The Gram-Positive Bacilli of Medical Importance

Chapter 19
TABLE 19.1

Gram-Positive Bacilli

- Endospore-formers
  - Bacillus
  - Clostridium

- Non-endospore-formers
  - Regular shape and staining properties
    - Listeria
    - Erysipelothrix
  - Irregular shape and staining properties
    - Non-acid-fast
      - Corynebacterium
      - Propionibacterium
    - Acid-fast
      - Mycobacterium
    - Actinomyces
      - Nocardia

Actinomycetes

Bacillus

- gram-positive, endospore-forming, motile rods
- mostly saprobic
- aerobic & catalase positive
- versatile in degrading complex macromolecules
- 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, 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
"Gross! This isn't anthrax, it's an envelope full of dandruff."
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
- 2\textsuperscript{nd} most common cause of food poisoning, worldwide
- virulence factors
  - toxins – alpha toxin – causes RBC rupture, edema & tissue destruction
  - collagenase
  - hyaluronidase
  - DNase
Clostridium perfringens

• treatment of gangrene – 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 intestine
- major cause of diarrhea in hospitals
**Clostridium tetani**

- common resident of soil & GI tracts of animals
- causes tetanus or lockjaw, a neuromuscular disease
- spores usually enter through accidental puncture wounds, burns, umbilical stumps, frostbite, & crushed body parts
- tetanospasmin – neurotoxin causes paralysis
- vaccine booster needed every 10 years
**Clostridium botulinum**

Causes 3 diseases

1. **food poisoning** - spores are in soil, may contaminate vegetables; improper canning does not kill spores & they germinate in the can producing botulinum toxin
   - toxin causes paralysis by preventing release of acetylcholine

2. **infant botulism** – caused by ingested spores that germinate & release toxin

3. **wound botulism** – spores enter wound & cause food poisoning symptoms
This party's a gas!
Hi Spore, do you believe in life after sterilization?
Listeria monocytogenes

- non-spore-forming gram-positive
- ranging from coccobacilli to long filaments
- 1-4 flagella
- no capsules
- resistant to cold, heat, salt, pH extremes & bile
- primary reservoir is soil & water
- can contaminate foods & grow during refrigeration
- Listeriosis in immunocompromised patients, fetuses & neonates affects brain & meninges
  - 20% death rate
- ampicillin & trimethoprim-sulfamethoxazole
- Prevention – pasteurization & cooking
Corynbacterium diphtheriae

- gram-positive irregular bacilli
- produce catalase
- possess mycolic acids & a unique type of peptidoglycan
- 2 stages of disease
  - local infection – upper respiratory tract
  - diphtherotoxin production & toxemia
- pseudomembrane formation can cause asphyxiation
Antitoxin first used for general passive immunization

- Incidence (cases/million population)
- Case fatality rate (%)

Toxoid used for general active immunization
Propionibacterium acnes

- gram-positive rods
- aerotolerant or anaerobic
- nontoxigenic
- common resident of sebaceous glands
- causes acne
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
- contain complex waxes & cord factor that prevent destruction by lysosomes of macrophages
- transmitted by airborne respiratory droplets
- only 5% 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
Extrapulmonary TB

- during secondary TB, bacilli disseminate to regional lymph nodes, kidneys, long bones, genital tract, brain, meninges
- these complications are grave
Diagnosis

1. *in vivo* or tuberculin testing
2. X rays
3. direct identification of acid-fast bacilli in specimen
4. cultural isolation and biochemical testing
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
Area of tubercles
Treatment of TB

• 6-24 months of at least 2 drugs from a list of 11

• one pill regimen called *Rifater* (isoniazid, rifampin, pyrazinamide)

