Applied Medical Parasitology

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Second Year
2018/2019
Acknowledgments

This two-year curriculum was developed through a participatory and collaborative approach between the Academic faculty staff affiliated to Egyptian Universities as Alexandria University, Ain Shams University, Cairo University, Mansoura University, Al-Azhar University, Tanta University, Beni Souef University, Port Said University, Suez Canal University and MTI University and the Ministry of Health and Population (General Directorate of Technical Health Education (THE). The design of this course draws on rich discussions through workshops. The outcome of the workshop was course specification with Indented learning outcomes and the course contents, which served as a guide to the initial design.

We would like to thank Prof. Sabah Al-Sharkawi the General Coordinator of General Directorate of Technical Health Education, Dr. Azza Dosoky the Head of Central Administration of HR Development, Dr. Seada Farghly the General Director of THE and all share persons working at General Administration of the THE for their time and critical feedback during the development of this course.

Special thanks to the Minister of Health and Population Dr. Hala Zayed and Former Minister of Health Dr. Ahmed Emad Edin Rady for their decision to recognize and professionalize health education by issuing a decree to develop and strengthen the technical health education curriculum for pre-service training within the technical health institutes.
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The main aim of medical Parasitology course is to provide the student with knowledge, comprehension and methods of application of medical Parasitology in practical life.

### ILOs

1. Describe the morphological characteristics, life cycles, methods of transmission of medically important helminths.
2. Mention the morphological characteristics, life cycles, methods of transmission of medically important Protozoa.
3. Discuss clinical picture associated with parasitic infections.
4. List the different diagnostic techniques for detecting parasites.
5. Outline the plan of treatment of each parasitic disease.

1. Interpret different clinical presentations and correlate them to suspected parasites.
2. Differentiate and compare similar stages of different parasites.
3. Choose the most suitable diagnostic technique for each parasitic problem.

### 1. Use the light microscopy
2. Examine mounted slides and identify different parasites
3. Examine laboratory specimens
4. Interpret the results of examination of parasitic specimens

1. Review the scientific literature on a research topic.
### General Skills:
- Retrieve recent data from web sites
- Acquire presentation skills

### Teaching Methods:
- Lectures: small group teaching
- Practical lessons
- Tutorial sessions after the practical lessons
- Enhancing self learning of students (students’ presentations)

### Using colored photos for parasites

### Using simple techniques to help in better understanding like PPT and videos

### Assessment:
- Mid-Term Examination (20 marks) (10 marks assignments & 10 marks quiz) After 6 weeks from the start
- Final-Term Examination (90 marks) At the end of the 12th week
- MCQs (20 marks)
- Short essay questions (70 marks)
- Practical Examination (40 marks)
- Total: 150 marks

### Books:
1. Course Notes
2. Essential Books (Text Books)
   - Department book
3. Recommended Books
   - a. Basic clinical Parasitology (Brown and Neva)
   - b. Colored Atlas of Parasitology
   - c. Medical Parasitology (Markell, Vogue, and John)
   - d. Tropical medicine and Parasitology (Peters and Gills)
4. Periodicals, Web Sites, …etc
   - Parasitology today (Trends in Parasitology) Journal.
   - Advanced pubmed web sites.
   - CDC website.

### Topics for students with limited capacities:
- Using colored photos for parasites
- Using simple techniques to help in better understanding like PPT and videos
This course will focus on full analysis for different parasitological related diseases in our community especially those common in Egypt causing serious health problems.

In this course will discuss medical helminthology, protozoology and entomology concerning their morphological features, life cycle, pathogenesis, clinical manifestations, different diagnostic techniques, the most recent lines of treatment and prevention with control strategy for each parasitic infection.

Finally the course will focus on immunology and molecular biology for different parasites affecting human health.

**Core Knowledge**

By the end of this course, students should be able to:
- Define most parasitological terms with its causing parasite.
- Describe morphology of important helminthic and protozoal parasitic infections.
- Explain how life cycle occurs in different parasitic illness.
- Describe clinical picture in different parasitic infections.
- List types of different and recent diagnostic methods in parasitic diseases.
  Identify lines of treatment, prevention and control strategy for each parasitic infection.

**Core Skills**

By the end of this course, students should be able to:
- Identify different parasites affecting human beings.
- Analyze symptoms and signs for each parasitic illness.
- Know about the most recent diagnostic procedures in laboratory work.
- Apply information about prevention and control methods in practical fields.
<table>
<thead>
<tr>
<th>ID</th>
<th>Topics</th>
<th>Interactive Lecture</th>
<th>Field Work</th>
<th>Assign</th>
<th>Research</th>
<th>Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-Introduction of parasitology &amp; helminthology 2-Liver flukes</td>
<td>2</td>
<td></td>
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<td>4</td>
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<td>3-Intestinal and lung flukes 4-Blood flukes</td>
<td>2</td>
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<td>4</td>
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<td>3</td>
<td>5-Introduction to cestodes and teaniais 6-Hydatid disease</td>
<td>2</td>
<td></td>
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<td>4</td>
<td>7-Hymenoleps nana infection 1h</td>
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<tr>
<td>5</td>
<td>8-Introduction to nematodes</td>
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<tr>
<td>6</td>
<td>9-Entrobius vermicularis infection with whip worm 10-Hook worms</td>
<td>2</td>
<td></td>
<td></td>
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<td>4</td>
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<tr>
<td>7</td>
<td>11-Strongoloides parasitic infection 12-Filarial worms</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>13-Introduction to protozoa 14-Amoebiasis and control strategy</td>
<td>2</td>
<td></td>
<td></td>
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<td>4</td>
</tr>
<tr>
<td>9</td>
<td>15-Free living amoeba 16-Oro intestinal flagellates and G.lamblia infection</td>
<td>2</td>
<td></td>
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<td>4</td>
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<tr>
<td>10</td>
<td>17- Urogenital flagellates and Trichomonus vaginalis infection 18-Hemosomatic flagellates and Lieshmaniasis</td>
<td>2</td>
<td></td>
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<td>4</td>
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<td>11</td>
<td>19-Infection with Trypanosoma species 20-Malaria</td>
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<td>4</td>
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<td>12</td>
<td>21-T.gondii infection 22-Infection with C.parvum</td>
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<td></td>
<td>4</td>
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<tr>
<td></td>
<td>23-Cyclospora parasitic infection 24-Isospora parasitic infection</td>
<td>2</td>
<td></td>
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<td>4</td>
</tr>
</tbody>
</table>

Total hours: 72 hours

24 hours

48 hours
Chapter  1
Introduction to parasitology

Objectives
  1- Aims to focus on general parasitological terms that will be discussed later on during the course.
  2- Gives general idea about life cycle, methods of infection and different harmful effects caused by parasitic infection.

Introduction

A parasite is an organism which lives on or within another organism called a host from which it obtains food and protection. Parasites vary according to their biological habits and can be divided into:
<table>
<thead>
<tr>
<th>Type of the parasite</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Obligatory parasites</td>
<td>organisms that cannot exist without a host</td>
<td>Plasmodium and Oxyuris</td>
</tr>
<tr>
<td>2- Facultative parasites</td>
<td>organisms that can either live freely in soil or water or as parasites in hosts when unfavorable environmental conditions occur</td>
<td>Strongyloides</td>
</tr>
<tr>
<td>3- Accidental parasites</td>
<td>free living organisms which enter the human body by mistake</td>
<td>larvae of flies accidentally ingested and live in the intestine of man</td>
</tr>
<tr>
<td>4- Temporary parasite</td>
<td>visits its host from one time to another for feeding</td>
<td>Soft tick</td>
</tr>
<tr>
<td>5- Specific parasite</td>
<td>affects only one species of host</td>
<td>Enterobius</td>
</tr>
<tr>
<td>6- Coprozoic (Spurious) parasites</td>
<td>Foreign organisms or stages of non human parasites which have been swallowed and pass through the intestine in feces without causing infection.</td>
<td></td>
</tr>
<tr>
<td>7- Ectoparasite</td>
<td>parasite which lives on the outside of the host</td>
<td>Pediculus</td>
</tr>
<tr>
<td>8- Endoparasite</td>
<td>parasite which lives within the body of the host</td>
<td>Ancylostoma</td>
</tr>
</tbody>
</table>
### Hosts

<table>
<thead>
<tr>
<th>Type of the host</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive</td>
<td>in which the adult stage of the parasite lives, or in which sexual reproduction takes place</td>
<td>man a definitive host for <em>Ascaris</em></td>
</tr>
<tr>
<td>Intermediate</td>
<td>in which the immature or larval stage of the parasite is found, or in which the parasite multiplies asexually</td>
<td>pigs act as intermediate hosts for <em>Taenia solium.</em></td>
</tr>
<tr>
<td>Reservoir</td>
<td>when a parasite utilizes a wide range of animal hosts besides man, such animals represent the reservoir hosts of the particular parasite and act as a continuous source for human infection</td>
<td></td>
</tr>
<tr>
<td>Paratenic (transport)</td>
<td>in which the parasite does not undergo any developmental changes</td>
<td>fish 2\textsuperscript{nd} intermediate host</td>
</tr>
<tr>
<td>Amplifier</td>
<td>is an intermediate host in which asexual multiplications occur</td>
<td>snail 1\textsuperscript{st} intermediate host</td>
</tr>
<tr>
<td>Vector</td>
<td>is a host that transmits parasites from one host to another. It is usually arthropod</td>
<td>Fleas act as vectors for <em>Pasteurella pestis</em> from rodents to man.</td>
</tr>
</tbody>
</table>
Objectives

1-Focus on morphological characters, life cycle, pathogenesis, clinical picture, laboratory procedures, lines of treatment and prevention with control strategy of different protozoa affecting human beings.

MEDICAL PROTOZOOLOGY

Protozoa: These are unicellular organisms that occur singly or in colony formation. Each protozoan is a complete unit capable of performing all functions.

Morphology: Protozoa have wide range of size (1-150μ). The structure of protozoan cell is formed of a cytoplasmic body and a nucleus.

1. Cytoplasm:

   a. Ectoplasm: The outer hyaline layer that is responsible for ingestion of food, excretion, respiration, protection and sensation.

      Some structures develop from ectoplasm as:
      - Organs of locomotion; pseudopodia, flagella and cilia.
      - Organs for food intake or excretion; peristome, cytostome and cytopyge.

   b. Endoplasm: The inner granular part of cytoplasm that is responsible for nutrition and reproduction. The endoplasm contains number of structures as: food vacuoles, foreign bodies, contractile vacuoles and chromatoid bodies.
2. Nucleus: It is the most important structure, as it regulates the various functions and reproduction. It is formed of:

a. Nuclear membrane.

b. Nuclear sap (nucleoplasm).

c. Chromatin granules.

d. Karyosome (nucleolus): It is a DNA containing body, situated centrally or peripherally within the nucleus.

General morphology of protozoa.
Life cycle:

1. Simple life cycle: Intestinal and luminal protozoa require only one host, within which they multiply asexually, and transfer from one host to another directly.

2. Complex life cycle: Most blood and tissue parasites pass alternatively in a vertebrate and an invertebrate host, this is called alternation of generation (i.e. transmission is indirect). The sexual multiplication occurs in one host and the asexual multiplication in another host.

Classification of Protozoa

1. Phylum: Sarcomastigophora (Amoebae and Flagellates):
   a. Sub-phylum: Sarcodina (Amoebae):
      i. Parasitic Amoeba.
      ii. Free-living Amoeba.
   b. Sub-phylum: Mastigophora (Flagellates):
      i. Intestinal and uro-genital flagellates e.g. Giardia intestinalis, Dientamoeba fragilis (Amoeba-like flagellate), and Trichomonas vaginalis.
      ii. Blood and tissue (haemo-somatic) flagellates: Leishmania and Trypanosoma species.

2. Phylum: Ciliophora, e.g. Balantidium coli.

3. Phylum: Apicomplexa (Sporozoa or Coccidia), e.g. Plasmodium, Toxoplasma gondii, Cryptosporidium parvum, Cystoisospora belli and Cyclospora cayetanensis.

SARCOMASTIGOPHORA
Sarcodina (Amoebae)
**Entamoeba histolytica**

Geographical distribution: Worldwide distribution especially in tropical areas and poor communities.

Morphology:

*Entamoeba histolytica* has 3 stages:

1. **Trophozoite (Vegetative or growing stage):**
   - Size: 10-60 µ (average 20 µ).
   - Shape: Irregular outline with finger-like pseudopodia and active movement.
   - Cytoplasm: It is formed of outer clear hyaline, refractile ectoplasm and inner granular endoplasm containing nucleus, food vacuoles, erythrocytes (RBCs), occasionally bacteria, and tissue debris.
   - Nucleus: It has centrally located fine karyosome and peripheral chromatin dots arranged regularly at the inner side of the nuclear membrane.

2. **Precyst:**
   - Smaller than the trophozoite but larger than cyst (10-20 µ).
   - Rounded or oval with blunt pseudopodia and sluggish movement.
   - No food vacuoles or RBCs.
   - It contains a single nucleus similar to that of the trophozoite.

3. **Cyst:**
   - It is rounded, 10-15 µ in diameter.
   - Has smooth refractile cyst wall.
- The early cyst contains glycogen vacuoles and 1-4 chromatoid bodies which are sausage-shaped with rounded ends. They are formed of RNA & DNA, and represent stored proteins which are consumed with repeated nuclear division.

- Immature cysts may be mono- or bi-nucleated.
- Mature cysts contain 4 nuclei formed by mitotic division.
- Nuclei are similar to that of the vegetative form.

Life cycle:
- Habitat:
  a. Trophozoite: Inhabits the wall and lumen of the large intestine, with extra-intestinal metastases (liver, lung and brain, etc.).
  b. Cyst: Inhabits the lumen of the large intestine.
- Definitive host: Man.
- Intermediate host: No.
- Reservoir hosts: Dogs, rats and monkeys.
- Infective stage: Mature quadrinucleated cyst.

Mode of infection:
1. Ingestion of mature quadrinucleated *E. histolytica* cysts in contaminated food or drink, or through infected food handlers.
2. Mechanical transmission by flies and cockroaches.
3. Autoinfection: feco-oral route (hand to mouth contact).
- On ingestion, the trophozoites disintegrate in the stomach, while only the mature cysts resist the stomach acidity and pass to the small intestine.
- The cyst wall is digested by action of trypsin and excystation occurs in the proximal small intestine, where metacystic stage escapes and divides into 8 small amoebae.
- These trophozoites move down to the ilio-caecal region, multiply by binary fission, and then pass to the lumen of colon, where they may remain, feeding on starch or mucus and pass in liquid stool, or may undergo encystation and cysts pass with formed stool.
- Also, trophozoite may invade the wall of large intestine by their lytic secretion to invade the host tissues through blood vessels (extra-intestinal invasion).

Pathogenesis:
*E. histolytica* causes intestinal and extra-intestinal amoebiasis.
- *E. histolytica* lives in large intestine usually as a commensal without producing any clinical manifestation, but sometimes they become pathogenic and attack the mucosa (10% of cases).

Life cycle of *Entamoeba histolytica.*
Pathogenesis:
- *Entamoeba* trophozoites attach themselves to the surface epithelium aided by an enzyme called *E. histolytica* lectin and start crawling over the mucosa.

- Trophozoites secrete cytolytic enzymes: haemolysins and pore-forming enzymes (amoeba pore), which lead to necrosis of epithelial cells with pore formation. Amoebae absorb nourishment from the dissolved tissues and ingest RBCs and tissue fragments through pseudopodia encirclement.

- Trophozoites enter to the submucosa through the hole formed in the epithelial layer and continue the process of cytolysis downwards and laterally.

- Early lesion is a tiny area of necrosis in the superficial mucosa or small nodular elevation with minute opening that leads to flask shaped cavity containing cytolysed cells, mucus and amoeba trophozoites, while amoeba cysts never found in tissues. This ulcer is called flask shaped or crater like ulcer.

- The lesions vary from small ulcers distributed over the mucosa, to large irregular ulcers, each with undermined edge and necrotic base with yellow purulent membrane covering its base. Ulcers are more common in the ileo-caecal region followed by the sigmoid-rectal region.

- With progress of lesions→ sloughing of large mucosal parts exposing large necrotic areas.

- Ulcer expansion can penetrate the intestinal wall →intestinal perforation with hemorrhage and peritonitis.

- Repeated inflammation and healing →deposition of fibrous tissue and granuloma formation around the ulcer with thickening of the intestinal wall that may be mistaken as a tumour or tuberculous granuloma and is called amoeboma. It is composed of collagen, fibrous tissue and chronic inflammatory cells.

- Invasion of blood vessels may lead to spread of amoebae causing extra intestinal amoebiasis:
  1. Amoebic liver abscess: It usually occurs due to direct transport of trophozoites from the large intestine via the portal vein.
- It may be single or multiple, located in the upper right lobe of the liver.
- The lesion starts as small necrotic foci which tend to coalesce into a single abscess and continues to enlarge as the trophozoites destroy and ingest liver cells.
- The abscess contains lysed hepatocytes, erythrocytes, bile and fat, giving its content a colour from yellowish to reddish (Anchovy-sauce).

2. Pulmonary amoebiasis:
- It usually results from direct extension from the liver across the diaphragm but may be also haematogenous.
- Lung abscess may be single or multiple, in the lower lobe of right lung.

3. Cerebral amoebiasis:
- Haematogenous spread from amoebic liver abscess or pulmonary amoebiasis usually causes single brain abscess.
- It results in secondary amoebic meningoencephalitis, with severe destruction of brain tissue.

Clinical picture:
The clinical picture of amoebiasis may be:
I. Intestinal amoebiasis:
   1. Asymptomatic infections:
      - These account for the majority of cases (80-90%).
      - There is vague abdominal discomfort, malaise, constipation alternating with mild diarrhea.
      - These patients are cyst passers and they are called healthy carriers.
   2. Symptomatic infections:
      a. Acute intestinal amoebiasis (Amoebic dysentery):
         - Incubation period from 1-4 weeks but may range from few days to months or years.
         - There is severe dysentery (colic + tenesmus + frequency of defecation + blood + mucus and shreds of necrotic mucosa in stool) and abdominal tenderness.
         - The patient is usually afebrile and non-toxic.
      b. Chronic amoebic colitis (Non-dysenteric colitis):
         - Chronic intermittent diarrhea.
         - Abdominal pain and distension (Uncomfortable belly or growling abdomen).
         - Weight loss and weakness.
c. Complications of symptomatic intestinal amoebiasis:
   1. Fulminant amoebic colitis. The patient is febrile and toxic.
   2. Amoeboma. It is palpable, firm, painful, movable, chronic nodular lesion occurring mainly in the caecum, sigmoid colon or rectum.
   3. Thick mega-colon and colonic stricture associated with obstructive symptoms.
   4. Appendicitis, intestinal perforation and peritonitis.
   5. Haemorrhage due to erosion of intestinal blood vessels.
   6. Peri-anal ulceration.

Differences between amoebic and bacillary dysentery.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Amoebic dysentery</th>
<th>Bacillary dysentery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clinical picture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incubation period</td>
<td>Long</td>
<td>Short (&lt; 7 days)</td>
</tr>
<tr>
<td>Onset</td>
<td>Slow</td>
<td>Acute</td>
</tr>
<tr>
<td>Abdominal tenderness</td>
<td>Localized</td>
<td>Generalized</td>
</tr>
<tr>
<td>Tenesmus</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>Fever</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>2. Stool:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature</td>
<td>Faeces mixed with blood and mucus</td>
<td>Blood and mucus with little or no faeces</td>
</tr>
<tr>
<td>Odour</td>
<td>Offensive</td>
<td>Nil</td>
</tr>
<tr>
<td>Consistency</td>
<td>Not adherent</td>
<td>Adherent to container</td>
</tr>
<tr>
<td>Frequency</td>
<td>6-8 times/day</td>
<td>&gt; 10 times/day</td>
</tr>
<tr>
<td>Reaction</td>
<td>Acidic</td>
<td>Alkaline</td>
</tr>
<tr>
<td>3. Microscopy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pus cells</td>
<td>Few</td>
<td>Numerous</td>
</tr>
<tr>
<td>RBCs</td>
<td>In clumps</td>
<td>Scattered or in rouleaux</td>
</tr>
<tr>
<td>Macrophages</td>
<td>Few</td>
<td>Numerous</td>
</tr>
<tr>
<td>Amoeba trophozoites</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Bacteria</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Charcot-Leyden Crystals</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

II. Extra intestinal amoebiasis:
   1. Hepatic amoebiasis:
   a. Diffuse amoebic hepatitis:
      - It is a non-specific reaction of liver to the necrotic debris and toxic materials.
- The liver is enlarged and tender with pain in the right hypochondrium.
- Temperature is usually elevated.

b. Amoebic liver abscess:
- The liver is enlarged and tender with pain in the right hypochondrium.
- Elevation of the right diaphragm with severe pain referred to the right shoulder.
- Fever, chills, toxemia, anorexia with leukocytosis.
- Jaundice occurs with multiple lesions or affection of biliary tract.
- The abscess may extend through the diaphragm to the lung, pericardium, peritoneal cavity or rupture through the abdominal wall.

2. Pulmonary amoebiasis:
- It is characterized by chest pain, cough, dyspnea, chills, fever and leukocytosis.
- Hepatobronchial fistula is usually associated with expectoration of chocolate-brown sputum.

3. Amoebic brain abscess: It acts as a brain tumor (Space-occupying lesion).

4. Cutaneous amoebiasis:
- It results from fistula formation (intestinal, hepatic, or perineal).
- Lesions can be highly destructive, simulating epithelioma.

5. Genitourinary amoebiasis:
- In females, vulva, vagina or cervix can be affected by spread from perineum or fistula formation.
- The destructive lesions resemble carcinoma.

Diagnosis:
- Clinical diagnosis:
  1. History of travel to or residence in an endemic area.
  2. Signs and symptoms on physical examination.
- Laboratory diagnosis:
  I. Diagnosis of intestinal amoebiasis:
  1. Stool examination:
     a. Macroscopy.
     b. Microscopy:
     - Proper collection, preservation and examination of stool samples using saline, iodine or eosin smears, or permanent stained smears with trichrome or iron-haematoxylin.
- Repeated stool examination and concentration methods by zinc sulphate floatation, may be required especially in chronic cases.

c. Stool culture: Using Robinson's medium. It is a sensitive method for diagnosing chronic and asymptomatic intestinal amoebiasis.

d. Detection of amoebic copro-antigens: By enzyme-linked immunosorbent assay (ELISA).

e. Molecular diagnosis.

2. Sigmoidoscopic examination: For detection of trophozoites and associated pathology.

3. Serodiagnosis: Antibodies to *E. histolytica* can be detected by indirect haemagglutination (IHA) test, immunofluorescence assay (IFA) test, and ELISA in invasive intestinal amoebiasis.

**II. Diagnosis of extra-intestinal amoebiasis:**

1. Microscopic examination:
   - For detection of trophozoites in:
     a. Aspirated pus or biopsy from amoebic liver or lung abscess.
     b. Sputum in pulmonary amoebiasis.
     c. CSF in cerebral amoebiasis.
   - Stool samples are not of much value as cyst can be detected in less than 15% of hepatic amoebiasis.

2. Serodiagnosis: The circulating amoebic antigens or antibodies can detected by IHA, IFA or ELISA.

3. Haematological diagnosis: Leukocytosis is noted in amoebic liver abscess.

4. Biochemical diagnosis: Raised alkaline phosphatase and serum glutamic oxaloacetic transaminase (SGOT) level in amoebic liver abscess.

5. Radiological examination: Amoebic liver, lung or brain abscesses can be diagnosed by ultra-sonography (US), computed axial tomography (CT) or magnetic resonance imaging (MRI).
Laboratory diagnosis of amoebiasis:

Treatment:

1. Luminal amoebicides: They act in the intestinal lumen.
   - Diloxanide fluorate (Furamide).
   - Metronidazole (Flagyl).
   - Tinidazole (Fasigen).
   - Paromomycin.
   - Iodoquinol.

2. Tissue amoebicides: They act against the tissue invasive form.
   a. Amoebicides acting on all types of tissues:
      - Metronidazole.
   - Tinidazole.
   - Emetine hydrochloride.
   b. Amoebicides acting only on liver tissue:
      - Chloroquine phosphate.
   c. Amoebicides acting only on the intestinal wall:
      - Tetracycline.

3. Amoebic liver abscess: Aspiration of pus + amoebicides.
   - Although metronidazole and tinidazole act as both luminal and tissue amoebicides, but none of them reach high level in the intestinal lumen. Therefore, patients with amoebic colitis or amoebic liver abscess should also take another luminal amoebicides (paromomycin) to ensure eradication of infection.

Prevention and control:

1. Environmental sanitation as: Anti-fly measures, proper sewage disposal, safe water supply and avoid using excreta as fertilizer.
2. Health education for: Washing green vegetables, fruits and hands before eating.
3. Treatment of cases, especially carriers.
Free-living amoebae

Free-living amoebae are found in moist soil, decaying vegetations and all types of water, especially water containing bacteria. They are amphizoic parasites, as they can multiply both in the host (endozoic) and in free-living (exozoic) conditions.

Three types of free-living amoebae are pathogenic to man:
1. *Naegleria fowleri* (an amoeboflagellate).
2. *Acanthamoeba castellani*.
3. *Balamuthia mandrillaris*.

*Naegleria fowleri* (Brain-eating amoeba) Geographical distribution: Cosmopolitan.

Morphology:
1. Trophozoite:
   a. Amoeboid form (Vegetative and growing form):
      - Size: 10-20µ.
      - Shape: Elongate with broad anterior end and tapering posterior end.
      - Cytoplasmic inclusion: Food vacuoles, contractile vacuole and phagocytic vacuoles known as amoebostomes.
      - Nucleus: Has a large central karyosome.
      - Motility: Actively motile with broad rounded pseudopodia (lobopodia).
      - It inhabits CNS tissues and multiplies by simple binary fission.
      - Trophozoite takes the amoebic form in tissues and CSF.
   b. Flagellate form:
      - Shape: Pear-shaped or oval.
      - Flagella: Two long equal flagellate.
      - Cytoplasmic inclusion: Single posterior contractile vacuole.
      - Nucleus: As trophozoite.
      - Amoeba changes to flagellated form when comes in contact with warm water and occasionally in CSF.
- It never presents in tissues.

2. Cyst:
- Size: 7-10µ.
- Shape: Rounded.
- Wall: Smooth double wall.
- Nucleus: Mono-nucleated.
- Cytoplasmic inclusions: Contractile and food vacuoles.
- It presents only in soil, never in tissues or CSF.

Life cycle:
- Habitat: Soil and warm fresh water. In man it attacks the CNS.
- Infective stage: Amoeboid trophozoite.

**Mode of infection:** Through the nasal route.

1. Swimming or sniffing in contaminated water.
2. Inhalation of contaminated air.

Amoeboid trophozoites in contaminated water enter the nose, migrate through the nasal mucosa → cribriform plate → olfactory nerve → olfactory pulp → base of the brain → disseminate to the brain tissue.

- The amoeboid trophozoite feeds and divides by binary fission. It transforms transiently into the flagellate trophozoite, which is none feeding and can't divide, but can reverts back to amoeboid form.
- The amoeboid trophozoite transforms into cyst stage.
- Exystation of the cyst releases trophozoite.

Pathogenesis:
*Naegleria fowleri* causes primary amoebic meningo-encephalitis (PAM or PAME).

- Amoeboid trophozoite is specifically neurotropic, penetrates the cribriform plate and multiplies along the base of the brain, where it feeds on nerve tissue, by means of an amoebostome, resulting in significant necrosis and bleeding; causing acute meningoencephalitis.
- In the subarachnoid space, an inflammatory exudate of neutrophils and monocytes is seen.
- In the grey matter, there is haemorrhage and extension of the inflammatory exudates, rounded amoebae and necrosis of the tissues are also seen.

- In the white matter of the brain and spinal cord, there is demyelination, although amoebae and cellular exudate are absent there. Demyelination may be due to the production of phospholytic enzyme or enzyme-like substance by the growing amoebae in the adjacent grey matter.

Clinical picture:
The signs and symptoms of *Naegleria fowleri* infection are similar to bacterial meningitis, which lowers the chances of initially diagnosing PAM. The clinical course of PAM is dramatic and death usually occurs within a week, so that diagnosis is usually made after the person has died.

1. Stage I: Nausea, vomiting, severe frontal headache, fever, blocked nose with alteration of smell or taste (acute onset of upper respiratory tract infection).

2. Stage II: Signs of meningeal irritation as stiffness of neck (Kernig's sign), photophobia, seizures, altered mental status, and coma.
Life cycle of *Naegleria fowleri*.

Diagnosis:
- **Clinical diagnosis:**
  History of swimming or diving in lakes, ponds or bath spa, 2-6 days prior to onset of meningeal irritation manifestations may suggest the possibility of PAM.
- **Laboratory diagnosis:**
  a. **Microscopic examination:** Wet mounts of fresh, uncentrifuged CSF revealing trophozoites are clues to a potential diagnosis of PAM. CSF is purulent but with no bacteria, marked raised cell count; mainly polymorph-nuclear leucocytes, elevated protein (> 1gm / L) and low glucose (< 5gm / L). This is in contrast to the viral meningitis where cells are mainly mononuclear cells with low protein.
  - CSF smears can be stained with: Haematoxylin and eosin (H&E), periodic acid-Schiff (PAS), Giemsa, or Wright stains.
  - At autopsy: Amoeboid trophozoites can be detected in brain tissue by immunofluorescent staining.
b. Culture: Using 1.5% non-nutrient agar seeded with *Escherichia coli*. Both trophozoites and cysts can be seen.

c. Molecular diagnosis.

d. Mice inoculation.

e. Blood sample: It reveals polymorph nuclear leukocytosis that may reach up to 25,000 with preponderance of neutrophils.

Treatment:
1. The patient must be hospitalized and given palliative treatment.
2. Amphotericin-B is administered intravenously and intrathecal.
3. Miconazole or rifampin may be given to potentiate the action of amphotericin-B.

Prevention and control:
1. Adequate chlorination of water of swimming pools and public water supplies.
2. Avoid immersing the head in water during swimming.

*Acanthamoeba castellani* and *Balamuthia mandrillaris*

Geographical distribution: Worldwide.

Morphology:
1. *Acanthamoeba castellani*
   a. Trophozoite: 20-40 µ, characterized by multiple small spiky pseudopodia (acanthopodia) with sluggish motility. Nucleus has large central karyosome.

   b. Cyst: Spherical, 15-20 µ, mononucleated and has polygonal double wall with many pores (osteoles).

   - There is no flagellate form.

2. *Balamuthia mandrillaris*: It is like *Acanthamoeba*, but the trophozoite is pleomorphic, large (12-60 µ), and actively motile by broad or finger-like pseudopodia. Cyst is 6-30 µ, more or less spherical, has three-layered cyst wall.

Life cycle:
- Habitat:
  - Both trophozoite and cyst stages may exist in the environment and in tissues.

    - In the environment: Brackish and fresh water, soil and dust.

    - In man: CNS, eye, skin and lungs.

- Infective stage: Trophozoite and cyst.

- Source of infection: Dust, water and contact lens fluid.
**Mode of infection:**

1. Inhalation of air, aerosol or dust contaminated with trophozoite or cyst.
2. Direct invasion through skin and mucosal ulcers.
3. Through the use of contaminated contact lenses.

- After inhalation, the trophozoites reach lungs, and then invade the CNS through the blood stream.
- Life cycle is simple between the active trophozoite and the resistant cyst stage, where trophozoites multiply by simple binary fission.

Pathogenesis:
1. They are opportunistic parasites causing severe disease in immuno-compromised persons; with infected tissues contain both trophozoites and cysts.
2. Tissue invasion is slow producing chronic granulomatous amoebic encephalitis (GAE).
3. Parasitic granuloma of skin & lungs and disseminated infection.
4. In addition, *Acanthamoeba* causes keratitis.

Clinical picture:
1. **Granulomatous amoebic encephalitis (GAE):**
   - The course is usually subacute or chronic, lasting from weeks to even years.
   - Clinical picture is that of intracranial space-occupying lesions with headache, seizures, mental deterioration, paresis, nausea and vomiting may also occur.
2. **Amoebic Keratitis:**
   - The disease is a chronic progressive ulcerative keratitis caused by *Acanthamoeba*, characterized by severe unilateral ocular pain, photophobia, annular corneal infiltration, congested conjunctiva and loss of vision or even eye perforation may occur.
3. **Chronic granulomatous skin lesions.**
Life cycle of *Acanthamoeba castellani*.

