

***Escherichia coli* cells: ~0.5 x 1.0 micrometers**
Typical rod-shaped bacteria:
fecal indicator and pathogenic strains



E. coli Genetics and Serology

Genetics:

- Single, circular DNA molecule, $\sim 4 \times 10^6$ base pairs
- Molecular weight of 4×10^9
- Total length of about 1.4mm.

Serology:

- *E. coli* can be subdivided by somatic (cell-wall) or O antigens and flagellar or H antigens.
 - >160 recognized O types and 55 recognized H types
 - over 8000 possible OH serotypes.
 - also capsular (K) and fimbrial antigens.

Virulence Properties of *E. coli*

Enterotoxins:

- at least two types: Heat Stable (ST) and Heat Labile (LT)
- Verotoxins or Shiga-like toxins (interchangeable terms):
 - Verotoxin term is based on the reactions of toxins on Vero cells
 - VT1 (SLT I): similar to Shiga-toxin (produced by some strains of *Shigella dysenteriae*)
 - VT2 (SLT II) which is only about 50% related Shiga toxin.
- Other Toxins:
 - Cytotoxic necrotising factor (CNF), a possible Enteropathogenic *E. coli* (EPEC) enterotoxin and a possible *E. coli* Sudden Infant Death Syndrome (SIDS)-toxin.
- Haemolysins:
 - extracellular haemolysin known as alpha-haemolysin (many strains)
 - cell-associated haemolysin, beta-haemolysin, (some strains)
 - enterohaemolysin: extracellular; Enterohaemorrhagic *E. coli* (EHEC)

Pathogenic *E. coli*

Enteric Infections:

- Enteroadherent *E. coli* (EAEC)
- Enteroaggregative *E. coli* (EAggEC)
- Enterohaemorrhagic *E. coli* (EHEC)
- Enteroinvasive *E. coli* (EIEC)
- Enteropathogenic *E. coli* (EPEC)
- Enterotoxigenic *E. coli* (ETEC)

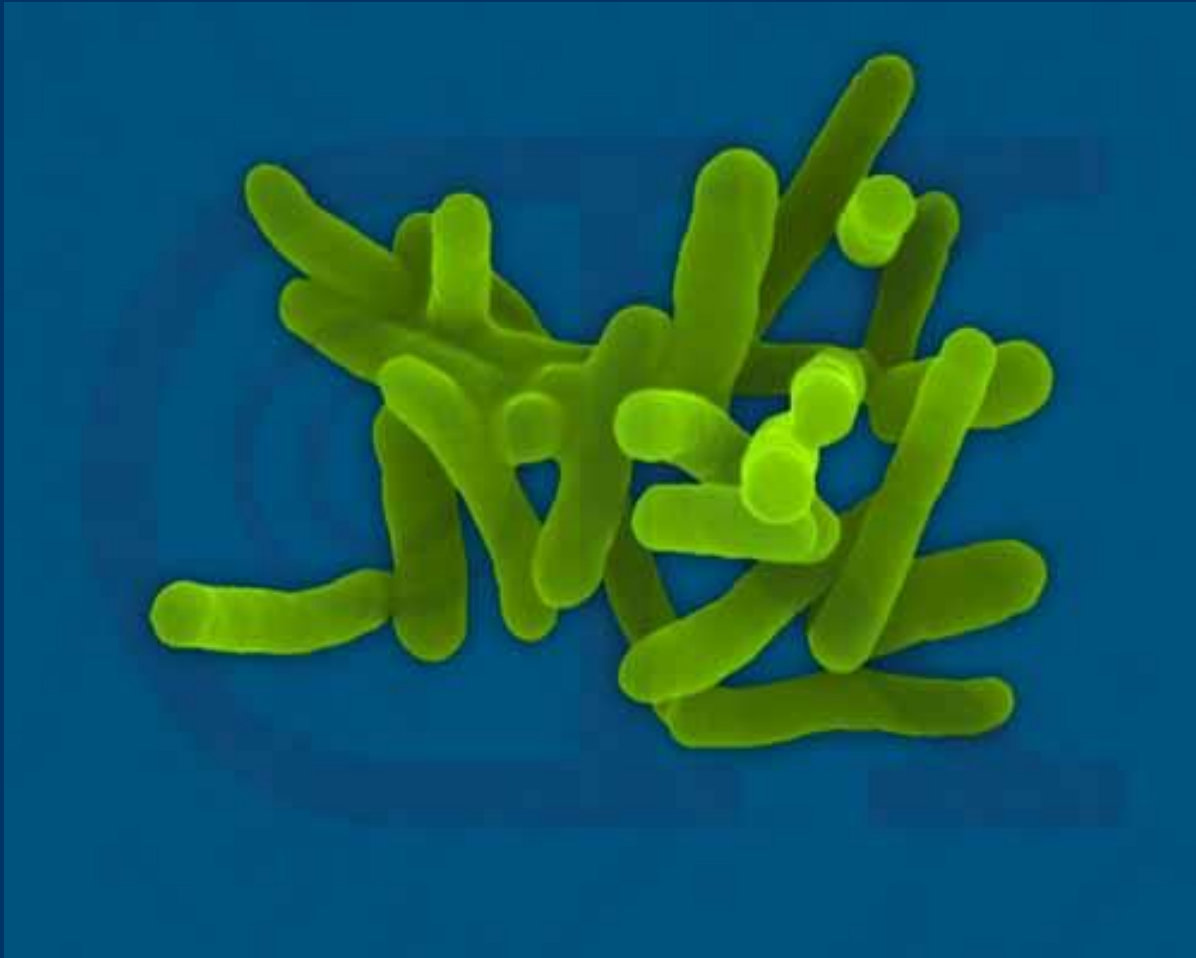
Extraintestinal Infections:

- Uropathogenic *E. coli* (UPEC): urinary tract infections
- Neonatal Meningitis *E. coli* (NMEC).

Virulence Properties of *E. coli*

- Fimbriae: CFAI/CFAll, Type 1 fimbriae, P fimbriae, S fimbriae
 - most important: K88, K99 and CFA fimbriae associated with enterotoxigenic *E. coli* (ETEC). They have differing species specificities.
 - The p-fimbriae: associated with urinary tract pathogens.
 - *E. coli* also produce common fimbriae not associated with virulence.
- Adhesins:
 - Intimin: non-fimbrial adhesin; causes the intimate association with target cells in enteropathogenic and enterohaemorrhagic *E. coli*.
 - Associated with the 'attachment and effacement' phenomenon
 - Causes destruction of the intestinal surface cells.
 - Other outer membrane proteins can act as adhesins.

Shigella spp.



Shigella and Shigellosis

- Fecal-oral transmission
 - person-to-person, fomites, food, water, ect.
- Waterborne and water-washed
- Reservoirs: humans and primates
- Infectious dose: low; as few as 10 cells to infect
- Incubation period: 1 to 7 days; typically, 1-3 days
- Duration of illness:
 - untreated: severe symptoms for about two weeks
 - Antibiotic treatment shortens illness and prevent spread to others

Shigellosis - Epidemiology

- Four species of *Shigella*: *flexneri*, *sonnei*, *dysenteriae*, *boydii*
- Major public health problem in many developing countries
 - causes about 5 to 10% of childhood diarrhoea
 - up to 25% of all diarrhea-related deaths can be associated with *Shigella*

Developing countries:

- *Sh. flexneri* is endemic (always present) in most communities
- *Sh. dysenteriae* type 1 often occurs in an epidemic pattern
 - organism can be absent for a number of years, then reappear and infect a large proportion of the population.
- These two species of *Shigella* generally produce the most severe illness.

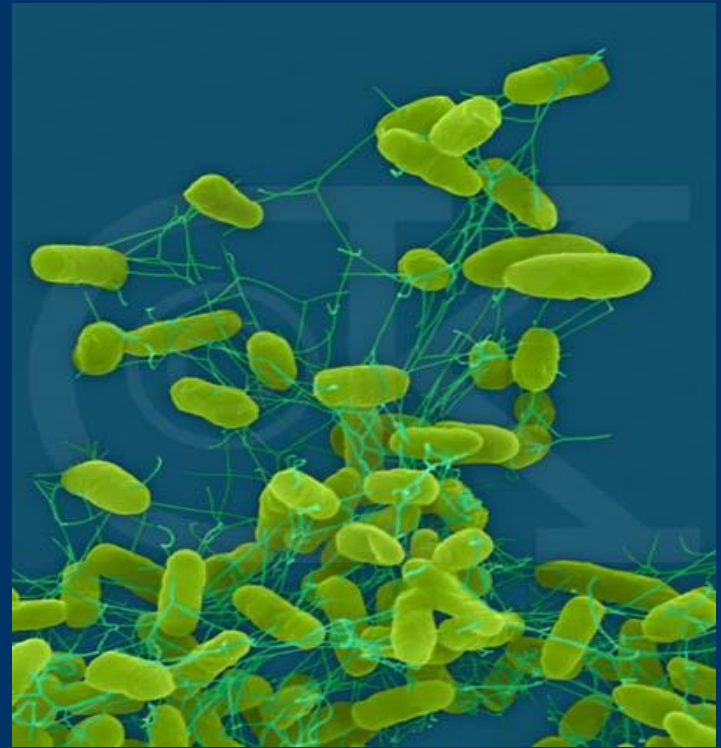
Developed countries:

- *Sh. sonnei* is the most common and is the least virulent
- *Sh. boydii* causes disease of intermediate severity
 - is least common, except in the Indian sub-continent.

