Gram negative Bacteria

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ENTEROBACTERIACEAE

- A large Family of aerobic bacterial flora of intestine of humans and other animals.
- Its members are nonsporting, non acid-fast, gram negative bacilli.

- Capsule ±
- Motility ±

- **General features** – aerobic and facultatively anaerobic, grow readily on ordinary media, ferment glucose, reduce nitrates to nitrites and form catalase but not oxidase.

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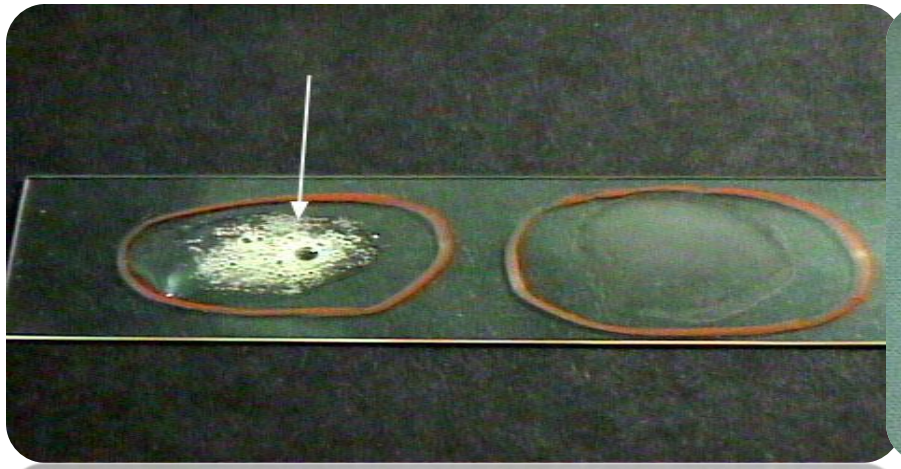
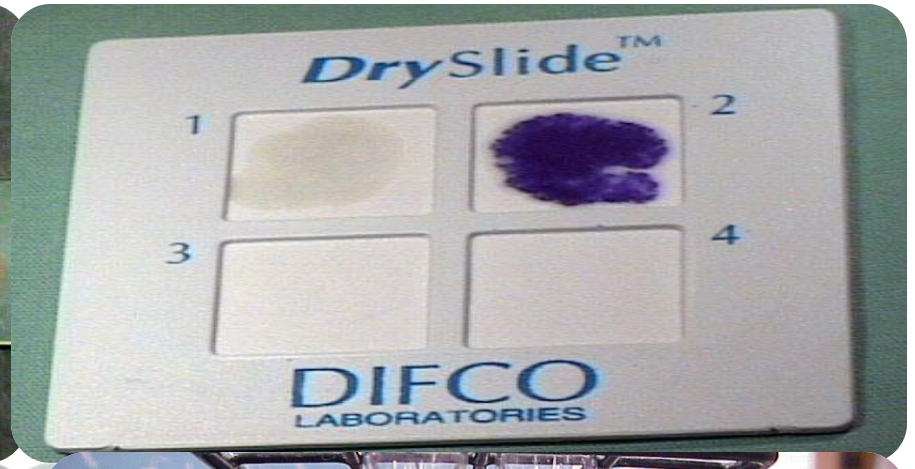
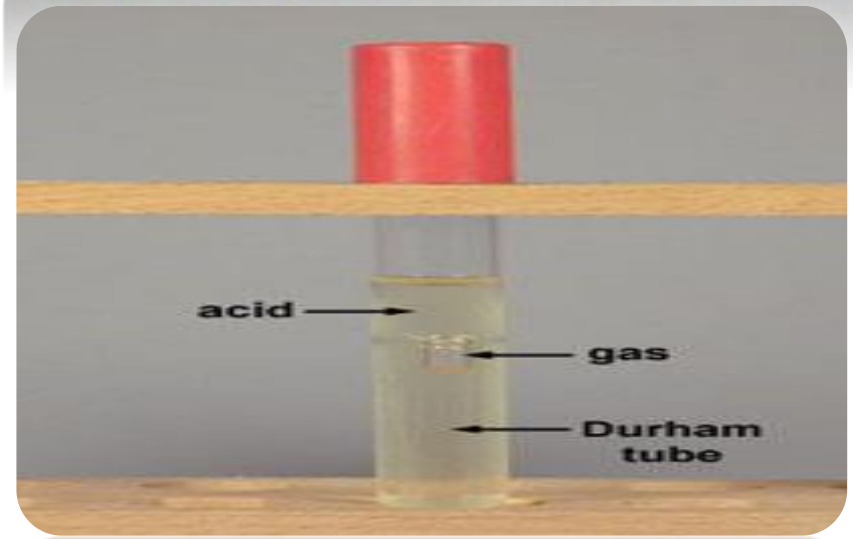
Catalase, glucose, nitrate +ve; oxidase -ve







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- Wide biochemical and antigenic heterogeneity.
- Genetic mechanisms like conjugation and transduction in these bacteria contribute to their infinite variety.
- Various classifications of Enterobacteriaceae have been put forward.
- Two important classifications are 1. based on taxonomy and 2. based on lactose fermentation.

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CLASSIFICATION BASED ON LACTOSE FERMENTATION

1. **Lactose fermenters**

   Escherichia coli

   Klebsiella sp.

   Enterobacter aerogenes

2. **Late lactose fermenters**

   Edwardsiella,
   Serratia,
   Citrobacter,
   Arizona,
   Providencia,
   Erwinia

3. **No lactose fermenters**

   Salmonella

   Shigella etc.

Lactose fermenter v/s non fermenter

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TAXONOMICAL CLASSIFICATION *ENTEROBACTERIACEAE*

- Tribe I: Escherichia
  - Genus
    - Escherichia
    - Edwardsville
    - Citrobacter
    - Salmonella
    - Shigella
- Tribe II: Klebsiella
  - Genus
    - Klebsiella
    - Enterobacter
    - Hafnia
    - Serratia
- Tribe III: Proteae
  - Genus
    - Proteus
    - Morganella
    - Providencia
- Tribe IV: Erwinieae
  - Genus
    - Erwinia

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- Genus Escherichia named after **Escherichia** who was the first to describe the colon bacillus under the name *Bacterium coli commune* (1885).

➢Species:

- *E. coli,*
- *E. fergusonii,*
- *E. hermanii,*
- *E. vulneris,*
- *E. blattae etc*

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ESCHERICHIA COLI

Morphology

*Gram negative bacilli

*1-3 x 0.4-0.7 µm

*Single, pairs

*Motile by peritrichate flagella

*Found in some – capsules, fimbriae, immobility

*Non spore forming

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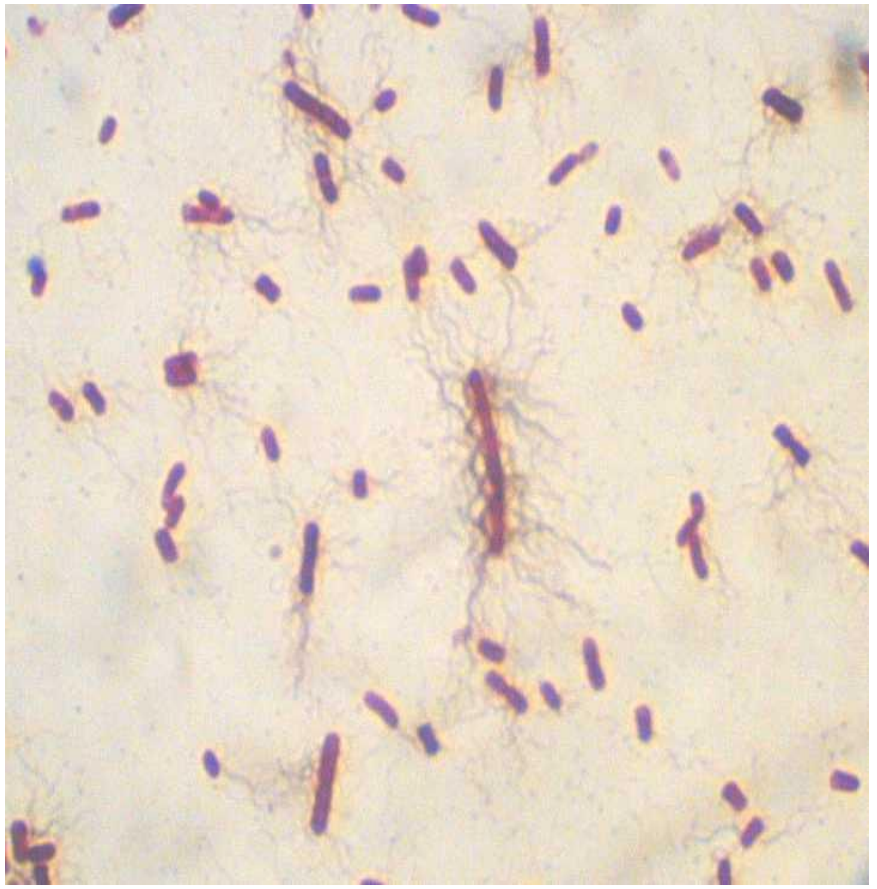
SHOWING GRAM NEGATIVE BACILLI AND PERITRICHOUS FLAGELLA



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CULTURE CHARACTERISTICS

- Aerobe and facultative anaerobe
- 10-40°C (37°C)

- S = smooth forms seen in fresh isolates, easily emulsifiable in saline.

- R = rough forms seen in older cultures, with irregular dull surface, often autoagglutinable in saline.

- **S-R variation** occurs as a result of repeated subcultures and is associated with the loss of surface antigens and usually of virulence.

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- Many pathogenic isolates have polysaccharide capsules.
- Some strains may occur in the mucoid form.

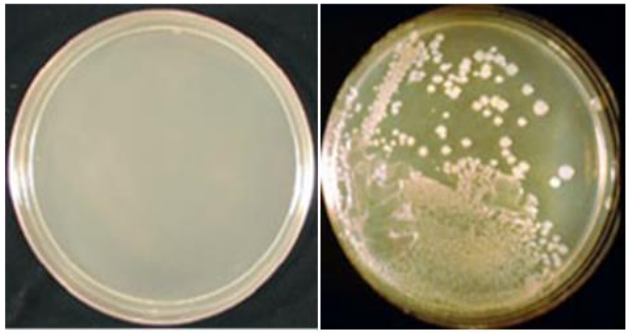
- **Nutrient agar** – colonies are large, thick, greyish white, moist, smooth, opaque or partially translucent discs.

- **Blood agar** - Many strains esp. pathogenic ones are hemolytic on blood agar.

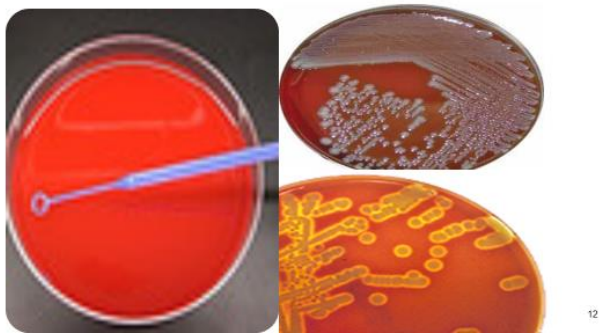
- **MacConkey medium** - colonies are bright pink due to lactose fermentation.

- **Broth** – general turbidity, heavy deposit.

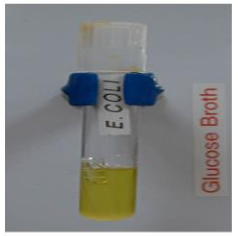
ECOLI ON NUTRIENT AGAR



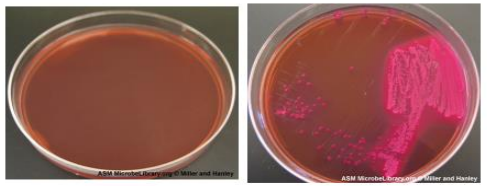
ECOLI ON BLOOD AGAR



ECOLI IN BROTH

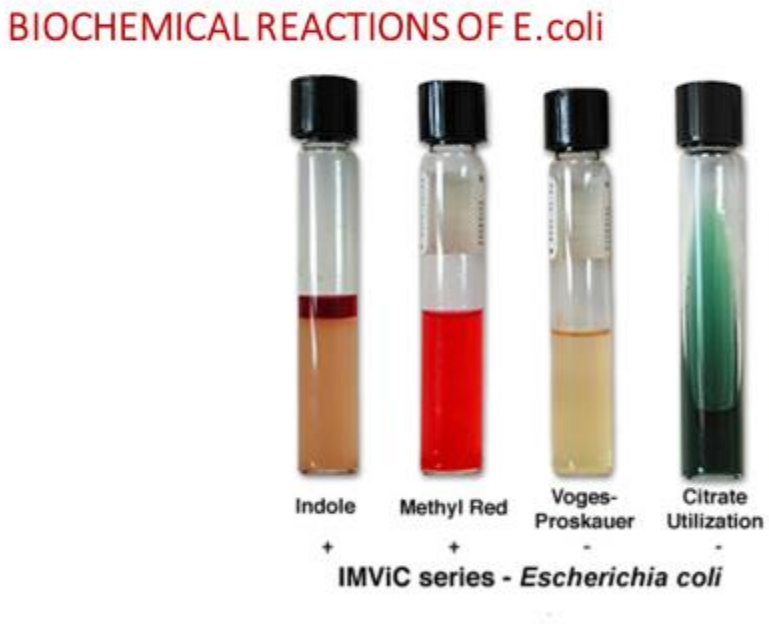


E.COLI ON MACCONKEY AGAR



BIOCHEMICAL REACTIONS

- Sugar fermentation – glucose, lactose, manitol, maltose and many other sugars fermented with **acid and gas** production.
- Sucrose generally not fermented.
- **IMViC ++--**
- Gelatin -, H2S -, urease -.



