Medical Bacteriology II

4th class Biomedical

By
Asst.Prof. Dr Akhter A Ahmed
official email: akhter.ahmed@su.edu.krd
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Gram-Negative Rods Related to the Enteric Tract (*Enterobacteriaceae*)

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Introduction

- **Gram-negative rods related to the enteric tract have been divided into three groups depending on the major anatomic location of disease, namely,**

(1) pathogens both within and outside the enteric tract, [*Escherichia, Salmonella*]

(2) pathogens primarily within the enteric tract, [*Shigella, Vibrio, Campylobacter, Helicobacter*]and

(3) pathogens outside the enteric tract [*Klebsiella–Enterobacter–Serratia* group, *Proteus–Providencia– Morganella* group, *Pseudomonas, Bacteroides, Prevotella, Fusobacterium*].

- **The Enterobacteriaceae are a large, heterogeneous 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,* and others).**

- **Some enteric organisms, eg, *Escherichia coli,* are part of the normal flora and incidentally cause disease, while others,**

- **the salmonellae and shigellae, are regularly pathogenic for humans.**

- **common Features of all members of this family are their anatomic location and four metabolic processes:**

(1) they are all facultative anaerobes.

(2) they all ferment glucose (fermentation of other sugars varies)

(3) none have cytochrome oxidase (i.e., they are oxidase-negative)

(4) they reduce nitrates to nitrites as part of their energy-generating processes.

Enteric G- Rods Antigens??????

Antigens

1. The cell wall antigen (also known as the somatic, or O, antigen) is the outer polysaccharide portion of the lipopolysaccharide.

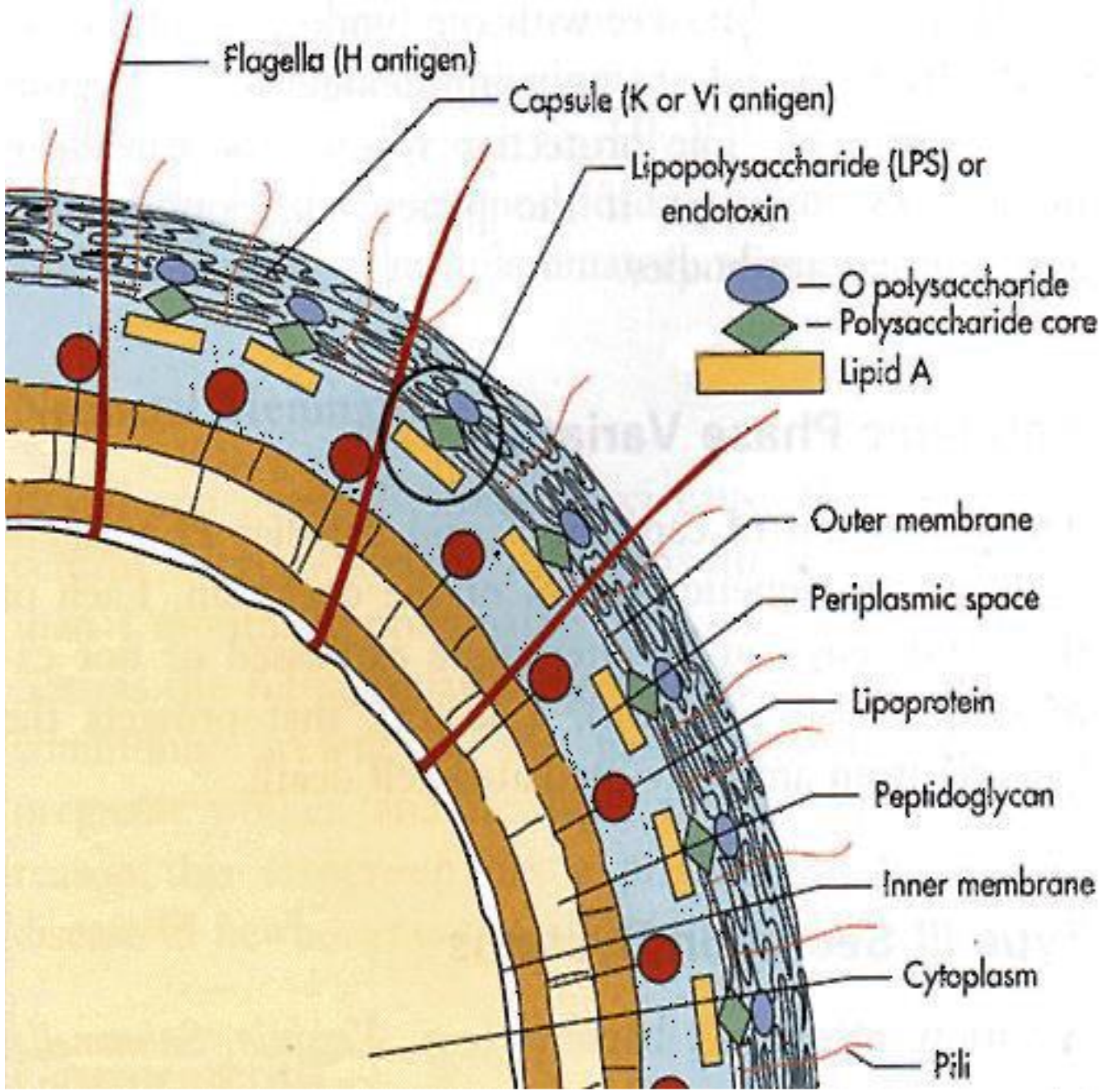
- **The O antigen is the basis for the serologic typing of many enteric rods.**

