

Urinary Tract Infections (UTI)

part (1)

Urogenital Tract Module

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Outlines

- Introduction
- Urinary Tract Defences
- Urinary tract infections pathophysiology
- Etiology
 - Pathogens: *E. coli*, *S. saprophyticus*, *P. mirabilis*, *K. pneumoniae*
 - Predisposing factors

Introduction

- Urinary tract infections (UTIs) are infections in any part of urinary system - the urethra, bladder, ureters, kidneys or prostate.
- UTIs are the most common outpatient infections.
- Between 50% and 60% of adult women will have at least one UTI in their life.
- 10% of postmenopausal women indicate that they had a UTI in the previous year.

Urinary Tract Defences

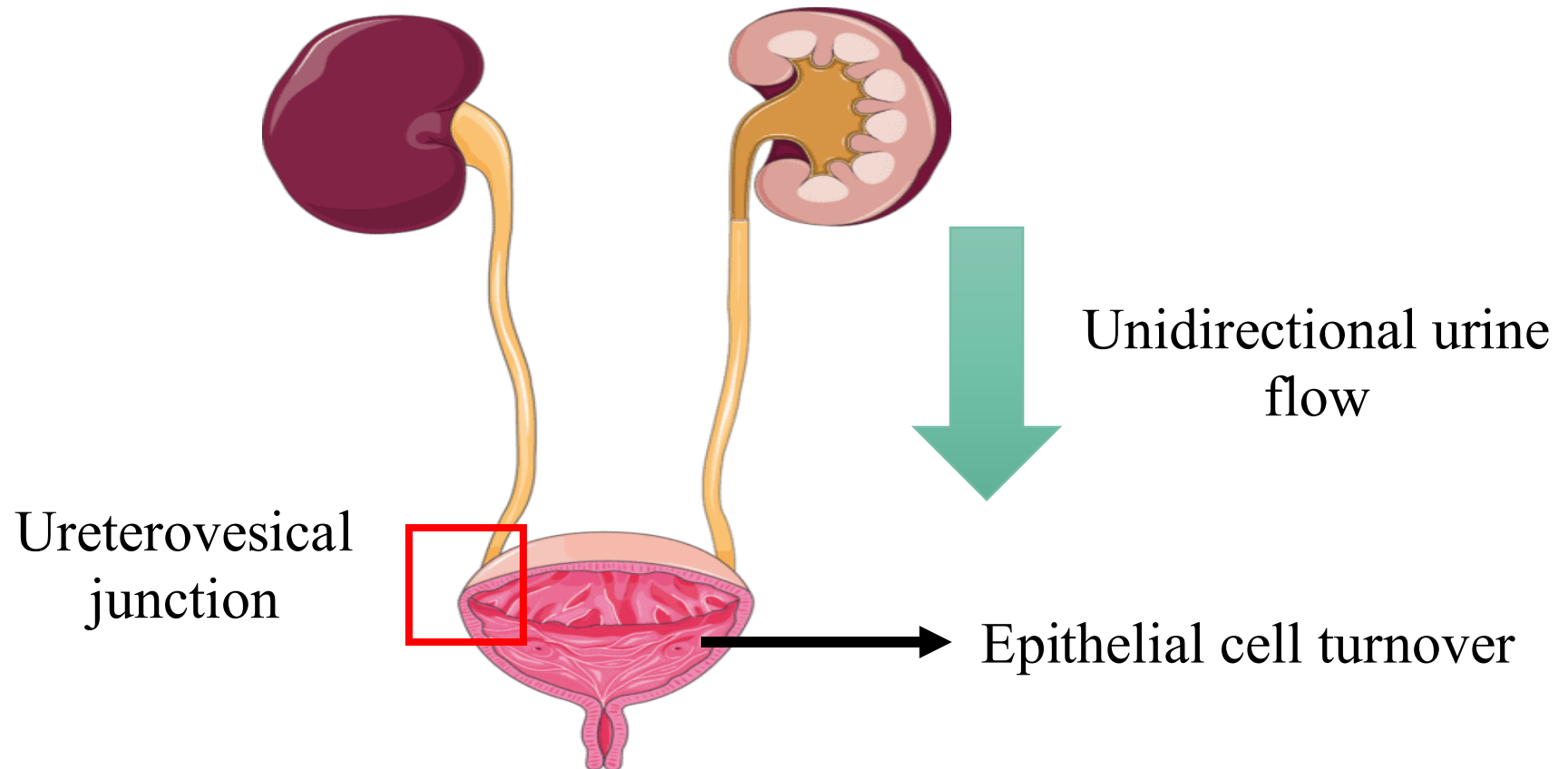
- The urinary tract is typically **a sterile environment**.
- Urinary tract employ several anatomical, physiological, and immunological defences to combat harmful microbes.

A. Anatomical and Mechanical Defences

- Unidirectional urine flow: The bulk flow of urine can work to rinse away non-attached or weakly adherent microbes from the bladder surface
- Ureterovesical junction prevents vesicoureteral reflux
- Epithelial cell turnover: shedding of infected cells

