CHAPTER 14
PARASITIC & FUNGAL INFECTIONS

WHY IS THIS IMPORTANT?

- Parasitic infections affect billions of people in the world.
- Fungal infections are usually opportunistic infections and have increased with the number of immunocompromised individuals.

OVERVIEW
PARASITIC INFECTIONS

- Parasites can be divided into two groups:
  - Protozoans – microscopic, single-celled eukaryotes.
  - Helminths – macroscopic, multicellular worms.
- Disease causing parasites depend on their infected host for survival.

SIGNIFICANCE OF PARASITIC INFECTIONS

- Parasitic infections are a major problem worldwide.
  - More than 500 million people are infected with malaria.
  - More than 2 million (mostly children) die each year from malaria.
  - *Entamoeba* are intestinal parasites that infect 10% of the world population.
  - *Trypanosoma* parasites infect 16 million people in Latin America each year.
Parasitic protozoans cause a wide variety of infections. They affect a large number of people throughout the world.

Parasitic protozoans vary in size. They contain membrane-bound nuclei and cytoplasm. The cytoplasm is divided into:
- Inner form – endoplasm
- Outer form – ectoplasm

They can be classified on the basis of their methods of movement and reproduction.

<table>
<thead>
<tr>
<th>Class</th>
<th>Organelles of Locomotion</th>
<th>Method of Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhizopods</td>
<td>Pseudopods</td>
<td>Binary fission</td>
</tr>
<tr>
<td>Ciliates</td>
<td>Cilia</td>
<td>Binary fission</td>
</tr>
<tr>
<td>Flagellates</td>
<td>Flagella</td>
<td>Binary fission</td>
</tr>
<tr>
<td>Sporozoans</td>
<td>None</td>
<td>Schizogony/gametogony</td>
</tr>
</tbody>
</table>

Note: M. C. Microbiology: A Clinical Approach © Garland Science
PARASITIC PROTOZOANS:
Morphology, Classification & Physiology

- Most infectious protozoans:
  - Are facultative anaerobes
  - Are heterotrophs
  - Have a highly developed reproductive system
- Some form cysts as a way of protecting themselves.
  - They can also be a mechanism of transmission from host to host.

PARASITIC HELMINTHS

- Helminths are worms.
- There are two types:
  - Free living
  - Parasitic
- They are bilaterally symmetrical and of various lengths.

PARASITIC HELMINTHS

- The body is covered by a tough cellular cuticle.
- Some have suckers, hooks, or plates which are used for attachment.
**PARASITIC HELMINTHS**

- All helminths have:
  - Differentiated organs
  - Primitive nervous systems
  - Primitive excretory systems
  - Highly developed reproductive systems
- They do not have a circulatory system.

**PARASITIC HELMINTHS**

- Three types of helminth can infect humans:
  - Nematodes (roundworms)
    - Gastrointestinal form – use only one host to complete their life cycle
    - Blood and tissue form – use multiple hosts to complete their life cycle

**PARASITIC HELMINTHS**

- Three types of helminth can infect humans:
  - Cestodes (tapeworms)
    - Have a flat, ribbon-shaped body
    - The head contains suckers and frequently has hooks for attachment.
    - They generate proglottids – reproductive segments with male and female gonads.
    - Have no digestive tract - nutrients are absorbed across their cuticle.
    - Some use one host and others two for their life cycle.
PARASITIC HELMINTHS

Three types of helminth can infect humans:

- Trematodes (flukes)
  - Have leaf-shaped bodies
  - They have two suckers.
    - Oral sucker – takes in nutrients and regurgitates waste
    - Distal sucker – used for attachment.
LIFE CYCLES & TRANSMISSION PATHWAYS OF PROTOZOANS & HELMINTHS

- The life cycles and transmission mechanisms vary depending on the organism.
- Some use a single host, others use multiple hosts.

Multiple hosts can be divided into:
- Definitive host – where sexual reproduction occurs
- Intermediate host – where asexual reproduction occurs

PATHOGENESIS OF PARASITIC INFECTION

- Pathogenesis of protozoan diseases is variable.
- For helminths:
  - The severity of infection is related to the number of worms.
  - A large worm load lead to increased disability of the host.
**PATHOGENESIS OF PARASITIC INFECTION**

- The host defense reaction can cause:
  - Tissue damage
  - Allergic or anaphylactic reactions

**SPOROZOANS**

- Sporozoans are intracellular parasites.
- They alternate between sexual and asexual reproduction.
- Most important diseases caused are:
  - Malaria
  - Toxoplasmosis
  - Together, they affect one third of the world population.

