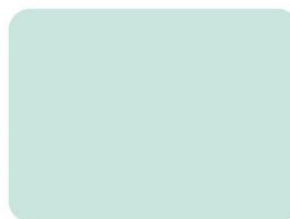
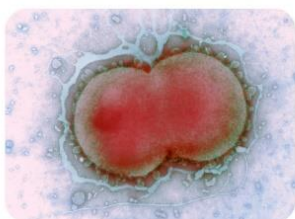
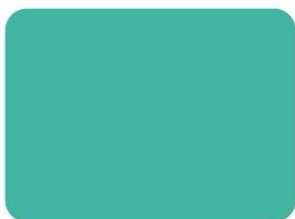
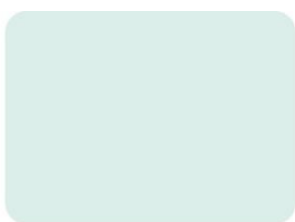




UK Standards for Microbiology Investigations

Investigation of specimens other than blood for parasites



Acknowledgments

UK Standards for Microbiology Investigations (UK SMIs) are developed under the auspices of UKHSA working in partnership with the partner organisations whose logos are displayed below and listed on [the UK SMI website](#). UK SMIs are developed, reviewed and revised by various working groups which are overseen by a [steering committee](#).

The contributions of many individuals in clinical, specialist and reference laboratories who have provided information and comments during the development of this document are acknowledged. We are grateful to the medical editors for editing the medical content.

UK SMIs are produced in association with:

Applied
Microbiology
International

Association for
Laboratory
Medicine

BIAM
British Infection Association

BRITISH SOCIETY FOR
ANTIMICROBIAL
CHEMOTHERAPY

BRITISH SOCIETY FOR
MEDICAL MYCOLOGY
BSM

BSMT
BRITISH SOCIETY FOR
MICROBIAL TECHNOLOGY

BRITISH SOCIETY FOR PARASITOLOGY
BSP

CYMRUETHAS • FEICROBIOLEG • CYMBU
WMA

Healthcare
Infection
Society

HSC Public Health
Agency

IBMS Institute of
Biomedical Science

MICROBIOLOGY
SOCIETY

NHS
National
Services
Scotland

PATHNET NI
Pathology Network, Northern Ireland

Public Health
Scotland

GIG | Iechyd Cyhoeddus
CYMRU Cymru
NHS Public Health
WALES Wales

RCGP Royal College of
General Practitioners

The Royal College of Pathologists
Pathology: the science behind the cure

SAM
Society for Anaerobic Microbiology

Scottish Microbiology
and Virology Network

THE UK CLINICAL
VIROLOGY NETWORK

UKAS
United Kingdom
Accreditation
Service

Displayed logos correct as of December 2024

Contents

Acknowledgments	2
Contents	3
Amendment table.....	5
1 General information	7
2 Scientific information.....	7
3 Scope of document	7
4 Introduction	7
5 Technical information/limitations	21
6 Safety considerations	23
7 Specimen collection.....	24
8 Specimen transport, storage and retention	27
9 Specimen processing/procedure.....	27
10 Reporting procedure.....	34
11 Referral to reference laboratories.....	34
12 Public health responsibilities of diagnostic laboratories.....	35
Appendix 1: Specimen types and possible parasites detectable	36
Appendix 2: Geographic distribution of parasitic infections.....	38
Appendix 3: Calibrating the microscope for measurement.....	40
Appendix 4: Common microscopic constituents of faeces.....	41
Appendix 5: Relative sizes of helminth eggs	42
Appendix 6: Oocysts of coccidia/ cryptogregarial/ microsporidia.....	43
Appendix 7: Comparison of tapeworms commonly found in humans	44
Appendix 8: Helminth larvae – characteristics	45
Appendix 9: Identification of <i>amoebic trophozoites</i> in stained smears	45
Appendix 10: <i>Balantidium coli</i> - trophozoite and cyst	47
Appendix 11: Identification of amoebic and flagellate cysts	48
Appendix 12: Identification of flagellate trophozoites	49

Appendix 13: Microfilariae found in humans	49
References.....	51

Amendment table

Each UK SMI document has an individual record of amendments. The amendments are listed on this page. The amendment history is available from standards@ukhsa.gov.uk.

Any alterations to this document should be controlled in accordance with the local document control process.

Amendment number/date	11
Issue number discarded	5.1
Insert issue number	5.2
Section(s) involved	Amendment
Whole document.	This is an administrative point change. The content of this UK SMI document has not changed. The last scientific and clinical review was conducted on 28/06/2017. Hyperlinks throughout document updated to Royal College of Pathologists website. Public Health England replaced with UK Health Security Agency throughout the document, including the updated Royal Coat of Arms Partner organisation logos updated. Broken links to devolved administrations replaced. References to NICE accreditation removed. Scope and Purpose replaced with General and Scientific information to align with current UK SMI template. 'Public health responsibilities of diagnostic laboratories' section added.

Amendment number/date	10/28.06.17
Issue number discarded	5
Insert issue number	5.1
Anticipated next review date*	01.03.20

Investigation of specimens other than blood for parasites

Section(s) involved	Amendment
Page 28.	Minor textual additions.
Page 33.	Minor clarity made to urine specimens for <i>S. haematobium</i> .

Amendment number/date	9/01.03.17
Issue number discarded	4.1
Insert issue number	5
Anticipated next review date*	01.03.20
Section(s) involved	Amendment
Whole document.	Updated the scope of the document to include the current molecular and traditional methods used for detection of parasites. Updated Technical Limitations section. Updated Safety Considerations section. References added. More diagrams added in the appendices.

*Reviews can be extended up to five years subject to resources available.

1 General information

[View general information](#) related to UK SMIs.

2 Scientific information

[View scientific information](#) related to UK SMIs.

3 Scope of document

Type of specimen

Faeces, urine, sellotape slide/perianal swab, CSF, bile, pus from abscesses, duodenal/jejunal aspirates, tissues, hydatid cyst, sputum/ bronchoalveolar lavage, biopsies from colonoscopy or surgery

This UK SMI describes the detection and isolation of a range of parasites (protozoa, nematodes, trematodes, cestodes) and organisms of previously uncertain taxonomic status traditionally included with the protozoa from a variety of clinical samples, excluding blood and corneal tissue scrapings. For corneal tissue scrapings for *Acanthamoeba* detection, refer to [UK SMI S 11 – Red or painful eye](#). This document covers the traditional and molecular methods of detection in detail.

This UK SMI should be used in conjunction with other UK SMIs.

4 Introduction

Although faecal specimens are the most commonly received samples for the detection of parasites, parasites may also be detected in a variety of other clinical specimens submitted to the laboratory. Clinical presentation, specimen preparation and organism identification of the parasites most commonly seen in the laboratories are described here, but others may be found. For completeness, uncommon species are also described.

Reference laboratories should be used to identify those parasites outside the laboratory's normal experience. Haematology, histopathology, and serology laboratories may also contribute significantly to the laboratory diagnosis of parasitic infections.

This introduction covers:

- protozoa
 - amoebae
 - flagellates/ciliates
 - coccidia
 - cryptogregarina
- nematodes

- trematodes
- cestodes
- other organisms of previously uncertain taxonomic status

4.1 Carriage rate

The carriage rate will vary among parasites and this will largely depend on:

- infecting species of the parasite
- geographic distribution
- seasons
- migration and travelling
- residence
- age
- poor hygiene
- previous exposure
- predisposing susceptibility such as immunocompromise (for example, AIDS, malnutrition)

Protozoa2

Intestinal amoebae

Amoebae that may be isolated from the human gastrointestinal tract include *Entamoeba histolytica*, *Entamoeba dispar*, *Entamoeba moshkovskii*, *Entamoeba coli*, *Entamoeba hartmanni*, *Endolimax nana* and *Iodamoeba butschlii*. All except *E. histolytica* are usually non-pathogenic (see Appendices 9-11).

E. histolytica and *E. dispar* are morphologically indistinguishable by light microscopy³. Of the two species, only *E. histolytica* is capable of causing invasive disease. When the diagnosis is made by light microscopy, cysts should be reported as *E. histolytica/E. dispar*⁴. Alternatively, diagnostic methods including antigen detection by enzyme immunoassay or DNA detection by PCR could be performed by laboratories to distinguish these two species^{2,3,5}. Where such is not possible, it is advised that laboratories should forward the samples to the appropriate specialist centres for further confirmation.

E. histolytica may cause ulcerative and inflammatory lesions in the colon. It spreads to extraintestinal sites, most commonly the liver, where marked tissue destruction occurs, leading to abscess formation. Inflammation of the colon produces symptoms of dysentery which include lower abdominal pain, increased frequency of bowel movements and liquid stools. Infection can lead to perforation of the colon, toxic megacolon, amoeboma, and perianal ulceration⁴.

Appropriate specimens include liquid aspirated or scraped from an area of inflamed bowel tissue or rectal scrape in dysentery, and freshly passed faeces for wet microscopy and formol-ether / ethyl acetate concentration. Motile trophozoites with ingested red blood cells found in stools, or trophozoites in tissue biopsies, both strongly suggest infection with *E. histolytica*².

Free-living amoebae

Human infection with free-living amoebae is uncommon. Such protozoa include: *Acanthamoeba* species, *Naegleria fowleri*, *Balamuthia mandrillaris* and *Sappinia diploidea*⁶. Infections include central nervous system invasion, mostly in immunocompromised individuals and *acanthamoeba* keratitis, common in contact-lens wearers.

Primary amoebic meningoencephalitis (PAM) is caused by *N. fowleri*. It occurs in adults and children who have recently been swimming in contaminated warm fresh water. Organisms gain access to the central nervous system by direct invasion through the nasal mucosae. Although treatment is available and there are a handful of reported survivors, the disease is usually fatal⁶.

When patients present with purulent meningitis or meningoencephalitis and a history of recent exposure to fresh water, PAM should be considered. The peripheral white blood cell count may be low early on in the disease, but will increase in time. The cerebrospinal fluid (CSF) appearance is haemorrhagic, glucose is low or normal and protein is elevated.

Laboratory diagnosis may be made by examining a wet mount and a stained preparation of the CSF for amoebic trophozoites (Appendix 9 and 11).

Granulomatous amoebic encephalitis (GAE) is caused by *Acanthamoeba* species and *Balamuthia mandrillaris*. It is a chronic opportunistic infection, occurring more often in immunosuppressed/AIDS patients spreading haematogenously from pulmonary or skin lesions to the central nervous system and it is often fatal. *Acanthamoeba* keratitis is associated with the use of soft contact lenses and ocular trauma; if not treated promptly may lead to corneal ulceration, and eventually to blindness. However, *Acanthamoeba* species may be isolated from contact lens fluid from individuals with no signs or symptoms of disease⁶.

GAE may be diagnosed by examining brain biopsy material. *Acanthamoeba* infection of the skin is frequently present with GAE: skin nodules or ulcers may be biopsied and examined by wet microscopy and a stained preparation (Appendix 9). Serological methods are also available.

Flagellates

***Giardia intestinalis* (synonymous with *Giardia duodenalis* and *Giardia lamblia*)⁷**

This organism may cause waterborne outbreaks of diarrhoea and is primarily spread from person to person, or zoonotically, via the faecal-oral route². Infection may present as self-limiting diarrhoea or a syndrome of chronic diarrhoea, steatorrhoea, malabsorption and weight loss. Symptoms include diarrhoea, abdominal cramps, bloating and flatulence. Vomiting, fever and tenesmus can also occur, but infection may also be asymptomatic².

Laboratory diagnosis for faeces is made by microscopy, or by antigen detection using enzyme immunoassay (EIA) or immunochromatographic lateral flow (ICLF) assay, or by PCR. Borderline positive and questionable negative reactions obtained by EIA and ICLF should be confirmed by another method⁷. Microscopy is of low sensitivity (31%) compared to PCR and evidence suggests a doubling of detection rates using automated EIA^{8,9}. One small study reported false positives by EIA compared to PCR¹⁰. The relative sensitivity of methods may be dependent on sample preparation and the assay used¹¹.

Due to the variable shedding of organisms, several stool specimens should be examined especially if microscopy is used. Ideally a total of three specimens should be taken 2-3 days apart.

Diagnosis can also be made by microscopic examination of duodenal or jejunal aspirates, and biopsies (see Appendix 11). Motile trophozoites can be seen in the direct examination of fresh faeces, duodenal and jejunal aspirates while cysts can be seen in a direct saline preparation or a formol-ether /ethyl acetate concentration of faeces.

Note: It should be noted it is not possible to identify trophozoites or cysts to species level by light microscopy. Molecular tests are required and are not currently available nationally.

Serology is not helpful and it is no longer available in the UK.

Dientamoeba fragilis²

The pathogenicity of *Dientamoeba fragilis* is debatable; however it has been documented in cases of non-invasive diarrhoea with fatigue. Unlike other protozoa it does not have a cystic stage, and is now regarded as amoeba/flagellate. The role of *Dientamoeba* in patients with HIV and bowel disorders is unclear and more research is required¹².

The trophozoite stage is very difficult to detect in wet saline preparations, and will not be seen in formol-ether/ethyl acetate concentrations. They can be detected by staining the faecal sample with trichrome, Giemsa or Field stains ([UK SMI TP 39 - Staining procedures](#)). Alternative methods including DNA detection by PCR have been developed¹².

Trichomonas vaginalis* and *Pentatrichomonas hominis

Both *Trichomonas vaginalis* and *Pentatrichomonas hominis* may be found in human infections. The majority of infections caused by *T. vaginalis* are sexually transmitted and it affects mainly the genitourinary tract whereas *P. hominis* inhabits the large bowel and is usually regarded as a non-pathogen, although it may cause mild gastrointestinal symptoms when present in large numbers ([UK SMI S 6 - Infectious syndromes affecting the genitourinary tract and reproductive organs](#))¹³.

Laboratory diagnosis is usually made by observing the motile trophozoites in the microscopic examination of a wet saline preparation. Preparations with stained acridine-orange may also be used, although this will involve fluorescence microscopy and consequential loss of immediacy. DNA detection by PCR has been developed for *Trichomonas vaginalis*^{14,15}.

Ciliates

Balantidium coli

B. coli is a ciliate infecting numerous mammals including humans and pigs and is found worldwide. Humans are usually resistant to *B. coli* infection, but achlorhydria or poor nutrition may increase the risk of colonisation. Colonisation is often asymptomatic. Patients may develop intermittent watery diarrhoea or an acute dysenteric colitis with stools containing mucus and blood².

Rapidly motile, large trophozoites may be observed microscopically in fresh faeces (Appendix 10). In preserved samples, diagnosis is by microscopy of a wet preparation, as neither the trophozoites or the cysts stain clearly with iodine or permanent stains¹.

Coccidia

Cyclospora

Cyclospora cayetanensis infection occurs in many tropical countries and outbreaks have been associated with drinking contaminated water and eating contaminated food affecting travellers and foreign residents¹⁶⁻¹⁸. Foodborne outbreaks have been reported in North America and Europe associated with the consumption of imported soft fruit, salad leaves, fresh herbs and vegetables^{19,20}.

Symptoms of *Cyclospora* infection include watery diarrhoea with weight loss, severe fatigue, nausea, vomiting and abdominal pain. Infection with *Cyclospora cayetanensis* also occurs in HIV-infected patients²¹.

Laboratory diagnosis is by appearance of oocysts in wet preparations and concentration methods can be used. Oocysts give a characteristic blue autofluorescence at 340-360nm. Modified Ziehl-Neelsen may be used as a permanent stain. *Cyclospora cayetanensis* stains poorly with auramine-phenol stain (see [UK SMI TP 39 - Staining procedures](#) and Appendices 3 and 6). Confirmation by microscopy and by PCR is available at the reference laboratories. There is no standardised subtyping scheme for *Cyclospora cayetanensis*.

Cystoisospora belli (formerly Isospora belli)²

Cystoisospora belli infection is relatively uncommon in developed countries, but is endemic in some parts of the world. It is usually transmitted by the ingestion of contaminated food or water. In immunocompetent patients it may cause non-specific, self-limited watery diarrhoea with malaise, anorexia, abdominal cramps and weight loss whereas severe infection can occur in immunocompromised hosts causing severe diarrhoea with electrolyte disturbances and morbidity²². AIDS patients are particularly susceptible to *Cystoisospora belli* infection (this being particularly common in underdeveloped countries especially Africa and the Middle East where the incidence ranges from 0.2% to 20% in patients with AIDS²³).

Laboratory diagnosis is achieved by microscopy of stool samples or intestinal mucus. Formol-ether concentration of faeces is recommended; as with *Cyclospora* species, *Cystoisospora* autofluoresce at 340-360nm (see [UK SMI TP 39 - Staining procedures](#) and Appendices 3 and 6). PCR assay has been developed to detect *Cystoisospora belli* in stool samples²⁴.