Urinary Tract Defences

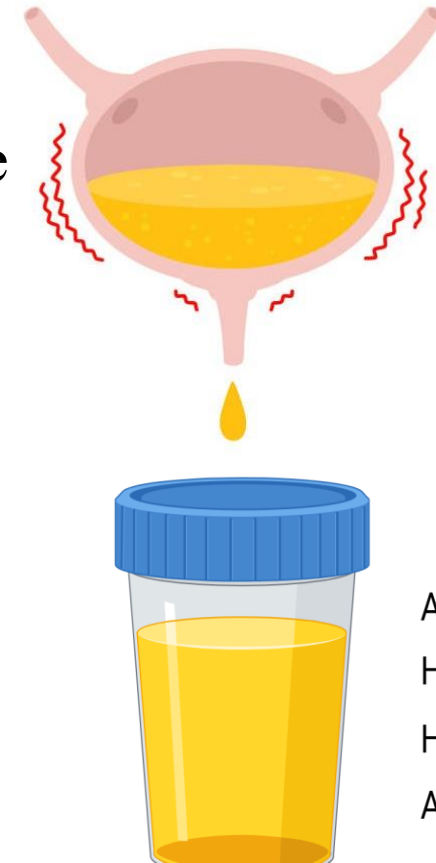
A. Anatomical and Mechanical Defences



Urinary Tract Defences

B. Physiological and biochemical defences

- Frequent urination and high urinary volumes also reduce the risk of UTIs.
- The mucus layer lining the bladder wall serves as a mechanical barrier to bacterial invasion.
- Urine properties: **Acidic pH**, **High osmolality** and **urea concentration** → **unfavourable conditions** for bacteria
- Antimicrobial peptides: Urothelial cells produce antimicrobial peptides and proinflammatory cytokines protecting the bladder from infections



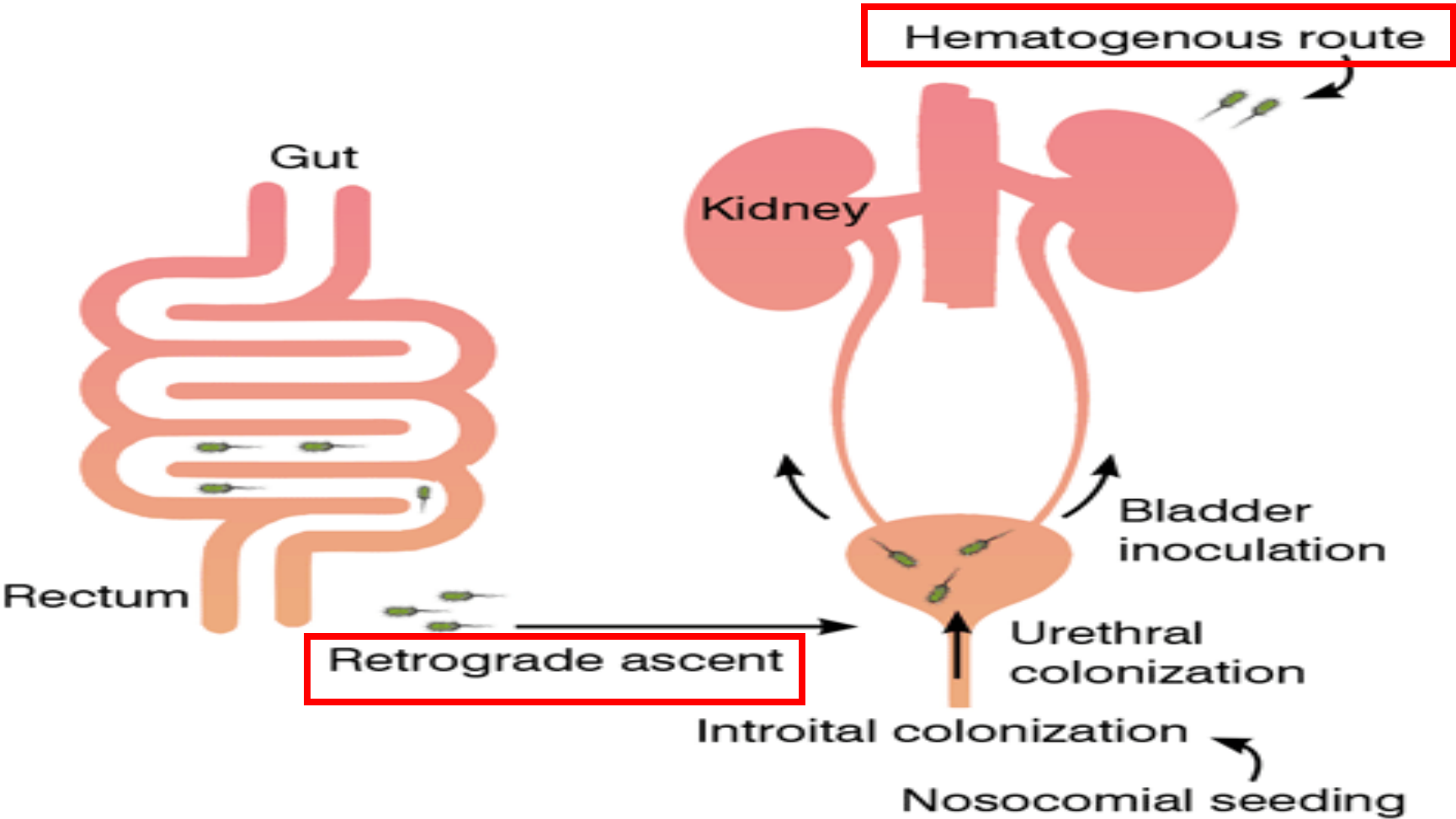
Acidic PH
High osmolality
High urea concentration
Antimicrobial peptides

Urinary Tract Defences

C. Immune response

- Innate Immune Responses: Urothelial cells express Toll-like receptors that detect uropathogens like *E. coli*, initiating immune responses (Pattern Recognition Receptors (PRRs))
- Adaptive Immune Responses: plasma cells produce secretory IgA that binds to pathogens, preventing their adhesion and facilitating their removal via urine.

Pathophysiology



Pathophysiology

There are two potential routes:

Ascending infection

- Uropathogens (most commonly **faecal flora**) colonize periurethral area → ascend to bladder via urethra
- If pathogen reaches kidney via ureter → pyelonephritis or upper UTI

Hematogenous infection

- Hematogenous pyelonephritis occurs most often in debilitated patients who are either chronically ill or receiving immunosuppressive therapy.
- Metastatic **staphylococcal** or **candidal** infections of the kidney may follow bacteraemia or fungemia, spreading from distant foci of infection in the bone, skin, or elsewhere.