**MALARIA** (*PLASMODIUM SPECIES*)

- Febrile illness
- Found throughout the world
- Transmitted by the bite of the *Anopheles* mosquito
- Mortality is mainly seen in children and immunocompromised adults.
LIFE CYCLE OF PLASMODIUM

- Sexual life cycle begins when a mosquito ingests infected blood.
  - Male fertilizes female gametocytes
  - Resulting zygote forms an oocyst filled with sporozoites
  - Oocyst ruptures releasing sporozoites into body
  - Sporozoites penetrate salivary glands.

LIFE CYCLE OF PLASMODIUM

- Asexual life cycle begins when a mosquito bites new host.
  - Sporozoites are introduced with mosquito saliva.
  - Sporozoites move to the liver and produce merozoites.
  - Hepatocytes rupture releasing the merozoites.
  - Merozoites infect red blood cells (ring stage).
LIFE CYCLE OF *PLASMODIUM*

- Within 72 hours, infected red blood cells begin to rupture.
  - Merozoites are released.
  - Some infect other RBCs.
  - Some transform into the gametocyte form.
- Gametocytes are then taken up by the next mosquito.

PATHOGENESIS OF MALARIA

- Symptoms of malaria include:
  - Fever
  - Anemia
  - Circulatory changes
- Anemia is caused by the destruction of red blood cells.
  - It is accompanied by depression of marrow function and an enlarged spleen.
- Thrombocytopenia is common in malaria.
PATHOGENESIS OF MALARIA

- The incubation period is about 2 weeks.
- Clinical manifestations depend on the species of *Plasmodium*.

PATHOGENESIS OF MALARIA

- Malaria is associated with a cycling of symptoms – malarial paroxysm.
  - Paroxysm begins with a cold stage (20-60 minutes)
    - Continuous shaking and chills
  - Then a hot stage – body temperature increase for 3-8 hours
    - Profuse sweating

PATHOGENESIS OF MALARIA

- The recurrent hot and cold stages cause exhaustion.
- By the third week, the sequence becomes synchronized.
- The most deadly form of malaria involves the central nervous system (CNS).
  - Cerebral malaria
  - Results in delusions, paralysis, coma, and death
TREATMENT OF MALARIA

- Two factors are involved:
  - Species of *Plasmodium*
  - Immunocompetency of the infected individual
- Successful treatment requires destruction of all the parasites.
- There are several treatments for malaria.

<table>
<thead>
<tr>
<th>Form of the Parasite</th>
<th>Clinical Goal</th>
<th>Drug of Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythrocytic schizont</td>
<td>Treatment of clinical attack</td>
<td>Chloroquine, quinine, antimalarials or sulfonamides for resistant P. falciparum</td>
</tr>
<tr>
<td></td>
<td>Suppression of clinical attack</td>
<td>Chloroquine, antimalarials and sulfonamides for resistant P. falciparum</td>
</tr>
<tr>
<td>Erythrocytic gametocyte</td>
<td>Care of relapsing malaria, care of falciparum malaria, control of <em>malariae</em> population</td>
<td>Chloroquine, primaquine</td>
</tr>
<tr>
<td>Hepatic schizont</td>
<td>Care of relapsing malaria</td>
<td>Primaquine</td>
</tr>
</tbody>
</table>

TOXOPLASMOSIS

*(TOXOPLASMA GONDII)*

- *Toxoplasma gondii* is an obligate intracellular parasite.
  - The definitive host is the domestic cat.
  - Transmission is by ingestion of oocysts in fecal material.
LIFE CYCLE OF *TOXOPLASMA*

- Toxoplasma infections begin as trophozoite form enters intestine of the cat.
  - Trophozoites undergo schizogony into merozoites.
  - Merozoites differentiate into gametes.

- Gametogony results in millions of oocysts.
  - These are released each day for 2-3 weeks.
  - They mature in the external environment.

- Humans are intermediate hosts.
  - Sporozoites are released from ruptured oocysts.
  - They travel inside macrophages to all organs.
  - Macrophages rupture and release new parasites.
PATHOGENESIS OF TOXOPLASMOSIS

- In primary infection, trophozoites proliferate.
  - Leads to cell death
  - Initiates an immune response by the host
    - This is normally enough to control the infection.