Sarcocystis

Infections with *Sarcocystis* species are zoonotic in origin. *Sarcocystis* species differ from other coccidia in that they require two hosts to complete their life cycle. Humans become the intermediate hosts after eating undercooked meat of the primary host which contains sarcocysts. Most infections of this type are asymptomatic, but symptoms such as abdominal pain, nausea, bloating and diarrhoea can be associated with presence of sporocysts in the faeces. Muscular sarcocystosis results when humans become infected by eating undercooked meat or from handling infected cats. Symptoms then include muscle soreness or swelling.

Laboratory diagnostic techniques are the same as for *Cystoisospora* species, with mature sporocysts being present in the faeces from nine days post-infection. They cannot easily be distinguished from *Cystoisospora* species microscopically; therefore identification should be performed by a Reference Laboratory.

Toxoplasma

Toxoplasma gondii infection is asymptomatic in most immunocompetent patients; however symptoms of pyrexia, malaise, lymphadenopathy, encephalitis and myalgia may be experienced. Ocular disease also occurs. Infections may be primary or reactivations. Reactivation of latent infection occurs in patients who become severely immunocompromised. Foetal infection may result from an acute maternal infection during pregnancy. For more information on investigation of *Toxoplasma* in pregnancy, it is advised that the appropriate specialist Reference Laboratory should be contacted.

Laboratory diagnostic procedures include direct microscopic observation of *Toxoplasma gondii* tachyzoites in bronchoalveolar lavage fluid (BAL) stained with Giemsa stain and PCR. PCR has been found to provide better results especially in laboratories where there is less microbiological experience²⁵.

Alternative methods include serological tests, culture and histology. Serology is still the gold standard test used in organ transplant and HIV patients although these tests may give poor results in immunocompromised patients²⁵.

Cryptogregarina

Cryptosporidium

Cryptosporidium has now been formally reclassified from the Coccidia to a new subclass with gregarine parasites, Cryptogregarina, following an extensive review of molecular and biological data²⁶.

Cryptosporidium species can cause profuse watery diarrhoea in humans²⁷. Children are particularly vulnerable due to lack of acquired immunity and poor personal hygiene. Infection shows seasonal variation with peak incidence in the spring and especially the autumn. Infection is a particular problem for patients who are severely immunocompromised². The usual manifestation is severe, chronic diarrhoeal disease with signs of malabsorption, but other presentations include atypical gastrointestinal disease such as cholangitis, cholecystitis, pancreatitis and hepatitis. Respiratory tract disease has also been reported.

Primary laboratory diagnosis is based on stained microscopy ([UK SMI TP 39 - Staining procedures](#)) or antigen detection by enzyme immunoassay followed by confirmation using microscopy stains or DNA detection by PCR^{28,29}. Specialist tests include sensitive immunofluorescence microscopy and PCR-based tests for species/genotype identification which are available in the appropriate specialist Reference Laboratory. The sensitivity of modified Ziehl-Neelsen microscopy for detecting *Cryptosporidium* oocysts has been shown to be significantly less than for other tests²⁸⁻³¹.

Other organisms of uncertain taxonomic status

Blastocystis hominis

Previously described as a flagellate, a yeast, a coccidian, and an amoeba, this organism is part of a diverse group of organisms called stramenopiles³². The importance of *B. hominis* as a human pathogen is debatable³³. Large numbers present in stools (more than five per high power field) may be associated with symptoms of nausea, abdominal pain, anorexia, flatus and diarrhoea².

Laboratory diagnosis by microscopy of primary wet smears (after formol-ether /ethyl acetate concentration), and smears stained with Giemsa and Field stain or differential

staining kits may be used to maximise recovery of cyst-like forms³⁴ (see [UK SMI TP 39 – Staining procedures](#)). Alternative methods include culture, PCR, ELISA and serological tests.

Culture techniques are, most likely, more sensitive than direct smears. Amplification of *Blastocystis*-specific DNA by polymerase chain reaction directly from stool has been reported and permits identification of the *Blastocystis* subtypes. However, serologic testing is not currently used for diagnosis of infection by this organism³⁵.

Microsporidia

There are over 150 genera and almost 1500 species of 'microsporidia'. The genera that are implicated in human diseases are *Anncaliia* (formerly *Brachiola*), *Nosema*, *Enterocytozoon*, *Encephalitozoon*, *Microsporidium*, *Pleistophora*, *Trachipleistophora*, *Tubulinosema* and *Vittaforma*³⁶. There are at least 15 microsporidian species that have been identified as human pathogens: *Anncaliia algerae*, *Anncaliia connori*, *Anncaliia vesicularum*, *Encephalitozoon cuniculi*, *Encephalitozoon hellem*, *Encephalitozoon intestinalis*, *Enterocytozoon bieneusi*, *Microsporidium ceylonensis*, *Microsporidium africanum*, *Nosema ocularum*, *Pleistophora* species, *Trachipleistophora hominis*, *Trachipleistophora anthropophthera*, *Vittaforma corneae*, and *Tubulinosema acridophagus*. These organisms are obligate intracellular organisms occurring in body fluids, tissues and the gastrointestinal tract. Originally classified as a parasite, these organisms are now known as fungi³⁷.

Microsporidiosis presents a particular problem in HIV-infected patients². These and other immunocompromised patients are frequently infected with opportunistic parasites that do not usually produce symptoms in immunocompetent individuals³⁸. Chronic diarrhoea is a major clinical feature in HIV infection and is a leading cause of morbidity and mortality³⁹. Microsporidial keratoconjunctivitis has recently been recognised in patients with AIDS.

Histological stains, immunological techniques and electron microscopy may be used to identify these organisms in urine, sputum, bronchoalveolar lavages, bile, duodenal aspirates, faeces, tissues and scrapes from the cornea and conjunctiva. Microsporidia can be stained with modified trichrome stain (see [UK SMI TP 39 – Staining procedures](#) Appendices 3 and 6).

Molecular identification of *Enterocytozoon bieneusi* and *Encephalitozoon intestinalis* (formerly *Septata intestinalis*), *Encephalitozoon hellem* and *Encephalitozoon cuniculi* on faeces can be done using species-specific PCR assays that are commercially available.

***Pneumocystis jirovecii* (formerly *Pneumocystis carinii*)⁴⁰**

Pneumocystis jirovecii was thought to be a protozoan, but has been reclassified and is now considered to be a parasitic fungus based on nucleic acid and biochemical analysis⁴¹. It is an extracellular organism that causes interstitial plasma cell pneumonia found in humans, and generally causes disease in immunocompromised and immunosuppressed patients and in premature, sick and malnourished infants⁴². The symptoms of *Pneumocystis* pneumonia include dyspnea, non-productive cough, and fever.

P. jirovecii pneumonia is a common opportunistic infection of patients with AIDS (for more information, see [UK SMI B 57 – Investigation of bronchoalveolar lavage, sputum and associated specimens](#)).

Laboratory diagnosis is made by staining specimens from induced sputum or bronchoalveolar lavage (BAL) for the microscopic identification of *P. jirovecii* trophozoites and cysts. This can be performed using Giemsa stain, a silver stain, or more specifically by direct or indirect immunofluorescent antigen detection (see [UK SMI TP 39 – Staining procedures](#)). Molecular methods (PCR assays) have been shown to be extremely useful for the detection of *P. jirovecii* in clinical specimens^{43,44}.

Nematodes (roundworms)

The Nematodes belong to the phylum 'Nematoda'. There are over 25,000 described species and of which many are parasitic. Laboratory diagnosis of nematode infestations relies mainly on the identification of eggs or larvae passed in the faeces. A wet preparation of faeces in saline following a formol-ether/ethyl acetate concentration permits the demonstration of ova microscopically (Appendix 5). The macroscopic presence of worms in the sample is also of diagnostic value.

Charcot-Leyden crystals in the stool can be seen with a wide range of parasitic bowel infections including amoebic dysentery. These crystals are hallmarks of eosinophil involvement in certain tissue reactions and are the result of eosinophil breakdown. Hexagonal bipyramidal crystals of Charcot-Leyden crystal protein can be seen by light microscopy or by fluorescence microscopy as bright yellow green fluorescing needles^{45,46}.

The occurrence of tissue and peripheral blood eosinophilia in travellers returning from long-term residence in, or a visit to, developing countries, or in immigrants from tropical areas, suggests the possibility of an infection with a helminth⁴⁷. Some protozoal infections also cause eosinophilia. The greatest numbers of eosinophils in tissue and blood occur when the association of a parasite and host tissue is the closest, for example with migrating larvae or after their extended retention in tissue. Examples include trichinosis, visceral larval migrans, *Ascaris* pneumonia, strongyloidiasis, filariasis and acute schistosomiasis. Organisms, such as tapeworms, that remain in the bowel, and do not invade the intestinal mucosa, cause little or no eosinophilia.

Enterobius vermicularis

Also known as the thread or pin worm, it causes perianal and perineal pruritus, mainly in children⁴⁸. Migrations of the parasite enable it to be found in the appendix, salpinges and in ulcerative lesions in the small or large bowel, but the causal relationship to clinical pathology is uncertain (Appendix 5).

Laboratory diagnosis is usually made by microscopy of a Sellotape preparation and/or perianal swab sample.

Trichuris trichiura

Also known as the whip worm, the infection can often be asymptomatic⁴⁸. The loss of blood caused by adult worms embedding their heads in the intestinal mucosa is usually negligible, but heavy infections can cause a mild anaemia, bloody diarrhoea, dehydration, growth retardation and rectal prolapse (see Appendix 5).

Laboratory diagnosis is by identifying eggs in the faeces. In heavy infections, the stools are frequently mucoid and contain Charcot-Leyden crystals while in light infections, concentration methods are required for diagnosis.

***Ascaris lumbricoides*^{47,48}**

This nematode infection is usually asymptomatic. However the worms can cause serious pulmonary disease and obstruct the biliary and intestinal tracts. Larvae migrate through the lungs and may cause peripheral blood eosinophilia and symptoms associated with pulmonary infiltration. Third stage larvae may be seen in sputum. In children with heavy infections, the mass of worms can obstruct the lumen of the small bowel. This causes abdominal distension, vomiting and cramps. It may also invade the biliary duct and cause epigastric pain, nausea and vomiting (Appendix 5).

Laboratory definitive diagnosis is usually made by microscopic examination of a faecal smear. Concentration techniques involving floatation or sedimentation of eggs may also be used. Diagnosis can also be made visually by the presence of the adult stage of *Ascaris lumbricoides* worm in freshly-passed faeces.

Hookworm

The two species of hookworm that cause human infection are *Ancylostoma duodenale* and *Necator americanus*⁴⁸. Larvae penetrate the skin causing intense pruritus, erythema and a papular, vesicular rash. Larvae migrate through the lungs and may cause respiratory symptoms and eosinophilia in the sputum and peripheral blood. *A. duodenale* can cause infection by the oral route whereas *N. americanus* cannot. Symptoms include anaemia, chronic protein deficiency, abdominal pain, diarrhoea, weight loss and malabsorption. Hookworm eggs may be seen in faecal samples, but it is not possible to distinguish between species without hatching the eggs (see Appendices 5 and 8).

In older faecal samples infected with hookworm, first-stage larvae may be seen which must be differentiated from those of *Strongyloides* (Appendix 8).

Diagnosis is made by direct microscopic examination showing eggs in stool specimens. It should also be noted that the two species (that is, both *Ancylostoma duodenale* and *Necator americanus*) cannot be distinguished on the basis of their eggs but a formol-ether/ethyl acetate concentration method should be used in most cases.

***Trichostrongylus* species**

They are also known as hairworms. These nematodes are distributed worldwide, but are rarely seen in Europeans. They may cause disease in humans and are associated with rural areas where herbivorous animals are raised. Infections in humans occur through ingestion of infective larvae from contaminated water or vegetables. Symptoms include abdominal pain, weight loss, diarrhoea, nausea, flatulence and generalised fatigue. Eosinophilia is seen frequently in symptomatic patients⁴⁹. Diagnosis is made by direct microscopic examination showing eggs in stool specimens.

Strongyloides stercoralis

Strongyloides stercoralis invade the intestinal mucosa and deposit thin-walled eggs which hatch to rhabditiform larvae⁴⁷. These larvae may be passed in the faeces or develop within the lumen of the bowel to infective larvae that can autoinfect the host. It may cause an overwhelming autoinfection in immunocompromised patients⁴⁸. Pulmonary symptoms resemble those seen in hookworm infections. Other symptoms include burning or colicky abdominal pain, diarrhoea and passage of mucus, nausea, vomiting, weight loss, and malabsorption. Patients may also develop a generalised or

localised urticarial rash beginning perianally and extending to the buttocks, abdomen and thighs.

First stage larvae (rhabditiform) are usually seen in faeces and eggs are only seen when diarrhoea is severe (see Appendix 8)⁵⁰. Third stage larvae (filariform) can be seen in the sputum in cases of autoinfection. Direct smear or concentration methods of stool examination are useful for diagnosis of strongyloidiasis. However, serological tests are a valuable aid in diagnosis. PCR has also been found very useful in the diagnosis of chronic *S. stercoralis* infections three to four weeks earlier than the currently used methods⁵¹.

Unusual nematode infections

Laboratory diagnosis of the following diverse infections may be beyond the scope of most routine diagnostic laboratories. As many of these infections are rare and only occur in tropical countries, it is recommended that samples from patients be dealt with by a reference laboratory:

Trichinella species are ingested in raw or undercooked meat^{47,52}. Most infections are asymptomatic, but large numbers of adult worms in the intestines can cause diarrhoea, abdominal discomfort and vomiting. Larvae burrow into skeletal muscles and cause fever, periorbital oedema and myositis with pain and swelling. Infection is confirmed by serology or a skin test for *Trichinella* specie. Muscle biopsy is usually unnecessary.

Visceral larval migrans (VLM) – This is also called Toxocariasis. Larvae migrate from the intestine to the liver, lung and trachea^{47,53}. The most frequent agent is *Toxocara canis*. *Toxocara* species and other helminths (*Ascaris lumbricoides*, *Gnathostoma spinigerum*) may also be associated with the syndrome. VLM occurs mainly in children under six years of age. Most infections are asymptomatic, however patients may present with cough, fever, wheezing and hepatomegaly. Rarely, larvae may localise in the eye. Eosinophilia accompanied by leucocytosis is suggestive of VLM. Serological tests are available.

Ocular larval migrans (OLM) is the invasion of the eye by *T. canis* (and less frequently *T. cati*) larvae which become trapped in the eye and result in an eosinophilic inflammatory mass⁵³.

Cutaneous larva migrans, or creeping eruption, is commonly caused by *Ancylostoma braziliense*⁵³. It presents as serpiginous, reddened, elevated, pruritic skin lesions. Other parasites such as *S. stercoralis* may also cause it.

Larvae of *Anisakis* species (associated with eating raw fish for example, sushi), *Phocanema* species and other genera, may penetrate the stomach and small intestine and cause abdominal symptoms which mimic appendicitis⁵³.

Laboratory diagnosis may be made by endoscopy, radiographic studies, or pathological examination of tissues. Serological tests are helpful in the diagnosis of Toxocariasis and Trichinellosis.

Angiostrongylus

Angiostrongylus cantonensis larvae can invade the brain and cause meningitis associated with eosinophilic pleocytosis in the CSF and peripheral eosinophilia⁵³. The larvae may rarely be seen in the CSF. *Gnathostoma spinigerum* may cause a similar illness. Humans become infected through ingestion of larvae in raw or undercooked snails, or contaminated water and vegetables. Abdominal angiostrongyliasis is caused

by *A. costaricensis*^{53,54}. The larvae penetrate and develop in the lower small bowel and colon.

Laboratory diagnosis may be made by examining biopsy specimens.

***Capillaria and Paracapillaria*^{42,53}**

Capillariasis is a parasitic infection caused by new nematodes species namely, *Paracapillaria philippinensis* (previously known as *Capillaria philippinensis*) and *Capillaria hepatica* (also known as *Calodium hepaticum*)⁵⁵. *P. philippinensis* may present as diarrhoea, vomiting, weight loss and malabsorption, while *C. hepatica* can cause acute/subacute hepatitis with peripheral eosinophilia and has similar symptoms as the former including ascites and hepatolithiasis. The main source of acquiring intestinal capillariasis is by eating of raw fresh water fish. This infection is seen in raw fish eating areas like the Philippines⁵⁶.

For the laboratory diagnosis of this infection, examination of faecal material by formol-ether/ ethyl acetate concentration or biopsy material is required. Alternative methods include immunodiagnosis which may be a supplementary diagnostic tool which helps to detect *P. philippinensis* infection as well as PCR which has been used successfully in the rapid diagnosis of *P. philippinensis*, thereby avoiding the delay in management and possible complications^{56,57}.

Dracunculus

Dracunculiasis (Guinea worm disease) is caused by the nematode parasite *Dracunculus medinensis* (known commonly as the Guinea worm). This infection is characterised by a chronic cutaneous ulcer from which the worm protrudes⁵². Some patients have a generalised reaction with urticaria, nausea, vomiting, diarrhoea and dyspnea. Painful ulcers develop which discharge fluid containing larvae. This may be examined microscopically to confirm the diagnosis.

