Microbiology

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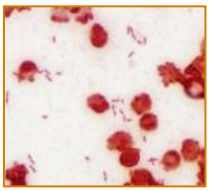
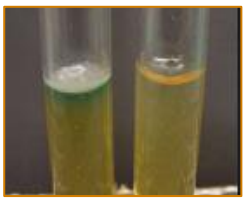
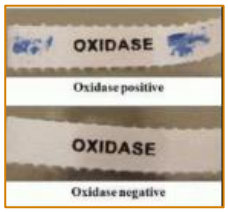
ARKAN
ACADEMY

Opportunistic and respiratory pathogen

- This lecture covers the bacterial genera that are Gram-negative bacilli and coccobacilli, commonly responsible for respiratory tract infections. The primary pathogens discussed are:
  1. Pseudomonas
  2. Legionella
  3. Moraxella
  4. Bordetella
  5. Haemophilus

- **Pseudomonas**
  - General Characteristics:
    - ✓ Motility: Pseudomonas are motile, straight or slightly curved, Gram-negative rods (0.5 to 1.0 × 1.5 to 5.0 µm), usually arranged in pairs.
    - ✓ Environmental Habitat: Found in soil, decaying organic matter, vegetation, and water. Commonly found in hospital environments.
    - ✓ Metabolism: Capable of using a wide variety of organic compounds as sources of carbon and nitrogen, leading to its broad environmental distribution.
    - ✓ Resistance: Known for its resistance to many antibiotics and disinfectants.
    - ✓ Pseudomonas infections are primarily opportunistic
    - ✓ Cytochrome Oxidase: Rapid test to differentiate Pseudomonas from Enterobacteriaceae.

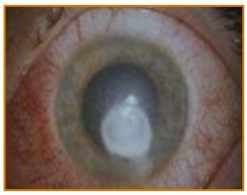
  - Identification:
    - ✓ Pyocyanin production (blue-green pigment) is a distinctive feature, particularly in **Pseudomonas aeruginosa**, the most important pathogen in this genus.
    - ✓ Distinctive odor: Fruity, grape-like or fresh tortilla smell.

  - Pathogenesis and Immunity:
    - ✓ Adhesins: Flagella, pili, lipopolysaccharide (LPS), and alginate (mucoid exopolysaccharide forming a prominent capsule).
    - ✓ Toxins and Enzymes:
      - **Exotoxin A**: Disrupts protein synthesis by blocking peptide chain elongation in eukaryotic cells.
      - **Phospholipase C**: is a heat-labile hemolysin that breaks down lipids and lecithin,facilitating tissue destruction
    - ✓ P. aeruginosa is intrinsically resistant to many antibiotics (the low rate of movement of antibiotics through the outer membrane pores into the bacterial cell, combined with the rapid efflux of antibiotics with efflux pumps. Also acquired and adaptive resistance.
    - ✓ Resistance Mechanisms: Intrinsic resistance due to outer membrane impermeability and efflux pumps, as well as acquired and adaptive resistance.

- Clinical Diseases:
  - ✓ Pulmonary Infections: Includes asymptomatic colonization in patients with **Cystic Fibrosis and** other chronic lung diseases) or benign inflammation of the bronchials (tracheobronchitis) to severe necrotizing bronchopneumonia. Previous therapy with broad-spectrum antibiotics and use of mechanical ventilation equipment predispose to infection.
  - ✓ Skin and Soft Tissue Infections: The most recognized are infections of burn wounds. Folliculitis (associated with immersion in contaminated waters such as hot tubs).
  - ✓ Urinary Tract Infections: seen primarily in patients with long-term indwelling urinary catheters.
  - ✓ Ear Infections: External otitis is frequently caused by P. aeruginosa, with swimming an important risk factor ("swimmer's ear").
  - ✓ Eye Infections: Occur after initial trauma to the cornea (e.g., abrasion from contact lens).
  - ✓ Bacteremia and Endocarditis: mortality rate in affected patients is higher with P. aeruginosa bacteremia.
  - ✓ The underlying conditions required for most infections are
    (1) The presence of the organism in a moist reservoir and
    (2) Compromised host defenses (e.g., cutaneous trauma, elimination of normal microbial flora as a result of antibiotic usage, neutropenia)