• vaccine based on attenuated bacilli Calmet-Guerin strain of *M. bovis* used in other countries
"It is the microbes that will have the last word"
Louis Pasteur
<table>
<thead>
<tr>
<th>Species</th>
<th>Primary Habitat</th>
<th>Disease in Humans</th>
<th>Treatment</th>
<th>Rate of Growth*</th>
<th>Pigmentation**</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. tuberculosis</em></td>
<td>Humans</td>
<td>Tuberculosis (TB)</td>
<td>Combined drugs</td>
<td>S</td>
<td>NP</td>
</tr>
<tr>
<td><em>M. bovis</em></td>
<td>Cattle</td>
<td>Tuberculosis</td>
<td>Same as TB</td>
<td>S</td>
<td>NP</td>
</tr>
<tr>
<td><em>M. ulcerans</em></td>
<td>Humans</td>
<td>Skin ulcers</td>
<td>Surgery, grafts</td>
<td>S</td>
<td>NP</td>
</tr>
<tr>
<td><em>M. kansasii</em></td>
<td>Not clear</td>
<td>Opportunistic lung infection</td>
<td>Difficult, similar to TB</td>
<td>S</td>
<td>PP</td>
</tr>
<tr>
<td><em>M. marinum</em></td>
<td>Water, fish</td>
<td>Swimming pool granuloma</td>
<td>Tetracycline, rifampin</td>
<td>S</td>
<td>PP</td>
</tr>
<tr>
<td><em>M. scrofulaceum</em></td>
<td>Soil, water</td>
<td>Scrofula</td>
<td>Removal of lymph nodes</td>
<td>S</td>
<td>PS</td>
</tr>
<tr>
<td><em>M. avium</em>-</td>
<td>Birds</td>
<td>Opportunistic AIDS infection; lung infection like TB</td>
<td>Combined drugs</td>
<td>S</td>
<td>NP</td>
</tr>
<tr>
<td><em>M. intracellulare</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. fortuitum</em>-</td>
<td>Soil, water, animals</td>
<td>Wound abscess; postsurgical infection</td>
<td>4–6-drug regimen; surgery</td>
<td>R</td>
<td>NP</td>
</tr>
<tr>
<td><em>M. chelonae</em> complex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. phlei</em></td>
<td>Sputum, soil</td>
<td>Not pathogenic</td>
<td>None</td>
<td>R</td>
<td>PS</td>
</tr>
<tr>
<td><em>M. smegmatis</em></td>
<td>Smegma, soil</td>
<td>Not pathogenic</td>
<td>None</td>
<td>R</td>
<td>Usually NP</td>
</tr>
<tr>
<td><em>M. leprae</em></td>
<td>Strict parasite of humans</td>
<td>Leprosy</td>
<td>See text</td>
<td>S</td>
<td>Cannot be grown in artificial media</td>
</tr>
</tbody>
</table>

The mycobacteria are grouped into major categories by their growth rate and their pigment production.

*Growth rate is rapid (R), occurring in less than 7 days, or slow (S), occurring in more than 7 days.

**Photochromogens (PP) develop yellow to dark orange pigment in the presence of light; scotochromogens (PS) synthesize pigment in darkness; and nonpigmented forms (NP) have no color.
**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
### TABLE 19.3

**The Two Major Clinical Forms of Leprosy**

<table>
<thead>
<tr>
<th>Tuberculoid Leprosy</th>
<th>Lepromatous Leprosy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Few bacilli in lesions</td>
<td>Many bacilli in lesions</td>
</tr>
<tr>
<td>Few shallow skin lesions in many areas</td>
<td>Numerous deeper lesions concentrated in cooler areas of body</td>
</tr>
<tr>
<td>Loss of pain sensation in lesions</td>
<td>Sensory loss more generalized; occurs late in disease</td>
</tr>
<tr>
<td>No skin nodules</td>
<td>Gross skin nodules</td>
</tr>
<tr>
<td>Occasional mutilation of extremities</td>
<td>Mutilation of extremities common</td>
</tr>
<tr>
<td>Reactive to lepromin*</td>
<td>Not reactive to lepromin</td>
</tr>
<tr>
<td>Lymph nodes not infiltrated by bacilli</td>
<td>Lymph nodes massively infiltrated by bacilli</td>
</tr>
<tr>
<td>Well-developed cell-mediated (T-cell) response</td>
<td>Poorly developed T-cell response</td>
</tr>
</tbody>
</table>

* Lepromin is an extract of the leprosy bacillus injected intradermally, like tuberculin, to detect delayed allergy to leprosy.
I'm not sure what the heck they are... All I know is they're cutting in on our territory...

Flesh-Eating Bacteria