Onchocerca volvulus

Onchocerciasis (known as river blindness) is caused by the filarial parasite *Onchocerca volvulus*. This parasite is transmitted by blackflies⁵². It causes an itchy dermatitis, subcutaneous nodules, keratitis and chorioretinitis. Laboratory diagnosis may be made by microscopic detection of microfilariae in blood and skin snips, indirect detection of microfilariae with the diethylcarbamazine patch test, detection of antibodies to onchocercal antigens, or detection of *O. volvulus* DNA in skin snips by PCR⁵⁸.

Adult worms can be found in nodule biopsy specimens (Appendix 13).

Mansonella streptocerca

This particular specie is transmitted by midges and blackflies⁵². Other species are generally found in blood. *Mansonella streptocerca* is usually diagnosed by finding microfilariae in blood and skin snips.

***Dirofilaria immitis*⁵³**

D. immitis causes lung nodules or subcutaneous abscess in humans. Migrating filariae die and cause local vasculitis which leads to pulmonary infarcts. Other species may cause subcutaneous masses. Laboratory diagnosis may be made by examining biopsies.

Trematodes (flukes)⁵⁹

Generally, the laboratory diagnosis of trematodes is achieved by microscopic identification of eggs passed in the faeces; exceptions to this will be listed. Blood samples may be required especially when the parasite burden is low and stools and urine samples may be negative. A wet preparation of the sample in saline followed by a formol-ether /ethyl acetate concentration permits the demonstration of ova microscopically.

Blood flukes

Schistosoma

There are five species of *Schistosoma*: *Schistosoma haematobium*, *Schistosoma intercalatum*, *Schistosoma japonicum*, *Schistosoma mansoni*, and *Schistosoma mekongi*. They may cause schistosomiasis⁶⁰. The adult worms inhabit the portal and mesenteric blood vessels (except for *S. haematobium* which inhabits the vesical venous plexus). Major disease syndromes include a papular or urticarial rash, Katayama fever and chronic fibro-obstructive sequelae. These syndromes coincide with and are related to three different stages of development of the parasites in the host: cercariae; mature worms; and eggs. Penetrating cercariae cause a papular pruritic itch called swimmer's itch or schistosomal dermatitis. When worms have matured and begin depositing eggs, Katayama fever or acute schistosomiasis develops. Some eggs remain in the body of the host. These can lead to granuloma formation and tissue damage which may obstruct portal blood flow to the liver and pulmonary blood flow to the lungs, as well as urine flow through the ureters and bladder. Haematuria is the most common presentation of *S. haematobium* infection⁴⁷. Chronic infection with *S. haematobium* can lead to bladder cancer⁵⁴.

Laboratory diagnosis is made by demonstrating eggs in the faeces (urine or semen for *S. haematobium*)⁶¹. Rectal snips or biopsies may also be examined. Serological tests can be of value when eggs cannot be found in clinical samples. PCR has been found to be very valuable for diagnosis in the early phase of schistosomiasis⁶².

Liver flukes

***Opisthorchis sinensis* (formerly known as *Clonorchis sinensis*)**

Also known as the Chinese liver fluke. Clonorchiasis is an infection caused by *Opisthorchis sinensis*. These may cause localised obstruction of the bile ducts and thickening of the walls in heavy infections, as well as cholangitis and cholangiohepatitis⁶⁰.

The standard diagnostic method is microscopic examination of faeces / duodenal aspirate thereby identifying eggs. Alternative methods include ELISA, which has become the most important method. Detecting DNA from eggs in faeces can be done using PCR and LAMP assays, which are highly sensitive and specific. Imaging diagnosis is also to be very useful and is now widely used⁶³.

Opisthorchis viverrini* and *Opisthorchis felineus

Also known as Southeast Asian liver fluke and cat liver fluke respectively. These liver fluke parasites generally cause the infection, Opisthorchiasis and this is acquired by humans ingesting raw or undercooked infected fish which contain metacercariae of *O. viverrini*.

Symptoms caused include abdominal pain, diarrhoea or constipation. Chronic symptoms include obstruction of the biliary tract, inflammation and fibrosis of the biliary tract, liver abscesses, pancreatitis, and suppurative cholangitis. In rare cases, they cause liver cholangiocarcinoma⁵⁹.

Diagnosis is as shown above in *Opisthorchis sinensis*.

Fasciola hepatica

Infestation has two distinct clinical phases corresponding to a hepatic migratory phase of the life cycle and to the presence of worms in their final habitat, the bile duct⁶⁰. The early phase may present with fever and pain in the upper quadrant. Later, biliary obstruction may occur.

Ova may be demonstrated in the faeces or the bile. Serological tests are also available.

Intestinal flukes

These include *Fasciolopsis buski*, *Heterophyes heterophyes*, *Nanophyetus salmincola*, *Metagonimus yokogawai* and *Echinostoma* species^{53,60}. Most *F. buski* infections are asymptomatic. Heavy infections can cause diarrhoea, abdominal pain and malabsorption. *H. heterophyes* causes abdominal pain and diarrhoea. *Echinostoma* species infection is rare but has been documented. *N. salmincola* causes diarrhoea, abdominal pain, bloating and eosinophilia.

Ova and parasites may be demonstrated in the faeces.

Lung flukes

***Paragonimus* species**

There are almost 50 species and subspecies of *Paragonimus*, of which over 13 of these are known to infect humans causing the condition, “paragonimiasis”. The most common is *Paragonimus westermani*, also known as the ‘oriental lung fluke’. Humans get infected when they eat uncooked or undercooked seafood such as freshwater crabs or crayfish that contain the parasites. They encapsulate within the lung parenchyma, usually close to the bronchioles⁶⁰. Eggs are deposited which pass into the bronchioles and are coughed up. These may then be detected in the sputum or, if they are swallowed, in the faeces. Patients develop eosinophilia and experience chest complaints; they may cough up brownish sputum and have intermittent haemoptyses. This leads on to chronic bronchitis or bronchiectasis with profuse expectoration and pleuritic chest pain.

Laboratory diagnosis may be made microscopically by demonstrating the presence of eggs (ova) in the sputum or faeces. Other alternative tests include EIA and serology tests, which has been useful for diagnosis in early infections⁶⁴.

Cestodes (tapeworms)

Generally, the laboratory diagnosis of cestodes is achieved by microscopic identification of eggs passed in the faeces. Exceptions to this will be listed. A wet preparation of sample in saline followed by a formol-ether concentration permits the demonstration of ova microscopically. The macroscopic presence of proglottids in the sample is also of diagnostic value (Appendix 5 and 7).

In humans, cestode infestations occur in one of two forms: mature tapeworms within the gastrointestinal tract, or as one or more larval forms (called hydatidosis,

cysticercosis, coenurosis and sparganosis) embedded in the liver, lung, muscle, brain, eye or other tissues.

Diphyllobothrium latum

Also known as the fish tapeworm, it is associated with cold, clear lakes found in Scandinavia, northern Europe, northern Japan, Canada, Alaska and North America. It causes a parasitic infection called 'diphyllobothriasis' in humans which is acquired by eating raw fish infected with the parasite. Infestations are usually asymptomatic, however when the parasite reaches a large size it may cause mechanical obstruction of the bowel resulting in diarrhoea and abdominal pain. Prolonged or heavy infections cause vitamin B12 deficiency. In some cases it can lead to neurological symptoms⁶⁵.

***Hymenolepsis nana* and related cestodes**

Hymenolepsis nana is the smallest of the tapeworms that infect humans. It is also known as the 'dwarf' tapeworm due to its particularly small size. It is the most common tapeworm infection of humans worldwide⁶⁵. This infection may cause mild abdominal discomfort, irritability, anorexia and diarrhoea. Although humans may acquire infection by accidental ingestion of infected beetles (often found in dry cereals), direct infection is more common and usually occurs in familial and institutional settings where hygiene is poor. *Hymenolepsis diminuta*, primarily a parasite of rats, is an occasional human parasite via the ingestion of beetles in cereals. *Dipylidium caninum* is commonly found in dogs and cats. Children in particular may become infected through close contact with the animals and their fleas.

Diagnosis can be achieved by recovery and identification of the characteristic ova in a formol-ether concentrate of faeces. Adult worms and proglottids are rarely seen in stool samples.

Taenia saginata

Also known as the beef tapeworm. It is more common in developing countries where hygiene is very poor. Humans become infected when raw or undercooked meat is ingested. They cause abdominal discomfort and patients experience proglottid migration from the anus⁶⁵.

Taenia solium

Also known as the pork tapeworm. The adult worms cause minimal symptoms, but the larval cysts cause local inflammation⁶⁵. Migration of these into the central nervous system causes seizures, hydrocephalus and arachnoiditis.

Cysticercosis (this is tissue infection with cysticerci of *T. solium*) can develop in humans by autoinfection from the adult worm. Involvement of the central nervous system is called neurocysticercosis⁶⁵.

Diagnosis can be achieved by stool microscopy, serology, immunodiagnostic methods or biopsy⁶⁶.

Taenia multiceps*, *Taenia serialis* and *Taenia brauni

Taenia multiceps and *Taenia serialis* are more commonly seen in Europe and USA while *Taenia brauni* is common in Africa. These species cause a cyst infection called coenurosis, and usually develop into tapeworms in dogs⁶⁵. Symptomatic disease in humans involves the eye, central nervous system, sub-cutaneous and muscular tissues. Laboratory diagnosis is by microscopic examination of appropriate material for the presence of protoscolices (similar to those of *T. solium*).

Spirometra mansonoides

The tissue infection, sparganosis is usually caused by *Spirometra mansonoides*. It is a tissue infection with plerocercoid larvae of several different cestode species, and symptoms include local inflammation of the skin at the site of invasion⁶⁵. Tissue injury may be severe, particularly in the eye, because some forms of the parasite spread to other areas of the body.

Laboratory diagnosis is by histological techniques only.

Echinococcus granulosus*, *Echinococcus vogeli* and *Echinococcus multilocularis

These tapeworms cause the parasitic disease called Echinococcosis which has two forms: cyst echinococcosis caused by *Echinococcus granulosus* or *Echinococcus vogeli*, and alveolar echinococcosis caused by *Echinococcus multilocularis*⁶⁵. Eggs hatch to form oncospheres that penetrate the gut mucosa and enter the circulation. These encyst in the host viscera and develop to form mature larval cysts. Symptoms occur due to the mechanical effects of enlarging cysts in confined spaces.

Laboratory diagnosis can be made by:

1. Imaging and serodiagnosis are the mainstay of diagnosis. Serological tests include Enzyme linked immunosorbent assay (ELISA), an indirect haemagglutination test and a complement fixation test
2. In the case of cyst echinococcosis, microscopic examination of the cyst fluid to look for the characteristic protoscolices which can be either invaginated or evaginated. The cyst fluid may also reveal free hooklets

Note: Diagnostic aspiration should only be undertaken in a specialist unit with experience in managing such parasites.

3. Histological examination of the cyst wall after surgical removal

Occasionally pulmonary cysts containing *E. granulosus* may rupture and intact protoscoleces and hooks can be coughed up in the sputum, and seen in microscopic preparations. Serological tests are also available.

5 Technical information/limitations

Limitations of UK SMIs

The recommendations made in UK SMIs are based on evidence (for example, sensitivity and specificity) where available, expert opinion and pragmatism, with consideration also being given to available resources. Laboratories should take account of local requirements and undertake additional investigations where appropriate. Prior to use, laboratories should ensure that all commercial and in-house tests have been validated and are fit for purpose.

Specimen containers^{67,68}

UK SMIs use the term, “CE marked leak proof container,” to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: “The design must

allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes.”

Rapid diagnostic tests

A variety of rapid identification methods of varying sensitivities and specificities are available. These techniques may have potential advantages/disadvantages and should therefore be evaluated and validated prior to use. Molecular methods (for example, multiplex PCR) and enzyme immunoassays (EIA) may perform better than conventional methods, and should therefore be considered for use where available, following validation to ensure appropriate clinical interpretation^{30,69}.

Commercial test kits

The quality of reagents in commercially available test kits may be variable or deteriorate under storage conditions; for that reason in-house as well as external controls are necessary to determine whether the kit is fit for purpose. Laboratories should use test kits according to manufacturers’ instructions.

Concentration methods

Faecal specimens should be submitted fresh, without formalin, as concentration is not required routinely prior to staining. Where concentration is deemed necessary, modified methods should be used to minimise oocyst losses and prevent interference with the adhesion of oocysts to slides and with staining.

Toxoplasma testing

Several commercial kits for *Toxoplasma* serologic testing are available. However, the sensitivity and specificity of these kits may vary widely from one commercial brand to another. This is of concern because serology results can influence decisions on continuation or termination of pregnancies.

Enzyme immunoassays (EIA)

Specimens (faeces) to be tested using EIA or other rapid assays should not be concentrated prior to testing because antigens (such as those targeted in diagnosis of *Giardia intestinalis* and *Cryptosporidium* species) are lost during the procedure such as in diagnosis of *Giardia intestinalis* and *Cryptosporidium* species. Most EIAs require the use of fresh or frozen stool specimens²⁸. However, there are now some commercially available test kits that use preserved faecal specimens for detection of antigens, and users should check the manufacturers’ instructions.

Preservation of specimens

Preservation in 10% formalin is necessary when faeces cannot be examined within the prescribed time interval. These specimens can be stored for several months. However it should be noted that it has its drawbacks which include its interference with PCR especially after extended fixation time, its inadequate preservation of morphology of the protozoan trophozoites as well as its non-suitability for some smears stained with trichrome stain⁷⁰.

Problems with identification

There are many microscopic artefacts that can be found in faeces which may be confused with trophozoites, (oo)cysts or eggs. See Appendix 4 for more information.

Problems with microscopy

The diagnosis of *E. histolytica* infection has always relied on microscopic examination of fresh or fixed stool specimens however, microscopy has its limitations which include its suboptimal sensitivity which is about 60%, and secondly, its inability to distinguish potentially pathogenic *E. histolytica* from morphologically identical but non-pathogenic *E. dispar*, *E. moshkovskii*, and other quadrinucleate cysts of *Entamoeba*^{3,4}.

Other drawbacks to microscopy generally include its tediousness when large numbers of specimens need to be examined and the lack of microscopic expertise among laboratory staff.

6 Safety considerations^{67,68,71-85}

6.1 Specimen collection, transport and storage^{67,68,71-74}

Use aseptic technique.

Collect specimens in appropriate CE marked leak proof containers and transport in sealed plastic bags, with the exception of Sellotape slide/perianal swab for *E. vermicularis* ova which should be transported in a sealed plastic bag¹.

In the case of CSF, any inoculated plates should also be transported in a robust, CE marked leak proof container.

Compliance with postal, transport and storage regulations is essential.

6.2 Specimen processing^{67,68,71-85}

All sample types

Containment Level 2 unless otherwise specified (see below).

Laboratory procedures that give rise to infectious aerosols must be conducted in a microbiological safety cabinet⁷⁷.

Disposable gloves should be worn for all parasitology investigations.

Refer to current guidance on the safe handling of all organisms documented in this UK SMI.

Faeces

Containment Level 3 is not required for investigation of *Echinococcus* species and *Taenia solium* but a Class 1 microbiological safety cabinet is essential.

Unpreserved tapeworm proglottids submitted to the laboratory for identification are hazardous due to the possibility of accidental infection, and the possibility of cysticercosis⁸⁶.

Care should be taken even with faecal specimens that have been fixed in preservatives as they could potentially be infectious. Fixation in formalin can take days

Investigation of specimens other than blood for parasites

to weeks to kill some parasite cysts or oocysts, for example, eggs of *Ascaris lumbricoides* may continue to develop and are infectious even when preserved in formalin.

Specimens for microscopy only should be prepared in 10% (v/v) formalin in water (this would not be suitable for the examination of trophozoites).

For formol-ether concentrations, ethyl acetate should be used in place of diethyl ether for safety reasons⁴². Procedures should be carried out in a well-ventilated area with no naked flames.

CSF

Containment Level 3 and a safety cabinet are required for the investigation for *Naegleria fowleri*.

Tissues, biopsies, hydatid cyst and pus from abscesses

Process specimens from the lung and pleural cavity, and hydatid cysts, in a Class 1 exhaust protective cabinet in a Containment Level 3 room.

Sputum/bronchoalveolar lavage

All specimens must be processed in a Class 1 exhaust protective cabinet in a Containment Level 3 room.

The above guidance should be supplemented with local COSHH and risk assessments.

7 Specimen collection

7.1 Type of specimens

Faeces, urine, sellotape slide/perianal swab, CSF, bile, pus from abscesses, duodenal/jejunal aspirates, tissues, hydatid cyst, sputum/bronchoalveolar lavage, biopsies from colonoscopy or surgery

7.2 Optimal time and method of collection⁸⁷

For safety considerations refer to Section 6.1.

Collect specimens before antimicrobial therapy where possible⁸⁷.

Faeces

Faeces should be presumably collected before antimicrobial or anti-diarrhoeal therapy where possible and between 10pm and midnight, or early in the morning, before defecation or bathing.

Sellotape slide/perianal swab should be collected for *E. vermicularis* ova¹.

Fresh faeces specimens are essential for the examination of trophozoites.