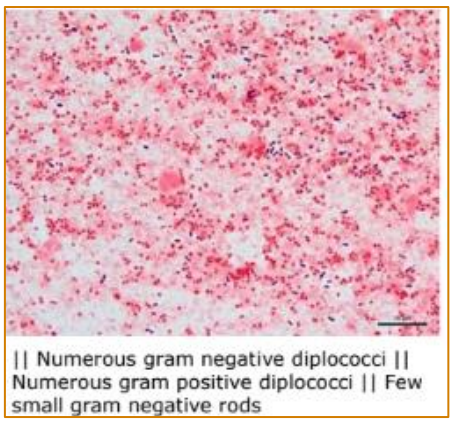

IGURE 27-3 *Pseudomonas* infection of burn wound.



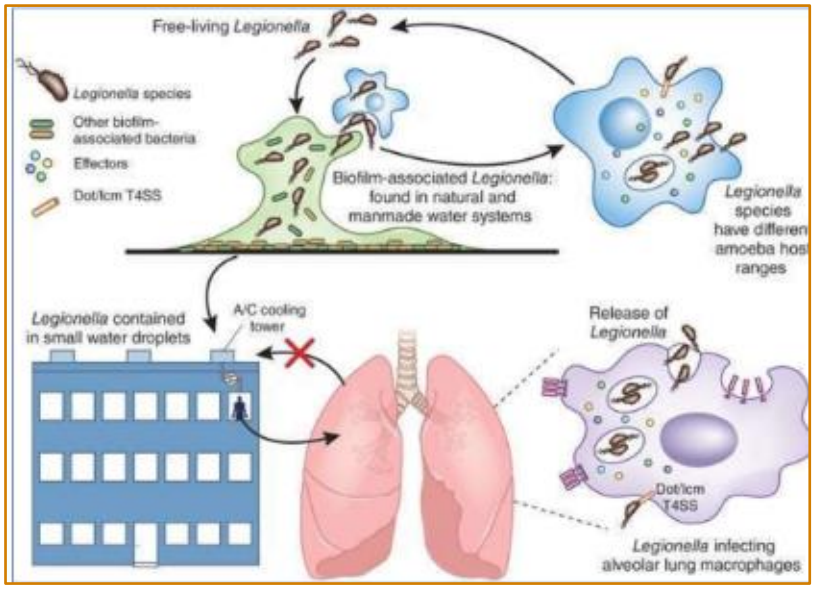
- Treatment:
  - ✓ antimicrobial therapy for Pseudomonas infections is frustrating because the bacteria are typically resistant to most antibiotics and the infected patient has compromised immune defences
  - ✓ A combination of antibiotics is generally required for therapy to be successful in patients with serious infections.

- **Moraxella**
  - *M. catarrhalis:*
    - ✓ Strictly aerobic, oxidase-positive, Gram-negative diplococcus.
    - ✓ The peak rate of colonisation by M. catarrhalis appears to occur around 2 years of age, with a striking difference in colonization rates between children and adults (very highto very low)

  - Clinical Significance:
    - ✓ Causes upper respiratory infections in **children** and **elderly adults**.
    - ✓ An important pathogen in **lower respiratory tract infections**, especially in individuals with **COPD**.
    - ✓ Considered a **nosocomial pathogen**.


|| Numerous gram negative diplococci || Numerous gram positive diplococci || Few small gram negative rods