- If the patient is immunocompromised:
  - Tissue necrosis continues.
  - Serious disease can lead to overactive host defense.
    - This causes additional damage to the host.

TREATMENT OF TOXOPLASMOSIS

- No treatment is usually required.
- If necessary, pyrimethamine, and sulfonamides can be used.
**RHIZOPODS**

- Rhizopods are amebas.
  - The most primitive form of protozoans that:
    - Multiply by simple binary fission
    - Move by using pseudopodia.
    - Produce a chitin wall for protection.
      - Referred to as a cyst.

**AMEBIASIS**

**(ENTAMOEBA HISTOLYTICA)**

- *Entamoeba histolytica* is an obligate intracellular parasite.
- It is passed from host to host as cysts.
  - Uses the fecal-oral route of infection
  - Ingestion of a single cyst can cause infection

- It is the third highest parasitic cause of deaths worldwide.
  - Only malaria and schistosomiasis are higher.
- Amebiasis is on the rise in the US.
**LIFE CYCLE OF ENTAMOEBA HISTOLYTICA**

- It is found in either the trophozoite or cyst form.
- Trophozoites in the lumen or wall of the colon can:
  - Feed on bacteria
  - Multiply rapidly and be defecated out during diarrhea
  - Use cytoplasmic projections to adhere to cells and tissues
- Cysts can survive environmental pressure.
  - They can also survive chlorine and acidic conditions.

**PATHOGENESIS OF AMEBIASIS**

- Initial infection is via the fecal-oral route.
- Systemic amebiasis occurs only after the colon colonized.
PATHOGENESIS OF AMEBIASIS

- The parasite produces several virulence factors and enzymes.
  - These can cause membrane lesions and cellular death.
- Infection is usually mild and asymptomatic.
  - Lesions can open the intestine for bacterial and viral infection.

PATHOGENESIS OF AMEBIASIS

- Cysts can pass through the stomach and into the small intestine.
- Here, they disintegrate and release four trophozoites:
  - These move to the colon and cause lesions.
  - Lesions can spread from the colon.
  - They can compromise blood flow causing necrosis.

PATHOGENESIS OF AMEBIASIS

- Symptoms include:
  - Diarrhea
  - Flatulence
  - Cramping
  - Abdominal pain
PATHOGENESIS OF AMEBIASIS

- Infection can last from months to years.
- Fulminating amoebic dysentery is the most virulent.
  - Seen in debilitated individuals
  - Onset is abrupt with high fever, severe cramping, and profuse diarrhea
  - Also characterized by blood in the stool

TREATMENT OF AMEBIASIS

- Treatments include:
  - Blood and fluid replacement
  - Administration of metronidazole
  - Sanitary disposal of feces

FLAGELLATES

- Flagellates are widespread in nature.
- They use flagella for movement through the host.
- They multiply by binary fission.
FLAGELLATES

- Only four flagellates cause human disease:
  - *Trichomonas*
  - *Giardia*
    - Noninvasive
    - Low morbidity rates
    - No intermediate host required

FLAGELLATES

- Only four flagellates cause human disease:
  - *Leishmania*
  - *Trypanosoma*
    - Invasive
    - High morbidity rates
    - Frequently lethal
    - Intermediate host required

TRICHOMONIASIS

*TRICHOMONAS VAGINALIS*

- Trichomoniasis is a sexually transmitted infection.
- It produces vaginitis in females with symptoms:
  - Pain
  - Dysuria
  - Discharge
TRICHOMONIASIS
(TRICHOMONAS VAGINALIS)

• It may cause prostatitis or urethritis in males.
• It can last from weeks to months.
• An estimated 180 million people worldwide are infected each year.
  • The peak age of infection is 16 to 35 years old.

LIFE CYCLE OF TRICHOMONAS

• Trichomonas does not form cysts.
• It can survive outside the host for 1 to 2 hours.
  • In water, semen, or urine, it can survive for up to 24 hours.

PATHOGENESIS OF TRICHOMONIASIS

• Direct contact transmission to genital endothelial cells causes the infection.
  • Cells are destroyed and inflammation occurs.
  • It is accompanied by petechial hemorrhaging.
• Trichomonas is noninvasive.
PATHOGENESIS OF TRICHOMONIASIS

- Infection causes persistent vaginitis.
  - Symptoms can last for months.
  - Severe cases can cause hemorrhaging and tissue erosion.

