Spore-forming Bacilli

Genus *Bacillus*

Genus *Clostridium*

**Bacillus**
- gram-positive, endospore-forming, motile rods
- mostly saprobic
- aerobic & catalase positive
- source of antibiotics
- primary habitat is soil
- 2 species of medical importance
  - *Bacillus anthracis*
  - *Bacillus cereus*

**Bacillus anthracis**
- large, block shaped rods
- central spores that develop under all conditions except in the living body
- virulence factors – capsule & exotoxins
- 3 types of anthrax
  - Cutaneous – spores enter through skin, cause black sore (eschar); least dangerous
  - Pulmonary – Inhalation of spores
  - Gastrointestinal – ingested spores
- treated with penicillin or tetracycline
- vaccine – toxoid 6X over 1.5 years; annual boosters
**Bacillus cereus**

- common airborne & dustborne
- grows in foods, spores survive cooking & reheating
- ingestion of toxin-containing food causes nausea, vomiting, abdominal cramps & diarrhea; 24 hour duration
- no treatment
- spores abundant in the environment

**Clostridium**

- gram-positive, spore-forming rods
- anaerobic & catalase negative
- 120 species
- oval or spherical spores produced only under anaerobic conditions
- synthesize organic acids & alcohols & exotoxins
- cause wound & tissue infections & food intoxications

**Clostridium perfringens**

- causes gas gangrene in damaged or dead tissues
- 2nd most common cause of food poisoning, worldwide
- virulence factors
  - alpha toxin: causes RBC rupture, edema & tissue destruction
  - collagenase
  - hyaluronidase
  - DNase

**Pathology of C. perfringens**

- Not highly invasive; requires damaged and dead tissue and anaerobic conditions
- Conditions stimulate spore germination, vegetative growth and release of exotoxins, and other virulence factors
- Fermentation of muscle carbohydrates results in the formation of gas and further destruction of tissue
Treatment of Gangrene

- Immediate cleansing of dirty wounds, deep wounds, decubitus ulcers, compound fractures, and infected incisions
  - debridement of diseased tissue
  - large doses of cephalosporin or penicillin
  - hyperbaric oxygen

Clostridium difficile

- normal resident of colon, in low numbers
- causes antibiotic-associated colitis
  - treatment with broad-spectrum antibiotics kills the other bacteria, allowing C. difficile to overgrow
- produces enterotoxins that damage the intestine
- major cause of diarrhea in hospitals

Treatment and Prevention of CDAC

- Mild uncomplicated cases respond to fluid and electrolyte replacement and withdrawal of antimicrobials
- Severe infections treated with oral vancomycin or metronidazole and replacement cultures
- Increased precautions to prevent spread

Clostridium tetani

- common resident of soil & GI tracts of animals
- causes tetanus or lockjaw
- spores usually enter through accidental puncture wounds, burns, umbilical stumps, frostbite, & crushed body parts
- tetanospasmin – neurotoxin causes paralysis

Treatment and Prevention

- Treatment aimed at deterring degree of toxemia and infection and maintaining homeostasis
- Antitoxin therapy with human tetanus immune globulin; inactivates circulating toxin but does not counteract that which is already bound
- Control infection with penicillin or tetracycline
- Vaccine available; booster needed every 10 years
**Clostridium botulinum**

- Food poisoning - spores are in soil, may contaminate vegetables; improper canning does not kill spores & they germinate in the can, producing botulin toxin  
  - Toxin causes paralysis by preventing release of acetylcholine
- Infant botulism – caused by ingested spores that germinate & release toxin
- Wound botulism – spores enter wound & cause food poisoning symptoms

**Listeria monocytogenes**

- Non-spore-forming gram-positive
- Ranging from cocciobacilli to long filaments
- No capsules
- Resistant to cold, heat, salt, pH extremes & bile
- Virulence attributed to ability to replicate in the cytoplasm of cells after inducing phagocytosis; avoids humoral immune system
- Can contaminate foods & grow during refrigeration
- Listeriosis in immunocompromised patients, fetuses & neonates affects brain & meninges
  - 20% death rate
- Ampicillin & trimethoprim-sulfamethoxazole
- Prevention – pasteurization & cooking

**Treatment and Prevention**

- Determine presence of toxin in food, intestinal contents or feces
- Administer antitoxin; cardiac and respiratory support
- Infectious botulism treated with penicillin
- Practice proper methods of preserving and handling canned foods; addition of preservatives
**Corynebacterium diphtheriae**

- gram-positive irregular bacilli
- produce catalase
- uses respiratory portal
- virulence factors assist in attachment and growth
  - diphtherotoxin – exotoxin
  - 2 part toxin – part A binds and induces endocytosis; part A 
    arrests protein synthesis
- 2 stages of disease
  - local infection – upper respiratory tract
  - diphtherotoxin production & toxemia
- pseudomembrane formation can cause asphyxiation

**Mycobacteria**

- gram-positive irregular bacilli
- acid-fast staining
- strict aerobes
- produce catalase
- possess mycolic acids & a unique type of peptidoglycan
- do not form capsules, flagella or spores
- grow slowly
- *Mycobacterium tuberculosis*
- *Mycobacterium leprae*
**Mycobacterium tuberculosis**

- produces no exotoxins or enzymes that contribute to infectiousness
- contains complex waxes & cord factor that prevent destruction by lysosomes of macrophages
- transmitted by airborne respiratory droplets
- only 5% of infected people develop clinical disease

**Primary TB**

- infectious dose 10 cells!
- phagocytosed by alveolar macrophages & multiply intracellularly
- after 3-4 weeks immune system attacks, forming tubercles, granulomas consisting of a central core containing bacilli surrounded by WBCs

**Secondary TB**

- reactivation of bacilli
- tubercles expand & drain into the bronchial tubes & upper respiratory tract
- gradually patient experiences more severe symptoms
  - violent coughing, greenish or bloody sputum, fever, anorexia, weight loss, fatigue
- untreated 60% mortality rate

**Extrapulmonary TB**

during secondary TB, bacilli disseminate to regional lymph nodes, kidneys, long bones, genital tract, brain, meninges

**Diagnosis of TB**

- in vivo or tuberculin testing
- X-rays
- direct identification of acid-fast bacilli in specimen
- cultural isolation and biochemical testing
Treatment of TB

- 6-24 months of at least 2 drugs from a list of 11
- one pill regimen called Rifater (isoniazid, rifampin, pyrazinamide)
- Drug resistance is growing!
- Clavulanate + meropenem (experimental)
- vaccine based on attenuated bacilli Calmet-Guerin strain of *M. bovis* used in other countries (low effectiveness for adults)

Mycobacterium leprae

- Hansen's bacillus
- strict parasite – has not been grown on artificial media or tissue culture
- slowest growing of all species
- multiplies within host cells in large packets called globi
- causes leprosy, a chronic disease that begins in the skin & mucous membranes & progresses into nerves

Leprosy

- endemic regions throughout the world
- spread through direct inoculation from leprotics
- 2 forms
  - tuberculoid – superficial infection without skin disfigurement which damages nerves and causes loss of pain perception
  - lepromatous – a deeply nodular infection that causes severe disfigurement of the face & extremities
- treatment by long-term combined therapy