Faeces may be passed directly to a sterile wide-mouthed CE marked leak proof container or may be passed to a clean, dry bedpan or similar container and transferred to a CE marked leak proof container.

Fresh, unpreserved specimens should be transported immediately. Cysts will not form once the specimen has been passed.

Protozoan trophozoites will not survive if the specimen dries out. Use of 10% formalin will kill trophozoites and renders them immotile. Liquid stool should therefore be examined ideally within 30 minutes from the time of collection without the addition of formalin (usually with a drop of saline) if trophozoites are sought. If delays cannot be avoided, the specimen should be preserved to avoid disintegration of the trophozoites.

Soft stools (which may contain both trophozoites and cysts) should preferably be examined within 1hr of passage⁸⁸.

Formed specimens (less likely to contain trophozoites) can be kept for up to one day, with overnight refrigeration if needed, prior to examination⁸⁹.

Microscopy for *E. vermicularis* ova¹

Sellotape slide

Apply clear Sellotape to the perianal region, pressing the adhesive side of the tape firmly against the left and right perianal folds several times; the tape can be wrapped around a tongue depressor to aid specimen collection. Smooth the tape back on the slide, adhesive side down.

Perianal swab

Perianal specimens are best obtained in the morning before bathing or defecation. Three specimens should be taken on consecutive days before pinworm infection is ruled out.

Cotton-wool swab in dry container should be used for collection.

Spread buttocks apart, and rub the moistened cotton wool swab over the area around the anus, but do not insert into the anus. Place cotton wool swab back in its container (no transport medium required). Occasionally, an adult worm may be collected from a patient and sent in saline or water for identification.

Urine (for *S. haematobium*)

In urinary schistosomiasis, very few ova are present in the urine. The number of ova in the urine varies throughout the day, being highest in urine obtained between 10am and 2pm⁹⁰. In patients with haematuria, eggs may be found trapped in the blood and mucus in the terminal portion of the urine specimen. It is therefore preferable to obtain total urine collected over the time period between 10am and 2pm⁹¹. Alternatively, a 24hr collection of terminal samples of urine may be helpful. Sterile containers without boric acid must be used⁹⁰.

If the urine cannot be examined within an hour of collection, it is advisable to add 1mL of undiluted formalin to preserve any eggs that may be present⁹⁰.

CSF

Specimens will be obtained by specialist collection according to local protocols.

Tissues, biopsies, hydatid cyst and pus from abscesses, bile, duodenal/jejunal aspirates

Specimens will be obtained by specialist collection according to local protocols.

Sputum/bronchoalveolar lavage

Sputum from the lower respiratory tract expectorated by deep coughing is required. When the cough is dry, physiotherapy, postural drainage or inhalation of an aerosol before expectoration may be helpful.

7.3 Adequate quantity and appropriate number of specimens⁸⁷

Faeces

Ideally three stool specimens collected over no more than a 10-day period. It is usually recommended that specimens are collected every other day. Unless the patient has severe diarrhoea or dysentery, no more than one specimen should be examined within a single 24 hour period, as shedding of cysts and ova tends to be intermittent.

If *E. histolytica* is suspected and the first three specimens are negative, consideration should be made for referral where available for molecular tests.

There are no prescribed limits for the size of sample required, as some laboratory procedures will require larger quantities than others.

Sellotape slide/perianal swab for *E. vermicularis* ova¹

It is recommended that samples should be taken for at least four to six consecutive days. If the results of all these are negative the patient can be considered free from infection. In practice, more than one specimen is rarely received.

Urine (for *S. haematobium*)

Ideally, a minimum volume of 10mL is required.

CSF

Ideally, a minimum volume of 1mL is required.

Tissues, biopsies, hydatid cyst and pus from abscesses

Pus

Ideally, the entire volume of pus or a minimum of 1mL is required.

Tissues/biopsies

Ideally, the specimen should be large enough to carry out all investigations required.

Bile, duodenal/jejunal aspirates

Ideally, a minimum volume of 1mL is required.

Sputum/bronchoalveolar lavage

Ideally, a minimum volume of 2mL is required.

8 Specimen transport, storage and retention^{67,68}

8.1 Optimal transport and storage conditions

For safety considerations refer to Section 6.1.

Specimens should be transported and processed as soon as possible⁸⁷.

Samples should be retained in accordance with The Royal College of Pathologists guidelines 'The retention and storage of pathological records and specimens'⁹².

Faeces

If prompt examination of stools cannot be carried out, the use of 10% formalin-water preservative is necessary to prevent deterioration of protozoan morphology, the hatching of first-stage hookworm larvae, and overgrowth of yeasts⁹³.

Sellotape slide/perianal swab for *E. vermicularis* ova¹

Refrigeration or store at room temperature (20 - 25°C) for up to 48hr.

Urine (for *S. haematobium*), bile, duodenal/jejunal aspirates and sputum/bronchoalveolar lavage

If processing is delayed, refrigeration is preferable to storage at room temperature (20-25°C).

Tissues, biopsies, hydatid cyst and pus from abscesses

If specimen of tissue/biopsy is small, place it in sterile water to prevent desiccation.

If processing is delayed, refrigeration is preferable to storage at room temperature (20-25°C).

9 Specimen processing/procedure^{67,68}

9.1 Test selection

Faeces

Select a representative portion of specimen for appropriate procedures such as culture for bacterial pathogens, testing for *Clostridium difficile* toxins ([UK SMI B 10 – Investigation of faecal specimens for *Clostridioides difficile*](#)) and virological examination, depending on clinical details.

Faecal concentrations are carried out on all specimens where examination of parasites is specifically requested, where there are definite clinical indications and when advised by senior laboratory staff.

All faecal samples from symptomatic individuals should be tested for *Cryptosporidium* oocysts⁹⁴.

Stain for microsporidia in symptomatic, HIV positive and immunocompromised patients.

Investigation of specimens other than blood for parasites

Incubation period and life cycle of individual parasitic infections should be determined in test selection.

For all other specimens

N/A

9.2 Appearance

N/A

9.3 Sample preparation

For safety considerations refer to Section 6.2. Follow manufacturers' instructions if commercial kits are used.

9.3.1 Pre-treatment

N/A

9.3.2 Specimen processing

Faeces

Sample parts of faeces samples that contain blood, pus, or mucus for direct examination as wet preparations or for staining.

If sampling formed faeces, collect and examine material from various parts of the faecal sample for concentration, wet preparations and for staining.

Faeces for microscopical examination of protozoa

Standard

If specimen is fresh, examine for motile trophozoites as follows:

1. Place one drop of 0.85% saline on the left-hand side of a clean microscope slide, and one drop of double-strength Lugol's iodine on the right-hand side (the distance between the drops should be sufficient to enable coverslips to be placed over each drop).
2. Using a different swab stick for each preparation, take a small amount of unfixed faeces and thoroughly emulsify in the saline and in the Lugol's iodine.
3. Place cover slips over each preparation on the slide. Examine both entire areas with a low power objective. Use a medium power objective to identify any suspicious morphological features.
4. If required, prepare smears on clean microscope slides for auramine-phenol and/or Giemsa staining (see [UK SMI TP 39 - Staining procedures](#)).
5. Also, concentrate the specimen with the formol-ether* concentration technique described below.

Faeces for examination of *Cryptosporidium* species^{88,95}

1. Prepare a medium to thick smear of faeces on a clean microscope slide and air dry.

Note: If specimen is dry or solid, 10% formalin may be added.

2. Fix in methanol for three minutes.

3. Smears can be stained by either auramine phenol or modified cold Ziehl-Neelsen (see [UK SMI TP 39 - Staining procedures](#)).

Modified formol-ether* concentration^{96,97}

***Ethyl acetate (not diethyl ether) must be used in a well-ventilated area with no naked flames**

The following method is the recommended technique for faecal concentration. There are many commercial kits for the concentration of faeces available which are based on the Ridley Allen method described below, which is the method of choice used by most clinical laboratories. Commercial concentration kits are often used.

1. Take a sample of faeces about the size of a large pea (approximately 1g) with a swab stick and emulsify it in 7mL of 10% formalin (one volume of 40% formaldehyde diluted with nine volumes of distilled water) in a clean universal container.
2. Sieve by pouring the whole contents of the universal through a sieve (a nylon tea-strainer or a square of wire gauze is suitable) and collect in a suitable container. Sieves are washed in copious amounts of clean water and re-used. Sieving the faeces and formalin mixture prior to centrifugation helps eliminate large pieces of faecal matter from the suspension.
3. Transfer the filtrate into a stoppered glass or polypropylene (ether resistant) container appropriate for centrifugation.
4. Add 3mL of ethyl acetate and a small drop of 0.1% Triton X 100 (helps emulsify the faecal specimen) and vortex for 15secs, or shake vigorously for 60secs.
5. Centrifuge the specimen at 1200 x g for 3min.
6. Loosen the fatty layer with a swab stick by passing it around the inside circumference of the tube, removing all residues of the fat from the tube.
7. Tip away the contents of the tube, allowing the last few drops to return to the bottom of the tube to cover the remaining deposit.
8. Resuspend the deposit in the remaining fluid. Place a drop of this on a clean microscope slide and place a coverslip over it.
9. Double strength iodine may be added to a separate preparation to enhance and facilitate comparison of morphological details.
10. Search the entire area using a low power objective; use a medium power objective to examine morphological features.

Commercially available concentrator kits containing sieves of varying pore sizes are available; the size of the pore affects the yield of parasite stages and the amount of debris present⁹⁸⁻¹⁰¹. A larger pore size may result in a higher yield of parasite stages, however the increase in debris leads to a denser deposit, making it more difficult to examine the slide; ova and cysts may therefore be obscured. If the pore size is too small, despite having a cleaner slide which is easy to examine, the yield of parasite stages will be reduced. Commercially available faecal concentrator kits should be validated prior to use, and manufacturers' instructions should be followed.

To maximise the recovery of parasites it is important to sieve the faecal formalin mixture, use a solvent, that is, ethyl acetate with triton X and centrifuge for the correct time and at the correct centrifugal force⁹⁹. Recovery of parasite stages may be greatly

diminished if a solvent (for example ethyl acetate) as an extractor of fat and debris is not used¹⁰¹. A recent study confirms and recommends that 1200 x g for 3min is optimal for parasite recovery^{101,102}.

Sellotape slide

1. Before examining the slide, it may be advantageous to lift the tape and place one drop of immersion oil or glycerol/alcohol under the middle of the tape and replace in position. This will improve the transparency of the tape.
2. Examine the slide using a low power objective.

Perianal swab

1. Add enough saline to cover the swab in its container and replace the cap.
2. Shake vigorously.
3. Withdraw the swab from the saline, rolling it against the side of the container to squeeze out the saline. Discard the swab.
4. Concentrate the resultant fluid by centrifugation at 800 x g for 2min.
5. Remove the supernatant with a disposable pipette, without disturbing the sediment.
6. Agitate the tube to resuspend the residue.
7. Using a disposable pipette, place a drop of sediment on a microscope slide, apply a coverslip and use a low power objective to examine the entire area.

Urine (for *S. haematobium*)⁹⁰

A complete urine sample collected between 10am – 2pm should be submitted. Alternatively, submit terminal stream urines collected over a whole 24 hour period. For large volumes of urine (>25mL)

Sedimentation method

1. Allow the specimen to sediment for 1hr.
2. Decant and discard the supernatant, then transfer the sediment along with some residual urine (approximately 1mL) to conical-bottom containers for centrifugation.
3. Centrifuge at 500 x g for 2min.
4. Decant and discard the supernatant then mix the sediment using a pipette.
5. Place 1- 2 drops of the whole deposit on several clean microscope slides and apply coverslips.
6. Examine the entire area of each slide preparation with a low power objective.

Other urine specimens

If specimen is already in a conical-bottom container, proceed as from number 3 above, if not, transfer the entire specimen to conical-bottom containers and proceed as from number 3 above.

Filtration method (recommended for non-cellular, crystal-free urine specimens)

1. Draw ≥10mL urine into a syringe, and then connect to a Swinnex filter (pore size 12µm).

Investigation of specimens other than blood for parasites

2. Gently ease the urine through the filter.
3. Draw in 20mL of air and ease this through the filter.
4. Remove the top of the filter and place the membrane on a microscope slide.
5. Add a drop of saline, apply a coverslip and view microscopically with a low power objective.

CSF¹⁰³

1. Perform direct microscopy of the CSF as soon as received (use a low or medium power objective).
2. Concentrate the CSF by centrifuging at 100 x g for 10min.
3. With a sterile pipette transfer the supernatant, leaving approximately 0.5mL, to another sterile container for additional testing if required (protein content, virology, etc.).
4. Resuspend the centrifuged deposit in the remaining fluid and place two drops in the centre of a bacteria-coated agar plate.
5. After the fluid has been absorbed, incubate and examine the plate as described for corneal scrapings (refer to [UK SMI S 11 – Red or painful eye](#))

Note: 35°C–37°C incubation will give better results for *Naegleria* species.

1. Also, place one drop of the centrifuged deposit on a clean microscope slide and place a cover slip over it. Screen the entire area with a low power objective; use a medium objective to identify any morphological features.

Hydatid cyst and pus from abscesses

For pus and hydatid cyst contents (including hydatid sand), prepare wet preparations and air-dried smears for staining (if required) (see [UK SMI TP 39 - Staining procedures](#)).

Tissues and biopsies¹⁰³

1. In addition to standard histological preparations make impression smears, teased and squash preparations.
2. Place specimen in a sterile Petri dish to examine it macroscopically and to select a sample for microscopic examination.
3. Select an area that appears to look different from normal. For example, select grey consolidated or granulomatous portion of a lung, liver or the ulcerated area of intestinal tissue.

Impression smears

1. If the sample is large enough, cut the tissue and use the cut surfaces to touch the slide.
2. Press the tissue against a clean microscope slide, lift and press again.
3. Turn the sample over and press the area of the cut surface against the slide to make two more impressions. This leaves three impressions in a row on one microscope slide.
4. If several tissue samples were supplied, make a row of impressions with each of the samples.

5. Air dry and fix in methanol for 1min before staining by Giemsa (see [UK SMI TP 39 - Staining procedures](#)).

Squash preparations

Squash preparations - for tissue parasites such as *Trichinella*:

1. Cut selected tissue portions into very fine fragments in a Petri dish, placing a fragment on a clean microscope slide.
2. Add one drop of sterile saline or sterile distilled water.
3. Cover with a second clean microscope slide and press the slides firmly together.
4. Examine microscopically with a low power objective.

Note: Care should be taken when squash preparations are performed as they can release lots of eggs increasing the risk to the operator.

Bile, duodenal/jejunal aspirates

Standard

1. Centrifuge specimen at 800 x g for 2min.
2. Decant supernatant to disinfectant.
3. Resuspend the centrifuged deposit in the remaining drops of supernatant.
4. Use the resuspended pellet to prepare smears for staining.
5. Stain using Ziehl-Neelsen and auramine-phenol for *Cryptosporidium*, Giemsa for *Cyclospora cayetanensis* and *C. belli* (see [UK SMI TP 39 - Staining procedures](#)), and iodine or plain wet preparation for *S. stercoralis* and *G. duodenalis*.

Supplementary

For examination of microsporidia:

1. Centrifuge specimen at 800 x g for 2min.
2. Decant supernatant to disinfectant.
3. Resuspend the centrifuged deposit in the remaining drops of supernatant.
4. Use the resuspended pellet to prepare smears for staining.
5. Stain with the modified trichrome stain (see [UK SMI TP 39 - Staining procedures](#)).

Sputum¹⁰³

1. Select any blood-tinged viscous areas for sampling.
2. Place 1mL of sputum in a centrifuge tube.
3. Add 1mL dithiothreitol and agitate gently for approximately 10sec. Allow to stand at room temperature for 15min.
4. Centrifuge at 1500 x g for 2min.
5. Decant the supernatant to a discard jar.
6. Resuspend the deposit in the few remaining drops of supernatant.

Investigation of specimens other than blood for parasites

7. Place one drop of this on a clean microscope slide and apply a cover slip.
Examine the entire area with a low power objective.

Induced sputum / BAL (for *P. jirovecii*)

Several methods exist for the staining and identification of *P. jirovecii*. Histological stains may be used, however immunofluorescent methods with monoclonal antibodies are used in many microbiology laboratories. Manufacturers' recommendations should be followed when using commercial kits and reagents. For more information, see [UK SMI B 57 – Investigation of bronchoalveolar lavage, sputum and associated specimens](#).

9.4 Microscopy

See Section 9.3.2 for all specimens.

9.5 Culture and investigation

See Section 9.3.2 for all specimens.

9.6 Identification

Minimum level

Identify parasites to species level and their stages where possible.

9.7 Antimicrobial susceptibility testing

N/A

9.8 Referral for outbreak investigations

For information regarding outbreak investigation referral, contact specific reference laboratory.

9.9 Referral to reference laboratories

For information on the tests offered, turnaround times, transport procedure and the other requirements of the reference laboratory [click here for user manuals and request forms](#).