- Symptoms include:
  - Discharge
  - Itching and burning
  - Dysuria
  - Disagreeable odor

- Oral metronidazole cures 95% of cases.
  - It should not be administered after the first trimester in pregnant patients.
  - Sexual partners should also be treated.
TRYPANOSOMIASIS (TRYPANOSOMA SPECIES)

- It is caused by the protozoan Trypanosoma.
  - Motile
  - Fusiform
  - Moves in a spiral fashion
- The vector is the tsetse fly (Glossina species).

TRYPANOSOMIASIS (TRYPANOSOMA SPECIES)

- There are two forms:
  - African form – causes sleeping sickness
  - American form – causes Chagas’ disease

TRYPANOSOMIASIS (TRYPANOSOMA SPECIES)

- Sleeping sickness is confined to central Africa.
  - There are ten to twenty thousand cases each year.
  - The reservoir is humans.
LIFE CYCLE OF TRYPANOSOMA

- It reproduces by longitudinal binary fission.
  - In mammalian hosts, it multiplies extracellularly.
  - It can eventually invade the blood.
- There are three subspecies and all cycle from insect to human.
- They can change their antigens and fool immune defenses.

PATHOGENESIS OF TRYPANOSOMIASIS

- Parasitemia causes localization of parasites in small blood vessels.
  - The heart and/or central nervous system are particularly vulnerable.

PATHOGENESIS OF TRYPANOSOMIASIS

- Symptoms include:
  - Hemorrhaging
  - Demyelinating panencephalitis
  - Headache
  - Fever
  - Lymphadenopathy
  - Skin rash
  - Impaired mental status
PATHOGENESIS OF TRYPANOSOMIASIS

- Symptoms can progress to:
  - Eventual diminished alertness.
  - Indistinct speech, tremors, and coma.
  - Coma can lead to death.

TREATMENT OF TRYPANOSOMIASIS

- If the CNS is involved agents that can cross the blood-brain barrier are needed.
  - Melarsoprol
- If there is no CNS involvement:
  - Treatment can use Pentamidine or Eflornithine.

HELMINTHIC INFECTIONS

- There are three types of parasitic helminth:
  - Nematodes
  - Cestodes
  - Trematodes
Nematodes are all roundworms. There are two subgroups:

- Intestinal nematodes
- Tissue nematodes

Intestinal nematodes have the following characteristics:

- Fusiform body shape
- Tough outer cuticle
- Male and female forms
- Thousands of offspring are produced
- Eggs must incubate outside the host to become infective
- There is a larval form.

There are several types of intestinal nematodes:

- Pinworms (*Enterobius vermicularis*)
- Whipworms (*Trichuris trichiura*)
- Large roundworms (*Ascaris lumbricoides* and *Strongyloides stercoralis*)
INTESTINAL NEMATODES

- Intestinal nematode infection can produce:
  - Malnutrition
  - Discomfort
  - Anemia
  - Occasionally death

- Severity of disease is directly correlated to worm load.
  - Small worm load – asymptomatic.
  - Large worm load – more serious disease.
  - Host immune defenses are slow to develop.
ENTEROBIASIS
(ENTEROBIUS VERMICULARIS)

- Pinworm (Enterobius vermicularis) is a ubiquitous parasite of humans.
- More than 200 million people are infected each year.
  - Most of these infections are in children.

ENTEROBIASIS
(ENTEROBIUS VERMICULARIS)

- Enterobiasis is mostly found in temperate climates of Europe and North America.
- It is readily transmitted where large numbers of children gather.
  - Nurseries, child care facilities, and orphanages

PATHOGENESIS OF ENTEROBIASIS

- Pinworms attach to the mucosa of the cecum.
- Females migrate down to the perianal tissue to lay eggs.
  - Eggs stick to tissue, bedding, towels or fingers.
  - Eggs can be inhaled or swallowed.
  - Eggs hatch in the upper intestine.
  - Larvae migrate down to the cecum.
PATHOGENESIS OF ENTEROBIASIS

- The infection cycle takes about 2 weeks.
- It can cause symptoms from irritability from itching.
  - Skin abrasions can occur from scratching.
  - Female worms sometimes move to the genitourinary tract of females.

TREATMENT OF ENTEROBIASIS

- Treatment is either:
  - Mebendazole
  - Pyrantel pamoate
ASCARIASIS
(ASCARIS LUMBRICOIDES)

- *Ascaris lumbricoides* is the largest and most common intestinal nematode.
- Female parasites can lay 250-500 thousand eggs per day.
  - They are very resistant to environmental pressure.
  - They can be viable for up to 6 years.