2. The H antigen is on the flagellar protein.

Only flagellated organisms, such as *Escherichia* and *Salmonella,* have H antigens, whereas the nonmotile ones, such as *Klebsiella* and *Shigella,* do not.

3. The capsular or K polysaccharide antigen is particularly prominent in heavily encapsulated organisms such as *Klebsiella.*

- **The K antigen is identified by the quellung (capsular swelling) and is used to serotype *E. coli* and *Salmonella typhi* for epidemiologic purposes.**
- **In *Sal. typhi,* the cause of typhoid fever, it is called the Vi (or virulence) antigen.**



Escherichia Coli

- **Important Properties**
- ***E. coli* is a straight gram-negative rod is the most abundant facultative anaerobe in the colon and feces.**

- ***E. coli* ferments lactose, a property that distinguishes it from the two major intestinal pathogens, *Shigella* and *Salmonella*.**

- **It has three antigens : the O, H, K,**

Pathogenesis

- The source of the *E. coli* → UTI is the patient's own colonic flora that colonizes the urogenital area.
- The source of the *E. coli* that causes neonatal meningitis is the mother's birth canal.
- In contrast, the *E. coli* that causes traveler's diarrhea is acquired by ingestion of food or water contaminated with human feces.
- *E. coli* V.F: pili, a capsule, endotoxin, and three exotoxins (enterotoxins).

Diseases

1.Urinary tract infection (UTI)—

- **90% UTI.**

- **The symptoms and signs include urinary frequency, dysuria, hematuria, and pyuria.**

- **Flank pain is associated with upper tract infection.**

- **Most of the UTI caused by a small number of O antigen type, these organisms are designated as uropathogenic *E coli*.**

- **produce hemolysin, → cytotoxic and facilitates tissue invasion.**

- **strains that cause pyelonephritis express K antigen and elaborate a specific type of pilus.**