Salmonella and Salmonellosis

- Belong to Enterobacteriaceae family
- Gram-negative bacilli; facultative and flagellated (motile).
- 3 major antigens:
 - "H" or flagellar antigen (phase 1 & 2)
 - "O" or somatic antigen (part of the LPS moiety)
 - "Vi" or capsular antigen (called "K" in other Enterobacteriaceae).
- **Possess LPS endotoxin characteristic of Gram-negative bacteria**
 - composed of an "O" polysaccharide ("O" antigen)
 - "R" core
 - endotoxic inner "Lipid A".
 - Endotoxins evoke fever and can activate complement, kinin and clotting factors.

Salmonella spp.

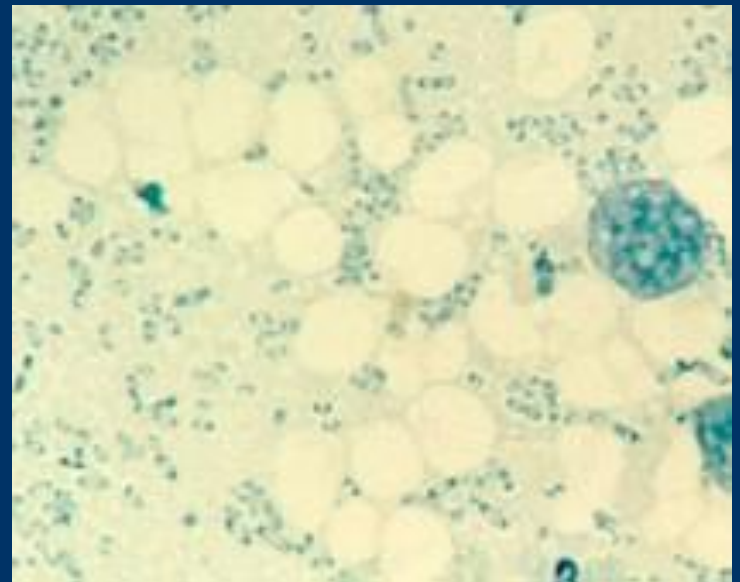
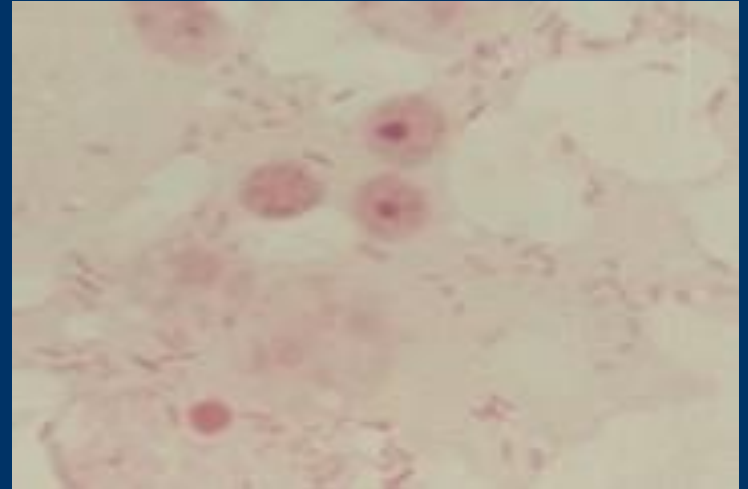


Typhoid fever: (*S. typhi* and *S. paratyphi*): Systemic Infection

- Fecal-oral transmission
- Systemic infection:
 - Macrophages, reticuloendothelial system (esp. liver, spleen and bone marrow), gallbladder and intestines as major sites of damage
- 1.5-2 week incubation period
- Symptoms: fever, headache, malaise, anorexia, then bloody diarrhea
- Mortality rate 10%, if untreated
- **Carrier state possible**
 - **"Typhoid Mary": infamous food handler; infected hundreds**
- Fecally shed at billions/gram by ill persons and carriers

Yersinia pestis

- Gram Stain:
 - Small, gram-negative bipolar-stained coccobacilli
- Wayson Stain:
 - Pink-blue cells with a closed safety pin look



Yersinia pestis: *Plague*

- U.S. averages 13 cases/yr (10 in 1998)
- 30% of cases are in Native Americans in the Southwest. 15% case fatality rate
- Most cases occur in summer

Plague Epidemiology

- Three Clinical Types:
 - bubonic (infected lymph nodes)
 - septicemic (blood-borne organisms)
 - pneumonic (transmissible by aerosol; deadliest)

Legionella spp.

- Gram-negative
- Aerobic
- Non-sporing
- Encapsulated
- ~46 species, 68 serogroups
- Ubiquitous aquatic organism
- Thrives in warm environments (32C-45C)

Legionella: Legionellosis and Pontiac Fever

Reservoirs and amplifiers:

- **Hot water systems**
- **circulating water ventilation systems (cooling towers)**
- **Plumbing (e.g., shower heads).**
- **Hot tubs, whirlpools, etc.**
- **Produce fresheners**

Cleveland Auto plant outbreak, March, 2001:

- **Plant cooling tower is considered a possible source of the outbreak.**
- **But, more than 100 other internal water sources -- favorite breeding grounds for the Legionella bacteria -- were also under investigation....**

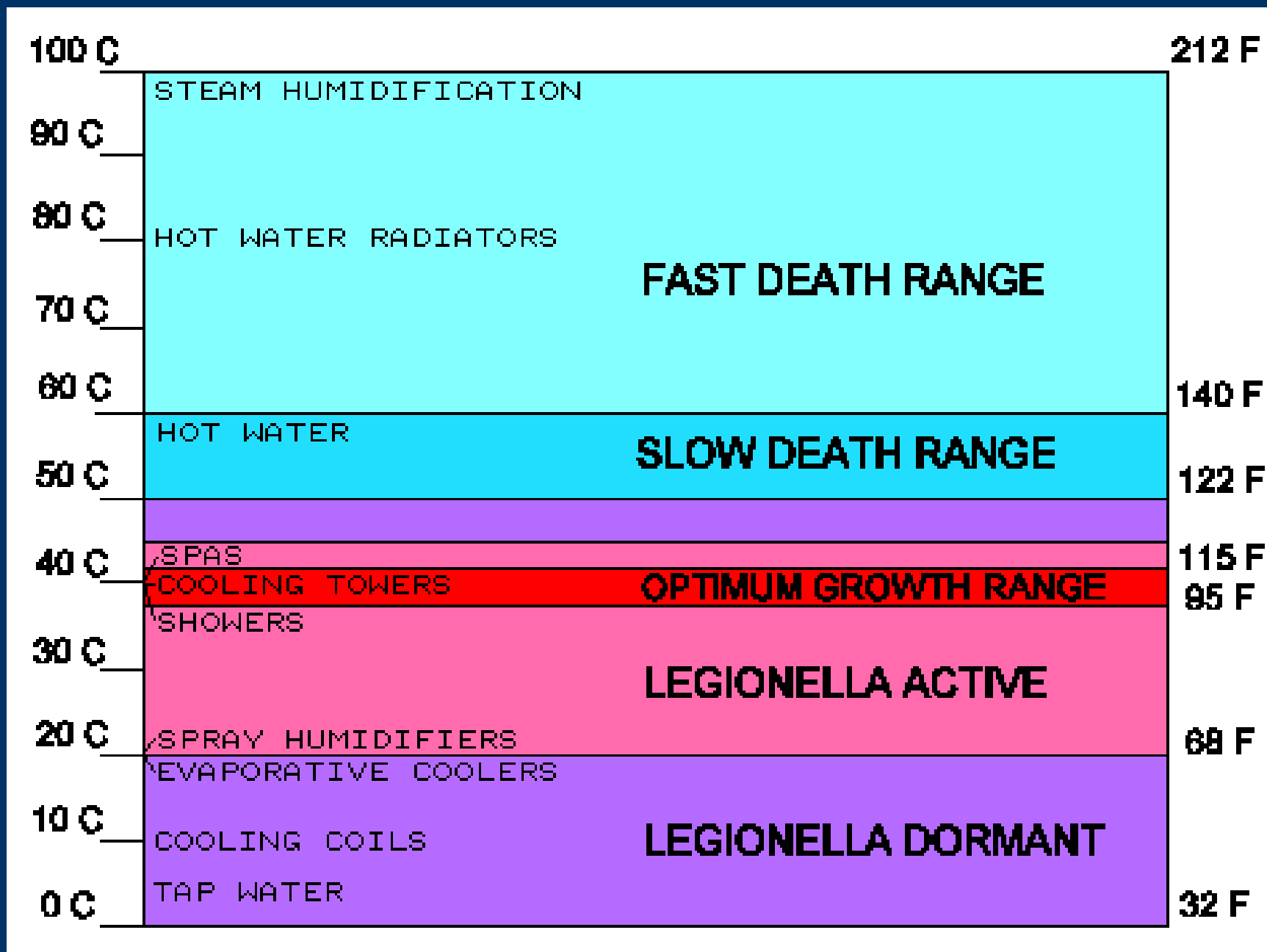
Legionnaire's Disease and Pontiac Fever

Legionnaire's disease:

- Bacterial pneumonia caused by *Legionella pneumophila*.
- A type of pneumonia that affects the lungs and may also affect the stomach and intestines, kidneys, and central nervous system.
- Incubation period: 2-10 days after exposure
- Frequently requires hospitalization
- Aerosol exposure from contaminated cooling towers, evaporative condensers, whirlpools, shower heads, faucets, & hot water tanks.

Pontiac fever: also caused by Legionella.