- There are two means of transmission:
  - Eggs can be picked up from soil.
  - Eggs can dry, become airborne, and be either inhaled or swallowed.
- Infection is often maintained by small children who defecate indiscriminately.

PATHOGENESIS OF ASCARIASIS

- Adult worms live in small intestines.
- Eggs are passed into the feces.
  - Eggs must embryonate in soil for 3 weeks.
PATHOGENESIS OF ASCARIASIS

- Once ingested, eggs produce a larval stage.
  - Larvae penetrate the intestinal mucosa and invade the liver.
  - They exit from the hepatic vein and then enter the heart and progress to the lung.
  - They rupture in the alveolar spaces. They can be coughed up and swallowed.

PATHOGENESIS OF ASCARIASIS

- Ascariasis results while larvae are in the lung or in the intestines.
- If the worm load is small, infections can be asymptomatic.

PATHOGENESIS OF ASCARIASIS

- If the worm load is large, symptoms can include:
  - Fever
  - Coughing
  - Wheezing
  - Shortness of breath
PATHOGENESIS OF ASCARIASIS

- Worms can pass out of the body in a variety of ways:
  - Vomiting
  - In stool
  - They can crawl out of the anus, nose, mouth, and ears.

PATHOGENESIS OF ASCARIASIS

- Prolonged infection with heavy worm loads can cause:
  - Malnutrition
  - Abdominal pain
  - Obstruction of the bile and pancreatic ducts

TREATMENT OF ASCARIASIS

- Treatment can be:
  - Albendazole
  - Mebendazole
  - Pyrantel pamoate
TISSUE NEMATODES

- Tissue nematodes can induce disease in:
  - Tissues
  - Blood
  - Lymph system

- Four major types of tissue nematodes use humans as definitive hosts.
  - They can live for years in subcutaneous tissues and lymph vessels.

TISSUE NEMATODES

- Tissue nematodes discharge live offspring called microfilariae.
  - Circulate through the blood or tissue
  - Can be ingested by blood sucking insects.

TRICHINOSIS (TRICHINELLA SPIRALIS)

- Caused by the parasite Trichinella spiralis:
  - Lives in the duodenum and jejunum of flesh eating mammals.
  - Particularly found in swine and bears.
TRICHINOSIS (TRICHINELLA SPIRALIS)

- *Trichinella* enters through the host vascular system and is distributed widely.
- Only parasites that penetrate the skeletal muscle survive.
  - It can become encapsulated in muscle.
  - It can remain viable for 5-10 years.

TRICHINOSIS (TRICHINELLA SPIRALIS)

- The disease is widespread amongst swine.
- Human infection results from eating undercooked meat.
  - Over one million people in the US carry either living or dead worms.
  - Most infections are asymptomatic.

PATHOGENESIS OF TRICHINOSIS

- Lesions are found in:
  - Striated muscle
  - Heart muscle
  - CNS
PATHOGENESIS OF TRICHINOSIS

- The area of infection is infiltrated by white blood cells, particularly eosinophiles.
- Worms mature in 24-48 hours of eating tainted meat.

PATHOGENESIS OF TRICHINOSIS

- Symptoms include:
  - Nausea
  - Abdominal pain
  - Diarrhea

PATHOGENESIS OF TRICHINOSIS

- Larval invasion starts one week later.
  - Lasts one to six weeks
  - Low worm load – asymptomatic
  - Large worm load – significant disease and possible death
PATHOGENESIS OF TRICHINOSIS

- Heart involvement can cause congestive heart failure.
- CNS involvement can cause encephalopathy or meningitis.

TREATMENT OF TRICHINOSIS

- The larval stage can be stopped with:
  - Mebendazole
  - Albendazole
- Host defenses may cause a hypersensitivity reaction.

CESTODES

- Cestodes are commonly called tapeworms.
  - The largest of the intestinal parasites
  - Lack a vascular and respiratory system
  - Lack a gut or body cavity
  - Nutrients are absorbed across the cuticle.
CESTODES

- The adult body has three sections:
  - Head – the scolex which may have a rostellum
  - Regenerative neck
  - Segmented body
**CESTODES**

- Proglottid segments contain a hermaphroditic unit.
  - Sexual reproduction occurs as the segments move further from the neck.
  - Distal proglottids eventually rupture and release eggs.
- All except one form of cestode require at least one intermediate host.

