Fungi

Mycology = Study of Fungi

All fungi are chemoheterotrophs- Require organic compounds for energy and carbon. Are aerobic or facultative anaerobes.

A. Vegetative Structures - Multicellular fungi, unlike yeast identification, are identified on the basis of physical appearance, including colony characteristics and reproductive spores.

1. Molds and Fleshy Fungi

a) Thallus - Long filaments of cells joined together - called hyphae

b) Septa - cross-walls dividing the hyphae into distinct, uninucleate cell like units. Called septate hyphae

c) Vegetative hyphae - portion that is used to obtain nutrients.

d) Aerial hyphae - Projects above media on which fungus is growing and often contains spores.

e) Mycelium - Filamentous mass

2. Yeasts

a) Nonfilamentous unicellular fungi that are spherical or oval

b) Some divide by fission that can either be evenly or unevenly (budding)

c) *Candida albicans* - Sometimes produces buds that fail to detach into daughter cells and are called pseudohyphae.

d) Colonies on agar can resemble bacterial colonies.

e) Can use oxygen or organic compounds as final oxygen receptor

3. Dimorphic Fungi

Some fungi, esp. pathogenic fungi exhibit two forms of growth, yeast like at 37^0 C and mold like at 25^0 C. *Histoplasma capsulatum, Coccidiodes immitis*

B. Life Cycle

1. Asexually by fragmentation of hyphae

2. Sexual spores result from fusion of nuclei from two opposite mating strains of the same species of fungi.

a) Used to classify fungus into divisions

3. Asexual spores, that when germinate are identical to parent

a) Used to identify fungus in laboratories

(1) Conidiospore - A unicellular or multicellular spore that is not enclosed in a sac. Are usually produced in a chain at the end of a conidiophore. Example: *Aspergillis*

(a) Another type of conidiospore is an arthrospore Formed by fragmentation of a septate hypha into single, slightly thickened cells. Example is *Coccidioides immitis*.

(b) Another type of conidiospore is a Blastospore Bud comes off parent cell. Example - *Cryptococcus*.

(2) Chlamydospore - A thick-walled spore formed by rounding and enlarging within a hyphal segment.. Example is *Candida albicans*.

(3) Sporangiospore - A spore formed within a sporgangium or sac at the end of aerial hyphae called a sporangiophore.. Example is *Rhizophus*.

C. Nutritional Adaptations - Differ from bacteria in the following ways.

1. Grow best at pH 5.0

2. Almost all molds are aerobic; most yeast are facultative anaerobes

3. Most fungi are more resistant to osmotic pressure (can grow in high sugar or salt concentration).

4. Fungi can grow on substances with low moisture.

5. Require less nitrogen than bacteria.

D. Medically Important Division of Fungi

1. Anamorphs (old name: Deuteromycota, fungi imperfect)

a) Placed here if have not been found to produce sexual spores (teleomorph); produce asexual chlamydospores, arthorspores, conidiospores, or budding.

b) Have septate hyphae. Most are anamorph (asexual) phases of Ascomycota and a few are Basidiomycota.

Example: *Coccidioides immitis*

2. Zygomycota

a) Saprophytic molds that have nonseptate hyphae and produce sporangiospores (asexual) and zygospores (sexual).

b) Life cycle: Sexual spores are zygospore - A large spore enclosed in a thick wall.

Examples are *Mucor* and *Rhizopus*

3. Ascomycota

a) Includes molds with septate hyphae and some yeast.

b) Life cycle –Asexual spores are usually conidiospores produced in long chains from the conidiophore. Sexual spore = ascus with ascospores

Examples are *Aspergillus* and *Histoplasma capsulatum*

4. Basidiomycota –Mushrooms-

a) Life cycle: Fig 12.8 Have septate hyphae and produce basidiospores; some produce conidiospores.

b) Example- *Cryptococcus neoformans* (anamorph)

E. Fungal Diseases

1. Systemic mycoses are fungal infections deep within the body and affect many tissues and organs.

a) Examples: Histoplasmosis and Coccidioidomycosis

2. Subcutaneous mycoses are fungal infections beneath the skin

a) Example: Sporothrix schenckii- Rose thorns

3. Cutaneous mycoses (called dermatophytes) affect keratin-containing tissues such as hair, nails, and skin.

a) Example: Microsporum - Ringworm

4. Opportunistic mycoses are caused by normal microbiota or fungi that are not usually pathogenic

a) Mucormycosis - Rhizopus and Mucor

b) Aspergillosis – Aspergillus sp.

c) Candidiaisis (Thrush) – Candida albicans

F. Economic Effect of Fungi

1. Spoilage of food. Grow where bacteria cannot.

2. Plant pathogens- Dutch elm disease, Chestnut blight

3. Saccharomyces cerevisiae used to make bread and wine

Protozoa

A. Definition - Unicellular, eukaryotic

B. Characteristics

1. Life Cycle - Reproduce asexually by fission, budding, or schizogony (multiple nuclear divisions then cytoplasm division producing many daughter cells).