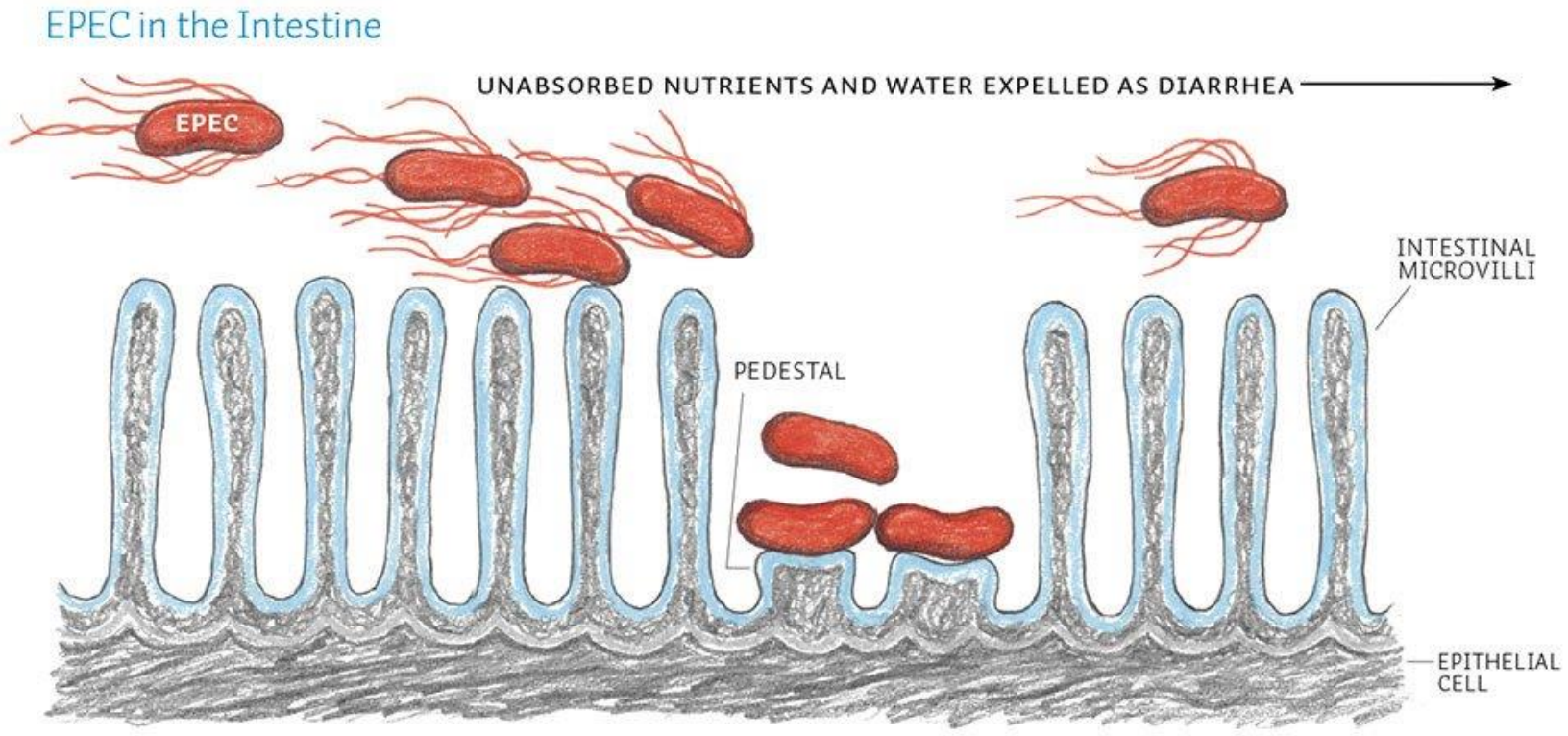
2-E coli-associated diarrhea

- ***E coli*** **that cause diarrhea are extremely common worldwide.**

- **These *E coli* are classified by the characteristics of their virulence properties and each group causes disease by a different mechanism.**

*Enteropathogenic *E coli* (EPEC)

- important cause of diarrhea in infants, especially in developing countries.
- EPEC adhere to the mucosal cells of the small bowel.
- The result of EPEC infection is watery diarrhea, which is usually self-limited.



**Enterotoxigenic *E coli* (ETEC)

- "traveler's diarrhea" and a very important cause of diarrhea in infants in developing countries.

