I. **Enterobacteriaceae** (enteric = intestine) “Enterics”

- Enterics are ubiquitous in nature
- Except for few, most are present in the intestinal tract of animals and humans as commensal flora; therefore, they are sometimes call “fecal coliforms”
- Some live in water, soil and sewage

Family *Enterobacteriaceae* often referred to as “enterics”:

- Gram negative bacilli or coccobacilli
- Non-spore forming
- Colony morphology on BAP of little value, as they look the same, except for *Klebsiella*
- Selective and differential media are used for initial colony evaluation (ex. MacConkey, HE, XLD agars)

:Four major features

(All ferment glucose (dextrose

(All reduce nitrates to nitrites (NO_3 to NO_2 or all the way to N_2

All are oxidase negative

All except Klebsiella, Shigella and Yersinia are motile by peritrichous flagella

II. *Pseudomanas*- NOT *Enterobacteriaceae*

Gram-negative rods

oxidase-positive (cytochrome *c* oxidase; part of the electron transport chain)

respire only; not fermentative

polar flagella

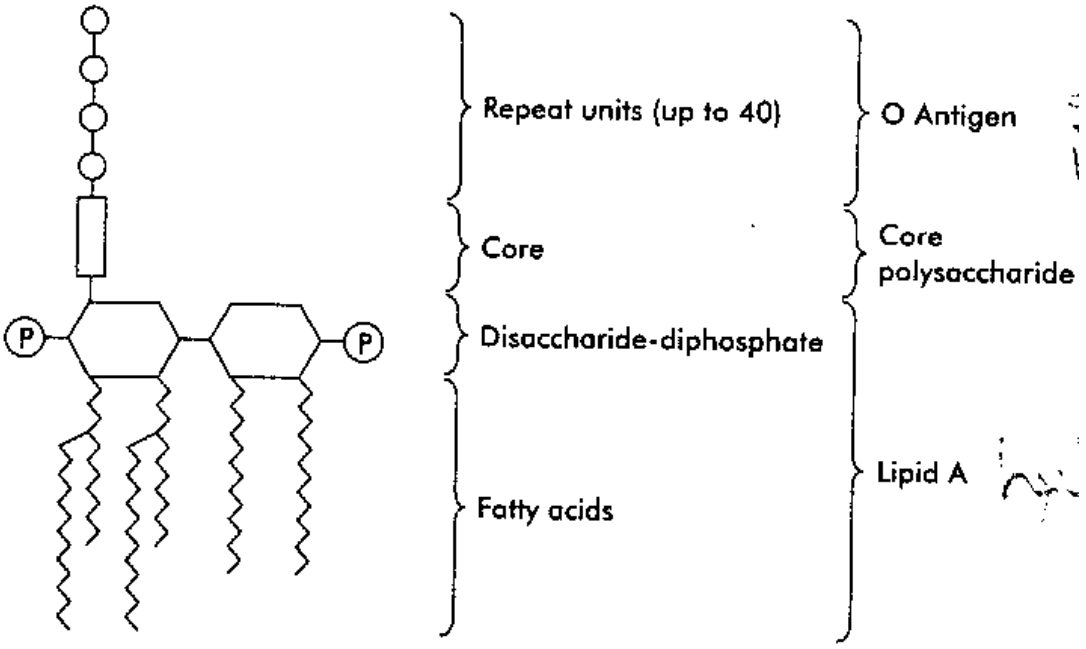
(may produce a green water soluble pigment)

(colonies often develop a distinct sheen with age)

(ubiquitious; *P. aeruginosa* is major cause of nosocomial infections, UTIs, wounds, pneumonia).

EXOTOXIN	ENDOTOXIN
Released from the cell before .1 or after lysis	Integral part of cell wall .1
Protein .2	Endotoxin is LPS; Lipid A is toxic .2 component
Heat labile .3	Heat stable .3
Antigenic and immunogenic .4	Antigenic; ??immunogenicity .4
Toxoids can be produced .5	Toxoids cannot be produced .5
Specific in effect on host .6	Many effects on host .6
Produced by gram-positive and gram-negative organisms .7	Produced by gram-negative organisms only .7

Structure of Lipopolysaccharide



Representative genera ***that are Medically Important*** **Enterobacteriaceae**

*E. coli (**Escherichia**)*

.***Klebsiella*** spp

.***Morganella*** spp

.***Proteus*** spp

.***Salmonella*** spp

.***Shigella*** spp

Enterobacter

Citrobacter

.***Serratia*** spp

Yersinia spp.

