Streptococcus & Enterococcus

General

- Characteristics
  - Gram-positive cocci
  - Non-motile
  - Many require serum or blood → usually use blood agar
  - Facultative anaerobic
  - Tolerate oxygen, but many of them grow better anaerobically
  - Grow best at 37°C
  - Colonies are distinctly smaller than those of staphylococci

- Habitat
  - Widely distributed in nature
  - Large numbers in the intestines of all animals as normal flora
  - Most are not disease-producer

Streptococcus

Gram-positive aerobic cocci

Catalase ($2H_2O_2 \rightarrow 2H_2O + O_2$)

Staphylococcus, Micrococcus, Peptidococcus, Pediococcus

Bunch of grapes + berry

Streptococcus, Enterococcus

5'ete: thread +occus: seed or berry

Lancefield test
- Discovered by Rebecca Lancefield in 1933
- Cell wall carbohydrates + group specific anti-serum → observe precipitation
- Lancefield groups
  - e.g. S. pyogenes – group A
  - S. agalactiae – group B

Hemolysis
1. β-hemolysis: complete lysis of blood cells
e.g. group A and B streptococci
2. α-hemolysis: less complete → green zone
e.g. S. suis
3. γ-hemolysis: no zone of hemolysis
e.g. enterococci
Capsule

- Capsule is less likely to be opsonized → prevent phagocytosis
- Group A streptococci have a capsule composed of hyaluronic acid (HA)
  → HA is a major component of extracellular matrix
  → mimics host tissues
  → “not immunogenic”
  → protects from phagocytosis

M protein

- Multifunctional virulence determinant
  - Binds to extracellular matrix proteins (e.g., collagen, fibronectin)
  → mediate adhesion of the organism to the host cell
  - Binds to Fc portion of IgG
  → “antiphagocytic”

Toxins

- Streptolysin O
  - Cholesterol-binding protein
  - Forming pores in the membrane
  - Leukotoxic, attacks RBC, and causes complete hemolysis
  - Very antigenic: measurement of “anti-streptolysin O” is a good indicator of *S. pyogenes* infection in humans
- Hyaluronidase: breaks down hyaluronic acid in tissues

*S. pyogenes* = Group A streptococcus (GAS)

- A single species in Group A
**S. pyogenes = Group A streptococcus (GAS)**

- **Reservoir**: Humans (mouth, throat, and vaginal tract)
- **Diseases**
  - Animals: a rare cause of bovine mastitis
  - Humans
    - Pharyngitis (strep-throat): sore throat, high fever
    - Rheumatic fever: arthritis and other signs after 2 to 3 weeks following acute pharyngitis
    - Erysipel: a skin and subcutaneous infection usually of the face
    - Streptococcal gangrene (necrotizing fasciitis):
      - Life-threatening "flesh eating" disease
      - Start with a minor injury → Entry into bloodstream → destruction of large areas of skin → death
      - Unusual degree of pain
      - Surgical removal and antibiotics
      - Rare disease

- **Immunity**
  - M protein vaccines: promising but too many M protein variants
- **Treatment**
  - Penicillin class antibiotics
  - B hemolytic streptococci do not readily develop resistance to penicillin

**S. equi ssp. equi (S. equi)**

- **Lancefield group C**
- **Growth**
  - B-hemolytic
  - Mucoid colonies (from capsule)
- **Habitats**
  - an obligate parasite of Equidae
  - Present in the upper respiratory tract and occasionally in the reproductive tract
  - Important infection source: clinically affected horses
  - Transmitted by droplet and contact
- **Produce a powerful cytotoxin damaging phagocytic cells**

- **Diseases**: only in horses, donkeys and mules
  - Strangles
    - Usually in horses less than 2 yr old, but horses of all ages are susceptible
    - Starts as an upper respiratory infection with a serious nasal discharge and fever
    - Abscessation of head and neck lymph nodes with painful swelling
    - Compresses airway
    - Interferes with breathing (strangles)
    - The swelling may rupture and produce creamy pus
    - After the rupture, the horse usually recovers
    - Strangles is not usually fatal
    - But! may cause systemic infection "bastard strangles" (eg. abscesses in lungs and brain) which often results in death
**S. equi ssp. equi (S. equi)**

- Purpura (means “purple”) hemorrhagica
  - Fever, edema, hemorrhages
  - May develop after strangles
  - Immune-mediated inflammation after streptococcal infection
  - Primary lesion: vasculitis and necrosis of blood vessel walls
- Omphalophlebitis (inflammation of the umbilical veins) in foals
- Reproductive tract infections: metritis, not as common as S. zooepidemicus

**Immunity**
- Good following infection
- Protection is associated with local (the nasal epithelium) production of antibodies against M-protein
- Vaccines: several on the market

**Diagnosis**
- Bacterial culture of exudate from abscesses or nasal swab samples
- Endoscopic examination of upper respiratory tracts