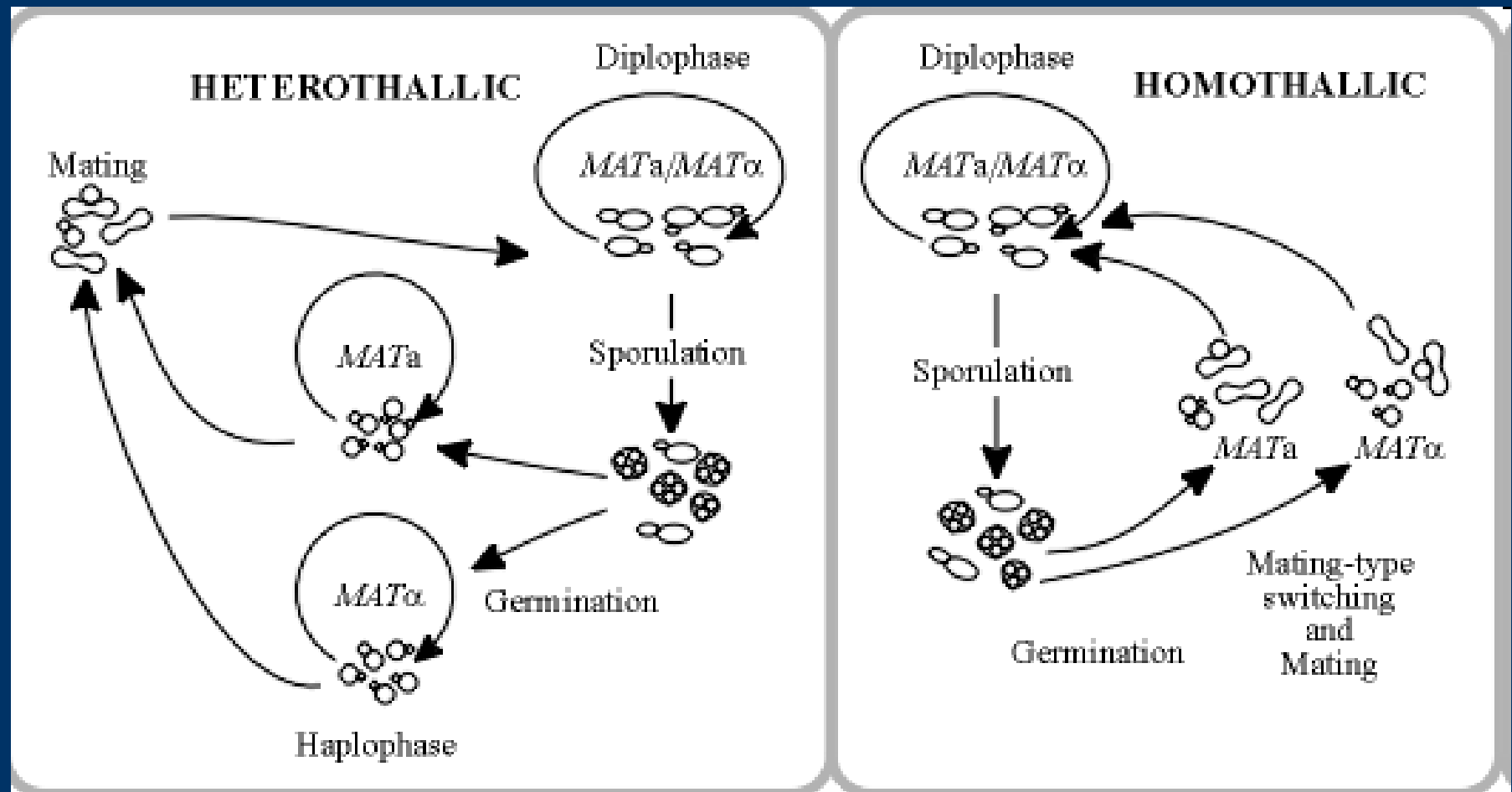
- A "flu-like" illness with fever, chills, headache, myalgia (pain in the muscles), cough, nausea, and breathlessness.
- Pneumonia does not occur.
- Usually lasts 2-5 days.
- Same sources as for Legionnaires' disease



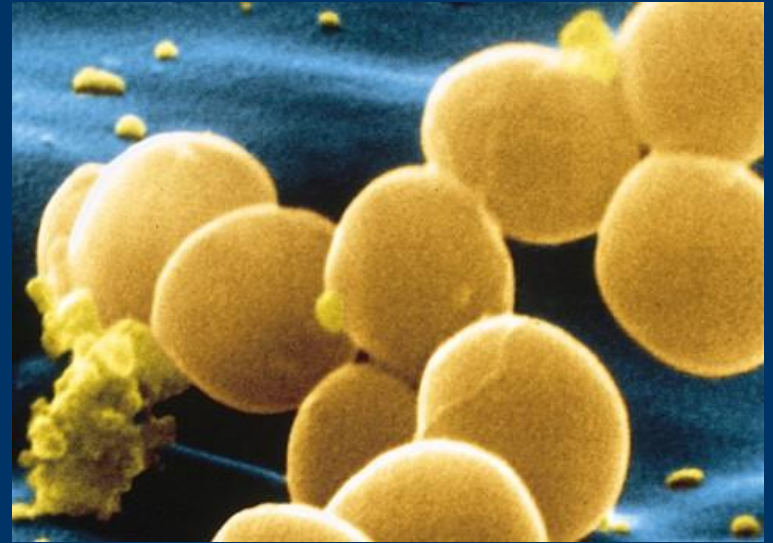
Fungi

Kingdom Fungi

- Major role in recycling of organic matter-
"Saprophytes" or "Saprobies"
- Eukaryotic, unicellular or multicellular structures with rigid chitinous cell wall
- No chlorophyll
- Asexual and sexual reproduction
 - Anamorph (mitosporic?) or Telomorph (meiosporic?)
 - Homothallic (resources to reproduce asexually in single organism) or heterothallic (sexes)



Yeasts – single-celled organisms; cell wall – chitin; typical eukaryotic cell; reproduce by budding; aerobic to anaerobic



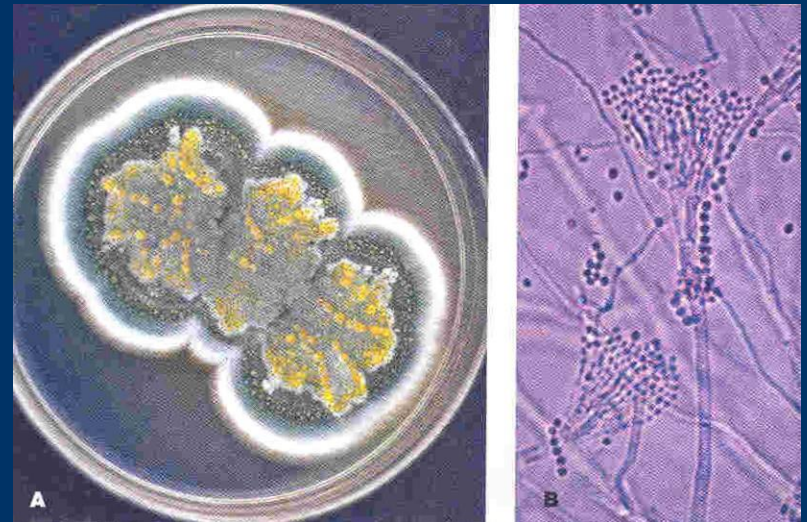
Molds – hypha (hyphae) – long thin filaments; aggregated hyphae form the mycelium; cell wall of chitin

Dimorphic fungi – can exist as either mold form or yeast form; may be temperature dependent

e.g. room temp – mold

body temp – yeast

(*Penicillium marneffi*, *Coccidioides immitis*)



Fungal Structures

- Hyphae
- Spores
- Conidia (asexual spores)

