microscopy and culture from pus if specimen sampling feasible; blood culture
Peritonitis		
Primary peritonitis (rare; usually the result of hematogenous dissemination)	*Streptococcus pneumoniae* *Streptococcus pyogenes* Gram-negative/-positive anaerobes; *Enterobacteriaceae;* enterococci; rarely *Staphylococcus aureus*	Microscopy and culture from pus; (specimen sampling during laparotomy, or puncture if necessary)
Secondary peritonitis (endogenous infection caused by enteric bacteria)	Usually mixed aerobic-anaerobic flora *Enterobacteriaceae* Gram-negative and Gram-positive anaerobes	Microscopy and culture from pus (specimen sampling during laparotomy, or puncture if necessary)

Table 12.6 *Continued: Digestive Glands and Peritoneum*

Infection	Most important pathogens	Laboratory diagnosis
Peritonitis following peritoneal dialysis (CAPD)	Gram-positive bacteria (60–80 %): *Staphylococcus* spp. *Streptococcus* spp. *Corynebacterium* spp. Gram-negative bacteria (15–30 %): *Enterobacteriaceae* *Pseudomonas* spp. *Acinetobacter* spp. *Candida* spp. (rare)	Microscopy and culture from cloudy dialysis fluid. Concentration of fluid necessary (e.g., filtration or centrifugation)
Intraperitoneal abscesses	Usually mixed aerobic-anaerobic flora: *Enterobacteriaceae* *Staphylococcus aureus* Gram-negative/-positive anaerobes *Streptococcus milleri*	Microscopy and culture from pus (specimen sampling during laparotomy, or puncture if necessary)
Protozoan infections (liver)		
Visceral leishmaniasis	*Leishmania donovani* *Leishmania infantum*	Microscopy and culture from lymph node or bone marrow punctate; DNA detection; serology
Trematode infections (liver, bile ducts)		
Schistosomosis	*Schistosoma mansoni*	Microscopical detection of worm eggs in stool; serology
Fasciolosis	*Fasciola hepatica*	Microscopical detection of worm eggs in stool; serology
Opisthorchiosis Clonorchiosis Dicrocoeliosis	*Opisthorchis* spp. *Clonorchis sinensis* *Dicrocoelium dendriticum*	Microscopical detection of worm eggs in stool
Cestode infections		
Echinococcosis (liver, peritoneal cavity)	*Echinococcosus granulosus* *Echinococcosus multilocularis*	Serology

Table 12.**7** Nervous System

Infection	Most important pathogens	Laboratory diagnosis
Meningitis		
Viruses	**Enteroviruses** **Herpes simplex virus** **Mumps virus**	Isolation from cerebrospinal fluid, stool, pharyngeal lavage; serology if herpes or mumps suspected PCR from cerebrospinal fluid
	Togaviruses Bunyaviruses Arenaviruses	In tropical viroses virus isolation from cerebrospinal fluid and blood and serology in reference laboratory
	Lymphocytic choriomeningitis virus Tickborne encephalitis virus (flavivirus)	Serology in blood, in cerebrospinal fluid if necessary
Bacteria	***Neisseria meningitidis*** (~20%) ***Streptococcus pneumoniae*** (~30%) ***Haemophilus influenzae b*** (Less frequent now due to vaccination in children) Rare: *Enterobacteriaceae* (senium) *Mycobacterium tuberculosis* *Leptospira interrogans* *Listeria monocytogenes*	Microscopy and culture from cerebrospinal fluid; antigen detection if required (rapid test)
	Neonates: *E. coli* Group B streptococci	
Fungi	*Cryptococcus neoformans* *Candida* spp. *Coccidioides immitis*	Microscopy and culture from cerebrospinal fluid; antigen detection; serology