ANTIGENIC STRUCTURE

- O = somatic antigen
- K = capsular antigen
- H = flagellar antigen

- So far, >170 types of O, 100 types of H and 75 types of K have been identified.
- Antigenic pattern of an organism based on these antigens is written as eg. O111:K58:H2, O54:K27:H41 etc.

- **K antigen** is the acidic polysaccharide antigen located in the envelope or microcapsule (K for kapsel, german for capsule).
- It encloses the O antigen and renders the strain inagglutinable by the O antiserum.
- It may also contribute to virulence by inhibiting phagocytosis.

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VIRULENCE FACTORS

➢Surface antigens: O and K

- **O antigen** – somatic lipopolysaccharide surface O antigen has endotoxic activity, protects the bacteria from phagocytosis and bactericidal effects of complement.

- **K antigen** – affords protection against phagocytosis and antibacterial factors in normal serum.

➢ **Fimbriae** – plasmid coded, found in small numbers and mediate mannose resistant hem agglutinins, act as virulence factors.

Examples:

- CFA = colonization factor antigens in enter toxigenic *E. coli* causing human diarrhea.

- P fimbriae which bind to uroepithelial cells and P blood group substance on human erythrocytes, have a role in urinary tract infection.

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❖TOXINS:

➢*E. coli* produce two kinds of exotoxins – haemolysins and enterotoxins.

➢Three distinct types of *E. coli* enterotoxins have been identified

- LT = heat labile toxin
- ST = heat stable toxin
- VT = serotoxin (also known as SLT = shiga like toxin).

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CLINICAL INFECTIONS

- URINARY TRACT INFECTIONS (UTI)
- DIARRHEA
- PYOGENIC INFECTIONS
- SEPTICAEMIA

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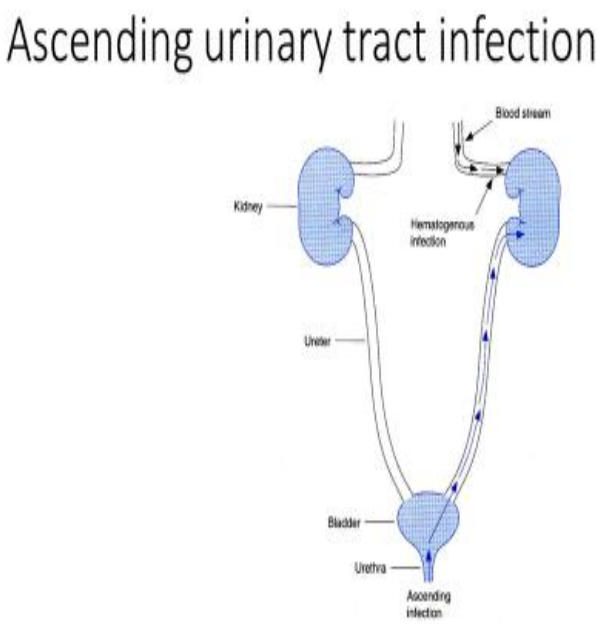
URINARY TRACT INFECTIONS

- **Community acquired:** *E. coli* and other coliforms account for the large majority of naturally acquired UTIs.

- **Hospital acquired:** Those acquired in the hospital, following instrumentation, are more often caused by other bacteria such as pseudomonas and proteus.

- The *E. coli* serotypes commonly responsible for UTI are those normally found in the feces, **O groups 1,2,4,6,7,etc.**



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➢Asymptomatic bacteriuria:

- Observed in some pregnant women, it means urinary infection without any symptoms.
- If it progresses, it may lead to symptomatic infection later in pregnancy, **pyelonephritis and hypertension** in the pregnant woman, as well as to **prematurity and perinatal death of the fetus.**

➢Urinary tract infection can be:

- Ascending = via urethra
- Descending = haematogenous route

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KASS' CONCEPT OF SIGNIFICANT BACTERIURIA

- Normal urine is sterile, but during voiding may get contaminated by genital commensals.
- Hence presence of bacteria in microscopy and culture of a urine sample need not necessarily mean UTI by that organism.
- To differentiate between actual pathogen and contaminant, Kass etc. devised the following formula.

- **Colony count in urine:**
- <10000/ml = contaminant
- 10000 to 100000/ml = indecisive, repeat test.
- >100000/ml = significant bacteriuria.

- **Exceptions:** in patients on antibacterial or diuretic drugs and with some bacteria like staph. Aureus, even low counts may be significant.

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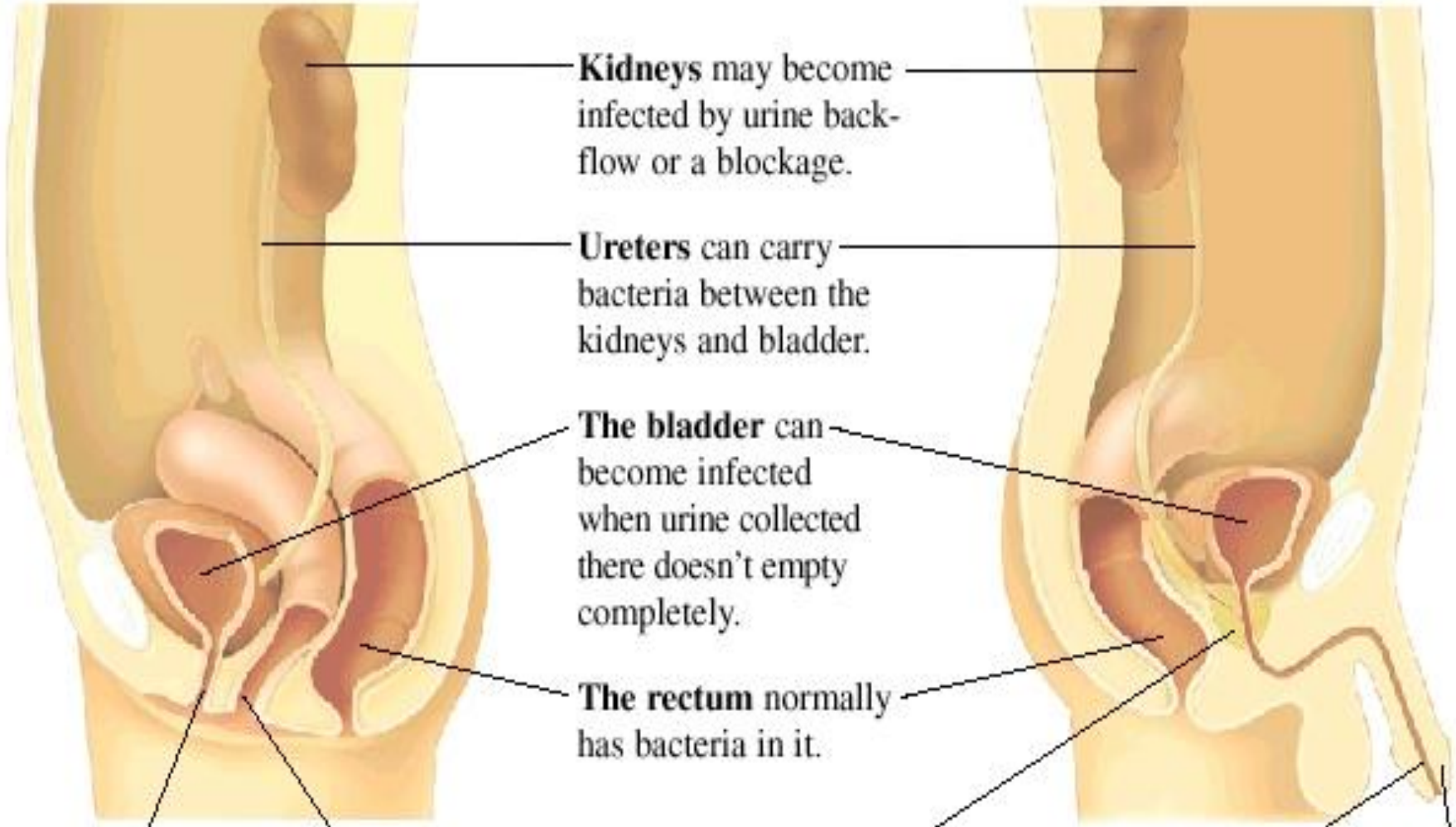

Kidneys may become infected by urine back-flow or a blockage.

Ureters can carry bacteria between the kidneys and bladder.

The bladder can become infected when urine collected there doesn't empty completely.

The rectum normally has bacteria in it.

The urethra in women is short and near the vagina. This makes it easy for bacteria to enter the urinary tract.

The vagina allows entry for bacteria from the rectum or from outside the body. These bacteria may then enter the urethra.

The prostate surrounds part of the urethra. As men age, the prostate may enlarge and block urine flow. This can cause infections.

The urethra is longer in men. This makes it harder for bacteria to reach the inner structures.

The penis comes in contact with bacteria that can travel up the urethra.

UTIs: Causative Pathogens

Type of UTI	Causative Pathogen
Acute uncomplicated cystitis/ recurrent cystitis/ acute uncomplicated pyelonephritis	• *E coli* • *S saprophyticus* • *P mirabilis* • *K pneumoniae*
Complicated UTI	• *E coli* • *K pneumoniae* • *P mirabilis* • Enterococci • *P aeruginosa*
Catheter-associated UTI	• *E coli* • Gram-positive enterococci

Orenstein R, et al. *Am Fam Phys*. 1999;59:1225-1234.

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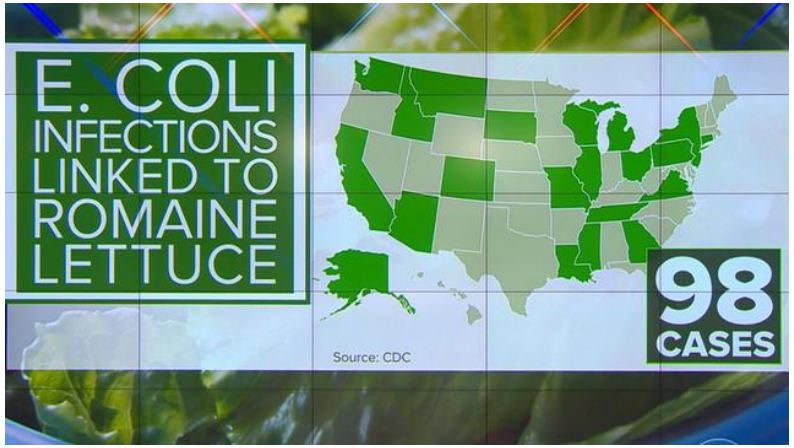
DIARRHEA CAUSING *E. COLI*

- EPEC = ENTEROPATHOGENIC E. COLI
- ETEC = ENTEROTOXIGENIC E. COLI
- EIEC = ENTEROINVASIVE E. COLI
- EHEC = ENTEROHAEMORRHAGIC E. COLI
- EAEC = ENTEROAGGREGATIVE E. COLI



https://edition.cnn.com/2013/06/28/health/e-coli-outbreaks-fast-facts/index.html

EPEC = ENTEROPATHOGENIC E.COLI

- **Associated with diarrhea in infants and children.**

- **Institutional outbreaks, sporadic diarrhea.**

- Do not produce enterotoxins.
- Not invasive.

- M/A: Attach to mucosa of upper small intestine, cause **disruption of brush border microvilli.**

- **Enter adherent E.coli** is another name given to them because they can adhere to HEp-2 cells.

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ETEC = ENTEROTOXIGENIC E.COLI

- Endemic in developing countries in tropics, all age groups.
- Mild watery diarrhea to fatal disease indistinguishable from cholera.

- Persons from developed countries visiting endemic areas often suffer from ETEC diarrhea – a condition known as **TRAVELER'S DIARRHEA**.

- Adhere to intestinal epithelium via fimbrial or colonization factor antigens (CFA I,II,III,IV,etc.).
- **Produce LT or ST or both.**

- Diagnosis done by demonstration of the toxin.