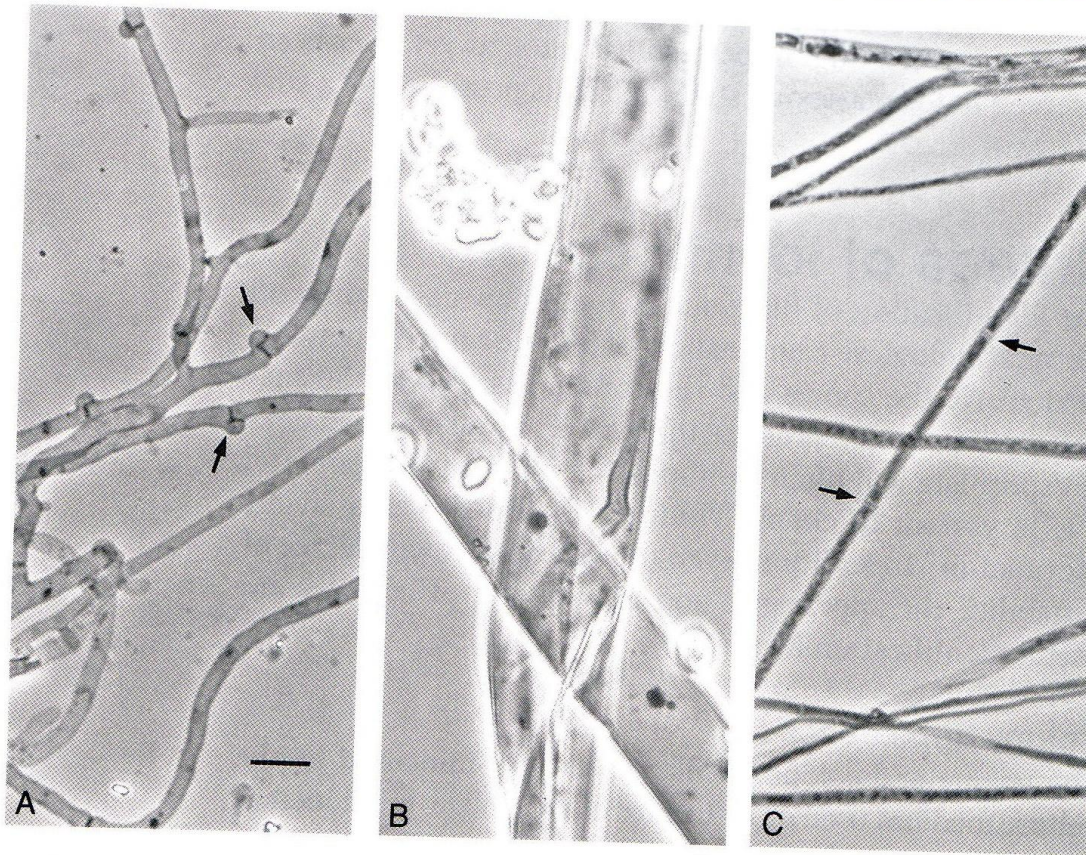
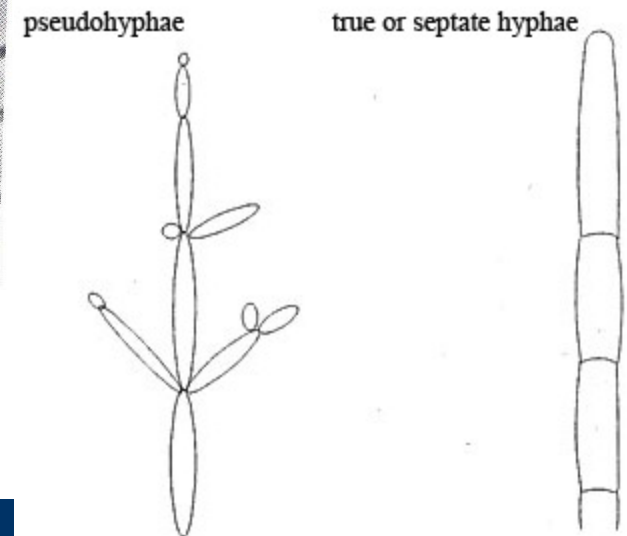
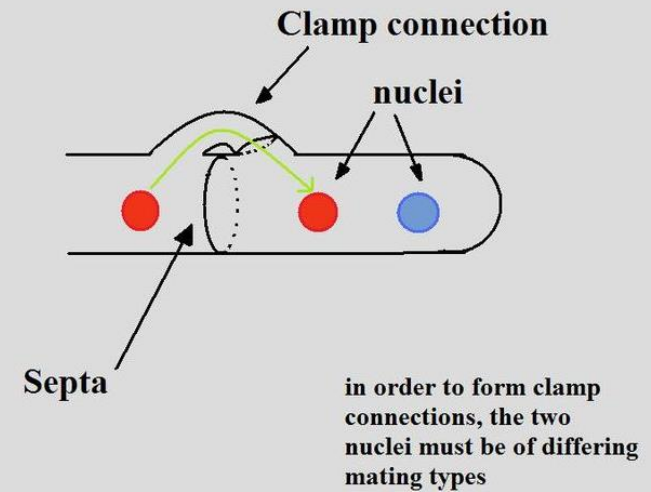


Figure 2. Different types of hyphae: A) hyphae with clamp connections[↑] of *Schizophyllum commune*, B) large, aseptate or few-septate hyphae of *Rhizopus* sp., C) narrow, septate[↑] hyphae of *Trichophyton rubrum*.



Medically Relevant Fungi

- Four Major Phyla:

- Ascomycota (ascospores)
- Basidiomycota (basidiospores)
- Zygomycota (zygospores)
- Microsporidia



- Fungi Imperfecti (no longer considered correct)
 - Deuteromycota

Spores

- Basidiomycota – mushrooms, smuts, rusts, e.g. *Cryptococcus*
- Ascomycota – sac fungi, yeasts, morels, truffles, e.g. *Pennicillium*, *Aspergillus*
- Zygomycota – e.g. *Mucor*

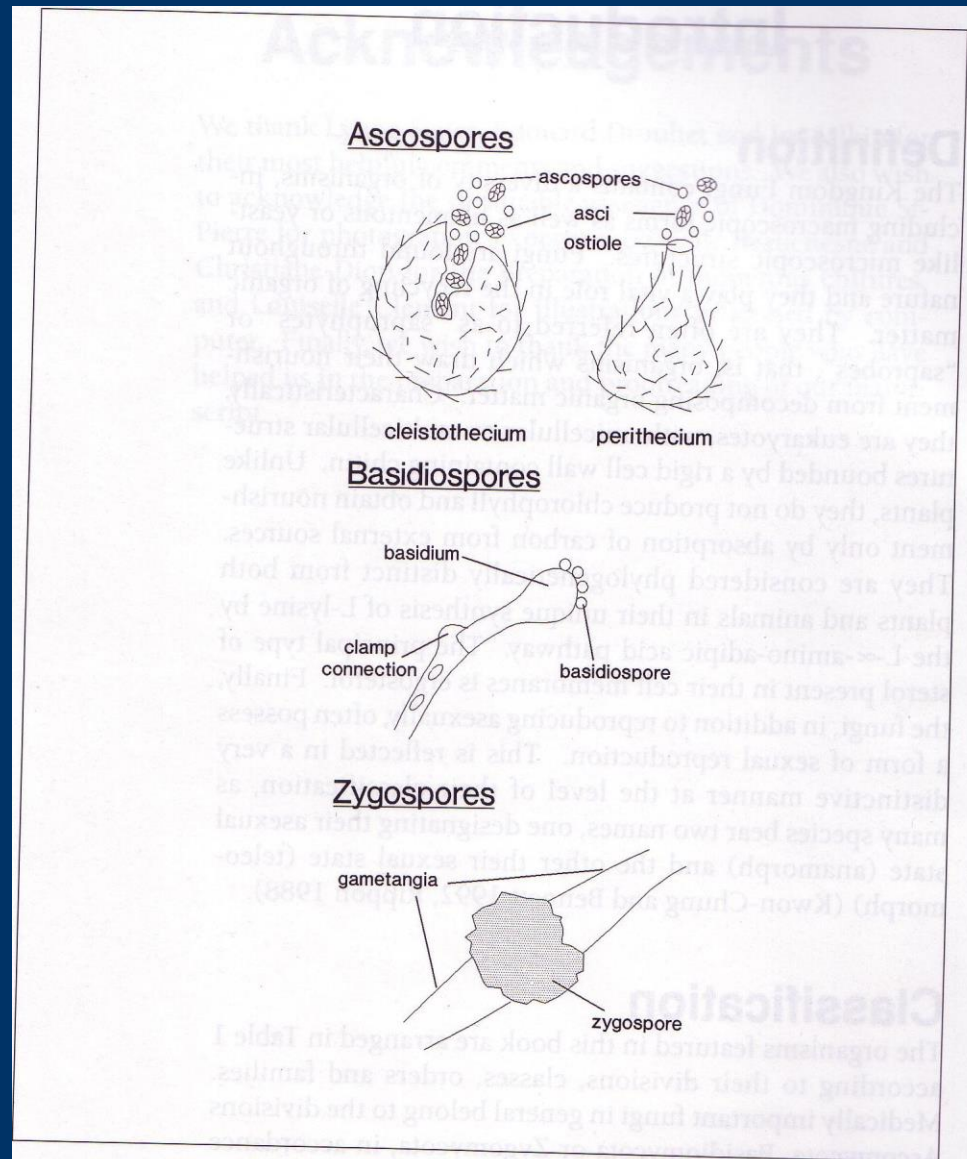


Figure 1. Sexually reproducing forms belonging to the divisions Ascomycota, Basidiomycota or Zygomycota, in accordance with the production of ascospores, basidiospores, or zygospores .

Blastoconidia

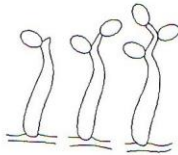
solitary



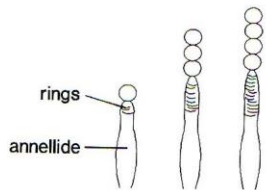
in chains



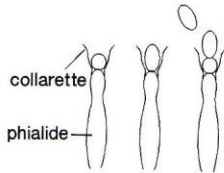
sympodial



Anneloconidia



Phialoconidia



Poroconidia

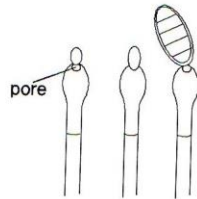


Figure 3. Blastic conidia.

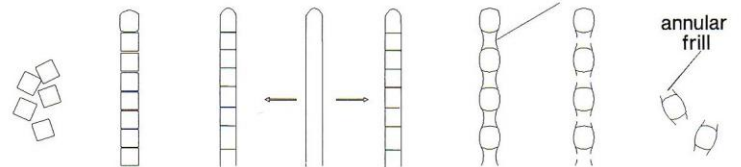
Conidia

Arthroconidia

simple

alternate

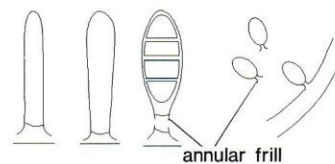
disjunct



Aleurioconidia

macroconidia

microconidia



Chlamydospores

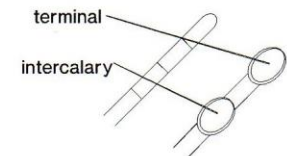


Figure 4. Thallic conidia, aleurioconidia and resting cells.