Table 12.7 *Continued: Nervous System*

Infection	Most important pathogens	Laboratory diagnosis
Encephalomyelitis		
Viruses	**Measles virus** Epstein-Barr virus	Serology
	HIV-1, HIV-2 **Herpes simplex virus** Varicella zoster virus Cytomegalovirus	PCR and isolation in brain biopsy or cerebrospinal fluid if required
	Mumps virus	Additionally: isolation from pharyngeal lavage
	Enteroviruses	Additionally: isolation from stool
	Togaviruses Bunyaviruses Arenaviruses	In tropical viroses viral serology in reference laboratories
	Rabies virus (lyssa virus)	Direct Immunofluorescence with brain specimen (autopsy) and/or corneal epithelium Serology
	Tickborne encephalitis virus	Serology
Bacteria	*Rickettsia* spp. *Brucella* spp.	Serology
	Borrelia burgdorferi	Serology and PCR; culture in biopsy if required
	Leptospira interrogans	Serology and culture in biopsy if required
	Treponema pallidum	Syphilis serology
	Listeria monocytogenes	Try microscopy and culture from cerebrospinal fluid and blood
	Mycobacterium tuberculosis	Microscopy and culture from cerebrospinal fluid; DNA test if required
Fungi	*Cryptococcus neoformans* *Aspergillus* spp. *Mucorales*	Try microscopy and culture from cerebrospinal fluid and blood; *Cryptococcus* antigen can be detected in cerebrospinal fluid. Serology

Table 12.**7** *Continued: Nervous System*

Infection	Most important pathogens	Laboratory diagnosis
Protozoa	*Naegleria fowleri* *Acanthamoeba* spp.	Microscopy (cerebrospinal fluid), culture, DNA detection
	Toxoplasma gondii	Serology, microscopy, culture, DNA detection (cerebrospinal fluid)
	Trypanosoma brucei gambiense *Trypanosoma brucei rhodesiense*	Microscopy (cerebrospinal fluid); Serology
	Plasmodium falciparum	Microscopy (blood); Serology
Helminths	*Taenia solium* (cysticercosis of the CNS)	Serology
	Echinococcus granulosus *Echinococcus multilocularis*	Serology
	Toxocara canis *Toxocara mystax*	Serology
Cerebral abscess Epidural abscess Subdural empyema	*Streptococcus milleri* Gram-negative anaerobes *Enterobacteriaceae* *Staphylococcus aureus*	Microscopy and culture for bacteria from pus
	Mucorales *Aspergillus* spp. *Candida* spp.	Microscopy and culture for fungi from pus; serology
	Toxoplasma gondii	Serology. Microscopy; DNA test (in cerebrospinal fluid)
Tetanus	*Clostridium tetani*	Toxin (animal test, PCR) in material excised from wound. Try microscopy and culture from excised material
Botulism	*Clostridium botulinum*	Toxin detection in blood or food (animal test, PCR)
Leprosy (peripheral nerves)	*Mycobacterium leprae*	Microscopy of biopsy specimen or scrapings from nasal mucosa

Table 12.**8** Cardiovascular system

Infection	Most Important Pathogens	Laboratory diagnosis
Endocarditis	*Streptococcus* spp. (60–80 %) *Staphylococcus* spp. (20–35 %) Gram-negative rods (2–13 %) Numerous other bacterial spp. (5 %) Fungi (2–4 %) Culture negative (5–25 %)	**Blood culture**, three sets from three different sites, within 1–2 h, before antimicrobials if possible. 10–20 ml venous blood into one aerobic and one anaerobic bottle, respectively.
Myocarditis/ pericarditis		
Viruses	**Enteroviruses** Adenoviruses Herpes virus group Influenzaviruses Parainfluenzaviruses	Serology, if necessary combined with isolation and PCR of punctate
Bacteria	***Staphylococcus aureus*** ***Streptococcus pneumoniae*** ***Enterobacteriaceae*** ***Mycobacterium tuberculosis***	Microscopy and culture from punctate DNA test from punctate if required
	Mycoplasma pneumoniae	Serology; culture from punctate
	Neisseria spp. Gram-negative anaerobes *Actinomyces* spp. *Nocardia* spp.	Microscopy and culture from punctate
	Rickettsia spp. *Chlamydia trachomatis*	Serology
Fungi	***Candida* spp.** ***Aspergillus* spp.** *Cryptococcus neoformans*	Serology; microscopy (direct IF); cell culture or PCR if required
Protozoa	*Toxoplasma gondii* *Trypanosoma cruzi*	Serology, if necessary in combination with culture and microscopy from punctate
Helminths	*Trichinella spiralis*	Serology