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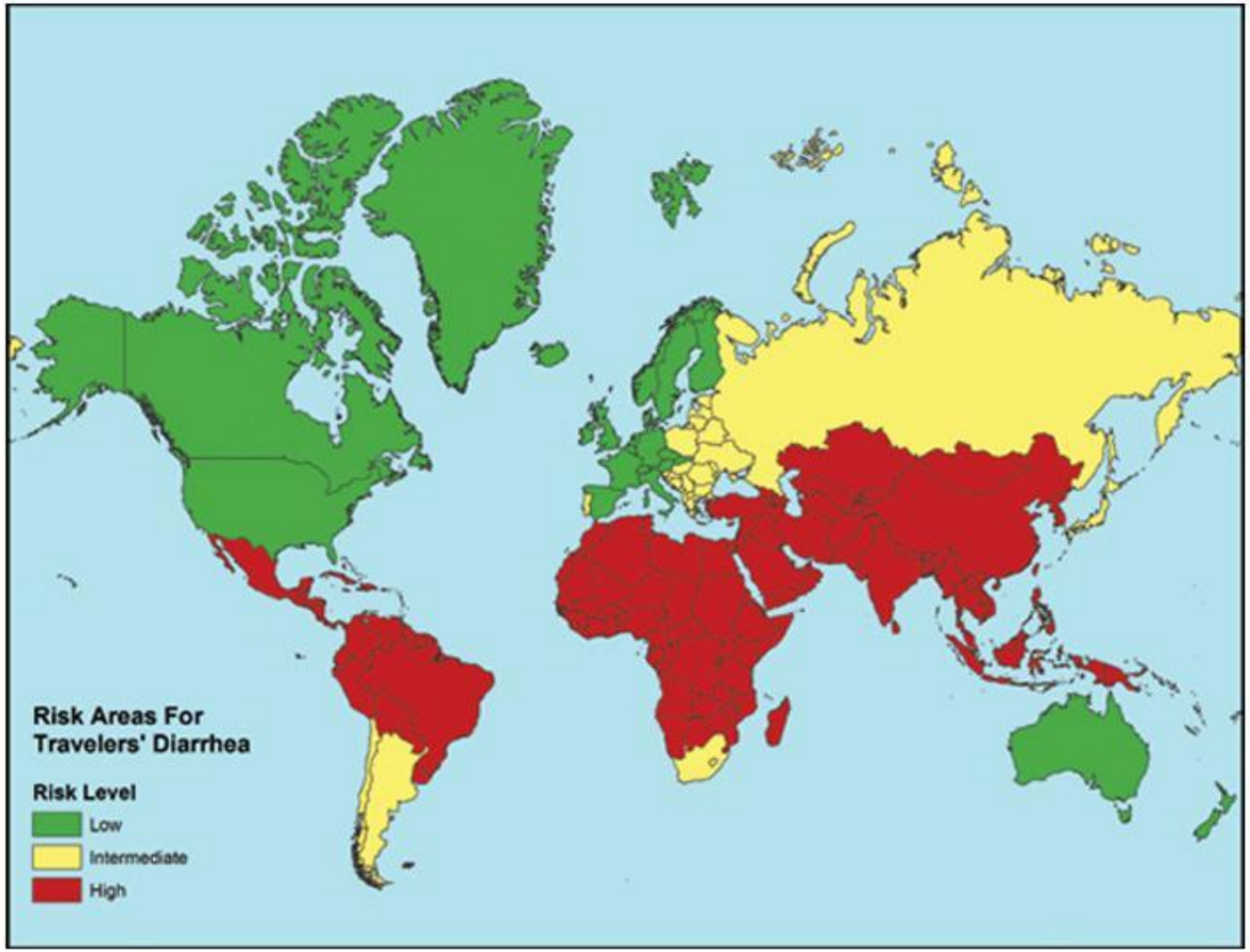
Figure 6.0


Risk Areas For
Travelers' Diarrhea
Risk Level
Low
Intermediate
High

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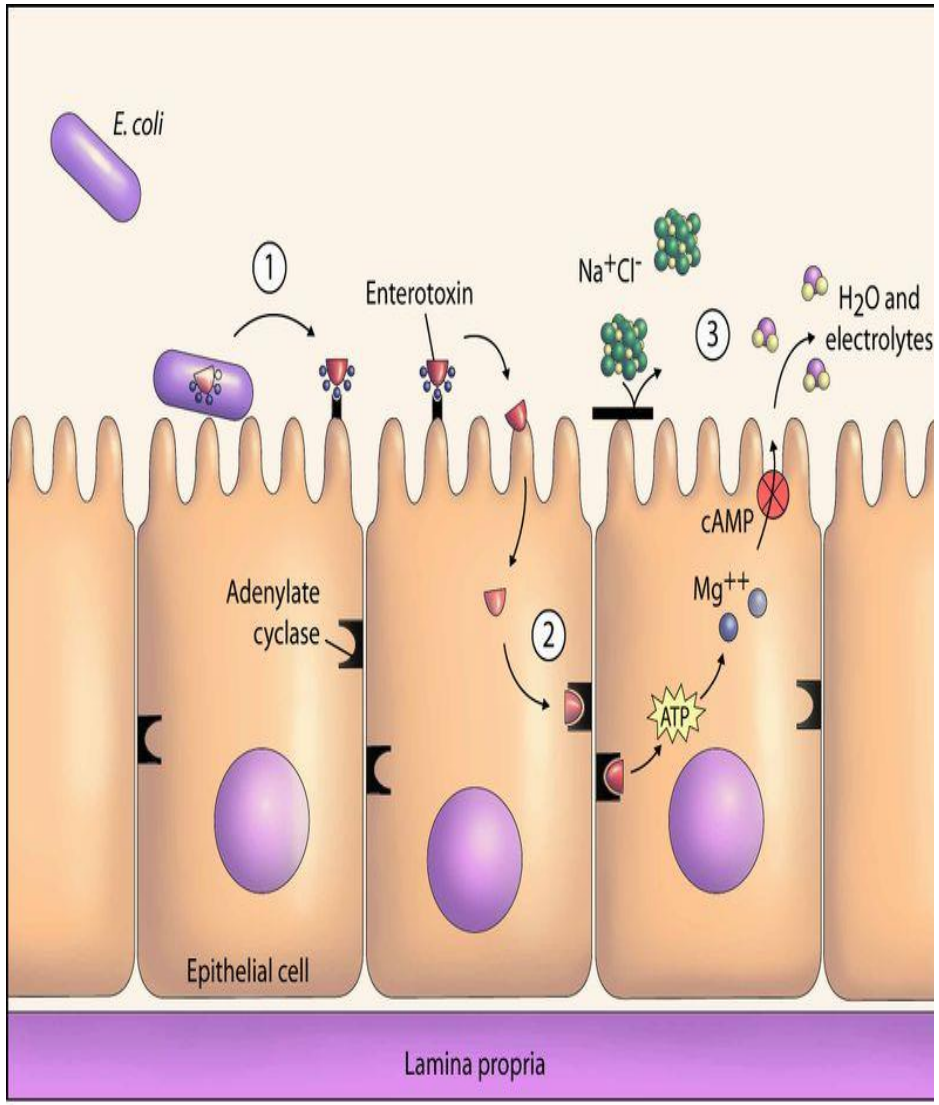
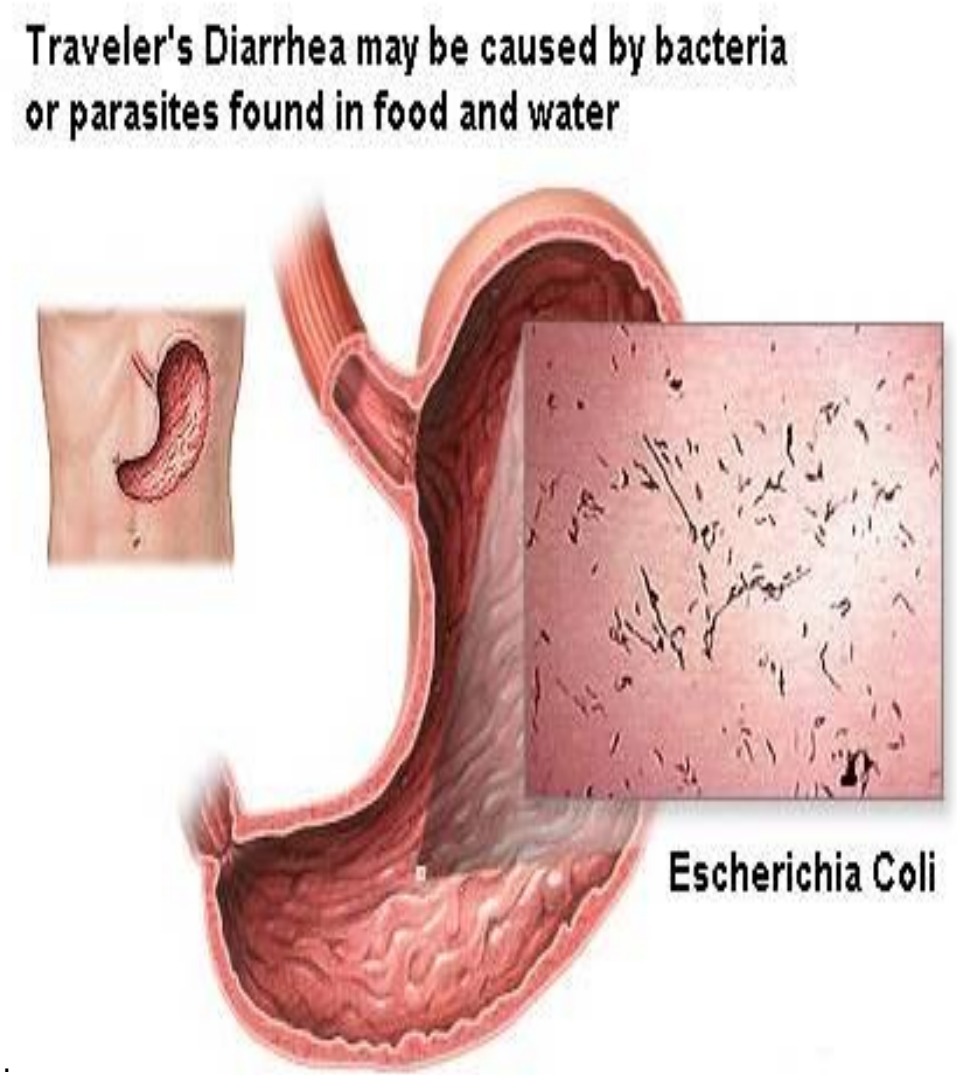
ETEC TRAVELER'S DIARRHOEA





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EIEC = ENTEROINVASIVE E.COLI

- **Resemble Shigella**
- ***Many are nonmotile, do not ferment lactose or ferment it late with only acid production, and do not form lysine decarboxylase.***

- Many of these show O antigen cross reactivity with Shigella.
- Earlier names given – Shigella alkalescens, Shigella dispar – and were grouped under Alkalescens-Dispar group.

- Named EIEC because they have the capacity to invade interstitial epithelial cells in vivo and penetrate HeLa cells in tissue culture.

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EHEC = ENTEROHAEMORRHAGIC E. COLI

- **Produce VT**
- Mild diarrhea to fatal **hemorrhagic colitis and hemorrhagic uremic syndrome (HUS)** particularly in young children and elderly.
- Primary target of VT = vascular endothelial cells.
- **O157:H7**, O26:H1 etc
- The disease may occur **sporadically or as outbreaks of food poisoning.**
- Changing lifestyle and eating habits.
- Salad vegetables such as **radish and alfalfa sprouts**, in which bacteria were found beneath the skin and in the deeper tissues.
- Diagnosis: demonstration of VT.

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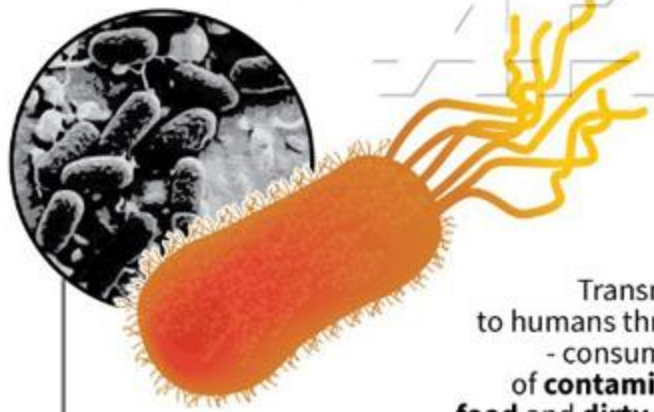
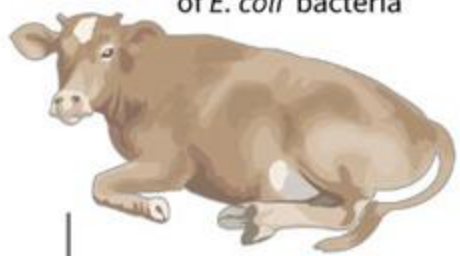
E. coli: when contamination leads to infection

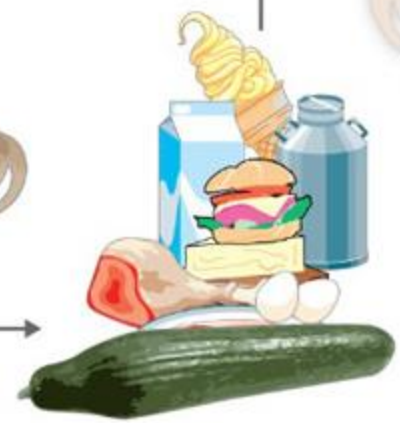
Enterohaemorrhagic Escherichia coli (Ehec)