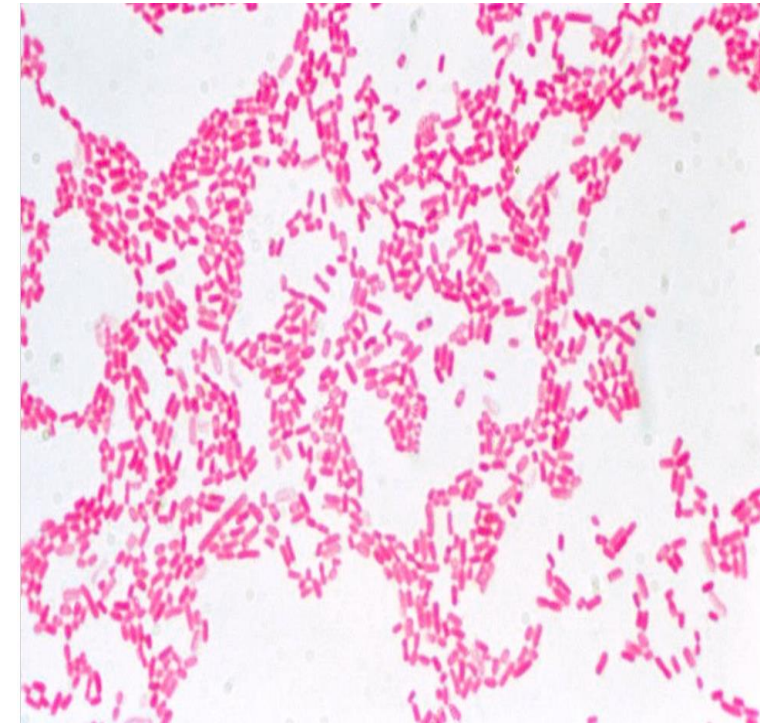
Etiology- Pathogens

E. coli

- *E. coli* is the leading cause of UTI (approx. 80%)

Features:

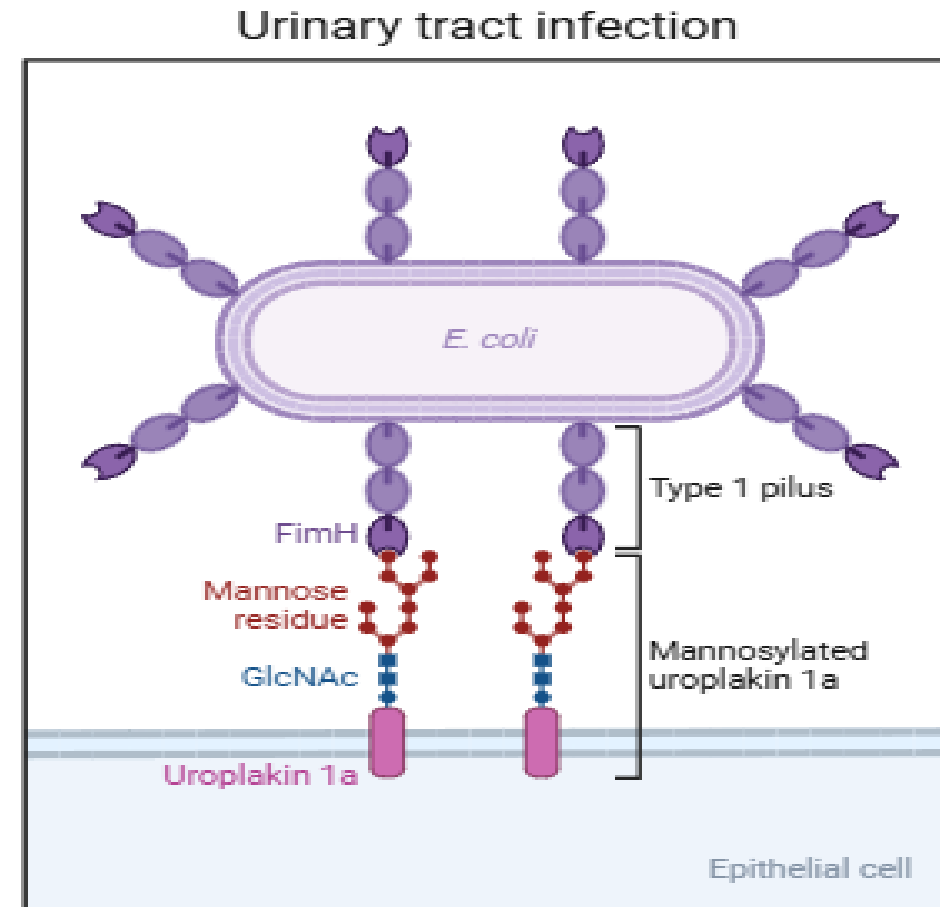
- Gram-negative bacillus (rod) (Enterobacteriaceae)
- Oxidase negative
- Facultative anaerobic
- Catalase-positive
- Ferments lactose (**pink** colonies on MacConkey agar)
- Either nonmotile or motile (flagellated)



Etiology- Pathogens

E. coli has virulence factors that facilitate colonization, ascension, and invasion:

- **Type 1 fimbriae:** attach to the uroepithelial cells (on the mannose residues of surface glycoproteins) → Prevent *E. coli* from being flushed out by the urine stream
- **P fimbriae:** Hair-like projections that interact with renal epithelial cells. It has important role in pyelonephritis



Etiology- Clinical Application

Cranberry and D-mannose are natural supplements frequently used to support urinary tract health and **prevent recurrent UTIs** by preventing bacteria to adhere to the walls of the urinary tract