1. Cysts
2. Trophozoite
3. Mitosis

- = Infective Stage
\(\uparrow\) = Diagnostic Stage

4. Amebae (cysts and trophozoites) can enter humans in various ways:
   - Through the eye
   - Through nasal passages to the lower respiratory tract
   - Through ulcerated or broken skin

1. Results in severe keratitis of the eye.
2. Results in granulomatous amebic encephalitis (GAE) and/or disseminated disease in individuals with compromised immune systems.
3. Results granulomatous amebic encephalitis (GAE), disseminated disease, or skin lesions in individuals with compromised immune systems.

Life cycle of *Balamuthia mandrillaris*.

1. Cyst
2. Trophozoite
3. Mitosis

- = Infective Stage
\(\uparrow\) = Diagnostic Stage

4. Amebae (cysts and trophozoites) can enter humans in various ways:
   - Through nasal passages to the lower respiratory tract
   - Through ulcerated or broken skin

1. Results in granulomatous amebic encephalitis (GAE), disseminated disease, or skin lesions in individuals who are immune competent as well as those with compromised immune systems.
Diagnosis:
- Clinical diagnosis: Full history taking and clinical examination.
- Laboratory diagnosis:

1. GAE:
   a. Identification of amoebic trophozoites and/or cysts in CSF or brain tissue biopsy by wet mount or after staining with H&E, PAS, Giemsa, or immunofluorescent technique.
   b. Culture on non-nutrient agar seeded with *Escherichia coli*.
   c. CT scan of brain.

2. Amoebic keratitis: Corneal scrapings or histologic sections for detection of the organism by direct microscopy or after staining and culture.

Treatment:
1. No effective treatment is available for GAE, but sulfadiazine, pentamidine and rifampicin are being used.
2. Keratitis is treated with antibiotics and topical miconazole ointment. In severe case, keratoplasty can be done.

Prevention and control:
1. Health education.
2. Avoid swimming in stagnant water.
3. The use of proper contact lens fluid.
4. Avoid wearing contact lenses whenever possible.

Case study:
A 12-year-old boy was admitted to hospital with symptoms of photosensitivity, altered mental status, and a sudden frontal headache starting two days prior. A cerebrospinal fluid (CSF) sample taken the day after the patient was admitted revealed motile amoeba. That same day the patient was treated with amphotericin B, however; the patient died two days after admittance to hospital.

Questions:
1. What is the possible parasitic cause?
2. Explain the mode of infection in this case.
3. Analyze the cause of demyelination in this infection.
4. Develop a control plan for this parasitic infection.
**Differences between free living amoebae.**

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<tr>
<td>a. Size</td>
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<td>Medium (20-40µ)</td>
<td>Large (12-60 µ)</td>
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<tr>
<td>b. Pseudopodia</td>
<td>Single, rounded and broad</td>
<td>Multiple, spine-like</td>
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<td>GAE, keratitis, skin granuloma, and disseminated disease</td>
<td>GAE, skin granuloma and disseminated disease</td>
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<td>Subacute or chronic</td>
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<tr>
<td>3. Opportunistic infection</td>
<td>-</td>
<td>+</td>
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MASTIGOPHORA (Flagellates) Intestinal and urogenital flagellates

General characters:
1- Infection occurs in the intestine or the uro-genital system.
2- The infective stage may be either the trophozoite or the cyst form.
3- Transmission of infection is a direct one.

Intestinal flagellates

*Giardia intestinalis* (*Giardia lamblia)*

Geographical distribution: World-wide. It is considered the main cause of diarrheal out breaks from contaminated water supplies.

Morphology:

1. Trophozoite:
   - It is pear-shaped, bilaterally symmetrical, measuring 12x6 µ. It has:
     - Two sucking discs, each contains vesicular nuclei.
     - Four pairs of flagella, each arises from a blepharoplast and has free end.
     - The intracytoplasmic parts of the caudal pair of flagella run along the midline as axostyles.
     - Two curved median parabasal bodies, lie posterior to the sucking discs.

2. Cyst:
   - It is oval, 10x5 µ, and has double-colourless wall.
   - Contains four nuclei usually gathered at one pole.
   - Remnants of flagella and median bodies and axostyles are clearly seen.

Life cycle:

- Habitat:
  
  a. Trophozoite: Inhabits the upper part of the small intestine, sticks closely to the mucosa and may penetrate down into the crypts of the mucosa. It may also be found in the gall bladder and biliary drainage.
  
  b. Cyst: Inhabits the lumen of the intestine.

- Definitive host: Man.

- Reservoir hosts: Many animals (dogs, rodents, monkeys…etc). *Giardia* is considered one of the most known zoonotic diseases.

- Infective stage: Mature quadrinucleated cyst.
**Mode of infection:**

1. Cysts may be ingested with food, drinks, contaminated water or transmitted by house flies, cockroaches ....etc.

2. Person to person transmission occurs especially in nurseries, male homosexuals, mentally ill persons and among school children. *Giardia* is considered one of the nosocomial (hospitally-transmitted) infections.

3. Autoinfection by hand to mouth transmission also occurs.

**Life cycle of *Giardia intestinalis***.

- Within half an hour of ingestion, the cyst excysts in the small intestine → two trophozoites, which multiply successively by longitudinal binary fission and colonize in the duodenum, feeding by pinocytosis.

- During unfavourable conditions, encystment occurs usually in the colon.

- Cysts are passed in stool and remain viable in soil and water for several weeks.

**Pathogenesis:**

- Trophozoites of *Giardia* live closely to the intestinal mucosa by their sucking discs. They may produce considerable mechanical irritation to the tissues.

- Attachment is facilitated by a lectin produced by the parasite and activated by
duodenal secretions, leading to derangement of normal villous architecture.

- Giardiasis causes shortening, blunting, and even total atrophy of the villi, with inflammatory foci in the crypts and lamina propria.

- Malabsorption of fat and carbohydrates and fatty diarrhea (steatorrhea) among children are the most important sequelae of giardiasis. Occasionally, *Giardia* may colonize the gall bladder causing cholangitis and cholecystitis.

**Pathogenic mechanisms postulated for malabsorption and steatorrhea:**

1. Inflammation and mechanical blockage of intestinal mucosa by large numbers of trophozoites.
2. Shortening and atrophy of intestinal villi with altered jejunal motility.
3. Reduced secretion of intestinal enzymes.
4. Bacterial jejunal colonization potentiates the damage done by *Giardia*.
5. De-conjugation of bile salts.
7. Competition for essential nutrients.
8. Achlorohydria, hypogammaglobulinaemia and deficiency of secretory IgA.

**Resistance to giardiasis:**

- Resistance to giardiasis and host defense is indicated by spontaneous cure of the disease which may occur after about 40 days.
- Lymphocytes, macrophages and secretory IgA may have a role.
- Human milk is able to kill *Giardia* trophozoites due to the presence of lipase and secretory IgA. So, it can afford protection.

Clinical picture:

- The prepatent period is usually 2 weeks.
- Giardiasis may be asymptomatic in a good proportion of cases.
- Symptoms may be in the form of:

1. Mucus diarrhea, fat malabsorption (steatorrhea), flatulence, dull epigastric pain, crampy abdominal pain, and anorexia.
2. Severe symptoms: Occur in immunocompromized patients as persistent diarrhea (steatorrhea), hypoproteinaemia, fat soluble vitamin deficiency, lactose intolerance, weight loss, biliary colic and jaundice may occur.

Diagnosis:
- Clinical diagnosis: Clinical history and presentation of the disease.
- Laboratory diagnosis:
  1. Stool examination:
     a. Macroscopy: Faecal specimens containing *G. lamblia* may have an offensive odour, are pale in colour and fatty.
     b. Microscopy:
        - Stool examination for trophozoites and/or cysts by direct smear, eosin and iodine smears, and by concentration methods.
        - Repeated stool examination for three times as the parasite is intermittently shed.
     c. Detection of *Giardia* copro-antigens: By ELISA, immunochromatographic strip tests and indirect immunofluorescent tests (IIF).
     d. Molecular diagnosis.
  2. Examination of duodenal contents for trophozoites:
     a. Entero-test (String test).
     b. Duodenal aspiration and duodenal biopsy.
  3. Serodiagnosis: Antibodies to *Giardia* are detected by IFA and ELISA.

Treatment:
1. Metronidazole (Flagyl).
2. Tinidazole (Fasigen) is more effective than metronidazole.
3. Albendazole.
4. Parmomycin, an oral aminoglycosides can be given to pregnant females.
Prevention and control:
- As amoebiasis.

**Case study:**
A 9-year old girl complained of epigastric pain, diarrhea and flatulence. Her stool was offensive, pale and greasy. Microscopic examination revealed motile protozoa.

**Questions:**
1. What is your suggestive diagnosis?
2. Define the habitat of the parasite and the probable sources of infection.
3. Demonstrate the infective stage.
4. Mention the possible complications of this parasitic infection if the patient is immunocompromized.
5. Create a proper treatment plan for this infection.

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**Urogenital flagellates**

*Trichomonas vaginalis*

Geographical distribution: Worldwide.

Morphology:
Trophozoite:
- It is pear-shaped, 17X10 µ, with a rapid jerky movement.
- It has an antero-lateral cytostome.
- The cytoplasm is granular with a single anterior nucleus.
- It has 4 flagella anteriorly, another flagellum attached to the body by undulating membrane, presents at the anterior 1/3 of body with no free end. The 6th flagellum passes through the body as axostyle which projects out of the body.
- A thick marked rod called the parabasal body is present between the axostyle and the undulating membrane.
- It has no cyst stage.

Life cycle:
- Habitat:
  a. Females: Posterior fornix of the vagina, cervix, and urethra.
  b. Males: Urethra, epididymis, seminal vesicles and prostate.

- Definitive host: Man.
- Infective stage: Trophozoite.

**Mode of infection:**

1. Sexual transmission or by contaminated toilet seats and towels.
2. From infected mothers to babies during birth.

- Multiplication: By longitudinal binary fission.

Pathogenesis:

- *Trichomonas vaginalis* causes trichomoniasis, trichomonad vaginitis, urethritis, epididymitis, vesiculitis and prostatitis.

- The parasite is able to kill target cells by direct contact without phagocytosis (dependent cytopathic effect).

- Additionally, *T. vaginalis* produces a cell detaching factor, its amount correlates with the severity of the clinical infection.

- In female, the vaginal wall is red, showing oedema, petechial hemorrhages (strawberry mucosa), mucosal erosion and necrosis. The mucosa is infiltrated
With lymphocytes, plasma cells and polymorphonuclear leucocytes. A relationship between trichomoniasis and cervical carcinoma is suggested.

- In male, urethritis, vesiculitis, epididymitis and prostatitis may occur.

**Predisposing factors for pathogenicity:**

1. Change of the normal vaginal bacterial flora and pH.
2. Decrease in the secretory IgA.

Clinical picture: Trichomoniasis may be asymptomatic in infected males (95%) and females (50%).

- Symptoms may be in the form of:
  1. **Females:**
     - Vaginal itching and burning with an offensive, frothy, profuse leucorrheic discharge forming a pool in the posterior fornix.
     - Dyspareunia (painful sexual intercourse), frequency of micturition and dysuria, also cystitis may occur.
  2. **Males:**
      - Dysuria, and prostate may be enlarged and tender.
  3. **New born:** *Trichomonas* respiratory tract infection and conjunctivitis may affect infants during vaginal delivery of an infected mother.

Diagnosis:
- Clinical diagnosis.
- Laboratory diagnosis:
  1. **Microscopy:**
     - In females:
       - Specimens are obtained through a vaginal speculum by using cotton–tipied applicator stick, and then the applicator is placed in glucose–saline before examination of the precipitate for the organisms.
       a. Direct wet smear examination for characteristic jerky motility and shape of trichomonad trophozoites.
       b. Fixed smears may be stained with Giemsa, Leishman and Papanicolaou stain.
     - In males: Examination of prostatic fluid.
     - In both sexes: Urine examination may beneficial.
  2. **Culture:** On modified Diamond's medium.
  3. **Immunodiagnosis:** For detection of *T.vaginalis* antigens.
a. Direct fluorescent antibody test using labeled monoclonal antibodies.

b. ELISA.


Treatment:
1. Both partners must be treated at the same time.
2. Metronidazole is the most effective drug.
3. Restoration of normal vaginal acidity by vaginal douching with lactic acid or vinegar seems beneficial in mild vaginal trichomoniasis.

Prevention and control:
1. Good personal hygiene.
2. Avoidance of sexual contact with infected partners and use of condoms.
3. Treatment of diagnosed cases, and simultaneous treatment of sexual partners.

Case study:
A pregnant female complained of vaginal itching and burning sensation with profuse and offensive discharge. Gynecological examination revealed redness, oedema, and strawberry-like vaginal mucosa.

Questions:
1. What is your suggestive diagnosis?
2. How is this infection transmitted?
3. Demonstrate the infective stage.
4. Mention the possible complications of this parasitic infection to her newborn.
5. Develop diagnostic procedures to confirm your diagnosis.
6. Propose a suitable treatment regimen for this case.
Blood or body fluid and tissue flagellates
(Haemo-somatic flagellates)
**Leishmania species**

General characters:
1. *Leishmania* species occur as intracellular amastigote form in vertebrate hosts and as promastigote form in insect and culture.

2. *Leishmania* species and subspecies infecting man, have the same morphology and life cycle in insect, but differ in geographical distribution, host specificity, vector, clinical picture, antigenic structure, etc... They cause 3 different diseases:
   - Visceral leishmaniasis caused by *Leishmania donovani* complex.
   - Cutaneous leishmaniasis caused by *Leishmania tropica* complex and *Leishmania mexicana* complex.
   - Mucocutaneous leishmaniasis caused by *Leishmania braziliensis* complex.

*Leishmania donovani* complex

Geographical distribution: All species of *Leishmania donovani* complex cause visceral leishmaniasis and are distributed as:

A. In old world:
   - *L. donovani*: India, Pakistan, Indonesia, Thailand, Central Africa and Sudan.
   - *L. infantum*: Mediterranean area, Middle East and China.

B. In new world:
   - *L. chagasi*: America (Central and South America).

Morphology:
1. Amastigote form (Leishman Donovan body): In reticuloendothelial cells (RECs) all over the human body and reservoir host (vertebrate hosts), typically intracellular in macrophages.

2. Promastigote form: In insect vector (invertebrate host) and culture.

Life cycle:
- Habitat: RECs of viscera, especially spleen, liver, bone marrow, intestinal mucosa and mesenteric lymph nodes.
- Definitive host: Man.
- Reservoir host: Dogs, rodents, wild and domestic animals.
- Insect vector: Female sand flies of the genus *Phelebotomus* in the old world, and *Lutzomyia* in the new world.
- Infective stage: Promastigotes.
Mode of infection:

1. Bite of infected sand fly.
2. Blood transfusion.
3. Direct from man to man in epidemics by nasal secretions.
4. Congenital (vertical transmission from mother to fetus).
5. Accidental infection in the laboratory.

- Man acquires the infection when the infected female sand fly attempts a blood meal, where some of the promastigotes in the buccal cavity are regurgitated, and introduced into the skin bite by their motility.

- Promastigotes are phagocytosed by skin macrophages, where they metamorphose into amastigotes that reproduce by binary fission.

- Ruptured parasitized cells release large number of amastigotes into circulation.

- Blood monocytes phagocytose the free amastigotes and carry them to the viscera, where they produce generalized infection of the RECs.

Life cycle of Leishmania donovani.

- Amastigotes in blood are taken by the female sand fly during blood meal.
- In the mid-gut of the sand fly, the amastigotes are metamorphosed into promastigotes and multiplied by binary fission (Cyclo-propagative development), until the lumen of the mid-gut is completely blocked.

- After 6-9 days, the promastigotes migrate to the pharynx which becomes blocked by the parasites, then to buccal cavity and proboscis.

- When blocked sand fly attempts subsequent blood meal, some of promastigotes are regurgitated, and introduced into the skin bite and the cycle is repeated.

Pathogenicity:

- *L. donovani* causes visceral leishmaniasis, kala-azar, black fever or dumdum fever, an opportunistic disease. Immunocompromised status and diets lacking protein, iron, vitamin A and zinc increase the risk of severe form.

- The parasitized macrophages are present in small numbers in the blood, but are numerous in the RECs mainly of kupffer cells of liver, littoral cells of spleen, peyer's patches of intestine, bone marrow and lymph nodes.

- The amastigotes multiply enormously in the fixed macrophages, causing blockade of the reticuloendothelial system. This leads to marked hyperplasia and destruction of reticuloendothelial tissue in these organs.

- Multiplication of amastigotes in the RECs of liver, spleen and lymph nodes results in hepatosplenomegaly and lymphadenopathy, respectively.

- The bone marrow is heavily infiltrated with parasitized macrophages, which replace the hematopoietic tissues resulting in pancytopenia.

- Lymphoid macrophage cells in intestinal submucosa are packed with parasites causing ulceration and dysenteric symptoms, with leishmanial bodies in faeces.

- Urinary tract: kidneys, pelvis and bladder wall may be infiltrated with parasitized macrophage cells causing break down of mucosa with viable leishmanial bodies escape in urine.

- Naso-pharyngeal affection results in mucopurulent discharge containing leishmanial bodies.

Clinical picture:

1. The incubation period is usually 2-6 months.

2. The onset can be acute or chronic.

3. A primary skin lesion at the site of infection (Leishmanioma) preceding visceral disease has been described in Sudan.
4. In Mediterranean area, kala-azar is common in infants and young children.

5. The clinical illness begins with fever. It may be continuous, remittent with a twice-daily rise, or irregular.

**Causes of fever in Kala-azar:** It is due to release of pyrogens by the invaded macrophages due to:

- Phagocytosis of amastigotes.
- Uptake of cellular debris from ruptured parasitized macrophages.

6. Hepatosplenomegaly with progressive and massive enlargement of the spleen.

7. Normocytic normochromic anemia is a significant feature of kala-azar with hemoglobin levels of 5-10 g/dl.

Types and causes and of anemia in Kala-azar:

**a.** Normocytic normochromic anemia:

- Increased sequestration and destruction of RBCs due to hypersplenism.
- Decreased erythropoiesis due infiltration of bone marrow by parasitized macrophages.
- Autoantibodies to red cells may cause hemolysis.
- Hemorrhage.
- Alterations in RBCs membrane permeability.
- Production of haemolysin by the parasites.

**b.** Macrocytic anemia: Due to reticuloendothelial hyperplasia and fatty infiltration of the liver leading to deficient storage of vitamin B12.

**c.** Microcytic anemia: Due to lack of iron absorption from intestine.

8. Lymphadenopathy in African patients.

9. Diarrhea and/or dysentery.

10. Epistaxis and bleeding from gums.


12. Skin becomes dry, thin, rough, and darkly pigmented (hence the name kala-azar, or black fever). A butterfly distribution over the nose is common.

13. Post kala-azar dermal leishmaniasis (PKDL):

   **It appears after spontaneous or drug cure (Pentostam) of kala-azar (6 months - 5 years).**

   **It is common in the Indian and African type of kala-azar.**
- It is due to migration of the parasites from viscera to the skin.
- The skin lesions are chronic, progressive and painless hypopigmented macules, erythematous patches, or yellowish pink non-ulcerative granulomatous nodules.
- It is localized in the outer surface of the body mostly the face especially on nose, chin, cheeks, lips, forehead and ears, resembling Lepromatous leprosy or disseminated cutaneous leishmaniasis.

Post kala-azar dermal leishmaniasis.

14. Untreated severe cases of visceral leishmaniasis are fatal, either directly from the disease or concurrent diseases as pneumonia, tuberculosis, and dysentery.

Diagnosis:
- Clinical diagnosis: In endemic areas, Kala-azar may be suspected in patients specially children with persistent, irregular or remittent fever, often with a double daily peak, hepatosplenomegaly, anemia, leucopenia and emaciation.
- Laboratory diagnosis:
  I. Direct:
  1. Microscopy:
     - Detection of amastigotes in smears made from the material collected from:
       - Peripheral blood by thick film or buffy coat smears, which show a diurnal periodicity.
       - Bone marrow puncture (sternal or iliac crest).
       - Splenic puncture (spleen pulp).
       - Enlarged lymph node aspirate or puncture.
       - Liver puncture.
       - Nasopharyngeal secretions, stool and urine as the parasite may also be found in atypical sites.
Nodular lesions in PKDL.
- The smears of body fluids are stained with Leishman, Giemsa or Wrights stain while H& E stain is used for tissue sections.
- Amastigotes can be seen inside the macrophages in large numbers and little extracellular form can also be seen.

2. Culture: Materials are cultured on NNN medium. Promastigotes in the form of rosette grouping of parasites can be detected 1-4 weeks after cultivation.

Culture form of *Leishmania donovani*.

3. Animal inoculation: Intra-peritoneal inoculation of hamster by aspirated specimens. In positive cases, the amastigotes can be seen in smears taken from ulcers or nodules at site of inoculation or from the spleen, weeks post infection.

II. Indirect:
1. Immunological diagnosis:
   a. Serological tests: Specific leishmanial antigens prepared from cultures are used to detect anti-leishmanial antibodies using some tests as: IFA, IHA, ELISA, complement fixation test (CFT), direct agglutination test (DAT), and a specific rapid immunochromatographic dipstick (ICT).
   b. Leishmanin skin test (Montenegro test):
      - It is a delayed hypersensitivity skin test.
      - 0.1ml of killed promastigotes of *L. donovani* is injected intradermal.
      - Positive result is indicated by an induration and erythema of 5 mm or more after 48-72 hours.
      - Positive test indicates past infection with *Leishmania* parasites as it becomes positive 6-8 weeks after cure.
      - The test is negative in active infection due to marked depression of cellular immune response and in PKDL.
2. Molecular diagnosis: It helps in species identification of *Leishmania*.
3. Blood picture:
   - Complete blood count shows normocytic normochromic anemia, leucopenia and thrombocytopenia (Aplastic anemia).
Serum shows hypergammaglobulinemia and low albumin level.

Treatment:
1. Supportive treatment:
   - Diet rich in vitamins, iron and liver therapy.
   - Treatment with appropriate antibiotics for secondary bacterial infection.
   - Blood transfusion, necessary for patients with severe anemia or bleeding.
2. Specific treatment:
   a. Systemic therapy (parenteral)
      - Pentavalent antimony compounds: Pentostam (Sodium stibogluconate).
      - Amphotericin B.
      - Interferon gamma, combined with pentostam, has recently been reported to be effective when relapse of the disease occur.
   b. Systemic therapy (oral)
      - Miltefosine: It is the first oral drug approved for treatment of leishmaniasis.

Prevention and control:
1. Control of sand flies by destruction of their breeding grounds near human habitations and by the use of residual chlorinated hydrocarbon.
2. Control of reservoir hosts will reduce the sources of infection.
3. Personal prophylaxis by using bed nets, window mesh screen, insect repellents and spraying of insecticides.
4. Treatment of infected persons.

Case study:
A 10- year- old boy from the Mediterranean area was complaining of fever and diarrhea for 4 weeks. Clinical examination revealed hepatosplenomegaly. His blood picture showed anaemia and leucopenia. Bone marrow specimens revealed intracellular and extracellular rounded parasites, about 3-4 µ, with central nucleus and an axoneme.

Questions:
1. What parasitic cause do you suspect?
2. Illustrate the mode of infection in such case.
3. What is the prognosis of this disease?
4. Propose other diagnostic procedures to confirm your diagnosis.
5. Predict two other complications that can occur with this infection.
**Leishmania tropica complex**

Geographical distribution: All species of *L. tropica* complex cause old world cutaneous leishmaniasis and are distributed as:

a. *Leishmania tropica*: Middle and Far-East, Mediterranean area.
b. *Leishmania major*: Central Asia, Middle-East and Africa. It is recorded in Egypt (Sinai, Sohag and Minia).

Morphology: *L. tropica* complex morphology is indistinguishable from that of *L. donovani*.

Life cycle:
- Habitat: The amastigote form inhabits the RECs of skin.
- Definitive host: Man.
- Reservoir host:
  - Dogs for *L. tropica*.
  - Desert gerbils and rodents for *L. major*.
  - Wild rabbits and rodents for *L. aethiopica*.
- Insect vector: Female sand fly of the genus *Phelebotomus*.
- Infective stage: Promastigotes.

**Mode of infection:**
1. Bite of infected sand fly.
2. Direct contact.
3. The stable fly (*Stomoxys calcitrans*) may transmit the organisms mechanically from an open ulcer or through unbroken skin.

- The life cycle is similar to that of *L. donovani* in sand fly. In man, after inoculation of promastigotes, the amastigotes reside and multiply in the RECs of the skin, without invasion of blood or internal organs.

Pathogenicity: Cutaneous leishmaniasis is characterized by:

1. Multiplication of amastigotes in the skin macrophages leading to formation of papule, nodule and ulcer.
2. The ulcer may be single or multiple, that heals over months to years, leaving scar.
3. Recovery from cutaneous leishmaniasis gives a life-long immunity against the same *Leishmania* species.
Clinical picture: The manifestations of cutaneous leishmaniasis are variable according to the causative species.

1. *Leishmania tropica*: It causes dry oriental sore, Delhi boil or urban cutaneous leishmaniasis.
   - The incubation period is long up to six months.
   - The lesion develops on the exposed parts of the body, particularly on the face and hands, as single or multiple lesions.
   - It appears as a localized nodule, with granulomatous reaction around.
   - The nodule ulcerates after several months and the ulcer appears with sharp cut edges, raised indurated margin and scanty exudates.
   - The dry ulcers usually heal spontaneously within a year.

2. *Leishmania major*: It causes wet sore, moist sore or rural cutaneous leishmaniasis.
   - The incubation period is short, few days or weeks.
   - The lesion usually affects the lower limbs.
   - It starts as small itchy papules, at first dry, then becomes moist, thick and brown, forming crusts which fall leaving shallow oozing ulcers with raised margin, granulation tissue at the base and seropurulent exudates.
   - Ulceration occurs very early and heals more rapidly than *L. tropica*.
   - Secondary bacterial infection usually occurs.

3. *Leishmania aethiopica*: It causes diffuse cutaneous leishmaniasis.
   - The disease is presented by chronic diffuse cutaneous lesions.
   - It starts as a single lesion, then spread slowly due to proliferation of the parasites, till the whole body is covered with nodules, but don't ulcerate.
   - It is characterized by low humoral and cell-mediated immunity.
   - It is difficult to treat.

Diagnosis:
- Clinical diagnosis: The type of lesion is a helpful feature.
- Laboratory diagnosis:
  I. Direct:
  1. Microscopy: For detection of amastigotes in:
     - Smears aspirated or scraped from the edge of the lesion and stained with Leishman, Giemsa or Wrights stain.
- Biopsy of skin lesion stained with H & E.

2. Culture: Materials are cultured on NNN media to see promastigotes.

3. Animal inoculation.

II. Indirect:
1. Leishmanin skin test (Montenegro test):
   - It is helpful, becomes positive few days after infection.
   - The test is negative in diffuse cutaneous leishmaniasis.

2. Serological tests: These are of limited value in the diagnosis of cutaneous leishmaniasis as the patient has no detectable level of circulating antibodies.

Treatment:
1. Local measures:
   - Surgical excision especially in single lesions.
   - Scraping (curettage).
   - Plastic surgery for scars or disfiguring nodules.
   - Local heating of lesion by infra-red rays or freezing therapy by carbon dioxide.
   - Local injection of 10% atebrine solution.
   - I.D. injection of interferon gamma around lesions promotes healing of ulcers.
   - Cleanliness to prevent secondary bacterial infection.
   - Secondary infection needs local or systemic antibiotic.

2. Systemic treatment:
   a. Systemic therapy (parenteral)
      - Pentostam is the drug of choice. Two or three courses may be needed.
      - If the sores are 1-3 in number, treatment may be facilitated by local infiltration of the drug into the edges of the ulcers.
      - Antimony-resistant cases or diffuse cutaneous leishmaniasis can be treated with pentamidine.
   b. Systemic therapy (oral)
      - Miltefosine.

Prevention and control:
- Due to sylvatic and rural nature of the disease, it is difficult to control the source of infection.
- Preventive and control measures are similar to those of visceral leishmaniasis.
**Leishmania mexicana complex and Leishmania braziliensis complex**

Geographical distribution: They cause new world cutaneous and mucocutaneous leishmaniasis, respectively, in Central and South America.

Morphology: It is the same as that of other species of *Leishmania*.

Life cycle:
- The life cycle is similar to that of *L. tropica complex* except:
  - Reservoir host: Forest rodents, cats and dogs.
  - Insect vector: *Lutzomyia* species.
  - Mode of infection:
    1. Bite of infected sand fly.
    2. Direct contact.

Pathogenicity and clinical picture:
1. *L. mexicana* complex:
   - It causes cutaneous leishmaniasis.
   - Lesion is usually single, causing destruction of ear cartilage (Chicleroulcer).
   - It occurs in the forest workers who collect the chicle gum.

2. *L. braziliensis* complex:
   - It causes muco-cutaneous leishmaniasis.
   - Lesion is small painless nodule as with oriental sore, which ulcerates.
   - Lymphatic spread occurs.
   - Muco-cutaneous lesions in the face generally develop, several years after the cutaneous one and commonly become painful, with erosion of the nasal septum, palate, or larynx which is accompanied by loss of voice.

**Case study:**
A young man arriving from Jordan after working there for several years. He has a chronic ulcer on his cheek with clean cut edge that resists treatment by antibiotics.

**Questions:**
1. What is your diagnosis?
2. Illustrate the mode of infection by this disease.
3. How can you investigate such case?
4. Propose a therapeutic scheme for this patient.
5. Develop a control plan for this parasitic infection.
- Oedema, tissue destruction, scarring of ulcerated lesions and secondary bacterial infection can combine, producing mutilation of the face (Espundia).
- Death may develop from aspiration pneumonia, or septicemia.

Diagnosis and treatment: As described for cutaneous leishmaniasis.

- In L. braziliensis, amastigotes can also be demonstrated in smears taken from lesions of mucous membrane.

Prevention and control: As mentioned for visceral leishmaniasis.

**Leishmania** species and sub-species involved in human diseases.

<table>
<thead>
<tr>
<th>Species and sub-species</th>
<th>Disease</th>
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<tr>
<td>a. L. donovani donovani</td>
<td>- Old World visceral leishmaniasis.</td>
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<tr>
<td>b. L. donovani infantum</td>
<td>- Post kala-azar dermal leishmaniasis</td>
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<tr>
<td>c. L. donovani chagasi</td>
<td>- Old World visceral leishmaniasis</td>
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<tr>
<td></td>
<td>- Infantile kala-azar</td>
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<tr>
<td><strong>2. L. tropica complex:</strong></td>
<td></td>
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<tr>
<td>a. L. tropica</td>
<td>- Old World cutaneous leishmaniasis</td>
</tr>
<tr>
<td>b. L. major</td>
<td>- Dry oriental sore or Delhi boil</td>
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<tr>
<td>c. L. aethiopica</td>
<td>- Old World cutaneous leishmaniasis</td>
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<td></td>
<td>- Wet oriental sore</td>
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<tr>
<td><strong>3. L. mexicana complex:</strong></td>
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<td>- New World cutaneous leishmaniasis</td>
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<td>- Diffuse cutaneous leishmaniasis</td>
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<td><strong>4. L. braziliensis complex</strong></td>
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<tr>
<td></td>
<td>- New World muco-cutaneous leishmaniasis</td>
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<tr>
<td></td>
<td>- Chiclero ulcer</td>
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<td></td>
<td>Espundia</td>
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</table>
Trypanosoma species

Trypanosomes infecting humans are classified according to the method of development in the insect vector into 2 groups:

1. Salivarian trypanosomes (anterior station development): Trypanosomes in the gut of insect vector migrate anteriorly to the mouth and salivary glands, so the infection is transmitted through saliva.

2. Stercorarian trypanosomes (posterior station development): Trypanosomes migrate to the hind-gut of insect vector and are passed in faeces.
   - Species: Trypanosoma cruzi, causing American trypanosomiasis.

Trypanosoma brucei gambiense

Geographical distribution: Central and West Africa.

Morphology:

1. In the vertebrate hosts: T. brucei gambiense exists as trypomastigotes, which have a small subterminal kinetoplast at the posterior end of the parasites, and are polymorphic, appearing in 3 forms:
   a. Long slender form: 30µ, with a long free flagellum and actively motile.
   b. Intermediate form: 25µ, with a short free flagellum.
   c. Short stumpy form: 20µ, without a free flagellum and sluggish.
2. In the insect vector:

   a. Long slender trypomastigotes.
   b. Epimastigotes.
   c. Metacyclic trypomastigotes (short stumpy trypomastigotes).