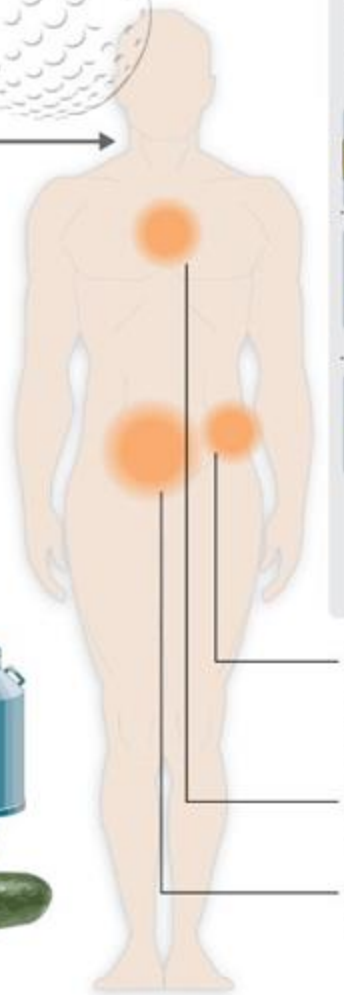


Cattle and other **ruminants** are the main source of *E. coli* bacteria



Transmitted to humans through:
- consumption of **contaminated food** and **dirty water**
- contact with an infected animal or person





Bacteria can spread from one person to another via faeces

How to avoid contamination:

- Wipe down work surfaces and kitchen utensils

- Keep hands clean, especially when touching raw meat or vegetables

- Wash vegetables and fruits well under running water
- Make sure meat is well cooked
- Bring unpasturised milk to the boil

Infection can cause acute renal failure and neurological problems (seizures, strokes)

Can also cause respiratory illness and pneumonia

Diarrhoea and in some cases bloody diarrhoea

Source: CDC/ScienceDaily

EHEC ATTACKS VASCULAR ENDOTHELIAL CELLS, ALSO PRODUCES VT

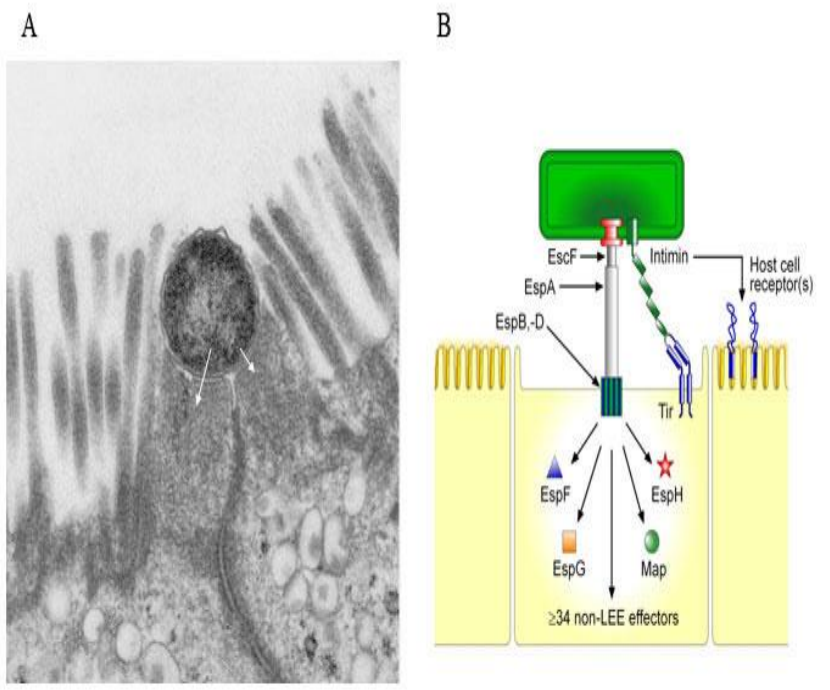
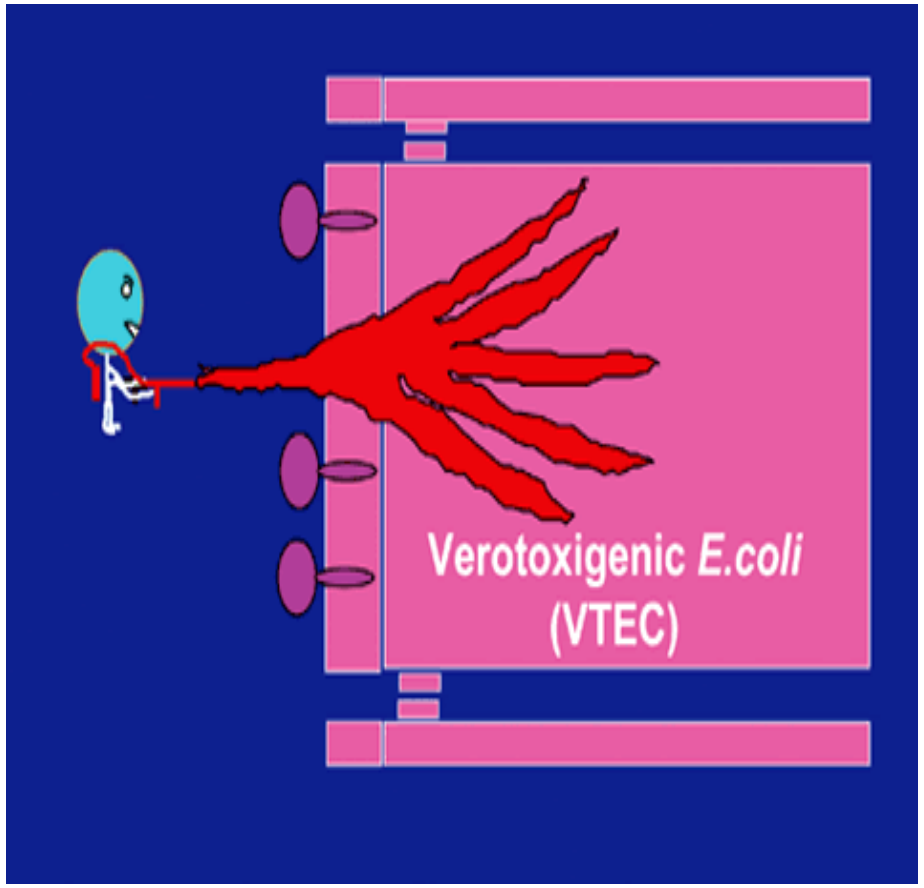


Fig. 3. Electron micrograph of a rare twin 'pedestal' (A) formed by EHEC O111 by subversion of actin dynamics following the injection of bacterial effectors into two bovine enterocytes via separate Type III secretion 'needles' (white arrows, shown schematically in B).



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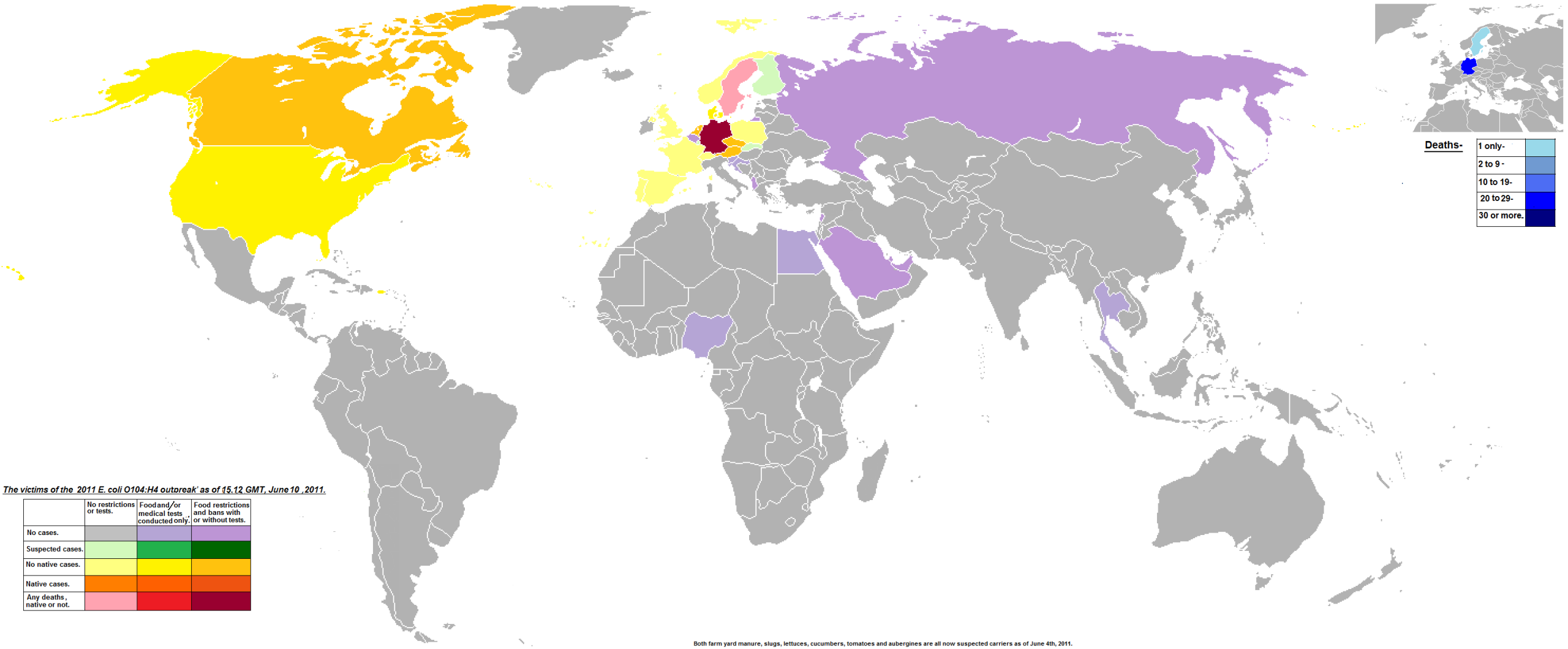

The victims of the 2011 E. coli O104:H4 outbreak' as of 15.12 GMT, June 10 , 2011.

	No restrictions or tests.	Food and/or medical tests conducted only.	Food restrictions and bans with or without tests.
No cases.			
Suspected cases.			
No native cases.			
Native cases.			
Any deaths , native or not.			

Both farm yard manure, slugs, lettuces, cucumbers, tomatoes and aubergines are all now suspected carriers as of June 4th, 2011.

EAEC = ENTEROAGGREGATIVE E.COLI

- Appear aggregated in a **stacked brick formation** on Hep-2 cells or glass.

- They have been associated with **persistent diarrhea**, especially in developing countries.

EAEC FORM STACKED BRICK LIKE FORMATION

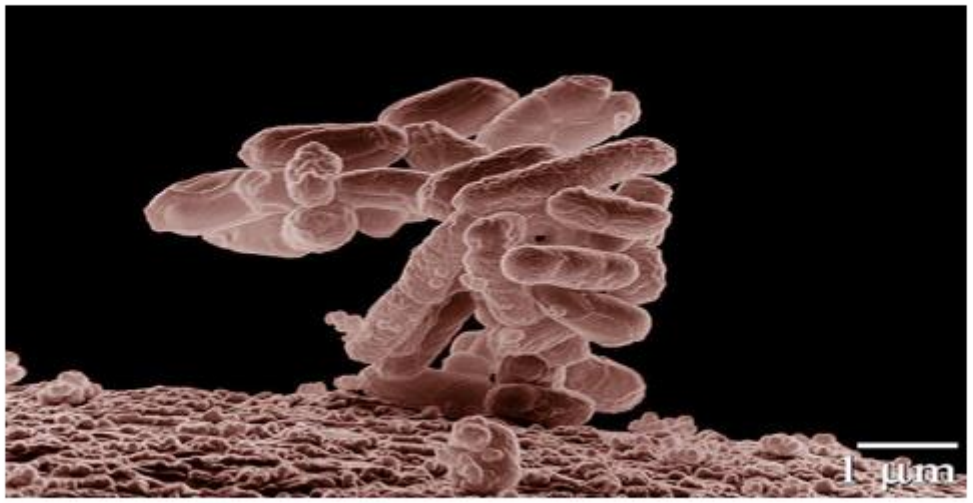

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Table 1. Some Pathogenic Groups of *E. coli*

Group	Virulence Factors and Genes	Signs and Symptoms	Diagnostic Tests	Treatment
Enterotoxigenic *E. coli* (ETEC)	Heat stable enterotoxin similar to cholera toxin	Relatively mild, watery diarrhea	Culturing, PCR	Self-limiting; if needed, fluoroquinolones, doxycycline, rifaximin, TMP/SMZ; antibiotic resistance is a problem
Enteroinvasive *E. coli* (EIEC)	*Inv* (invasive plasmid) genes	Relatively mild, watery diarrhea; dysentery or inflammatory colitis may occur	Culturing, PCR; testing for *inv*gene; additional assays to distinguish from *Shigella*	Supportive therapy only; antibiotics not recommended
Enteropathogenic *E. col i* (EPEC)	Locus of enterocyte effacement (LEE) pathogenicity island	Severe fever, vomiting, nonbloody diarrhea, dehydration; potentially fatal	Culturing, PCR; detection of LEE lacking Shiga-like toxin genes	Self-limiting; if needed, fluoroquinolones, doxycycline, rifaximin (TMP/SMZ); antibiotic resistance is a problem
Enterohemorrhagic *E. c oli* (EHEC)	Verotoxin	May be mild or very severe; bloody diarrhea; may result in HUS	Culturing; plate on MacConkey agar with sorbitol agar as it does not ferment sorbitol; PCR detection of LEE containing Shiga-like toxin genes	Antibiotics are not recommended due to the risk of HUS

PYOGENIC INFECTIONS:

- *E. coli* forms the most common cause of intra-abdominal infections, such as peritonitis and abscess resulting from spillage of bowel contents.
- Pyogenic infections in the perianal area.
- ***Neonatal meningitis***

SEPTICAEMIA:

- Blood stream invasion by *E. coli* may lead to fatal conditions like ***septic shock and systemic inflammatory response syndrome (SIDS).***

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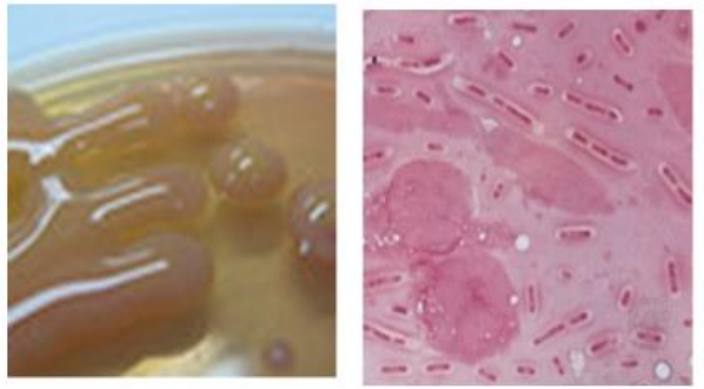
KLEBSIELLA SPP.