2. Encystment - Some produce a cyst for protection during adverse environmental conditions. Loss of moisture in feces transforms trophozoite to cyst. Sometimes don't see trophozoite in feces, just cyst.

3. Nutrition - usually aerobic heterotrophs (may be anaerobic in gut) and vegetative stage (trophozoite) feeds upon bacteria and small particulate nutrients. Digestion takes place in membrane-enclosed vacuoles.

C. Medically Important Phyla – Phyla based on rRNA sequencing.

1. Phylum Archaezoa: eukaryotes that lack mitochondria. Often spindle shaped with 2 or more flagella acting as a whip projecting from front end for locomotion. Many live as symbionts in animal guts.

a) *Trichomonas vaginalis*_.Has no cyst so must be transmitted quickly and shows undulating membrane. In vagina and male urinary tract. Transmitted sexually.

b) *Giardia lamblia*. Found in small intestine of humans and other animals. Causes giardiasis.

c) *Chilomastix* .Found in human intestine. Mildly pathogenic to symbiont.

2. Phylum Microsporans - Like Archaezoa they lack mitochondria. They are obligate intra cellular parasites that have microtubules. Causes chronic diarrhea and keratoconjunctivitis usually in AIDS patients.

3. Phylum Rhizopoda- amoeba that move by extending blunt lobe like projections of cytoplasm called pseudopods.

a) *Entamoeba histolytica*_.Amoebic dysentery

b) *Acanthamoeba*_- Grows in tap water and infects cornea and causes blindness

4. Phylum Apicomplexa – Apicomplexans are non motile in mature forms and are obligate intracellular parasites. Have organelles at the tips of

their cells that contain enzymes that allow them to enter the host's tissues. Have complex life cycle with transfer between multiple hosts.

a) Plasmodium vivax - Causes malaria. Mosquito vector.

b) *Babesia microti* - Causes fever and anemia in immunosuppressed individuals. Tick vector.

c) Toxoplasma gondii - Life cycle involves domestic cat. Dangerous to pregnant women as it can cause congenital infection of fetus in utero.

d) Cryptosporidium - Newly recognized. Found in AIDS and other immunocompromised individuals. Can cause respiratory and gallbladder infection and may cause death. Mild illness in immunocompetant individuals. Water borne transmission.

e) Cyclospora - Similar to Cryptosporidium - Causes diarrhea. Emerging pathogen.

5. Ciliates (Phylum Ciliophora)- Have cilia arranged on precise rows that are shorter than flagella and move in unison to propel the cell.

a) Paramecium b) Balantidium coli - Causative agent of severe dysentery.

6. Phylum Euglenozoa: flagellated cells with disk like mitochondria and absence of sexual reproduction.

a) Hemoflagellates - Are transmitted by the bites of blood-feeding insects and are found in the circulatory system of the bitten host. They have long slender bodies and an undulating membrane suited to life in a viscous fluid.

(1) Genus *Trypanosoma*: (a) *T. brucei gambiense* - transmitted by tsete fly. Causes African Sleeping sickness.

(b) T. cruzi - transmitted by the "kissing bug" and is causative agent of Chagas' disease.

(2) Naegleria fowleri- Infects brain of humans swimming in warm water.

III. Helminths

Two phyla are Platyhelminthes (flatworms) and Nematoda (roundworms)

A. Characteristics - Multicellular, eukaryotic animals that generally possess digestive, circulatory, nervous, excretory, and reproductive systems. Following generalizations distinguishes parasitic helminths from free-living relatives:

1. May lack a digestive tract. Absorb nutrients from host.

2. Reduced nervous system. Don't need it.

3. Reduced or lack locomotion system.

4. Reproductive system is complex with production of large numbers of eggs.

B. Life cycle - Very complex

1. Adult stage (sexual) is found in the definitive host.

2. Each larval stage requires an intermediate host.

3. Helminths can be monoecious (hermaphroditic) or dioecious (separate sexes).

Platyhelminthes (phylum) - Flattened worms, front to back. 2 classes: trematodes and cestodes.