Life cycle: It passes in 2 hosts.
- Habitat: Blood, lymphatics, lymph nodes, CNS and CSF.
- Vertebrate hosts: Mainly man, although domestic animals as pigs, goats and dogs can act as chronic asymptomatic carriers of the parasite.
- Invertebrate hosts: Both sexes of Glossina palpalis and Glossina tachinoides.
- Infective stage: Metacyclic trypomastigotes.

**Mode of infection:**

1. Biological transmission by the bite of infected Glossina.
2. Blood transfusion.
3. Congenital.
4. Mechanical transmission of infection by blood-suckling flies.

- Man acquires the infection by the bite of Glossina, where the infective metacyclic trypomastigotes are inoculated in the skin during a blood meal.
- The metacyclic trypanosomes multiply by binary fission at site of inoculation, causing local swelling, called trypanosomal chancre.
- The metacyclic forms are transformed into trypomastigotes which spread, via the blood stream and lymphatics, throughout the body, and continue replication by binary fission as extracellular stages.
- The tsetse fly becomes infected with trypomastigotes when taking a blood meal from an infected vertebrate host.
- In the midgut, the short stumpy trypomastigotes are transformed into long ribbon forms (procyclic trypomastigotes), multiply by binary fission, leave the midgut, and transform into epimastigotes, which reach the salivary glands, and continue multiplication by binary fission, then transform to the non-dividing metacyclic trypomastigotes (infective form) in vector saliva.
- The life cycle in vector is a cyclo-propagative development of about 3 weeks.
- Tsetse fly harbouring the infective metacyclic forms is infective to man and the cycle is repeated.

Pathogenicity:
- *T. brucei gambiense* causes West African trypanosomiasis (West African sleeping sickness). This Gambian form is characterized by:

1. Trypanosomal chancre: It is a local inflammatory response at the site of tsetse bite, with intense cellular infiltration, oedema and divided trypomastigotes.

2. Systemic spread of trypomastigotes via tissue fluid, mainly leads to lymphadenopathy. The lymph nodes show congestion, haemorrhage and marked macrophages infiltrate, then undergo degenerative changes with excess fibrosis.

3. Spread of trypomastigotes to CNS leads to chronic meningoencephalitis. Increases in glial cells occur throughout CNS, and perivascular infiltration with mononuclear cells, leading to ischemic softening of tissues and petechial haemorrhage. There is also neuronal degeneration, and heavy infiltration of meninges with lymphocytes, plasma cells, and morula cells of Mott.
Life cycle of *Trypanosoma brucei*

Clinical picture:

1. Trypanosomal chancre appears within few days at the site of bite. It is an indurated painful swelling, which lasts for 1-2 weeks.

2. Stage I disease: Characterized by haematogenous and lymphatic dissemination of the parasites.
   a. Parasitaemia with irregular headache, fever, rash, joint and muscle pain and anaemia.
   b. Enlargement of cervical lymph nodes especially of the posterior cervical region (Winterbottom's sign), or generalized lymphadenopathy.
   c. Hepatosplenomegaly.

3. Stage II disease: It involves invasion of CNS, which occurs after several months, and sleeping sickness starts. It is manifested by behavioral and personality changes, such as a mental apathy, slow speech, tremors, involuntary movements and convulsions, abnormalities in the sleep patterns as nocturnal insomnia with sleepiness during the day, hypersomnia and finally coma followed by death from the disease, or concurrent infection.

Diagnosis:
- Clinical diagnosis: History of traveling or residence in areas of Africa where the disease occurs.
- Laboratory diagnosis:
  1. Direct:
     Demonstration of trypanosomes in samples from chancre aspirate, blood (thick blood or buffy coat smears), lymph node aspirate, bone marrow, and CSF by:
1. Microscopy:
   a. Wet mount smears examination to detect motility of trypanosomes.
   b. Examination of Giemsa-stained smears to detect the morphological characteristics of the polymorphic trypomastigotes.

2. Culture: The organisms are difficult to grow on NNN medium; hence culture is not routinely used for primary isolation of the parasites.
3. Animal inoculation: Intraperitoneal inoculation of specimens into guinea pigs, rats or mice. The animal is killed after one week and examined for the trypomastigotes and characteristic pathological lesions.

- Posterior nuclear shift phenomenon: A blood sample of a patient with sleeping sickness is injected into a laboratory animal. Examination of animal's blood sample, one week post infection, shows shift of the nucleus of some trypanosomes to the posterior end of the parasites. This phenomenon disappears after repeated sub-passage in the experimental animals.

II. Indirect:
   1. Serodiagnosis:

   a. Antibody detection: IHA, IFA, CFT, ELISA, and card agglutination test for trypanosomiasis (CATT) are used to detect very high levels of the specific antibodies (IgM) in the serum 2-3 weeks after infection. Also, specific antibodies are detected in CSF by IFA and ELISA.

   b. Antigen detection: Antigens from serum and CSF can be detected by ELISA.

2. CSF examination:

   - There is raised pressure, cell count (mainly lymphocytes) and proteins in CSF.

   - Morula cells of Mott, which are atypical plasma cells with unilateral nucleus and many cytoplasm vacuoles, representing stored immunoglobulins. They are pathognomonic of sleeping sickness.

3. Haematological diagnosis:
   - Anaemia and thrombocytopenia.
   - Moderate leukocytosis.
   - High levels of immunoglobulins, mainly IgM.


5. Imaging: CT scan of the brain shows cerebral oedema and MRI shows white matter enhancement in patients with late stage CNS involvement.
Treatment:
1. In stage I, when CNS is not involved:
   - Suramin.
   - Pentamidine.
2. In stage II, when CNS is involved:
   - Melarsoprol (Mel-B): is the drug of choice, as it can pass the blood brain barrier. This drug shouldn't be administered to pregnant women.
3. In both early & late stages of the disease:
   - Eflornithine or DFMO (Ornithyl).

Prevention and control:
- Mass treatment of patients.
- Combat of tsetse flies.

Case study:
An African patient presented with enlarged cervical lymph nodes, hepatosplenomegaly, fever and generalized weakness. He had a history of having indurated painful swelling on his face before his complaints.

Questions:
1. What is your possible diagnosis and the causative parasite?
2. If blood film is negative, what other specimens may reveal the organism?
3. Illustrate the mode of infection in such case.
4. What change in the serum proteins is highly suggestive of active infection?

Trypanosoma brucei rhodesiense
Geographical distribution: East and Central Africa.
Morphology, habitat and life cycle: They are similar to T. brucei gambiense, but the disease is actually a zoonosis, with the reservoir hosts are wild animals as antelope, and domestic animals as cattle, and the vector is Glossina morsitans.
Pathogenicity and clinical picture:
- T. brucei rhodesiense causes East African trypanosomiasis (East African sleeping sickness). The disease is similar to Gambian form with some variations:
  - Short I.P. with more rapid and fatal course.
- CNS is involved early and patients usually die before reaching the sleeping sickness stage
- Fever and rigors are more frequent and severe.
- Trypanosomes appear in blood early with plentiful numbers.
- Myocarditis and emaciation are prominent.
- Lymphadenopathy is less prominent.

Diagnosis: As in *T. brucei gambiense*, but trypanosomes are plentiful in blood and show more posterior nuclear shift after animal inoculation with blood.

Treatment:
- Must be early and suramin is the drug of choice.
- In case of neurological involvement, melarsoprol can be given.

Prevention and control:
- Treatment of patients.
- Control of vectors.

Differences between West African and East African trypanosomiasis.

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<th>West African</th>
<th>East African</th>
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<td><em>Trypanosoma brucei gambiense</em></td>
<td><em>Trypanosoma brucei rhodesiense</em></td>
</tr>
<tr>
<td>2. Distribution</td>
<td>West and Central Africa</td>
<td>East and Central Africa</td>
</tr>
<tr>
<td>3. Insect vectors</td>
<td><em>Glossina palpalis</em> &amp; <em>Glossina tachinoides</em></td>
<td><em>Glossina moristans</em></td>
</tr>
<tr>
<td>4. Reservoirs</td>
<td>Mainly humans</td>
<td>Mainly animals as antelopes, pigs, goats, dogs and cattle</td>
</tr>
<tr>
<td>5. Course of the disease</td>
<td>Chronic</td>
<td>Acute</td>
</tr>
<tr>
<td>6. Lymphadenopathy</td>
<td>More common</td>
<td>Less common</td>
</tr>
<tr>
<td>7. Mortality rate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>8. Trypanosomes in the peripheral blood</td>
<td>Few</td>
<td>Numerous and appear early</td>
</tr>
<tr>
<td>9. Virulence to laboratory animals</td>
<td>Less virulent</td>
<td>More virulent</td>
</tr>
<tr>
<td>10. Posterior nuclear shift现象</td>
<td>Rare</td>
<td>Common</td>
</tr>
</tbody>
</table>
**Trypanosma cruzi**

Geographical distribution: South and Central America.

Morphology:

1. In the vertebrate hosts: *Trypanosoma cruzi* exists in both amastigote and trypomastigote forms.
   a. Amastigotes: They are multiplying intracellular parasites.
   b. Trypomastigotes: They are non-multiplying extracellular forms, monomorphic, C- or S-shaped, with large kinetoplast and wedge-shaped posterior end.

2. In the insect vector: Trypomastigotes, epimastigotes and metacyclic trypomastigotes.

Life cycle:

- Habitat:
  a. Amastigotes in the cells of striated muscles (heart and skeletal), neurological cells of the nervous tissues and inside the cells of the reticuloendothelial system.
  b. Trypomastigotes in the peripheral blood.

- Definitive host: Man.
- Insect vector: *Triatoma megista* (winged bug or of reduviid bug).
- Reservoir host: Wild animals as armadillos & opossums, and domestic animals.
- Infective stage: Metacyclic trypomastigotes.

**Mode of infection:**

1. Contamination of skin wounds, conjunctiva and mucous membranes by bug’s faeces, containing the infective metacyclic trypomastigotes.
2. Blood transfusion.
3. Organ transplantation.
4. Accidental laboratory-acquired infection.
5. Transplacental.

- Man acquires the infection when the infective metacyclic trypanosomes in faeces of night-biting *Triatoma* are deposited during blood meal, and rubbed into the bite puncture, skin abrasion or mucous membranes as conjunctiva.

- Metacyclic trypanosomes are engulfed by local histiocytes, transform to amastigotes and multiply by binary fission, producing skin swelling (Chagoma).
- Infected cells rupture, liberating amastigotes which transform into trypomastigotes, invading circulation with dissemination to a variety of tissues.
- The bloodstream trypomastigotes do not replicate (different from the African trypanosomes). Replication resumes only when the parasites enter another cell.
- Kissing bug is infected by feeding on host blood contains trypomastigotes.
- In the insect vector there is a cyclo-propagative development, as the ingested trypomastigotes transform into epimastigotes in the midgut, where they multiply.
- After 10 days, the epimastigotes differentiate into non-dividing metacyclic trypomastigotes (infective form) in the hindgut, that pass out with faeces during blood meal and the cycle is repeated.

Pathogenicity and clinical picture:
- *T. cruzi* causes Chagas’ disease or South American trypanosomiasis.
  Pathogenicity depends on the affected parasitized cells and stage of the disease.

1. Acute stage: It occurs 1-2 weeks after infection and may last for 1-4 months.
- It is often seen in children and infants.

*Life cycle of Trypanosma cruzi.*
a. Chagoma: A localized oedematous swelling with erythema at the site of inoculation accompanied with local lymphadenopathy. It contains multiplying amastigotes in histiocytes.

b. Romana's sign: Inoculation of the parasite in conjunctiva causes unilateral facial oedema of cheek, upper and lower eyelids, usually with conjunctivitis and enlargement of ipsilateral pre-auricular lymph nodes.

![Romana's sign.](image)

c. In few patients, there may be fever, generalized lymphadenopathy, hepatosplenomegaly, toxic depression of bone marrow and anaemia.

- In severe infections, the patients may die of meningoencephalitis and acute myocarditis and acute congestive heart failure.

- Usually within 1-2 months, acute manifestations resolve and patients enter the asymptomatic or intermediate phase of chronic *T. cruzi* infection.

2. Chronic stage:
- It is found in adults and adolescents and becomes manifested years or even decades after the initial infection.

- Multiplication of *T. cruzi* inside the tissue cells causes inflammatory response, irreversible cellular destruction and fibrosis of muscles and nerves that control the tone of hollow organs, this is manifested by:
  - Cardiomegaly, cardiac arrhythmias and congestive heart failure.
  - Megaoesophagus, due to destruction of intramural plexus; manifested by dysphagia and aspiration pneumonia.
  - Megacolon, due to destruction of mesenteric plexus; manifested by intractable constipation and abdominal distention.
  - Other megaviscera, as the small intestine, urinary bladder and uterus.
  - Thyroiditis and thyroid insufficiency.
- Less commonly, peripheral nervous involvement causing spastic paralysis.
- Immunosuppression results in exacerbation of infection.

Diagnosis:
- Clinical diagnosis: History of traveling or residence in areas of South and Central America where the disease occurs.
- Laboratory diagnosis:
  I. Direct:
  Diagnosis is made by demonstration of *T. cruzi* in peripheral blood or tissue biopsy of involved lymph node or muscle (calf and deltoid), liver, spleen and bone marrow by:
  1. Microscopy:
     a. Examination of wet mount of peripheral blood reveals motile trypomastigotes.
        Thin and thick blood smears, stained with Giemsa, shows monomorphic trypanosomal forms in C or S shape. However, a blood smear works well only in the acute stage when parasites are seen circulating in blood.
     b. H & E stained tissue specimens show amastigotes.
  2. Culture: It is more sensitive than smear microscope. Epimastigotes and trypomastigotes are found on the NNN medium, 1-6 weeks after incubation.
  3. Animal inoculation: Intra-peritoneal inoculation of specimens into guinea pig or mice. After 10 days, blood is collected and examined for the trypomastigotes.

  4. Xenodiagnosis: This is the method of choice in suspected Chagas' disease, if other methods failed to detect very low parasitaemia, especially during the early phase of the disease. It depends on feeding a clean bred triatomine bugs on the suspected patient blood, 2-4 weeks later, dissection of the *Triatoma* gut reveals epimastigotes and metacyclic trypomastigote forms.

II. Indirect:
  1. Immunological diagnosis:
     a. Serological tests: They are the methods of choice for diagnosis of chronic Chagas' disease. Diagnosis is made by testing with at least two different serologic tests.
        * Antigen detection: *T. cruzi* antigens can be detected in urine and sera using ELISA.
        * Antibody detection: Antibodies (IgG) against *T. cruzi* can be detected by:
IHA, IFA, ELISA, CFT, DAT, and Chagas’ Stat-Pak rapid immunochromatographic test. False positive results are common with other disease as Leishmaniasis.

b. Cruzin test: It is an intradermal test used for the diagnosis of Chagas' disease. The antigen (cruzin) used is prepared from cultured trypanosomes. It gives a delayed hypersensitivity reaction in positive cases.

2. Molecular diagnosis: Can be used for diagnosis of chronic Chagas' disease.

3. Endoscope: It is valuable for diagnosis of megaviscera.

4. Barium dye meal and barium dye enema: They help in visualization of megaoesophagus and megacolon, respectively.

5. X-ray chest and electrocardiography (ECG): They are useful for diagnosis and prognosis of cardiomyopathy seen in chronic Chagas' disease.

Treatment:
1. Nifurtimox (lampit): It inhibits intracellular development of *T. cruzi*. It is the drug of choice in treatment of acute and early chronic cases.
2. Benznidazole (Radanil).
4. Treatment of megacolon: if possible, is dependent on removal of the aganglionic undilated segment and the redundant portion of the dilated segment.

Prevention and control:
1. Control of winged bugs.
2. Treatment of cases.
3. Personal protection by using repellants and bed net.
4. Control of reservoir hosts.
5. Serological screening of blood donors for *T. cruzi*.

Case study:
A South American patient with a past history of unilateral oedema of eyelids and face, is complaining now of irregular heartbeats and severe constipation. On examination, ventricular arrhythmia was observed. X ray after barium dye meal showed marked enlargement of colon.

Questions:
1. Mention the possible parasitic cause and the mode of infection.
2. Propose other diagnostic procedures for this case.
3. Develop a control plan for this parasitic infection.
APICOMPLEXA

General characters: Sporozoa or Coccidia
1. The coccidian are unicellular protozoa belonging to the phylum Apicomplexa.
2. They live intracellular, at least during a part of their life cycle.
3. They do not possess any organs of locomotion, but at some stages (sporozoites, merozoites and ookinete) in their life cycle, possess a structure called apical complex, by which they can attach to and penetrate host cells.
4. All coccidian have sexual gametogony phase and asexual schizogony phase.
5. Many of them show an alternation of hosts; a definitive and intermediate host.
6. They include:
   a. Haemosporina: *Plasmodium* and *Babesia*.
   b. Eimeriorina: *Toxoplasma gondii*, *Cryptosporidium parvum*, *Cystoisospora belli* and *Cyclospora cayetanensis*.

Haemosporina

*Plasmodium*

Species:
Four species of *Plasmodium* cause human malaria:

Geographical distribution:
- *P. vivax*: The most widely distributed species found in tropical, subtropical and temperate areas.
- *P. ovale*: West Africa.
- *P. malariae*: Tropical Africa and Far East.
- *P. falciparum*: Africa and Far East.

Life cycle:
- Definitive host: Female *Anopheles* mosquito.
- Intermediate host: Man.
- Reservoir host: No. However, in *P. malariae*, chimpanzee can be affected and act as a reservoir of infection.
- Habitat:
In mosquito: Gut, salivary glands.
In man: Intracellular inside the liver cells and RBCs.

- Infective stage:
  a. Sporozoites (in mosquito-borne malaria).
  b. Merozoites and/or trophozoites (in blood-borne malaria).

Mode of infection:
1. Bite of infected female *Anopheles*.
2. Blood-borne transmission:
   a. Blood transfusion (whole blood and packed RBCs).
   b. Shared syringes among drug addicts.
   c. Transplacental transmission.
   d. Organ transplantation.

- The life cycle of malaria parasites is heteroxenous (alternation of generations between two hosts), where an asexual cycle occurs in man (intermediate host), and sexual cycle occurs in female *Anopheles* (definitive host).

**I. Human cycle (Asexual cycle):**

- In this cycle the malaria parasites multiply asexually by division; schizogony, which occurs in 2 sites, in the liver cells (exoerythrocytic schizogony) and in the RBCs (erythrocytic schizogony).

  1. Exoerythrocytic schizogony or merogony (Tissue phase):
     a. Initial tissue phase:
        - During blood meal, a malaria-infected female *Anopheles* inoculates sporozoites with saliva into human host, which are carried within 30 minutes, by blood stream to the liver, and form parasitophorous vacuoles in hepatocytes.
        - The spindle-shaped sporozoites become rounded and transform into trophozoites, which multiply by schizogony, resulting in formation of thousands of pear-shaped merozoites with enlarged infected liver cells.
        - The mature schizont and the infected liver cells rupture in 6-15 days, releasing thousands of merozoites into the blood stream, with no clinical symptoms.
        - The interval between the inoculation of sporozoites into the human host and the first appearance of malaria parasite in blood is called the pre-patent period.

     b. Latent tissue phase:
        - In *P. vivax* and *P. ovale*, some sporozoites remain dormant in liver cells as hypnozoites. Months or years later, some hypnozoites are activated, start exo-erythrocytic schizogony, and release merozoites invading RBCs causing relapse.
Comparison of exo-erythrocytic phases of human malaria parasites.

<table>
<thead>
<tr>
<th>Differences</th>
<th><em>P. vivax</em></th>
<th><em>P. ovale</em></th>
<th><em>P. malariae</em></th>
<th><em>P. falciparum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Duration in days</td>
<td>8</td>
<td>9</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>2. Hypnozoites</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. No. of merozoites</td>
<td>10,000</td>
<td>15,000</td>
<td>2,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

2. Erythrocytic schizogony or merogony:
- The merozoites released by exo-erythrocytic schizogony attach to the RBCs by their apical complex, and then lie within an intra-erythrocytic parasitophorous vacuoles formed by red cell membrane, by a process of invagination.
- In the infected RBC, the merozoite appears rounded with vacuolated cytoplasm and the nucleus at one pole. This parasite is called the ring stage or young trophozoites.
- Young trophozoite feeds on the haemoglobin of RBC. The degradation products of haemoglobin appears as residual pigment granules inside the cytoplasm of the parasite, called malaria pigment or haemozoin pigment. Also, stippling occurs in the cytoplasm of infected RBCs.
- As the ring stage develops, it enlarges in size and becomes irregular in shape. This is called the old trophozoite.
- The nucleus of old trophozoite divides by mitosis followed by division of cytoplasm to become mature schizonts within 2-3 days.
- The mature schizont contains 8-32 merozoites and haemozoin. The cytoplasm not sharing in the formation of merozoites is called the residual body.
- The mature schizont ruptures releasing the merozoites, haemozoin and residual body into the circulation. Therefore, the typical malarial paroxysms occur by the 3rd or the 4th day, and malaria is described as tertian or quartan.
- Erythrocytic merozoites can re-invade new RBCs and repeat the erythrocytic cycle destroying each erythrocyte they infect, but never re-invade liver cells.

3. Gametogony:
- After few erythrocytic cycles, some merozoites invade new RBCs and instead of developing into trophozoites and schizonts, develop into sexually differentiated forms, gametocytes, where maturation is completed in 4 days.
- The mature gametocytes are round-shaped (*P. vivax, P. ovale* and *P. malariae*) or crescent-shaped (*P. falciparum*), with prominent pigment granules.
- The female gametocyte is large (macrogametocyte) with compact eccentric nucleus and pale blue cytoplasm, while the male gametocyte is small (microgametocyte) with large central nucleus and pale blue cytoplasm.

- Gametocytes do not cause any febrile illness in the host and individual who harbours gametocytes is a carrier. They are produced for propagation of species.

- Gametogony starts inside RBCs of intermediate host and is completed in the mosquito, the definitive host.

![Stages of erythrocytic schizogony of human malaria parasites.](image)

**II. Mosquito cycle (Sexual cycle or Sporogony):**

- When female *Anopheles* ingests parasitized RBCs during a blood meal, all parasitic stages are digested in the stomach, except micro- and macrogametocytes, which start a complex cycle of cyclo-propagative development.

- They escape from their RBCs envelope, and from one microgametocyte, 4-8 microgametes are developed by process of division called exflagellation. While, macrogametocyte matures by a process of nuclear reduction division giving rise to only one macrogamete.

**Exflagellation:** It is a process in which the male microgametocyte in the stomach of female *Anopheles*, undergoes division of its chromatin into 6-8 nuclei that migrate to the periphery of the parasite with part of the cytoplasm. They form several whip-like actively motile filaments (uninuclear microgametes), which then detach from the parent cell forming the individual microgametes.

- After half to two hours of the blood meal, one of the male gametes fertilizes the female gamete forming a rounded zygote.
- The zygote elongates and develops into a motile ookinete with an apical complex.
- Ookinete penetrates the gut wall, comes beneath the basement membrane, secretes a thin wall and develops into a spherical oocyst.
- The oocyst undergoes asexual division by sporogony, and thousands of sporozoites are formed. Rupture of oocyst will release sporozoites into the body cavity of female *Anopheles*, where some find their way to salivary glands.
- Sporogony is completed in about 1-4 weeks.
- When female *Anopheles* takes a blood meal from another human, the sporozoites are injected with the mosquito's saliva and the cycle is repeated.

Pathogenicity of malaria:
The major clinical manifestations of malaria are due to the products of erythrocytic schizogony and host’s reaction to them.

I. Destruction of parasitized RBCs:
- Rupture of infected RBCs at the end of a schizogony cycle results in:
  a. Tissue hypoxia because of reduction of blood flow by parasitized RBCs and subsequent fatty degeneration of liver and spleen.
  b. Release of haemozoin and parasite metabolites in blood stream resulting in hepatosplenomegaly. The soft, large spleen becomes susceptible to spontaneous rupture and in chronic infection it becomes firm and fibrotic. Kidneys are also enlarged and congested.
  c. Haemolytic anaemia and jaundice.

<table>
<thead>
<tr>
<th>Causes of anaemia in malaria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Obligatory destruction of RBCs at merogony.</td>
</tr>
<tr>
<td>2. Destruction of large number of RBCs by complement-mediated and autoimmune hemolysis.</td>
</tr>
<tr>
<td>3. Increased clearance of both parasitized and non-parasitized RBCs by the spleen.</td>
</tr>
<tr>
<td>4. Decrease erythropoiesis in bone marrow due to increased tumour necrosis factor.</td>
</tr>
<tr>
<td>5. Shortened red cell survival.</td>
</tr>
<tr>
<td>6. Failure of the host to recycle the iron bound in haemozoin pigments.</td>
</tr>
</tbody>
</table>
Life cycle of malaria parasites.

II. Host inflammatory response:
Occurs as an immune response of the host to the liberated parasite metabolites and malaria pigments.

a. Fever coincides with rupture of erythrocytic schizont with release of merozoites, parasitic pigments, and residual body in the blood stream. These materials activate tissue macrophages, which in turn produce interleukin-1, tumour necrosis factor and pyrogens which cause fever.

b. Activation of complement and immune complexes formation as a result of the antigen excess situation in chronic quartan malaria may lead to the deposition of these circulating antigen-antibody complexes within renal glomeruli leading to nephrotic syndrome.

III. Additional pathology associated with *P. falciparum*:

a. In *P. falciparum* infection, erythrocytic schizogony takes place in capillaries of internal organs as brain, kidney, spleen, bone marrow, and intestine. Knobs formation on the surface of RBCs infected with late stages of parasites (during the second half of the 48 hour life cycle) and the resulting increase in rigidity, lead to their adherence to receptors on the
endothelium of internal capillaries, a phenomenon termed cytoadherence. Also, infected RBCs adhere to uninfected RBCs, resulting in rosetting. These lead to sequestration of RBCs which ultimately block blood flow, with subsequent infarctions and haemorrhage, mainly in brain and large intestine. All these factors contributing to the development of severe disease (malignant malaria or pernicious syndrome).

b. Acute renal failure, tubular necrosis from tissue anoxia.
c. Black water fever (malarial haemoglobulinuria) due to massive intravascular haemolysis caused by anti-erythrocyte antibodies, leading to massive absorption of haemoglobin by renal tubules with its passage in urine causing haemoglobinuria (red urine). Sometimes, the haemoglobin is transformed into met-haemoglobin in the renal tubules, causing black-coloured urine; black water.
d. Adrenal and retinal haemorrhage.
e. Pulmonary oedema due to disseminated intravascular clotting.
f. Cardiac oedema, blocked capillaries and degenerated foci.
g. Spontaneous abortion.

Clinical picture:

1. Incubation period:
   - It is the interval between the inoculation of the sporozoites into the human host and appearance of the earliest manifestation of the disease (1st paroxysm).
   - It represents the duration of exo-erythrocytic cycle.
   - Patient may feel malaise, muscle pain, headache, loss of appetite and fever.

2. Malarial paroxysms:

The typical picture of malaria consists of series of febrile paroxysm, followed by anaemia and splenomegaly.

The febrile paroxysm occurs in 3 successive stages; cold, hot and sweating.

a. Cold stage: Intense cold and uncontrollable shivering for 15-60 minutes.
b. Hot stage: Intense heat, flushing, nausea, vomiting and severe headache, lasting for 2-6 hours.
c. Sweating stage: Decreased temperature and profuse sweating, lasting for 2-3 hours.
   - The paroxysm usually begins in the early afternoon and lasts for 8-12 hours.
   - It synchronizes with the erythrocytic schizogony cycle. With a 48-hour cycle, the fever recurs every third day; tertian malaria, and with 72-hour cycle, the fever recurs every fourth day; quartan malaria.
3. Anaemia of microcytic or a normocytic hypochromic type and jaundice.

4. Splenomegaly and hepatomegaly.

5. **Tropical splenomegaly syndrome (TSS) or hyper-reactive malarial syndrome (HMS):** A chronic benign condition occurs with any type of plasmodia, seen in some adults in endemic areas. This results from abnormal immunological response to malaria and is characterized by:
   - Hypersplenism and hepatomegaly.
   - High titers of circulating anti-malarial antibodies.
   - Hypergammaglobulinemia (IgM).
   - Presence of circulating immune complex.
   - Absence of malaria parasites in peripheral blood smears.
   - Normocytic normochromic anaemia which does not respond to haematinics or antihelmentics.
   - Differs from other types of splenomegaly in its response to anti-malarial drugs.

6. Nephrotic syndrome (oedema, proteinuria and hypo-albuminaemia) in *P. malariae* infection.

7. Pernicious malaria (acute falciparum malaria): It is a series of phenomena occurring in *P. falciparum* infection, which if not treated, threatens patient’s life.

   **Clinical types:**

   a. Cerebral malaria: Manifested by headache, hyperpyrexia, coma and paralysis.

   b. Black water fever: It is seen in patients with repeated *P. falciparum* infection and inadequate treatment with quinine. Clinical manifestations include vomiting, prostration with passage of dark red or black urine. This condition may be complicated with acute renal failure and circulatory collapse.

   c. Algid malaria: Characterized by peripheral circulatory failure, rapid pulse, low blood pressure, cold wet skin and profound shock. There may be severe abdominal pain, vomiting (gastric type), watery diarrhea (choleric type), or passage of blood in feces (dysenteric type).

   d. Septicaemic malaria: It is characterized by high continuous fever with dissemination of parasite to various organs, causing multiorgan failure.

8. Recurrence of malarial attack:

   a. Relapse: It is the recurrence of clinical manifestations of malaria and the reappearance of peripheral parasitaemia months or years after subsidence of a previous attack, in the absence of a new mosquito bite.
   - Species: Relapse occurs in *P. vivax* and *P. ovale* (infections last up to 4 years).
Cause: It is due to activation of the dormant hypnozoites initiating exo- erythrocytic schizogony, with the production of erythrotrropic merozoites.
- Can be prevented by giving primaquine to eradicate hypnozoites.

b. Recrudescence: It is a recurrence of clinical attack of malaria, few weeks or many years after apparent clinical cure, without re-infection.
- Species: Recrudescence can occur in all *Plasmodium* species, but it is more common in *P. falciparum* (up to 2 years) and *P. malariae* (up to 40 years).
- Causes: It results from the persistence of some erythrocytic parasites at a sub-clinical level, which start to multiply to reach significant numbers. It may be due to:
  a. Incomplete anti-malarial therapy.
  b. Anti-malarial drug resistance.
  c. Changes of the surface antigens (antigenic variation) of the parasites resulting in evasion of the host immune response.
  d. Splenectomy or immunosuppression.
- Can be prevented by adequate drug therapy or use of new antimalarial drugs in case of drug resistance.

Diagnosis:
- Clinical diagnosis: In endemic areas, malaria must be suspected in all cases of typical malarial paroxysm or fever.
- Laboratory diagnosis:

1. Parasitic diagnosis: Examination of thin and/or thick Leishman or Geimsa-stained blood smears. All erythrocytic stages can be detected in peripheral blood except in *P. falciparum*, only ring form alone or with gametocytes can be detected.

- Provocative tests are indicated in chronic infection, when no parasites are seen in peripheral blood. This may be done by subcutaneous injection of 0.5 ml adrenaline (Ascoli’s test), injection of TAB vaccine, milk or cold shower. So, the spleen contracts and squeezes its blood content to the peripheral circulation.

2. Therapeutic diagnosis: The non-subsidence of the febrile paroxysms after the administration of anti-malarial drug for 3 days, means that the case is not malaria.

3. Serodiagnosis:
   a. Circulating antibodies can be detected by IHA, IFA and ELISA.
   b. Circulating antigens can be detected by ELISA.
   c. Rapid immunochromatographic test for detection of malaria antigens by using a dipstick impregnated with specific monoclonal antibodies.


6. Biochemical diagnosis:
   - Hypergammaglobulinemia and low albumin level.
   - Hyperglycemia or hypoglycemia.
   - Hyperkalemia.

Treatment:

I. General and supportive measures: Given to treat symptoms and complications, e.g. antipyretics, fluids and electrolytes replacement and blood transfusion.

II. Antimalarial drugs: They are used with various objectives as:
   - Therapeutic: To eradicate the erythrocytic cycle and produce clinical cure.
   - Radical cure: To eradicate the exoerythrocytic cycle to prevent relapse.
   - Gametocidal: To destroy gametes to prevent transmission of infection to mosquito.
   - Chemoprophylaxis: To prevent infection in non-immune person visiting endemic areas.

A. Treatment of uncomplicated malaria:

1. Suppressive treatment (Erythrocytic schizonticides): These drugs act on the
erythrocytic stages, e.g. 4-aminoquinoline as chloroquine, quinine, and atebrine.