- *K. pneumoniae*
- *K. ozaenae*
- *K. rhinoscleromatis*
- *K. oxytoca etc.*

KLEBSIELLA

GENERAL FEATURES

LARGE DOME SHAPED MUCOID COLONIES AND CAPSULAR HALO



- Non-motile
- Capsulated
- Forms **large dome shaped mucoid colonies.**
- Short plump straight rods.
- **Capsular halo** seen prominently in gram stain.
- Commensals, saprophytes.

KLEBSIELLA PNEUMONIAE
(FRIEDLANDER'S BACILLUS, BACILLUS MUCOSUS CAPSULATUS)

- Sugar fermentation – acid + gas
- IMViC --++
- Urease +

- Second most populous member of aerobic bacterial flora of the intestine.

- Important cause of nosocomial infections.

- Pneumonia, UTI, pyogenic infections, septicemia, and rarely diarrhea.

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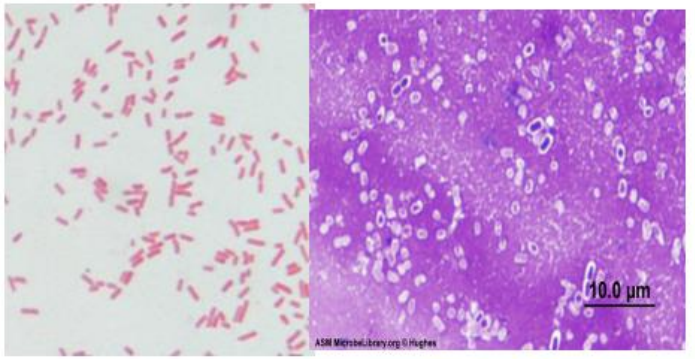
KLEBSIELLA PNEUMONIA

KLEBSIELLA - MICROSCOPY



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- Serious disease with high case fatality.
- Middle age or older persons.
- Alcoholism, chronic bronchopulmonary disease, diabetes.
- Massive mucoid inflammatory exudate of lobar or lobular distribution, involving one or more lobes of the lung.
- Necrosis and abscess formation.
- **Serotypes 1, 2, 3.**

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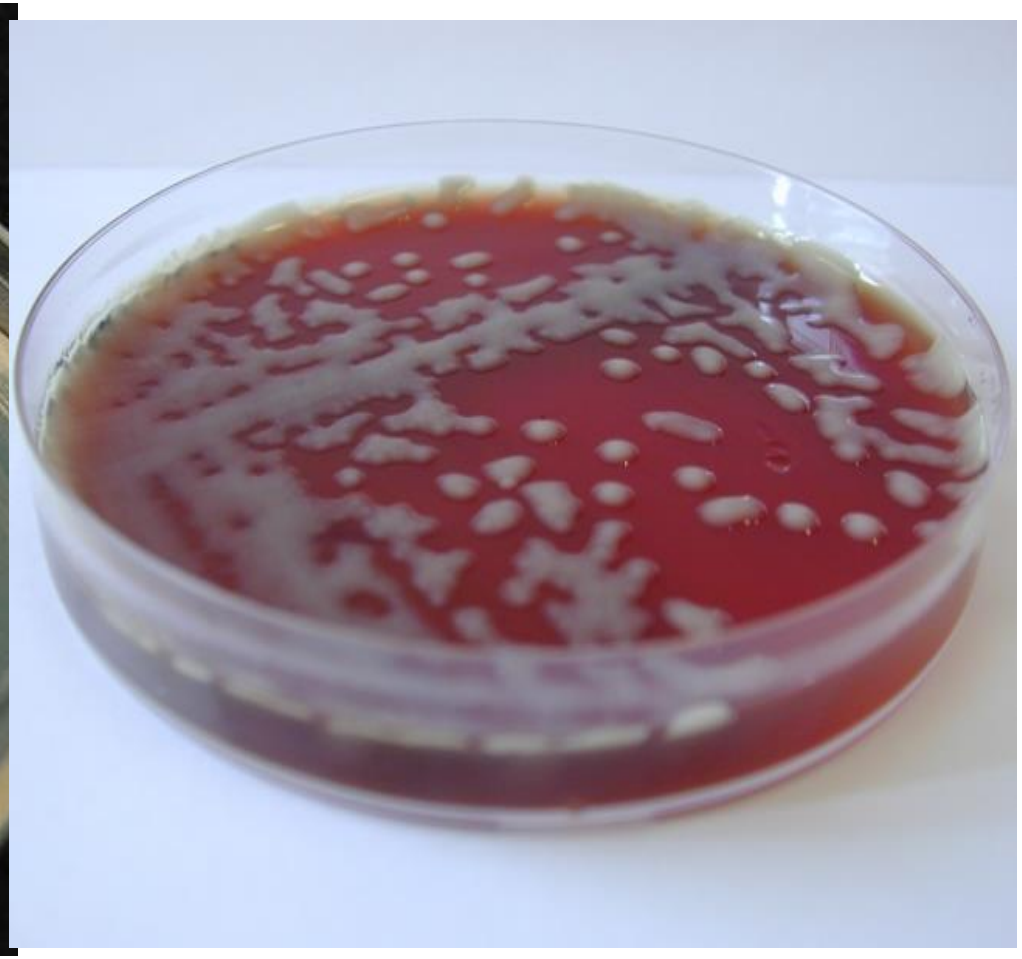
Klebsiella on Nutrient agar and Blood agar



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VIRULENCE FACTORS

- CAPSULE: Mucoid capsule is ant phagocytic and acts as a major virulence factor.

- PLASMID EXCHANGE: Klebsiella participates in exchange of plasmids with other Enterobacteriaceae. The exchange of plasmid is presumed to be the basis for two constant characteristics of Klebsiella species.

a. Antibiotic resistance

   Many strains are highly resistant to most antibiotics.

b. Toxins

   Some Klebsiella strains carry plasmids that code for toxins similar to heat labile and heat stable exotoxins of E.coli.

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CLINICAL SYNDROME

1. PNEUMONIA

- *K. pneumoniae* is found in 10% normal individuals as normal flora of respiratory tract.
- Pneumonia in diabetics, alcoholics and immunocompromised patients.
- Lung abscess

2. URINARY TRACT INFECTIONS

3. SEPTICAEMIA

4. WOUND INFECTION

5. MENINGITIS

6. EPIDEMIC DIARRHOEA – in newborns.

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LABORATORY DIAGNOSIS

- Specimen: urine, pus, blood etc. depending on the site of infection.
- Culture: It grows on MacConkey and Blood agar media. Colonies appear mucoid and pink in MacConkey agar media.
- Biochemical: they ferment glucose and lactose producing acid and gas.
- Typing: based on about 90 capsular (K) antigens there are three types – K2, K3 and K21.

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PROTEUS

- Lactose non fermenters.
- The name proteus refers to their **pleomorphism**, after the greek god proteus who could assume any shape.

- **Urease +**
- **PPA +**
- Noncapsulated, pleomorphic, motile rods.

- Weil Felix observed that flagellated strains growing on agar formed a thin surface film resembling the mist produced by breathing on glass and named this variety the Haunch form (haunch=film of breath).
- Nonflagellated strains did not form, so called Ohne Haunch.
- **Hence O = somatic antigen, H = flagellar antigen.**

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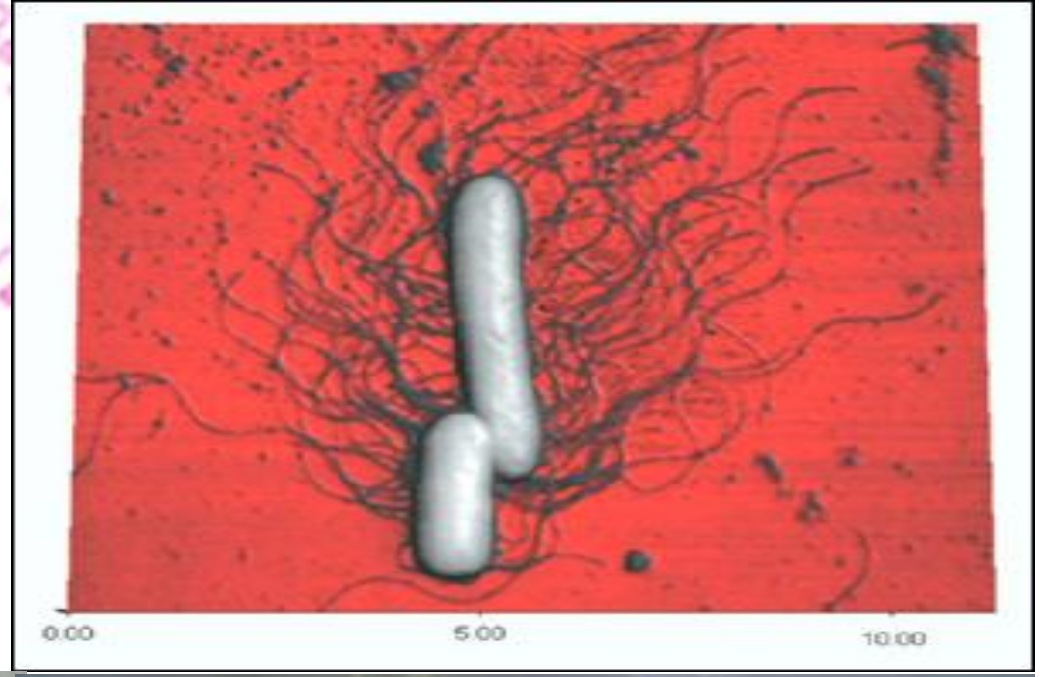
Proteus vulgaris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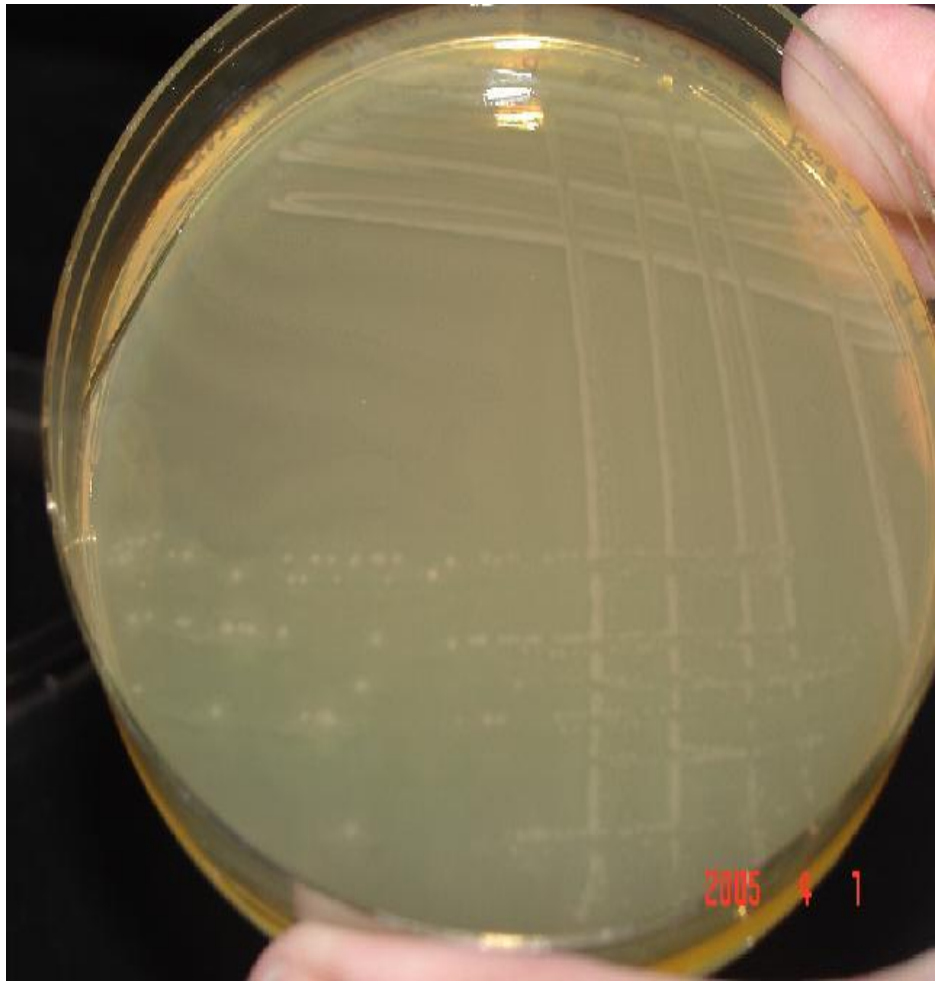
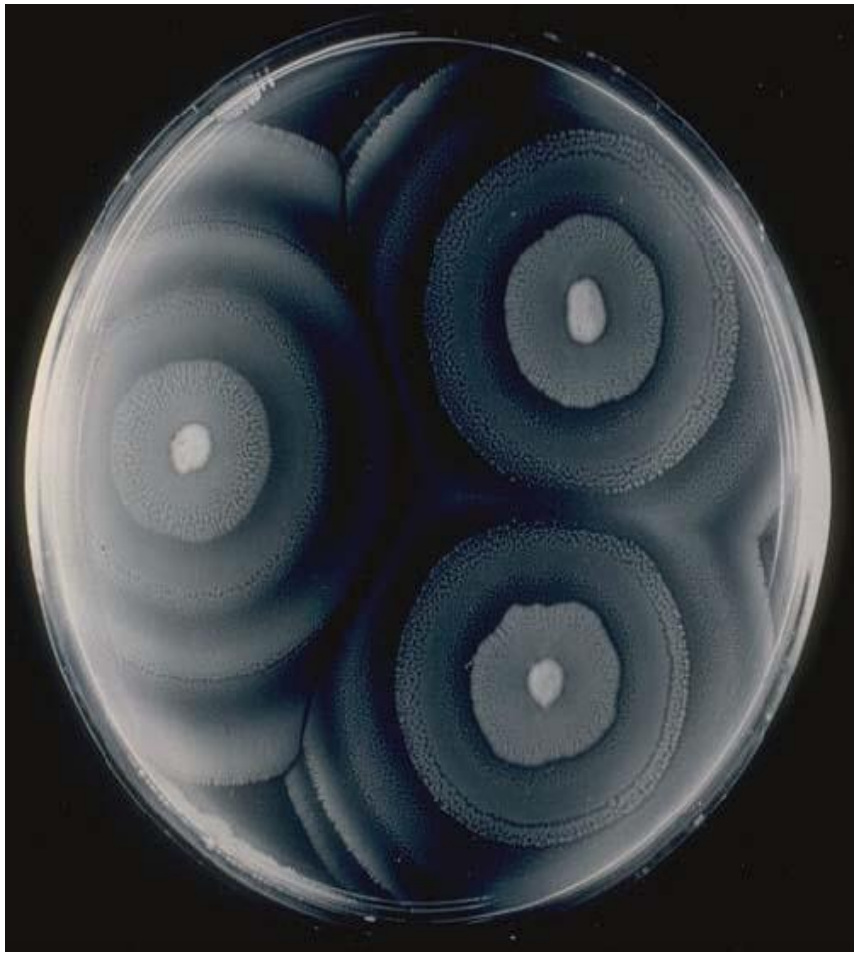
SWARMING OF PROTEUS ON NUTRIENT AGAR AND BLOOD AGAR