Organisms with unusual or unexpected resistance, and whenever there is a laboratory or clinical problem, or anomaly that requires elucidation should, be sent to the appropriate reference laboratory.

Contact appropriate devolved national reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

[England](#)

[Wales](#)

[Scotland](#)

[Northern Ireland](#)

10 Reporting procedure

10.1 Microscopy

Report on any parasites seen.

Faeces

Include comment on the presence of all stages of parasites seen, whether they are pathogenic or non-pathogenic.

Microscopy reporting time

Written report 16–72hr stating, if appropriate, that a further report will be issued.

Urgent microscopy: telephone when available.

10.2 Culture

CSF

Report presence or absence of *Acanthamoeba* species and/or *Naegleria fowleri*.

Culture reporting time

CSF

Written report on day four stating if appropriate, that a further report will be issued.

Clinically urgent requests: telephone when available.

10.3 Antimicrobial susceptibility testing

N/A

11 Referral to reference laboratories

For information on the tests offered, turnaround times, transport procedure and the other requirements of the reference laboratory [see user manuals and request forms](#)

Contact appropriate reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

[England](#)

[Wales](#)

[Scotland](#)

[Northern Ireland](#)

Note: In case of sending away to laboratories for processing, ensure that specimen is placed in appropriate package and transported accordingly.

12 Public health responsibilities of diagnostic laboratories

Diagnostic laboratories have public health responsibility as part of their duties. Amongst these are additional local testing, or referral to further characterise the organism as required, primarily for public health purposes e.g. routine cryptosporidium detection; serotyping or microbial subtyping; and a duty to refer appropriate specimens and isolates of public health importance to a reference laboratory.

Diagnostic laboratory outputs inform public health intervention, and surveillance data is required to develop policy and guidance forming an essential component of healthcare. It is recognised that additional testing and referral of samples may entail some costs that has to be borne by the laboratory but in certain jurisdictions these costs are covered centrally.

Diagnostic laboratories should be mindful of the impact of laboratory investigations on public health and consider requests from the reference laboratories for specimen referral or enhanced information.

Appendix 1: Specimen types and possible parasites detectable

Specimen types	Possible parasites present
Bile	<i>Fasciola hepatica</i> , <i>Opisthorchis sinensis</i> , <i>Cryptosporidium</i> species
CSF	<i>Acanthamoeba</i> species, <i>Angiostrongylus cantonensis</i> , <i>Balamuthia mandrillaris</i> , Microsporidia - <i>Encephalitozoon cuniculi</i> , <i>Naegleria fowleri</i> , any nematodes producing VLM (Visceral Larva Migrants), cestodes, <i>Taenia solium</i> , <i>Echinococcus</i> species
Duodenal and jejunal aspirates	<i>Cryptosporidium</i> species, <i>Cyclospora cayetanesis</i> , <i>Giardia duodenalis</i> Microsporidia - <i>Enterocytozoon bienewisi</i> , <i>Strongyloides</i> species
Faeces	<i>Ancylostoma duodenale</i> , <i>Ascaris lumbricoides</i> , adult <i>Acaris</i> sp. worms and ova, <i>Balantidium coli</i> , <i>Blastocystis hominis</i> , <i>Paracapillaria philippinensis</i> , <i>Chilomastix mesnili</i> , <i>Cryptosporidium</i> species, <i>Cyclospora cayetanesis</i> , <i>Dientamoeba fragilis</i> , <i>Diphyllobothrium latum</i> , <i>Echinostoma</i> species, <i>Endolimax nana</i> , <i>Entamoeba histolytica</i> , other <i>Entamoeba</i> species, <i>Enteromonas hominis</i> , <i>Fasciola hepatica</i> , <i>Fasciolopsis buski</i> , <i>Giardia duodenalis</i> , <i>Heterophyes heterophyes</i> , <i>Hymenolepis nana</i> , <i>Iodamoeba butschlii</i> , <i>Cystoisospora belli</i> , Microsporidia [<i>Enterocytozoon bienewisi</i> and <i>Encephalitozoon (Septata) intestinalis</i>], <i>Metagonimus yokogawai</i> , <i>Nanophyetes salmincola</i> , <i>Necator americanus</i> , <i>Opisthorchis sinensis</i> , <i>Paragonimus</i> species, <i>Retortomonas intestinalis</i> , <i>Sarcocystis</i> species, <i>Schistosoma</i> species <i>Strongyloides stercoralis</i> , <i>Taenia saginata</i> worms and ova, <i>Taenia solium</i> , <i>Trichuris trichiura</i> , <i>Enterobius</i> species adult worms and ova
Liver and spleen aspirates Hydatid cyst Pus	<i>Entamoeba histolytica</i> , <i>Leishmania</i> species, <i>Echinococcus granulosus</i> , <i>Fasciola hepatica</i>
Sellotape slide	<i>Enterobius vermicularis</i>
Sputum / BAL	<i>Ascaris lumbricoides</i> , <i>Cryptosporidium</i> species, Microsporidia, <i>Paragonimus westermani</i> , <i>Strongyloides stercoralis</i> , <i>Pneumocystis jirovecii</i>
Swabs	<i>Trichomonas vaginalis</i> – genital swab Microsporidia – eye swab
Tissues and biopsies	<i>Acanthamoeba</i> species - brain biopsy, skin nodules and ulcers; <i>Angiostrongylus costaricensis</i> , <i>Anisakis</i> species, <i>Cryptosporidium</i> species – small bowel and liver biopsy; Filarial worms, <i>Giardia duodenalis</i> - duodenal biopsy; <i>Leishmania</i> species - lymph node biopsy, cutaneous ulcers; <i>Anncalia</i> species, <i>Nosema</i> species, <i>Vittaforma corneae</i> , <i>Microsporidium africanum</i> and <i>Microsporidium ceylonensis</i> - Cornea ulcer Microsporidia [<i>Pleistophora</i> , <i>Nosema</i> , <i>Trachipleistophora</i> and <i>Phocanema</i> species], <i>Schistosoma</i> species, <i>Taenia solium</i> , <i>Trichinella</i> and other tissue nematodes - muscle biopsy
Urine	<i>Schistosoma haematobium</i> , Microsporidia

Investigation of specimens other than blood for parasites

Serology testing	<i>Entamoeba histolytica</i> , <i>Acanthamoeba</i> species, Cysticercosis (<i>Taenia solium</i>), <i>Echinococcus granulosus</i> , <i>Fasciola hepatica</i> , <i>Filaria</i> , <i>Cryptosporidium</i> species, <i>Leishmania</i> species, <i>Schistosoma</i> species, <i>Strongyloides stercoralis</i> , <i>Toxocara</i> species, <i>Toxoplasma gondii</i> , <i>Trichinella</i> species, any nematodes producing VLM (Visceral Larva Migrans),
------------------	--

Appendix 2: Geographic distribution of parasitic infections

Infection / Infective organism	Geographic distribution
Amoebiasis/ <i>Entamoeba histolytica</i>	Worldwide
Free-living amoebae - <i>Acanthamoeba</i> , <i>Naegleria</i> sp.	Worldwide
Flagellates:	
Giardiasis, Trichomoniasis	Worldwide
Coccidia:	
Cryptosporidiosis/ <i>Cryptosporidium</i> sp.	Worldwide
Cyclosporiasis/ <i>Cyclospora</i> sp.,	Worldwide particularly high incidence areas such as Mexico, Honduras,
Microsporidia	Worldwide
Cystosporiasis/ <i>Cystoisospora</i> sp.,	Worldwide
Sarcocystosis/ <i>Sarcocystis</i> sp., Toxoplasmosis/ <i>Toxoplasma gondii</i> , <i>Pneumocystis jirovecii</i>	Worldwide
Nematode infections (GI-tract) – <i>Enterobius</i> , <i>Trichuris</i> , <i>Ascaris</i>	Worldwide
Hookworms:	
<i>Ancylostoma duodenale</i>	Europe, S America, India, China, SE Asia, Indonesia, Australia, some Pacific isles
<i>Strongyloides</i> sp.	Tropics and subtropics
<i>Trichostrongylus</i> species	Worldwide
<i>Necator americanus</i>	N and S America, sub-Saharan Africa, India, China, SE Asia, Indonesia, Australia some Pacific isles
Unusual nematodes:	Worldwide
Trichinellosis, Toxocariasis	Asia
Gnathostomiasis (fever and pulmonary infiltrates)	
Gnathostomiasis, <i>Angiostrongylus</i> sp. (myeloencephalitis)	Africa, America, Asia, Australasia
Capillariasis	Africa, America, Asia, Europe
Dracunculiasis	Africa, Asia
Onchocerciasis	Africa, America (central and south), Asia
Trematodes (blood flukes):	Africa, America (central and south), Asia
Schistosomiasis	
Liver flukes:	Worldwide
Fascioliasis	America (south), Asia, Europe
Opisthorchiasis	

Investigation of specimens other than blood for parasites

Intestinal flukes: Fasciolopsiasis	Southern and Eastern Asia
Lung flukes: Paragonimiasis/ <i>Paragonimus</i> species	Far East, Indian subcontinent, Africa, some Pacific Isles
Cestodes (Tapeworms): <i>Diphyllobothrium latum</i>	America (north), Canada, Europe, Japan, Russia, Scandinavia
<i>Hymenolepsis nana</i> , Taeniasis/ <i>Taenia saginata/solium</i> , Cystercercosis/ <i>Taenia solium</i>	Worldwide
Echinococcosis/ <i>Echinococcus</i> sp.	Africa, America, Asia, Europe, Australasia
Sparganosis/ <i>Spirometra mansonoides</i>	America, Asia (particularly China and Japan)
Coenurosis/ <i>Taenia multiceps/serialis</i>	Africa, America, Europe

Appendix 3: Calibrating the microscope for measurement

Calibrating the microscope for measurement

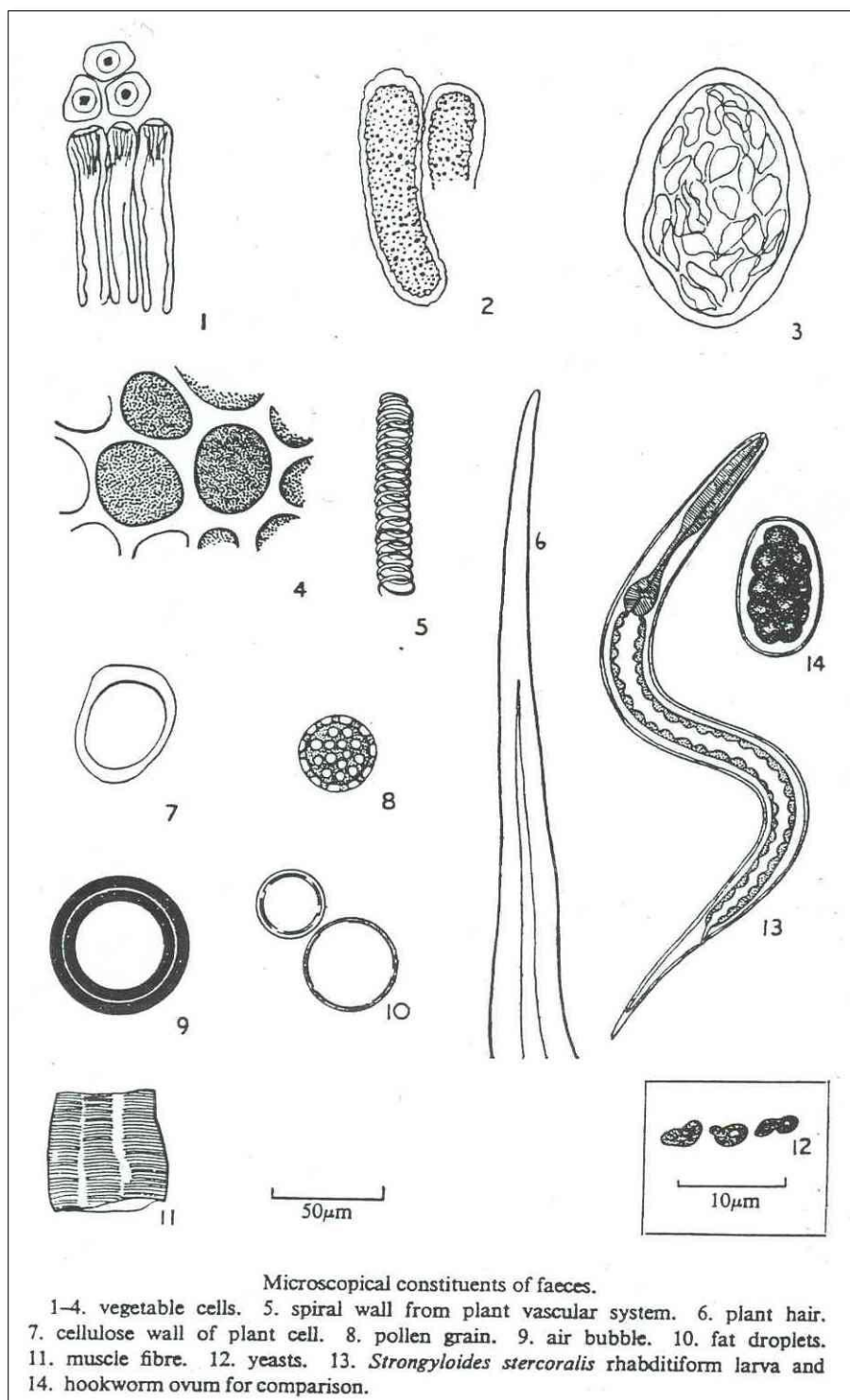
The size of ova and cysts is an important identifying feature of many parasites. Size can be determined with an eyepiece micrometer. The calibration of the microscope is carried out as follows:

Equipment required includes an eyepiece micrometer and a stage micrometer.

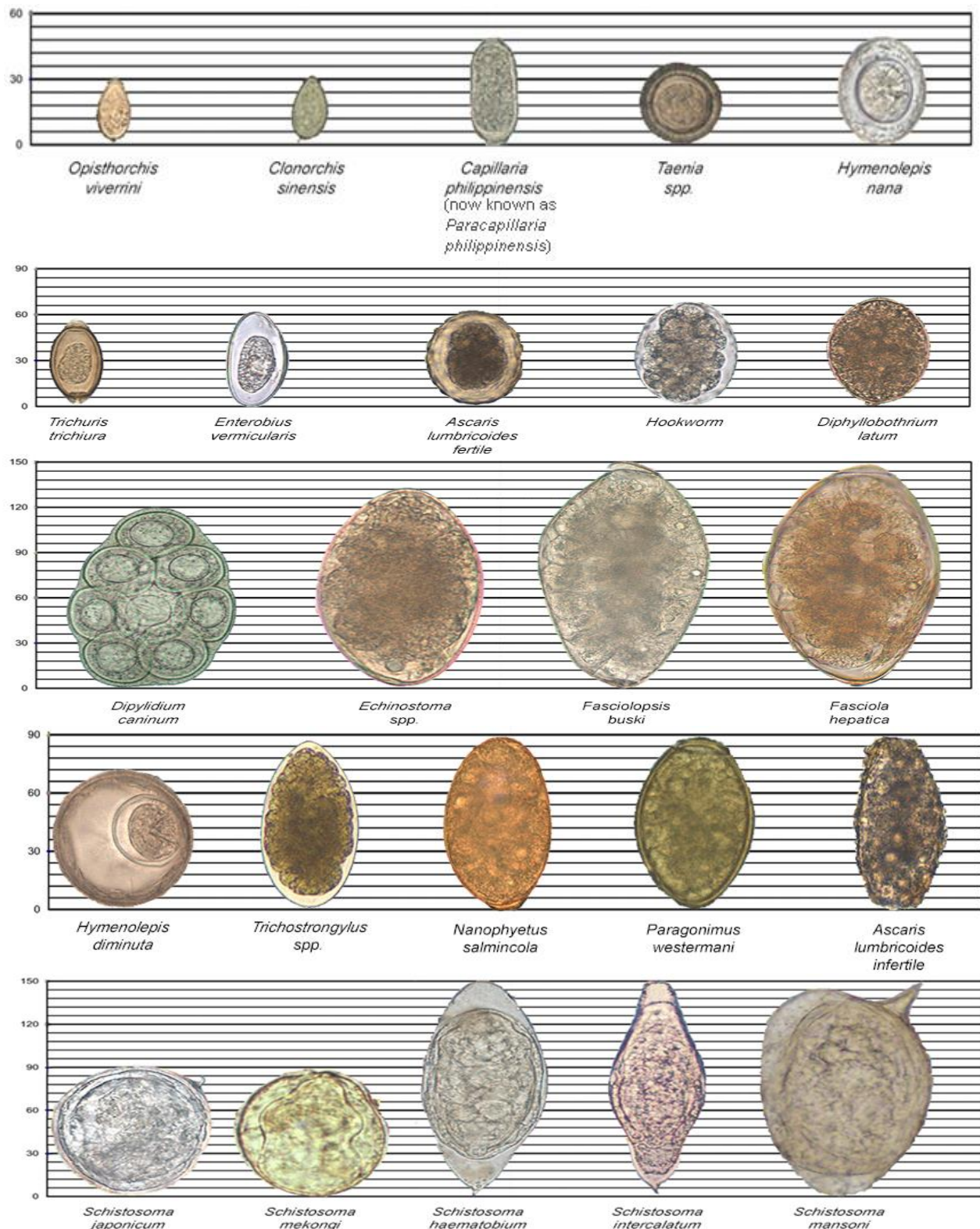
- 1 The eyepiece scale is divided in 100 small divisions.
- 2 The stage micrometer scale extends over 1mm being divided in 0.1mm divisions, each being divided again in 0.01mm divisions.
- 3 Insert the eyepiece graticule to the eyepiece, and replace into the microscope.
- 4 Place the stage micrometer on the microscope stage.
- 5 Focus the low-power objective on the stage scale.
- 6 Adjust the eyepiece and stage scales until they are parallel and overlap.
- 7 Note the number of eyepiece divisions and its corresponding stage measurement, for example, 10 eyepiece divisions = 0.20mm on the stage scale.
- 8 Calculate value of one eyepiece division as follows:
 $10 \text{ eyepiece divisions} = 0.20$
 $1 \text{ eyepiece division} = 0.20/10 = 0.020\text{mm} = 20\mu\text{m}$
Note: To convert the calculated value (0.020mm) above to μm , it should be multiplied by 1000 $\mu\text{m}/\text{mm}$ to give 20 μm
- 9 Repeat from step 5 with each objective, noting and recording the reading from each.
- 10 Calibration need only be done once for each microscope, and its objectives and eyepieces.