Ascomycetes – sac fungi

red, brown and blue-green fungi associated with food spoilage
plant diseases

chestnut blight and Dutch elm disease

edible morels and truffles

examples:

Morchella esculenta

common morel



Claviceps purpurea – parasite of rye and other grasses

disease called ergot

ergotism in humans – poisoning in humans

St. Anthony's fire – killed thousands in Middle Ages

psychotic delusions, nervous spasms, convulsions

ergot alkaloids – LSD

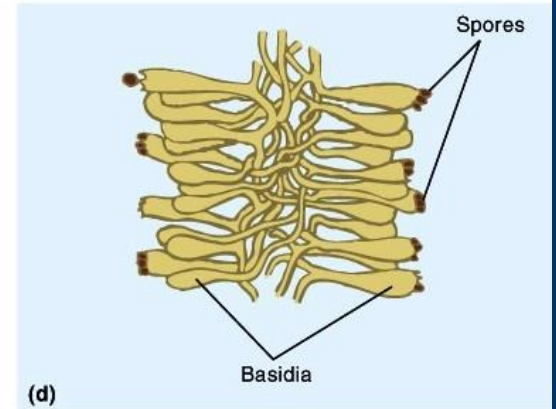
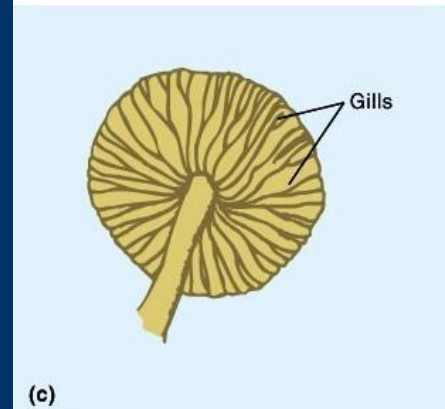
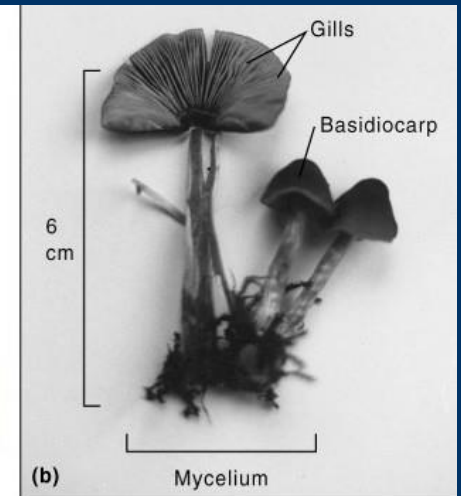
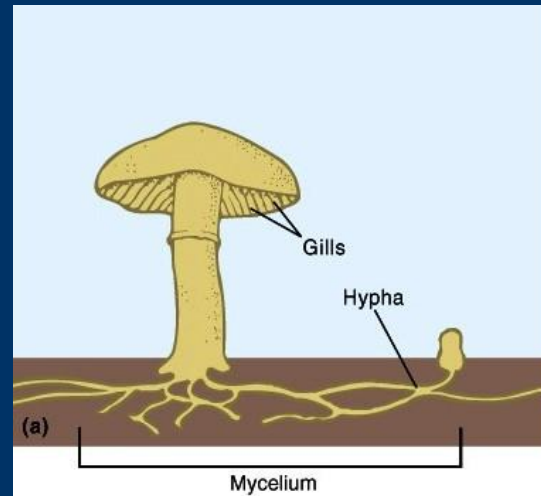
Basidiomycetes – club fungi

smuts, rusts, shelf fungi, puffballs, toadstools, mushrooms

basidium – club-shaped structure on which spores are produced

basidiocarp – mushroom

most are saprophytes



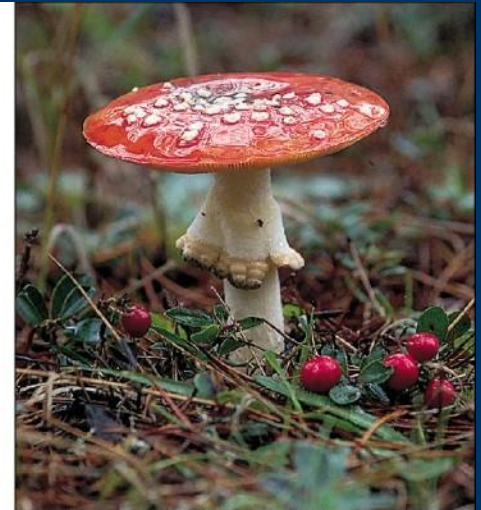
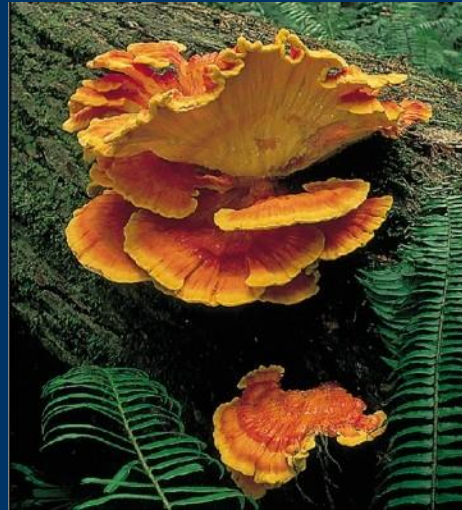
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basidiocarp – mushroom

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Basidiomycetes – club fungi

examples:

smuts & rusts – crop damage in millions

Agicarium campestris – multimillion-dollar business

Amanita phalloides – toxic

two toxins – phalloidin and α -amanitin

phalloidin – liver toxin

α -amanitin – lining of the intestinal tract

Cryptococcus neoformans – cryptococcosis

lungs and central nervous system

Zygomycetes

most soil organisms

a few pathogens of plants, insects, animals

form thick-walled zygospores

sexual reproduction – fusion of + and - strains

examples:

bread mold *Rhizopus*; black spores

***Mucor* – production of sofú from soybeans
some pathogens**

Fungal Disease

- Infection (mycosis)
- Allergy
- Hypersensitivity Pneumonitis (HP) and Organic Dust Toxic Syndrome (ODST)
- Toxicosis
- VOCs???

Fungal Infections

TABLE 2 Diseases transmitted by airborne fungi and affected tissues^a

Fungus (fungi)	Disease	Affected organ(s)/tissues
<i>Histoplasma capsulatum</i>	Histoplasmosis	Lung, eye, skin and bone
<i>Cryptococcus neoformans</i>	Cryptococcosis	Lung, central nervous system, meninges, skin, and viscera
<i>Coccidioides immitis</i>	Coccidioidomycosis	Lung, multiorgan dissemination (skin, bone, meninges, joints)
<i>Blastomyces dermatitidis</i>	Blastomycosis	Lung, skin and mucous membrane, bone, joints
<i>Aspergillus</i> spp., particularly <i>A. fumigatus</i>	Aspergillosis	Lung, bronchial airways and sinus cavities, ear canal, eye (cornea)
<i>Sporothrix schenckii</i>	Sporotrichosis	Granulomatous pneumonitis (rare), skin, joints, central nervous system, eyes
Mucorales, Zygomycetes	Mucormycosis	Nose, sinuses, eye, lung, brain and other organs, gastrointestinal system

^a Sources: references 82 and 115.

Fungal Infections

- Mycosis: any fungal Infection
- Systemic mycoses: fungal infection deep inside body. Can result from inhalation of spores. Ex: Valley fever (coccidioidomycosis)
- Subcutaneous mycoses: infection beneath skin as a result of puncture

Fungal Infections, cont.

- Cutaneous mycoses: infections of epidermis, hair, and nails. Direct contact with infected person, animal, hair, or cells is required.
- Superficial mycoses: infections of hair shaft and surface (dead) epidermal cells
- Opportunistic: compromised host



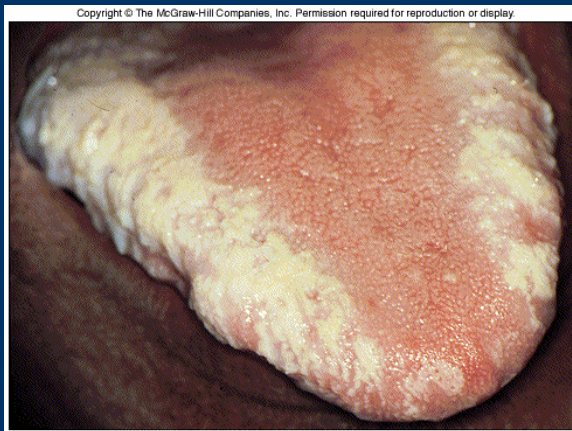
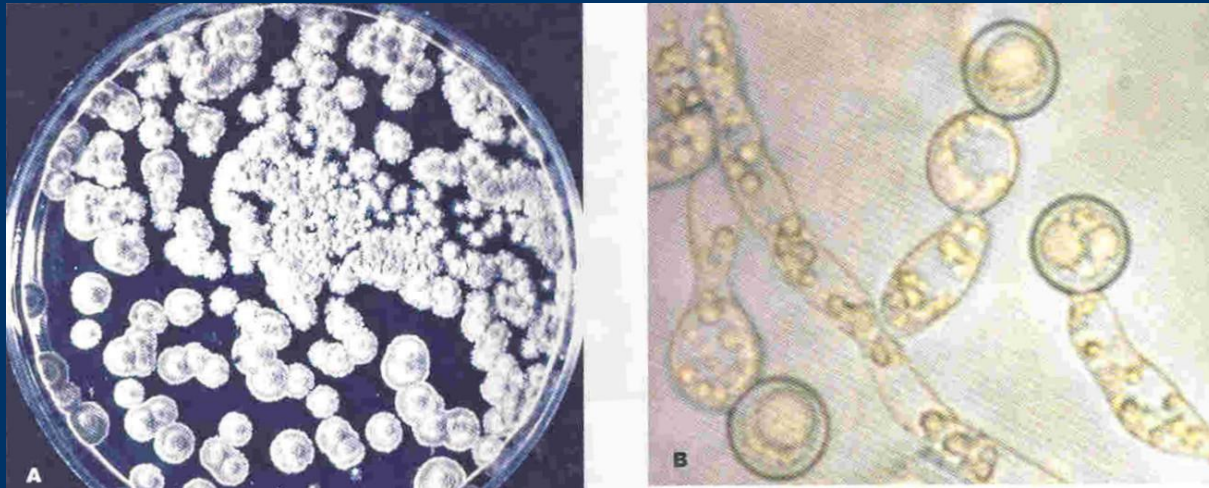
MEDICALLY IMPORTANT FUNGI