- **Swarming:** wavy growth, thin filmy layer in concentric circles shown by *P. vulgaris* and *P. mirabilis* in culture plates..

Swarming a Distinguishing Character in Proteus



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CLINICAL SYNDROME

- URINARY TRACT INFECTIONS
- WOUND INFECTIONS
- SEPTICAEMIA
- ACUTE OTITIS MEDIA

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WEIL FELIX REACTION

- They observed that certain nonmotile strains of proteus were agglutinated with sera from typhus fever patients.

- This heterophile agglutination due to sharing of a carbohydrate hapten by certain strains of proteus and rickettsia forms basis of weil Felix reaction for Dx of certain rickettsial infections.

- Nonmotile proteus strains **OX2, OX19 (P.vulgaris)** and **OXK (P.mirabilis)** used in agglutination test.

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QUESTIONS

- Which E.coli causes institutional outbreaks of diarrhea in small children?
- Which E.coli causes traveler's diarrhea?
- Which sample should be collected for investigating a case of Urinary tract infection?
- What is Kass' concept of significant bacteriuria?
- Which E.coli is associated with hemolytic uremic syndrome?
- Consumption of radish and alfalfa sprouts is associated with which Diarrhoeagenic E. coli?
- Describe the colony of Klebsiella pneumoniae.
- Why is proteus named so?
- Describe key biochemical characteristics of proteus.
- What is swarming?
- Which diarrhea causing E.coli is associated with dysentery?

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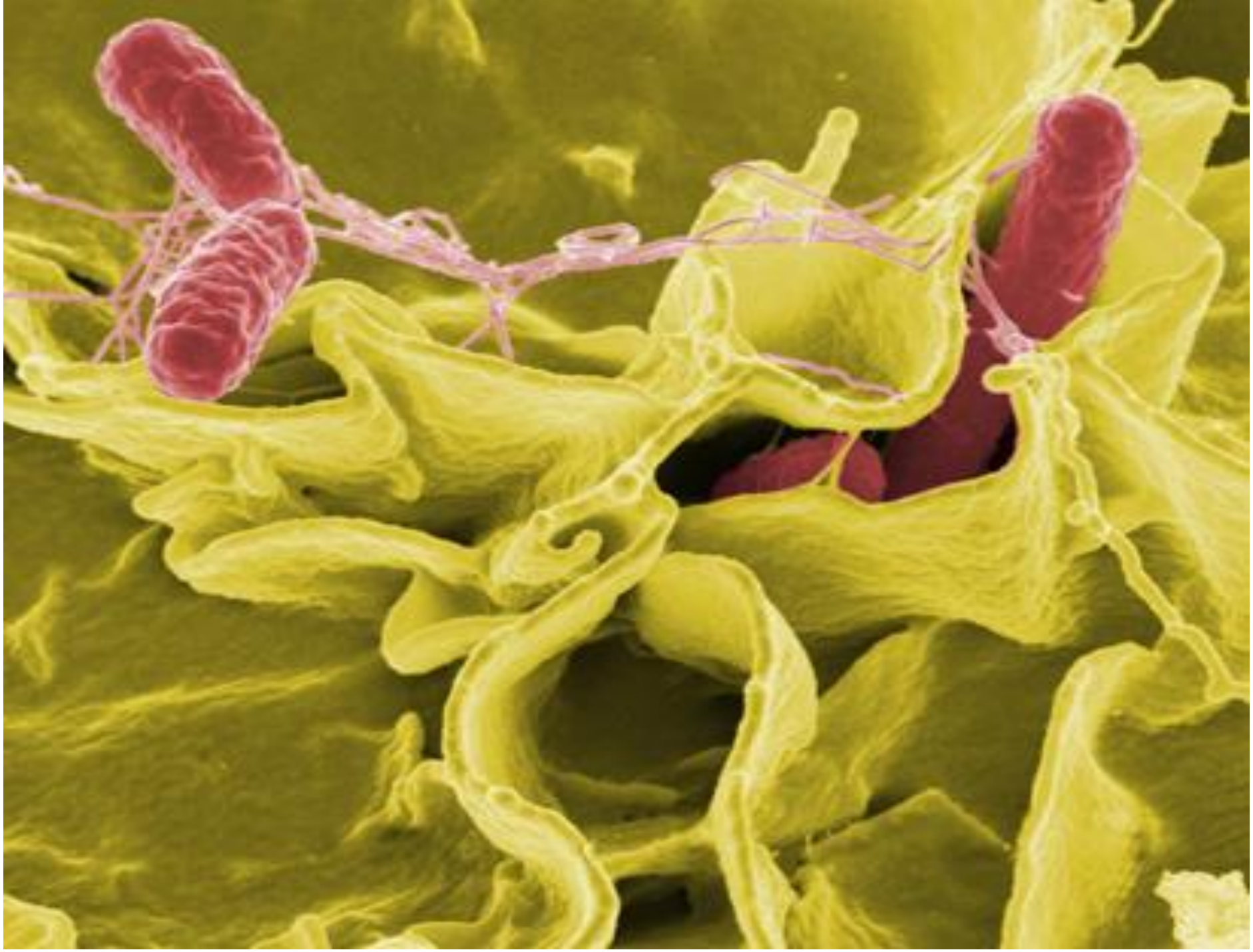
Salmonella

- This is a Gram-negative facultative rod-shaped bacterium belonging to family ***Enterobacteriaceae,***

- *Salmonellae* live in the intestinal tracts of warm and cold blooded animals. Some species are ubiquitous. Other species are specifically adapted to a particular host.

- In humans, *Salmonella* are the cause of two diseases called **salmonellosis**:
  - **enteric fever (typhoid),** resulting from bacterial invasion of the bloodstream, and
  - **acute gastroenteritis,** resulting from a foodborne infection/intoxication.



Classification

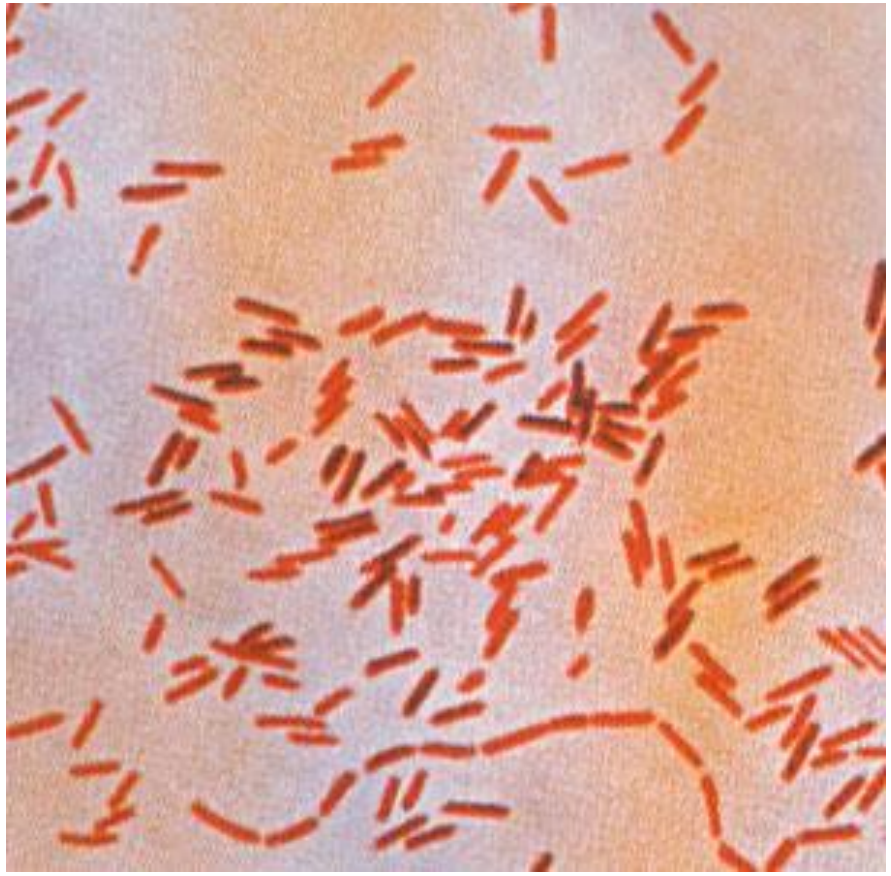
- The taxonomy of the salmonellae has been in flux for many years, and it is problematic, with more than 2463 serotypes.
- Under the current American CDC (Center for Disease Control) classification scheme there are two species: *Salmonella enterica* and *Salmonella bongori.* *S. enterica* is further divided into 6 subspecies.