Table 12.**9** Hematopoietic and Lymphoreticular System

Infection	Most important pathogens	Laboratory diagnosis
HIV infection (AIDS)	HIV-1; HIV-2	Serology: EIA and Western blot. Also p24 antigen assay for primary infection. Quantitative genome test with RT-PCR for therapeutic indication and course (viral load).
Infectious mononucleosis	**Epstein–Barr virus (EBV)** Cytomegalovirus (rare)	Serology Isolation from urine and saliva; serology
Brucellosis	*Brucella abortus* *Brucella melitensis* *Brucella suis*	Blood culture: three sets from three different sites, within 1–2 h, before antimicrobials if possible. 10–20 ml venous blood into one aerobic and one anaerobic bottle, respectively. Incubation for up to 4 weeks is necessary—inform laboratory of suspected *Brucella* infection. Serology
Tularemia	*Francisella tularensis*	Culture from lymph node biopsy, sputum and blood; serology
Plague	*Yersinia pestis*	Microscopy and culture from bubo pus, possibly from sputum (pulmonary plague)
Melioidosis	*Burkholderia pseudomallei*	Microscopy and culture from sputum, abscess pus or blood
Malleus (glanders)	*Burkholderia mallei*	Microscopy and culture from nasal secretion, abscess pus or blood
Rat-bite fever	*Streptobacillus moniliformis*	Culture from lesion specimen
Sodoku	*Spirillum minus*	Attempt microscopical detection in blood or wound secretion

Table 12.**9** *Continued: Hematopoietic and Lymphoreticular System*

Infection	Most important pathogens	Laboratory diagnosis
Oroya fever and verruga peruana	*Bartonella bacilliformis*	Blood culture (see above for brucellosis)
Relapsing fever	*Borrelia recurrentis* *Borrelia duttonii* Other borreliae	Microscopy (Giemsa staining) of blood while fever is rising
Bacillary angiomatosis (AIDS)	*Bartonella henselae*	Serology; microscopy and culture from lymph node biopsy as required
Cat scratch disease	*Bartonella henselae;* *Bartonella claridgeia* *Afipia felis* (rare)	Microscopy of puncture pus: Warthin-Starry silver stain. Culture on special medium (difficult)
Malaria	*Plasmodium* spp.	Microscopy (blood smear, thick film); antigen detection with ParaSight test. Serology (not in acute malaria)
Babesiosis	*Babesia* spp.	Microscopy of blood swabs
Toxoplasmosis	*Toxoplasma gondii*	Serology
Visceral leishmaniosis	*Leishmania donovani* *Leishmania infantum*	Serology; microscopy and culture of lymph node or bone marrow punctate, DNA detection
Filariosis (lymphatic)	*Wuchereria bancrofti* *Brugia malayi*	Microscopical detection of microfilaria in nocturnal blood; serology
Ehrlichiosis	*Ehrlichia* spp.	Isolation in cell culture. PCR. Serology (immunofluorescence)

Table 12.**10** Skin and Subcutaneous Connective Tissue (local or systemic infections with mainly cutaneous manifestation)