1. Trematodes (class)- Flukes

a) Have an oral and ventral sucker which attaches to host.

b) Given common names according to tissue in which they live

(1) Clonorchis sinensis - Liver fluke - Occurs in Asia

c) Life Cycle - Eggs of trematodes hatch into free-swimming miracidia that enter the first intermediate host; two generations of rediae develop in the first intermediate host; the rediae become cercariae that bore out of the first intermediate host and penetrate the second intermediate host, cercariae encyst as metacercariae in the second intermediate host; after they are ingested by the definitive host, the metacercariae develop into adults.

d) Example (1) *Paragonimus westermani* - Lung fluke - Occurs throughout the world including US & Canada

(2) Life Cycle - Eggs of trematodes hatch into free-swimming miracidia that enter the first intermediate host; two generations of rediae develop in the first intermediate host; the rediae become cercariae that bore out of the first intermediate host and penetrate the second intermediate host, cercariae encyst as metacercariae in the second intermediate host; after they are ingested by the definitive host, the metacercariae develop into adults.

(3) Lab diagnosis is made by finding fluke eggs in sputum and feces

2. Cestodes (class)- Tapeworms

a) The head (scolex) has suckers (or hooks) for attaching to host.

b) Body consists of segments called proglottids which are continuously produced at the neck region. Each contains male and female reproductive organs. The ones farthest from the neck are the mature ones which contain fertilized eggs. These infect the proper intermediate host.

c) Humans as definitive hosts

(1) Taenia saginata - Beef tapeworm. Humans are the definitive host. Organism can reach 6 m ; cattle are intermediate hosts. As mature proglottids (with eggs) are excreted from humans they wiggle away and are ingested by cattle. The larvae hatch and bore through the intestinal wall and then migrate to muscle and then are ingested by humans again.

Lab diagnosis is made by seeing mature proglottids and eggs in feces.

(2) Taenia solium - Pork tapeworm. Adult worms living in human intestines produce eggs which pass in the feces. Then eggs are eaten by pigs, hatch and larvae are encysted in pigs muscle. In US transmission is mainly from human to human. Humans can be intermediate host too!

d) Humans as Intermediate hosts

(1) Echinococcus granulosus - Man may be intermediate host (usually sheep), dogs and coyotes are definitive hosts.

D. Nematodes (phylum Nematoda) - Roundworms

1. Characteristics

a) Cylindrical and tapered at each end

b) Have a complete digestive system - mouth, intestine, and anus

c) Most are dioecious.

d) Males are smaller than females and have one or two hardened spicules on their posterior ends. Used to guide sperm to the female's genital pore.

2. Infections - 2 categories

a) Eggs Infective for Humans

(1) Enterobius vermicularis pinworm- Figure 12.29 Entire life is spent in humans. Found in large intestine. . Scotch tape prep (Graham sticky tape method) used in diagnosis. See eggs stuck to tape.

(2) Ascaris lumbricoides - Adult lives in humans and domestic animals. Transmitted by eggs being eaten. Can make lab diagnosis with eggs or adult worms. Fig 25.25

b) Larvae Infective for Humans

(1) Necator americanus - Hookworms found in small intestine of humans. Figure 12.30. Diagnosis is made on basis of eggs in feces. See hooked shaped adult and cutting plates in mouth used for attachment in gut.

(2) Trichinella spiralis - Come from eating encysted larvae in under-cooked pork. Diagnosis is made by larvae in muscle biopsy.

IV. Arthropods As Vectors - Largest phylum in animal kingdom. Some inadvertently act as a mechanical vector (houseflies) others require a biological vector (Plasmodium). Control strategies of vector borne diseases usually focus on eliminating the vector, e.g. mosquitoes.

TABLE 12.1 **Major Differences Among Eukaryotic Microorganisms: Fungi, Algae, Protozoa, and Helminths**

	Fungi	Algae	Protozoa	Helminths
Kingdom	Fungi	Protist	Protist	Animalia
Nutritional type	Chemoheterotroph	Photoautotroph	Chemoheterotroph	Chemoheterotroph
Multicellularity	All, except yeasts	Some	None	All
Cellular arrangement	Unicellular, filamentous, fleshy (such as mushrooms)	Unicellular, colonial, filamentous; tissues	Unicellular	Tissues and organs
Food acquisition method	Absorptive	Diffusion	Absorptive; ingestive (cytostome)	Ingestive (mouth); absorptive
Characteristic features	Sexual and asexual spores	Pigments	Motility; some form cysts	Many have elaborate life cycles, including egg, larva, and adult
Embryo formation	None	None	None	All

TABLE 12.2 **Selected Features of Fungi and Bacteria Compared**

	Fungi	Bacteria
Cell type	Eukaryotic	Prokaryotic
Cell membrane	Sterols present	Sterols absent, except in *Mycoplasma*
Cell wall	Glucans; mannans; chitin (no peptidoglycan)	Peptidoglycan
Spores	Sexual and asexual reproductive spores	Endospores (not for reproduction); some asexual reproductive spores
Metabolism	Limited to heterotrophic; aerobic, facultatively anaerobic	Heterotrophic, autotrophic; aerobic, facultatively anaerobic, anaerobic