- Some strains of ETEC produce a heat-labile exotoxin (LT).
- subunit A&B
- B attaches to the brush border of epithelial cells of the small intestine

- subunit A, activates adenylyl cyclase → increases the local concentration cAMP, → hypersecretion of water and chlorides and inhibits the reabsorption of sodium.

- **Some strains of ETEC produce the heat-stable enterotoxin ST activates guanylyl cyclase in enteric epithelial cells and stimulates fluid secretion.**

- **Many ST-positive strains also produce LT.**
- **The strains with both toxins produce a more severe diarrhea.**

Enterohemorrhagic strains of *E. coli* (Shiga toxin–producing *E. coli* [STEC])

- (i.e., those with the **O157:H7 serotype**)
- **STEC has been associated with hemorrhagic colitis, a severe form of diarrhea.**
- cause bloody diarrhea by producing an **exotoxin called Shiga toxin**, because it is very similar to that produced by Shigella species.
- Shiga toxin acts by **stopping protein synthesis**.
- Shiga toxin is encoded by temperate (lysogenic) bacteriophages.

- Shiga toxin is also called **verotoxin** because it has a cytopathic effect on Vero (monkey) cells in culture.

- These O157:H7 strains are associated with outbreaks of bloody diarrhea following ingestion of **undercooked burger**, often at fast-food restaurants.

- Also, direct contact with animals (e.g., visits to farms and petting zoos) has resulted in bloody diarrhea caused by O157:H7 strains.

- *E. coli* O157 has a low **ID_{50} of approximately 100 organisms**.

Hemolytic-Uremic Syndrome

- Some patients with bloody diarrhea caused by O157:H7 strains also have a life-threatening complication called hemolytic-uremic syndrome (HUS), which occurs when Shiga toxin enters the bloodstream.
- This syndrome consists of hemolytic anemia, thrombocytopenia, and acute renal failure.
- The hemolytic anemia and renal failure occur because there are receptors for Shiga toxin on the surface of the endothelium of small blood vessels and on the surface of kidney epithelium.

****Enteroinvasive *E coli* (EIEC)

- **produces a disease very similar to shigellosis.**
- **in children in developing countries and in travelers to these countries.**
- **Like *Shigella*, EIEC strains are non-lactose or late lactose fermenters and are nonmotile.**
- **EIEC produce disease by invading intestinal mucosal epithelial cells.**

*****Enteroaggregative *E coli* (EAEC)

- **acute and chronic diarrhea (>14 days in duration) in persons in developing countries.**
- **food-borne illnesses in industrialized countries.**
- **EAEC produce ST-like toxin and a hemolysin.**

3. Sepsis—When normal host defenses are inadequate, *E coli* may reach the bloodstream and cause sepsis.

- **Newborns may be highly susceptible to *E coli* sepsis because they lack IgM antibodies.**
- **Sepsis may occur secondary to UTI**

