Enterobacteriaceae

- The Enterobacteriaceae are a large group of **gram-negative rods** whose natural habitat is the intestinal tract of humans and animals.
- The family includes many genera (***Escherichia, Shigella, Salmonella, Enterobacter, Klebsiella, Serratia, Proteus***, ***Citrobacter, Providencia Morganella***, ***Yersinia*** and others). Enterobacteriaceae also called **coliforms**.
- The enteric bacteria are sometimes found as part of the normal flora of the upper **respiratory** and **genital tracts**. When clinically important infections occur, they are usually caused by ***E coli***, but the other enteric bacteria are causes of **hospital-acquired infections** and occasionally cause **community-acquired infections**.

Escherichia coli: Pathogenesis

1. Urinary Tract Infection:

- *E coli* are the most common cause of urinary tract infection.
- The **symptoms and signs** include:
  -Urinary frequency, dysuria, hematuria, and pyuria.
  -Flank pain is associated with upper tract infection.
  -Urinary tract infection can result in bacteremia with clinical signs of sepsis.

2. *E coli*-Associated Diarrheal Diseases These *E coli* are classified by the characteristics of their virulence properties:

a- Enterotoxigenic *E coli* (ETEC) is a common cause of "**traveler's diarrhea**" and a very important cause of diarrhea in **infants**. ETEC adherence to the epithelial cells of the small bowel. Some strains of ETEC produce **exotoxin** and other produce **enterotoxin**. Its subunit B attaches to the **GM_1 ganglioside** at the brush border of epithelial cells of the small intestine and facilitates the entry of subunit A into the cell, where the latter activates **adenylyl cyclase**. This markedly increases the local concentration of **cyclic adenosine monophosphate** (cAMP), which results in intense and prolonged **hypersecretion** of water and chlorides and inhibits the reabsorption of sodium. The gut lumen is distended with fluid, and hypermotility and diarrhea ensue, lasting for several days.

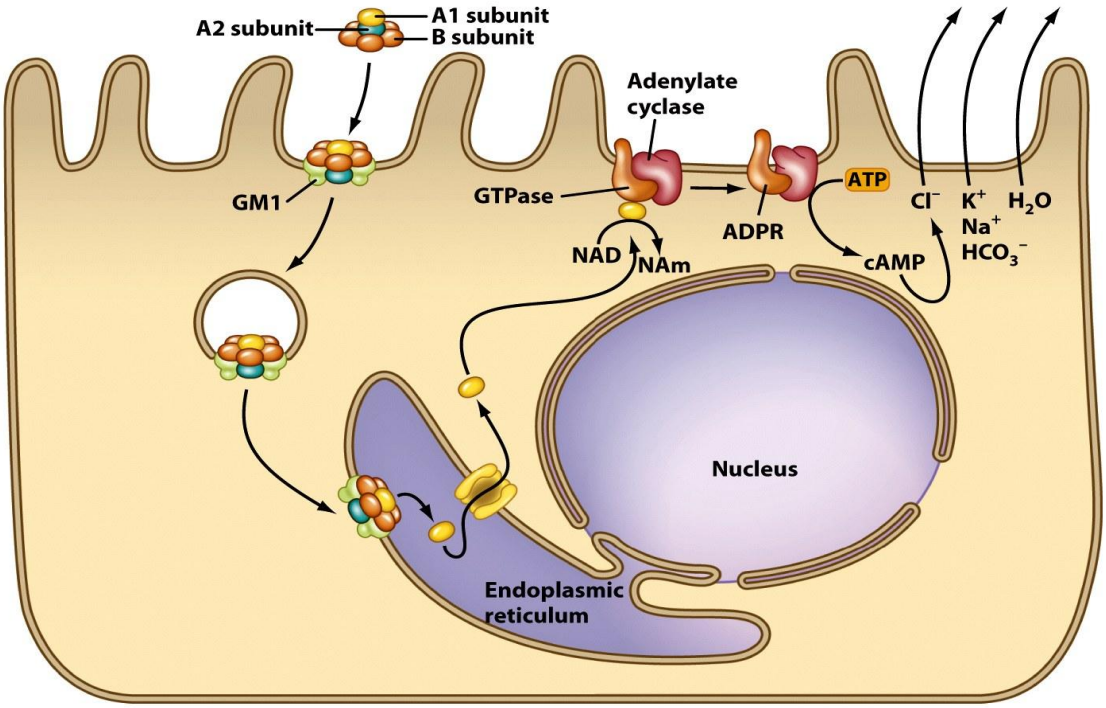

Figure 25.19a Microbiology: An Evolving Science

b- **Enterohemorrhagic *E coli* (EHEC)**
c- **Enteroinvasive *E coli* (EIEC)**
d- **Enteroaggregative *E coli* (EAEC)**
e- **Enteropathogenic *E coli* (EPEC)**

3. **Sepsis**
4. **Meningitis**

Klebsiella pneumoniae It causes a bacterial pneumonia.

