Corynebacterium

- General
  - Aerobic or facultative anaerobic
  - Catalase positive
  - Non-spore forming
  - Non-motile except C. aquaticum
    (Pathogenic species are non-motile)
  - Pleomorphic rod shaped
    angular clusters resembling "Chinese letters"

- Gram stain
  - Negative ? Positive ?

- Morphology
  - Cocci ? Bacilli (rod)?

- Spore formation
  - Bacillus ← Positive ? Negative ?

- Catalase
  - Positive ? Negative ?

- Motility
  - Listeria ← Positive ? Negative ?

Figure 2.8

C. renale Group

- C. renale, C. cystitidis, C. pilosum → "C. renale group"
  - C. renale is the major

- General
  - Short rods
  - Growth is favored by blood or serum, grows well in sterile urine
  - Rapid "urease" positive: \((\text{NH}_2)_2\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2\text{NH}_3\)

- Habitat
  - Widely distributed in the urethra and prepuce in normal cattle and sheep (considered as normal flora)
  - Opportunistic pathogens

- Transmission
  - May be venereal
  - Possibly indirect transmission (they survive well in soil)
C. renale Group

- The major pathogenic member of the group
- Normal flora of the lower urogenital tract

Cattle
- Infections are almost always in cows (pregnant or postparturient)
- Ascending infection of the urinary tract, cystitis, Pyelonephritis (polyuria, pyuria, hemoglobinuria, enlarged kidney)
- Kidney infection: C. renale

Sheep
- Posthitis (pizzle rot; ulcerative dermatitis of prepuce)
- ↑ Protein (diet) → ↑ Urea (urine) → ↑ Ammonia (by urease)
- ↑ ammonia causes a severe irritation and ulceration of the prepuce (mild irritation to severe inflammation and blockage of the prepuce)
- The organism can venereally spread to ewes, causing inflammation in vagina

Treatment: Penicillin (effective if given early in the disease)

C. pseudotuberculosis

- General
  - Pleomorphic, short rod, coccoid in some isolates
  - Facultative anaerobic
  - Facultative intracellular parasite
  - Two biotypes
    1) ovis – nitrate negative; frequently isolated from sheep and goats
    2) equi – nitrate positive; infecting horses and cattle
      - Both types are isolated from cattle

Transmission
- Commonly found in the skin of sheep and goats
- Pus from infected animals
- Residing in soil
- May enter via wounds or by inhalation

Pathogenesis
- Phospholipase D: an exotoxin associated with spread in the host

C. pseudotuberculosis: In sheep and goats

- Caseous lymphadenitis (inflammation of a lymph node)
  - Also called “cheesy gland”: dryish pus
  - Two forms
    1) Superficial form (abscesses of lymph node)
      - Firm or slightly soft subcutaneous swelling
      - Visible under the skin near the lymph node
    2) Visceral form (abscesses of internal organs)
      - Metastatic lesions
      - Inhalation of the organism → lung infection
Ulcerative lymphangitis (inflammation of a lymphatic vessel)
- Infection occurs in lower limbs
- Usually, only one leg is involved

Pectoral abscesses
- Develop abscesses in the pectoral muscles
  → Swell and resemble a pigeon's chest: “Pigeon fever” (horses)

**C. pseudotuberculosis: in horses and cattle**

**C. pseudotuberculosis**

- **Diagnosis**
  - Isolation of *C. pseudotuberculosis*
  - ELISA (detecting phospholipase D)
  - PCR

- **Treatment**
  - Drainage of the abscesses
  - Antibiotic control is not easy:
    - because bacteria stay protected inside abscesses
    - Penicillin may prolong the disease by delaying abscess maturation
    - Usually, antibiotic therapy is not efficient

- **Vaccination**
  - Vaccination is recommended

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**C. diphtheriae**

- **Human pathogen**
  - Diphtheria: Upper respiratory infection especially in kids under 4 yrs
    → respiratory obstruction
    → High mortality: 30~50%

- **Diphtheria toxin**
  - Prevents protein synthesis → cause cell death
  - Associated with bacteriophage encoding the toxin (tox+)

- **Vaccination:** DPT (Diphtheria-Pertussis-Tetanus)
  - routine vaccination program in developed countries
  - only 10% of children in developing countries
    → (1 million deaths per year)

- **Treatment:** Administration of antitoxin is the only successful method
**C. ulcerans**

- Reservoir: mainly cattle
- Disease
  - Often isolated from bovine mastitis cases
  - Can spread to humans through consumption of unpasteurized milk and milk products, but mostly source of infection is not defined
  - Pharyngitis in humans
- Able to produce diphtheria toxin, when lysogenized by tox-carrying phage → serious illness to unvaccinated individuals