Courtesy of UK NEQAS Parasitology Teaching Programme 2003/2004; Faecal Parasites. Co-ordinated by Hilary Edwards.

Appendix 4: Common microscopic constituents of faeces¹¹⁰



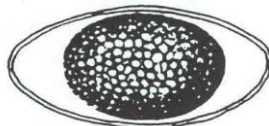
Appendix 5: Relative sizes of helminth eggs*



*Measurements in micrometres (µm)

Appendix 6: Oocysts of coccidia/ cryptogregarina/ microsporidia

*Cystoisospora belli*¹



Immature oocyst

(32 x 16µm)



Mature oocyst

Oocysts are transparent. Reduced illumination is recommended. Modified Ziehl-Neelsen can be used for direct smears

Cryptosporidium species

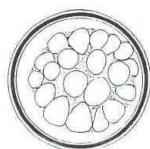


Oocyst

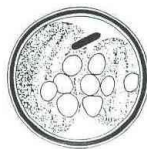
5µm

Auramine-phenol and modified Ziehl-Neelsen stains are recommended

Cyclospora species (CLB)



unsporulated



sporulated

8 – 10µm

In an unstained wet preparation, a central morula contains several refractile spheres. In fresh water, the morula divides into 2 smaller structures.

Cyclospora cayentanesis can be seen in formol-ether concentrations as refractile spheres which do not stain with iodine or auramine-phenol stain but are variably acid-fast, staining pink or not at all with modified Ziehl-Neelsen stain. It will auto-fluoresce blue at 340 – 360 nm

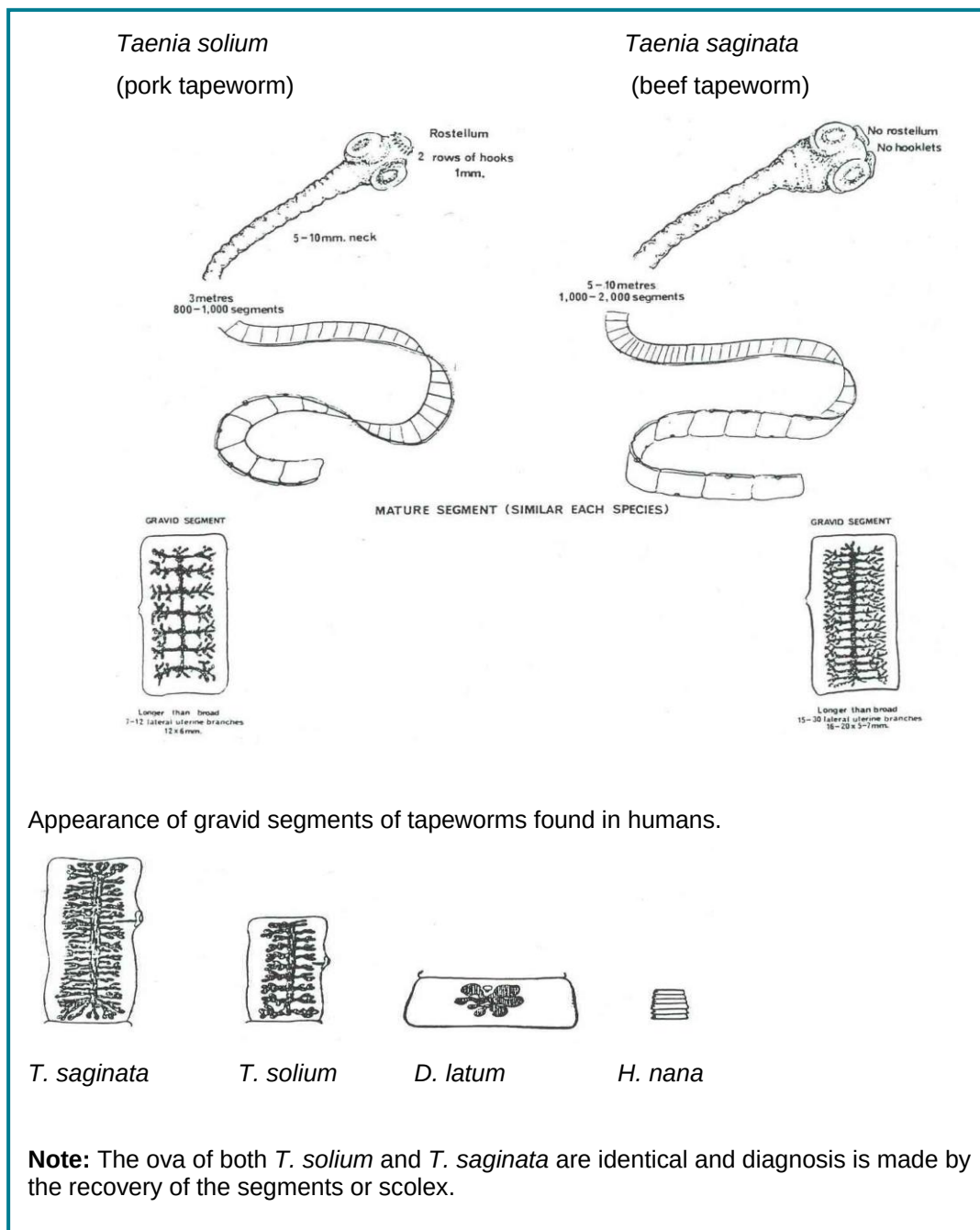
Microsporidia species



1-4µm depending on the species

Although microsporidia may appear acid-fast when stained with modified Ziehl-Neelsen, the trichrome stain is recommended. Microsporidian spores are ovoid and refractile and the spore wall stains bright pink-red. Occasionally the spores stain with a red 'belt' across the centre of the spore, or show polar granules, which are both diagnostic features

Appendix 7: Comparison of tapeworms commonly found in humans¹¹¹

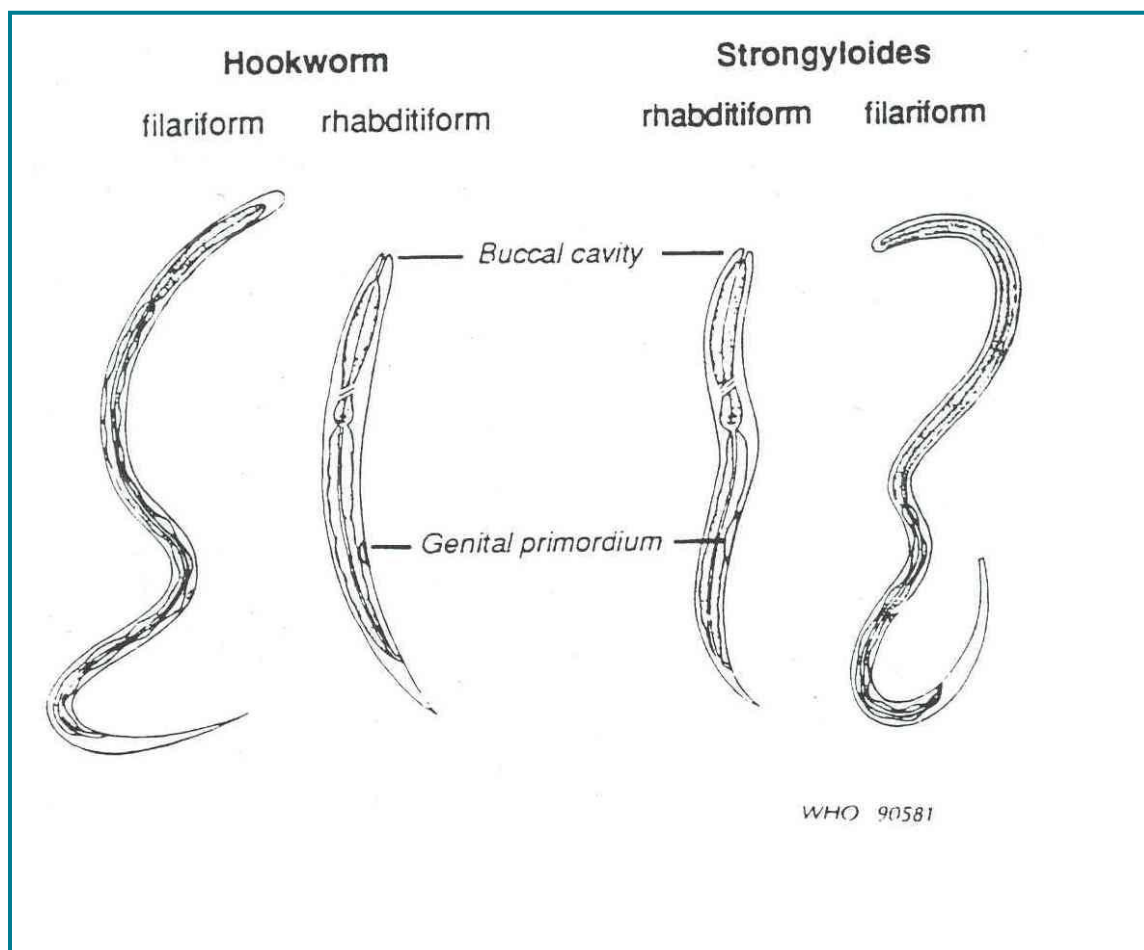


Appendix 8: Helminth larvae – characteristics¹¹²

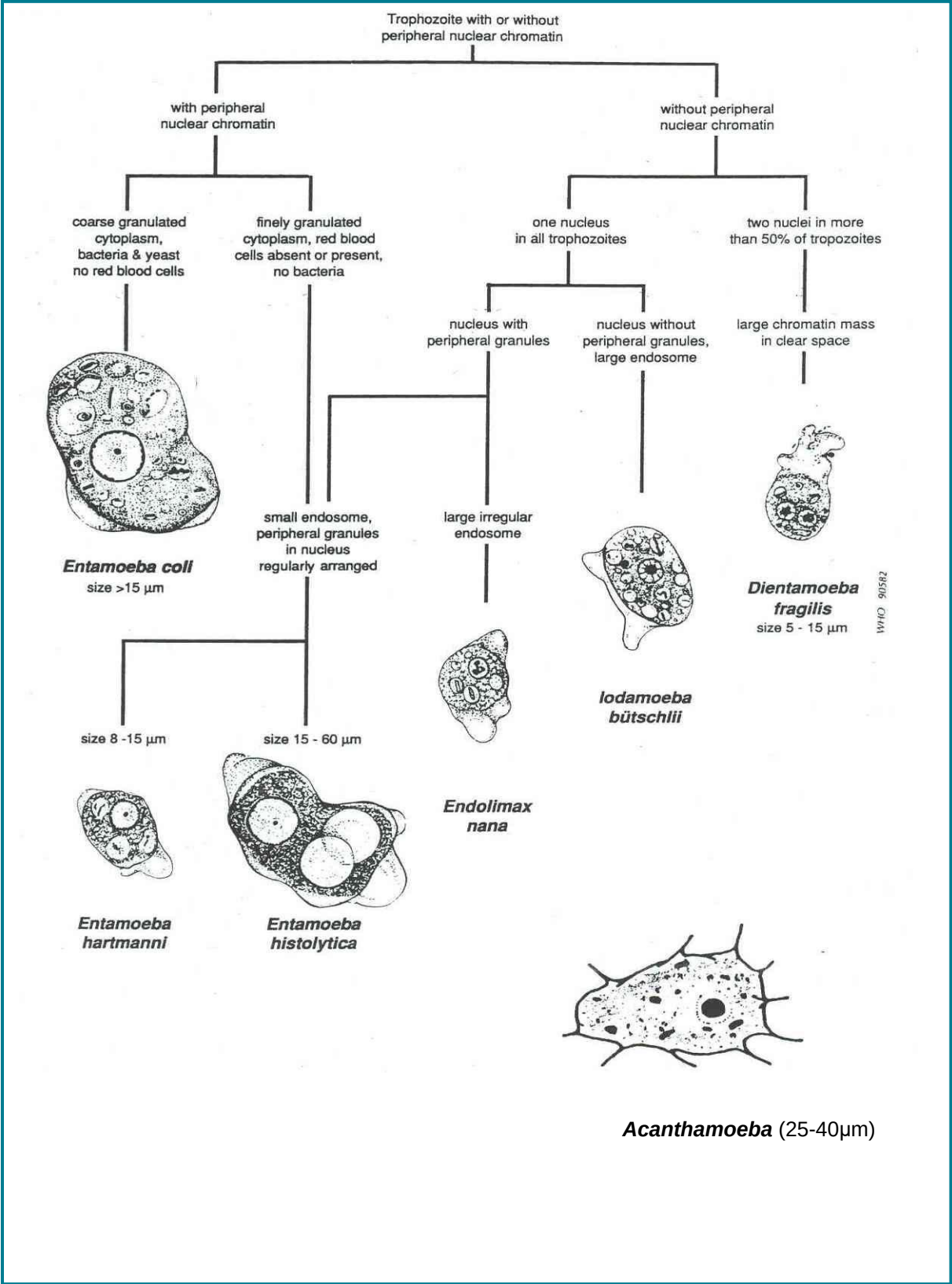
Hookworm <i>Filariform larvae</i> Size 500 x 14-20 µm Sheathed Tapered tail Oesophagus one-third of body length <i>Rhabditiform larvae</i> Size 100 - 150 x 15-17µm Long buccal cavity – 15µm Oesophagus one-third of body length with two swellings Genital primordium small – 7µm Anal pore 80µm from posterior end	<i>Strongyloides</i> <i>Filariform larvae</i> Size 500 x 14-20µm Unsheathed Blunt or forked tail Oesophagus half of body length <i>Rhabditiform larvae</i> Size 200 - 300 x 15-18µm Short buccal cavity – 4µm Oesophagus one-third of body length with two swellings Genital primordium large – 22µm Anal pore 50µm from posterior end
---	--

In fresh stool specimens, the most likely larvae to be seen are rhabditiform larvae of *Strongyloides stercoralis*. If the stool is >12 hours old, the larvae may develop into filariform larvae which must be differentiated from hookworm larvae (these may appear in the stool within 12–24hr).