Infection	Most important pathogens	Laboratory diagnosis
a) Viruses		
Smallpox	Variola virus Parapox viruses (orf virus, milker's nodules virus)	Electron microscopy of vesicle/pustule content; isolation; serology; (use reference laboratory)
Herpes	Herpes simplex virus	Electron microscopy of vesicle content; cell culture
Varicella (chicken pox)	Varicella zoster virus	Serology (IgG, IgM); electron microscopy of vesicle content; direct IF, cell culture
Measles (morbilli, rubeola)	Measles virus (*Morbillivirus*)	Isolation from pharyngeal lavage and urine if required; serology
German measles (rubella)	Rubella virus (*Rubivirus*)	Serology
Hemorrhagic fever	Bunyaviruses (e.g., hantavirus) Arenaviruses Flaviviruses (e.g., Dengue viruses) Marburg virus Ebola virus	Serology; cell culture and PCR from blood or liver as required; animal test as required; laboratory diagnosis only possible in reference laboratories
Molluscum contagiosum	Molluscum contagiosum virus	Microscopy of skin lesions; molluscum bodies
Warts Papillomas	*Papillomavirus*	Genomic test with DNA probe or electron microscopy
Erythema infectiosum	*Parvovirus* B19	Serology
Exanthema subitum	Human herpes virus 6 (HHV 6)	Serology

Table 12.**10** *Continued: Skin and Subcutaneous Connective Tissue*

Infection	Most important pathogens	Laboratory diagnosis
b) Bacteria and fungi		
Furuncles Carbuncles Pemphigus Folliculitis Impetigo Erysipelas	***Staphylococcus aureus*** ***Streptococcus pyogenes***	Microscopy and culture from swab
Gangrenous cellulitis	**Often mixed flora:** *Clostridium* spp. Gram-negative anaerobes *Pseudomonas* spp. *Enterobacteriaceae*	Microscopy from swab or pus, use transport medium for anaerobes
Erysipeloid	*Erysipelothrix rhusiopathiae*	Microscopy and culture from skin lesion swab
Erythema migrans	*Borrelia burgdorferi*	Serology
Cutaneous anthrax	*Bacillus anthracis*	Microscopy and culture from skin lesion swab
Leprosy	*Mycobacterium leprae*	Microscopy (Ziehl-Neelsen stain) of material from skin lesions (biopsy) or scrapings from nasal mucosa
Rickettsioses (spotted fever and others)	*Rickettsia* spp.	Serology, culturing (embryonated hen's egg) or animal test if necessary
Nonvenereal treponema infections (endemic syphilis, pinta, yaws)	*Treponema pallidum* (subsp. *endemicum*) *Treponema pallidum* (subsp. *pertenue*) *Treponema carateum*	Try microscopy of material from skin lesions; serology (syphilis tests)

Table 12.**10** *Continued: Skin and Subcutaneous Connective Tissue*

Infection	Most important pathogens	Laboratory diagnosis
Madura foot mycosis/mycetoma		
Bacteria	*Nocardia brasiliensis* *Actinomadura madurae* *Streptomyces somaliensis*	Microscopy and culture from lesion material
Fungi	*Madurella* spp. *Pseudoallescheria* spp. *Aspergillus* spp., and others	Microscopy and culture from lesion material
Dermatomycoses	Dermatophytes *Candida* spp.	Microscopy and culture from cutaneous scales
Sporotrichosis	*Sporothrix schenckii*	Microscopy and culture from lesion pus
Chromomycosis	Black molds (various types)	Microscopy and culture from lesion pus
c) Protozoa, helminths, and arthropods		
Cutaneous leishmaniosis (oriental sore)	*Leishmania tropica* *Leishmania major*	Microscopy and culture from lesion biopsy; DNA detection (PCR)
American cutaneous and mucocutaneous leishmaniosis	*Leishmania braziliensis* *Leishmania mexicana*	Microscopy and culture from skin and mucosal lesion biopsy; DNA detection (PCR)
Cercarial dermatitis	Cercariae from *Schistosoma* spp.	Serology
Cutaneous larva migrans ("creeping eruption")	Larvae of *Ancylostoma* spp. and *Strongyloides* species	Clinical diagnosis
Onchocercosis	*Onchocerca volvulus* (microfilariae)	Microscopical detection of microfilariae in "skin snips"; serology

