Escherichia Coli

Gram negative bacillus (rod)

Many flagella

Grows very fast (20 minute doubling time)

Genetic Diversity

Every E. coli strain must have 2,167 core genes (Most viruses have around 20 total)

4,271 total genes on average

10,131 possible genes (Most strains are benign)

Acquisition of mobile genetic elements can change E. coli from a commensal to a highly adapted and deadly pathogen

8 "Pathovars" of Pathogenic E. Coli

Serovar: Distinct variation of bacteria

Pathovar: Serovar for pathogens

$\sim$400 million infections

Types of E. Coli:

1. Enterohaemorrhagic (EHEC)
2. Enteropathogenic (EPEC)
3. Uropathogenic (UPEC)
4. Diffusely Adherent (DAEC)
5. Enteroinvasive (EIEC)
6. Enteroaggregative (EAEC)
7. Neonatalmeningitis (NMEC)

EPEC vs. EHEC / STEC

EPEC:

1. Causes childhood diarrhea
2. Transmits human to human
3. No Shiga toxin

EHEC / STEC

1. Food/water-borne pathogen in industrialized countries

2. Zoonotic from cattle or other animals
3. Secreted Shiga toxin can lead to Hemolytic Uremic Syndrome (HUS)

   Lysed cells can clog kidneys and lead to kidney failure
4. 265,000 illneses each year in the US
5. 3,600 hospitalizations
6. 30 deaths

Both have same mechanism of intestinal colonization

How do bacteria not get washed out of intestine?

Attatch via pedestals

EHEC / EPEC induce pedestal formation to stay attatched

1. Inject E. coli receptor protein into epithelial cells
2. E. coli protein in epithelial cells binds to the bacteria enabling attachment

Serotyping by E. Coli Antigens

Surface antigens include polysaccharide side chains (O antigen), capsular antigen (K), and flagellar protein (H)

200 O antigens, 80 K antigens, and 56 H antigens

→ Flagella is 1 PAMP, but 56 different possible antigens

EHEC / STEC

EHEC (Shiga toxin producing E. coli)

Found on contaminated beef

Several serotypes in EHEC frequently associated with human disease

1. **O157:H7**
2. O26:H11
3. O91:H21
4. O111:H8
5. O157:H7

How does Shiga toxin work?

1. Shiga toxin (Stx) genes are found in pathogenic E. coli and Shigella dysenteria

2. Forms a pentamer of B subunits that bind and enter host cells, allowing a single A subunit to enter the cell
3. The A subunit of the toxin injures the eukkaryotic ribosome and inhibits protein synthesis in target cells and can kill cells
4. Shiga toxin can attack epithelial cells, endothelial cells, and immune cells
5. Shiga toxin can attack cells in intestine (colitis / diarrhea) and kidney / endothelial cells in kidney (HUS)
6. Antibodies to Stx are protective against severe disease

Outbreaks

Jack in the Box: 1992

1. Over 600 people infected in 6 states

   Mostly children

   4 deaths

   50 cases of kidney failure from HUS
2. Cause: Knowingly undercooking burgers

2 class action suits and USDA began testing all ground beef in 1994

$\sim$100,000 EHEC infections each year in the US

How Did EHEC Acquire Shiga Toxin?

1. Virus infects and kills shigella
2. Virus picks up Stx gene piece
3. Virus infects commensal E. coli
4. Stx phage integrates into E. coli genome

Transmission in Animals

Healthy cattle are the major reservoirs of E. coli O157:H7

Contaminated bovine products and crops are predominant sources for human infections

Animal transmission through fecal contamination of food or water

"Super-shedder" cows: Colonized at rectum for long periods of time, shedding more than 95% of E. coli in a herd

Human Transmission

Undercooked or unpasteurized animal products

1. Ground Beef
2. Other Meats
3. Milk, Cheese

Foods contaminated with animal feces

1. Fruits
2. Vegetables

Contaminated water

1. Wells
2. Swimming (lakes, streams)

Contaminated soil

1. Campgrounds
2. Sites grazed by livestock

Disease in Humans

Hemorrhagic Colitis

1. Bloody diarrhea
2. Sever abdominal cramps
3. Possibly fever, nausea, vomiting
4. Many cases are self limiting and resolve in $\sim$1 week

Hemolytic Uremic Syndrome (HUS)

1. Children, elderly, immunocompromised
2. Kidney failure, hemolytic anemia, thrombocytopenia (tiny blood clots clog capillaries)

Treatment

1. Mainly supportive
2. Antibiotics are usually avoided as they may not reduce symptoms, prevent complications, nor reduce shedding of bacteria
3. May even increase risk of HUS

Salmonella Enterica

Comprises a number of subspecies, all of which are common sources of food poisoning

2 main serovars:

1. S. Typhimurium

    Causes gastroenteritis

    Short-term infection of GI tract

    Broad range humans / animals

2. S. Typhi

    Typhoid fever (Makes typhoid toxin)

    Life threatening systemic infection

    3-5% are carriers that shed at high levels

    Human-specific