4. Meningitis- Approximately 75% of *E coli* from meningitis cases have the K1 antigen.

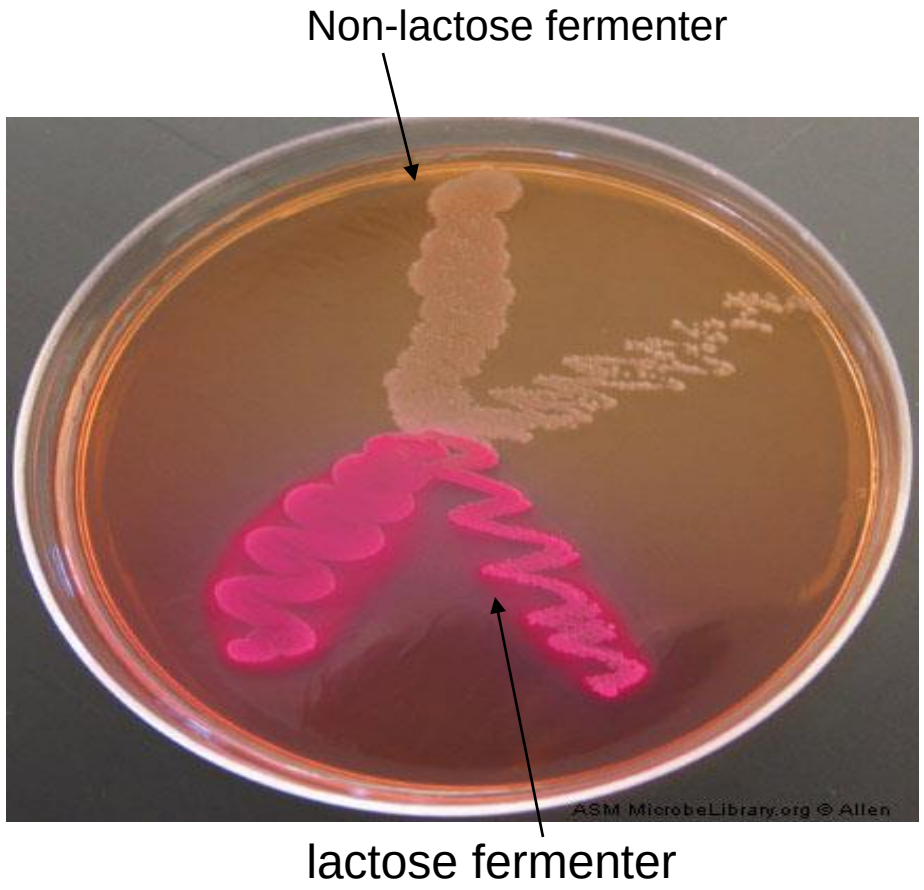
Laboratory Diagnosis

- **Specimens on BA, EMB agar or MacConkey's agar.**

- **forms pink colonies on MA. On EMB agar, metallic green sheen.**

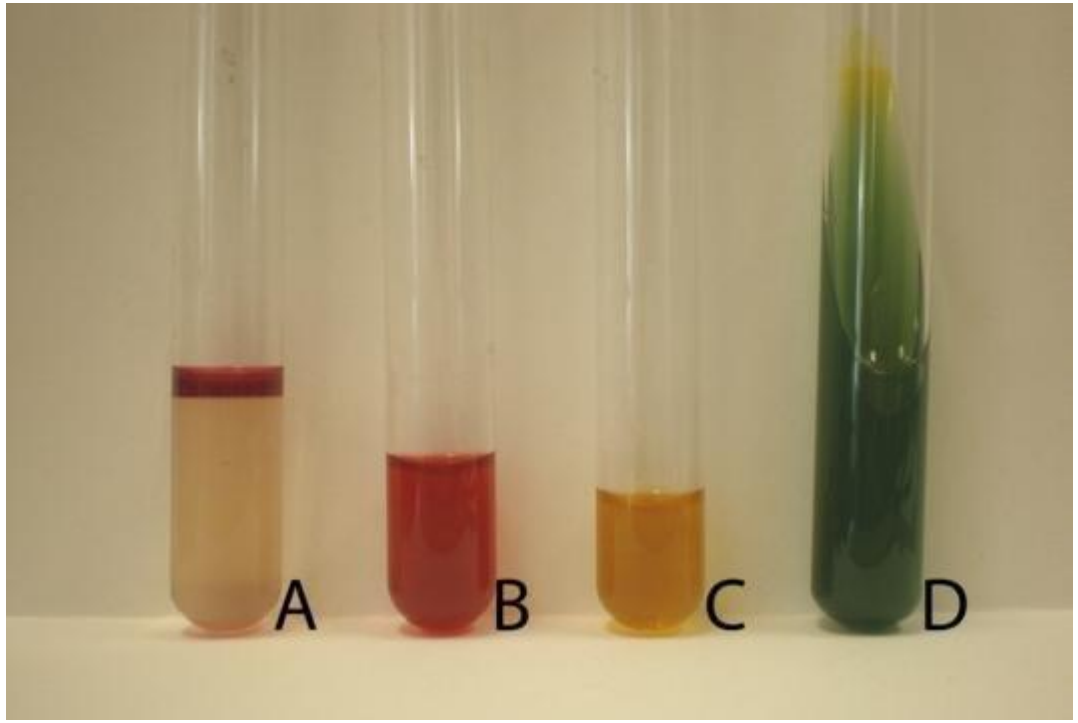
- ***E. coli* O157:H7 does not ferment sorbitol, which serves as an important criterion that distinguishes it from other strains of *E. coli.***