Table 12.**10** *Continued: Skin and Subcutaneous Connective Tissue*

Infection	Most important pathogens	Laboratory diagnosis
Loaosis	*Loa loa* (migrating filariae)	Microscopy of diurnal blood for microfilariae; serology
Cysticercosis	*Taenia solium*	Serology (radiology)
Dracunculosis	*Dracunculus* spp.	Clinical diagnosis
Tickbite	*Ixodes ricinus* and other tick species	Inspection of skin
Scabies	*Sarcoptes scabiei*	Microscopy
Louse infestation	*Pediculus* spp., *Phthirus pubis*	Inspection of hair, skin, and clothing (body lice) for lice and nits
Myiasis	Fly larvae (maggots)	Inspection
Flea infestation	Various flea species, in most cases from animals	Detection of fleas and flea fecal material on animals and in their surroundings
Sand flea bites	*Tunga penetrans*	Clinical diagnosis, histology if needed

Table 12.**11** Bone, Joints, and Muscles

Infection	Most important pathogens	Laboratory diagnosis
Pleurodynia, epidemic myalgia (Bornholm disease)	**Coxsackie viruses group B** (possibly echoviruses)	Isolation from stool and pharyngeal lavage; serology
Clostridial infections 1. Gas gangrene (with myonecrosis) 2. Clostridial cellulitis (without myonecrosis)	***Clostridium perfringens*** Other clostridial spp.	Microscopy and culture from wound secretion. Transport materials in anaerobic system

Table 12.**11** Bone, Joints, and Muscles

Infection	Most important pathogens	Laboratory diagnosis
Necrotizing fasciitis Type 1 (syn. polymicrobial gangrene)	Often aerobic/anaerobic mixed flora: *Clostridium* spp., Gram-positive and Gram-negative anaerobes, *Staphylococcus aureus*, *Streptococcus bovis*, *Enterobacteriaceae*	Microscopy and culture from wound secretion. Transport materials in anaerobic system
Type 2 (syn. Streptococcal necrotizing myositis)	*Streptococcus pyogenes*	Microscopy and culture from wound secretion
Trichinellosis (Muscle)	*Trichinella spiralis*	Microscopical detection in muscle biopsy; serology
Cysticercosis (Muscle)	*Taenia solium*	Serology (radiology)
Osteomyelitis/ostitis	***Staphylococcus aureus*** Coagulase-negative staphylococci *Streptococcus* spp. *Enterobacteriaceae* *Pseudomonas* spp. Gram-positive and Gram-negative anaerobes (rare)	Microscopy and culture for bacteria, preferably based on biopsy or surgical material. Swab from fistular duct not useful for diagnosis
Septic arthritis	***Staphylococcus aureus*** *Streptococcus pyogenes* *Streptococcus pneumoniae* *Haemophilus influenzae* *Neisseria gonorrhoeae* *Enterobacteriaceae* *Pseudomonas* spp.	Microscopy and culture from synovial fluid with parallel blood culture

Table 12.**12** Eyes and ears

Infection	Most important pathogens	Laboratory diagnosis
Trachoma	*Chlamydia trachomatis*, serovars A, B, Ba, C	Microscopical detection of inclusions in conjunctival cells (Giemsa stain); direct immunofluorescence; cell culture; antigen detection using EIA; PCR. Serology: recombinant immunoassay for antibodies to genus-specific antigen (LPS or MOMP). Microimmunofluorescence for antibodies to species- and var-specific antibodies.
Conjunctivitis/scleritis		
Viruses	Adenoviruses Enteroviruses Influenzaviruses Measles virus	Isolation from swab
Bacteria	*Neisseria* spp. *Streptococcus* spp. *Staphylococcus aureus* *Haemophilus* spp. *Enterobacteriaceae* *Pseudomonas* spp. *Mycobacterium* spp. *Moraxella lacunata*	Microscopy and culture for bacteria in conjunctival secretion or in scrapings
	Chlamydia trachomatis (inclusion conjunctivitis)	See at "trachoma" (this table)
	Treponema pallidum	Serology (basic diagnostics)
Fungi	*Candida* spp. *Sporothrix schenckii*	Microscopy and culture for fungi in conjunctival secretion or in corneal scrapings
Helminths	*Onchocerca volvulus*	Microscopy for microfilariae in skin snips (or conjunctival) biopsy; serology
	Loa loa	Microscopy for microfilariae in diurnal blood; serology