Opportunistic - compromised host

Candidiasis – vaginal infections

10% of blood infections in hospital infections

thrush – oral infection



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TABLE 4 Fungal agents of HP and occupational dust exposure

Fungal agent	Source(s)	Disease(s)
<i>Aspergillus clavatus</i>	Moldy malt	Malt worker's lung
<i>Aureobasidium pullulans</i>	Steam	Sauna-taker's lung
<i>Alternaria</i> spp.	Wood	Wood worker's lung
<i>Botrytis cinerea</i>	Moldy fruits	Winegrowers' lung
<i>Cryptostroma corticale</i>	Wood	Maple bark stripper's lung
<i>Farnai rectivirgula</i>	Straw	Potato riddler's lung
<i>Serpula</i> (Merilius) <i>lacrymans</i>	Moldy building	Dry rot lung
<i>Penicillium</i> spp.	Cork	Suberosis, woodman's disease
<i>Penicillium casei</i>	Cheese	Cheese worker's lung
<i>Mucor stolinifer</i>	Moldy paprika	Paprika worker's lung
<i>Trichosporon cutaneum</i>	House dust	Japan summer pneumonitis

safe threshold limits for fungal indoor exposure cannot be established (3, 94), and it is generally recommended to avoid or minimize unnecessary fungal indoor exposures (6).

TABLE 5 Comparative features of HP and ODTS^a

Feature	HP (extrinsic allergic alveolitis)	ODTS (toxic pneumonitis)
Immune responses	Type IV delayed hypersensitivity, cell-mediated immune reaction	Nonallergenic, noninfectious, lack of IgG
Affected tissue/organ	Lung alveoli, forming granulomas	Inflammatory lung reaction
Exposure levels	10 ⁶ –10 ¹⁰ CFU of thermophilic actinomycetes or fungi/m ³	High concentrations of fungi (>10 ⁹ spores/m ³), endotoxins (>1–2 µg/m ³), or (1–3)-β-D-glucan
Clinical features	Dyspnea, cough, fatigue, poor appetite, weight loss, abnormal chest X ray, abnormal pulmonary functions, high antibody precipitins; may cause pulmonary fibrosis in long term	Dyspnea, cough, headaches, fever, chills, malaise, acute inflammatory lung reaction, negative chest X ray; may recover after exposure cessation

^a Source: reference 150.

Fungal Toxins

- Most fungal toxins produced by:
 - **Aspergillus spp.**
 - **Penicillium spp.**
 - **Fusarium spp.**
 - **Alternaria spp.**
 - Rhizopus
 - Mucor

TABLE 6 Some toxigenic fungi, fungal chemical metabolites, and their health effects

Fungi	Chemical metabolite	Health effect(s)
<i>Penicillium</i> (>200 species)	Patulin Citrinin Ochratoxin A Citroviridin Emodin Gliotoxin Verruculogen Secalonic acid D	Hemorrhage of lung, brain disease Renal damage, vasodilatation, bronchial constriction, increased muscular tone Nephrotoxic, hepatotoxic Neurotoxic Reduced cellular oxygen uptake Lung disease Neurotoxic: trembling in animals Lung, teratogenic in rodents
<i>Aspergillus</i> spp. <i>A. clavatus</i> <i>A. flavus</i> and <i>A. parasiticus</i> <i>A. versicolor</i> <i>A. ochraceus</i>	Patulin Aflatoxin B1 Sterigmatocystin Ochratoxin A	Hemorrhage of lung, brain disease Liver cancer, respiratory cancer, cytochrome P-450-monooxygenase disorder Carcinogen Nephrotoxic, hepatotoxic
<i>Stachybotrys chartarum</i> , <i>Fusarium</i> spp., <i>Trichoderma</i> spp.	Trichothecenes ^a (more than 50 derivatives known): T-2, nivalenol, deoxynivalenol, diacetoxyscirpenol, satratoxin H and G, other macrocyclic trichothecenes, spiro lactone, zearalenone	Immune suppression and dysfunction, cytotoxic, bleeding, dermal necrosis; high-dose ingestion is lethal (human case reports); low-dose, chronic is potentially lethal; teratogenic, abortogenic (in animals), hemorrhage; alimentary toxic aleukia reported in Russia and Siberia; staggering wheat in Siberia; red mold disease in Japan; neurotoxic/nervous behavior abnormality; cocarcinogen/chemotoxic (?); anticomplement function; phytoestrogen may alter immune function; stimulates growth of uterus and vulva; atrophy of ovary
<i>Claviceps</i> spp.	Ergot alkaloids	Prolactin inhibitor, vascular constriction, uterus contraction promoted

^a Trichothecenes are also produced by *Myrothecium*, *Trichothecium*, and *Gibberella* (teleomorph of some *Fusarium* spp.).

Important Mycotoxins

- Aflatoxins
- Fumonisin
- Ochratoxin
- Trichothecenes
- Zearalenone and Zearalenones
- Tenuazonic
- Patulin
- Xanthomegnin and Viomellein
- Nephrotoxic glycopeptides
- Sterigmatocystin
- Fusarochromanone
- Ergot alkaloids
- Citrinin
- 3-Nitropropionic acid
- Roquefortine C
- Secalonic acid D
- Verrucosidin

Dermatophytosis (Ringworm and Tinea)

Dermatophytes which have the ability to utilize keratin as a nutrient source.

The disease process in dermatophytosis is unique for two reasons:

1. No living tissue is invaded; the keratinised stratum corneum is simply colonized.
 - the presence of the fungus and its metabolic products usually induces an allergic and inflammatory eczematous response in the host.
2. The dermatophytes are the only fungi that have evolved a dependency on human or animal infection for the survival and dissemination of their species.

Tinea is general term for skin mycoses; not taxonomical; Characterized by location – e.g. Tinea pedis (athletes foot), Tinea cruris (Jock itch), Tinea corporis (ringworm)

Can be caused by variety of fungi – e. g. Trichopyton spp., Microsporum spp.





Tinea nigra.

Tinea nigra is a superficial fungal infection of skin characterized by brown to black macules, which usually occur on the palmar aspects of hands and occasionally the plantar and other surfaces of the skin. Lesions are non-inflammatory and non-scaling.

Distribution: World-wide, but more common in tropical regions of Central and South America, Africa, South-East Asia and Australia.

Aetiological Agent: *Exophiala werneckii* a common saprophytic fungus believed to occur in soil, compost, humus and on wood in humid tropical and sub-tropical regions. Familial spread of infection reported.



Tinea Versicolor

Pityriasis; A chronic, superficial fungal disease of the skin characterized by well-demarcated white, pink, fawn, or brownish lesions, often coalescing, and covered with thin furfuraceous scales. Lesions occur on the trunk, shoulders and arms, rarely on the neck and face, and fluoresce a pale greenish colour under Wood's ultra-violet light. Young adults are affected most often, but the disease may occur in childhood and old age.

Distribution: World-wide but more common in tropical than temperate climates.

Aetiological Agent: *Malassezia furfur* a lipophilic yeast forming part of the normal flora of human skin.

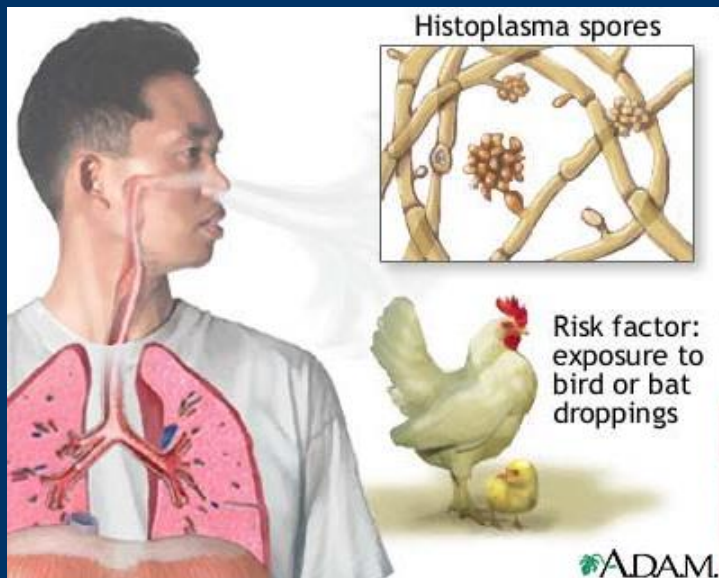


Histoplasmosis

An intracellular mycotic infection of the reticuloendothelial system caused by the inhalation of the fungus. Approximately 95% of cases of histoplasmosis are subclinical. Five percent of the cases have chronic progressive lung disease, chronic cutaneous or systemic disease or an acute fulminating fatal systemic disease. All stages of this disease may mimic tuberculosis.

Distribution: World-wide, especially U.S.A. Sporadic cases do occur in Australia.

Aetiological Agent: *Histoplasma capsulatum*, especially from soil enriched with excreta from chicken, starlings and bats.