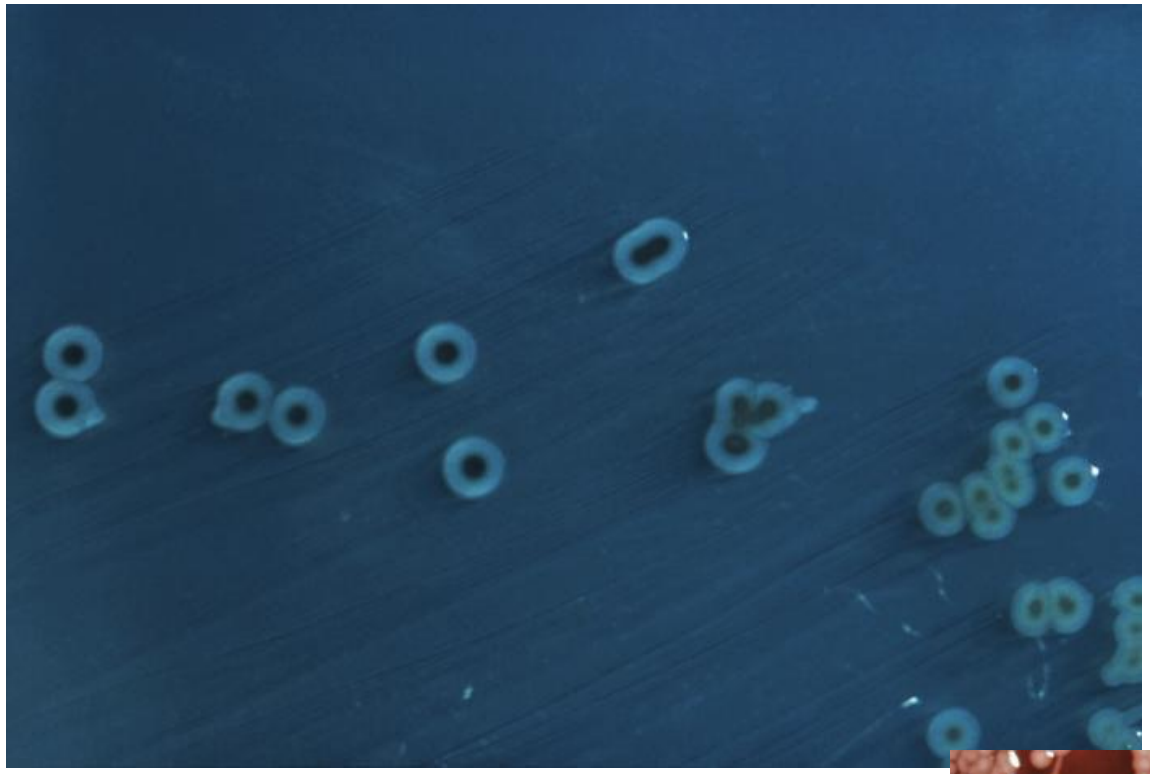
- Earlier classification system included
  - (1) the Kaufmanns-White system, which identified each serotype as an individual Salmonella species,
  - (2) the Edwards-Ewing system, which divided the salmonellae into 3 species (*S. choleraesuis, S. enteritidis, and S. typhi*) and hundred of serotypes, and
  - (3) a DNA hybridization scheme that lumped the salmonelae into two species known as *S. enteritidis* and *S. bongori.*
    - *S. enteritidis* is then subdivided this species into the subspecies *arizonae, diarizonae, enterica, houtanae, indica and salamae.*

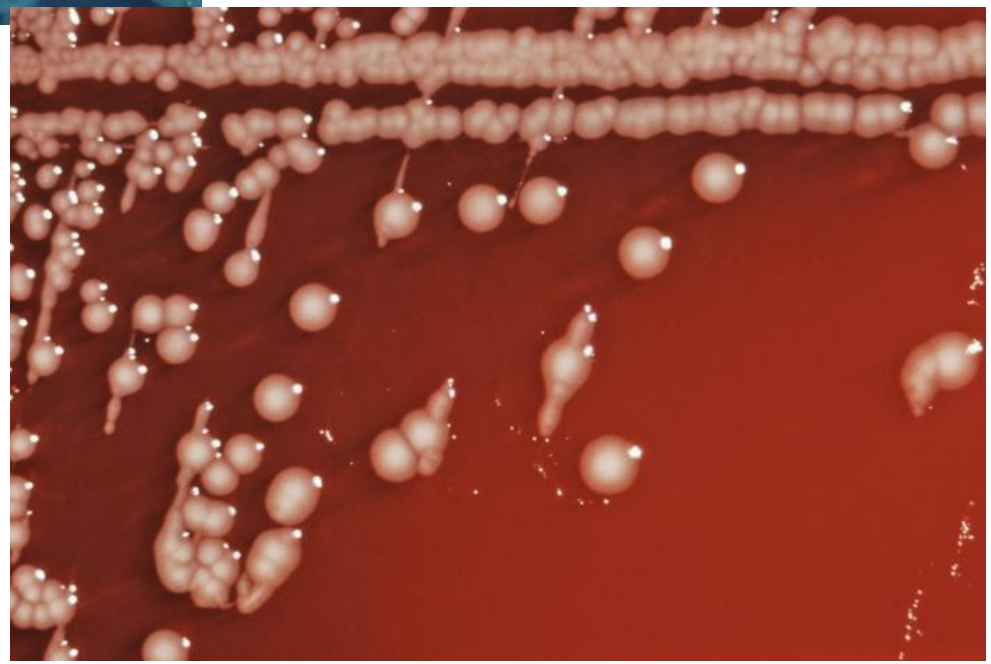
- **S. enterica** contains more than 2500 serotypes (2541 in l 2004) differentiated on the O and H- Antigens
- Salmonella serotype (serovar) Typhimurium,
- Salmonella serotype Enteritidis,
- Salmonella serotype Typhi,
- Salmonella serotype Paratyphi,
- Salmonella serotype Cholerae suis etc.

***Ex.: Salmonella enterica* subspecies *enterica* serovar Typhi or *Salmonella* Typhi**

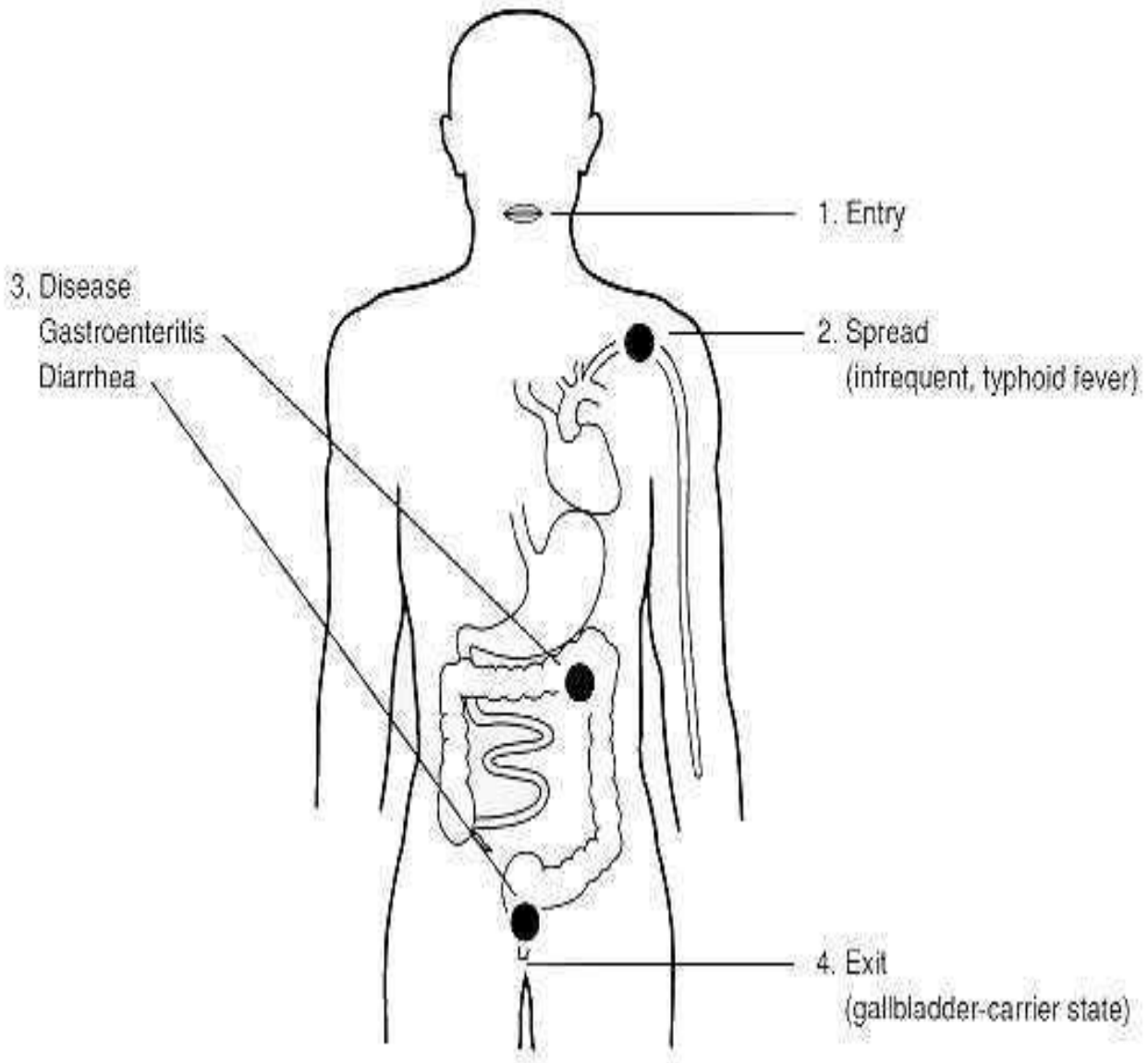
- Although the classification of salmonellae relies primarily on serotyping of surface antigens, the typhi serotype can be differentiated from other serotypes on the basis of its relatively inert biochemical behavior.
- The typhi serotype is negative for Simmons citrate, gas from glucose, acetate utilization, etc.







(2) The Salmonella infection cycle.



- Intestinal infection with salmonellae can follow one of two infection cycle. One cycle causes enteritis, other causes typhoid

(a) Enteritis.

- Most serotypes cause enteritis, an infection that is limited to the terminal ileum. The salmonellae invade the intestinal wall and produce enterotoxins that cause nausea, vomiting and diarrhea. Bacteria rarely spread beyond the gastrointestinal wall.

(b) Enteric fever (Typhoid).

- Two serotypes typhi and paratyphi can cause typhoid.
- The salmonella invade the wall of the terminal ileum and than spread to the intestinal lymphatics, where they are phagocytosed by PMNs and macrophages.
- Salmonella phagocytosed by PMNs are killed, but those phagocytosed by macrophages survive and multiply within phagocytic vacuoles.
- Wandering macrophages that contain salmonellae act as “taxicabs” that deliver salmonellae to various reticuloendothelial tissues.
- Infected macrophages are eventually destroyed and salmonellae released from lysed macrophages cause septicemia.

- Some salmonellae begin to disseminate hematogenously to a variety of ectopic sites, including the bones, lungs, liver, brain where they cause osteomyelitis, pyelonephritis, empyema, hepatic necrosis, meningitis.
- Other salmonella remain in the intestine, where they invade the gut wall and may cause ulceration, perforation and hemorrhage.
- Salmonellae multiply avidly in the gallbladder and bile, and the infected bile continues to circulate salmonellae to the intestine.
- Salmonellae also multiply well in gut associated lymphoid tissue and may ulcerate Payer’s patches

Epidemiology:

- In many countries Salmonella enteritis is the third most commonly reported form of “**food poisoning**”.
- The infection is zoonotic, and the poultry is the source of infection.
- Other sources of infection include milk products, food and water contaminated with animal feces or urine

Shigella

General Characteristics

- Coliform bacilli (enteric rods)
- Nonmotile gram-negative facultative anaerobes
- Four species
  - *Shigella sonnei* (most common in industrial world)
  - *Shigella flexneri* (most common in developing countries)
  - *Shigella boydii*
  - *Shigella dysenteriae*
- Non-lactose fermenting
- Resistant to bile salts

Epidemiology and Clinical Syndromes of Shigella

Shigellosis = Generic term for disease

- Low infectious dose (10^2-10^4 CFU)
- Humans are only reservoir
- Transmission by fecal-oral route
- Incubation period = 1-3 days
- Watery diarrhea with fever; changing to dysentery
- Major cause of bacillary dysentery (severe 2nd stage) in pediatric age group (1-10 yrs) via fecal-oral route
- Outbreaks in daycare centers, nurseries, institutions
- Estimated 15% of pediatric diarrhea in U.S.
- Leading cause of infant diarrhea and mortality (death) in developing countries

DEFINITIONS

- Enterotoxin = an exotoxin with enteric activity, i.e., affects the intestinal tract
- Dysentery = inflammation of intestines (especially the colon (colitis) of the large intestine) with accompanying severe abdominal cramps, tenesmus (straining to defecate), and frequent, low-volume stools containing blood, mucus, and fecal leukocytes (PMN's)
- Bacillary dysentery = dysentery caused by bacterial infection with invasion of host cells/tissues and/or production of exotoxins

Characteristics of Shiga Toxin

- Enterotoxic, neurotoxic and cytotoxic
- Encoded by chromosomal genes
- Two domain (A-5B) structure
- Similar to the Shiga-like toxin of enterohemorrhagic *E. coli* (EHEC)
  - NOTE: except that Shiga-like toxin is encoded by lysogenic bacteriophage