**Treatment**
- Penicillin
  - Controversial because antibiotic treatment may prolong the course of disease by preventing the maturation of abscesses

**Control**
- Infected horses should be physically separated
- Most horses can shed S. equi for 1 month after recovery

**Vaccination**
- Commercial vaccines are available, which only reduce the severity of infection

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**S. equi ssp. zooepidemicus**

- Lancefield group C
- Hemolysis: wide zone of beta
- Horse is the primary host
  - Commensal of the skin, upper respiratory mucosa and tonsils of horses

**Diseases**
- Horse: most common agent in wound infections
  - Common secondary invader in respiratory disease
  - Umbilical cord infections (omphalophlebitis)
  - Mastitis
- Mare: common organism in uterine and cervical infections
- Other animals and humans: occasional infections

**Vaccination:** not normally practiced

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**S. suis**

- Lancefield group D, R, S, and T
  - Single, pairs, or short chains
  - α-hemolytic
  - Among 35 serotypes, types 1 and 2: diseases in animals
  - Type 2: human infection

**Reservoirs**
- Pigs (asymptomatic carriage as high as 80%)
  - Healthy pigs can carry in the nasal cavities, tonsils, upper respiratory and genital tracts
  - Transmitted nasally or orally
  - Most carriers do not develop diseases
- Isolated from various animals, horses, dogs, cats, birds
**S. suis**

- **Diseases**
  - Pigs
    - Young pigs are most at risk: arthritis, septicemia, meningitis
    - The organism is indigenous in the vagina
      → infects pigs at birth
    - Older pigs: endocarditis, sudden death
  - Birds: occasionally septicaemia
  - Humans
    - Zoonotic disease: Infection is acquired through exposure to contaminated pigs or pork
    - Meningitis, septicemia, hearing loss

- **Treatment**
  - Amoxicillin and ampicillin

- **Vaccination:** Commercially available but inconsistent results

**S. porcinus**

- **Group E, P, U, and V**
  - Transmitted orally
  - Highly contagious
- **Reservoirs**
  - Recovered infected pigs are most common source of infection
    → recovered pigs harbor the organism in tonsils
  - Transmit by nose-to-nose and via water and food
- **Diseases**
  - Pigs
    - Cervical lymphadenitis (Jowl abscess): similar to strangles, but clinically less severe
    - Occasionally meningitis, arthritis, or septicemia
    - The disease is rarely observed today
  - Treatment: antibiotics are not effective in eliminating the bacteria
  - Vaccine: a vaccine was available but it was taken off the market

**S. dysgalactiae ssp. equisimilis**

- **Group C, G, L**
- β-hemolytic

- **Diseases**
  - Pigs
    - Causes metritis and cervicitis
    → spreads to piglets
    → causes suppurative arthritis in pigs (0~6 weeks of age)
  - Horses: pneumonia
  - Dogs: metritis
  - Humans: pharyngitis, bacteremia, endocarditis, other problems

- **Vaccination:** no commercial vaccines

**S. canis**

- **Group G**
- β-hemolytic

- **Reservoirs**
  - Widely distributed in dogs
    → male genital tract appears to be a natural habitat

- **Diseases**
  - Dogs
    - Tonsillitis, metritis, umbilical infections, wound infections
  - Cats
    - Similar diseases, especially wound infections
Mastitis & Streptococcus

● What is mastitis?
  inflammation of the mammary gland caused by microorganisms

● Clinical mastitis
  - Mild signs: flakes or clots in the milk, slight swelling
  - Severe signs: hot, swollen udder, fever, loss of appetite, death

● Subclinical mastitis
  - No visible signs of disease
  - Somatic cell count (SCC) of the milk ↑
  - Milk production ↓

Mastitis & Streptococcus

● Somatic cell count (SCC)
  - # of leukocytes or epithelial cells/ ml of milk
  - Normal milk: <200,000 cells/ ml of milk
  - Inflammation increases SCC

● California Mastitis Test (CMT)
  - A simple, rapid, and inexpensive test
  - Mix the CMT agent with milk
    → the agent lyases somatic cells
    → release nucleic acid materials
    → form a gel

Mastitis & Streptococcus: S. agalactiae

● General
  - The only member of Group B streptococci (GBS)
  - Used to be the single most important cause of mastitis
    → but this organism has been eliminated from many herds
  - An obligate intramammary pathogen
    → spread by the milking equipment
    → β hemolysis; very small zone of hemolysis

● Diseases
  - Animals
    - Mastitis in dairy cattle, goats and sheep
    - Cause an acute localized mastitis with swelling, abnormal milk, and marked reduction of milk production (agalactia)
  - Humans
    - Ear infections and septicemia in infants and pregnant women
### Mastitis & Streptococcus: S. agalactiae

- **Vaccination**
  - No vaccine available
  - Usually, much easier and more economical to eliminate infected cows from the herd

- **Treatment**
  - Intramammary infusion of penicillin, or novobiocin+penicillin
  
