The Gram Positive Bacilli of Medical Importance
Chapter 19

MCB 2010
Palm Beach State College
Professor Tcherina Duncombe
Medically Important Gram-Positive Bacilli
3 General Groups

• **Endospore-formers:** *Bacillus, Clostridium*

• **Non-endospore-formers:** *Listeria*

• **Irregular shaped and staining properties:**
  *Corynebacterium, Propionibacterium, Mycobacterium, Actinomyces*
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**Gram-Positive Rods**

- Regular shape and staining properties
  - Listeria
  - Erysipelothrix

**Non-endospore-formers**

- Irregular shape and staining properties
  - Non-acid-fast
    - Corynebacterium
    - Propionibacterium
  - Acid-fast
    - Mycobacterium

- Filamentous, branching cells
  - Actinomyces
  - Nocardia
General Characteristics
Genus *Bacillus*

- Gram-positive/endospore-forming, motile rods
- Mostly saprobic
- Aerobic/catalase positive
- Versatile in degrading complex macromolecules
- Source of antibiotics
- Primary habitat: soil
- 2 species of medical importance:
  - *Bacillus anthracis* right
  - *Bacillus cereus* left
**Bacillus anthracis**

- Large, block-shaped rods
- **Central spores**: develop under all conditions except in the living body
- **Virulence factors** – polypeptide capsule/exotoxins

- **3 types of anthrax:**
  - **cutaneous** – spores enter through skin, black sore- eschar; least dangerous
  - **pulmonary** – inhalation of spores
  - **gastrointestinal** – ingested spores

Treatment: penicillin, tetracycline

Vaccines

*(phage 5 sensitive)*
**Bacillus cereus**

- Common airborne /dustborne; usual methods of disinfection/ antisepsis: ineffective

- Grows in foods, spores survive cooking/ reheating

- Ingestion of toxin-containing food causes nausea, vomiting, abdominal cramps, diarrhea; 24 hour duration

- No treatment

- Increasingly reported in immunosuppressed

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Genus *Clostridium*

- Gram-positive, spore-forming rods
- Obligate Anaerobes
- Catalase negative
- Oval or spherical spores
- Synthesize organic acids, alcohols, exotoxins
- Cause wound infections, tissue infections, food intoxications

*C. difficile*
**Clostridium difficile-Associated Disease (CDAD)**

- Normal flora colon, in low numbers
- Causes **antibiotic associated colitis**
  - relatively non-invasive; treatment: broad-spectrum antibiotics kills other bacteria: *C. difficile* overgrowth
- **Enterotoxins** that damage intestines
- Major cause of diarrhea in hospitals
- Increasingly more common in community acquired diarrhea
- **Treatment**: stop antimicrobials/fluid electrolyte replacement
- Oral medications
**Clostridium perfringens**

**Gas Gangrene**

- **Soft tissue:** wound infections: **myonecrosis**
- **Spores:** soil, human skin, intestine, vagina
- **Predisposing factors:** surgical incisions, compound fractures, diabetic ulcers, septic abortions, puncture wounds, gunshot wounds

**Virulence factors**

**toxins** –
- alpha toxin – causes RBC rupture, edema and tissue destruction
- collagenase
- hyaluronidase
- Dnase

**Treatment:** antibiotics/hyperbaric O\(_2\)/amputation
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Muscle fibers

Clostridium

Gas-filled spaces

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**Clostridium tetani:** Tetanus

- Common resident of soil and GI tracts of animals
- Causes tetanus or lockjaw, a neuromuscular disease
- Most commonly among geriatric patients and IV drug abusers; neonates in developing countries
• **Spores:** enter accidental puncture wounds, burns, umbilical stumps, frostbite, crushed body parts.

• **Anaerobic environ:** ideal for vegetative cells growth/release toxin.

• **Tetanospasmin:** neurotoxin: paralysis: bind to motor nerve endings; block release of neurotransmitter for muscular contraction inhibition
  • **Muscles** contract uncontrollably
  • **Death** most often due to paralysis of respiratory muscles
  • **Treatment:** antitoxin/antibiotics/muscle relaxers
  • **Vaccine:** booster every 10 years
**Clostridium Botulinum**

- *Clostridium botulinum* – spore-forming anaerobe; commonly inhabits soil and water
- **Botulism** – intoxication associated with inadequate food preservation
- **Spores**: present on food when gathered/processed.
- If reliable temperature/not achieved: *air evacuated*: but spores remain
- **Anaerobic conditions**: spore germination/vegetative growth.
Now for a true story. It wasn’t murder, just an unfortunate accident that involved a woman, some green beans, and a home canning jar. Canning jars have lids designed to exhibit a slight indentation in their centers when food is fresh. If the indentation inverts (pops up), the vegetables may be contaminated, and should be discarded.