2. Prophylactic treatment (Tissue schizonticides): These drugs act on the exoerythrocytic stages, e.g. 8-aminoquinolines as primaquine.
- In blood-borne malaria (no exoerythrocytic stages), one of the anti-exoerythrocytic drugs should be given because it has a gametocidal effect.

3. Radical treatment: Two drugs are given to eradicate plasmodia, one acting on the erythrocytic stages, to improve the symptoms (chloroquine), and another one acting on the exoerythrocytic stages to prevent relapse (primaquine).

B. Treatment of complicated falciparum malaria:

1. Chloroquine-sensitive falciparum malaria: Treated with chloroquine along with primaquine (gametocidal).

2. Chloroquine-resistant falciparum malaria: Artemisinin combined therapy (ACT) should be used.
- ACT consists of an artemisinin or its derivatives combined with long-acting antimalarial drug as amodiaquine, mefloquine or sulfadoxine-pyrimethamine.
Differences between mosquito-borne and blood-borne malaria.

<table>
<thead>
<tr>
<th>Differences</th>
<th>Mosquito-borne malaria</th>
<th>Blood-borne malaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Infective stage</td>
<td>Sporozoite</td>
<td>Merozoite and/or trophozoites</td>
</tr>
<tr>
<td>2. Incubation period</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>3. Exo-erythrocytic schizogony</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>4. Hypnozoites</td>
<td>May be present</td>
<td>Absent</td>
</tr>
<tr>
<td>5. Relapse</td>
<td>May occur</td>
<td>Does not occur</td>
</tr>
<tr>
<td>6. Schizonticidal drugs</td>
<td>No radical cure</td>
<td>Can be radically cured</td>
</tr>
<tr>
<td>7. Radical treatment</td>
<td>Required</td>
<td>Not required</td>
</tr>
</tbody>
</table>

Prevention and control:
1. Mass treatment of infected cases.
2. Mosquito control.
3. Chemoprophylaxis: It is used to prevent erythrocytic infections by giving one of the tissue schizonticides. Primaquine is given for healthy individuals, one day before visiting a malaria-endemic area and continued for 4 weeks after the last exposure.
4. Vaccination.

Case study:
A 30-year-old Sudanese male was referred to a hospital in coma. Clinical examination revealed high-grade fever (41°C), low pulse rate (58/min), soft palpable spleen, hepatomegaly, jaundice and signs of cardiac oedema. His wife reported that during the last two weeks he suffered from recurrent attacks of fever, preceded by shivering and ended by profuse sweating.

Questions:
1. What is your possible diagnosis and the causative parasite?
2. Illustrate the mode of infection in such case.
3. How to confirm your diagnosis?
4. Predict two other phenomena that can occur if this infection is untreated.
5. Propose a therapeutic plan for this case.
General characters:
1. These coccidian parasites are characterized by a thick-walled oocyst stage that is typically excreted with the faeces of the definitive host.
2. Some coccidians (*Toxoplasma*) have a complicated life cycle, involving tissue cysts and multiple hosts (i.e., heteroxenous).
3. Other coccidians (*Cryptosporidium, Cystoisospora, and Cyclospora*) carry out their entire life cycle within the intestinal epithelial cells of the host.
4. They are generally considered opportunistic pathogens.

*Toxoplasma gondii*

Geographical distribution: Worldwide.
Morphology:

*Toxoplasma gondii* occurs in 4 forms:
1. Trophozoite (Tachyzoite):
   - It is crescent, 3X6 µ, with pointed anterior end and rounded posterior end.
   - It has an ovoid posterior nucleus and anterior paranuclear granules.
   - It is the active multiplying stage, seen intracellular in various tissues.
   - It multiplies by endodyogeny within cytoplasmic vacuoles of any nucleated cell.
   - It is found in the acute stage of infection.
2. Pseudocyst:
   - It is full of rapidly multiplying tachyzoites.
   - It has no cyst wall.
   - It is localized inside the RECs.
   - The tachyzoites multiply by endodyogeny and ectomerogeny.
   - It is found in the acute stage of infection.
3. True tissue cyst:
   - The cyst is round or oval, 5-50 µ and contains slowly multiplying bradyzoites.
   - It has cyst wall.
   - It is found in the brain (most common site), skeletal and cardiac muscles and various organs.
   - The bradyzoites multiply by endodyogeny and ectomerogeny.
   - It is found in the chronic stage of infection.
   - It remains viable for years, and immunosuppression causes reactivation of cysts.
4. Oocyst:
- This stage is only present in cats and other felines.
- It is oval, 10X12 µ and surrounded by a thick resistant wall.
- Non-infectious when excreted in unsporulated or immature stage in cat’s faeces.
- It sporulates, by sporogony, within 1-5 days and becomes infectious.
- The mature or sporulated oocyst contains 2 sporocysts, each containing 4 sporozoites (disporocystic tetrazoic oocyst).
- It may remain viable in moist shaded soil for a year or more.

Life cycle:
- Habitat:
  *T. gondii* is an obligate intracellular parasite, which is found inside the RECs, brain, skeletal and cardiac muscles, and any other nucleated cells.
- Definitive host: Cats and other felines.
- Intermediate host: Man and other mammals (mice, rabbits, goat, sheep, cattle, and pigs), reptiles and birds.
- Infective stage: All stages are infectious to humans; tachyzoites, pseudocysts, true tissue cysts and sporulated oocysts.

*Toxoplasma gondii.* A. Trophozoites; B. Pseudocyst; C. True cyst; D. Unsporulated oocyst; E. Sporulated oocyst.
Mode of infection:

1. Oral route via ingestion of:
   - Mature oocysts in food and drinks contaminated with cat's faeces.
   - Pseudocysts or true cysts in raw or undercooked contaminated meat.
   - Tachyzoites in unpasteurized goat's and cow's milk.

2. Inhalation of mature oocysts.


4. Organ transplantation.

5. Contamination of mucous membrane, skin abrasions during handling and preparation of fresh infected meat, or laboratory workers who handle infected blood can also acquire infection through accidental inoculation.

6. Transplacental route, where the tachyzoites can be transmitted from infected pregnant woman to the fetus via the blood stream (placenta).

7. Sexually transmitted or by artificial insemination with semen from infected male.

- The life cycle of *T. gondii* is heteroxenous (alternation of generations between two hosts), where an asexual cycle occurs in the intermediate host, and sexual cycle occurs in the definitive host.

   **I. Exoenteric cycle (Asexual cycle):**
   - It occurs in intermediate hosts (man, and other mammals, reptiles and birds).
   - Sporozoites from sporulated oocysts and trophozoites from tissue cysts, enter the epithelial cells of intestinal mucosa, and proliferate as tachyzoites by endodyogeny.
   - Tachyzoites continue to multiply and may spread locally to invade new cells.
   - Some tachyzoites also spread to distant extra-intestinal organs (e.g. brain, heart, skeletal muscles, eye, liver, spleen and placenta) by invading lymphatic and blood, forming tissue cysts.
   - Tachyzoites invade and multiply inside the RECs by either endodyogeny or ectomerogeny to form pseudocysts.
   - When the pseudocyst ruptures, the tachyzoites will invade either new macrophages or any other cells, multiply by endodyogeny or ectomerogeny, forming true tissue cysts full of bradyzoites.
- The dormant bradyzoites inside the cyst can be reactivated in immunosuppression causing renewed infection in the host.
- The released trophozoites can enter the blood and the cycle is repeated.
- Man acts as blind or final host or dead end for *T. gondii*.

**II. Enteric cycle (Sexual cycle):**
- It occurs in cats and other felines, definitive hosts.
- Both sexual reproduction (gametogony) and asexual reproduction (schizogony) occur within the mucosal epithelial cells of the small intestine of cat.
- Cats acquire infection by their predatory habit of feeding on muscles, brain and other tissues of infected mice, harboring the tissue cysts, or by eating raw infected meat of domestic animals, or by ingestion of mature oocysts passed in their faeces.
- The sporozoites and trophozoites are released in the small intestine, penetrate its mucosal epithelial cells and multiply inside by several asexual cycles of schizogony (endopolygony), leading to formation of merozoites.
- Some merozoites (from rupture of schizont) may enter extraintestinal tissues resulting in formation of tissue cysts in other organs of the body as in man.
- Other merozoites invade the intestinal mucosa again and transform into micro- and macrogametocytes, and sexual cycle (gametogony) begins, with formation of microgamete and macrogamete.
- A macrogamete is fertilized by microgamete with production of zygote which develops into an oocyst.
- Unsporulated oocysts are shed in the cat’s faeces for 1-2 weeks, and take 1-5 days to sporulate in the environment and become infective.
- Man and other intermediate hosts acquire infection by ingesting the sporulating oocysts and the cycle is repeated.

**Pathogenicity:**
- In toxoplasmosis, proliferation of tachyzoites in the host cells (intestinal and extra-intestinal), causes cellular death with focal necrosis and surrounding inflammatory cells.

1. In acute infection, the outcome of the disease depends on host immune status.
   a. In immunocompetent individuals, tachyzoites disappear from various organs.
b. In immunocompromised patients, there is dissemination of the parasites through the blood stream to various organs as brain, eyes, lungs, heart, liver, spleen, kidneys, lymph nodes, bone marrow and skeletal muscles, where they form pseudocysts causing severe necrotizing lesions and disease progression.

2. In chronic infection, true tissue cysts remain viable in tissues for years in resting form. In immunodeficient status, their reactivation cause clinical disease.

Clinical picture:
1. Congenital toxoplasmosis:
   - This occurs when the mother get infected for the first time during pregnancy. But, in some woman with chronic infection, reactivation of tissue cysts leads to liberation of trophozoites, which may infect the fetus.
   - The risk of fetal infection rises with progress of pregnancy. In contrast, the severity of fetal damage is high, when infection is transmitted in early pregnancy.
   - Clinical manifestations of congenital infections may be:
     a. Early manifestations: Still birth, abortion, hydrocephalus, microcephaly and microphthalmia. The most common sequelae are retinochoroiditis that affects vision and results in blindness, cerebral calcification, convulsions (clinical triad). In some cases, fever, lymphadenopathy, hepatosplenomegaly, anaemia, thrombocytopenia, petechial rash, jaundice, and myocarditis may present at birth.

b. Late manifestations: Mental retardation, visual affection and psychomotor disturbance in adolescence and adulthood.

2. Acquired toxoplasmosis:
   - It is asymptomatic in 80-90% of healthy hosts.
   - The classical clinical sign of acute acquired toxoplasmosis is lymphadenopathy and the deep cervical lymph nodes are the most commonly affected. The infected lymph nodes are discrete and non-tender.
   - Mild fever, headache, myalgia (Flu-like syndrome), and hepatosplenomegaly are often present.

3. Toxoplasmosis in immunocompromised patients:
   - In these patients affection of brain is more common, with meningoencephalitis, and neuropsychiatric manifestations.
   - Pneumonia, myocarditis, chorioretinitis and hepatosplenomegaly may occur.
Diagnosis:
- Clinical diagnosis:
  - A combination of signs as hydrocephalus or microcephaly, chorioretinitis and signs of intracerebral calcification make diagnosis of congenital toxoplasmosis probable.
- Acquired toxoplasmosis is diagnosed by exclusion from other diseases of the reticuloendothelial and lymphatic systems.
- Laboratory diagnosis:
  
  I. Direct:

  1. Microscopy:
    - Detection of trophozoites and tissue cysts in lymph node, bone marrow, spleen, placenta, blood, CSF, and amniotic fluid smears stained by Giemsa, PAS, or Gomori methanamine silver (GMS) stain.

  2. Animal inoculation: *Toxoplasma* can be detected by intraperitoneal inoculation of infective material in mice. After 7-10 days, peritoneal fluid is examined for trophozoites. Mice are sacrificed after 3 weeks and examined for tissue cysts.
II. Indirect:

1. Serodiagnosis:

   a. Sabin-Feldman dye test: It detects a circulating cytoplasm modifying antibody. Patient’s serum is mixed with a *Toxoplasma* trophozoites suspension and methylene blue is added. **If the parasite fails to take the stain, the test is considered positive.** The test gives false positive results in *Sarcocytis* and *Trichomonas vaginalis* infections.

   b. Antibody detection:
   - Tests for detecting IgG antibody include: ELISA, IFA, and IHA.
     - The serum IgM can be measured by ELISA.
     - Detection of specific IgM antibodies indicates acute infection, while positive IgG titer indicates latent infection.
   - IgM detected in babies’ blood is fetal in origin as maternal IgM doesn’t cross the placenta.
   - IgA-ELISA test is also used for detecting congenital infection in newborns.

   c. Antigen detection:
   - Detection of antigen by ELISA indicates recent *Toxoplasma* infection.
   - It is useful in immunocompromised patients.
   - Detection of antigen in amniotic fluid is helpful to diagnose congenital toxoplasmosis.

2. Molecular diagnosis:
   - Can be used for diagnosis of *T. gondii* DNA in blood, CSF, urine, and different tissues.
   - It is valuable especially in immunocompromised patients in whom antibody titers are low or absent.
   - Also, it can be used on amniotic fluid in case of congenital infection.

3. Imaging:
   - MRI and CT scan are used to diagnose CNS involvement.
   - US of fetus at 20-24 week of pregnancy is useful to diagnose congenital toxoplasmosis.

Treatment:

1. Congenital toxoplasmosis:
   - Neonates with congenital infection are treated with pyrimethamine and sulfadiazine with folinic acid for one year.
   - Systemic corticosteroids may be given to alleviate chorioretinitis.
2. Immunocompetent individuals:
   - Most healthy people recover from toxoplasmosis without treatment.
   - Persons who develop persistent, severe symptoms can be treated with a combination of drugs such as pyrimethamine and sulfadiazine or clindamycin, plus folinic acid.
3. Immunocompromised individuals:
   - Immunosuppressed patients who are positive for *T. gondii* and have a CD4\(^+\) T-lymphocyte count less than 100/µl should receive prophylactic measures against *Toxoplasma* encephalitis. Trimethoprim-sulfamethoxazole is the drug of choice, or dapsone-pyrimethamine.
   - Prophylaxis against *Toxoplasma* encephalitis should be discontinued in patients whose CD4\(^+\) T-lymphocyte becomes more than 200/µl for 3 months after successful treatment.
4. Pregnant women:
   - Spiramycin (Rovamycin) should be taken for 4 weeks, to treat the infected pregnant women to reduce the risk of transplacental transmission.

Prevention and control:
1. Women who are or may become pregnant should avoid contacts with cats or cleaning the litter box, and undergo routine serological screening.
2. Individuals at risk, mainly children and immunocompromised individuals should avoid contacts with cats and their faeces.
3. Proper washing of hands, vegetables and fruits before eating.
4. Proper washing of hands and utensils after handling raw meat.
5. Proper freezing and cooking of meat before eating.
6. Never fed raw meat to cats; only dry, cooked or canned meat should be fed.
7. Cats should be kept indoors and litter boxes changed daily. Cats' faeces should be flushed down the toilet or burned. Litter pans should be cleaned by immersing them in boiling water.
8. Screening for *T. gondii* antibody should be done in all blood banks.

**Case study:**
A young lady works in medical laboratory. She had been married 3 years ago, and she got pregnant and aborted twice.

**Questions:**
1. What is the possible parasitic cause?
2. What is the probable method of infection in such case?
3. Propose a good therapeutic plan for this case.
4. Develop a control plan for this parasitic infection.
**Cryptosporidium parvum**

Geographical distribution: Worldwide.

Morphology:
- Oocyst is spherical or oval, 4–6 µ in diameter.
- It contains 4 naked curved sporozoites (no sporocyst) with a residuum in between, which is formed of numerous granules and a spherical globule.

- There are 2 types of oocysts, thick- walled (80%) and thin- walled (20%).

Life cycle:
- Habitat: Beneath the brush border of the small intestinal mucosa (mainly jejunum), within the host cell membrane, but not within the cell cytoplasm (intracellular but extra cytoplasmic position).
- Definitive host: Man.
- Intermediate host: No.
- Reservoir hosts: Cattle, dogs and cats.
- Infective stage: Oocysts.

**Mode of infection:**
1. Faecal-oral route by ingestion of thick-walled oocysts in contaminated food or drinks.
2. Internal autoinfection by thin walled oocysts, which release sporozoites in situ.
3. Zoonotic transmission from the reservoir animals.
4. Air-borne infection.
5. Sexual transmission among homosexual individuals.

- The parasite completes its life cycle, asexual (schizogony) and sexual (gametogony) phases in a single host (monoxenous).
- Ingested oocysts release sporozoites in the upper gastro-intestinal tract, which invade epithelial cells of small intestine to be restricted to the apical surface of the cells; intracellular but extra cytoplasmic, within a parasitophorous vacuole.
- There, they undergo asexual multiplication (schizogony) and then sexual multiplication (gametogony) with formation of macro- and micro-gamonts.
- After fertilization, zygotes change to oocysts that sporulate in the infected host.
- Sporozoites released from the thin-walled oocysts infect the same host by internal autoinfection, while thick-walled oocysts are infective upon excretion in faeces, thus permitting direct and immediate faecal-oral transmission.
- Oocysts can remain viable in the environment for long period.

Pathogenicity:
- *C. parvum* causes cryptosporidiosis, a significant cause of water-borne outbreaks, travellers, house hold, nosocomial, and day care unit's diarrhea.
- The pathogenesis of *Cryptosporidium* is restricted to the apical surface of the epithelial cells of small intestine without affection of the host cell cytoplasm.
- Inflammatory changes occur as a result of infection, with crypts hyperplasia and villous atrophy of the affected area of small intestine, causing profuse watery diarrhea.

Causes of diarrhea in cryptosporidiosis:
1. Villous atrophy.
2. Reduction in the intestinal mucosal surface.
3. Decrease in the absorbing capacity of the small intestine.
4. Decrease in the digestive enzymes of the intestinal mucosal.
- Malabsorption and bacterial fermentation of unabsorbed sugar and fatty acids cause offensive diarrhea.

- In immunocompromised patients, dissemination of infection to lungs, oesophagus, colon, biliary tract, pancreas, and urinary bladder may occur.

Clinical picture:

1. In immunocompetent persons:
   - Most cases are asymptomatic.
   - There may be a short-term enteropathy with self-limited diarrhea lasting for 1-2 weeks. The most frequent symptoms are watery and offensive diarrhea, nausea, vomiting, abdominal cramps, anorexia, loss of weight and low-grade fever.

2. In immunocompromised patients:
   - Chronic, severe, profuse, watery, green, frothy and offensive diarrhea, as frequent as 5-10 or may reach over 25 motions / day, causing significant fluid and electrolyte depletion, weight loss, emaciation and abdominal pain.
   - Malabsorption may also lead to dehydration, weight loss, and death if it is not controlled.
   - Extraintestinal infection of respiratory system (respiratory cryptosporidiosis), hepatitis, cholecystitis, cholangitis and pancreatitis have been reported.

Diagnosis:

- Clinical diagnosis: Clinical history and presentation of the disease.
- Laboratory diagnosis:

  I. Direct:
  1. Stool examination:
     a. Microscopic examination of direct smear preferably after concentration by flotation techniques as: Sheather’s sugar, sodium chloride, zinc sulphate, or formalin-ether flotation.
     b. Acid fast staining techniques for detection of Cryptosporidium oocysts as: Modified Ziehl-Neelsen stain where oocysts appear deep red with blue granules against pale green background, or by kinyoun acid-fast or safranin stain.
     c. Fluorescent staining with auramine-phenol.
  2. Examination of duodenal aspirates obtained by entero-test.
  3. Examination of jejunal biopsy.

II. Indirect:

  1. Serodiagnosis:
     a. Antibody detection: IFA and ELISA.
b. Antigen detection: ELISA for detection of *Cryptosporidium* antigens in stool.

2. Molecular diagnosis: For detection of *Cryptosporidium* DNA in stool and biopsy material.

Treatment:
1. In immunocompetent patients: Cryptosporidiosis is self-limited.
2. In immunocompromised patients:
   - Nitazoxanide or paromomycin.
   - Supportive treatment: Fluid, electrolyte and nutrient replacement.

Prevention and control:
1. Treatment of infected patients.
2. Environmental sanitation as: Anti-fly measures, proper sewage disposal, safe water supply and avoid using excreta as fertilizer.
3. Washing green vegetables and fruits before eating.
4. Avoid contamination of food and drinks with faecal oocysts.
5. Strict personal hygiene as washing of hands after defecation and before eating.
6. Avoidance of zoonotic infection.
7. *Cryptosporidium* oocysts are very tough, resist most disinfectants. Only prolonged exposure to a chlorine concentration of 80 ppm for 2 hours, 10% formalin, or temperatures > 60 °C, or less than -20°C can kill them.
8. Proper filtration through a ≤ 1 µ filter or smaller or boiling of drinking water for 1 minute is essential particularly for immunocompromized patients.
9. In hospitals, contaminated instruments and equipments should be autoclaved to 65°C for 20-30 minutes to avoid nosocomial infection.
10. Contact with infected materials must be avoided by using gloves, gowns and hand washing.
Cystoisospora belli
(Formerly known as Isospora belli)

Geographical distribution: More common in tropics and sub-tropics.

Morphology:

1. Unsporulated oocyst:
   - It is oval, 30 X 12 μ, and surrounded by a translucent double-layered cyst wall.
   - It contains a spherical mass of protoplasm, which divides into 2 sporoblasts before sporulation.
- Since sporulation requires 3-4 days, unsporulated oocyst is the form usually seen in faeces.

2. Mature sporulated oocyst:

- It contains two sporocysts.
- Has 4 curved, sausage-shaped nucleated sporozoites (disporocystic tetrazoic).

![Mass of protoplasm](image1)

Cystoisospora belli. A. Immature oocyst; B. Mature oocyst.

Life cycle:
- Habitat: Epithelial lining of the small intestine (duodenum and jejunum).
- Definitive host: Man is the only recognized source of Cystoisospora belli infection, unlike cryptosporidiosis, cystoisosporiasis is not a zoonotic disease.
- Infective stage: Mature sporulated oocyst.
- Mode of infection: By ingestion of food or drink contaminated with sporulated oocysts.

**Cystoisospora belli** is a **host-specific parasite**, completing its life cycle (asexual and sexual phases) **in man**.

- After ingestion of sporulated oocyst, sporocysts excyst in the small intestine and release their sporozoites, which invade the epithelial cells and initiate asexual multiplication (schizogony) within a parasitophorous vacuole.
- Upon rupture of the schizonts, the merozoites are released, invade new epithelial cells, and continue the cycle of asexual multiplication.
- Some merozoites begin the sexual cycle (gametogony), with the development of gametocytes. Fertilization results in the development of oocysts.
- Immature unsporulated oocysts are released in the lumen of the bowel, while sporulation occurs in the environment within 3-4 day.
- If the sporulated oocysts are ingested by man, the cycle is repeated.
- Sporulated oocysts remain viable for months in the environment.
Life cycle of *Cystoisospora belli*.

Pathogenicity:
- *Cystoisospora belli* causes cystoisosporiasis, a cause of traveller’s diarrhea, with more severe form of the disease in infants and young children than adults.
- The pathogenesis of *Cystoisospora belli* is similar to that of *Cryptosporidium*, except that *Cystoisospora belli* invades the host cell cytoplasm.
- Inflammatory changes develop in the affected epithelium after invasion of enterocytes by the parasites, resulting in flattened mucosa with villous atrophy and crypts hyperplasia, and infiltration of lamina propria with eosinophils, lymphocytes and plasma cells.
- Peripheral eosinophilia.
- In immunocompromised patients, the infection is disseminated to liver, bile duct, large intestine and spleen.

Clinical picture:
1. In immunocompetent individuals:
   - Most cases are asymptomatic.
   - There may be a short-term enteropathy with self-limited diarrhea (few days to a
week), steatorrhea, abdominal colic and fever. Bowel movements usually from 6-10/ day, watery to soft foamy, and offensive, associated with weight loss.

2. In immunocompromised patients:
- It often presents with chronic, profuse, watery diarrhea, anorexia, weakness and weight loss associated with malabsorption syndrome. Dehydration can develop and be life-threatening.
- Extraintestinal infection of liver, spleen and bile duct has been observed.

Diagnosis:
- Clinical diagnosis.
- Laboratory diagnosis:
  I. Direct:
    1. Stool examination:
      a. Microscopic examination of direct smear preferably after concentration by floatation techniques.
      b. Acid fast staining techniques for detection of *Cystoisospora belli* oocysts as: Modified Ziehl-Neelsen, which shows pink-staining oocysts that contain bright red sporoblasts (protoplasmic mass), the cyst wall doesn’t stain, and it is usually outlined by a stain precipitate, or by kinyoun acid-fast or safranin stain.
      c. Fluorescent staining with auramine-phenol.
    2. Examination of duodenal aspirates obtained by entero-test.
    3. Examination of intestinal biopsy.
  II. Indirect:
    1. Charcot Leyden crystals can be detected in stool.
    2. Eosinophilia, which is generally not seen in other enteric protozoal infections, can be detected in cystoisosporiasis.

Treatment:
1. In immunocompetent patients: No treatment in self-limiting infection.
2. In immunocompromised patients:
   - Oral cotrimoxazole, a combination of trimethoprim and sulfamethoxazole (Bactrim, Septra, and Cotrim).
   - For patients intolerant to sulfonamides, pyreimethamine can be used.
   - It may be necessary to continue a maintenance dose with cotrimoxazole to prevent relapses.
   - Fluid and electrolyte replacement.
Prevention and Control:
1. Treatment of infected patients.
2. Control of food and water born infection.
3. Utilize approaches used for inactivation of *Cryptosporidium parvum* oocysts.

**Cyclospora cayetanensis**

Geographical distribution: More common in tropical and sub-tropical regions.

Morphology:

1. Unsporulated oocyst:
   - It is spherical, 8-10µ, with central morula, containing 6-9 retractile granules.
   - Since sporulation requires 5-10 days, unsporulated oocyst is the form usually seen in faeces.

2. Mature sporulated oocyst:
   - It contains 2 sporocysts; each contains 2 crescent-shaped sporozoites (disporocystic dizoic).

Life cycle:

- Habitat: Jujenal enterocytes.
- Definitive host: Man.
- Infective stage: Mature sporulated oocysts.
- Mode of infection: By ingestion of food or drink contaminated with sporulated oocysts.

- *Cyclospora cayetanensis* is a host-specific parasite, completing its life cycle phases in man.

- After ingestion of the sporulated oocysts, they excyst in the small intestine, and the released sporozoites invade the jujenal enterocytes, living within a parasitophorous vacuole, where they initiate asexual cycle (schizogony).

- Then, sexual cycle (gametogony) takes place resulting in the formation of unsporulated oocysts which are excreted in patients’ faeces.

- An obligatory phase of maturation of oocysts in the environment occurs in 5-10 days with the development of sporulated oocysts.
- If man ingests the sporulated oocysts, the cycle is repeated.

Pathogenicity:
- *Cyclocospora cayetanensis* causes cyclosporiasis. The disease is the cause of unexplained summer diarrhea and similar illness following travel to tropics.

- The pathogenesis of *Cycloclospora* is of similar to that *Cryptosporidium* except that *Cycloclospora* invades the host cell cytoplasm, while *cryptosporidium* is restricted to the apical surface of the cells.

- The parasitic invasion of the enterocytes, leads to damage and death of the cells due to parasite multiplication and inflammation mediated by T-cells or mast cells, resulting in villous atrophy and crypts hyperplasia.

Clinical picture:
1. In immunocompetent patients: Diarrhea is self-limited within 3-4 days. There is abrupt onset of watery diarrhoea that tends to relapse. It is accompanied by nausea, vomiting, flatulence and abdominal cramps.

- Infection may cause anorexia, fatigue, loss of weight and low grade fever.
2. In immunocompromized patients: Diarrhea is severe, prolonged for 3 weeks or longer and tends to recur, with colicky abdominal pain, malaise, vomiting, dehydration, substantial weight loss and muscle pain. Biliary affection may also develop.

Diagnosis:
- Clinical diagnosis.
- Laboratory diagnosis:

1. Stool examination:
   a. Microscopic examination of direct smear preferably after concentration by floatation techniques.
      - The key for diagnosis is concentration of the oocysts from faecal samples without the use of formalin because of low number of oocysts. Sheather’s sucrose flotation is the best procedure. Also, the addition of 2.5-5% potassium dichromate allows the sporocysts to sporulate at room temperature, and become more visible.
   b. Acid fast staining techniques for detection of oocysts as: Modified Ziehl-Neelsen, or safranin stain.
   c. Examination by UV Fluorescence microscope: Oocysts exhibit blue auto fluorescence.

2. Examination of duodenal aspirates obtained by entero-test.

3. Examination of jejunal biopsy.

Treatment:
- Cotrimoxazole, a combined treatment with trimethoprim and sulfamethoxazole is effective.

Prevention and Control:
1. Treatment of infected patients.
2. *Cyclospora* oocysts resist chlorine; infection can be prevented by boiling of water or disinfection by Ozone.
3. Proper washing of vegetables and fruits.
Case study:
A 40-year-old homosexual man with severe diarrhea was admitted to a University Medical Center. The patient had up to 10 episodes of diarrhea per day, and lost 9 kg in the period of 1 week. Stool specimens were tested for a wide panel of enteric pathogens (bacteria, viruses, helminths, and protozoa). The parasitologic examination of stools showed oocysts in the range of 4-5µ. No other pathogen was found in the specimens. The patient was treated with paromomycin. On the second day of treatment, the diarrhea promptly resolved, decreasing from 10 to 2 attacks per day.

Questions:
1. What is the possible parasitic cause?
2. What is the probable method of infection in such case?
3. Propose other procedures to confirm the diagnosis.
4. Predict two complications that can occur if this infection is untreated.
5. Develop a control plan for this parasitic infection.
Objectives

1. Discuss morphological characters, life cycle, pathogenesis, clinical picture, laboratory procedures, lines of treatment and prevention with control strategy of different helminthes.

MEDICAL HELMINTHOLOGY

This part deals with the study of helminths (worms) that parasitize man. They belong to two main groups:

1. **Platyhelminths** (flat worms)
   - Class: Trematoda
   - Class: Cestoda

2. **Nemathelminths** (round worms)
   - Class: Nematoda

**PLATYHELMINTHS**

Class: Trematoda (Flukes)

General characters:
- The members of this class are commonly known as flukes.
- Adults are leaf-like, pear-shaped or elongated worms.
- All trematodes possess two suckers as organs of attachment.
- Covered externally by a cuticle that may be smooth, spiny or tuberculated.
- The body is made up of systems:
**Hepatic or Liver Flukes**

*Fasciola gigantica* (Large liver fluke)

Geographical distribution: Human infection has been reported from many regions including Egypt, Africa and Far East.

Morphology:

1. Large Fleshy leaf-like worm, measures 3 -7x1 cm.
2. Body formed of small anterior conical part (cephalic cone), shoulders with parallel borders and posterior round end.
4. Digestive system: mouth leads to oesophagus with muscular pharynx, two long intestinal caeca with lateral compound branches and medial T or Y-shaped ones.
5. Genital system (reproductive system):
   a. Common genital pore: anterior to the ventral sucker.
   b. Testes: two highly branched, one behind the other, about the middle third of the body
   c. Ovary: branched at the right side in front of the testis.
   d. Uterus: short and convoluted.
   e. Vitelline glands: highly branched and extend along the lateral fields.

**Life cycle:**

- **Habitat:** adult worms live in the bile ducts and gall bladder.
- **Definitive host:** man.
- **Intermediate host:** snail *Lymnaea cailliaudi*.
- **Reservoir hosts:** herbivorous animals as cattle, sheep, goat and camels.
- **Infected stage:** encysted metacercaria in water and on aquatic vegetation.
- **Stages in the life cycle:** egg → miracidium → sporocyst → 1st and 2nd generation redia → cercariae → encysted metacercariae → adult.

**Egg:**
- **Size:** 160x80 µ.
- **Shape:** oval.
- **Shell:** thin.
- **Color:** light yellowish brown (bile stained).
- **Contents:** immature (yolk cells).
- **Special character:** operculated.

- Eggs are discharged with feces of infected host, in fresh water of canals, drains and River Nile, hatch within 2 weeks into miracidium.
The life cycle of *Fasciola spp.*

Miracidium: a phototropic pyriform ciliated organism that can swim in water and penetrates the snail intermediate host.

Sporocyst: Simple elongated sac in the snail.

Redia: Cylindrical larva in the snail.

**Cercaria:** *Leptocercous cercaria* formed of body (0.3mm) and simple tail (0.7mm).

- Body with 2 suckers (oral and ventral), primitive gut, excretory system of flame cells, and cystogenous glands that secrete the cyst wall.
- Cercaria comes out from the snail and moves in water, gets attached to aquatic vegetation.