**PATHOGENESIS OF CESTODE INFECTION**

- In the primary host:
  - The worm stays in the lumen of the gut.
  - Only minor symptoms are seen.
- In the intermediate host:
  - Larval stages of the worm cause serious tissue invasion.
  - Most patients are asymptomatic.

**PATHOGENESIS OF CESTODE INFECTION**

- Symptoms include:
  - Gastric disfunction
  - Nausea
  - Diarrhea
  - Weight loss
TREATMENT FOR CESTODE INFECTION

- Praziquantel niclosamide – kills the worm
  - Peristalsis then pushes the worm out of the digestive system.

TREMATODES

- Trematodes are known as flukes.
  - Have a bilateral symmetry
  - Have two deep suckers:
    - One in the oral cavity
    - One on the ventral side of the worm

TREMATODES

- Trematodes can live for decades in human tissue and blood vessels.
  - They produce progressive damage to vital organs.
- There are two major categories of trematodes:
  - Hermaphrodites
  - Schistosomes
LIFE CYCLE OF TREMATODES

- Eggs are excreted from the human host.
  - They must reach water in order to hatch.
- Hatching releases larvae called miracidia.
  - Miracidia penetrate snails, the intermediate host.

- Miracidia develop into cercariae.
  - Cercariae are released from the snail.
  - In hermaphrodite species:
    - Cercariae encyst in animals or plants.
  - In schistosome species:
    - Cercariae invade skin of humans.

DISEASE CAUSING TREMATODES

- Three major groups of flukes invade humans:
  - Lung flukes – *Paragonimus species*
  - Liver flukes – *Clonorchis species*
  - Blood flukes – *Schistosoma species*
PATHOGENESIS OF PARAGONIMIASIS

- Lung flukes cause more than 5 million infections worldwide.
  - Infections are frequently caused by consuming infected shell fish
  - Infections cause eosinophilia and inflammation.
- After infection a capsule forms around the fluke.

PATHOGENESIS OF PARAGONIMIASIS

- Patient may have as many as 25 capsules.
  - They can spread into bronchioles of the lungs.
  - This causes expectoration of brownish eggs, blood, and inflammatory exudate.
- Capsules form cystic rings and become calcified.

PATHOGENESIS OF PARAGONIMIASIS

- Adult flukes in the intestine cause:
  - Pain
  - Bloody diarrhea
- Adult flukes in the CNS cause:
  - Epilepsy
  - Paralysis
TREATMENT OF PARAGONIMIASIS

- Treatment is with:
  - Praziquantel
  - Bithionol

CLONORCHIASIS

- Clonorchiasis is caused by the liver fluke.
  - It forms metacercaria.
  - Metacercaria encyst in fish.

- Humans eat fish and larvae are released into the duodenum.
  - They ascend to the common bile duct, causing:
    - Fever
    - Chills
    - Mild jaundice
CLONORCHIASIS

- Low adult worm load is usually asymptomatic.
- High adult worm load can cause:
  - Inflammation
  - Fibrosis around the bile duct.

CLONORCHIASIS

- The adult form can survive up to 50 years in human host.
- Liver flukes can also infect cats, dogs, rats, and pigs.

TREATMENT OF CLONORCHIASIS

- Treatment is with:
  - Praziquantel
  - Albendazole
SCHISTOSOMIASIS

- Five species of *Schistosoma* can infect humans
  - Two to three hundred million people are infected worldwide.
  - Up to one million people die each year.

PATHOGENESIS OF SCHISTOSOMIASIS

- Worms have a cylindrical body.
- There are male and female forms.
- Schistosome couples mate in the portal vein.
  - They stay cojoined for life.
  - They use suckers to ascend the mesenteric vessels.
- They lay eggs in the submucosal veins of the ascending colon.
  - 300 to 3000 eggs can be laid per day for as long as 35 years.

- Eggs rupture into the lumen of the colon or in the bladder.
  - They are excreted to the outside.
  - If they reach water they will hatch into the miracidia form.
PATHOGENESIS OF SCHISTOSOMIASIS

- Miracidia invade snails.
  - They develop into cercariae which can penetrate human skin.
- Cercariae move from the skin into the systemic circulation.
  - They then move to the portal vein.

PATHOGENESIS OF SCHISTOSOMIASIS

- Schistosomiasis is widespread worldwide.
- It has extensive morbidity.
- Most individuals are affected with low worm loads and are asymptomatic.