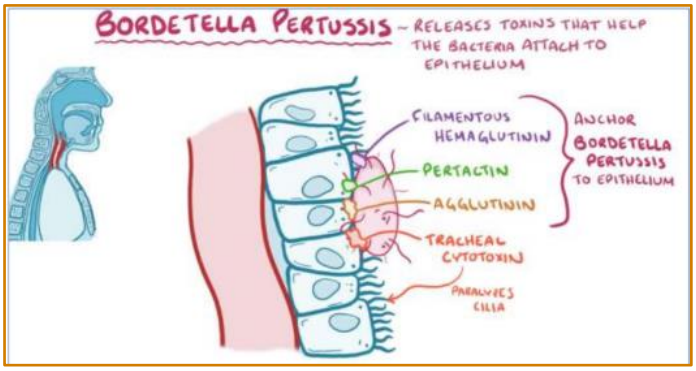
- **Legionella**
  - General Characteristics:
    - ✓ Legionella pneumophila: Slender, pleomorphic Gram-negative rods, primarily responsible for Legionnaires' disease and Pontiac fever.
    - ✓ Obligative aerobic and nutritionally fastidious, requiring media supplemented with cysteine.
    - ✓ Commonly transmitted through contaminated aerosols (e.g., air conditioning units, whirlpool spas, showerheads water misters).
    - ✓ Can survive in moist environments for extended periods.
  - Pathogenesis:
    - ✓ Facultative intracellular bacteria: Infect and replicate in macrophages and amoeba.
    - ✓ The immune response, including cytokines from infected macrophages, stimulates a robust inflammatory response that is characteristic of infections with Legionella.



  - Clinical Diseases:
    - ✓ L. pneumophila is the cause of 90% of all Legionella infections, affecting the lungs and present in one of two forms :
      (1) an influenza-like illness (referred to as Pontiac fever (self-limited, febrile illness)) and
      (2) a severe form of pneumonia (i.e., legionnaires disease).
    - ✓ Pontiac Fever: A self-limited, influenza-like illness.
    - ✓ Legionnaires' Disease: Severe pneumonia with high morbidity if untreated.
  - Diagnosis:
    - ✓ Commonly cultured on Buffered Charcoal Yeast Extract (BCYE) agar.

- ***Bordetella***
  - General Characteristics:
    - ✓ Extremely small, fastidious, strictly aerobic Gram-negative coccobacilli. Even under ideal conditions, recovery of B. pertussis in culture is difficult.
    - ✓ Bordetella pertussis is the causative agent of pertussis (whooping cough).
    - ✓ Transmitted primarily through respiratory droplets.
    - ✓ Pertussis is a human disease with no other recognized animal or environmental reservoir
    - ✓ Since widespread use of the vaccine began, incidence has decreased more than 75% compared with the pre-vaccine era. vaccines contain inactivated pertussis toxin,filamentous hemagglutinin, and pertactin

- Pathogenesis:
  - ✓ Pertussis is primarily a toxin-mediated disease. Pertussis toxin (A-B toxin) inactivates the protein that controls adenylate cyclase activity, leading to an increase in cyclic adenosine monophosphate (cAMP) levels and a subsequent increase in respiratory secretions and mucus production.
  - ✓ The bacteria attach to the cilia of the respiratory epithelial cells, produce toxins that paralyze the cilia, and cause inflammation of the respiratory tract, which interferes with the clearing of pulmonary secretions.
  - ✓ Toxins: Pertussis toxin (A-B toxin) disrupts adenylate cyclase activity, increasing cyclic AMP levels, leading to increased respiratory secretions and mucus production.
  - ✓ Attachment to respiratory epithelial cells and ciliary paralysis is also key in disease pathogenesis.



- Clinical Diseases:
  - ✓ Pertussis: Characterized by classic **paroxysmal cough** ("whooping" sound).

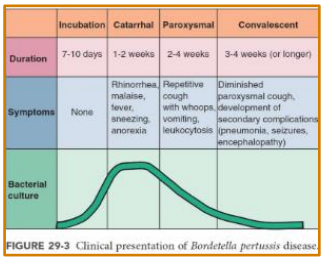
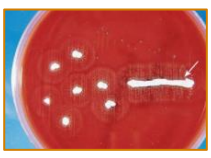
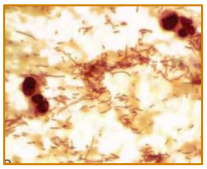


FIGURE 29-3 Clinical presentation of *Bordetella pertussis* disease.

- Vaccination:
  - ✓ DTaP vaccine includes inactivated pertussis toxin, **filamentous hemagglutinin**, and **pertactin**. It has significantly decreased incidence of the disease.