Serratia causes pneumonia, bacteremia, and endocarditis.

Enterobacter, ***Citrobacter***, ***Providencia*** **species** causes urinary tract infections and sepsis.

Proteus they are cause urinary tract infections and produce bacteremia, pneumonia. *Proteus* species produce urease, resulting in rapid hydrolysis of urea with liberation of ammonia. Thus, in urinary tract infections with Proteus, the urine becomes alkaline, promoting stone formation and making acidification virtually impossible. The rapid motility of Proteus may contribute to its invasion of the urinary tract.

Diagnostic Laboratory Tests:

1. **Clinical:** Clinical diagnosis.
2. **Laboratory**:
   a/ cultur on selective media (e.g., MacConkey agar, eosin-methylene blue [EMB] agar.
   b. Biochemical identification.
   c. Serologic testing.

Treatment:

- Sulfonamides, ampicillin, cephalosporins, fluoroquinolones (ciprofloxacin), and aminoglycosides (streptomycin).
- **Surgical correction**.
- **Restoration** of fluid and electrolyte balance.
- For the **prevention of traveler's diarrhea** daily ingestion of bismuth subsalicylate suspension and tetracyclines or (ciprofloxacin or trimethoprim-sulfamethoxazole) for prophylaxis.

The Shigellae: they produce **bacillary dysentery**

Pathogenesis & Pathology:

- Shigella infections are limited to the **gastrointestinal** tract; bloodstream invasion is rare.
- The essential pathologic process is invasion of the **mucosal epithelial** cells (eg, M cells).
- **Multiplication** and spread within the epithelial cell cytoplasm, and passage to adjacent cells.
- **Microabscesses** in the wall of the large intestine and terminal ileum lead to **necrosis** of the mucous membrane, superficial **ulceration**, bleeding, and formation of a "**pseudomembrane**" on the ulcerated area. This consists of fibrin, leukocytes, cell debris, a necrotic mucous membrane, and bacteria. As the process subsides, **granulation** tissue fills the ulcers and **scar** tissue forms.

Clinical Findings

- After **incubation period (1–2 days**), there is a sudden onset of abdominal pain, fever, and watery diarrhea.
- The number of **stools increases**; they are less liquid but often contain mucus and blood.
- **rectal spasms**
- In **adult** cases, fever and diarrhea subside spontaneously in 2–5 days. However, in **children and the elderly**, loss of water and electrolytes may lead to **dehydration**, acidosis, and even **death**.
- On **recovery**, most persons shed dysentery bacilli for only a short period, but a few remain **chronic** intestinal **carriers** and may have **recurrent** bouts of the disease.

Immunity: Injection of **killed shigellae** stimulates production of antibodies in serum but fails to protect humans against infection. **IgA** antibodies in the gut important in limiting reinfection; these may be stimulated by **live attenuated** strains given orally as experimental vaccines.

Treatment: Ciprofloxacin, ampicillin, doxycycline, and trimethoprim-sulfamethoxazole.

Epidemiology, Prevention, & Control

Shigellae are transmitted by "food, fingers, feces, and flies" from person to person. Most cases of shigella infection occur in children under 10 years of age. Control efforts **(1) sanitary control** of water, food, and milk; sewage disposal; and fly **(2) isolation** of patients and disinfection of excreta; **(3)** detection of **subclinical cases** and carriers, and **(4) antibiotic** treatment of infected individuals.

The Salmonella

They cause **enteritis**, **systemic infection**, and **enteric fever**.

Pathogenesis & Clinical Findings:

Among the host factors those resistances to salmonella infection are **gastric acidity, normal intestinal** microbial flora, and local **intestinal immunity**.