PATHOGENESIS OF SCHISTOSOMIASIS

- Heavy worm loads can serious disease.
  - Bladder infection leading to renal failure
  - Abdominal pain in the intestines and blood in the stool
  - Epilepsy and paralysis if found in the CNS
  - Death can also result
TREATMENT OF SCHISTOSOMIASIS

- There is no specific treatment.
  - Corticosteroids may limit the severity of the infection.

FUNGAL INFECTIONS

- Mycology is the study of fungi.
- Fungi are important for the environment.
- Fungi are commensal organisms.
  - They are normally harmless to humans.
  - Fungi can be opportunistic pathogens.

FUNGAL STRUCTURE & GROWTH

- Fungi are eukaryotes.
- There are two forms:
  - Molds – multicellular
  - Yeasts – unicellular
Fungal membranes contain ergosterol.
The cell wall of fungi is different from bacteria and contains:
- Polysaccharides
- Mannan
- Glucan
- Chitin

Fungi use heterotrophic metabolism.
- They obtain carbon from decaying organic matter.
- Most are obligate aerobes but some are facultative anaerobes.
  - No fungi are obligate anaerobes.

Fungi reproduce either sexually or asexually.
Asexual reproduction:
- Through conidia
  - Involves mitotic division and budding
Sexual reproduction:
- Involves spores - ascospores, zygospores, or basidiospores
YEASTS AND MOLDS

- Molds - multicellular
- Yeasts - unicellular
- The simplest form of growth is budding.
  - Buds are called blastoconidia.
  - Seen in yeasts.

Some fungi form hyphae
- Tube like extensions of cytoplasm
- Some have septae - cross walls.
- Seen in molds.

©  CDC/ Dr. Edwin P. Ewing, Jr.
YEASTS AND MOLDS

- Molds form aerial hyphae.
- Hyphae contain reproductive structures.
  - Conidia
  - Spores

- Hyphae have a wide variety of shapes and sizes.
  - Their distinct morphology and development are used to identify fungi.
**DIMORPHISM**

- Some fungi can grow in mold or yeast form.
- The yeast form requires environmental conditions similar to *in vivo*.
  - Proper temperature
  - Increased nutrients
- The mold form requires:
  - Ambient temperatures
  - Minimal nutrients

**CLASSIFICATION OF PATHOGENIC FUNGI**

- Kingdom Fungi has 4 subgroups called divisions.
- Classification is based on:
  - Nature of the sexual spores
  - Septation of the hyphae

**CLASSIFICATION OF PATHOGENIC FUNGI**

- Medically important fungi are classified by:
  - Ribosomal RNA typing
  - The tissue types they parasitize
  - The diseases they produce
CLASSIFICATION OF PATHOGENIC FUNGI

- Fungal diseases are classified into 4 groups:
  - Superficial mycoses
  - Mucocutaneous mycoses
  - Subcutaneous mycoses
  - Deep mycoses

SUPERFICIAL MYCOSES

- Fungal infections that do not involve a tissue response:
  - Piedra – colonization of the hair shaft causing black or white nodules
  - Tinea nigra – brown or black superficial skin lesions
  - Tinea capitis – folliculitis on the scalp and eyebrows

SUPERFICIAL MYCOSES

- Fungal infections that do not involve a tissue response:
  - Favus – destruction of the hair follicle.
  - Pityriasis – dermatitis characterized by redness of the skin and itching:
    - Caused by hypersensitivity reactions to fungi normally found on skin
    - Mostly seen in immunocompromised patients.
CUTANEOUS AND MUCOCUTANEOUS MYCOSES

- Associated with:
  - Skin
  - Eyes
  - Sinuses
  - Oropharynx and external ears
  - Vagina

- Ringworm – skin lesions characterized by red margins, scales and itching:
  - Restricted to the stratum corneum.
  - Classified based on location of infection
    - Tinea pedis – on the feet or between the toes
    - Tinea corporis – between the fingers, in wrinkles on the palms
    - Tinea cruris – lesions on the hairy skin around the genitalia
    - Tinea capitis – scalp and eyebrows

www.doctorfungus.org
CUTANEOUS AND MUCOCUTANEOUS MYCOSES

- Onychomycosis – chronic infection of the nail bed
  - Commonly seen in toes
- Hyperkeratosis – extended scaly areas on the hands and feet