Encysted metacercariae:

- Spherical 0.25mm.
- Thick white cyst walls.
- They need about 12 hours after encystation to cause infection, and they live in water for 6–10 months.
Mode of infection:
- By eating raw water vegetations or vegetables washed in infected water and by drinking infected water polluted by the **encysted metacercaria**.

  - In the duodenum, the cyst wall dissolves and the metacercaria penetrate the wall of the intestine to reach peritoneal cavity.
  - Metacercariae pass to the liver through its capsule → through the liver tissue to their final habitat in the bile duct, where they mature to adult in about two months after infection, eggs appear in the stool 3-4 months after infection.

Pathogenicity and clinical picture: Four Symptomatic Patterns

- **Acute Phase**
  - Rarely seen in humans.
  - Fever, tender hepatomegaly, and abdominal pain are frequent symptoms.
  - Vomiting, diarrhea, and anemia may be present.

- **Chronic Phase**
  - Symptoms include: Irregular fever, biliary colic, abdominal pain, tender hepatomegaly, and jaundice.
  - In children: severe anemia and high eosinophilia are common.
  - Inflammation of the bile ducts leads to fibrosis and a condition called “pipe-stem liver”.
  - Liver rot: mechanical and toxic destruction of liver tissue by passage of large number of immature worms through the liver tissue leads to necrosis, fibrosis, hepatitis, and hepatomegaly
  - Severe infections can lead to death.

Halzoun:
- Occurs when an individual consumes infected raw liver.
- The living *Fasciola* adult worm attach to the mucosa of the pharynx by its suckers. This causes oedematous congestion of the pharynx and larynx resulting in dysphagia and suffocation.

The case is treated by:
  a) Gargling with alcoholic drink.
  b) Giving emetic drugs.
  c) Picking up of the worm by forceps.

- Tracheostomy in suffocation
- **Ectopic Infection**: In frequent, but can occur in peritoneal cavity, intestinal wall, lungs, subcutaneous tissue, and very rarely in other locations.

**N.B.**:

**False fascioliasis**: it is due to eating of infected animals liver and passage of eggs in the stool. This must be excluded by repeated stool analysis one week after liver free diet.

**Diagnosis**:

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Fever, hepatomegaly, habit of green salad consumption</th>
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<tbody>
<tr>
<td>Laboratory</td>
<td>1-Stool examination: for detection of eggs, after asking the patient to stop eating liver for a few days before examination. N.B.: Flukes do not begin to produce eggs until about 4 months after infection. Prior to 4 months: serological tests can be used. - Serological tests: are of value during the migratory stage of the worms and ectopic infection for estimation of specific antibodies, as ELISA, IHA. - Examination of sample of aspirated duodenal contents. 4- Eosinophilia. 5-Ultrasound and CT</td>
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</tbody>
</table>

**Treatment**:

1. Bithionol (Bitin).
2. Triclabendazole (Fasinex).

**Prevention and control**:

2. Snail control.
4. Protection: - Pure filtered water supply. - Proper washing or cooking of aquatic vegetation.

**Fasciola hepatica**

**Pathogenicity**:

- The adult worm can live in sheep for 5 year and cause liver cirrhosis and ascitis.
  - In man; the young adults burrow through the liver tissue feeding on its cells causing inflammation, necrosis (liver rot) and marked eosinophilia.
  - The other pathological findings are similar to *F. gigantica*.
It is similar to *Fasciola gigantica* but differs in:

<table>
<thead>
<tr>
<th><em>Fasciola gigantica</em></th>
<th><em>Fasciola hepatica</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Size: 3-7x 1 cm.</td>
<td>Smaller, 2-3x1.3 cm.</td>
</tr>
<tr>
<td>4) Ventral sucker: bigger.</td>
<td>Oral and ventral suckers are equal.</td>
</tr>
<tr>
<td>5) Medial intestinal caeca: T or Y shaped.</td>
<td>Rudimentary.</td>
</tr>
<tr>
<td>6) Snail host: In Egypt: <em>Lymnea cailliaudi</em>.</td>
<td>In Europe: <em>Lymnea truncatula</em>.</td>
</tr>
<tr>
<td>7) Reservoir host: Herbivorous animals as cattle &amp; buffalos.</td>
<td>Sheep.</td>
</tr>
</tbody>
</table>

Diagnosis, treatment, prevention and control are similar to *F. gigantica*.

**Case study:**

A 36-year-old man suffering from intermittent fever, diarrhea, indigestion and abdominal pain in the right hypochondrium. Upon examination, he had a slightly enlarged tender liver and yellow colouration of the sclera. When questioned regarding his eating habits, the patient admitted to having a fondness for uncooked water-cress and raw vegetables. Stool examination for ova& parasites was ordered. Blood sample was collected for complete blood count and liver function tests. Haematology results showed evidence of anaemia and eosinophilia (60% eosinophils). The patient's liver enzyme levels were slightly elevated. The diagnosis was made microscopically after the observation of large, oval, 160x80 u, yellowish-brown, operculated eggs in the concentrated stool specimen.

Questions:

1. Which parasite might be causing this infection?
2. Which other helminth lays eggs indistinguishable from the eggs described in this specimen?
3. How does transmission of this parasite occur?
4. What are the usual symptoms of the disease in humans?
5. How the diagnosis of this infection is usually made?
6. How do you exclude false diagnosis?
Intestinal flukes

*Heterophyes heterophyes*

Geographical distribution: Common in Egypt in Nile Delta, especially around the lakes of Manzala and Borollos, Turkey and Far East (Japan, China, Korea, Philippine).

Morphology:

1. Size: 1.5-3mmx 0.5 mm.
2. Shape: Pear shape, the anterior end is more or less narrow, while the posterior end is broadly rounded, some spines cover the cuticle especially anteriorly.
3. Suckers: three suckers
   - Oral sucker: small around the mouth.
   - Ventral sucker: large about the middle of the body.
   - Genital sucker: posterolateral to the ventral sucker.
4. Genital system:
   - Testes: two oval, smooth, and opposite each other in the posterior part of the body.
   - Ovary: One ovary, smooth in front of the testes.

Life cycle:

- Habitat: adult lives between the villi of the small intestine.
- Definitive host: man.
- Intermediate host: first is a snail, called *Pirenella conica*.
- Second is fish, Tilapia (Bolty) and Mugil (Boury).
- Reservoir host: cat, dog, and any fish eating animals.
- Infective stage: encysted metacercaria in the muscles of the fish (2\textsuperscript{nd} I. H.).
- Stages in the life cycle: egg $\rightarrow$ miracidium $\rightarrow$ sporocyst $\rightarrow$ 1st and 2nd generation redia $\rightarrow$ cercaria $\rightarrow$ encysted metacercaria $\rightarrow$ adult.

Egg: Size: 30x15 µ.
Shape: Oval.
Shell: Thick with operculum at one pole and a small Knob at the other. Colour: golden yellow.
Contents: Full mature embryo (miracidium).

Eggs pass with the stool, which must reach to brackish water.
In water, the eggs are ingested by the snail first intermediate host (*Pirenella conica*) common in lakes Manzala and Borollos in Egypt.
In the snail, the miracidium hatches into a sporocyst, that gives rediae then cercariae, which escape from the snail in about 30 days and become free in water.
Life cycle of *H. heterophyes*

**Cercaria:** - Consists of body and tail.
- The body: is oval, has 2 suckers, primitive gut, 2 dark eye spots and 7 pairs of penetration glands.
- The tail: is simple, covered from one side by membrane which reaches to the tip of the tail then ascend to cover the distal 1/3 of the other side, it is called *lophocercous cercaria* (pipe like).

- The cercaria in water searches for the second intermediate host, which is fish, *Tilapia* (Bolty) and *Mugil* (Boury).
- It penetrates the tissue of fish and becomes encysted metacercaria under the scales or in the muscles, and become infective within 20 days, it is spherical and 250 µ.

**Mode of infection:** By eating insufficient cooked, roasted or salted fish, staked less than ten days (sweet fesekh), containing the infective stage (encysted metacercariae).

-In the small intestine the cyst wall is dissolved, the metacercariae embedded between the villi, maturate and the eggs appear in the stool 2-5 weeks after infection.

Pathogenicity and clinical picture:
Intestinal
Attachment of the parasite to the mucosal membranes; inflammation with superficial ulcers and necrosis occur.
*Mild infection with no symptoms
*Heavy infections cause:
- Abdominal colic. - Abdominal discomfort.
- Chronic intermittent diarrhea, sometimes with blood

Extra-intestinal
The eggs may reach the general circulation to different organs and form parasitic granuloma and fibrosis

**Diagnosis:** Stool examination for the characteristic eggs.
**Treatment:**
1. Praziquantel (Biltricide).
2. Niclosamide (Yomesan).

**Prevention and control:**
1. Sanitary disposal of feces.
2. Avoid eating raw, insufficient cooked fish or salted fish, salted less than 10 days (sweet fessekh), and proper grilling of fish.
3. Fried fish is safe as temperature needed for frying is high enough to kill metacercariae.
4. Periodic examination of fishermen stool for *Heterophyes* eggs.
5. Mass treatment of infected cases.
6. Snail control.

**Lung fluke**

*Paragonimus westermani*

**Geographical distribution:** Heavily infected areas are found primarily in the Far East including Japan, Korea and Taiwan; it is also found in central Africa.

**Adult morphology:**

<table>
<thead>
<tr>
<th>Shape</th>
<th>Ovoid, thick, reddish brown, rounded anteriorly and tapering posteriorly.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>0.5 - 1.5 cm in length</td>
</tr>
<tr>
<td>Suckers</td>
<td>the oral and ventral suckers are equal</td>
</tr>
<tr>
<td>Genital system</td>
<td>a) Testes: deeply lobed situated nearly side by side midway between the ventral sucker and posterior end.</td>
</tr>
<tr>
<td></td>
<td>b) Ovary: large, lobed and situated behind the ventral sucker, the uterus coils opposite to it</td>
</tr>
</tbody>
</table>

**Life cycle:**
Habitat: Worms generally live in pairs encapsulated in pockets of the lungs.

Definitive host: Man

Intermediate hosts:
1st I.H. → snail *Melania* & *Semisulcospira.*
2nd I.H. → crabs and crayfish

Reservoir host: Carnivores as dog, fox, wolf, tiger, and pig

Infected stage: Encysted metacercaria in muscles, gills, legs, and viscera of crabs and crayfish.

Stages in the life cycle: egg → miracidium → sporocyst → redia → cercaria → metacercaria → adult.

- The life cycle is completed in 6-8 months.

Egg:

<table>
<thead>
<tr>
<th>Size</th>
<th>100 x 50 µ</th>
<th>Color</th>
<th>Golden brown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Ovoid</td>
<td>Content</td>
<td>Immature miracidium</td>
</tr>
<tr>
<td>Shell</td>
<td>Thick shell</td>
<td>Special characters</td>
<td>With flat operculum</td>
</tr>
</tbody>
</table>

- The eggs escape from the pulmonary pockets through the bronchioles and are coughed out with sputum, or swallowed and pass immature with feces.

- Eggs require from 15 days to several weeks in water to complete embryonation then
hatch and miracidia escape.
Miracidium: enters the snail first I.H. then develops into sporocysts → rediae → cercariae in 3-5 months.

Cercaria: Microcercous with a knob like tail. The released cercariae penetrate the crustaceans 2nd I.H. then develop into metacercariae.

Metacercaria: requires 6-8 weeks to become infective.

**Mode of infection:**

- Human and mammals’ infection occur by eating raw or insufficiently cooked crabs or crayfish infected with the encysted metacercariae.
- Metacercariae excyst in the small intestine pass through the intestinal wall, grow for about one week into young flukes, penetrate the diaphragm and pleural cavity and come to rest in the lung, forming cystic cavities then get mature.

Pathogenicity and clinical picture:
1. The worms provoke granulomatous reactions leading to fibrotic encapsulations of the parasites with a picture of generalized or localized diffuse fibrosis, pneumonia and tubercles like abscesses.

<table>
<thead>
<tr>
<th>2. Clinically: The disease is insidious in onset.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- There may be initial episodes of chills and fever with persistent cough and haemoptysis.</td>
</tr>
<tr>
<td>- The sputum is viscous and flecked with dark golden brown particles and may be bloody.</td>
</tr>
</tbody>
</table>

3. Eosinophilia (20 - 25 %).

4. Pleural effusion may occur.

Diagnosis:

1. By finding the characteristic eggs in sputum, feces or in aspirated pleural effusion.
2. Plain x-ray chest and computerized tomography show nodular shadows & cavities.
3. Immunodiagnostic tests as ELISA to detect early & chronic infection.

Treatment: Praziquantel.

Prevention and control:

1. Avoid eating raw, inadequately cooked or freshly salted crabs or crayfish.
2. Treatment of cases.
3. Snail control.
Blood flukes (Schistosomes)

Human beings are infected with three main species of schistosomes:

1. *Schistosoma haematobium*: causing urinary schistosomiasis. (present in Egypt)
2. *Schistosoma mansoni*: causing intestinal schistosomiasis. (present in Egypt)
   (not present in Egypt)

*Schistosoma haematobium*
(Urinary schistosomiasis)

Geographical distribution:
Africa: scattered areas. In Egypt, it is prevalent all over the Nile Valley.
Asia: Syria, Palestine, Iraq, Iran, Saudi Arabia, Yemen, India.
Europe: Cyprus and South Portugal.

Adult morphology:

<table>
<thead>
<tr>
<th>Size</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 -2cm x 1 mm</td>
<td>long (2 - 2.5 cm x0.25mm)</td>
</tr>
<tr>
<td>Shape</td>
<td>flattened, lateral margins are folded ventrally to form the gynaecophoric canal</td>
<td>cylindrical (round in cross section)</td>
</tr>
<tr>
<td>Tegument</td>
<td>provided with fine tubercles on the dorsal surface</td>
<td>smooth.</td>
</tr>
<tr>
<td>Suckers</td>
<td>sub-terminal oral sucker around the mouth and a larger ventral sucker some distance behind</td>
<td>weakly developed</td>
</tr>
<tr>
<td>Digestive system</td>
<td>mouth, oesophagus without muscular pharynx, two simple intestinal caeca that unite in the middle into single blind caecum</td>
<td>like male but union of intestinal caeca occurs at the posterior third</td>
</tr>
<tr>
<td>Genital system</td>
<td>Testes :4-5 separate testes, smooth, globular arranged in one line posterolateral to the ventral sucker. Male genital pore :behind the ventral sucker.</td>
<td>Ovary :oval, smooth lies just in front of the intestinal union. Uterus: long, straight, terminates at the genital pore, contains one row of 20 - 30 ova Vitelline glands: extend from behind the ovary till the posterior end.</td>
</tr>
</tbody>
</table>
Life cycle:
- Habitat: Schistosoma haematobium adults live in the vesical and pelvic venous plexuses in man surrounding the kidney, pelvis, urinary bladder, urethra, prostate, seminal vesicles, lower 1/3 of uterus and vagina.
- Definitive host: man.
- Intermediate host: snail Bulinus truncatus in Egypt.
- Reservoir host: no reservoir host.
- Infective stage: furcocercus cercaria.
- Stages in life cycle: egg → miracidium → sporocyst → furcocercous cercaria → adult.

Life cycle of Schistosoma species
Egg: Eggs sweep out in urine and rarely with feces.

<table>
<thead>
<tr>
<th>Size</th>
<th>120 x 60 µ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>oval</td>
</tr>
<tr>
<td>Shell</td>
<td>thin with terminal spine.</td>
</tr>
<tr>
<td>Colour</td>
<td>translucent.</td>
</tr>
<tr>
<td>Contents</td>
<td>mature miracidium.</td>
</tr>
</tbody>
</table>

Miracidium: - In fresh water the miracidium hatches.
- It is distributed homogeneously in water.
- It penetrates the soft tissue of the snail intermediate host (*Bulinus truncates*) where it develops into first and second generation sporocysts then cercariae that escape into water. Each miracidium gives rise to 250,000 cercariae.

Cercaria: (furcocercus cercaria)
- Body: 200 µ in length with 2 suckers, primitive gut and 5 pairs of penetration glands.
- Tail: 300 µ in length, bifid or bi-forked Forked cercaria is the infective stage.
- The cycle inside the snail takes 1-2 months.
- It survives in canal water for 48 hours and is attracted to man by the body temperature.
- The body of cercaria enters the skin or mucous membrane leaving the tail

**Mode of infection:**
1. Infection occurs by skin penetration within minutes up to half an hour as water begins to dry, after bathing, washing or playing in infected canals. Penetration is helped by the penetration glands and mechanically by the tail activity.
2. Drinking water may lead to infection when cercaria penetrates the (schistosomulum). It is carried by the blood ➔ left side of the heart ➔ systemic circulation ➔ intestinal capillary bed ➔ intra-hepatic branches of the portal vein where it matures in 7 weeks.
   - Then male carries the female in the gynaecophoric canal and migrates out of the liver in the portal vein against the blood stream to reach the vesical and pelvic plexuses to deposit the eggs.
   - Eggs appear in urine 10 weeks after infection.
Pathogenicity and clinical picture:
Disease: schistosomiasis haematobium, vesical or urinary bilharziasis:
There are four progressive stages:

<table>
<thead>
<tr>
<th>Stage of invasion</th>
<th>Skin reaction due to cercarial penetration in the form of local dermatitis, itching (bather's itch), irritation and papular rash.</th>
</tr>
</thead>
</table>
| Stage of migration | Due to circulating schistosomules  
Lung: verminous pneumonitis (small patches of inflammation) & hemorrhage, with cough, sputum & heamoptysis.  
b- Liver and spleen: hepatosplenomegaly.  
Metabolic products of maturing parasites $\rightarrow$ toxic and allergic manifestations e.g. urticaria, fever, headache, cough, wheezes, muscle pain, leucocytosis & eosinophilia. |
| Stage of egg deposition and extrusion (early-acute stage) | Active egg deposition with escape of eggs in urine $\rightarrow$ tissue damage and hemorrhage that manifest with:  
Terminal haematuria (blood in the last part of micturation) which is due to increased contraction of bladder $\rightarrow$ injury of venules by egg spine $\rightarrow$ drops of blood in urine.  
b- Frequency of micturation.  
c- Dysuria (burning pain during micturation). |
| Stage of tissue proliferation, repair and fibrosis (chronic-late stage) | -Eggs trapped in the wall of blood vessels stimulate both humoral and cellular immune response to miracidial antigen $\rightarrow$ aggregation of inflammatory cells around eggs (granulomas) and fibrosis with the formation of sandy patches, bilharzial nodules, papillomata which may ulcerate.  
- Inflammatory reaction heals by fibrosis :  
a- Urinary bladder: polyps, ulcers, cystitis, contracted bladder, calcified bladder, diverticulosis, malignancy (due to parasite toxic secretions).  
b- Ureters: stricture, hydroureter.  
c-Kidneys: hydronephrosis, 2ry infection (pyonephrosis) & renal failure.  
d-Urethra: stricture, fistula.  
e-Genital organs: pseudo-elephantiasis of the penis, granuloma in prostate, seminal vesicle, spermatic cord, ovaries, uterus and vagina.  
Embolic lesions: *Schistosoma* eggs are swept by blood to reach various organs (liver, lungs, brain or other organs).  
Eggs swept from the pelvic and vesical plexuses to $\rightarrow$ the pulmonary artery branches produce granulomata and fibrosis with obliteration of blood flow $\rightarrow$ pulmonary hypertension, right ventricular hypertrophy and right sided heart failure (Bilharzial cor-Pulmonale). |
Diagnosis:

I. Clinical: history of terminal haematuria & dysuria in endemic area is suggestive. In mild infection, haematuria manifests only after muscular activity. Infection of seminal vesicle manifests by blood in seminal fluid.

II. Laboratory:

a. Direct methods:

1. Detection of eggs in urine: microscopical examination of last drop of urine sample for the eggs after sedimentation or centrifugation (concentration method).

2. Cystoscopy: in chronic cases when eggs cannot be detected in urine, for histopathological lesions as well as eggs.

*Eggs should be examined for viability by the hatching test to differentiate between living and dead eggs: fresh water is added to the urine sediment and examined after 30 minutes by a hand lens to demonstrate swimming miracidia.

<table>
<thead>
<tr>
<th>Living egg</th>
<th>Dead egg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Translucent</td>
<td>Opaque</td>
</tr>
<tr>
<td>Intact moving miracidium</td>
<td>Dead miracidium (not motile or silent)</td>
</tr>
<tr>
<td>Contracting and relaxing.</td>
<td></td>
</tr>
<tr>
<td>Surrounded by R.B.Cs.</td>
<td>No R.B.Cs</td>
</tr>
<tr>
<td>Hatches in fresh water (Positive hatching test)</td>
<td>Does not hatch (Negative hatching test)</td>
</tr>
</tbody>
</table>


4. ELISA for circulating antigens.

b. Indirect methods: Serological tests for detection of antigen antibody reaction.

1. Indirect haemagglutination test (IHA).
2. Indirect fluorescent antibody test (IFA).
3. Enzyme-linked immunosorbent assay (ELISA): for antibodies detection.

Treatment:

1. Praziquantel (Biltricide or Distocide).
2. Metrifonate (Bilarcil).
**Schistosoma mansoni**  
*(Intestinal schistosomiasis)*

Geographical distribution:
It is widespread in Africa.

In Egypt, it was prevalent in the region of the Nile delta, but after construction of the high dam, it invaded upper Egypt.

Also *S. mansoni* is found in Saudi Arabia, Yemen and Tropical America.

Morphology: similar to *S. haematobium* with few differences listed below:

1. Male: -size: shorter, 8-10mm x 1mm.  
   -Cuticle: more coarsely tuberculated.  
   -Digestive system: intestinal caeca unite at the anterior third.  
   -Testes: 6-9 as a mass.

2. Female: -size: shorter, 14-22mm x 0.15mm.  
   -Digestive system: union of intestinal caeca occurs at the anterior third.  
   -Ovary: at the anterior third.  
   -Uterus: short with 1-4 ova.

3. Egg: size: 140 x 70 µ.  
   Shape: oval.  
   Contents: mature miracidium.

Eggs sweep out with feces and rarely in urine.

4. Miracidium: found in the upper layer of water, has fused penetration glands.

5. Cercariae: provided with 6 pairs of unicellular penetration glands.

**Life cycle:**
-Habitat: radicals of the inferior mesenteric vein draining the large intestine, and in the portal system.  
-Definitive host: man.  
-Intermediate host: snail *Biomphalaria alexandrina* in Egypt.  
-Reservoir host: monkeys and rodents.
Pathogenicity and clinical picture:

**Disease**: schistosomiasis mansoni, intestinal bilharziasis.

**Pathogenicity of Schistosoma mansoni** is similar to that of *Schistosoma haematobium* with the following variations:

- **Stage of egg deposition and extrusion (early or acute stage):**
  
  Active egg deposition especially in the pelvic colon and rectum leads to erosion of submucosa and villous tissue followed by inflammation, tissue damage and hemorrhage. The patient suffers from:
  
  a. Dysentery with mucous and blood in the stool.
  b. Abdominal pain.
  c. Frequent stool.

- **Stage of tissue proliferation, repair and fibrosis (chronic or late stage):**
  
  a. Eggs trapped in the wall lead to formation of sandy patches, nodules and papillomata. The wall becomes thickened, fibrosed and may be complicated with strictures, sinuses, fistulae and prolapse.
  b. Embolic lesions: female *S. mansoni* produces about 300 eggs/day. 50% are swept by blood and reach the liver. They block the presinusoidal capillaries and the soluble egg antigen (SEA) elicits T-cell dependent granulomas around each egg → periportal fibrosis and portal hypertension → splenomegaly, ascitis and oesophageal varices due to opening of the porto-systemic shunts at the cardiac end of the oesophagus.
  c. Haematemeses: due to ruptured oesophageal varices.
  d. Melena: digested blood after ruptured oesophageal varices.
  e. Eggs directed to the lungs by collateral circulation lead to cor-Pulmonale.
  f. Renal involvement occurs due to precipitation of immune complexes in the glomerular vascular bed leading to end-stage renal failure.

**Diagnosis:**

**I. Clinical:**

a- Early: diarrhea and dysentery with mucus and blood in stool.

b- Late:
  
  • Anal fissures and perianal sinuses.
  • Bilharzial hepatic fibrosis causing:
    - Portal hypertension.
    - Splenomegaly &ascitis.
- Hepatic dysfunction.
  - Portal hypertension, haematemesis and melena.
  - Blood loss, leading to iron deficiency anaemia.

II. Laboratory:

a. Direct methods:
   1. Stool examination: detection of the characteristic eggs in stool (lateral spine).
   2. Rectal swab using a gloved finger lubricated with soap to palpate the pathological lesion in the rectum and the fecal sample are then examined on a slide for *Schistosoma mansoni* eggs.
   3. Sigmoidoscopy and rectal biopsy to visualize the mucosa of sigmoid colon for pathological lesions and *Schistosoma* eggs.
   4. ELISA for circulating antigens.

b. Indirect methods: as schistosomiasis haematobium.

Treatment:

1. Praziquantel: a single oral dose is effective against all *Schistosoma* species infecting man.
2. Oxamniquine (Vansil).
3. Chemotherapy followed by surgical interference in portal hypertension.

N.B.: urine and stool examination should be done after 3 months of treatment for *Schistosoma* eggs. The viability test should be done to decide whether the patient is cured or not.

Case study:

A 13-year-old male, from a village near Mansoura, presented to the Out-Patient Clinic of Mansoura University Hospital with complaints of painful urination, the presence of blood in his urine, fatigue, fever and general body aches. Upon examination, the physician ordered a urine analysis and urine culture to rule out a urinary tract infection. Culture results were negative for pathogenic bacteria. Microscopic examination of the urine sediment revealed proteinuria, many RBCs (haematuria) and few white blood cells. Oval, translucent eggs with prominent terminal spines were also detected.

Questions:

1. Which parasite is the cause of this patient's infection?
2. How is this infection transmitted?
3. Mention the complications of this parasitic infection.
4. Describe the detected egg.
5. Compare this egg with those of other members of this genus.
6. Which types of specimens should be collected for diagnosis?
7. How is this infection diagnosed?
8. Describe the "hatching test" and mention its value.
9. What is the association of this infection with bladder cancer?

10. How is this infection treated?

11. How is infection with this parasite prevented and controlled?

Adults are flat, ribbon like and segmented, their length varies from few millimetre to several meters.
- The body is divided into scolex, neck and several proglottids or segments.
- The scolex is provided with organs for attachment.
- The neck is the region of growth.
- The proglottids strobila or segments are differentiated into immature, mature and gravid segments (according to the degree of maturity of the genital organs).
- They have neither a body cavity nor an alimentary tract. Nutrients are absorbed through their cuticle or integument which has also a protective function by secreting substances that inactivate the host digestive enzymes.

**Taenia saginata (Beef tapeworm)**

Geographical distribution: Cosmopolitan.

Morphology: 1-

**Adult:**
- Size: 10 meters, 2000 segments.
- Scolex: globular, 2 mm in diameter, with 4 suckers without rostellum or hooks.
  - Mature segments: squarish or slightly broader than long (about 1 x 1 cm) containing irregularly alternating lateral genital pores.
  - Male system: numerous testes (300).
  - Female system: bilobed ovary lying posteriorly in the segment with a compact vitelline gland behind it.
- Gravid segments: longer than broad (about 20x7mm) with the uterus having 15-20 lateral branches on each side.

**2-Egg:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>30-40 µ</td>
</tr>
<tr>
<td>Shape</td>
<td>spheroid.</td>
</tr>
<tr>
<td>Shell</td>
<td>thick radially striated embryophore</td>
</tr>
<tr>
<td>Colour</td>
<td>yellowish-brown.</td>
</tr>
<tr>
<td>Contents</td>
<td>hexacanth embryo (onchosphere)</td>
</tr>
</tbody>
</table>
3- **Cysticercus bovis**: a bladder-like structure lined with a germinal layer enclosing a cavity containing fluid. It has an invaginated scolex with 4 suckers. It measures about 1-2 cm.

**Life cycle:**

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Adult worm lives in the small intestine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive host</td>
<td>Man.</td>
</tr>
<tr>
<td>Intermediate host</td>
<td>Cattle.</td>
</tr>
<tr>
<td>Reservoir host</td>
<td>No</td>
</tr>
<tr>
<td>Infective stage</td>
<td><em>cysticercus bovis</em>.</td>
</tr>
</tbody>
</table>

-Stages in the life cycle: egg $\rightarrow$ onchosphere (Hexacanth embryo) $\rightarrow$ *cysticercus bovis* in (I. H.) $\rightarrow$ adult in (D. H.).

- Mature eggs and gravid segments pass in the human faeces.
- Gravid segments are detached separately and disintegrate liberating eggs. Sometimes these segments creep out of the anus by their own activity.

- The eggs or gravid segments are ingested by the intermediate host $\rightarrow$ the onchosphere hatches $\rightarrow$ penetrates through the intestinal wall into the lymphatic or blood vessels to the right side of the heart to the lung to the systemic circulation where it is distributed everywhere specially in active muscles, brain, bones, etc... There, it develops into *Cysticercus bovis* in about 12 weeks and remains viable for about one year. In muscles, cysticerci become surrounded by fibrous capsules formed by the host, which may be calcified later on.

**Mode of infection:** Ingestion of undercooked beef containing viable *Cysticercus bovis*.

- In the intestine, the scolex is evaginated, attaches to the mucosa and the worm develops to maturity in about 10 weeks.

Pathogenicity and clinical picture:

1- Intestinal disturbances as hunger pain, indigestion, abdominal discomfort, diarrhea or constipation.
2- Loss of weight and appetite.
3- Intestinal obstruction.
4- Segments of *T. saginata* migrating out of the anus, cause irritation, itching, insomnia and anxiety.

**Diagnosis:**

1. Searching mainly for gravid proglottids in faeces to differentiate *T. saginata* from *T. solium*. If not found, give a saline purge (segments pressed between 2 slides and examined for the number of lateral uterine branches on each side).
2. Finding eggs in faeces is rare, maybe in peri-anal scraping using a
Treatment:
1. Niclosamide (Yomesan): the tablets should be taken in the morning on an empty stomach and well chewed. The strobila is often evacuated within a few hours, if not a purgative is recommended.
2. Praziquantel.

Prevention and control:
1. Proper sanitary disposal of human faeces to prevent cattle infection.
2. Proper inspection of beef for cysticerci at slaughterhouses.
3. Proper cooking of beef products to kill any cysticerci present (cysticerci are killed at -56°C). Freezing at -10°C for 5-10 days are sufficient to kill the cysticerci.
5. Health education.
**Taenia solium** (Pork tapeworm)

Geographical distribution: cosmopolitan wherever raw or insufficiently cooked pork is ingested. Thus it is very rare in Islamic countries.

Morphology: similar to *Taenia saginata* but with the following differences:

1. Shorter in length, 4 meters with 1000 segments.
2. Scolex: globular with a rostellum armed with double rows of taenoid hooks.
3. Mature segments contain a less number of testes about 150.
4. The ovary is trilobed.
5. The gravid segment: the uterus possesses 9-11 lateral branches on each side.

Life cycle:

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive host</td>
<td>Man</td>
</tr>
<tr>
<td>Intermediate host</td>
<td>Pig</td>
</tr>
<tr>
<td>Reservoir host</td>
<td>No</td>
</tr>
<tr>
<td>Infective stage</td>
<td>Cysticercus cellulosae</td>
</tr>
</tbody>
</table>

Stages in the life cycle: egg → hexacanth embryo → cysticercus cellulosae.

1. Gravid segments pass with defecation.
2. They dry in the soil, rupture and release the eggs which are morphologically indistinguishable from those of *T. saginata* but not stained with Ziehl-Neelsen stain.
3. Pigs and hogs feed on human faeces. The eggs are swallowed pass to the duodenum or jejunum where the shells disintegrate. The onchospheres, liberated by the aid of their lytic secretions and hooks penetrate through the intestinal wall into the mesenteric venules and are carried throughout the body, they are then filtered between the muscles and metamorphose into cysticerci.
4. Cysticerci are spherical or ovoid cysts with the head invaginated appearing as a milky spot. Microscopically the rostellum, suckers and hooks are apparent; this larval stage is known as cysticercus cellulosae.

**Mode of infection:**

- Human beings are infected with *T. solium* following consumption of imperfectly cooked pig’s meat containing the cysticercus cellulosae.