  “S. agalactiae is an intramammary pathogen”

### Mastitis & Other streptococci

- **S. dysgalactiae ssp. dysgalactiae (S. dysgalactiae)**
  - Group C
  - α hemolytic
  - Present on the skin and in the mouth
  - gain entry via wounds
  - Cause mastitis in dairy cows
  - Infections occur synergistically with *Arcanobacterium pyogenes*

- **S. uberis and S. parauberis**
  - Cause approximately 14 to 26% of clinical mastitis cases in Canada, and the United States, respectively
  - Environmental contamination and soiling of the udder predispose the infection

### S. pneumoniae

- **Important cause of respiratory disease in humans**
  - An obligate human pathogen
  - Respiratory diseases, pneumonia
  - A frequent cause of mortality in humans
  
  called “Captain of the men of death”

  still a leading cause of human death

<table>
<thead>
<tr>
<th>Lancefield Group</th>
<th>Name</th>
<th>hemolysis</th>
<th>Reservoir</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>S. pyogenes</td>
<td>β</td>
<td>Humans (mouth, throat)</td>
<td>Human: pharyngitis, rheumatic fever, erysipelas</td>
</tr>
<tr>
<td>B</td>
<td>S. agalactiae</td>
<td>β (weak)</td>
<td>Intramammary pathogen</td>
<td>Cattle, goat, sheep: mastitis</td>
</tr>
<tr>
<td>C, G, L</td>
<td>S. dysgalactiae ssp. dysgalactiae</td>
<td>α</td>
<td>Skin, mouth</td>
<td>Cow: mastitis</td>
</tr>
<tr>
<td>S. equi ssp. equi</td>
<td>β</td>
<td>Equine (respiratory tract)</td>
<td>Horse: urangetella, purpura, omphalophlebitis</td>
<td></td>
</tr>
<tr>
<td>S. equi ssp. zooepidemicus</td>
<td>β</td>
<td>Horse (skin, respiratory tract)</td>
<td>Horse: wound infection, mastitis, cervicitis</td>
<td></td>
</tr>
<tr>
<td>C, G, L</td>
<td>S. dysgalactiae ssp. equitennis</td>
<td>β</td>
<td>Pigs: mastitis, cervicitis</td>
<td>Horse: pneumonia</td>
</tr>
<tr>
<td>C, L</td>
<td>S. dysgalactiae ssp. equidae</td>
<td>β</td>
<td>Dog (genital tract)</td>
<td>Dog: tonsilitis, mastitis</td>
</tr>
<tr>
<td>D, R, S,T</td>
<td>S. suis</td>
<td>α</td>
<td>Pig (mostly asymptomatic carrier)</td>
<td>Pig: septicaemia, meningitis, arthritis, endocarditis</td>
</tr>
<tr>
<td>E, P, U, V</td>
<td>S. porcinus</td>
<td>β</td>
<td>Infected pigs (tonsil)</td>
<td>Pig: cervical lymphadenitis</td>
</tr>
<tr>
<td>None</td>
<td>S. uberis</td>
<td>α, γ</td>
<td>Coar: mastitis</td>
<td></td>
</tr>
</tbody>
</table>
**S. equi ssp. equi vs S. equi ssp. zooepidemicus**

- Fermentation

<table>
<thead>
<tr>
<th></th>
<th>Sorbitol</th>
<th>Trehalose</th>
<th>Lactose</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. equi ssp. equi</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>S. equi ssp. zooepidemicus</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

**Mastitic streptococci**

- CAMP test: factors from *S. agalactiae* augment hemolytic activity of *S. aureus*

<table>
<thead>
<tr>
<th></th>
<th>CAMP</th>
<th>Esculin hydrolysis on Edwards medium</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. agalactiae</em></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><em>S. dysgalactiae</em></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>S. uberis</em></td>
<td>-</td>
<td>+ (grey)</td>
</tr>
</tbody>
</table>

**Enterococcus**

- **Characteristics**
  - Enterococcal group D streptococci are classified: common inhabitants of the intestinal tracts of mammals and birds
  - α,γ hemolytic (mostly non-hemolytic)
  - Most likely to be seen single cells or as diplococci
  - cf. streptococci are chains of cells
  - More resistant to heat, salt, and antibiotics than streptococci

**Enterococcus**

- **Diseases**
  - Humans
    - Urinary tract infections, septicemia, endocarditis
    - Leading cause of hospital-acquired bacteremia
    - Surgical wounds, immunosuppression are associated
    - *E. faecalis*: 80% of enterococcal infections
    - *E. faecium*: more associated with antibiotic resistance
    - VRE: vancomycin-resistant *Enterococcus*
  - Animals
    - *E. durans, E. hirae, E. villorum*: associated with sporadic diarrhea in cats, dogs, calves, and piglets
    - *E. faecalis*: mastitis in cattle, urinary tract infections in dogs