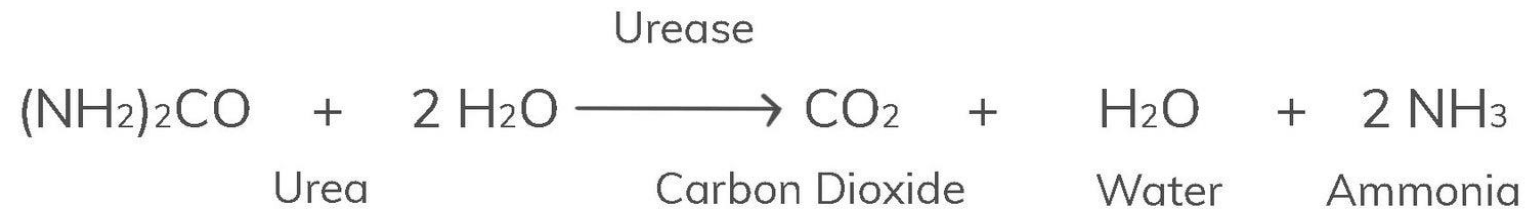


Etiology- Pathogens



- *Proteus mirabilis*:

- Gram negative rod-shaped bacterium (Enterobacteriaceae).
- It shows swarming motility and urease activity.
- Hydrolyse urea into **ammonia** and carbon dioxide → leading to increase in local pH.

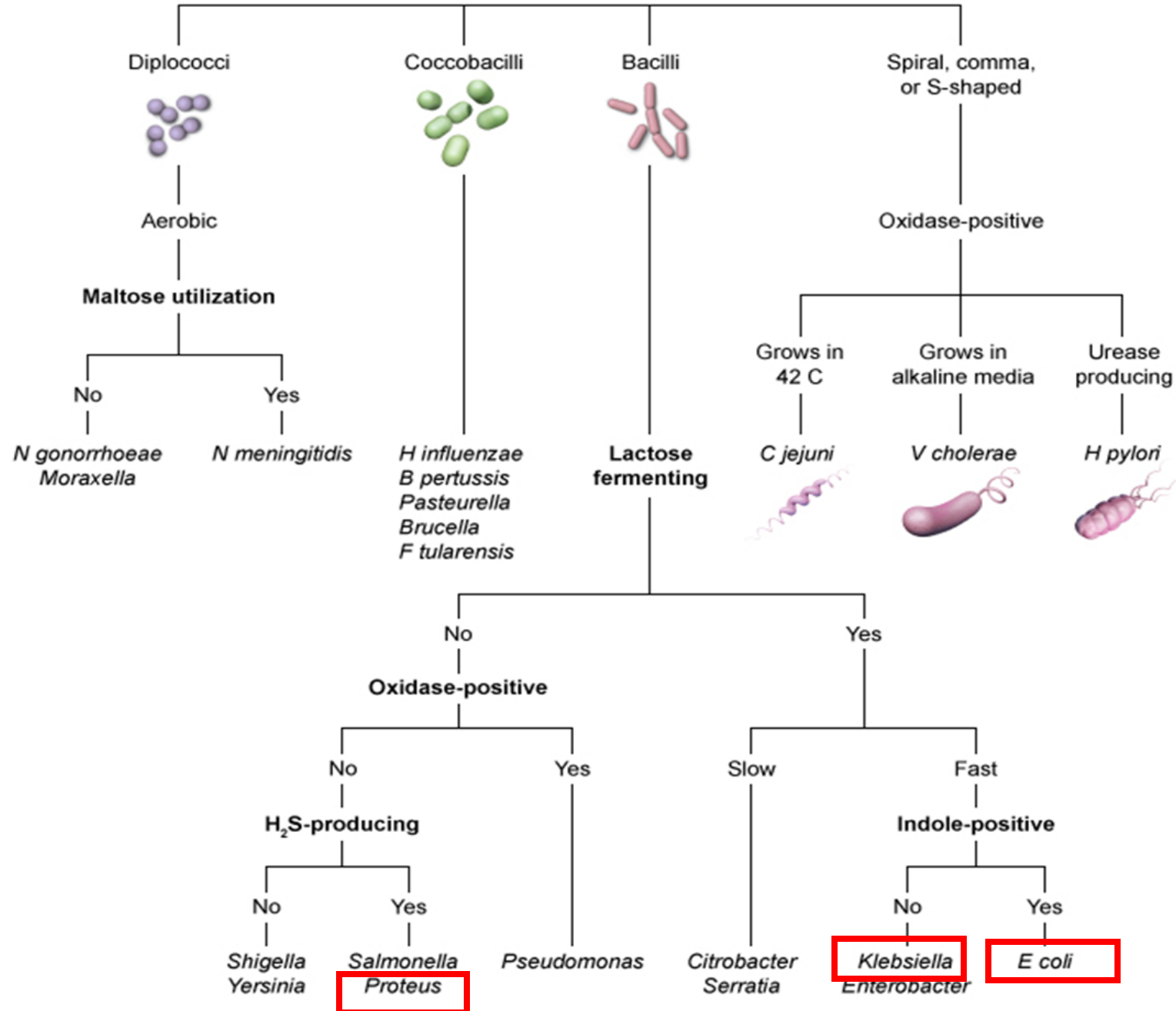


- The alkaline pH leads to precipitation of calcium and magnesium ions and the formation of urinary stones composed of **magnesium ammonium phosphate (struvite)** and **calcium phosphate (apatite)**

Etiology- Pathogens

- ***Klebsiella pneumoniae***: 3rd leading cause of UTI
 - Gram-negative rod-shaped bacterium (Enterobacteriaceae), non-motile, lactose-fermenting.
- ***Staphylococcus saprophyticus***:
 - Gram-positive, catalase positive, coagulase negative cocci.
 - Differentiated from *S. epidermidis* by being novobiocin resistant.
 - Associated with UTIs **in sexually active** women.
- ***Enterococcus faecalis***:
 - Gram-positive cocci, typically arranged in pairs and short chains .
 - *E. faecalis* is found in the large intestine in high concentrations
 - Associated with hospital-acquired infections frequently and with **urinary catheterization or instrumentation**