- In the stomach the cyst wall is digested out, the head evaginates in the upper level of the small intestine, attaches by its suckers to the wall of the small intestines and develops into a mature adult worm in 5-12 weeks.
Pathogenicity:

<table>
<thead>
<tr>
<th>1- Taeniasis solium</th>
<th>Man ingests <em>cysticercus cellulosae</em> in pig's muscles, and the adult parasite develops. The disease is similar to taeniasis saginata.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- Cysticercosis</td>
<td>Man ingests eggs of <em>T. solium</em>, and develops <em>cysticercus cellulosae</em> in the extra-intestinal tissues.</td>
</tr>
</tbody>
</table>
Diagnosis:
- Stool examination reveals the presence of the gravid segments, rarely eggs.
- Eggs cannot be differentiated from those of *T. saginata* morphologically, but they do not take the Zeihl-Neelsen stain.

Treatment: Similar to *T. saginata* but:
- Atebrine is preferable as it leads to expulsion of the parasite but causes nausea and vomiting. So, anti-emetic must be given one hour before Atebrine to avoid anti-peristalsis and subsequently internal autoinfection.

**Niclosamide and Paromomycin should be avoided as they disintegrate the worm releasing large number of eggs in the lumen of intestine which increase possibility of cysticercosis due to internal autoinfection.**

Prevention and control: 1. Similar to *T. saginata*, but mainly directed towards pigs.
2. Prompt treatment of infected persons to eliminate the danger of auto infection.
3. Infected persons should not take emetics or nauseating drugs.
### Differences between *T. saginata* and *T. solium.*

<table>
<thead>
<tr>
<th></th>
<th><em>T. saginata</em> (Beef tape worm)</th>
<th><em>Taenia solium</em> (Pork tape worm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disease:</strong></td>
<td>Taeniasis saginata.</td>
<td>Taeniasis solium</td>
</tr>
<tr>
<td><strong>Distribution:</strong></td>
<td>Cosmopolitan where beef is eaten</td>
<td>Cosmopolitan where pork is eaten.</td>
</tr>
<tr>
<td><strong>Adult: Size:</strong></td>
<td>10 meters</td>
<td>5 meters</td>
</tr>
<tr>
<td><strong>Scolex:</strong></td>
<td>Quadrate, about 1-2 mm in diameter with no rostellum or hooks</td>
<td>Globular about 1 mm in diameter. There is a rostellum with 2 rows of large and small hooks</td>
</tr>
<tr>
<td><strong>Number of segments:</strong></td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Mature segment:</strong></td>
<td>Testes are numerous (300-400), ovary bilobed, vaginal opening with sphincter.</td>
<td>Testes are fewer (150) ovary trilobed, no vaginal sphincter.</td>
</tr>
<tr>
<td><strong>Gravid segment:</strong></td>
<td>Longer than broad uterus with 15-20 (18) lateral branches, segments detach singly (creeping out without defecation).</td>
<td>Longer than broad. With 9-11 lateral branches, segments detach in groups of about five with stool.</td>
</tr>
<tr>
<td><strong>Egg</strong></td>
<td>not infective to man and stained with Zeihl-Neelsen stain.</td>
<td>Infective to man (\rightarrow) cysticercosis) - not stained</td>
</tr>
<tr>
<td><strong>Definitive host:</strong></td>
<td>Man</td>
<td>Man</td>
</tr>
<tr>
<td><strong>Intermediate host:</strong></td>
<td>Cattle</td>
<td>Pigs and man</td>
</tr>
<tr>
<td><strong>Larval stage:</strong></td>
<td><em>Cysticercus bovis</em> (scolex without hooks)</td>
<td><em>Cysticercus cellulosa</em> (scolex with hooks)</td>
</tr>
<tr>
<td><strong>Stage in man:</strong></td>
<td>Adult</td>
<td>Adult and larva (<em>cysticercus cellulosa</em>).</td>
</tr>
<tr>
<td><strong>Mode of infection:</strong></td>
<td>Ingestion of undercooked beef (\rightarrow) taeniasis</td>
<td>Ingestion of undercooked pork (\rightarrow) taeniasis - Ingestion of eggs (\rightarrow) cysticercosis.</td>
</tr>
</tbody>
</table>
Case study:
A 29-year-old woman presented to the physician complaining of diarrhea, mild indigestion, hunger pains, loss of weight and frequent abdominal pain. She passed white segments, each about 2 cm long, with or without defecation causing perineal irritation and pruritus. She is fond of eating roasted meat.

The patient was instructed to submit three stool specimens, on alternate days that were examined for ova and parasites. Also, blood sample was drawn for complete blood count.

The blood count revealed eosinophilia (16% eosinophils). On examination of the concentrated stool sediments, several yellow-brown, spherical, 40 µ in diameter, thick-shelled eggs were detected. The eggs were characterized by radial striations. Gravid segments were also detected in the stool specimens; each contained 15-20 lateral uterine branches, on either side, when stained with an Indian ink.

Questions:
1. Which parasite is causing the patient's illness?
2. Name the 2 species of this genus which cause human disease.
3. Can they be differentiated by the morphological appearance of their eggs? Explain.
4. Can these 2 species be differentiated by the appearance of their proglottids? Explain.
5. Compare the morphological characteristics of the scolices of these 2 species.
6. What is the infective stage? What is the mode of infection?
7. Why is it important to differentiate between these 2 species?
8. How is this infection treated?
9. What is the sure sign of complete cure?
**Hymenolepis nana (Dwarf tapeworm)**

Geographical distribution: cosmopolitan. It is the commonest tapeworm in children.

Morphology: 1-

Adult:
- Size: 0.5-5 cm (the smallest tapeworm of man).
- Scolex: globular, 0.2 mm in diameter, with 4 suckers. A retractile rostellum with a crown of hooks (long handle, short blade and a guard).
- Strobila: 200 segments.
- Mature segments: broader than long (0.5 x 0.15 mm).

-Male system: 3 globular testes, in the middle of the segment.
-Female system: as in *Taenia* but the ovary is small and central.
-Genital pores are unilateral and always open to one side.
  - Gravid segments: broader than long (0.2x 0.9 mm) and are occupied by a sac-like uterus full of eggs.

2-Egg:

<table>
<thead>
<tr>
<th>Size</th>
<th>30-50 µ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Spheroid with 2 envelopes; outer egg shell, inner embryophore with two polar thickenings from each arises 4-8 filaments.</td>
</tr>
<tr>
<td>Colour</td>
<td>Translucent.</td>
</tr>
<tr>
<td>Contents</td>
<td>Mature hexacanth embryo.</td>
</tr>
</tbody>
</table>

3- Cysticercoid: a bladder-like structure, 0.5-1 mm in diameter, having double wall, similar to cysticercus but the head is withdrawn in upright position (invaginated everted), and it has a tail-like appendage (*Cercocystic cysticercoid*).

Life cycle:

<table>
<thead>
<tr>
<th>Habitat</th>
<th>The small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive host</td>
<td>Man</td>
</tr>
<tr>
<td>Reservoir hosts</td>
<td>Rodents (rats and mice).</td>
</tr>
<tr>
<td>Intermediate host</td>
<td>Man, may be insects like flea larva or grain beetles.</td>
</tr>
<tr>
<td>Infective stage</td>
<td>Mature eggs and <em>cercocystic cysticercoid</em>.</td>
</tr>
</tbody>
</table>


-Mature eggs pass in faeces of definitive and reservoir hosts are immediately infective without requiring intermediate host.

-When the final host swallows the egg in food, drink or by autoinfection, the
onchosphere hatches in the small intestine, penetrates into the submucosa to become a cysticercoid. After about one week, it returns to the lumen and develops into an adult worm. Man acts as definitive as well as intermediate host.

- Eggs appear in faeces about two weeks after infection.
- Also development may take place in an intermediate host if the egg is swallowed by flea larva (or flour insects, beetles and cockroaches).
- The onchosphere liberates in the intestine of the insect, penetrates into the body cavity where it develops into a cysticercoid. When such flea is ingested with food the cysticercoid is liberated and develops into adult.

**Mode of infection:**

1. Swallowing of infected insects or their larvae containing cysticercoid.
2. Contaminated food, water with eggs.
3. Autoinfection: by ingestion of mature eggs, either from person to person or by external autoinfection or internal autoinfection.

Pathogenicity and clinical picture:

1. In light infection, usually there are no manifestations.
2. In heavy infections: ulcerations of the mucosa lead to enteritis. There may be abdominal discomfort, colic and diarrhea with passage of mucus.
3. Some patients specially children suffer from dizziness and may be convulsion, attributed to neurotoxin product of the worms.

Diagnosis: finding eggs in faeces.

Treatment:

1. Niclosamide: treatment is prolonged or repeated in 3 weeks to kill worms that emerge from cysticercoids in the submucosa.
2. Praziquantel: a single oral dose after breakfast. It acts on both cysticercoid in the villi and the adult in the lumen of small intestine.
3. All infected members of the family should be treated at the same time.

Prevention and control:

1. Avoid contaminated food and drink.
2. Personal cleanliness and proper sanitary disposal.
3. Health education.
4. Mass treatment to prevent autoinfection and infection of others.
5. Rodents control.
Life cycle of *H. nana*
**Echinococcus granulosus** *(Dog tapeworm)*

Geographical distribution: cosmopolitan, more in cattle raising countries.

Morphology:

**Adult:**

- **Size:** about 5 mm.
- **Scolex:** globular with 4 suckers and double crown of hooks (similar to *T. solium*).
- **Strobila:** composed of 3 segments, one immature, one mature and one gravid.
- **Mature segment:** longer than broad. Reproductive organs as *Taenia*.
- **Gravid segment:** is 1/2 length of the worm, longer than broad. The uterus develops lateral pouches which are full of eggs.
- **Egg:** similar to *Taenia*.

**Hydatid cyst:** a complex cyst composed of daughter daughter inside and may be outside the mother cyst and contains several scolices.

**Life cycle:**

<table>
<thead>
<tr>
<th>Habitat</th>
<th>small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive hosts</td>
<td>dogs or other carnivorous animals</td>
</tr>
<tr>
<td>Intermediate hosts</td>
<td>herbivorous animals and occasionally man</td>
</tr>
<tr>
<td>Infective stage to dog</td>
<td>hydatid cyst</td>
</tr>
<tr>
<td>Infective stage to man</td>
<td>Eggs</td>
</tr>
</tbody>
</table>

- Gravid segments and mature eggs pass in the faeces of definitive host.
- When the egg is ingested by the intermediate host, the liberated onchosphere penetrates the intestinal wall into the blood stream to various parts of the body where it develops into a hydatid cyst, causing hydatid disease.

**Echinococcus multilocularis**

Geographical distribution: Central Europe and Siberia.

**Life cycle:**
- **Habitat:** small intestine.
- **Definitive host:** fox
- **Intermediate host:** field rodents and man.
- **Infective stage to fox:** hydatid cyst.
- **Infective stage to man:** eggs.

**Morphology and life cycle:**

Adults resemble *Echinococcus granulosus*, but are smaller. Eggs passed in fox's faeces are taken by the intermediate host in which they develop into *alveolar* or *multilocular* hydatid cysts.
Hydatid disease (Hydatidosis, Echinococciosis)

Definition: it is the presence of hydatid cyst, larval stage of *E. granulosus* and *E. multilocularis* in the human tissues. The liver is the commonest organ affected (70%) followed by the lungs (20%), then the brain and other organs (10%).

**Mode of human infection:** ingestion of eggs of *Echinococcus* species by the following ways:

1. Ingestion of water or vegetable polluted by infected dog's faeces.
2. Handling infected dogs where hair is usually contaminated with eggs.
3. Man is infected with the alveolar cyst during the skinning of foxes to make furs or from collecting strawberries polluted with fox's faeces.

Morphology and types of hydatid cyst:

1. Unilocular hydatid cyst: it is the larval stage of *E. granulosus*.
   
   Size: 1-10 cm.
   
   Shape: spherical enclosed in a fibrous capsule produced by the host.
   
   The wall of the cyst has 2 layers:
   
   (l) Outer laminated non-cellular layer.
   
   (2) Inner cellular germinal layer which secretes the laminated layer and produces scolices, brood capsules and daughter cysts.
   
   Contents:
   
   (a) Individual scolices (microscopic).
   
   (b) Brood capsules: invagination of the germinal layer from which scolices develop.
   
   (c) Daughter cysts: cysts formed of the 2 layers of the mother cyst, giving rise to scolices, brood capsules and even grand daughter cysts.
   
   (d) Hydatid fluid.
   
   (e) Hydatid sand: detached scolices, brood capsules and daughter cysts that fall in the hydatid fluid are called hydatid sand.
   
   (f) Exogenous daughter cysts: a daughter cyst is produced outside the mother cyst by herniation through the fibrous capsule, and may separate from it.

2. Sterile cyst or acephalocyst: the germinal layer fails to produce scolices, brood capsules or daughter cysts.
III. Osseous cyst: growth of hydatid cyst in bones is along the medullary cavity with erosion of osseous tissue.

IV. Alveolar or multilocular hydatid cyst: it is the larval stage of another species *Echinococcus multilocularis* or *Alveococcus multilocularis*. It differs from the common unilocular variety in the following:
- There is no laminated layer, hence the cyst has no regular shape and not defined from the surrounding tissue. The germinal layer infiltrates the tissue.
  - There is no free fluid, but a jelly-like substance in irregular cavities separated by fibrous strands.
  - The central area of the cyst undergoes necrosis while growth continues at the periphery.
  - Growth is neoplastic and metastasis occurs.
- In man the cyst is usually sterile or produces only few scolices and brood capsules.

Pathogenicity and clinical picture: depend on the size of the cyst and the organ affected.
2. Pulmonary hydatid cyst: dyspnea, cough, chest pain and haemoptysis.
3. Cerebral hydatid cyst: symptoms of increased intracranial tension and epilepsy.
5. Rupture of the cyst results in anaphylactic shock and transplantation of the germinal layer in other tissues producing secondary cysts.

Diagnosis:
I. Clinical diagnosis: slowly growing cyst (space occupying and pressure effects) with hydatid thrill in case of large abdominal cyst. History of contact with dogs.
II. Laboratory diagnosis:
A- Direct:
  - Puncture and aspiration to demonstrate hydatid cyst (may lead to leakage of fluid and the risk of anaphylactic shock).
  - Radiological: X-ray, ultrasonography (U.S.), C.T. scans.
  - Blood examination reveals eosinophilia in 20-25% of cases.
B- Indirect:
  - Intradermal allergic test (Casoni test): 0.2 ml of sterile hydatid fluid is injected intradermally. In positive cases an erythematous wheel is formed within 20 min and a delayed reaction appears after 24 hours.
  - Serological methods: using hydatid fluid antigen for detection of antibodies by:
    1. Precipitin reaction: equal parts of hydatid fluid and patient's serum incubated at
Treatment:

1. Surgical treatment: is recommended for unilocular cysts in accessible sites with pre-operative administration of Mebendazole.

2. Sterilization: some of hydatid fluid is replaced by 10% formalin for 5 minutes then the content is aspirated and repeatedly washed with saline or ethanol to kill the germinat layer and scolices causing cyst collapse.

3. Medical treatment: when surgical interference is impossible or contra-indicated, Mebendazole can be used in high dose and for a long period (about 3 months up to one year), as the drug stop proliferation.

Prevention and control:

1. Hydatid cysts found in slaughtered animals should be destroyed and not fed to dogs.

2. Stray dogs should be destroyed.

3. Pet dogs should be examined and dewormed periodically.

4. Avoid close contact and playing with dogs.

5. Avoid contamination of hands, food and drink with dog's faeces.

Case study

A 45-year-old man was presented with pain in the upper quadrant of the abdomen. He had a history of contact with dogs many years ago. On examination, the physician noted an enlarged liver with a palpable mass in the right hypochondrium. The patient was submitted for stool, blood and radiological (plain x-ray, CT and MRI) examinations.

Stool examination is negative for ova or parasites. The blood count revealed eosinophilia (24 % eosinophils). Radiological studies revealed a rounded space-occupying lesion, 12 cm in diameter in the liver. Microscopic examination of a biopsy specimen confirmed the diagnosis of the parasitic infection. During surgical removal of the hepatic cyst, aspiration of the cyst contents was performed and the contents were also examined microscopically.

Questions:

1. Based on the patient's symptoms, which parasitic infection do he has?
2. What aspect of the patient's history is a clue to his infection?
3. Describe the morphology of this cyst.
4. What danger to the patient exists during surgical removal and aspiration of the cyst?
5. Can sputum examination help in the diagnosis?
6. What is the parasitological diagnostic value of Ziehl-Neelsen stain?
7. How would you treat this patient?
NEMATHELMINTHS
Class: Nematoda (Round worms)

General characters:
- Cylindrical worms, unisexual, have a body cavity.
-Male is smaller than female and commonly has a curved posterior end.

<table>
<thead>
<tr>
<th>The body wall consists of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- An outer non-cellular cuticle, which may inflated anteriorly to form cervical alae and posteriorly to form copulatory bursa.</td>
</tr>
<tr>
<td>2- Thin sub-cuticular layer.</td>
</tr>
<tr>
<td>3- A layer of muscle cells. The body wall surrounds a cavity, within which lie the digestive, reproductive, parts of the nervous and excretory</td>
</tr>
</tbody>
</table>

Digestive system: is a simple tube beginning by the mouth which is surrounded by lips or papillae. In some species it is provided with teeth or plates. It leads into a tubular or funnel-shaped buccal cavity

-There is no circulatory system. The fluid of the body cavity contains haemoglobin, glucose, protein, salts and vitamins and fulfills the function of blood.

Nervous system: consists of nerve rings surrounding the oesophagus. From these six nerve trunks pass anteriorly and six nerve trunks extend posteriorly.

Reproductive system:
The male reproductive organs consisted of a single coiled or convoluted tube. It is differentiated as testis, vas deferens, seminal vesicle and ejaculatory duct and one or two copulatory spicules.
The female reproductive system may be either a single or bifurcated tube differentiated into ovary, seminal receptacle, uterus, and vagina.

Ascaris lumbricoides
(Giant intestinal round worm)

Geographical distribution: cosmopolitan, especially in tropical and subtropical countries.

Morphology: 1-
Adult:
  a. Long with tapering ends.
  b. Creamy or pink in colour.
c. Finely striated cuticle.
d. Terminal mouth with 3 lips, one dorsal and two subventral. Each lip is provided with fine teeth and sensory papillae.
e. Club-shaped oesophagus.

Male: - 15-20 cm in length x 3 mm thickness.
  - Posterior end curved ventrally.
  - Has one set of genitalia provided with two small equal spicules.

Female: - About 20-40 cm in length and 6 mm thickness.
  - Posterior end straight.
  - Has two sets of genitalia.
  - The vulva opens ventrally at the junction of the anterior third and posterior two thirds of the body.
2- Egg: Three types of eggs:

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Shape</th>
<th>Color</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Fertilized egg</td>
<td>60 x 45 µ</td>
<td>Oval with 2 coverings:</td>
<td>Brownish</td>
<td>Immature ovum (one-cell stage).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Outer thick regular albuminous mammillations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Inner thick egg shell.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Unfertilized egg</td>
<td>90 x 45 µ</td>
<td>Long and narrow Less developed thin irregular albuminous mammillations</td>
<td>Brownish</td>
<td>Retractile granules.</td>
</tr>
<tr>
<td>(c) Decorticated egg</td>
<td></td>
<td>Similar to fertilized egg with no mammillated layer.</td>
<td>Brownish</td>
<td></td>
</tr>
</tbody>
</table>

Life cycle of Ascaris lumbricoides
Life cycle:

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitive host</td>
<td>Man</td>
</tr>
<tr>
<td>Infective stage</td>
<td>Eggs containing second-stage rhabditiform larva.</td>
</tr>
</tbody>
</table>

It is a specific parasite of man with no I.H. or R.H.

Stages in the life cycle: egg → larvated egg → larva → adult.
- Immature eggs pass in the faeces (200,000 eggs/female/day).
- Under favorable environmental conditions in the soil (temperature of about 25°C, humidity, shady soil and oxygen) a rhabditiform larva develops inside the egg in about two weeks. After one week this larva moults into a second-stage rhabditiform larvae inside the egg.

Mode of infection:

1. Swallowing water or raw vegetables polluted with embryonated eggs containing the infective larva.
2. Through contaminated hands by polluted soil.
3. By inhalation to nasopharynx.
4. House flies and cockroaches may carry the larvated eggs to human food.

Eggs hatch in the intestine and the rhabditiform larvae penetrate the intestinal wall entering the circulation → the right side of the heart → the lungs where they break out of the pulmonary capillaries into the alveoli. They remain for some days and undergo their second and third moult (Filariform larvae).

They then pass up the bronchioles to the bronchi, the trachea, and the epiglottis where they are swallowed to reach their final habitat in the small intestine. They moult for the fourth time and become adults.

Eggs appear in faeces about 2 months after infection and the adult live from 12 to 18 months.

Occasionally, when the infection is high, the larvae may pass through the capillary filter surrounding the alveoli to the left side of the heart. From there, get into the systemic circulation reaching to abnormal foci.

Pathogenicity and clinical picture:

I. Migrating larvae:

1. Lung: in light infection, there is slight damage with unnoticed pathological lesions. In heavy infection, the migrating larvae in the lungs result in condition known as *Ascaris* pneumonitis or Loeffler's syndrome especially in children. Clinically, from 1-5 days after exposure, cases
manifest with fever, cough, and dyspnea lasting for 1-2 weeks.

In extreme cases there may be lobular pneumonitis, cellular infiltration, serous exudates and haemorrhage causing cough and bronchial irritation, expectoration with blood stained sputum and oedema of lips, microscopically the larvae may be detected in the sputum, with many eosinophils.

2. General circulation: occasionally some larvae reach the general circulation and distributed to various organs as lymph nodes, brain, spleen & kidneys leading to abnormal clinical manifestations as a result of visceral larva migrans.

II- Adult worm: The usual infection consists of 5-10 worms, often goes unnoticed by the host and is discovered on a routine stool examination or by the discovery of an adult worm passed spontaneously in stool. The most frequent complaint is abdominal pain with distension, diarrhea or constipation, vomiting and dyspepsia.

<table>
<thead>
<tr>
<th>1. Traumatic effects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- In heavy infection → intestinal obstruction.</td>
</tr>
<tr>
<td>- Obstruction of the bile ducts by the worms → obstructive jaundice.</td>
</tr>
<tr>
<td>- Appendix → appendicitis.</td>
</tr>
<tr>
<td>- Obstruction of ampulla of Vater → acute hemorrhagic pancreatitis.</td>
</tr>
<tr>
<td>- Perforation of intestinal wall → peritonitis.</td>
</tr>
<tr>
<td>- Some worms may ascend via the stomach and oesophagus to the nasopharynx, enter the larynx causing suffocation especially in children.</td>
</tr>
<tr>
<td>- It may come out of mouth or nose or even go to Eustachian tube from the pharynx resulting in damage of the middle ear.</td>
</tr>
<tr>
<td>2. Toxic effects: metabolic by-products of living or dead worms may give rise to fever, allergic manifestations and nervous irritability.</td>
</tr>
</tbody>
</table>

**Diagnosis:**

I. Clinical: symptoms of ascariasis are indistinguishable from those of other intestinal helminthic infections.

II. Laboratory:

1. Detection of eggs in stool (direct smear, after concentration, Stoll's technique).
2. Detection of migrating larvae in sputum or in gastric lavage contents.
3. Detection of adults passing out with or without stool or in vomitus.
4. Eosinophilia (7-12%).
Treatment:
1. Levamizol hydrochloride (Ketrax) as a single oral dose.
2. Mebendazole (Antiver, Vermox) or Flubendazole (Fluvermal).
3. Surgical treatment of complications e.g. obstruction of intestine, appendix or bile ducts.

Prevention and control:
5. Sanitary disposal of excreta.
6. Health education and cleanliness (washing hands before meal).
7. Proper washing of green raw vegetables.
8. Pure water supply.
9. Control of flies and other insects.
10. Stool should not be used as a fertilizer unless being treated by chemicals or temperature of 50°C or higher to kill eggs.

Case study:
A 21-year-old woman presented suffering from abdominal colic, nausea, vomiting and diarrhea. After a physical examination, which was un-remarkable, the physician ordered a stool analysis for eggs and parasites. Microscopic examination of a concentrated wet-mount preparation revealed several types of eggs. These eggs had thick shells and were oval, with some being more broadly oval than others. Some eggs lacked the outer mammillated covering found on the majority of eggs.

The diagnosis of this intestinal parasitic infection was made on the basis of microscopic analysis of stool specimen.

Questions:
1. Which parasite would you suspect of causing this patient’s infection?
2. Describe the variable appearance of eggs of this parasite.
3. Which nematodes are most likely to cause human intestinal infection?
4. What is the infective stage?
5. How is this infection transmitted?
6. Do you think that this patient can transmit this parasitic infection to other members of the family during food handling? Why?
7. Describe the life cycle of this parasite.
8. Describe the clinical manifestations of this infection.
9. Which complications may cause this infection to be life-threatening?
10. How is this infection treated and controlled?
**Enterobius vermicularis**  
(Oxyuris, pinworm or seat-worm)

Geographical distribution: cosmopolitan.

Morphology:

1- Adult: translucent cuticle, finely transversely striated. There are 2 wings like expansions (cervical alae) at the anterior end. The mouth with 3 small retractile lips, followed by small buccal cavity.

The oesophagus is double-bulbed. Intestine ends at the anus ventrally.

Male: 0.5 cm, its posterior end curved ventrally, one set of genital organs that open with the anus in the cloaca and one spoon-shaped spicule.

Female: 1cm, with a long thin sharply pointed tail occupying about 1/3 total length (hence the common name pin worm). 2 sets of genital organs and vulva at the junction of the anterior fourth with the rest of the body.

2-Egg:

<table>
<thead>
<tr>
<th>Size</th>
<th>50x25 µ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Plano-convex (one side is convex and the other is straight).</td>
</tr>
<tr>
<td>Shell</td>
<td>2 layers and covered by a 3rd outer thin albuminous sticky layer.</td>
</tr>
<tr>
<td>Color</td>
<td>Colorless.</td>
</tr>
<tr>
<td>Content</td>
<td>Fully developed larva.</td>
</tr>
</tbody>
</table>

Life cycle:

- Habitat: adult worm lives in the caecum, appendix and adjacent parts of small and large intestine.
- Definitive host: only man.
- Infective stage: fully embryonated eggs containing fully developed larvae.
- The gravid female migrates to the perianal and perineal area where they lay eggs. The eggs are infectious several hours after deposition.

Mode of infection:

1. Ingestion of eggs through contaminated food and drink.
2. **Autoinfection**: eggs are carried under finger nails to the mouth after scratching of perianal skin (anus to mouth infection).
3. **Retro-infection**: eggs hatch on the perianal region and larvae migrate back through the anus to the rectum and caecum.
4. **Air-borne infection**
5. Contact with patients (direct hand to hand or indirect contact by handling contaminated articles as clothes, bed linens, toilet seats, door knobs).
Pathogenicity and clinical picture:
The clinical symptoms are largely due to perianal, perineal and vaginal irritation caused by the migration of the gravid female worm.

1. Local irritation and discomfort, with nocturnal itching and enuresis, insomnia, irritability, restlessness, neurosis, hyperactivity, gridding of teeth and inability to concentrate.

2. **Pruritus ani due to:**
   a. Nocturnal migration of the female worm on the perianal skin with worm like movement.
   b. Skin sensitization by ruptured worms during scratching.
   c. Striations on the cuticle cause skin irritation.

3. Vaginitis and salpingitis by migrating gravid females. Granulomas are formed around eggs or worms.

4. Irritation of intestinal mucosa with minute ulcers, hemorrhage and 2ry bacterial infection at site of attachment.

5. Obstructive appendicitis rarely occurs.

Diagnosis:
I. Clinical: Pinworm infection is suspected in children who show perianal itching, restlessness and insomnia.

II. Laboratory:
1. Detection of adult worms in feces or in the perianal region.
2. Detection of the eggs:
   - In stool: seldom found (in only 5% of infected patients), unless uterus of gravid female ruptures during migration to the perianal region.
   - In urine of female patients.
   - On perianal region by swab, this must be done early in the morning before defecation or bathing and should be repeated for several days before the patient is considered free.

Types of swabs:
 a. Scotch adhesive tape swab: a piece of scotch tape, hold over a tongue depressor is rolled over the perianal skin and removed. The adhesive tape is put on a slide with a drop of toluene and examined for eggs.
 b. Vaseline swab: the perianal skin is swabbed with a piece of cotton soaked in Vaseline and the swab is put in a mixture of ether and water to dissolve the
Vaseline. The mixture is centrifuged and the deposit is examined for eggs.

c. National Institute of Health (N.I.H.) swab: it is a piece of non adhesive cellophane fixed to a glass rod. The glass rod is inserted through a perforated stopper in a test tube. The perianal skin is swabbed in the morning by the cellophane paper. The cellophane paper is united, spread between 2 slides with a drop of toluene and examined for eggs.

Treatment:

1. Mebendazole (Vermox), Flubendazole (Fluvermol) or Pyrantel pamoate (Combantrin) as a single oral dose and a 2nd dose must be given after 2 weeks to prevent re-infection.

2. Local: mercurial ointment is applied to the perianal skin especially at night to relieve itching and kills females that come out to deposit eggs and prevent dispersal of eggs.

Prevention and control:

1. Mass treatment of the whole companions of the infected person.
2. Personal cleanliness.
3. Protection of food and drink from contamination by dust and hands of patients.

Case study :

A 7-year-old boy was not sleeping well, had been irritable, and had complained to his mother about anal itching and irritation. The boy's younger sibling also began to complain of similar symptoms.

The children were taken to the pediatrician for evaluation. He ordered a parasitological laboratory test to provide a strict diagnosis. A worm egg seen microscopically enabled the laboratory to identify the worm causing the symptoms.

Questions:

1. Which parasite is causing the children's discomfort?
2. Which type of laboratory procedure would the physician have ordered to make a diagnosis?
3. What are the precautions to be followed during performing this procedure?
4. How is the infection transmitted?
5. Describe the life cycle of this parasite.
6. How is the diagnosis made, using this procedure?
7. Which intestinal protozoon has been associated with this helminthic infection?
8. How is this infection treated?
9. What are the precautions to be followed to eradicate this parasitic infection?
Trichuris trichiura (Trichocephalus trichiura or whipworm)

Geographical distribution: cosmopolitan, more in worm moist regions.

Morphology:

1- Adult: body is demarcated into an anterior attenuated whip-like thin part (3/5) that contains a cellular oesophagus, and a more robust posterior thick part bluntly rounded (2/5) contains the rest of organs.

Male: 3-4 cm in length coiled posterior end with a single copulatory spicule inside a retractile sheath and a terminal cloaca.

Female: 4-5 cm in length, straight blunt posterior end, has one set of genitalia and the vulva opens at the junction of thin and thick parts. Anal orifice is terminal.
Habitat: adult inhabit the human large intestine mainly the caecum but is also found in the appendix and lower ileum.
Definitive host: man.
Reservoir host: some mammals.
Infective stage: egg containing first stage larva.
Stages in the life cycle: egg → larva → adult

**2- Egg:**

<table>
<thead>
<tr>
<th>Size</th>
<th>50 X 25 μ.</th>
<th>Shape</th>
<th>barrel-shaped.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>yellowish-brown.</td>
<td>Content</td>
<td>immature embryo.</td>
</tr>
<tr>
<td>Shell</td>
<td>thick-shell, with bipolar mucoid plugs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Life cycle:**

- Habitat: adult inhabit the human large intestine mainly the caecum but is also found in the appendix and lower ileum.
- Definitive host: man.
- Reservoir host: some mammals.
- Infective stage: egg containing first stage larva.
- Stages in the life cycle: egg → larva → adult

**Mode of infection:**

Ingestion of larvated egg with contaminated food and drinks.

- When the embryonated egg is ingested by man, the larva escapes from the egg shell in the upper small intestine and penetrates the intestinal villi, where it remains for 3 to 10 days.
- After reaching the adult stage, it passes downward to the caecum. A spear like projection at its anterior extremity enables the worm to penetrate into and deeply embed its anterior portion into the intestinal sub-mucosa of the host.
- The female is oviparous, life span about 4-6 years, and number of eggs deposited/female/day is about 2000 eggs.
- Ova pass with stool 2 months after infection and require 3-5 weeks for the larva to develop inside and become infective in favorable environment (worm, moist and shaded soil).