Enterobacteriaceae on M.A



E coli .On EMB colonies are metallic green sheen

IMViC test



Indol test **MR test** **VP test** **citrate test**

Treatment

- **Treatment of *E. coli* infections depends on the site of disease and the resistance pattern of the specific isolate.**
- **For example, an uncomplicated lower urinary tract infection can be treated for just 1 to 3 days with oral trimethoprim-sulfamethoxazole, ampicillin.**

- ***E. coli* sepsis requires cefotaxime, with or without an aminoglycoside, such as gentamicin**).

- **For the treatment of neonatal meningitis, a combination of ampicillin and cefotaxime is usually given.**

- **Antibiotic therapy is usually *not* indicated in *E. coli* diarrheal diseases.**
- **Rehydration is typically all that is necessary in this self-limited disease.**

Klebsiella–Enterobacter–Serratia Group

Diseases

- **opportunistic pathogens that cause nosocomial infections, especially pneumonia and UTI.**

- ***Klebsiella pneumoniae* is an important respiratory tract pathogen outside hospitals as well.**

Important Properties

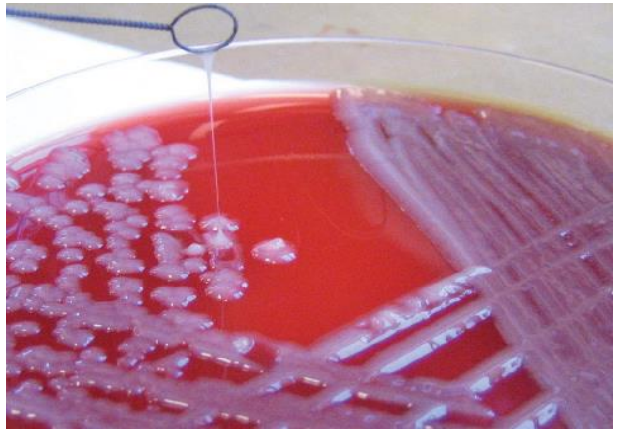
- found in the large intestine but are also present in soil and water.
- These organisms have very similar properties and are usually distinguished on the basis of several biochemical reactions and motility.
- *K. pneumoniae* has a very large polysaccharide capsule, which gives its colonies a striking mucoid appearance.
- *Ser. marcescens* produces red-pigmented colonies.

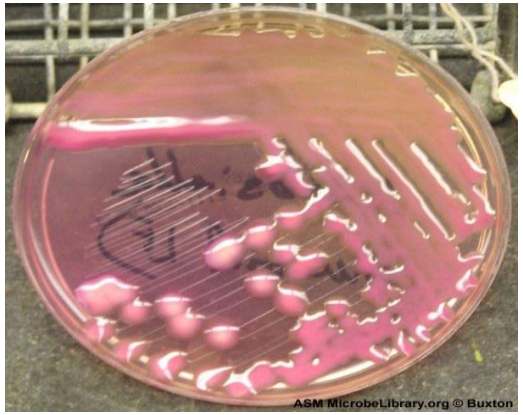
Pathogenesis

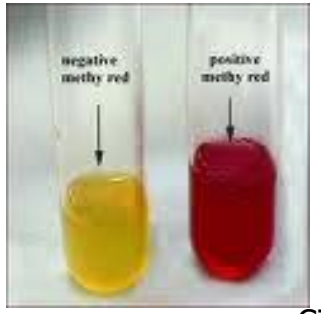
- ***K. pneumoniae*** **is most likely to be a primary, nonopportunistic pathogen; this property is related to its antiphagocytic capsule.**