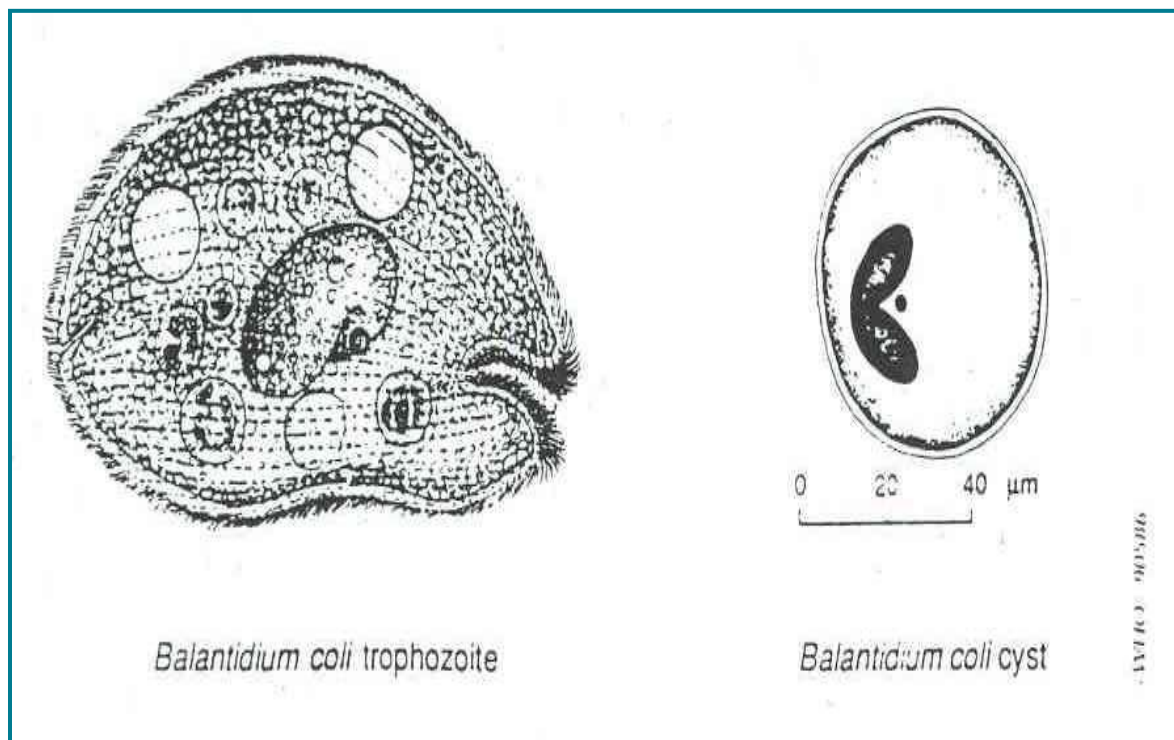
Helminth larvae



Appendix 9: Identification of *amoebic trophozoites* in stained smears¹



Appendix 10: *Balantidium coli* - trophozoite and cyst¹

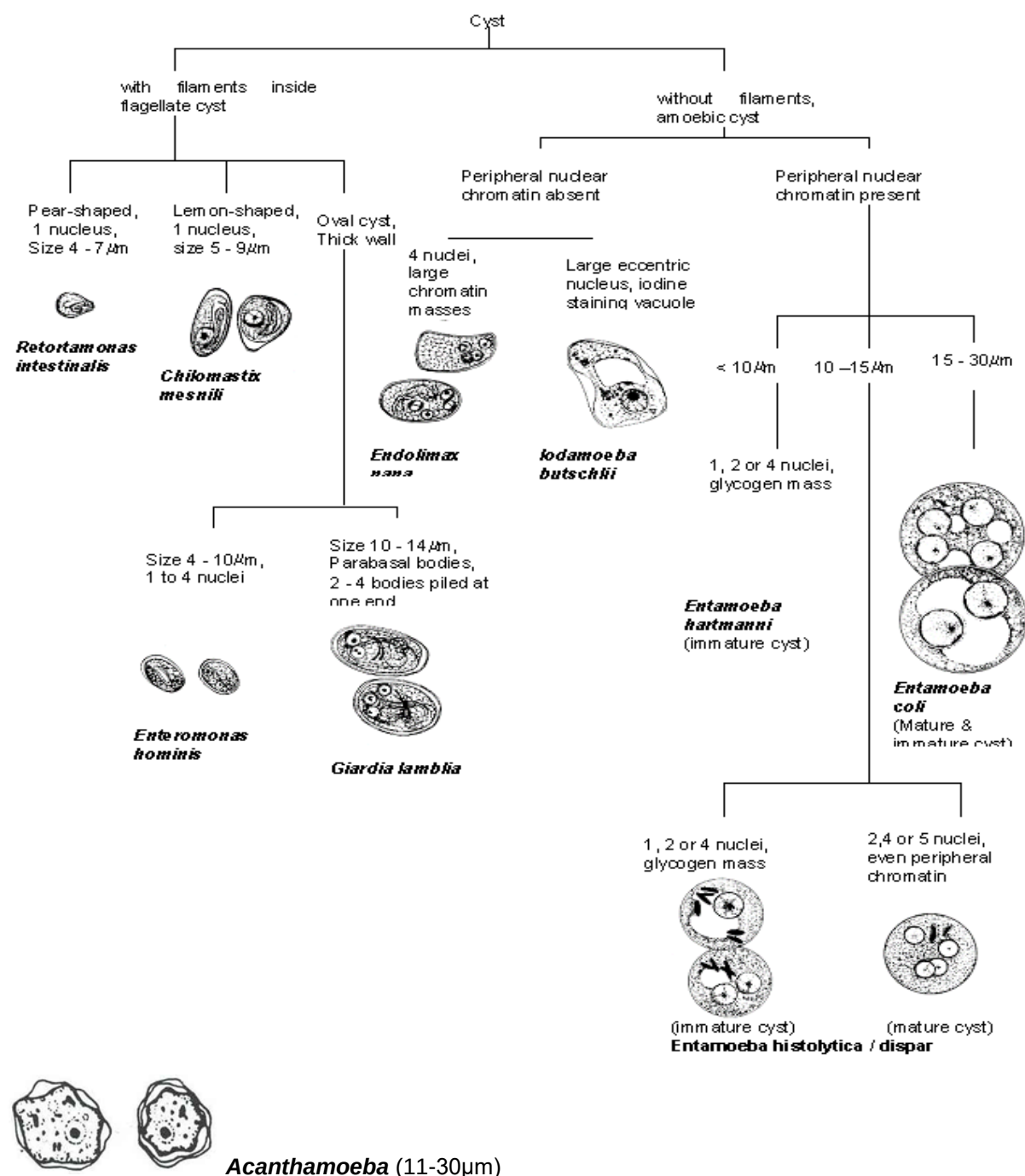


The characteristics between the *Balantidium coli* Trophozoite and *Balantidium coli* cyst

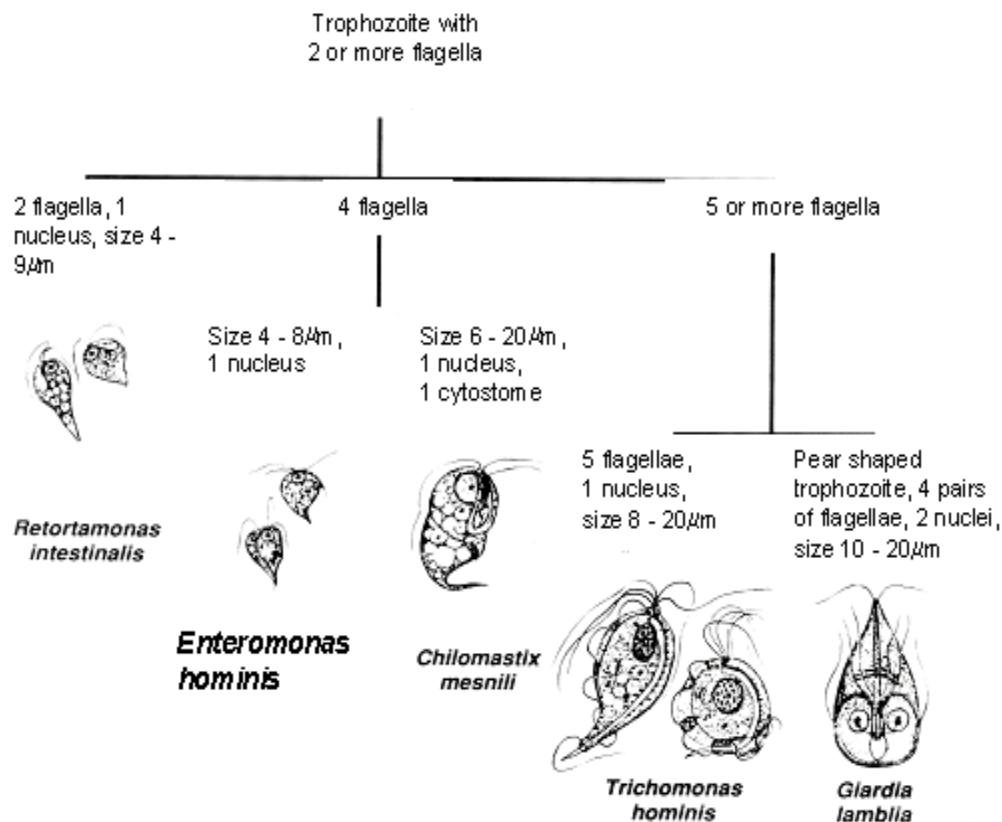
Trophozoite	Cyst
Oval and covered in short cilia measure approximately 30-150µm in length x 25-120µm in width but may attain lengths of up to 200µm A funnel shaped cytosome can be seen near the anterior end Micronucleus and macronucleus may be observed in stained preparations	Spherical or ellipsoidal Measures from 30-200µm by 20-120µm Contains 1 macronucleus and 1 micronucleus Presence of cilia in young cysts but disappear after prolonged encystment

Note: Wet preparations of fresh and concentrated stool samples reveal the characteristic cysts and motile trophozoites. They are easier to identify in direct-smear saline preparations than permanently stained faecal smears.

Appendix 11: Identification of amoebic and flagellate cysts

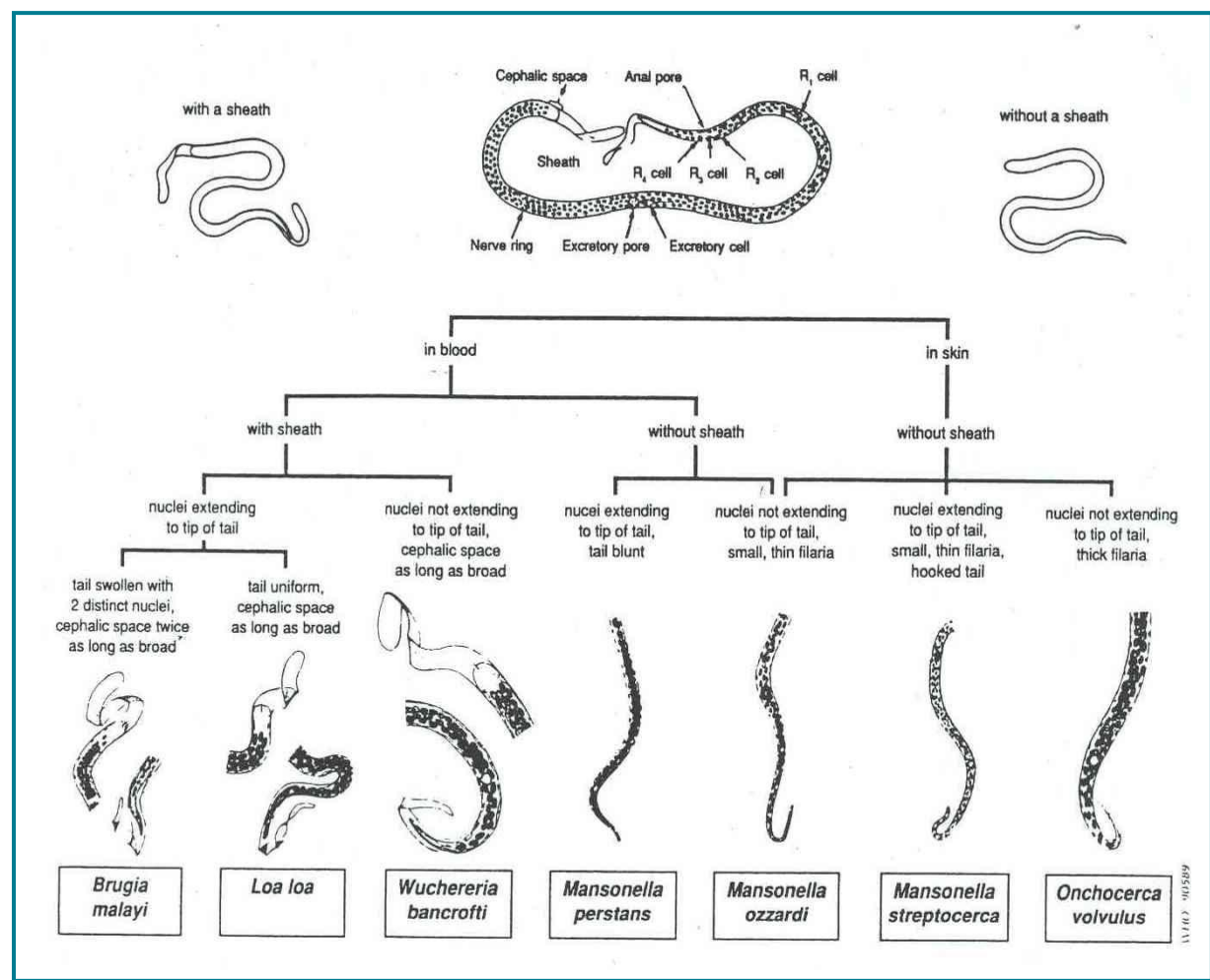


Appendix 12: Identification of flagellate trophozoites¹



Note: It should be noted that *Trichomonas hominis* does not have a cyst stage.
(Adapted and redrawn, WHO, 1991)

Appendix 13: Microfilariae found in humans¹



References

An explanation of the reference assessment used is available in the [scientific information section on the UK SMI website](#).

1. World Health Organization Basic laboratory methods in medical parasitology, pages 77-78. Geneva: World Health Organization; 1991. **B, V**
2. Fletcher SM, Stark D, Harkness J, Ellis J. Enteric protozoa in the developed world: a public health perspective. Clinical Microbiology Reviews 2012;25:420-49. **B, III**
3. Efunshile MA, Ngwu BA, Kurtzhals JA, Sahar S, Konig B, Stensvold CR. Molecular Detection of the Carriage Rate of Four Intestinal Protozoa with Real-Time Polymerase Chain Reaction: Possible Overdiagnosis of Entamoeba histolytica in Nigeria. The American journal of tropical medicine and hygiene 2015;93:257-62. **B, I**
4. Tanyuksel M, Petri WA. Laboratory diagnosis of amebiasis. Clinical Microbiology Reviews 2003;16:713-29. **B, III**
5. Fotadar R, Stark D, Beebe N, Marriott D, Ellis J, Harkness J. Laboratory diagnostic techniques for entamoeba species. Clinical Microbiology Reviews 2007;20:511-32. **B, III**
6. Visvesvara GS, Moura H, Schuster FL. Pathogenic and opportunistic free-living amoebae: Acanthamoeba spp., Balamuthia mandrillaris, Naegleria fowleri, and Sappinia diploidea. FEMS ImmunolMedMicrobiol 2007;50:1-26. **B, III**
7. Plutzer J, Ongerth J, Karanis P. Giardia taxonomy, phylogeny and epidemiology: Facts and open questions. IntJHygEnvironHealth 2010;213:321-33. **B, III**
8. Gotfred-Rasmussen H, Lund M, Enemark HL, Erlandsen M, Petersen E. Comparison of sensitivity and specificity of 4 methods for detection of Giardia duodenalis in feces: immunofluorescence and PCR are superior to microscopy of concentrated iodine-stained samples. Diagnostic microbiology and infectious disease 2016;84:187-90. **B, II**
9. Ellam H, Verlander NQ, Lamden K, Cheesbrough JS, Durband CA, James S. Surveillance of giardiasis in Northwest England 1996-2006: impact of an enzyme immunoassay test. Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin 2008;13. **B, II**
10. Van den Bossche D, Cnops L, Verschueren J, Van Esbroeck M. Comparison of four rapid diagnostic tests, ELISA, microscopy and PCR for the detection of Giardia lamblia, Cryptosporidium spp. and Entamoeba histolytica in feces. Journal of microbiological methods 2015;110:78-84. **B, II**

11. Minetti C CR, Beeching NJ, Probert C, Lamden K. . Giardiasis. BMJ 2016. **B, III**
12. Barratt JL, Harkness J, Marriott D, Ellis JT, Stark D. A review of *Dientamoeba fragilis* carriage in humans: several reasons why this organism should be considered in the diagnosis of gastrointestinal illness. Gut Microbes 2011;2:3-12. **B, III**
13. Ackers JP. Trichomonads. In: Gillespie SH, Hawkey PM, editors. Medical Parasitology - A Practical Approach. Oxford: Oxford University Press; 1995. p. 137. **B, VI**
14. Hobbs MM, Sena, A. C. Modern diagnosis of *Trichomonas vaginalis* infection. Sexually transmitted infections 2013;89:434-8. **B, III**
15. Association of Public Health Laboratories. Advances in Laboratory Detection of *Trichomonas vaginalis*. APHL. 1-5. 2013. **B, III**
16. Public Health Laboratory Service. Outbreak of cyclospora infection in North America. Commun Dis Rep CDR Wkly 1996;6:223, 6. **B, III**
17. Lopez AS, Bendik JM, Alliance JY, Roberts JM, da Silva AJ, Moura IN et al. Epidemiology of *Cyclospora cayetanensis* and other intestinal parasites in a community in Haiti. JClinMicrobiol 2003;41:2047-54. **B, II**
18. Nichols GL, Freedman J, Pollock KG, Rumble C, Chalmers RM, Chiodini P et al. Cyclospora infection linked to travel to Mexico, June to September 2015. Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin 2015;20. **B, III**
19. Doller PC, Dietrich K, Filipp N, Brockmann S, Dreweck C, Vonthein R et al. Cyclosporiasis outbreak in Germany associated with the consumption of salad. EmergInfectDis 2002;8:992-4. **B, II**
20. Insulander M, Svenungsson B, Lebbad M, Karlsson L, de Jong B. A foodborne outbreak of *Cyclospora* infection in Stockholm, Sweden. FoodbornePathogDis 2010;7:1585-7. **B, II**
21. Ortega YR, Sterling CR, Gilman RH, Cama VA, Diaz F. *Cyclospora* species--a new protozoan pathogen of humans. N EnglJ Med 1993;328:1308-12. **B, II**
22. Navaneethan U, Venkatesh PG, Downs-Kelly E, Shen B. *Isospora belli* superinfection in a patient with eosinophilic gastroenteritis--a diagnostic challenge. Journal of Crohn's & colitis 2012;6:236-9. **B, III**
23. Ud Din N, Torka P, Hutchison RE, Riddell SW, Wright J, Gajra A. Severe *Isospora* (*Cystoisospora*) *belli* Diarrhea Preceding the Diagnosis of Human T-Cell-Leukemia-Virus-1-Associated T-Cell Lymphoma. Case reports in infectious diseases 2012;2012:640104. **B, III**