**Pathogenicity and clinical picture:**

1. Light infection is asymptomatic.
2. Heavy chronic infection manifests with:
   a. Frequent, small, blood-streaked diarrheal stools, dysentery.
   b. Abdominal pain and tenderness, nausea, vomiting and weight loss.
   c. Rectal prolapse due to oedema as a result of large number of worms embedded in the mucosa, dysentery and toxic effect on the pelvic nerve.
   d. Hypochromic anemia due to suction of blood by the parasite and hemorrhage that occur at their attachment sites. Hyperchomic anemia may also occur by the toxic parasitic products (*Trichocephalus* pernicious anemia).
   e. Appendicitis.
   f. Protein loosing enteropathy in heavy infections.
   g. Intestinal wall perforation and peritonitis.
   h. Eosinophilia (30-60 %) in acute heavy infection.
Diagnosis:
I. Clinical: can't be differentiated from infection with other intestinal nematodes.
II. Laboratory:
   1- Stool examination for the characteristic egg.
   2- Proctoscopy: worms can be seen attached to the inflamed and ulcerated rectal mucosa.

Treatment:
Mebendazole (Vermox or Antivir) or Flubendazole (Fluvermal).

Prevention and control:
1. Treatment of infected patients.
2. Sanitary disposal of human stool.
3. Strict hygienic measures for hands, food and drink.
4. Control of house fly.

Case study:
A 6-year-old boy presented to the pediatrician suffering from diarrhea, abdominal pain and nausea. Blood was drawn for complete blood count. Three stool specimens were collected and submitted for examination for ova and parasites.

Blood picture revealed hemoglobin of 11.5 gm/dl. Microscopic analysis of the concentrated stool specimens revealed numerous bile-stained, barrel-shaped eggs. The eggs were characterized by having clear, prominent and protruding bi-polar plugs.
Questions:
1. What is this infection according to the ova detected?
2. Describe the morphological characteristics of the adult worms.
3. What is the infective stage of this parasite?
4. Describe the life cycle of this parasite?
5. What is the main complication of this infection?
6. How is the diagnosis of this infection made?
7. Which other nematode egg may be confused with this parasite? Can they be differentiated by the morphological appearance? Describe.
8. How does the patient's blood test results relate to this infection?
9. How is infection with this parasite treated?
10. How is infection with this parasite prevented and controlled?

**Hook worms**

Geographical distribution: Tropical and subtropical countries.

*Ancylostoma duodenale*

Morphology: 1-

Adult:

a. The anterior end is bent dorsally.
b. Large mouth cavity (buccal capsule) with two pairs of teeth at the anterior margin (ventral or upper) and two dental plates at posterior margin (dorsal or lower) and two sub-ventral lancets in its bottom.
c. Club-shaped oesophagus (1/6 the length of the worm).

Male:
- About 1 cm in length
- Has one set of genitals provided with a copulatory bursa (posterior expansion of the cuticle ) and two long separate spicules.

Female:
- About 1.2 cm in length.
- Has two sets of genitalia.
- Vulva is at the junction of the middle and posterior thirds of the body.

*Necator americanus*

Morphology:

1-Adult: -Grayish yellow in colour.
- It has a hook-like anterior end. The head is curved opposite to the body curvature.
- Buccal capsule is armed ventrally and dorsally by cutting plates (dental plates). Four lancets at the bottom (two sub-ventral and two sub-dorsal).

Male: - Measures 8 mm in length and 0.3 mm in diameter.
- The copulatory bursa is long and wide.
- The 2 copulatory spicules are fused distally provided with a blade.

Female:  
- Measures 10 mm in length and 0.5 mm in diameter.
- Its posterior end is straight.
- Vulva is at the middle of the body.

<table>
<thead>
<tr>
<th>2- Egg (Diagnostic stage):</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape:</strong> oval with blunt poles. <strong>Color:</strong> translucent.</td>
</tr>
<tr>
<td><strong>Contents:</strong> immature ovum (4-cell stage).</td>
</tr>
<tr>
<td>An empty narrow space exists between the content and</td>
</tr>
</tbody>
</table>

3- Rhabditiform larva:
- About 250-500 µ in length.
- Rhabditiform oesophagus.
- Long buccal cavity.
- Pointed tail end.

3- Rhabditiform larva:
4. Filariform larva:
- About 600-700 µ in length with a sheath
- Club-shaped oesophagus (1/3 body length).
- Sharply pointed tail.
- Does not feed but move.
- Thermotropic, histotropic, phototropic and negative geotropic.
- Present in top layer of soil.

Life cycle:

- **Habitat**: small intestine (Jejunum).
- **Definitive host**: man.
- **Reservoir hosts**: no.
- **Infected stage**: sheathed filariform larvae.

Stages of the life cycle:

- Egg → rhabditiform larva → infective filariform larva (IFL) → adult.

  - Adults live in the small intestine of man attached by the mouth capsule to the mucosa.
  - Immature eggs pass in the feces (20,000 eggs/female/day in *Ancylostoma* and 10,000 eggs/female/day in *Necator americanus*).
  - Under favorable environmental conditions in the soil (moist shaded areas, sandy or loose soil, alkaline and free of salinity, suitable temperature and sufficient oxygen), a rhabditiform larva develops and hatches in about 2 days (development does not occur in undiluted stools, being acidic).
  - It feeds and molts in about 3 days giving another rhabditiform larva (500 µ). It molts again after about 7 days (keeping its skin; ensheathed) to become an infective filariform larva.

Mode of infection:

- Man is infected when the filariform larva penetrates his intact skin or mucous membrane of the mouth.

  - The filariform larva is attracted to man by histo-tropism and by warmth of the body (positive thermo-tropism). It shows other tropisms to various factors, e.g. negative geotropism and positive hygro-tropism.

  - The larvae on reaching the blood are carried to the right side of the heart → the lungs → penetrate the capillaries into the alveoli → pass up the tracheal tree, over the epiglottis → swallowed to reach their final habitat in the small intestine.

  - During their migration in the lung they molt for the third time, the fourth molt occurs in the small intestine giving the adult stage.
Eggs appear in stools about 2 months after infection.

Pathology and clinical picture:

<table>
<thead>
<tr>
<th>Due to larvae</th>
<th>Due to adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Ground itching</td>
<td>-Verminous pneumonia</td>
</tr>
<tr>
<td>-Cutaneous larvae migrans</td>
<td>-Anemia</td>
</tr>
<tr>
<td></td>
<td>-GIT symptoms</td>
</tr>
</tbody>
</table>

(A) Skin lesion:
- Ground itch: local dermatitis caused by FL penetration at the site of entry or contact with soil (feet, buttocks, hands).
- Cutaneous larvae migrans:
  It is due to migration of IFL in the skin
  Appear as maculopapular rash and itching (± pustules due to 2ry infection).

(B) Lung lesion:
- Löffler’s syndrome: caused by Ancylostoma larval migration in the lungs (verminous pneumonitis).
- It is presented by fever, cough, dyspnea, haemoptysis and oesinophilia.
- All symptoms are transient < 2 weeks.

(C) Intestinal lesion:
I- GIT: colic, vomiting, diarrhea.
II- Chronic iron-deficiency anaemia (hypochromic, microcytic ) due to blood loss.

Mechanisms of anaemia:
1- Tear by buccal capsule (parasite attached to sucked mucosa, by curved teeth and cutting plates → ulcer → haemorrhage).
2- Anticoagulant secretion by cephalic glands (continued bleeding after detachment).
3- Toxic bone marrow depression.
4- Enteritis (due to 2ry infection) decrease absorption of iron.

III- Complications
- Hypoproteinaemia (due to loss of proteins in blood) & subcutaneous oedema.
- Physical and mental retardation.
- Heart failure (due to tachycardia and hypoxia).

Diagnosis:
I- Clinical: the clinical picture though characteristic is not sufficient to differentiate it from the nutritional deficiency anaemia and oedema from other helminthic infection.
II- Laboratory: depends upon finding the eggs in feces.

Treatment:
1- Mebendazole (Vermox) or Flubendazole.
2- Pyrantel pamoate (combantrin).
3- Supportive treatment: Iron, vitamins and high protein diet.
Prevention and control:
1- Mass treatment of the infected population.
2- Sanitary disposal of human faeces and not to use them as fertilizer.
3- Wearing shoes and gloves for people handling mud or working in mines, gardening, poultry and brick-making.

Differences between hook worms (*A. duodenale* and *N. americanus*)

<table>
<thead>
<tr>
<th></th>
<th>Ancylostoma duodenale</th>
<th>Necator americanus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>Tropical and subtropical</td>
<td>More tropical (south America).</td>
</tr>
<tr>
<td>Adults: size:</td>
<td>Larger: male 1 cm, female 1.2 cm.</td>
<td>Smaller, male 0.8 cm, female 1 cm.</td>
</tr>
<tr>
<td>Anterior end:</td>
<td>Slight bent dorsally.</td>
<td>Strongly bent against body curvature</td>
</tr>
<tr>
<td>Spicules:</td>
<td>2 long separate.</td>
<td>2 fused distally with a blade</td>
</tr>
<tr>
<td>Vulva:</td>
<td>Post. 1/3 of body.</td>
<td>Middle of body.</td>
</tr>
<tr>
<td>Number of eggs/day</td>
<td>20,000/female/day</td>
<td>10,000/female/day.</td>
</tr>
<tr>
<td>Life span:</td>
<td>8 years.</td>
<td>4 years.</td>
</tr>
</tbody>
</table>

Case study:
A 41-year-old farmer presented with vague gastrointestinal complains, fatigue, weakness, pallor and loss of weight. The physician ordered a stool analysis. Three stool specimens, collected on alternate days, were submitted for examination for ova and parasites. Blood sample was also drawn for complete blood count. A moderate number of eggs were detected with occult blood in the stool. Each is oval, translucent with blunt poles and clear extra-embryonic space. A single larva was also observed in one stool specimen. This specimen had sat overnight at room temperature before being examined. Hematology result revealed hemoglobin of 10.0 gm/dl.

Questions:
1. Based on the patient's symptoms and morphology of the detected
165

eggs, which parasites are possible causes of the patient's symptoms?
2. How is this infection transmitted to humans?
3. Describe the life cycle of these parasites.
4. Would you expect to find both eggs and larvae of these parasites in an infected patient's stool specimen? Explain.
5. Describe the 2 larval stages of these helminths.
6. Which other nematode has larval stages, in the stool that may be confused with the larvae of these parasites?
7. What are the causes and type of anaemia that may occur in children heavily infected with these parasites?
8. How is this infection treated?
9. How can you control this parasitic infection?

Life cycle of hook worms
Strongyloides stercoralis (Dwarf Thread worm)

Geographic distribution: Tropical and subtropical areas.

Morphology:

1- Adult:

**Male (parasitic or free-living):** 0.7 mm in length with rhabditiform oesophagus. Posterior end curved ventrally and it has two spicules and a gubernaculum.

**Parasitic female:** 2.2 mm in length with cylindrical oesophagus (1/3 body length) posterior end straight.

- It has two sets of genitalia with 2 uteri full of eggs; the vulva opens at the junction of the middle and posterior thirds of the worm.

**Free-living female:** 1.1 mm in length with rhabditiform oesophagus and two sets of genitalia with two uteri full of eggs.

- The vulva opens at the middle of the body.

2- Egg: seldom found in stool; sub-mucosa or in soil, hatches after 2 hours.

Size: 55x30 µ.

Shape: oval, very thin shell.

Colour: translucent.

Contents: mature rhabditiform larva.

Life cycle:

- Habitat:

  **Parasitic adults** live in the small intestine. Fertilized females are deeply embedded in the mucosa, where they oviposit; and males live in the lumen of the intestine.

  **Free living adults** occur in the soil.
Definitive host: man.

Infective stage: infective filariform larvae.

Stage in the life cycle: egg → Rhabditiform larva → infective filariform larva or free living males and females.

- After fertilization the male dies and the female burrows deeply in the mucosa of duodenum and jejunum.
- Eggs are laid sub-mucosal, hatch into rhabditiform larvae within few hours → migrate into the lumen and pass to the faeces.
- Rhabditiform larvae after giving filariform larvae are infective to man (Direct cycle) or give rise to free living forms (Indirect cycle) when the free environmental conditions are suitable where they give rise to egg in soil then rhabditiform larvae and so on.
- After penetration of the IFL through the skin or the mucous membrane, they reach the circulation. Larvae are carried by the blood → the pulmonary capillaries and become extravasated in the alveoli. They ascend along the bronchial tree → the larynx and nasopharynx. Larvae become swallowed to reach their final habitat in the small intestine. Some of the larvae may remain in the alveolar tissue reaching maturity and initiate another cycle. Life span is 5 years.

Differences between hookworm and Strongyloides larvae

<table>
<thead>
<tr>
<th></th>
<th>Hookworm</th>
<th>Strongyloides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhabditiform larva:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size:</td>
<td>250 -500 µ</td>
<td>200 µ</td>
</tr>
<tr>
<td>Presence in fresh stool:</td>
<td>Not found in stool</td>
<td>Found in stool</td>
</tr>
<tr>
<td>Buccal cavity:</td>
<td>Long (as long as ant. body width).</td>
<td>Short (1/3 ant. body width).</td>
</tr>
<tr>
<td>Time to become filariform larva:</td>
<td>6-7 days</td>
<td>2-3 days</td>
</tr>
<tr>
<td>Filariform larva:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size :</td>
<td>600 µ</td>
<td>500</td>
</tr>
<tr>
<td>Length of oesophagus:</td>
<td>1/3 body length</td>
<td>1/2 Body length</td>
</tr>
<tr>
<td>Tail tip:</td>
<td>Pointed</td>
<td>Notched</td>
</tr>
<tr>
<td>Sheath:</td>
<td>Present</td>
<td>Absent</td>
</tr>
</tbody>
</table>

Mode of infection:

Infection with Strongyloides stercoralis can occur by:

1. Infective filariform larvae penetrating the skin of man when he gets in contact with infected soil. This occurs while walking bare foot, gardening or setting naked on the soil.
2. Autoinfection occurs by the infective filariform larvae that develop in the intestine of the patient. Development of rhabditiform larvae to infective filariform larvae in the intestine of the patient occurs in cases of constipation and intestinal disturbances.

Autoinfection may be:

a) Exogenous autoinfection: when infective filariform larvae develop outside the anus and penetrate the perianal skin.

b) Endogenous autoinfection: infective filariform larvae develop in the large intestine and penetrate the mucosa of the intestine. Autoinfection causes hyper-infection especially in immunosuppressed patients.

Pathogenicity and clinical picture:

1. Lesions resembling the ground itch of hook-worm infection are seen following penetration of the skin.

2. Pneumonitis may be produced by the larvae, but as in hook-worm infection, is generally less severe than in ascariasis.

3. The adult worms in the intestine may cause no symptoms or moderate to severe diarrhea (chronic intermittent painless diarrhea).

4. Malabsorption syndrome with steatorrhea can occur. Ulceration of the intestinal mucosa may give rise to symptoms resembling those of duodenal ulcer, sometimes with melena and anaemia, or ulcerative colitis.
5. **Hyper-infection** may lead to severe debilitation or death and the larvae that are found in virtually all parts of the body may give rise to **ectopic strongyloidiasis** (in lung or kidney).

**Diagnosis:**

1. **Stool analysis:**
   - Demonstration of rhabditiform larvae (diagnostic stage) (or occasionally filariform larvae) in freshly passed stool.
   - Direct fecal smear is often effective in cases of massive infections and various concentration techniques (zinc floatation and centrifugation), increase the chance of finding larvae.
   - Eggs may be seen in the stool rarely after purgation or in severe diarrhea.
   - Stool culture (to see the larvae and adults).

2. **Duodenal aspiration** may be done in mild infection (the larvae passed in the stool are few), for detection of eggs and rhabditiform larva.

3. **Blood picture** may show eosinophilia of 10-40%

4. **Sputum examination** shows the larvae especially if the adults are present in lungs.

**Treatment:** Mebendazole (vermox)

**Prevention and control:** similar to hookworms

**Case study:**
A 57-year-old patient had suffered from multiple myeloma for several years and had undergone bone marrow transplantation. Initially appeared to be recovering well following the surgery, but several weeks later he presented with symptoms of intermittent painless diarrhea, cough, dyspnea and abdominal pain. The patient's pulmonary complaint was diagnosed as chronic obstructive lung disease, and he was treated with high dose of intravenous steroids.

One month later, the patient was re-admitted with fever, and wheezing. Although treated aggressively with antibiotics, the patient's condition deteriorated and he died 30 days after being readmitted.

A complete autopsy was performed and microscopic analysis showed nematode larvae in his internal organs including small intestine, lungs heart and liver.

**Questions:**

1. Which nematode is most probably responsible for this disease?
2. How is this infection transmitted to humans?
3. Describe the life cycle of this parasite.
4. Describe the characteristics of hyper-infection syndrome caused by this parasite.
5. How do you diagnose this type of parasitic infection?
6. Which other nematode larvae may be confused with this parasite?
7. Which role might the steroid therapy have played in the severity of this patient's illness?
8. How is this infection treated?

Life cycle of *Strongyloides stercoralis*
Filarial worms

General morphology: Adult:
- Thread-like in shape.
- Creamy white in colour.
- Anterior and posterior ends of male & female are provided with sensory papillae.
- Mouth: simple without lips and buccal cavity.
- Oesophagus: cylindrical.

Male: - About 4 cm in length and 0.2 mm in diameter.
  - Curved posterior end.
  - 2 unequal and dissimilar spicules.
  - Subterminal cloaca.

Female: - About 8 cm in length and 0.4 mm in diameter (except *Onchocerca volvulus* may reach 50 cm)
  - 2 sets of genitalia.
  - Vulva anterior in the oesophageal region.
  - Subterminal anus.
  - Viviparous give birth to microfilaria.

2- Microfilaria (MF):
- Highly motile, thread-like pre larva containing columns of nuclei.
- Microfilariae are either sheathed or unsheathed.
- The morphology of the microfilaria, location in the host and type of periodicity is of value in differentiating species.

3- Infective larva (filariform larva):
- 1500 - 2000 x20 µ.
  - Cylindrical oesophagus.
  - Lies in the labium of the insect vector.
**Wuchereria bancrofti**

Geographical distribution: Tropical and subtropical countries.

In Egypt it is endemic in some localities, in Damietta (Ezbet-El-Borg), Dakahlia (Meet-Ghamr) and Sharkia (Hehya) Governorates.

Morphology:

1 - Adult: as described before.

<table>
<thead>
<tr>
<th>2- Microfilaria:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- 300 x10 μ.</td>
</tr>
<tr>
<td>- Sheathed, the sheath is loose and redundant (project beyond anterior and posterior ends).</td>
</tr>
<tr>
<td>- Bluntly rounded anterior end.</td>
</tr>
<tr>
<td>- Tapering posterior end and free of nuclei.</td>
</tr>
<tr>
<td>- Nocturnal periodicity (maximum at 12 P.M.).</td>
</tr>
</tbody>
</table>

Life cycle: as described before

-Habitat: adult in lymph vessels and lymph nodes especially that draining lower part of the body, while microfilariae are in the peripheral blood.

-Definitive host: man.

-Intermediate host (vector): mainly female *Culex*, also female *Anopheles* and *Aedes*.

-Reservoir host: no.

-Infecive stage: filariform larva in the mouth of infected mosquitoes. Mode of infection: Through the skin during the bite of infected mosquito.

Pathogenicity and clinical picture:

Disease: Bancroftian filariasis, wuchereriasis, elephantiasis.

- The various pathogenic complications of this disease are mainly due to the adults, the microfilariae seem to have no pathogenic manifestations although they have been associated with granulomatous inflammation of the lung, liver and spleen.

I- Asymptomatic filariasis: this occurs in endemic areas, there is microfilaria in the blood without clinical manifestations.

II- Symptomatic: The main pathological lesions are:

1- Acute inflammatory manifestations:

Due to toxic products of living or dead adult worms with superimposed secondary bacterial infection, it occurs in recurrent attacks and is manifested by:

- Lymphangitis of the genitalia (funiculitis, epididymitis, orchitis and scrotal oedema) with swelling and redness of affected parts.

- Lymphadenitis especially in the groin and axilla.
-Fever, chills, headache, vomiting and malaise.
-Leucocytosis and eosinophilia.

2- Chronic obstructive manifestations:

Due to fibrosis following the inflammatory process, the coiled worms inside lymphatics and endothelial proliferation, this may result in:

- Dilatation of lymphatics leading to varicosities especially in genital organs and abdominal wall as hydrocele, scrotal lymphoedema and lymphatic varices.
- Rupture of distended lymphatics (varicosities) e.g. in urinary passages \(\rightarrow\) chyluria, pleural sac \(\rightarrow\) chylothorax, the peritoneal cavity \(\rightarrow\) chylous ascitis, tunica vaginalis of testis \(\rightarrow\) chylocele, intestine \(\rightarrow\) chylous diarrhea.
- Elephantiasis: oedema of the affected part followed by hypertrophy of the skin and subcutaneous connective tissue, the part become hard, tender and the skin becomes thickened, rough, stretched and fissured lead to secondary bacterial infection. It is common in lower limbs and genitalia (scrotum, penis and vulva) rare in arms and breasts.

3- Tropical pulmonary eosinophilia (diffuse filarial lung disease):

-It is caused by immunologic hyper-responsiveness of the host to microfilarial antigens \(\rightarrow\) local destruction of microfilariae in the pulmonary vascular system and diffuse interstitial lung disease.
- Clinically there is dyspnea, cough, asthmatic attacks and eosinophilia, which respond well to treatment with hetrazan.
- Blood examination: microfilariae are not detected in the peripheral blood (occult filariasis).

Diagnosis:

I. Clinical: clinical picture as before.

II. Laboratory:

1- Direct:

a- Detection of microfilariae in peripheral blood by the following methods:

- Direct fresh smear under dark ground illumination to see motile microfilariae.
- Giemsa-stained thick blood film to show the stained fixed microfilaria.
- Concentration of microfilariae (knott's method): if microfilariae are scanty, 2ml of blood are mixed with 10ml of 2% formalin, allow the mixture to stand for 10 minutes then centrifuge, decant the supernatant and examine the sediment.

b- Provocative test:

Diethylcarbamazine is given orally (2- 8 mg /kg- body weight) to stimulate the microfilariae to circulate in the peripheral blood during day time.

The test is contraindicated in areas with Loa loa or Onchocerca volvulus coinfection.
The following points should be noted during examination:

- Microfilariae begin to appear a year or more after infection.
- Microfilariae are rarely found when lymphatics have become obstructed.
- Blood must be collected at night (between 10 P.M.- 2 A.M.).
- Microfilariae are highest in capillary blood than in venous blood.
- Microfilariae are more in blood from the ear lobe than from fingers.

a. Detection of microfilariae in chylous urine or from fluid aspirated from hydrocele and peritoneal cavities.

b. Urine examination: collect 10-20 ml of morning urine, add 2ml ether to dissolve chyle, then centrifuge at low speed and examine the sediment.

c. Detection of adult worms: Lymph node biopsy.

- X-ray to detect calcified dead worm.

2- Indirect:

- It is used during the incubation period and in late chronic infections when microfilariae are absent from peripheral blood.
- The antigen used is prepared from the dog filaria (*Dirofilaria immitis*) for detection of circulating filarial antibodies using the following tests; IFAT, CFT and ELISA.

Treatment:

1. Diethylcarbamazine (Hetrazan) is the drug of choice, has a lethal action on microfilariae.

2. Surgical treatment: removal of elephantoid tissue.
Life cycle of *Wuchereria bancrofti*
Objectives
1-Allow students to recognize different parasites with parasite stages under microscope to know morphological differences making them perfect to differentiate between different species.

SECTION I
PRACTICAL HELMINTHOLOGY

A- CLASS : TREMATODA
FASCIOLAE

1- *Fasciola gigantica*, adult :
   a. Length : 6-7 cm.
   b. Elongated with parallel borders.
   c. Ventral sucker is larger than oral one.
   d. Lateral compound and inner T- or Y-shaped caecal branches.
   e. 2 branched testes (in tandem).
   f. One branched ovary, anterior to the anterior testis, in the middle of the body.
   g. Numerous vitelline follicles at the lateral borders.
2- *Fasciola hepatica*, adult:
   a. Length: 2-3 cm.
   b. Converging lateral borders.
   c. Cephalic cone and shoulders are prominent anteriorly.
   d. Oral and ventral suckers are equal.
   e. The medial caecal branches are simple diverticula.

3- *Fasciolopsis buski*, adult:
   a. Length: 4 cm.
   b. Oval-shaped.
   c. Ventral sucker is larger than the oral one.
   d. Simple intestinal caeca.
   e. 2 branched testes in the posterior 1/2 of the body.
   f. Branched ovary in front of the testes.
   g. Vitellaria fill the lateral borders.
### 4- *Fasciola* egg:
- Oval.
- Thin, operculated shell.
- Size: 140X70 u.
- Yellowish-brown.
- Contains an immature embryo.

### 5- *Fasciola* miracidium:
- Small and conical-shaped.
- Ciliated body.
- Provided with 2 eye spots.
- 2 antero-lateral penetration glands.
- Germ cells are grouped posteriorly.

### 6- *Fasciola* redia:
- Cylindrical body.
- Primitive gut.
- One pair of marginal processes posteriorly.
- Groups of germ cells inside.
- Contains multiple primitive cercariae.

### 7- *Fasciola* cercaria:
- Flattened body and simple thin tail (leptocercous).
- Body with primitive gut and cystogenous glands.
### HETEROPHYES HETEROPHYES

#### 1- Adult:
- **a-** Pyriform in shape with broad posterior end.
- **b-** Size: 2X0.4 mm.
- **c-** 3 suckers, oral (small), ventral (large) and genital.
- **d-** 2 simple intestinal caeca.
- **e-** 2 oval testes, opposite each other, posteriorly.
- **f-** Oval mid plane ovary in front of testes.
- **g-** Few large postero-lateral vitelline follicles.

#### 2- Egg:
- **a-** Oval.
- **b-** Size: 30X15 u.
- **c-** Yellowish-brown.
- **d-** Thick-shelled.
- **e-** Operculated.
- **f-** Small knob at the abopercular end.
- **g-** Mature (contains miracidium).

#### 3- Encysted metacercaria:
- **a-** Rounded.
- **b-** 300 u. in diameter.
- **c-** Between muscle fibers of fish.
**HUMAN SCHISTOSOMES**

1. *S. haematobium*, male :
   a. 10-15 mm. in length.
   b. Oral and ventral suckers.
   c. With gynaecophoric canal.
   d. Finely tuberculated surface.
   e. Union of intestinal caeca at the middle of the body.
   f. 4-5 rounded, separate testes behind the ventral sucker.

2. *S. mansoni*, male :
   a. 10 mm. in length.
   b. Coarsely tuberculated surface.
   c. Union of intestinal caeca at junction of anterior 1/3 and posterior 2/3.
   d. 6-9 testicles in a mass.

3. *S. japonicum*, male :
   a. 12-20 mm. in length.
   b. Non tuberculated surface.
   c. Union of intestinal caeca is very late posteriorly.
   d. 6-9 testes compressed in a single column.
4- *S. haematobium*, female:
   a- Cylindrical and smooth body.
   b- 20 mm. in length.
   c- Union of intestinal caeca and ovary at the junction of anterior 2/3 with posterior 1/3.
   d- Uterus is long and contains 20-30 eggs.
   e- Vitelline glands fill posterior 1/3.

5- *S. mansoni*, female:
   a- Cylindrical and smooth body.
   b- 15 mm. in length.
   c- Union of intestinal caeca and ovary at the junction of anterior 1/3 with posterior 2/3.
   d- Uterus is short and contains few eggs.
   e- Vitelline glands fill posterior 2/3.

6- *S. mansoni*, couple:
   a- Female is lodged in the gynaecophoric canal of male.
   b- Female morphology is similar to that of *S. mansoni*.
   c- Male morphology is similar to that of *S. mansoni*. 
7- *S. japonicum*, egg:
   a- Oval.
   b- Size: 100X50 u.
   c- Thin shell with lateral, short, curved spine.
   d- Contains miracidium.

8- *Schistosoma* cercaria:
   a- Elongated body and tail.
   b- Length: 500 u.
   c- Length, body: tail = 2:3.
   d- Tail is furked (furcocercous).
   e- Body: 5-6 pairs of penetration glands.
   f- Oral and ventral suckers.
   g- Primitive gut.

---

**PARAGONIMUS WESTERMANNI**

Adult:
   a- Ovoid, reddish-brown.
   b- Equal oral and ventral suckers.
      Ventral one at middle of the body.
   c- Simple intestinal caeca.
   d- 2 lobed testes opposite each other, between ventral sucker and posterior end.
   e- Lobed ovary posterior to the ventral sucker.
   f- Multiple vitelline follicles at the lateral borders.
### B- CLASS : CESTOIDEA
#### TAENIAE

1. *Taenia saginata*, Scolex :
   - a- Quadrate-shaped.
   - b- 4 cup-shaped suckers.
   - c- Neither rostellum nor hooks.

2. *Taenia solium*, Scolex :
   - a- Rounded.
   - b- 4 cup-shaped suckers.
   - c- Rostellum with 2 alternating (short and long) crowns of taenoid hooks (22-32).

3. *Taenia*, Mature Segment :
   - a- Slightly broader than long (1 cm. in breadth).
   - b- Irregular alternation of common genital pores on the lateral borders.
   - c- Posterior bi-lobed ovary.
   - d- Closed median uterine tube.
   - e- Bilateral numerous testicular follicles.
   - f- Vitelline gland is compact mass posterior to the ovary.
<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>4-</strong> <em>T. saginata</em>, gravid segment :</td>
<td></td>
</tr>
<tr>
<td>a-</td>
<td>Longer than broad.</td>
</tr>
<tr>
<td>b-</td>
<td>Size : 20X6 mm.</td>
</tr>
<tr>
<td>c-</td>
<td>Main lateral uterine branches : 15-20 on each side.</td>
</tr>
<tr>
<td></td>
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<tr>
<td><strong>5-</strong> <em>T. solium</em>, gravid segment :</td>
<td></td>
</tr>
<tr>
<td>a-</td>
<td>Longer than broad.</td>
</tr>
<tr>
<td>b-</td>
<td>Size : 12X6 mm.</td>
</tr>
<tr>
<td>c-</td>
<td>Main lateral uterine branches : 6-12 on each side.</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td><strong>6-</strong> <em>Taenia</em> egg :</td>
<td></td>
</tr>
<tr>
<td>a-</td>
<td>Rounded.</td>
</tr>
<tr>
<td>b-</td>
<td>40 u. in diameter.</td>
</tr>
<tr>
<td>c-</td>
<td>Brownish in colour.</td>
</tr>
<tr>
<td>d-</td>
<td>With thick double-layer and radially-striated embryophore.</td>
</tr>
<tr>
<td>e-</td>
<td>Contains hexacanth embryo.</td>
</tr>
</tbody>
</table>
7- *Cysticercus bovis* :
   a- Rounded and bladder-like.
   b- 0.5-1.0 cm. in diameter.
   c- Whitish in colour.
   d- Invaginated and inverted scolex with 4 suckers without hooks.

8- *Cysticercus cellulosae* :
   a- Rounded and bladder-like.
   b- Smaller than *C. bovis*.
   c- Whitish in colour.
   d- Invaginated and inverted scolex with 4 suckers and 2 rows of taenoid hooks.

2- Hydatid Cyst :
   a- Wall is differentiated into 3 layers:
      i- Internal nucleated germinal layer.
      ii- Middle non-nucleated laminated layer.
      iii- Outer fibrous tissue layer.
   b- Cyst cavity, contains:
      i- Brood capsules and scolices, originating from the germinal layer
      ii- Daughter cysts, originating from the germinal and laminated layers.
3- Alveolar hydatid cyst:
   a- Irregular cavities filled with
       gelatinous material and separated
       by fibrous tissue septa.
   b- No germinal layer.
   c- No brood capsules or scolices
       (parasitologically sterile).

4- Hydatid sand:
   Multiple a) scolices, b) brood
   capsules and c) daughter cysts.
   a- Scolex: invaginated and inverted with
      2 rows of hooks.
   b- Brood capsules:
      i- Wall: germinal layer.
      ii- Cavity: contains multiple
          scolices.
   c- Daughter cyst: formed of the
      germinal and laminated layers.

HYMENOLEPIS NANA
1- Scolex :
   a- Spherical.
   b- 4 cup-shaped suckers.
   c- Retractile rostellum with one row of modified taenoid hooks (long handle and short blade).

2- Mature segment :
   a- Broader than long.
   b- 3 rounded testes, close together, in the middle of the segment, one poral and 2 aporal.
   c- Globular ovary between testes.
   d- Compact mass of vitelline glands behind ovary.
   f- Uni-lateral genital pores.
**C- CLASS : NEMATODA**

**ASCARIS LUMBRICOIDES**

1- Adult worms (in jar):
   - a- Long cylindrical with tapering ends.
   - b- Yellowish-creamy in colour.
   - c- Male : 15-20 cm. with curved posterior end.
   - d- Female : 20-40 cm. with straight posterior end.