- ***K. pneumoniae*** **infections → advanced age, chronic respiratory disease, diabetes, or alcoholism.**

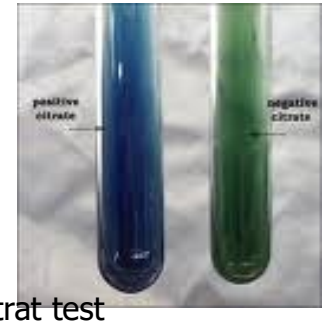
- ***Enterobacter*** **and** ***Serratia*** **infections are clearly related to hospitalization as intravenous catheterization, respiratory intubation, and urinary tract manipulations.**



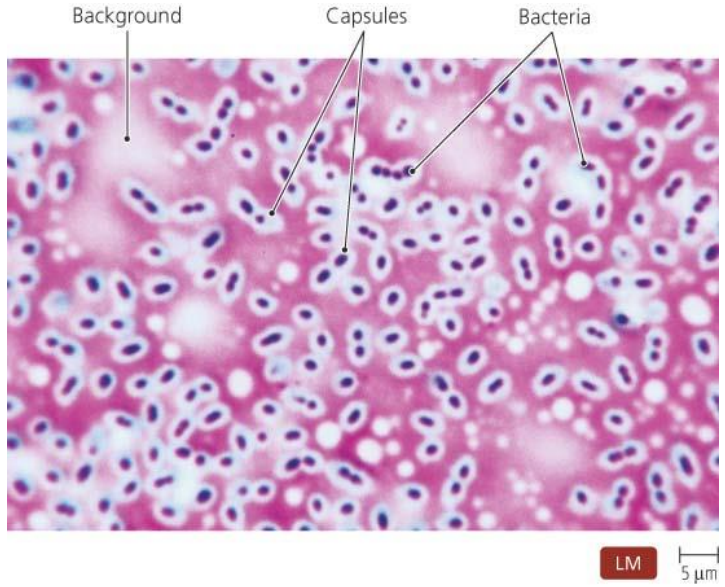




VP test



Citrat test



Klebsiella pneumoniae

Enterobacter cloacae

Serratia marcescens

Proteus–Providencia–Morganella Group

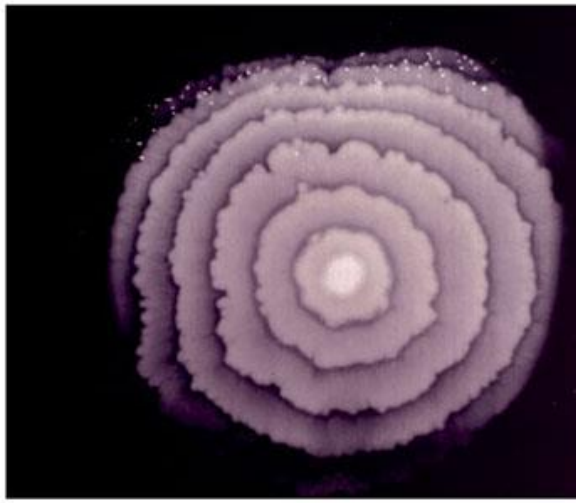
Diseases

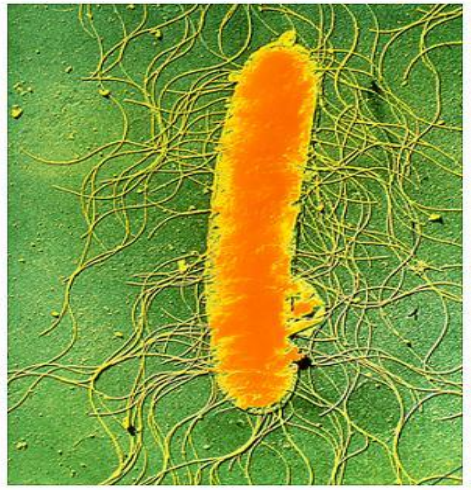
- **These organisms primarily cause urinary tract infections, both community- and hospital-acquired.**