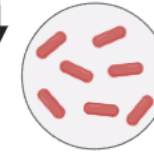
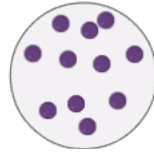
Gram-negative bacteria



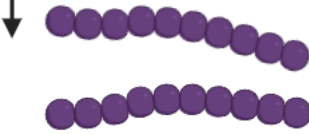
Gram-positive

Cocci

Rods



Catalase test



Streptococci

Staphylococci

Growth on sheep's blood agar

Coagulase test



S. saprophyticus
S. epidermidis

S. aureus

γ -hemolytic

β -hemolytic

α -hemolytic

Enterococcus

Group A

S. pyogenes

Capsule

S. pneumoniae

Group B

S. agalactiae

No Capsule

Viridans streptococci

S. saprophyticus is resistant to novobiocin.

S. epidermidis is sensitive to Novobiocin

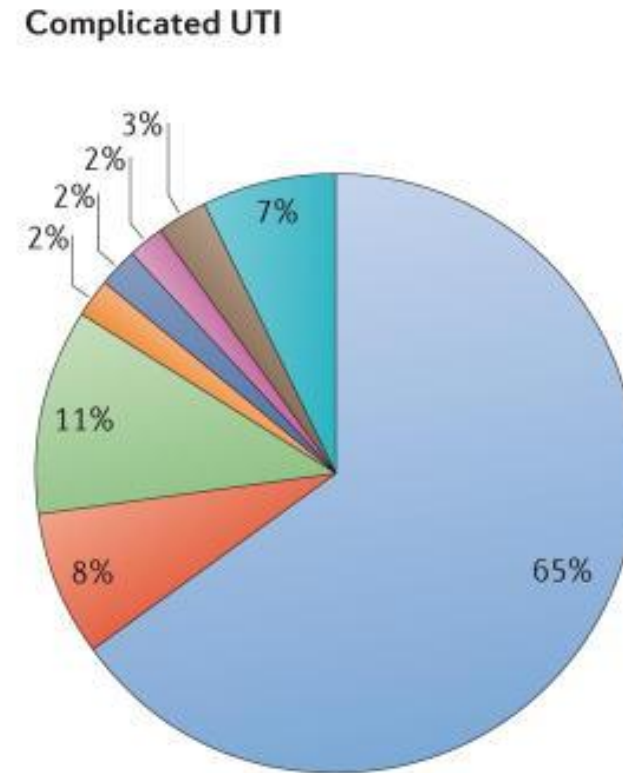
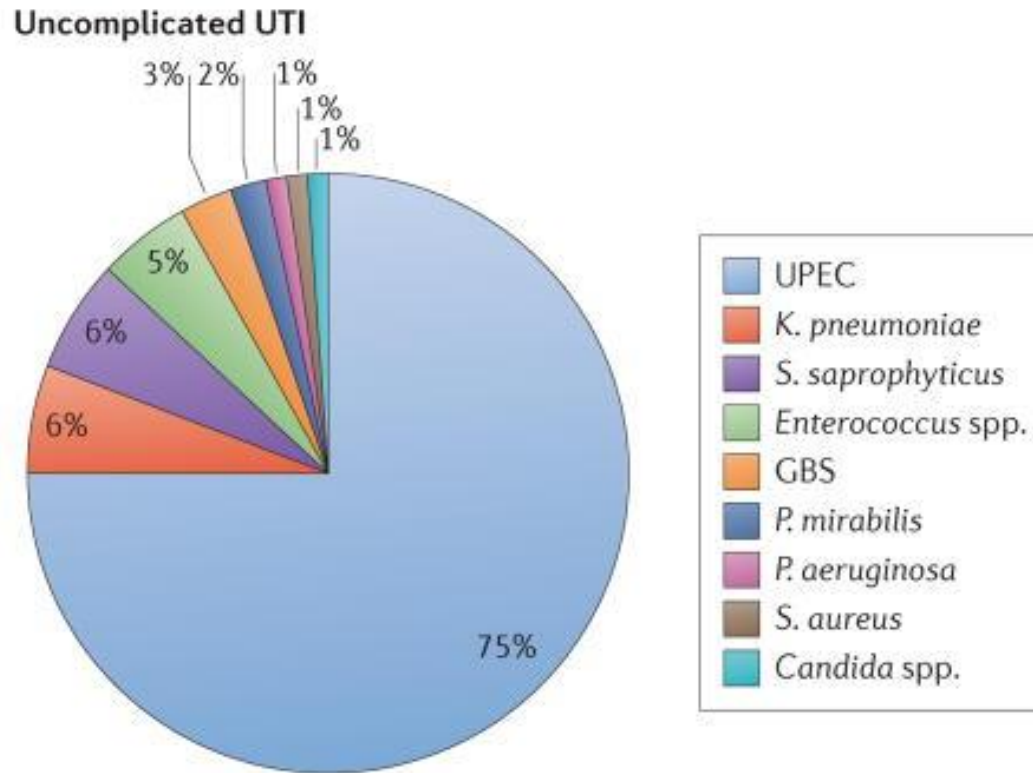


Etiology- Pathogens

Other causes

- **Viruses:** an uncommon cause of UTIs (Adenovirus, cytomegalovirus)
 - Immunocompromised patients are particularly susceptible to viral UTIs.
 - Adenoviruses cause acute **haemorrhagic cystitis** in children and in some young adults
- **Fungi:** rare but important causes of UTI.
 - The most common fungal species causing UTI is **Candida albicans**