Table 12.**12** *Continued: Eyes and ears*

Infection	Most important pathogens	Laboratory diagnosis
Keratitis		
Viruses	Herpes simplex virus Adenoviruses Varicella zoster virus	Cell culture and PCR from swab or corneal scrapings
Bacteria	*Staphylococcus* spp. *Streptococcus* spp. *Neisseria gonorrheae* *Enterobacteriaceae* *Pseudomonas* spp. *Bacillus* spp. *Mycobacterium* spp. *Moraxella lacunata* *Actinomyces* spp. *Nocardia* spp.	Microscopy and culture for bacteria swab or corneal scrapings
	Chlamydia trachomatis	Diagnostic procedures with corneal swab or scrapings see at "trachoma" (this table)
	Treponema pallidum	Serology (basic diagnostics)
Fungi	*Candida* spp. *Aspergillus* spp. *Fusarium solani*	Microscopy and culture for fungi in swab or corneal scrapings
Protozoa	*Acanthamoeba* spp.	Culture and microscopy from conjunctival lavage and contact lens washing fluid, DNA detection
Endophthalmitis		
Viruses	Herpes simplex viruses Varicella zoster virus Measles virus Rubella virus (german measles)	Cell culture and PCR in aqueous and vitreous aspiration; serology with aqueous humor as required

Table 12.**12** *Continued: Eyes and ears*

Infection	Most important pathogens	Laboratory diagnosis
Bacteria	*Staphylococcus* spp. *Streptococcus* spp. *Neisseria gonorrhoeae* *Enterobacteriaceae* *Pseudomonas* spp. *Bacillus* spp. *Mycobacterium* spp. *Moraxella lacunata* *Actinomyces* spp. *Nocardia* spp.	Microscopy (gram) and culture for aerobic and anaerobic bacteria and mycobacteria in aqueous and vitreous aspiration.
	Chlamydia trachomatis	Cell culture or PCR in aqueous and vitreous aspiration; serology with aqueous humor as required; antibodies in blood
	Treponema pallidum	Serology (basic diagnostics)
Fungi	*Candida* spp. *Aspergillus* spp. *Blastomyces dermatitidis* *Histoplasma capsulatum* *Mucorales* *Sporothrix schenckii* *Fusarium* spp. *Trichosporon* spp.	Microscopy (Gram, Giemsa) and culture for fungi in aqueous and vitreous aspiration.
Protozoa	*Acanthamoeba* spp.	Microscopy and culturing (conjunctival fluid and contact lens washing fluid), DNA detection
	Toxoplasma gondii	Serology
Helminths	*Onchocerca volvulus*	Direct detection of microfilariae in aqueous humor with slit lamp; serology
	Toxocara canis	Serology
	Taenia solium (ocular cysticercosis)	Serology

Table 12.**12** *Continued: Eyes and ears*

Infection	Most important pathogens	Laboratory diagnosis
Otitis externa	***Pseudomonas aeruginosa*** *Staphylococcus aureus* *Streptococcus pyogenes*	Microscopy and culture for bacteria of swab material
	Aspergillus spp. *Candida* spp.	Microscopy and culture for fungi of swab material
Otitis media	***Streptococcus pneumoniae*** ***Haemophilus influenzae*** *Streptococcus pyogenes* *Staphylococcus aureus* *Moraxella catarrhalis* (children) Respiratory viruses (25%)	Microscopy and culture for bacteria of middle ear punctate as required