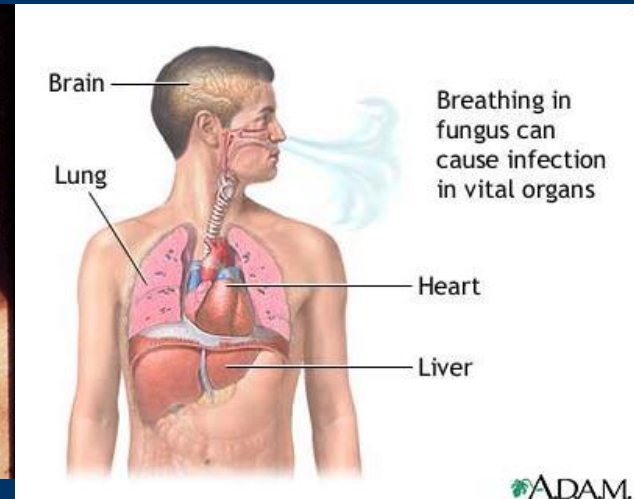


Coccidioidomycosis

Initially, a respiratory infection, resulting from the inhalation of conidia, that typically resolves rapidly leaving the patient with a strong specific immunity to re-infection. However, in some individuals the disease may progress to a chronic pulmonary condition or as a systemic disease involving the meninges, bones, joints and subcutaneous and cutaneous tissues.

Distribution: Endemic in south-western U.S.A., northern Mexico and various centres in South America.

Aetiological Agent: *Coccidioides immitis*, a soil inhabiting fungus.

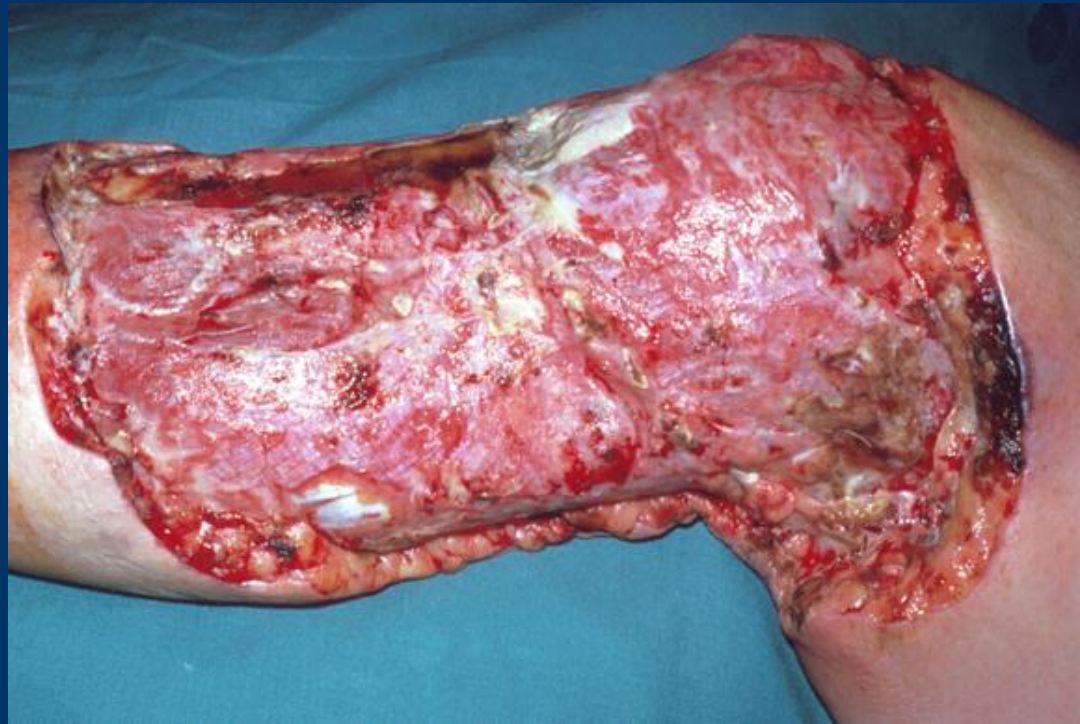


Subcutaneous zygomycosis (Mucormycosis)

- Usually the result of a "barrier break" or traumatic implantation of fungal elements.
- Lesions vary considerably in morphology but include plaques, pustules, ulcerations, deep abscesses and ragged necrotic patches.
- Most heal with little treatment (debridement and amphotericin B) and they are not usually associated with dissemination.

Distribution: World-wide.

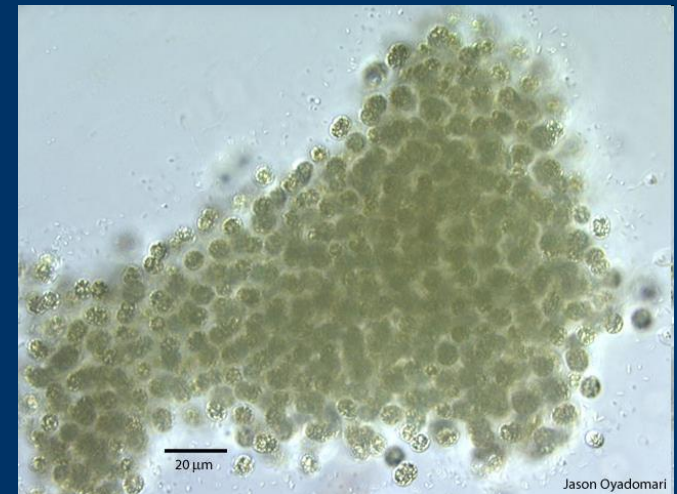
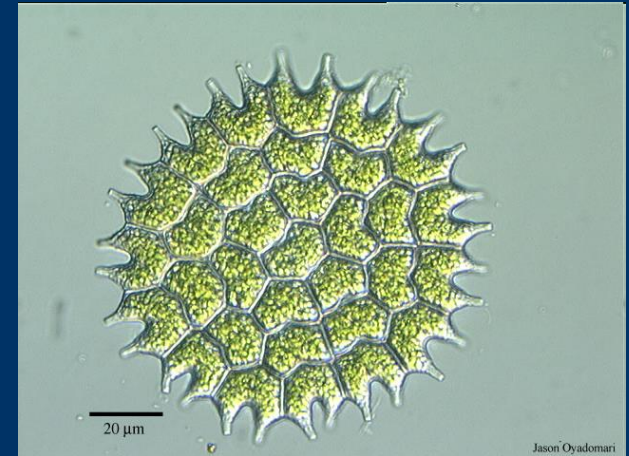
Aetiological Agents: Cosmopolitan members of the Mucorales including species of *Rhizopus*, *Mucor*, *Rhizomucor*, *Absidia*, *Cunninghamella*, *Saksenaea* and *Mortierella*.



Algae

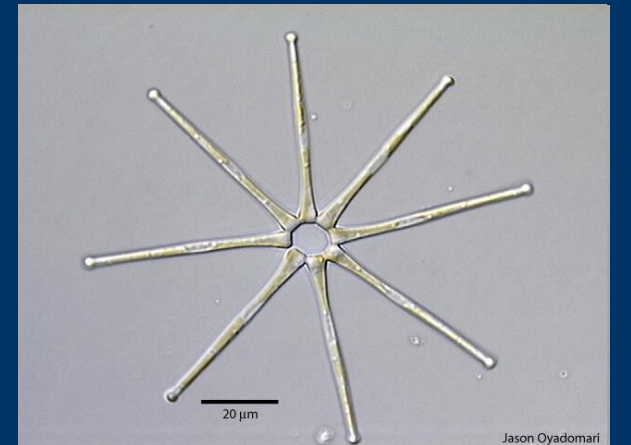
Algae Divisions

- **Chlorophyta** (green algae)
 - Least harmful, generally considered beneficial
 - Growth in reservoirs; mild taste and odor; some filamentous mat formers
- **Cyanophyta** (blue-green algae)
 - Prokaryotes
 - Most significant concerns for water quality
 - Taste and odor problems; filter cloggers; oxygen depletion; toxicity



Algae Divisions

- **Ochrophyta (Chromophyta)**
 - **Chrysophyceae** (Yellow-Green/Golden-Brown Algae)
 - Taste and odor problems; reservoir growth; filter cloggers
 - Frustules used for filtration
 - **Bacillariophyceae**
 - Diatoms
- **Dinophyta (Pyrrhophyta, Dinozoa)**
 - Dinoflagellates
 - Taste and odor problems
 - Red tide problems



Algae Divisions

- **Euglenophyta**
(protozoan-like algae)
 - Indicators of pollution
 - Filter cloggers
- **Cryptophyta**
(cryptomonads)
 - Taste and odor problems
- **Rhodophyta** (red algae)
 - Growth on reservoir walls and irrigation ditches



Taste and Odor

- **Dirty or Musty**
 - Geosmin and MIB (2-methylisoborneol)
 - blue-green algae, actinomycetes
- **Fishy, Cod liver Oil**
 - Chrysophyta, Pyrrophyta
- **Septic Odor**
 - Pryrophyta
- **Cucumber Odor**
 - Chrysophyta

Pyrrhophyta (Dinoflagellates)

- unicellular
 - many have stiff, patterned plates
- many photosynthetic
 - some ingest other cells
- most are marine
 - some cause phosphorescence in ocean waters
 - some endosymbionts
 - zooxanthellae – unarmored form seen in host