Etiology- Pathogens

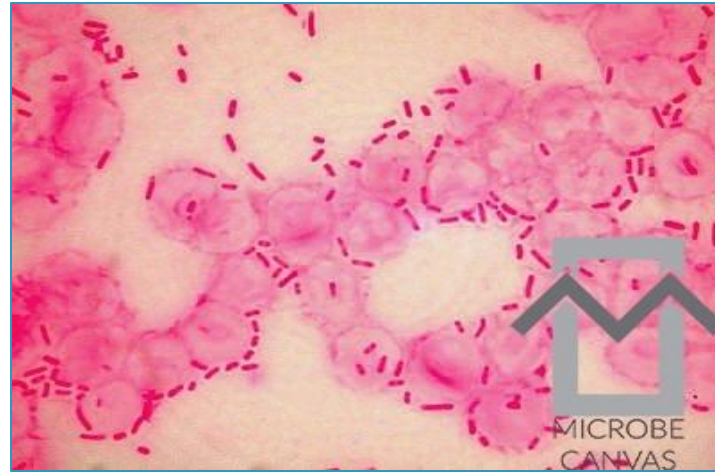


(UPEC): Uropathogenic *Escherichia coli*

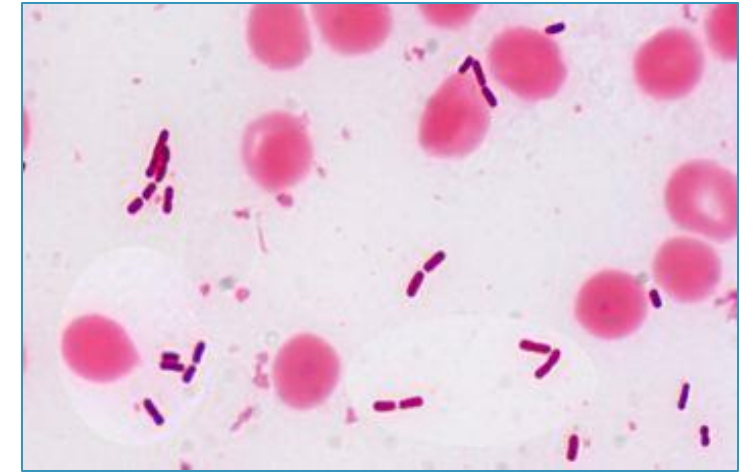
Etiology- Pathogens



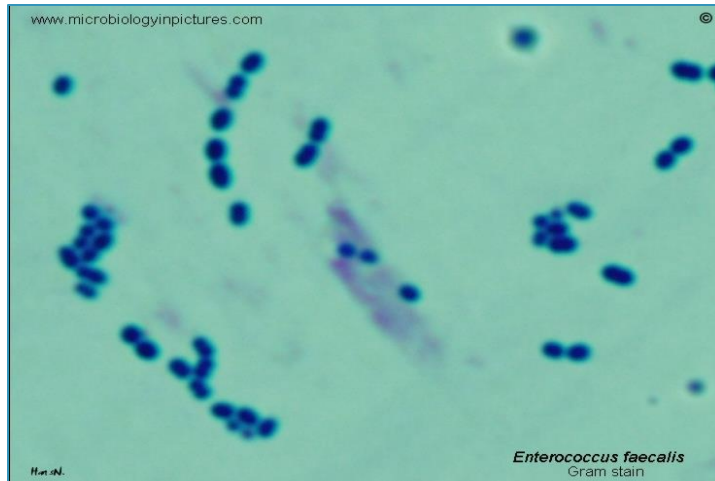
E. coli



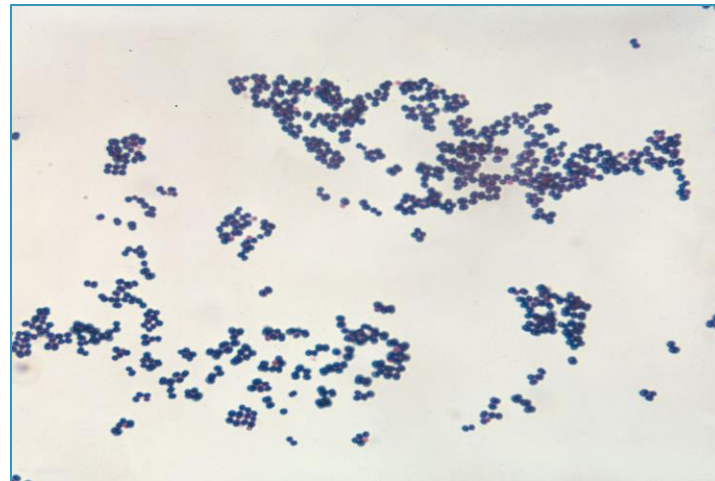
K. pneumoniae



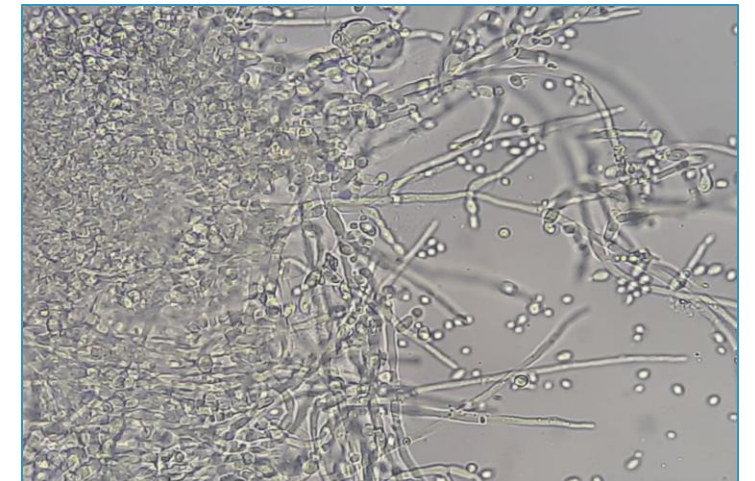
P. mirabilis



E. faecalis



S. saprophyticus



C. albicans

Etiology- Predisposing Factors

Host-dependent factors

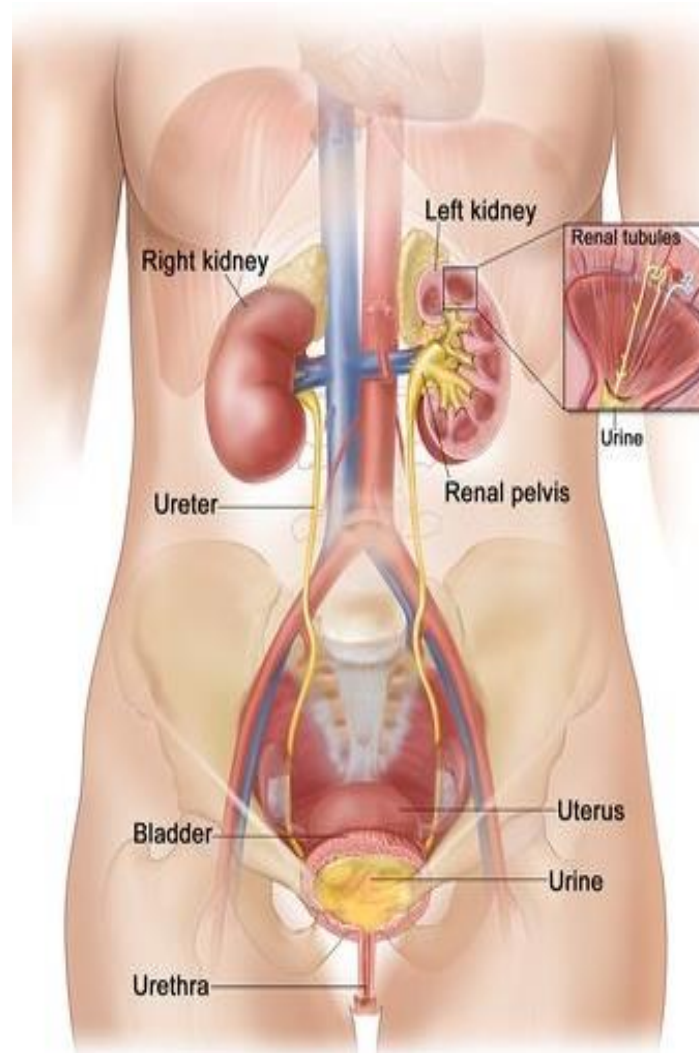
Gender

Pregnancy

Post menopause

Obstruction

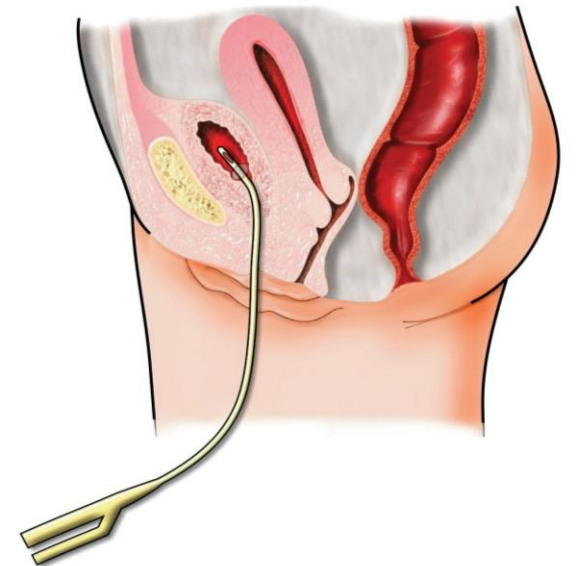
Structural or functional abnormalities of the urinary tract