- ***Haemophilus***
  - General Characteristics:
    - ✓ Haemophilae are small, sometimes pleomorphic, gram-negative rods present on the mucous membranes of humans.
    - ✓ Haemophilus influenzae is the species most commonly associated with disease, also *Haemophilus aegyptius,* and *Haemophilus ducreyi.*
    - ✓ Requires supplementation of media with one or both of the following growth-stimulating factors:
      (1) hemin (also called X factor for "unknown factor")
      (2) nicotinamide adenine dinucleotide (NAD; also called V factor for "vitamin")
    - ✓ Haemophilus species are present in almost all individuals, primarily colonizing the mucosal membranes of the respiratory tract.


- Virulence Factors:
  - ✓ The surface of many, but not all, strains of H. influenzae is covered with a polysaccharide capsule, and six antigenic serotypes (a through f)
  - ✓ The major virulence factor in H. influenzae type b is the antiphagocytic polysaccharide capsule, which contains ribose, ribitol, and phosphate (commonly referred to as polyribitol phosphate **[**PRP**]**).
  - ✓ Antibodies directed against the capsule greatly stimulate bacterial phagocytosis and complement-mediated bactericidal activity. These antibodies develop because of natural infection**,** vaccination with purified PRP, or the passive transfer of maternal antibodies.
  - ✓ When vaccines containing purified PRP antigens conjugated to protein carriers (i.e., diphtheria toxoid,tetanus toxoid, meningococcal outer membrane protein) were introduced in December 1987, aprotective antibody response in infants aged 2 months and older was produced, and systemic disease in children younger than age 5 was virtually eliminated in the United States.
  - ✓ Most of the H. influenzae type b infections now occur in children who are not immune (because of incomplete vaccination or a poor response to the vaccine) and in elderly adults with waning immunity.

- Clinical Diseases:
  - ✓ **H. influenzae type b**:
    - Was responsible for more than 95% of all invasive *Haemophilus* infections. After introduction of the vaccine, more than half of all invasive disease is now caused by nonencapsulated (nontypeable) strains
    - A common cause of disease in unvaccinated children
    - Meningitis, epiglottitis [obstructive laryngitis], cellulitis.
    - *H. influenzae type b* remains the most significant pediatric pathogen in many countries of the world.
  - ✓ **Non-typeable strains**:
    - Nonencapsulated strains of H. influenza are opportunistic pathogens that can cause infections of the upper and lower airways.
    - Most studies have shown that H.influenzae and Streptococcus pneumoniae are the two most common
    - Cause otitis media, sinusitis, and chronic bronchitis.

- Diagnosis:
  - ✓ Gram stain and morphology
  - ✓ Chocolate agar is commonly used for cultivation [demonstration of a requirement for both X and V factors]
  - ✓ The immunologic detection of H. influenzae antigen, specifically the PRP capsular antigen, is a rapid and sensitive way to diagnose H. influenzae type b disease.

- Treatment
  - ✓ Patients with systemic H. influenzae infections require prompt antimicrobial therapy because the mortality rate in patients with untreated meningitis or epiglottitis approaches 100%.

- Other Haemophilus Species:
  - ✓ *H. aegyptius:* also called the Koch-Weeks bacillus, causes an acute **purulent conjunctivitis**
  - ✓ *H. ducreyi:* can cause **chancroids**, a sexually transmitted disease that is most commonly diagnosed in men. Approximately 5 to 7 days after exposure, a tender papule with an erythematous base develops on the genitalia or perianal area.

Species	Primary Diseases	Frequency
H. influenzae	Pneumonia, sinusitis, otitis, meningitis, epiglottitis, cellulitis, bacteremia	Common worldwide; uncommon in United States
H. aegyptius	Conjunctivitis	Uncommon
H. ducreyi	Chancroid	Uncommon in United States
H. parainfluenzae	Bacteremia, endocarditis, opportunistic infections	Rare

- **Aggregatibacter**
  - Characteristic's:
    - ✓ Human pathogen genus are: ***A. actinomycetemcomitans*** and ***A. aphrophilus***.
    - ✓ Found in the human mouth, can spread into the blood and then stick to a previously damaged heart valve or artificial valve leading to the development of endocarditis.
    - ✓ ***A. actinomycetemcomitans*** is :
      - Gram negative, Facultative anaerobes
      - Non motile bacterium
      - Often associated with localized aggressive periodontitis.

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