Culture methods

blood agar
selective/differential medium
MacConkey

on Mac
lac+ --> coliform

E. coli
Klebsiella
Enterobacter

lac- ---> other enteric

Pseudomonas

Biochemical test

Voges-proskauer - butanediol pathway of fermentation

Motility

Indole - breakdown of tryptophan to produce indole

Citrate - use of citrate as a sole carbon source

Glucose

Lactose

Urea

TSI - glucose fermentation; lactose and/or sucrose fermentation; gas production; H2S production

Virulence and Antigenic Factors of Enterics

Ability to colonize, adhere, produce various toxins and invade tissues

Some possess plasmids that may mediate resistance to antibiotics

Many enterics possess antigens that can be used to identify groups

O antigen – somatic, heat-stable antigen located in the cell wall -

H antigen – flagellar, heat labile antigen -

-K antigen – capsular, heat-labile antigen

Based on clinical infections produced, enterics are divided into two :categories

Opportunistic pathogens – normally part of the usual intestinal flora that may produce infection outside the intestine

Primary intestinal pathogens – *Salmonella*, *Shigella*, and *Yersinia* sp

Escherichia coli

Most significant species in the genus

Important potential pathogen in humans

Common isolate from colon flora

Positive indole and methyl red tests

Simmons citrate negative

Voges-Proskauer test negative

Does NOT produce H_2S

Usually motile

Dry, pink (lactose positive) colony with surrounding pink area on MacConkey

●I**nfections**

Diseases

Bacteremia (most commonly isolated gram-negative rod) , **-** primarily from a genitourinary tract infection or a gastrointestinal .source

Urinary tract infection (most common cause of bacterial UTIs); **-** limited to bladder (cystitis) or can spread to kidneys (pyelonephritis) (or prostate (prostatitis

Gastroenteritis At least five different pathogenic groups cause **-** gastroenteritis (EPEC, ETEC, EHEC, EIEC, EAEC); most cause diseases in developing countries, although EHEC is an important cause of hemorrhagic colitis (HC) and hemolytic uremic syndrome ((HUS

Neonatal meningitis (usually with strains carrying the K1 **-** capsular antigen)*. E. coli* is one of the most common causes of septicemia and meningitis among neonates; acquired in the birth canal before or during delivery

(**Intraabdominal infections** (associated with intestinal perforation **-**

Most infections are endogenous

Gastrointestinal Infections

Enteropathogenic (EPEC) – primarily in infants and children; outbreaks in hospital nurseries and day care centers; stool has .mucous but not blood

Enterotoxigenic (ETEC) – "traveler's diarrhea"; watery diarrhea without blood; self-limiting; usually not identified

Enteroinvasive (EIEC) – produce dysentery with bowel penetration, invasion and destruction of intestinal mucosa; .watery diarrhea with blood

Enterohemorrhagic (EHEC serotype 0157:H7) – associated with hemorrhagic diarrhea and hemolytic-uremic syndrome (HUS), which includes low platelet count, hemolytic anemia, and kidney failure; potentially fatal, especially in young children; undercooked hamburger and unpasteurized milk .have spread the infection

Enteroaggregative (EAEC) – cause diarrhea by adhering to the mucosal surface of the intestine; watery diarrhea; symptoms may persist for over two weeks

Klebsiella species

Usually found in GI tract

Four major species, *K. pneumoniae* is mostly commonly isolated species

Possesses a polysaccharide capsule, which protects against phagocytosis and antibiotics AND makes the colonies moist and mucoid

Has a distinctive "yeasty" odor

Frequent cause of nosocomial pneumonia

Enterobacter species

Comprised of 12 species; *E. cloacae and E. aerogenes* are most common

Isolated from wounds, urine, blood and CSF

Major characteristics

Colonies resemble *Klebsiella*

Motile

MR negative; VP positive

Serratia species

Seven species, but *S. marcescens* is the only one clinically important

Frequently found in nosocomial infections of urinary or respiratory tracts

Implicated in bacteremic outbreaks in nurseries, cardiac surgery, and burn units

Fairly resistant to antibiotics

Major characteristics

Ferments lactose slowly

Produce characteristic pink pigment, especially when cultures are left at room temperature

Proteus

All are normal intestinal flora

Opportunistic pathogens

All are lactose negative

P. mirabilis and *P. vulgaris* are widely recognized human pathogens

Isolated from urine, wounds, and ear and bacteremic infections

Both produce swarming colonies on non-selective media and have a distinctive “burned chocolate” odor

Both are strongly urease positive

”It exhibits characteristic “swarming

Salmonella

Enrichment broth:Tetrathionat, selenit broth

Selective media: MacConkey, SS agar, Hektoen Enteric Agar, Bismuth sulfide agar

(Human (S.Typhi, S. paratyphi

(-) Citrate

Vi antigen positive

Gas from glucose negative

Tolerant to acids in phagocytic vesicles •

Can survive in macrophages and spread from the intestine to other • (body sites (particularly true of *S. typhi*