Other factors

Postcoital cystitis

Catheter-associated UTI



Etiology- Predisposing Factors

- **Gender:**

- Female individuals: anatomically predisposed because **the urethra is shorter** and anal and genital regions are **in close proximity** → bacteria spreading from the anal region → colonization of urethra → ascending UTIs.
- Male individuals: higher risk in uncircumcised male infants

- **Pregnancy:** hormonal changes during pregnancy lead to:

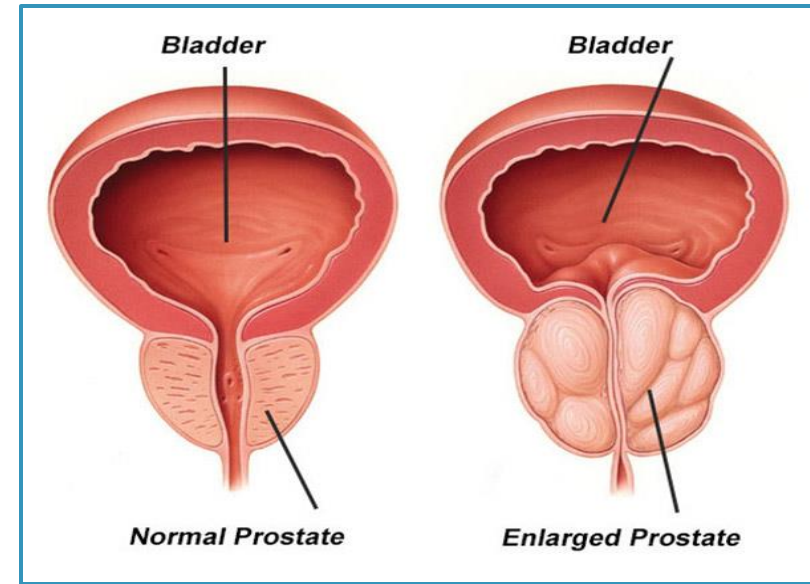
- decreased ureteral tone
- decreased ureteral peristalsis
- and temporary incompetence of the vesicoureteral valves