A woman was preparing dinner for her family and decided to serve some of her home-canned green beans that evening. She picked up a jar of beans, but thought the pop-up didn’t look quite right. So, to satisfy her curiosity, she opened the jar, touched her finger to the bean juice, and tasted it. It tasted fine to her, so she cooked the beans, and served the steaming hot dish to her family. The next day, the woman died, but her family survived. The beans contained botulism toxin, produced by the bacteria, Clostridium botulinum. C. botulinum lives naturally in the soil.
Botulin
Potent Exotoxin

• Toxin carried to neuromuscular junctions: blocks the release of acetylcholine: necessary for muscle contraction to occur.

• Double or blurred vision

• Difficulty swallowing

• Neuromuscular symptoms
Gram Positive Non-Spore-Formers

- *Listeria monocytogenes*: soil, water: luncheon meats, hot dogs, cheeses: survive long storage and refrigeration: ELISA, ampicillin
Listeria monocytogenes

- Non-spore-forming
- Gram-positive
- Range: coccobacilli to long filaments
- 1-4 flagella
- No capsules
- Resistant: cold, heat, salt, pH extremes and bile
Virulence

- ability to replicate in cytoplasm of cells after inducing phagocytosis

Avoids humoral immune system
Medically important genera:

- *Corynebacterium*
- *Propionibacterium*
- *Mycobacterium*
- *Actinomyces*
- *Nocardia*
Gram-Positive Irregular Non-Spore-Forming Bacilli

- Pleomorphic; stain unevenly
- 20 genera; *Corynebacterium*, *Mycobacterium*, and *Nocardia* greatest clinical significance
- Catalase +
- Mycolic acids: FA: acid-fast
- Unique peptidoglycan
Corynbiaacterium diptheriae

- Gram +
- Irregular bacilli
- : homeless, crowded unsanitary condition
- Virulence factors: attachment/growth.
  - Diphtherotoxin: exotoxin
  - 2 part toxin:
    - part B binds/induces endocytosis;
    - part A arrests protein synthesis
  - vaccine (DPT)
2 stages of disease:

1. Local infection – upper respiratory tract inflammation
   - sore throat, nausea, vomiting, swollen lymph nodes;
     **pseudomembrane** formation can cause asphyxiation

2. **Diptherotoxin** production/toxemia
   - target organs primarily heart and nerves

**Acquired via respiratory droplets from carriers or actively infected individuals**
DPT Vaccine
Genus *Mycobacterium*

- Gram-positive irregular bacilli
- Acid-fast staining: mycolic acids
- Strict aerobes
- Catalase +
- No capsules/No flagella/ No spores
- Grow slowly
Mycobacterium tuberculosis

• Tubercle bacillus
• Produces no exotoxins or enzymes that contribute to infectiousness
• Virulence factors - contain complex waxes and cord factor that prevent destruction by lysosomes or macrophages
Acid Fast Bacilli

- *Mycobacterium tuberculosis*: aerobes, tubercles (infection sites) due to cell-mediated response: hypersensitivity test
Epidemiology of Tuberculosis

• Predisposing factors include: inadequate nutrition, debilitation of the immune system, poor access to medical care, lung damage, and genetics.

• Estimate 1/3\textsuperscript{rd} of world population and 15 million in U.S. carry tubercle bacillus; highest rate in U.S. occurring in recent immigrants.

• Bacillus very resistant; transmitted by airborne respiratory droplets.
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 – **tubercle**
- If center of tubercle breaks down into necrotic **caseous** lesions, they gradually heal by calcification.
Diagnosis

1. *In vivo* or tuberculin testing

**Mantoux test** – local intradermal injection of purified protein derivative (PPD); look for red wheal to form in 48-72 hours-*induration*; established guidelines to indicate interpretation of result based on size of wheal and specific population factors

1. X rays
2. Direct identification of acid-fast bacil in specimen
3. Cultural isolation and biochemical testing
Gram-Negative Bacilli of Medical Importance
Chapter 20

MCB 2010
PBCC
Professor Tcherina Duncombe
3 Categories

- Aerobes
- Facultative anaerobes
- Obligate anaerobes
- Enterics
Haemophilus: Blood – Loving Bacilli

- Fastidious: require some chemicals from blood for their metabolism

- *H. influenzae*: bacterial meningitis: children 3 months to 5 years: antibiotic, vaccine

- *H. aegyptius*: pinkeye