Endotoxin •

Most infections are acquired by eating contaminated food products •

Direct fecal-oral spread in children •

S. typhi and *S. paratyphi* are strict human pathogens •

Individuals at risk for infection include those who eat improperly cooked • poultry or eggs, patients with reduced gastric acid levels, and immunocompromised patients

Infections occur worldwide, particularly in the warm months of the year •

Clinical Manifestations

Gastroenteritis -

Enteric fever -

- Bacteremia and vascular infections

Carrier state -

(Asymptomatic colonization (primarily with *S. typhi* and *S. paratyphi*

Enteric fever (also called typhoid fever [*S. typhi*] or paratyphoid fever [*S.* .([*paratyphi*

Incubation 5-21 days

Fever, relative bradycardia, leukopenia, anemia, constipation, rose spots

Neuropsychiatric manifestations

Mortality rate was 10-15% in preantibiotic era

Bacteremia (most commonly seen with *S. typhi, S. paratyphi, S.* (*choleraesuis,* and *S. enteritidis, S.dublin*

Carrier state S.typhi %1-4, nontyphi Salmonella %0.2-0.6, no symptoms

Diagnosis

Culture

Stool, urine ,blood, rose spots, bone marrow

Selective media

Typhoid fever 1.week blood culture

week stool culture .3≤

Widal

Anti-O Ab

Anti-H Ab

(Anti-Vi Ab (Long term carriers

Diagnosis of typhoid fever

Blood cultures are positive during the first week and after the second week

Stool cultures and sometimes urine cultures are positive after the second .week

The Widal test is a serological test for antibodies against Salmonella typhi. .One looks for a 4-fold rise in titer between acute and convalescent stages

of those infected become short term carriers and a smaller % become 10% long-term carriers due to persistence of the bacteria in the gallbladder or **.**urinary bladder

Shigella

S. dysenteriae, Shigella flexneri, Shigella boydii, and *Shigella sonnei*

S. sonnei is the most common cause of shigellosis in the industrial .(world(developed contries

.*S. flexneri* is the most common cause in developing countries

*:*They are very much like *Escherichia*

Nonmotile -

Noncapsulated -

H2S negative -

Endotoxin and genes for adherence, invasion, and intracellular • replication

Permeability barrier of outer membrane •

Exotoxin (Shiga toxin) is produced by *S. dysenteriae;* disrupts protein synthesis and produces endothelial damage

Hemolytic colitis (HC) and hemolytic uremic syndrome (HUS) associated with *Shigella*

Humans are only reservoir for these bacteria

Disease spread person to person by fecal-oral route

Patients at highest risk for disease are young children in daycare centers, .nurseries, male homosexuals

.(Relatively few organisms can produce disease (highly infectious

.Disease occurs worldwide with no seasonal incidence

(Gastroenteritis (shigellosis

Most common form is an initial watery diarrhea progressing within 1 to 2 (days to abdominal cramps and tenesmus (with or without bloody stools

Asymptomatic carriage develops in a small number of patients (reservoir (for future infections

A severe form of disease is caused by *S. dysenteriae* (bacterial ,dysentery). Bloody diarrhae containing mucus

Yersinia

Y. pestis, Yersinia enterocolitica, Yersinia pseudotuberculosis

Y. pestis is covered with a protein capsule, *it causes* systemic disease with a high mortality, *Capsule on Y. pestis is antiphagocytic*

Y. pestis is also resistant to serum killing, Yersinia with genes for adherence, cytotoxic activity, inhibition of phagocytic migration and engulfment, and inhibition of platelet aggregation

Y. pestis is a zoonotic infection with humans the accidental host; natural reservoirs include rats, squirrels, rabbits, and domestic animals

Disease is spread by flea bites or direct contact with infected tissues or person to person by inhalation of infectious aerosols from a patient with .pulmonary disease

Other *Yersinia* infections are spread through exposure to contaminated • *(*food products or blood products *(Y. enterocolitica*

Y. pestis causes bubonic plague (most common) and pulmonary plague, both having a high mortality rate

Other *Yersinia* species cause gastroenteritis (acute watery diarrhea or chronic diarrhea) and transfusion-related sepsis

All *Yersinia* infections are zoonotic

***Yersinia enterocolitica* and *Y. pseudotuberculosis* – clinical significance**

Both are acquired by ingestion of contaminated food or .water

Y. enterocolitica is a common cause of human disease, whereas, *Y. pseudotuberculosis* is mainly a disease of .other animals

Both cause a disease involving fever and abdominal
.pain. Y. enterocolitica also causes a watery diarrhea