Important Properties

- **Prominent feature produce phenylalanine deaminase.**
- **In addition, they produce the enzyme urease, which cleaves urea to form NH_3 and CO_2.**
- **Certain species are very motile and produce a striking swarming effect on blood agar**

Enterobacteriaceae
Proteus





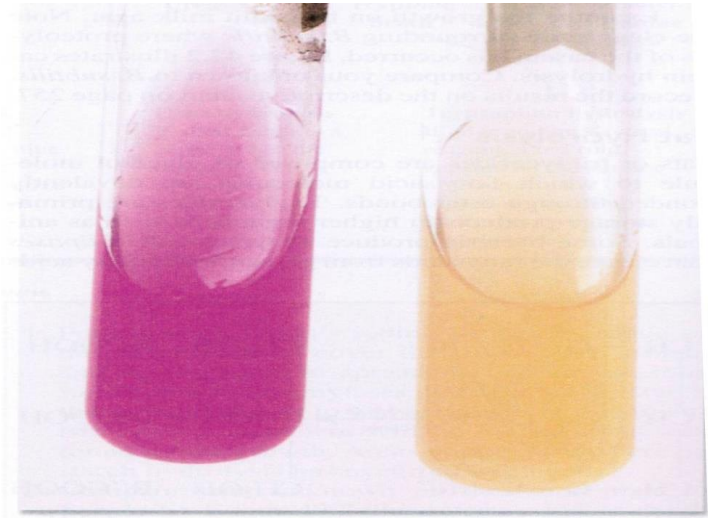
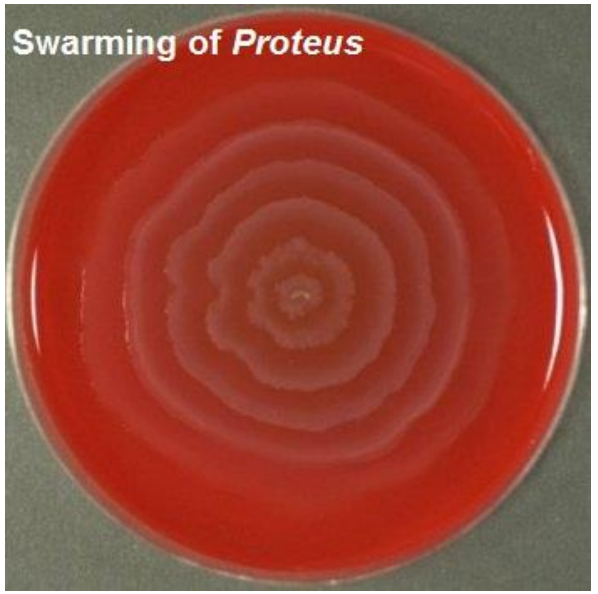


FIGURE 42.4 Urease test. Tube on the left is positive (*Proteus*); tube on the right is negative. © The McGraw-Hill Companies/Auburn University Photographic Service



Pathogenesis

- **The organisms are present in the human colon as well as in soil and water.**
- **Their tendency to cause UTI is probably due to their presence in the colon and to colonization of the urethra, especially in women.**
- **The motility of *Proteus* organisms may contribute to their ability to invade the urinary tract.**

- **Urease importance in UTI & Stone formation**

- **(calculi) called "struvite" composed of magnesium ammonium phosphate.**

Question Group 1

Q-A 37-year-old woman with a history of urinary tract infections comes to the emergency department with burning on urination along with frequency and urgency. She says her urine smells like ammonia. The cause of her urinary tract infection is likely to be

(A) *E. aerogenes*

(B) *Proteus mirabilis*

(C) *Citrobacter freundii*

(D) *E. coli*

(E) *S. marcescens*

Question G2

Q. Heat-labile toxin of ETEC acts by which of the following mechanisms?

(A) Activation of adenylyl cyclase

(B) Aggregative adherence

(C) Ribosomal dysfunction

(D) None of the above

Next Lecture

- ***Enteric Gram -Negative Rods***
  Salmonella & Shigella Species