**Bacillus**

- Gram-positive, large rods
- A large number (>50) of species and widespread in nature, but majority are non-pathogenic
- Endospore formation
- Aerobes or facultative anaerobes, catalase positive
- Majority are motile (except for B. anthracis and B. mycoides)

**Identification**

- Gram stain
  - Negative
  - Positive
- Morphology
  - Coci
  - Bacilli (rod)
- Spore formation
- Catalase
  - Positive
  - Negative
- Motility
- Listeria
  - Positive
  - Negative
- Corynebacterium
B. anthracis: general

- Cause "anthrax" - A severe disease affecting almost all mammalian species
- Non-motile, non-hemolytic
  - Capsules will form in cultures grown on media containing bicarbonate or serum

B. anthracis: Anthrax

- Cattle and sheep: Herbivores are "highly susceptible"
  - Often developing a rapid and fatal septicemic disease
  - Bloody diarrhea, and bloody discharge from nose, mouth → Sudden death
- Pigs and horses: Moderately susceptible
- Carnivores: Comparatively resistant
- Birds: Almost totally resistant

<table>
<thead>
<tr>
<th>Animal</th>
<th>Disease Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle, sheep</td>
<td>Fatal peracute or acute septicemic anthrax</td>
</tr>
<tr>
<td>Pigs, dogs, cats</td>
<td>Subacute anthrax with edematous swelling in pharyngeal region</td>
</tr>
<tr>
<td>Horses</td>
<td>Subacute anthrax with localized edematous swellings of the head, neck, shoulders, throat</td>
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B. anthracis: Anthrax

- Cattle, sheep: Fatal peracute or acute septicemic anthrax
- Pigs, dogs, cats: Subacute anthrax with edematous swelling in pharyngeal region
- Horses: Subacute anthrax with localized edematous swellings of the head, neck, shoulders, throat

B. anthracis: Endospore

- Endospore formation
  - Important in persistence and spread of anthrax
  - Spores are resistant to heat, acid, etc.
  - Spores of B. anthracis can survive more than 50 years!

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination</td>
<td>Spores in soil</td>
</tr>
<tr>
<td>Septicemia</td>
<td>Host death</td>
</tr>
<tr>
<td>Toxemia</td>
<td>Spread of spores</td>
</tr>
</tbody>
</table>

Humans

1. Malignant carbuncle: cutaneous anthrax
   - the organism is introduced through a wound
   → develop dark painless lesions
   → if not treated
   → bacteremia and death

2. Gastroenteritis
   - Rare, but from eating infected carcasses

3. Woolsorter’s disease: respiratory form
   - Inhalation of spores by those who handle hides, wool, and hair from infected animals
   - Preferred route for biowarfare
**B. anthracis: Virulence Factors**

- Two large plasmids (pX01 and pX02) carry the genes for anthrax toxins and capsule

![Diagram of plasmids and toxins]

**B. anthracis: Anthrax toxins**

- **Protective antigen (PA)**
  - Transports toxin components to the host cell cytosol
- **Edema factor (EF)**
  - Adenylate cyclase (ATP → cAMP)
  - cAMP ↑ → accumulation of fluids → edema
- **Lethal factor (LF)**
  - LF is a protease
  - Proteolytically cleaves MAPKKs, intracellular signaling proteins → causing cell death
  - Inhibit the regulation of immune response

![Diagram of toxin mechanisms]

**B. anthracis: Capsule**

- **Virulence factors**
  - “Polypeptide” capsule (poly-D-glutamic acid)
  - cf. capsule is usually “polysaccarides”

![Image of capsule and surface proteins]

- **Resistance to phagocytosis**
  - Unencapsulated bacilli are more susceptible to phagocytosis

**B. anthracis: Diagnosis**

- **Performing necropsies on animals dead of anthrax is “undesirable”** since exposing the tissues to the atmosphere will result in the formation of large numbers of spores → may contaminate the environment for many years

- **Aspirate the aqueous/blood discharge for culture**
  - *B. anthracis* grows readily on blood agar (non-hemolytic)
  - Produces capsules on BHI agar containing 0.5% sodium bicarbonate incubated in 10-30% CO₂

- **PCR**
  - To detect genes encoding the toxins and the capsule
**B. anthracis: Prevention and Treatment**

- **Vaccination**
  - Spore vaccines and avirulent nonencapsulated strain were used successfully
  - Use of the vaccine in livestock has declined markedly due to the decreased incidence

- **Antibiotics**
  - Penicillin: effective
  - Tetracycline
  - Ciprofloxacin is used in humans

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**Other pathogenic Bacillus spp.**

- **B. cereus**
  - **Human**: Food poisoning often associated with cooked rice held at improper temperatures
  - **Cattle**: Mastitis occasionally
  - **Dogs**: Food poisoning when fed highly contaminated canned food

- **B. licheniformis**
  - Ubiquitous in the environment
  - Associated with abortions in cattle and sheep
    (an opportunistic pathogen)