1. The "Enteric Fevers" (Typhoid Fever):

- The ingested salmonellae reach the **small intestine**, from which they enter the **lymphatic** and then the **bloodstream**.
- They are carried by the blood to **many organs**
- The organisms multiply in intestinal lymphoid tissue and are **excreted in stools.**
- After an incubation period of **10–14 days**, fever, malaise, headache, constipation, bradycardia, and myalgia occur. The fever rises to a high plateau, and the **spleen and liver** become enlarged. **Rose spots**, usually on the skin of the abdomen or chest, are seen briefly in rare cases.
- The **white blood cell count** is normal or low. The chief complications of enteric fever were **intestinal hemorrhage** and perforation, and the mortality rate was 10–15%.
- The principal lesions are **hyperplasia** and **necrosis** of lymphoid tissue (eg, Peyer's patches), **hepatitis**, focal necrosis of the liver, and inflammation of the **gallbladder**, **periosteum**, **lungs**, and other organs.

2. **Bacteremia with Focal Lesions**
3. **Enterocolitis**

Immunity: Reinfection may occur but is often milder than the first infection. However, relapses may occur in 2–3 weeks after recovery in spite of antibodies.

Treatment

- **Replacement** of fluids and electrolytes is essential.
- **Antimicrobial** therapy with ampicillin, trimethoprim-sulfamethoxazole, or a third-generation cephalosporin.
- In most carriers, the organisms persist in the **gallbladder** (particularly if gallstones are present) and in the biliary tract. Some chronic carriers have been cured by ampicillin alone, but cholecystectomy must be combined with drug treatment.

Carriers: some individuals continue to **harbor salmonellae** in their tissues for variable lengths of time. Three percent of survivors of typhoid become permanent carriers, harboring the organisms in the **gallbladder**, **biliary tract**, or, rarely, the intestine or urinary tract.

Sources of Infection:

- Water Contamination with feces.
- Milk and Other Dairy Products
- Meats and Meat Products, Eggs.
- Animal Dyes: Dyes (eg, carmine) used in drugs, foods, and cosmetics.
- Household Pets: dogs, cats, etc.

Prevention & Control:

- **Sanitary** measures.
- **Infected** poultry, meats, and eggs must be thoroughly cooked.
- **Carriers** must not be allowed to work as food handlers.
- Two injections of acetone-killed bacterial suspensions of *Salmonella* Typhi, followed by a booster injection some months later.
- Oral administration of a **live avirulent** mutant strain of *Salmonella* Typhi in areas of high endemicity.

Pseudomonas

Pathogenesis

This organism is widely distributed in **nature** and is commonly present in **moist** environments in hospitals. It is pathogenic only when introduced into **areas devoid of normal defenses**, e.g.,

- Disruption of mucous membrane and skin.
- Usage of intravenous or urinary catheters.
- Neutropenia (as in cancer therapy).

P. aeruginosa is **invasive** and toxigenic. It attaches to and colonizes the mucous membrane or skin, invades locally, and produces **systemic diseases** and **septicemia**.

Clinical Diseases:

1. Infection of wounds and burns.
2. Meningitis
3. Tracheobronchitis and pulmonary infection
4. Eye infections
5. Ear infections otitis externa (swimmers); malignant in diabetic patients. Chronic otitis media
6. Urinary tract infection

7. Sepsis

Laboratory Diagnosis:

- Specimen: skin lesions, pus, urine, blood, spinal fluid, sputum.
- Culture.
- Several subtyping methods, including phage typing and molecular typing, are available for epidemiologic purposes.

Treatment:

- **Combined antibiotic** therapy is required to avoid resistance
- Avoid using **inappropriate antibiotics**, which can suppress the normal flora and permit overgrowth of resistant Pseudomonads.

Prevention and Control:

- *Pseudomonas* spp. normally inhabits soil, water, and vegetation and can be isolated from the skin, throat, and stool of healthy persons.
- Spread is via contact with fomites or by ingestion of contaminated food and water.
- High risk population: patients receiving broad-spectrum antibiotics, with leukemia, burns, cystic fibrosis, and immunosuppression.

Control:

- Patients at high risk should not be admitted to a ward where cases of pseudomonas infection are present.
- Patients infected with *P.aeruginosa* should be isolated.
- Sterilize all instruments, apparatus, and dressing.
- Monitor clinically relevant isolates of *P. aeruginosa* by a suitable typing system to identify epidemic strains.

Reference: Lange Medical Microbiology, 24th Edition: Jawetz, Melnick, & Adelberg/ Chapter 16. Enteric Gram-Negative Rods (Enterobacteriaceae).