CUTANEOUS AND MUCOCUTANEOUS MYCOSES

- Keratitis – colonization or infiltration of the corneal epithelium
  - Can occur after surgery
  - Can occur as a result of the use of corticosteroids
  - Can occur as a result of careless application of contact lens
  - Affected eyes can become ulcerated or scarred

CUTANEOUS AND MUCOCUTANEOUS MYCOSES

- Mucocutaneous candidiasis – colonization of the mucous membranes
  - Caused by the yeast *Candida albicans*
  - Often associated with a loss of immunocompetence
CUTANEOUS AND MUCOCUTANEOUS MYCOSES

- There are two clinical types of mucocutaneous candidiasis:
  - Thrush – fungal growth in the oral cavity
    - An indicator of immunodeficiency.
  - Vulvovaginitis – fungal growth in the vaginal canal
    - Can be associated with a hormonal imbalance.

SUBCUTANEOUS MYCOSES

- Localized primary infections of subcutaneous tissue:
  - Can cause the development of cysts and granulomas.
  - Provoke an innate immune response - eosinophilia.

SUBCUTANEOUS MYCOSES

- There are several types:
  - Sporotrichosis – traumatic implantation of fungal organisms
  - Paranasal conidiobolae mycoses – infection of the paranasal sinuses
    - Causes the formation of granulomas.
  - Zygomatic rhinitis – fungus invades tissue through arteries
    - Causes thrombosis
    - Can involve the CNS.
DEEP MYCOSES

- Usually seen in immunosuppressed patients with:
  - AIDS
  - Cancer
  - Diabetes
- Can be acquired by:
  - Inhalation of fungi or fungal spores
  - Use of contaminated medical equipment

DEEP MYCOSES

- Deep mycoses can cause a systemic infection – disseminated mycoses
  - Can spread to the skin

DEEP MYCOSES

- Can be found on www.doctorfungus.org
DEEP MYCOSES

- Coccidiomycoses – caused by genus *Coccidioides*
  - Primary respiratory infection
  - Leads to fever, erythremia, and bronchial pneumonia
  - Usually resolves spontaneously due to immune defense
  - Some cases are fatal

DEEP MYCOSES

- Histoplasmosis – caused by *Histoplasma capsulatum*
  - Often associated with immunodeficiency
  - Causes the formation of granulomas
    - Can necrotize and become calcified
  - If disseminated, histoplasmosis can be fatal.
DEEP MYCOSES

- Aspergillosis – caused by several species of *Aspergillus*
  - Associated with immunodeficiency
  - Can be invasive and disseminate to the blood and lungs
    - Causes acute pneumonia
  - Mortality is very high.
    - Death can occur in a matter of weeks.

PATHOGENESIS OF FUNGAL INFECTIONS

- Thousands of fungal spore are inhaled every day.
  - Fungi are part of normal microbial flora.
- Fungal infections very uncommon in immunocompetent individuals.
- Fungal infections are more common in immunodeficient patients.

PATHOGENESIS OF FUNGAL INFECTIONS

- Disseminated mycoses are very hard to treat.
- Pathogenesis of fungal infection is divided into three stages:
  - Adherence
  - Invasion
  - Tissue injury
PATHOGENESIS OF FUNGAL INFECTIONS

- Adherence
  - Several fungal species, particularly yeasts, can adhere to mucosal surfaces.
    - Usually involves an adhesion molecule on the fungus and host cell receptor.

PATHOGENESIS OF FUNGAL INFECTIONS

- Invasion
  - Some fungi are introduced through breaks in the skin.
  - The small size of spores can get past host defenses in the lungs.
  - Some dimorphic fungi can become invasive.
    - They switch from yeast form to mold form.
    - The hyphae invade tissues and disseminate.

PATHOGENESIS OF FUNGAL INFECTIONS

- Tissue Injury
  - Fungi do not produce exotoxins \textit{in vivo}.
  - Primary tissue injury is due to host inflammatory response.
HOST DEFENSE AGAINST FUNGAL INFECTIONS

- Host defense against fungal infection is primarily through:
  - Phagocytosis
  - Adaptive immune response

- Phagocytosis
  - Most people have a high level of resistance to fungal infection.
    - Due to neutrophils that attack fungal hyphae
  - Dimorphic fungi can resist phagocytosis

- Adaptive Immune Response
  - Humoral response (production of antibody) is always seen.
  - T cells activate macrophages causing:
    - Increased phagocytosis
    - Production of gamma interferon