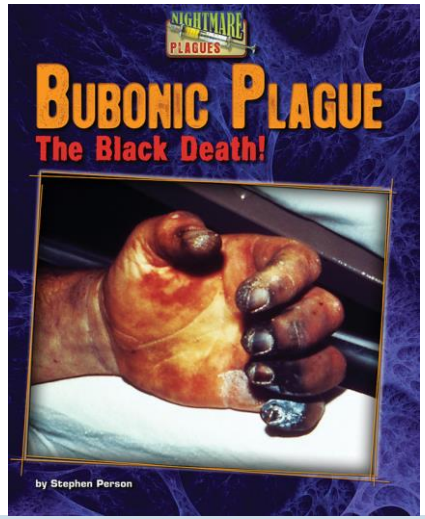
Yersinia pestis

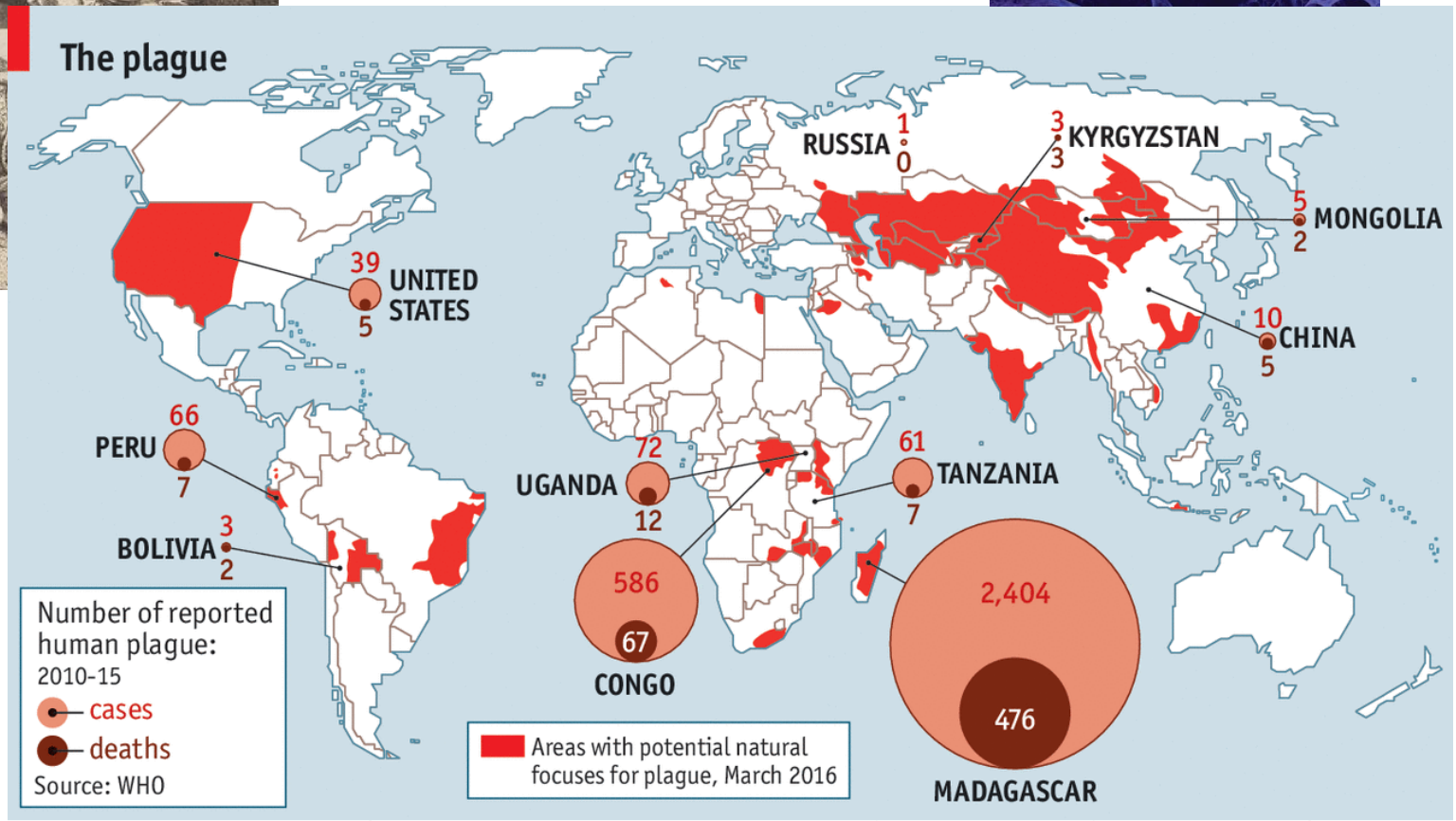
Clinical Forms of Plague (a.k.a., Black Death):

- Bubonic plague with swollen and painful axillary (arm pit) & inguinal (groin) lymph nodes (buboes)
  - Transmitted from mammalian reservoirs by flea (arthropod) bites or contact with contaminated animal tissues
- Pneumonic plaque
  - Person-to-person spread

Yersinia enterocolitica

- Enterocolitis
- Transfusion-related septicemia





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Epidemiology and History of Plague

- **<u>Zoonotic infection</u>**; Humans are accidental hosts
- Outbreaks are cyclical corresponding to rodent reservoir and arthropod vector populations
- Plague recorded more than 2000 years ago
- Three pandemics
  - 1st 542AD; 100million dead in 60 years; from N.Africa
  - 2nd 14th century; Black Death; 25million dead in Europe alone (>1/4 of entire population); from central Asia; disease became endemic in urban rat population and smaller epidemics occurred through 17th century
  - 3rd ended in 1990s; Burma to China (1894) & Hong Kong to other continents including N. America via rat-infected ships; 20million dead in India alone; foci of infection firmly established in wild rodents in rural areas
- Folk stories & nursery rhymes: *Pied Piper of Hamelin* (*Ring Around the Rosie* is “urban myth”??)

Epidemiology of Yersinia Infection

DISEASE/BACTERIAL FACTORS

Y. pestis: plague
Y. enterocolitica: enterocolitis, transfusion-related septicemia
Y. pseudotuberculosis: enterocolitis
Y. pestis: present in animal reservoir, fleas
Other *Yersinia:* present in domestic animals (GI tract) and contaminated food products
Numerous virulence factors (see Box 24-1)

TRANSMISSION

Y. pestis: spread from mammalian reservoir (rats, prairie dogs, dogs, mice, rabbits) via fleas or contact with contaminated animal tissues
Other *Yersinia:* ingestion of contaminated food products, infusion of contaminated blood products

WHO IS AT RISK?

Y. pestis: communities with endemic plague and exposure to infected animals
Y. enterocolitica: individuals eating contaminated food, recipients of contaminated blood products

GEOGRAPHY/SEASON

Y. pestis: primarily Asia and Africa
Y. pestis disease is cyclical, as reservoir population increases/decreases
Other *Yersinia:* infections worldwide but primarily in cold climates

MODES OF CONTROL

Y. pestis: control of rodent vector and improved hygiene vaccination, chemoprophylaxis
Y. enterocolitica: proper food preparation

Epidemiological Cycles of Plague

➢ Sylvatic (wild) Cycle of Plague

- Reservoir (foci) = wild rodents (prairie dogs, rabbits, mice, dogs)
- Vector = wild rodent flea

➢ Urban (domestic) Cycle of Plague

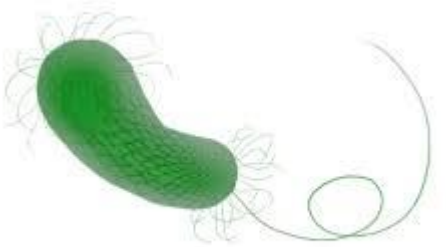
- Reservoir = domestic (urban) black rat
  - √ Over 8 million in NYC = human population
- Vector = oriental rat flea (*Xenopsylla cheopis*)

➢ Human Cycle of Plague

- Bubonic plague acquired from contact with either sylvatic or urban reservoirs or arthropod vector bite and further transmitted in human population by spread of pneumonic plague

Pathogenic Pseudomonas species

1. *Pseudomonas aeruginosa*
2. *Ps. pseudomallei*
3. *Ps. mallei*



Pseudomonas aeruginosa

May grow in :

- **Disinfectants**
- Contact lens solutions
- Medicinal solutions
- Humidifiers of respirators

PATHOGENICITY

- *P. aeruginosa is an opportunistic pathogen that infect immunocompromized patient.*
- Usually causes hard to treat nosocomial infections.
- It shows resistance to most antibiotics.

DISEASES caused by *P. aeruginosa include:*

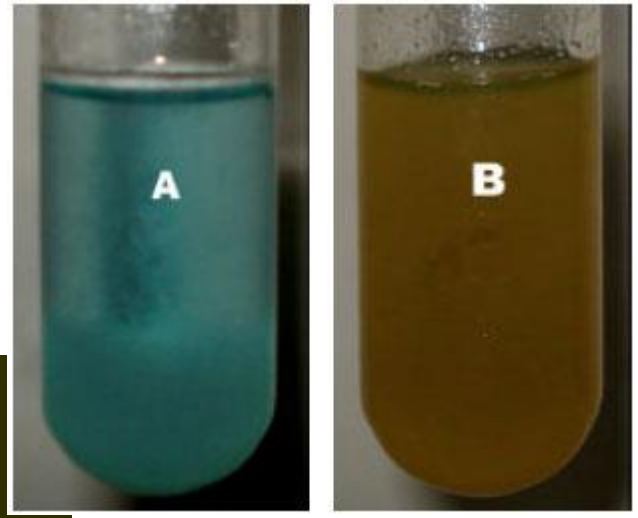
1. Urinary tract infection (UTI)
2. Otitis media
3. Wound infection
4. Sinus infection
5. Bronchopneumonia
6. Sepsis
7. Burn infectio
8. Meningitis
9. Endocarditis

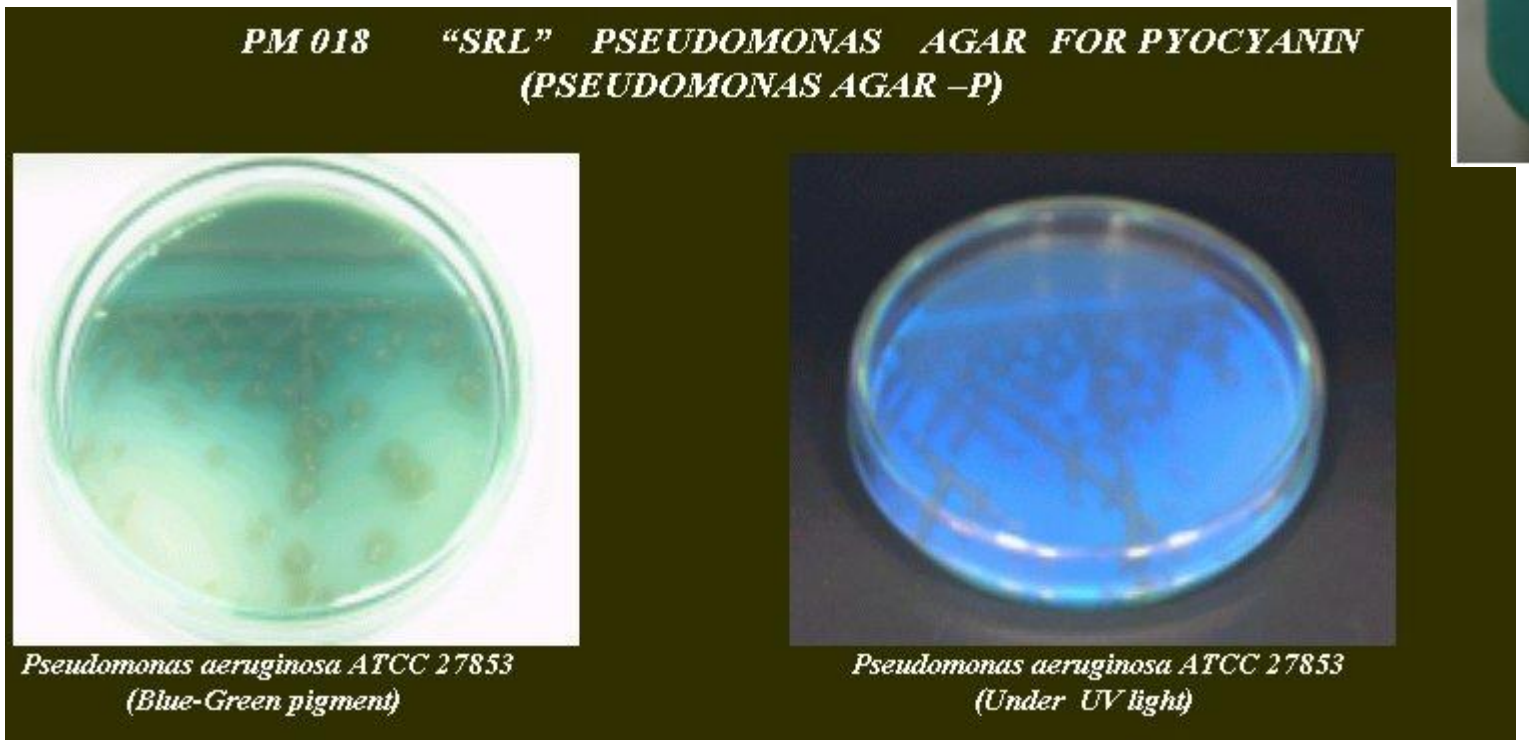



Biochemical tests

GENUS	OXIDASE	GLUCOSE OX.	FLAGELLA
Pseudomonas	V	V	Polar
Achromobacter	+	+	Peritrichous
Flavobacterium	+	+	None
Kingella	+	+	None
Brucella	+	V	None
Alcaligenes	+	-	Peritrichous
Bordetella	V	-	(V) peritrichous
Moraxella	+	-	None
Acinetobacter	-	V	None

Pyocin: Pyocin is an antibiotic produced by *Pseudomonas aeruginosa* that can inhibit the growth of other bacterial species. This test is less commonly used.






THANK
YOU