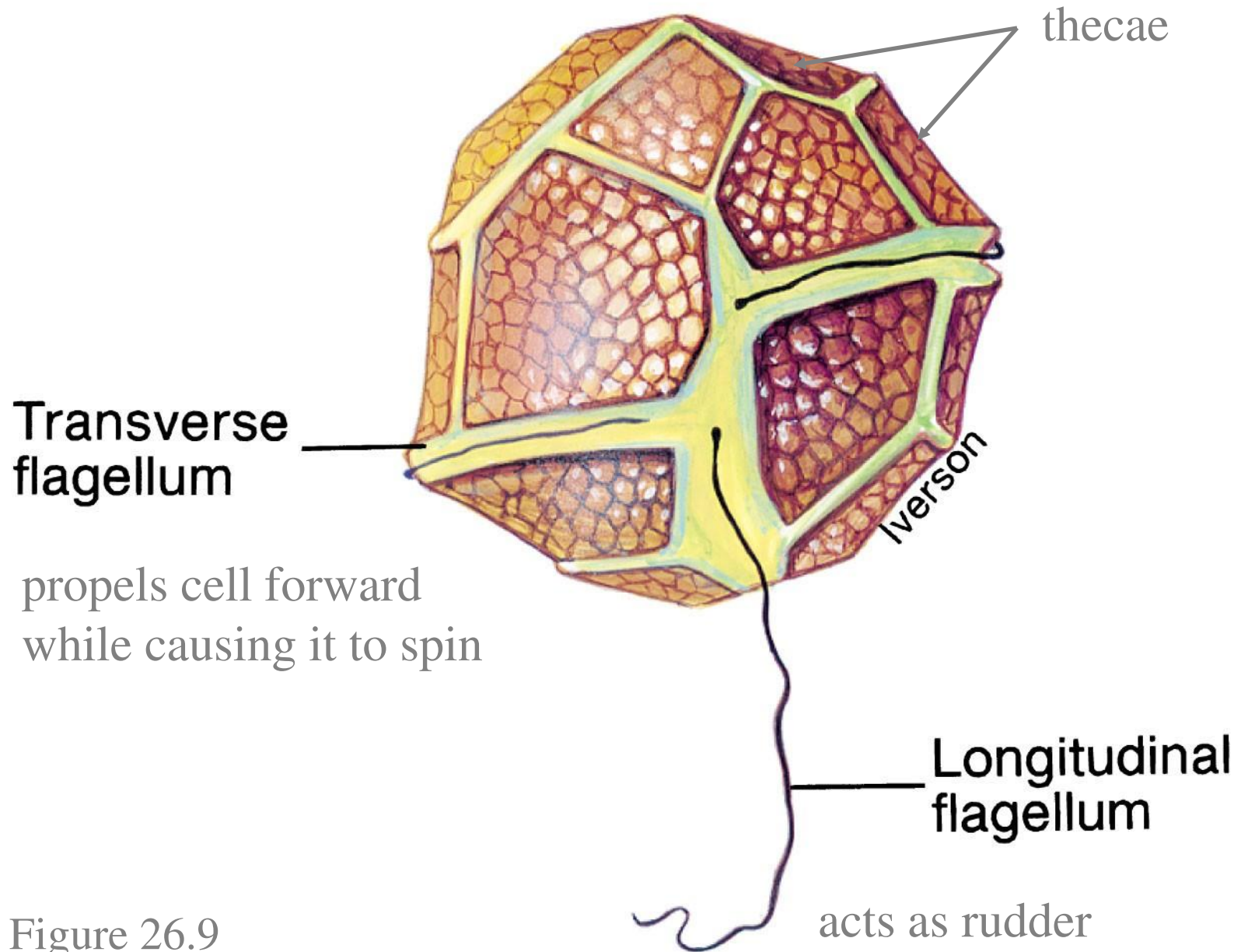


Figure 26.9

Freshwater Algal Toxins

- **Anatoxin** (e.g. *Anabaena*)
 - Staggering, paralysis, gasping, convulsions, death
 - 200 µg/kg LD₅₀
- **Microcystin** (e.g. *Anabaena*, *Microcystis*, *Oscillatoria*)
 - Jaundice, shock, abdominal pain/distention. Weakness, nausea, vomiting, severe thirst, rapid/weak pulse, death
 - 300-600 µg/kg LD₅₀
- **Saxitoxin/Neosaxitoxin** (e.g. *Anaphizomenon*)
 - Weakness, staggering, loss of muscle coordination, difficulty in swallowing, labored respiration, muscle paralysis, death, tingling around mouth or fingertips, slurred speech
 - 9 µg/kg LD₅₀
- **Hepatotoxin** (e.g. *Gleotrichia*)
 - Jaundice, abdominal pain/distention, weakness, nausea/vomiting
- **Cytotoxin** (e.g. *Gleotrichia*)
 - Skin irritation, gastrointestinal upset

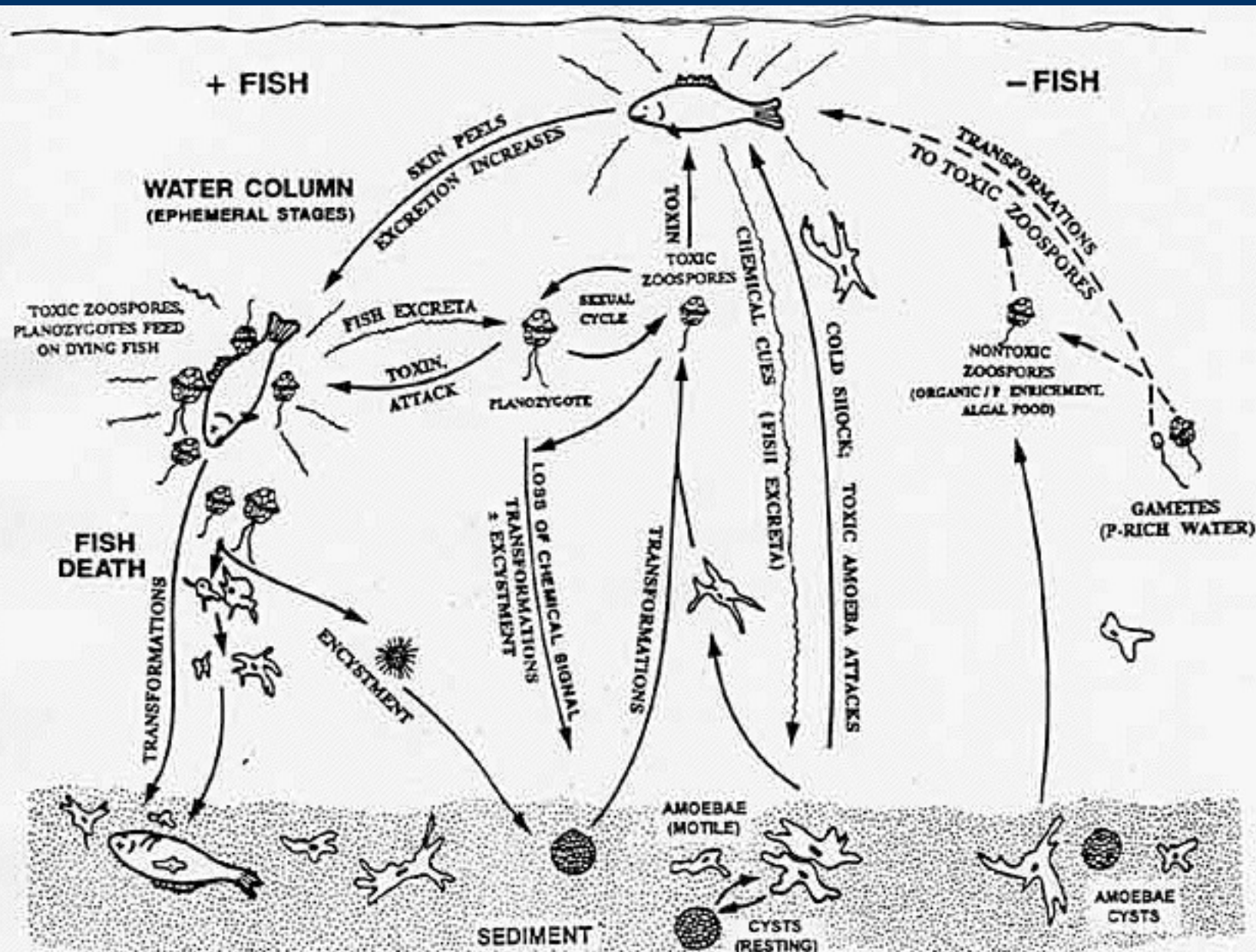
Marine Algal Toxins

- PSP- Saxitoxins, Gonyautoxins, C-Toxins- *Alexandrium* (formerly *Gonyaulax*) spp.
- ASP- Domoic Acid – *Pseudonitzschia* spp.
- DSP- Okadaic acid, dinophysiotoxins, pectenotoxins, and yessotoxin- *Dinophysis* spp. and *Prorocentrum* spp.
- Ciguatera toxin, Maitotoxin, & Scaritoxin- *Gambierdiscus toxicus*
- NSP/Brevetoxin- *Karenia brevis* (formerly *Ptychodiscus* or *Gymnodinium breve*)
- Pfiesteria-like Toxins- Three putative toxins- lipid soluble dermoneurotoxic toxin, lipid-soluble lethality factor, water-soluble neurotoxin

Pfiesteria piscicida

- *Pfiesteria piscicida* - colorless, single-celled organism (dinoflagellate)
- Capable of 24 distinct forms depending on water characteristics, major ones:
 - Amoeba forms
 - Zoospores
 - Gametes
 - Planozygote
 - Cyst forms





Pfiesteria and Fish

- Toxic zoospores excrete toxins that drug fish and destroy skin
- Gametes, zoospores and planozygotes feed on substances from sores on fish
- Amoeba forms feed on dead fish
- Toxins affect liver, brain, kidney and pancreas of fish
- Toxins affect other aquatic life as well

Pfiesteria Toxins and Humans

- Can affect humans by touching or ingesting water or breathing aerosolized water containing toxins
- Respiratory problems
- Headaches
- Moodiness
- Aching joints and muscles
- Disorientation
- Memory loss