2- Anterior end:
   - a- Mouth : 3 lips, one dorsal and 2 sub-ventral.
   - b- Oesophagus : club-shaped.

3- Fertilized egg:
   - a- Broad oval.
   - b- Size : 60X40 u.
   - c- Yellowish-brown in colour.
   - d- Thick-shelled with regular albuminous mammillations.
   - e- Immature (contains large single cell stage embryo).

4- Un-fertilized egg:
   - a- More oval.
   - b- Size : 90X45 u.
   - c- Yellowish-brown.
   - d- Thin-shell with poor mammillations.
   - e- Contains refractile granules.

**ENTEROBIUS VERMICULARIS**
1- Male:
   a- 2-5 mm. in length.
   b- 2 cervical alae anteriorly.
   c- Simple mouth with 3 small lips.
   d- Double-bulbed oesophagus.
   e- Sub-terminal cloaca.
   f- Curved posterior end with single spoon-shaped spicule.

2- Female:
   a- 8-13 mm. long.
   b- 2 cervical alae anteriorly.
   c- Simple mouth with 3 small lips.
   d- Double-bulbed oesophagus.
   e- Posterior 1/3 is thin and straight (tail).
   f- Vulva at the junction of anterior 1/4 with posterior 3/4.
   g- Anal orifice at the junction of anterior 2/3 with posterior 1/3.

3- Egg:
   a- D-shaped (plano-convex).
   b- Size: 55X25 u.
   c- Shell: double-walled.
   d- Translucent.
   e- Contains fully developed larva.

TRICHOCEPHALUS TRICHIURUS
1- Male :
   a- 3-4 cm. in length.
   b- Anterior thin part (3/5) and posterior thick one (2/5).
   c- Simple mouth.
   d- Cellular oesophagus.
   e- Terminal cloaca.
   f- Coiled posterior end with single spicule.

2- Female :
   a- 4-5 cm. long.
   b- Thin and thick parts as male.
   c- Simple mouth.
   d- Cellular oesophagus.
   e- Vulva at the junction of thin (anterior 3/5) and thick (posterior 2/5) parts.
   f- Straight posterior end with terminal anal orifice.

3- Egg :
   a- Barrel-shaped.
   b- 50X25u.
   c- Thick-shelled with translucent bipolar mucoid plugs.
   d- Yellowish-brown.
   e- Immature (contains an embryo in the single cell stage).

**ANCYLOSTOMA DUODENALE**
1- Male :
   a- 10 mm. in length.
   b- Anterior end is curved ventrally with the body curvature.
   c- Mouth with buccal capsule.
   d- Club-shaped oesophagus.
   e- Terminal cloaca.
   f- Posterior end with bursa and 2 long separate spicules.

2- Female :
   a- 12 mm. in length.
   b- Anterior end is curved ventrally with the body curvature.
   c- Mouth with buccal capsule.
   d- Club-shaped oesophagus.
   e- Sub-terminal anus.
   f- Straight posterior end.
   g- Vulva opens at the junction of anterior 2/3 with the posterior 1/3.

3- Rhabditiform larva:
a- 200-300 u. in length.
b- Long oral vestibule.
c- Rhabditiform oesophagus (1/3 body length).
d- Pointed posterior end.

4- Filariform larva
a- 500-700 u. in length.
b- Club-shaped oesophagus (1/3 body length).
c- Pointed posterior end.
d- Sheathed.

NECATOR AMERICANUS
1- Male:
   a- 8 mm. in length.
   b- Anterior end is curved dorsally against body curvature (hook-like).
   c- Mouth with buccal capsule.
   d- Club-shaped oesophagus.
   e- Terminal cloaca.
   f- Posterior end with bursa and 2 long fused spicules with a hook-like end.

2- Female:
   a- 10 mm. in length.
   b- Anterior end curved dorsally against body curvature (hook-like).
   c- Mouth with buccal capsule.
   d- Club-shaped oesophagus.
   e- Sub-terminal anal orifice.
   f- Straight posterior end.
   g- Vulva opens at the middle of the body.
Free-living female:
- One mm. in length.
- Simple mouth.
- Rhabditiform oesophagus.
- Vulva opens at the middle of the body.
SECTION II
PRACTICAL PROTOZOOLOGY

1- CLASS : LOBOSEA
AMOEBAE
A- FREE-LIVING AMOEBAE

1- *Naegleria fowleri*, trophozoite
(amoeboid form):

a- 15 u in diameter.
b- Cytoplasm: ecto- and endoplasm.
c- Pseudopodia: single and broad.
d- Nucleus:
   i- Karyosome: large and central.
   ii- No peripheral chromatin.

2- *Acanthamoeba castellani*,
trophozoite:

a- 30 u in diameter.
b- Cytoplasm: poor differentiation into ecto- and endoplasm.
c- Pseudopodia: Spine-like and multiple (filamentous).
d- Nucleus:
   i- Karyosome: large and central.
   ii- No peripheral chromatin.

B- PARASITIC AMOEBAE
   i- *Entamoeba histolytica* :
1- Trophozoite:
   a- 15-20 µ in diameter.
   b- Cytoplasm: ecto- and endoplasm.
   c- Pseudopodia may be present.
   d- Food vacuoles: contain R.B.Cs.
   e- Nucleus:
      i- Karyosome: small and central.
      ii- Peripheral chromatin: fine and regular granules.

2- Cyst:
   a- Rounded.
   b- 12-15 µ in diameter.
   c- Contains 4 nuclei (at different levels) and rod-shaped chromatoid bodies with rounded ends.
1- CLASS : ZOOMASTIGOPHORA
INTESTINAL FLAGELLATES

Giardia intestinalis :

1- Trophozoite:
   a- Pear-shaped with broad anterior end. (15x8 u.).
   b- 2 sucking discs anteriorly.
   c- 2 oval vesicular nuclei anteriorly.
   d- 4 pairs of flagella.
   e- 2 axostyles in the middle.
   f- Comma-shaped parabasal body across the axostyles.

2- Cyst:
   a- Oval.
   b- Size: 12X7 u.
   c- Double-walled.
   a- 4 nuclei at one pole.
   b- Remnants of axostyles and parabasal body.
URO-GENITAL FLAGELLATES
Trichomonas vaginalis :

**Trophozoite** :
a- Spheroid in shape.
b- 18X9 u.
c- 2 pairs of flagella anteriorly.
d- Antero-lateral cytostome.
e- Single oval vesicular nucleus anteriorly.

HAEMO-SOMATIC FLAGELLATES

1- *Leishmania* form :
a- Ovoid, 3-5 u. in diameter.
b- Cytoplasm: pale bluish in colour.
c- Oval central vesicular nucleus: red-coloured.
d- Parabasal body: red-coloured.
e- No free flagellum.

2- Monomorphic trypanosomes *(Trypanosoma cruzi)* :
a- C- or U-shaped and mono-sized (20 u. in length).
b- Central nucleus.
c- Large posterior para-basal body.
d- Sharp posterior end.
e- Free flagellum.
f- Between blood cells.
g- Few in number in the blood film.
3- Polymorphic trypanosomes
( *T. gambiense*, *T. rhodesiense*) :
  a- Elongated bodies and multi-sized (14-33 u. in length).
  b- Extra-cellular.
  c- Central vesicular nucleus.
  d- Posterior kinetoplast.
  e- Long undulating membrane.
  f- Free flagellum.
  g- Multiple in the blood film.

**PLASMODIA**
**A- Plasmodium vivax** :

1- *Ring form* :
  a- Single ring.
  b- Large (fills 1/2 R.B.C.).
  c- Enlarged parasitized RBCs.

2- *Schizont* :
  a- Large (fills R.B.C.)
  b- Contains 16 (12-24) merozoites arranged irregularly.
### 3- Gametocyte:

a- Large (fills R.B.C.).

b- Rounded or oval.

---

### B- *Plasmodium malariae*:

**Schizont**:

<table>
<thead>
<tr>
<th>a- Large (fills R.B.C.).</th>
</tr>
</thead>
<tbody>
<tr>
<td>b- Contains 8 (6-12) merozoites</td>
</tr>
<tr>
<td>arranged regularly (rosette-shape).</td>
</tr>
<tr>
<td>c- Normal size of parasitized RBCs.</td>
</tr>
</tbody>
</table>

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### C- *Plasmodium falciparum*:

1. **Ring stage**:

<table>
<thead>
<tr>
<th>a- Multiple marginal rings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>b- Small-sized (fills 1/6 R.B.C.).</td>
</tr>
<tr>
<td>c- Normal size of parasitized R.B.Cs.</td>
</tr>
<tr>
<td><strong>2- Gametocyte:</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>a- Kidney-shaped.</td>
</tr>
<tr>
<td>b- Central compact or diffuse nucleus.</td>
</tr>
<tr>
<td>c- Pale or deep blue cytoplasm.</td>
</tr>
</tbody>
</table>

**TOXOPLASMA GONDII**

<table>
<thead>
<tr>
<th><strong>Trophozoite:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a- Crescent-shaped.</td>
<td></td>
</tr>
<tr>
<td>b- One pole is more rounded than the other.</td>
<td></td>
</tr>
<tr>
<td>c- 6X3 u.</td>
<td></td>
</tr>
<tr>
<td>d- Nucleus is eccentric (near the rounded end).</td>
<td></td>
</tr>
<tr>
<td>e- Para-nuclear body (near the pointed end).</td>
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</tbody>
</table>
MOSQUITOES
A. *Culex*:

1. Male, head:
   a. Antenna: Plumose hairs.
   b. Maxillary palps: 2 long and 4-segmented.

2. Female, head:
   a. Antenna: pilose hairs.
   b. Maxillary palps: 2 short and 4-segmented.
3- Egg-rafts:
   a- Laid in groups (250-500 eggs).
   b- Ovoid, one end broader than the other.

4- Larva:
   a- Abdomen covered with simple hairs.
   b- Long narrow siphon on 8th abdominal segment.
   c- Comb: 3-4 rows on 8th abdominal segment.
5- Pupa:
   a- Comma-shaped.
   b- Cephalo-thorax and abdomen.
   c- Respiratory trumpets are narrow
      (on lateral view).

6- Wing:
   Wing venation: C,Sc,1,22,3,44,55,6.
B- Anopheles:

1- Male, head:
   a- Antenna: Plumose hairs.
   b- Maxillary palps: 2 long and 4-segmented with swollen ends.

2- Female, head:
   a- Antenna: pilose hairs.
   b- Maxillary palps: 2 long, 4-segmented, without clubbing.
3- Egg:
   a- Single.
   b- Slipper-shaped.
   c- Provided with air floats.
   d- Brown in colour.

4- Larva:
   a- Abdomen: covered by palmate hairs and simple ones.
   b- No respiratory siphon.
   c- Two respiratory spiracles on 8th abdominal segment.
5- Pupa:
a- Comma-shaped.
b- Cephalo-thorax and abdomen.
c- Respiratory trumpets:
   Short and broad (on lateral view).

6- Wing:
a- Dark spots on veins.
b- Wing venation:
   C,Sc,1,22,3,44,55,6.
C- **Aedes** :

1- Egg:
   a- Laid singly.
   b- Black in colour.
   c- Spindle-shaped.
   d- Surface : with protuberances.

2- Larva :
   a- Body covered by simple hairs.
   b- Short & broad respiratory siphon (barrel-shaped).
   c- Single row of comb on 8th abdominal segment.
MUSCA DOMESTICA

1- Adult :
   a- Grey in colour.
   b- Head : with 2 large compound eyes.
   c- Mouth parts are hidden ventrally.
   d- Thorax : has 4 longitudinal dark stripes.
   e- Abdomen : 4-segmented with 4 longitudinal dark stripes.

2- Antenna :
   a- 3-segmented, 2 small and the 3rd is the longest with arista.
   b- Arista is covered by simple hairs on both sides up to the tip.
3- Mouth parts (en face view):
   a- Triangular rostrum with 2 short single-segmented maxillary palps.
   b- Haustellum.
   c- 2 labellae with pseudotracheal tubules.

4- Mouth parts (lateral view):
   a- Rostrum.
   b- Haustellum.
   c- Single labellum.
5- Wing:
   a- Venation:
       C, Sc, 1, 2, 3, 4, 5 & 6.
   b- The 4th vein makes an acute angle and forms a closed cell with the 3rd one at apex.

6- Egg:
   a- Banana-shaped.
   b- One mm. in length.
   c- Creamy-white.
   d- One end broader than the other.
   e- 2 longitudinal ridges on the surface.
7- Larva:
Posterior respiratory spiracles with:
   a- D-shaped closed peritremes.
   b- 3 m-shaped slits.
   c- Medial button.

8- Pupa:
   a- Barrel-shaped.
   b- Dark brown.
   c- Respiratory slits on the last segment.
STOMOXYS CALCITRANS

1- Adult:
   a- Small-sized.
   b- Grey in colour.
   c- Protruded mouth parts.
   d- Abdomen: 4-segmented with 2 elongated median and 4 dorso-lateral rounded dark spots.

2- Mouth parts:
   a- Triangular rostrum.
   b- 2 short, single segmented maxillary palps.
   c- Fusiform labium
   d- Small toothed labellae.
3- Antenna :
   a- Aristate.
   b- Arista covered with simple hairs only on the dorsal side.

4- Wing :
   a- Simple veins.
   b- 4th vein with obtuse angle and makes an open cell with the 3rd one at apex.

5- Larva :
   Posterior respiratory spiracles with :
   a- Triangular, widely separated and closed peritremes.
   b- 3 S-shaped slits.
   c- Central button.
1- Mouth parts:
   a- Triangular rostrum with 2 long single-segmented maxillary palps (as long as labium).
   b- Labium with basal bulb.
   c- Small toothed labellae.

2- Antenna:
   a- Aristate antenna.
   b- Arista covered by compound (branched) hairs only on the dorsal side.
3- Wing:
The 4th vein has 2 curves making, with the 5th one, a cleaver-shaped cell.

4- Pupa:
   a- Dark yellow in colour.
   b- Barrel-shaped.
   c- 2 posterior prominent knobs.
1- Adult:
   a- Large-sized.
   b- Grey-coloured.
   c- Abdomen with chess-board design.

2- Antenna:
   a- Aristate.
   b- Arista covered with simple hairs on both sides only of the proximal 2/3.
3- Wing:
Similar to that of *Musca* but the 4th vein makes a very acute angle and closed cell with the 3rd one at the apex.

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4- Larva:
Posterior respiratory spiracles with:
a- Rounded, open peritremes.
b- 3 converging straight slits.
c- Medial button.
WOHLFAHRTIA

1- Adult :
   a. Large-sized.
   b. Grey-coloured.
   c. Abdomen with 9 black spots and a dark longitudinal mid-dorsal band.

2- Antenna :
   a. Aristate.
   b. Arista is bare (no hairs).
## METALLIC FLIES

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1   | *Calliphora*, adult | a. Large-sized.  
      b. Dull blue-coloured.  
      c. Thorax and abdomen are covered with hairs.  
      d. Eyes are red-coloured. |
      b. Thorax covered with long hairs. |
| 3   | *Chrysomyia*, adult | a. Green-coloured.  
      b. Thorax covered with short hairs.  
      c. Abdomen with 2 transverse dark stripes. |
FLEAS

B- ORDER : SIPHONAPTERA

A- Xenopsylla cheopis :

1- Male :
   a- Body : Compressed laterally and hairy.
   b- Brown-coloured.
   c- Triangular head with mouth parts, 2 simple eyes and one pair of 3-segmented antenna.
   d- 3 thoracic and 9 abdominal segments.
   e- Meso-pleural suture on 2nd thoracic segment.
   f- Spring-like aedeagus on abdomen.

2- Female :
   As male with rounded posterior abdominal end and comma-shaped spermatheca.
B- *Pulex irritans* :

1- Male :
   a- Rounded anterior border of the head.
   b- Single post-cephalic bristle.
   c- Spring-like aedeagus on the abdomen.

2- Female :
   As male with comma-shaped spermatheca on the abdomen.
C- Ctenocephalus canis:

1- Male:
   a- Combed.
   b- Has 2 combs, genal and pronotal.
   c- With aedeagus.

2- Female:
   a- Combed.
   b- Has 2 combs, genal and pronotal.
   d- With spermatheca.

D- Flea Larva:

   a- 14-segmented.
   b- Covered with short posteriorly-directed hairs.

C- ORDER: HEMIPTERA
i- **CIMEX LECTULARIUS**

1- Male :
   a- Brown-coloured.
   b- Pentagonal head with 2 eyes and two 4-segmented antennae.
   c- Pro-thorax is protruded anteriorly.
   d- Posterior end of the abdomen with laterally–curved aedeagus.

2- Female :
   Posterior abdominal end with:
   a- Rounded border.
   b- Ventral vaginal opening.
3. Egg:
   a. Oval with a slight bend anteriorly.
   b. Large, one mm. in length.
   c. Whitish in colour.
   d. Operculated, with an oblique lid.

4. Nymph:
   As adult, but:
   a. Smaller.
   b. Paler, and
   c. Sexually immature.

ii. TRIATOMA MEGISTA

Adult (in box):
   a. Bee-sized and black-coloured.
   b. Head: elongated and cone-shaped.
   c. Winged: 2 pairs of wings.
   d. Red markings on wings, thorax and abdomen.
   e. Abdomen with flattened margins.
**D- ORDER : ANOPLURA**

**i- PEDICULUS HUMANUS**

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<table>
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<tr>
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<tbody>
<tr>
<td><strong>1- Male:</strong></td>
<td></td>
</tr>
</tbody>
</table>
|   | a- Grey-coloured.  
|   | b- Head : one pair of 5-segmented antennae.  
|   | c- Thorax : weakly segmented.  
|   | d- Abdomen :  
|   | i- 8-segmented with 6 pairs of respiratory spiracles.  
|   | ii- Spine-like aedeagus posteriorly. |
|   |   |
| **2- Female:** |   |
|   | As male, but the posterior abdominal segment is notched.  

3- Egg:
   a- Oval.
   b- Operculated.
   c- Cemented to hair by ¾ of its length.

4- Nymph:
   Similar to adult, but:
   i- Smaller.
   ii- Paler and
   iii- Sexually immature.

ii- PHTHRUS PUBIS
1- Male:
a- Head: engaged in the thorax.
b- Thorax: larger than abdomen.
c- Abdomen: 5-segmented.
d- 2 pairs of lateral abdominal processes.

2- Female:
a- Abdomen: 5-segmented.
b- 4 pairs of lateral abdominal processes.
2- CLASS : ARACHNIDA
A- ORDER : ACARINA
i- SARCOPTES SCABIEI

1- Male :
   a- Grey-coloured.
   b- Rounded in shape.
   c- 4 pairs of legs venterally.
   d- Anterior 2 pairs of legs ends with suckers.
   e- 3rd pair of legs ends with long bristles.
   f- 4th pair ends with suckers.

2- Female :
   a- Anterior 2 pairs of legs ends with suckers.
   b- Posterior 2 pairs of legs ends with long bristles.

ii- TICKS
A- Hard Tick (Dermacentor andersoni)

1- Male:
   a- Scutum covers all the dorsal surface.
   b- Capitulum protruded anteriorly.
   c- Has 4 pairs of legs.
   d- The posterior margin is festooned.

2- Female:
   As male, but:
   Scutum covers only the anterior part of the dorsal surface.

3- Larva:
   a- 3 pairs of legs.
   b- Capitulum protruded anteriorly.
   c- Posterior end is festooned.
   d- Small scutum on the dorsal surface anteriorly.

B- Soft tick:
<table>
<thead>
<tr>
<th>1- <em>Argas persicus</em>, adult :</th>
</tr>
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<tbody>
<tr>
<td>a- Triangular body.</td>
</tr>
<tr>
<td>b- Sharp margins.</td>
</tr>
<tr>
<td>c- Reddish-brown in colour.</td>
</tr>
<tr>
<td>d- Dorsal surface is shining and no scutum.</td>
</tr>
<tr>
<td>e- Capitulum is hidden ventrally.</td>
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<tr>
<td>f- No festoons posteriorly.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2- <em>Ornithodoros moubata</em>, adult :</th>
</tr>
</thead>
<tbody>
<tr>
<td>a- Rounded body.</td>
</tr>
<tr>
<td>b- Dusty-brown in colour.</td>
</tr>
<tr>
<td>c- Dorsal surface is leathery.</td>
</tr>
<tr>
<td>d- Ventrally-hidden capitulum.</td>
</tr>
<tr>
<td>e- No body festoons.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3- Larva :</th>
</tr>
</thead>
<tbody>
<tr>
<td>a- 3 pairs of legs.</td>
</tr>
<tr>
<td>b- Ventrally-hidden capitulum.</td>
</tr>
<tr>
<td>c- No posterior festoons.</td>
</tr>
</tbody>
</table>
References and recommended readings:

References:
Department book
Clinical Parasitology. A Practical Approach, 2013

Recommended readings:

a- Basic clinical Parasitology (Brown and Neva)
b- Colored Atlas of Parasitology
c- Medical Parasitology (Markell, Vogue, and John)
d- Tropical medicine and Parasitology (Peters and Gills)

Book Coordinator; Mostafa Fathallah

General Directorate of Technical Education for Health
Chapter 5

Cases and collections
Case 3

A farmer complaining of painful urination and presence of blood in his urine, by examination of this urine we found eggs with terminal spines.

Questions:

1- What is the causative parasite?
Schistoma haematobium

2- What is the infective stage?
Furcocercus cercaria

3- What is the mode of infection?
Direct skin penetration by cercaria

4- What are the complications of this infection?
Cystitis, stones
Cancer bladder
Hydroureter
Hydronephrosis, renal failure

5- What is the habitat of this parasite?
Pelvic, vesical venous plexuses surround urinary system, genital system

6- Mention the stages of its life cycle?
Adults → Eggs → Miracidium → Sporocyst → Cercaria (No redia stage)
Case 4

A child complained of abdominal colic, hunger pain, weight loss, perianal itching and passing segments in stool.

Questions

1- What is the causative organism?
   Taenia saginata

2- What is the infective stage?
   Cysticercus bovis in beef

3- What is the mode of infection?
   Ingestion of infective stage in insufficiently cooked beef

4- What is the diagnostic stage?
   Eggs of taenia and gravid segments in stool

5- What is the method of prevention?
   Good cooking of meat to kill the larvae.
Case 5

Child complained of pain in the right hypochondrium.

On examination, there was enlarged liver. Ultrasound showed huge cyst.

Questions:

1- What is the causative organism?
   Echinococcus granulosus causing Hydatid disease

2- What is the infective stage?
   Eggs of Echinococcus granulosus

3- What is the mode of infection?
   Ingestion of eggs in contaminated food or drink with dog faeces.

4- What are the common sites?
   Liver, lung, brain

5- What is the methods of prevention?
   Avoid contamination of hands, food, drinks with dogs faeces.
Case 6

Child complaining of diarrhea and abdominal colic, by examination of his stool, there are eggs with 4 filaments in each pole.

Questions:

1- What is the causative parasite?
   Hymenolepis nana

2- Habitat of the parasite
   Small intestine of man

3- What is the method of infection?
   Autoinfection
   Contaminated foods and drinks.

4- Infective stage
   Eggs

5- Methods of prevention
   Good washing of hands
   Treatment of cases
   Washing of vegetables and pure water supply.
Case 7

Farmer complained of abdominal pain, allergy, dyspepsia, and pass worm about 20 cm length.

Questions:

1. What is the parasite?
   Ascaris

2. What is the infective stage?
   Larvated egg

3. What is the mode of infection?
   Ingestion of infective stage in contaminated water and vegetables

4. What is the diagnostic stages?
   Eggs and adult worms

5. What is the methods prevention?
   Proper washing of hands and vegetables before eating
   Pure water supply
Case 8

Child complained of itching around the anus especially at night and nervousness and nocturnal enuresis.

Questions:

1- What is the parasite?
   Enterobius (oxyuris)

2- What is the infective stage?
   Larvated egg

3- What is the mode of infection?
   Ingestion of infective stage in contaminated food and drink
   Inhalation of infective stage
   Autoinfection

4- What is the diagnostic stage?
   Egg and adult (1-2 cm) in stool

5- What is the methods of prevention?
   Personal hygiene (cutting nails - washing hands - good washing of clothes).
Case 9

Patient suffering from severe anaemia, abdominal colic and by examination of the stool we find eggs with 4 cell embryo.

1- What is the causative parasite?
   Ancylostoma duodenale
2- What is the infective stage?
   Filariform larva in soil
3- What is the methods of infection?
   Penetration of skin and mucus membrane
4- Habitat
   Small intestine of man
5- Methods of prevention
   Treatment of cases
   Wearing shoes and gloves in the field.
Case 10

Man complained of edema and swelling of lower limbs, genitalia with thickened and rough skin.

Questions

1- What is the parasite?
Filaria which cause elephantiasis

2- What is the infective stage?
Filariform larva in mosquitoes

3- What is the mode of infection?
Bite of female anopheles mosquito (culex)

4- What is the diagnostic stage?
Microfilaria in blood

5- What is the prevention?
Mosquitoes control via insecticides e.g.: pyrosol and repellents
Treatment of cases

6- Habitat
Lymph nodes and lymphatics of lower limbs and genitalia.
Notes in
PARASITOLOGY
EXAMINATIONS
Cases
Case 1

Patient complained of pain in the upper right quadrant of the abdomen, fever and jaundice.

On examination he had enlarged tender liver.

Questions:

1- What is the causative parasite?
   Fasciola

2- What is the infective stage?
   Encysted metacercaria on vegetables

3- What is the mode of infection?
   Ingestion of infective stage in contaminated vegetables and water drinks.

4- What is the diagnostic stage?
   Fasciola egg in stool

5- What is the methods of control and prevention?
   a. Good washing of vegetables before usage
   b. Destruction of the snails

6- What is the habitat is this parasite?
   Biliary passages of the liver.
Case 2

Fisherman complained of severe diarrhea after eating bory and bolty.

Questions:
1- **What is the causative parasite?**
   Heterophyes heterophyes
2- **What is the infective stage?**
   Encysted metacercaria inside fish muscles
3- **What is the diagnostic stage?**
   Heterophys egg in stool
4- **What is the method of prevention?**
   Proper cooking and salting of fish (bory & bolty).
5- **What is the habitat of this parasite?**
   Small intestine of man, cats, dogs, birds.
Case 11

- Patient suffering from dysentery, Abdominal pain, by stool examination revealed mucus, blood and revealed quadri nucleated cysts.

1- What is the possible parasite?
Entamoeba histolytica

2- Mention the infective stage?
Mature quadri - nucleated cyst

3- What is the methods of transmission?
Ingestion of contaminated food or water with eggs
Autoinfection

4- What is the methods of prevention, control?
Avoid defecation on the ground
Control of flies
Personel hygiene

5- Mention the extra intestinal lesions?
Liver and lung amoebic abscesses
Case 12

Woman suffered from vaginal discharge with burning sensation.

Questions:

1- **What is the parasite?**
   Trichomonas vaginalis
2- **What is the infective stage?**
   Trophozoite
3- **What is the mode of infection?**
   Sexual intercourse and contaminated under wears, WC seats.
4- **What is the diagnostic stage?**
   Trophozoite in vaginal discharge
5- **What is the prevention?**
   General good hygiene
6- **Habitat:** Urogenital system of female and males.
Case 13

Patient complained of fatty diarrhea and abdominal colic, by examination the stool we found oval quadrinucleated cysts.

Questions:

1- What is the causative parasite?
   Giardia lamblia
2- Habitat:
   Small intestine of man (duodenum)
3- Infective stage
   Quadrinucleated cyst
4- Stages in life cycle
   Trophozoites and cysts
5- Methods of prevention
   Washing of hands
   Treatment of cases
   Good washing of raw vegetables and drinking pure water.
Case 14

Patient complained of fever consist of cold stage (2 hours) and hot stage (4 hours) and sweating stage (2 hours)

Repeated every three days, on blood examination there is anaemia.

Questions

1- What is the disease?
   Malaria

2- What is the infective stage?
   Sporozoites by female anopheles

3- What is the mode of infection?
   By bite of female mosquitoes (female anopheles)

4- What is the diagnostic stages?
   Parasitic stages in blood sample

5- What is the prevention?
   Mosquitoes control via insecticides as pyrosol and repellents.
Case 15

Woman complained of repeated abortions and she had cat in her house.

Questions:

1- What is the parasite?
   Toxoplasma

2- What is the infective stage?
   Oocyst

3- What is the mode of infection?
   Contaminated food and drink with infected cat faeces

4- What is the diagnosis?
   Serum examination as ELISA and IHA

5- What is the methods of prevention?
   Periodic examination of cats, avoid contamination of food or drink with cat faeces.
Case 16

Soldier complains of severe itching especially at night associated with reddish skin and small vesicles at wrists and interdigital spaces.

Questions

1- What is the causative parasite?
Sarcopetes scabii

2- Habitat
Under the skin

3- What is the mode of infection?
Contact with infected persons or clothes

4- What is the diagnosis?
Depend on clinical picture.

5- What is the methods of prevention?
Avoid contact with infected persons or his clothes and personnel cleanliness.
Case 16

Soldier complains of severe itching especially at night associated with reddish skin and small vesicles at wrists and interdigital spaces.

Questions

1- What is the causative parasite?
Sarcopetes scabiei

2- Habitat
Under the skin

3- What is the mode of infection?
Contact with infected persons or clothes

4- What is the diagnosis?
Depend on clinical picture.

5- What is the methods of prevention?
Avoid contact with infected persons or his clothes and personnel cleanliness.
collections

Parasites causing diarrhea and mention the infective stage, mode of infection and prevention in each parasite

1- Heterophyes
2- H.nana
3- Giardia
4- Entamoeba histolytica
5- Ancylostoma
6- Ascaris

Parasites causing dysentery, mention the infective stage, mode of infection and prevention in each parasite?

1- Schistosomamansoni
2- Entamoebahistolytica

Parasites causing fever and mention the infective stage, mode of infection, and prevention in each parasite

1- Malaria
2- Toxoplasma
Parasites causing haematuria, and mention the infective stage, mode of infection, and prevention in each parasite

Schistosoma haematobium

Parasites causing jaundice, and mention the infective stage, mode of infection, and prevention in each parasite?

1- Fasciola
2- Malaria
3- Giardia
4- Schistosoma

Parasites causing dyspepsia, and mention the infective stage, mode of infection and prevention in each parasite

1- Ascaris
2- Ancylostoma
3- Hymenolepis nana
Parasites causing perianal itching, and mention the infective stage, mode of infection and prevention in each parasite:

Oxyuris

Parasites causing elephantiasis, and mention the infective stage, mode of infection, and prevention in each parasite:

Filaria

Parasites causing vaginal discharge and itching, mention the infective stage, mode of infection and prevention in each parasite:

1-Trichomonas vaginalis
2-Oxyuris

Parasites causing anaemia, and mention the infective stage, mode of infection and prevention in each parasite:

1-Malaria
2-Ancylostoma
3-Schistosoma
Common questions.

Parasites causing diarrhea:
1-Heterophyes.
2-Hymenolepis nana.
3-Ascaris.
4-Ancylostoma.
5-Giardia.

Parasites causing dysentery:
1-Entamoeba histolytica.
2-Schistosoma mansoni.

Parasites causing Anaemia:
1-Schistosoma.
2-Ancylostoma.
3-Malaria.
4-Lieshmania.

Parasites causing abdominal colic:
1-Fasciola.
2-Heterophyes.
3-Schistosoma.
4-Taenia.
5-H.nana.
6-Ascaris.
7-Ancylostoma.
8-Giardia.
9-Entamoeba histolytica.

Parasites causing hepatosplenomegaly:
1-Schistosoma.
2-Malaria.
3-Amoeba.
4-Leishmania:

Parasites causing jaundice:
1-Fasciola.
2-giardia.
3-schistosoma.
4-Malaria.
Parasites found in the liver:
1-Fasciola gigantica.
2-Schistosoma mansoni.
3-Hydatid cyst.
4-Visceral larva migrans.
5-Entamoeba histolytica.
6-Malaria.
7-Leishmaniasis donovani.
8-Trypanosoma cruzi.
9-Toxoplasma gondii.

Parasites of the small intestine:
1-Ascaris.
2-Trichinella spiralis.
3-Ancylostoma.

Parasites of the large intestine:
1-Trichocephalus.
2-Enterobius (Oxyuris).
3-Entamoeba histolytica.
4-Plasmodium falciparum.

Parasites that may be acquired from servants in the houses:
1-E. histolytica.
2-Giardia.
3-Enterobius.
4-Hymenolepis nana.
5-Cysticercosis.
6-Sarcoptes scabiei.
7-Lice.