24. ten Hove RJ, van Lieshout L, Brienen EA, Perez MA, Verweij JJ. Real-time polymerase chain reaction for detection of *Isospora belli* in stool samples. *Diagnostic microbiology and infectious disease* 2008;61:280-3. **B, II**
25. Desoubeaux G, Cabanne E, Franck-Martel C, Gombert M, Gyan E, Lissandre S et al. Pulmonary toxoplasmosis in immunocompromised patients with interstitial pneumonia: a single-centre prospective study assessing PCR-based diagnosis. *J Clin Pathol* 2016. **B, II**
26. Cavalier-Smith T. Gregarine site-heterogeneous 18S rDNA trees, revision of gregarine higher classification, and the evolutionary diversification of Sporozoa. *European journal of protistology* 2014;50:472-95. **B, III**
27. Casemore DP. *Cryptosporidium* and other protozoan parasites and the water route of infection. *Health and Hygiene* 1991;12:78-83. **B, III**
28. Chalmers RM, Atchison C, Barlow K, Young Y, Roche A, Manuel R. An audit of the laboratory diagnosis of cryptosporidiosis in England and Wales. *Journal of medical microbiology* 2015;64:688-93. **B, II**
29. Omoruyi BE, Nwodo UU, Udem CS, Okonkwo FO. Comparative diagnostic techniques for cryptosporidium infection. *Molecules* 2014;19:2674-83. **B, II**
30. Chalmers RM, Campbell BM, Crouch N, Charlett A, Davies AP. Comparison of diagnostic sensitivity and specificity of seven *Cryptosporidium* assays used in the UK. *JMedMicrobiol* 2011;60:1598-604. **B, II**
31. Chalmers RM, Campbell B, Crouch N, Davies AP. Clinical laboratory practices for detection and reporting of *Cryptosporidium* in community cases of diarrhoea in the United Kingdom, 2008. *EuroSurveill* 2010;15. **B, II**
32. Tan KS. New insights on classification, identification, and clinical relevance of *Blastocystis* spp. *ClinMicrobiolRev* 2008;21:639-65. **B, III**
33. Stenzel DJ, Boreham PF. *Blastocystis hominis* revisited. *ClinMicrobiolRev* 1996;9:563-84. **B, III**
34. Windsor JJ, Bamber AI, Macfarlane L. Detection of *Dientamoeba fragilis* and *Blastocystis hominis* using a simple staining method. *BrJBiomedSci* 2006;63:27-8. **C, II**
35. Coyle CM, Varughese J, Weiss LM, Tanowitz HB. *Blastocystis*: to treat or not to treat. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America* 2012;54:105-10. **B, II**
36. Franzen C, Muller A. Microsporidiosis: human diseases and diagnosis. *MicrobesInfect* 2001;3:389-400. **B, III**

37. Capella-Gutierrez S, Marcet-Houben M, Gabaldon T. Phylogenomics supports microsporidia as the earliest diverging clade of sequenced fungi. *BMC Biol* 2012;10:47. **B, III**
38. Aspöck H, Hassl A. Parasitic infections in HIV patients in Austria: first results of a long-term study. *Zentralbl Bakteriol* 1990;272:540-6. **B, II**
39. Cegielski JP, Msengi AE, Dukes CS, Mbise R, Redding-Lallinger R, Minjas JN et al. Intestinal parasites and HIV infection in Tanzanian children with chronic diarrhea. *AIDS* 1993;7:213-21. **B, II**
40. Stringer JR, Beard CB, Miller RF. Spelling *Pneumocystis jirovecii*. *Emerg Infect Dis* 2009;15:506. **A, VI**
41. Stringer JR, Beard CB, Miller RF, Wakefield AE. A new name (*Pneumocystis jirovecii*) for *Pneumocystis* from humans. *Emerg Infect Dis* 2002;8:891-6. **B, III**
42. Neva FA, Brown, H.W.,. *Intestinal Nematodes of Human Beings*. Basic Clinical Parasitology. 6th ed. London: Prentice Hall International; 1994. p. 113-51. **B, VI**
43. Durand-Joly I, Chabe M, Soula F, Delhaes L, Camus D, Dei-Cas E. Molecular diagnosis of *Pneumocystis pneumonia*. *FEMS immunology and medical microbiology* 2005;45:405-10. **B, III**
44. Lu JJ, Chen CH, Bartlett MS, Smith JW, Lee CH. Comparison of six different PCR methods for detection of *Pneumocystis carinii*. *Journal of clinical microbiology* 1995;33:2785-8. **B, II**
45. Leonidas DD, Elbert BL, Zhou Z, Leffler H, Ackerman SJ, Acharya KR. Crystal structure of human Charcot-Leyden crystal protein, an eosinophil lysophospholipase, identifies it as a new member of the carbohydrate-binding family of galectins. *Structure* 1995;3:1379-93. **B, III**
46. Kupper T, Spies S, Wehle K, Pfitzer P. Detection of Charcot-Leyden crystals by fluorescence microscopy of Papanicolaou-stained smears of sputum, bronchoalveolar lavage fluid, and bronchial secretions. *Cytopathology* 1994;5:262-9. **B, II**
47. Wolfe MS. Eosinophilia in the returning traveler. *Infect Dis Clin North Am* 1992;6:489-502. **B, III**
48. Mahmoud AA. Intestinal nematodes (roundworms). In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 5th ed. Vol 2. Edinburgh: Churchill Livingstone; 2000. p. 2938-43. **B, VI**
49. Phosuk I, Intapan PM, Prasongdee TK, Changtrakul Y, Sanpool O, Janwan P et al. Human Trichostrongyliasis: A Hospital Case Series. *The Southeast Asian journal of tropical medicine and public health* 2015;46:191-7. **B, III**

50. Medical Parasitology. Pennsylvania: WB Saunders & Co. Ltd.; 1986. **B, VI**
51. Repetto SA, Ruybal P, Solana ME, Lopez C, Berini CA, Alba Soto CD et al. Comparison between PCR and larvae visualization methods for diagnosis of *Strongyloides stercoralis* out of endemic area: A proposed algorithm. *Acta tropica* 2016;157:169-77. **B, II**
52. Grove DI. Tissue nematodes (trichinosis, dracunculiasis, filariasis). In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 5th ed.Vol 2. Edinburgh: Churchill Livingstone; 2000. p. 2943-50. **B, VI**
53. Nash TE. Visceral larva migrans and other unusual helminth infections. In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*. 5th ed.Vol 2. Edinburgh: Churchill Livingstone; 2000. p. 2965-70. **B, VI**
54. Neafie RC, Marty AM. Unusual infections in humans. *ClinMicrobiolRev* 1993;6:34-56. **B, III**
55. Moravec F. Redescription and systematic status of *Capillaria philippinensis*, an intestinal parasite of human beings. *The Journal of parasitology* 2001;87:161-4. **B, II**
56. Saichua P, Nithikathkul C, Kaewpitoon N. Human intestinal capillariasis in Thailand. *World journal of gastroenterology* 2008;14:506-10. **B, III**
57. El-Dib NA, El-Badry AA, Ta-Tang TH, Rubio JM. Molecular detection of *Capillaria philippinensis*: An emerging zoonosis in Egypt. *Experimental parasitology* 2015;154:127-33. **B, II**
58. Lloyd MM, Gilbert R, Taha NT, Weil GJ, Meite A, Kouakou IM et al. Conventional parasitology and DNA-based diagnostic methods for onchocerciasis elimination programmes. *Acta tropica* 2015;146:114-8. **B, II**
59. Keiser J, Utzinger J. Food-borne trematodiases. *ClinMicrobiolRev* 2009;22:466-83. **B, III**
60. Mahmoud AA. Trematodes (schistosomiasis) and other flukes. In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell, Douglas and Bennett's Principles and Practice of Infectious Diseases*. 5th ed.Vol 2. Edinburgh: Churchill Livingstone; 2000. p. 2950-6. **B, VI**
61. Beltrame A, Zammarchi L, Zuglian G, Gobbi F, Angheben A, Marchese V et al. Schistosomiasis Screening of Travelers to Corsica, France. *Emerging infectious diseases* 2016;22:159-60. **B, VI**
62. Van Meensel B, Van Wijngaerden E, Verhaegen J, Peetermans WE, Lontie ML, Ripert C. Laboratory diagnosis of schistosomiasis and Katayama syndrome in returning travellers. *Acta clinica Belgica* 2014;69:267-72. **B, III**

63. Hong ST, Fang Y. Clonorchis sinensis and clonorchiasis, an update. Parasitology international 2012;61:17-24. **B, III**
64. Centers for Disease Control and Prevention. Parasites - Paragonimiasis (also known as Paragonimus Infection) Centers for Disease Control and Prevention. 2013. **B, VI**
65. King CH. Cestodes (tapeworms). In: Mandell GL, Bennett JE, Dolin R, editors. Mandell, Douglas and Bennett's Principles and Practice of Infectious Diseases. 5th ed. Vol 2. Edinburgh: Churchill Livingstone; 2000. p. 2956-65. **B, VI**
66. Del Brutto OH. Neurocysticercosis: a review. ScientificWorldJournal 2012;2012:159821. **B, III**
67. European Parliament. UK Standards for Microbiology Investigations (UK SMIs) use the term "CE marked leak proof container" to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: "The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes". 1998.
68. Official Journal of the European Communities. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on *in vitro* diagnostic medical devices 1998. 1-37.
69. Becker SL, Vogt J, Knopp S, Panning M, Warhurst DC, Polman K et al. Persistent digestive disorders in the tropics: causative infectious pathogens and reference diagnostic tests. BMC Infect Dis 2013;13:37. **B, III**
70. Centers for Disease Control and Prevention. Laboratory Identification of Parasitic Diseases of Public Health Concern - specimen collection. Centers for Disease Control and Prevention. 2013. **B, VI**
71. Health and Safety Executive. Safe use of pneumatic air tube transport systems for pathology specimens. 2009.
72. Department for transport. Transport of Infectious Substances, 2011 Revision 5. 2011.
73. World Health Organization. Guidance on regulations for the Transport of Infectious Substances 2013-2014. 2012.
74. Home Office. Anti-terrorism, Crime and Security Act. 2001.
75. Advisory Committee on Dangerous Pathogens. The Approved List of Biological Agents. Health and Safety Executive 2013. 1-32.

76. Advisory Committee on Dangerous Pathogens. Infections at work: Controlling the risks. Her Majesty's Stationery Office 2003.
77. Advisory Committee on Dangerous Pathogens. Biological agents: Managing the risks in laboratories and healthcare premises. Health and Safety Executive 2005.
78. Advisory Committee on Dangerous Pathogens. Biological Agents: Managing the Risks in Laboratories and Healthcare Premises. Appendix 1.2 Transport of Infectious Substances - Revision. Health and Safety Executive 2008.
79. Centers for Disease Control and Prevention. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. MMWR Surveill Summ 2012;61:1-102.
80. Health and Safety Executive. Control of Substances Hazardous to Health Regulations. The Control of Substances Hazardous to Health Regulations 2002. 5th ed.: HSE Books,; 2002.
81. Health and Safety Executive. Five Steps to Risk Assessment: A Step by Step Guide to a Safer and Healthier Workplace. HSE Books, . 2002.
82. Health and Safety Executive. A Guide to Risk Assessment Requirements: Common Provisions in Health and Safety Law. HSE Books, . 2002.
83. Health Services Advisory Committee. Safe Working and the Prevention of Infection in Clinical Laboratories and Similar Facilities. HSE Books 2003.
84. British Standards Institution (BSI). BS EN12469 - Biotechnology - performance criteria for microbiological safety cabinets 2000.
85. British Standards Institution (BSI). BS 5726:2005 - Microbiological safety cabinets. Information to be supplied by the purchaser and to the vendor and to the installer, and siting and use of cabinets. Recommendations and guidance. 2005. 1-14.
86. Warhurst DC. Diagnosis of amoebic infection. In: Gillespie SH, Hawkey PM, editors. Medical Parasitology - A Practical Approach. Oxford: Oxford University Press; 1995. p. 129. **B, VI**
87. Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB, Jr. et al. A Guide to Utilization of the Microbiology Laboratory for Diagnosis of Infectious Diseases: 2013 Recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM). ClinInfectDis 2013;57:e22-e121.
88. Garcia LS. Acceptable fecal specimens for ova and parasite examinations. Clin Microbiol Newslett 1989;11:153-5. **B, VI**

89. Centers for Disease Control and Prevention. Laboratory Identification of Parasitic Diseases of Public Health Concern - Diagnostic Procedure. Centers for Disease Control and Prevention,. 2013. **B, VI**
90. World Health Organization Basic laboratory methods in medical parasitology, page 33-36. Geneva: World Health Organization; 1991. **B, VI**
91. Marshall I. Schistosomiasis. In: Gillespie SH, Hawkey PM, editors. Medical Parasitology - A Practical Approach. Oxford: Oxford University Press; 1995. p. 195. **B, VI**
92. The Royal College of Pathologists. The retention and storage of pathological records and specimens (5th edition). 1-59. 2015.
93. Smith HV. Intestinal protozoa. In: Gillespie SH, Hawkey PM, editors. Medical Parasitology - A Practical Approach. Oxford: Oxford University Press; 1995. p. 96. **B, VI**
94. Casemore DP, Roberts C. Guidelines for screening for *Cryptosporidium* in stools: report of a joint working group. J Clin Pathol 1993;46:2-4. **A, V**
95. World Health Organization Basic laboratory methods in medical parasitology, page 18. Geneva: World Health Organization; 1991. **B, V**
96. Allen AV, Ridley DS. Further observations on the formol-ether concentration technique for faecal parasites. J Clin Pathol 1970;23:545-6. **A, V**
97. Uga S, Tanaka K, Iwamoto N. Evaluation and modification of the formalin-ether sedimentation technique. Trop Biomed 2010;27:177-84. **B, II**
98. Anamnart W, Pattanawongsa A, Intapan PM, Maleewong W. Factors affecting recovery of *Strongyloides stercoralis* larvae: an approach to a newly modified formalin-ether concentration technique for diagnosis of strongyloidiasis. J Clin Microbiol 2010;48:97-100. **B, II**
99. Perry JL, Matthews JS, Miller GR. Parasite detection efficiencies of five stool concentration systems. J Clin Microbiol 1990;28:1094-7. **B, II**
100. Becker SL, Lohourignon LK, Speich B, Rinaldi L, Knopp S, N'goran EK et al. Comparison of the Flotac-400 dual technique and the formalin-ether concentration technique for diagnosis of human intestinal protozoon infection. J Clin Microbiol 2011;49:2183-90. **B, I**
101. Saez AC, Manser MM, Andrews N, Chiodini PL. Comparison between the Midi Parasep and Midi Parasep Solvent Free (SF) faecal parasite concentrators. J Clin Pathol 2011;64:901-4. **B, II**
102. Manser MM, Saez AC, Chiodini PL. Faecal Parasitology: Concentration Methodology Needs to be Better Standardised. PLoS neglected tropical diseases 2016;10:e0004579. **B, II**

103. Garcia LS. Parasitology. In: Isenberg HD, editor. Clinical Microbiology Procedures Handbook Vol 1. Washington D.C.: American Society for Microbiology; 1992. p. 7.1.-7.10.8.2. **B, VI**
104. Public Health England. Laboratory Reporting to Public Health England: A Guide for Diagnostic Laboratories 2013. 1-37.
105. Department of Health. Health Protection Legislation (England) Guidance. 1-112. 2010.
106. Scottish Government. Public Health (Scotland) Act. 2008.
107. Scottish Government. Public Health etc. (Scotland) Act 2008. Implementation of Part 2: Notifiable Diseases, Organisms and Health Risk States. 2009.
108. The Welsh Assembly Government. Health Protection Legislation (Wales) Guidance. 2010.
109. Home Office. Public Health Act (Northern Ireland) 1967 Chapter 36. 1967.
110. Guide to Human Parasitology for Medical Practitioners. London: HK Lewis & Co. Ltd.; 1977. **B, VI**
111. Atlas of Medical Helminthology and Protozoology. Edinburgh: Churchill Livingstone; 1975. **B, VI**
112. World Health Organization Basic laboratory methods in medical parasitology, pages 70. Geneva: World Health Organization; 1991. **B, VI**