→ **increased risk of UTIs**

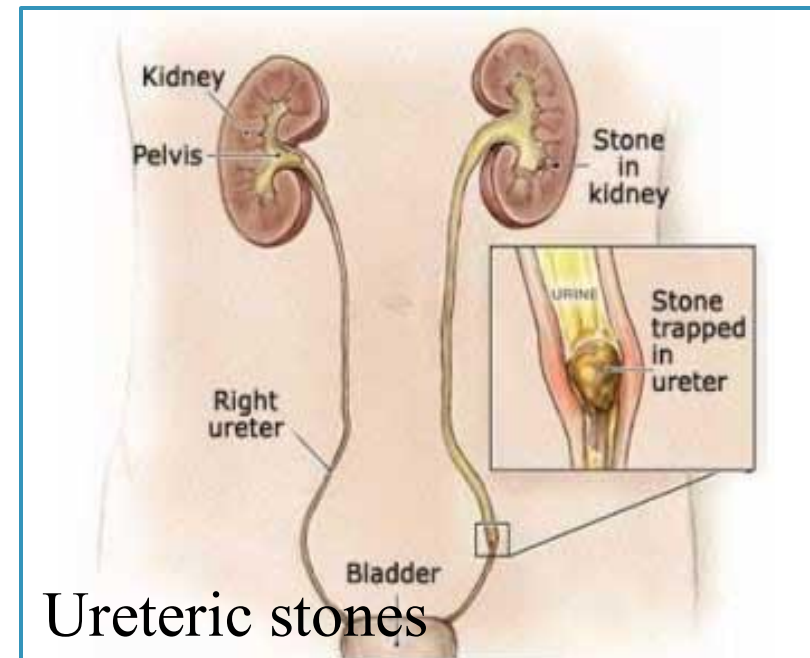
Etiology- Predisposing Factors

- **Obstruction:** any impediment to the free flow of urine —tumour, stricture, stone, or prostatic hypertrophy

→ results in hydronephrosis and a greatly increased frequency of UTI

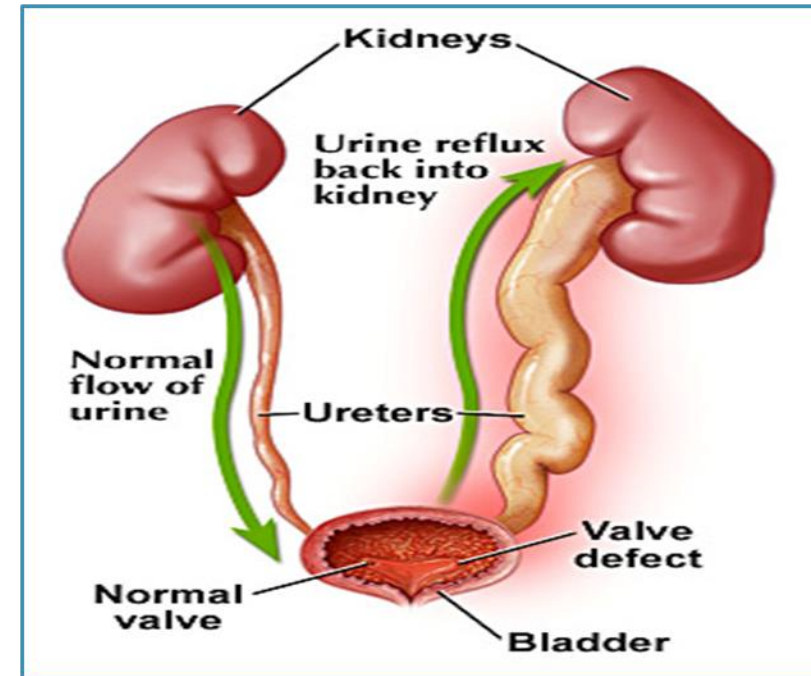


Benign prostatic hyperplasia



Etiology- Predisposing Factors

- **Structural or functional abnormalities** of the urinary tract prevent bladder emptying and/or result in urinary stasis
- Examples include:
 - Congenital malformations causing vesicoureteral reflux
 - Neurogenic bladder



Vesicoureteral reflux

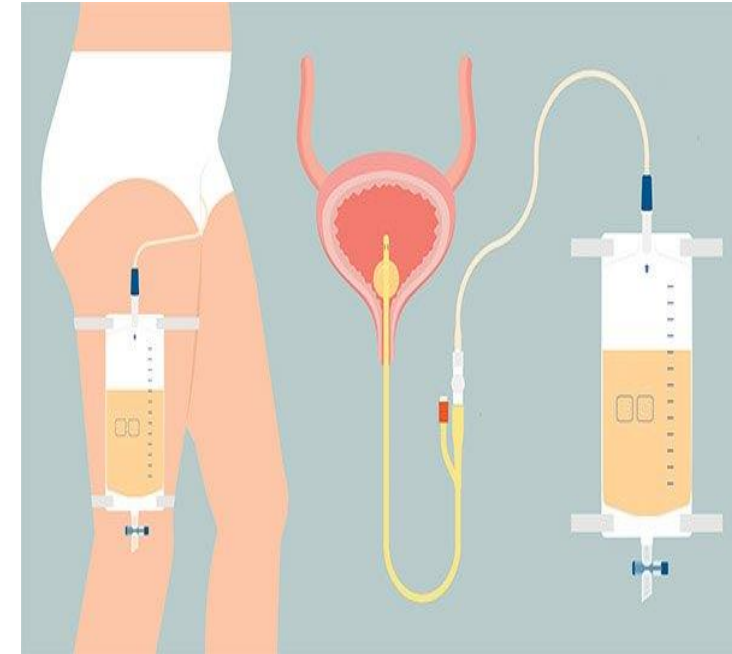
Etiology- Predisposing Factors

- **Post menopause:** ↓ oestrogen → ↓ vaginal lactobacilli (vaginal normal flora) → ↑ vaginal pH → ↑ colonization by *E. coli*
- **Postcoital cystitis (honeymoon cystitis):** a lower urinary tract infection that occurs in women after recent sexual activity.
 - Irritation of the urethra facilitate bacterial entry into the urethra (e.g., from the genital and/or anal region).

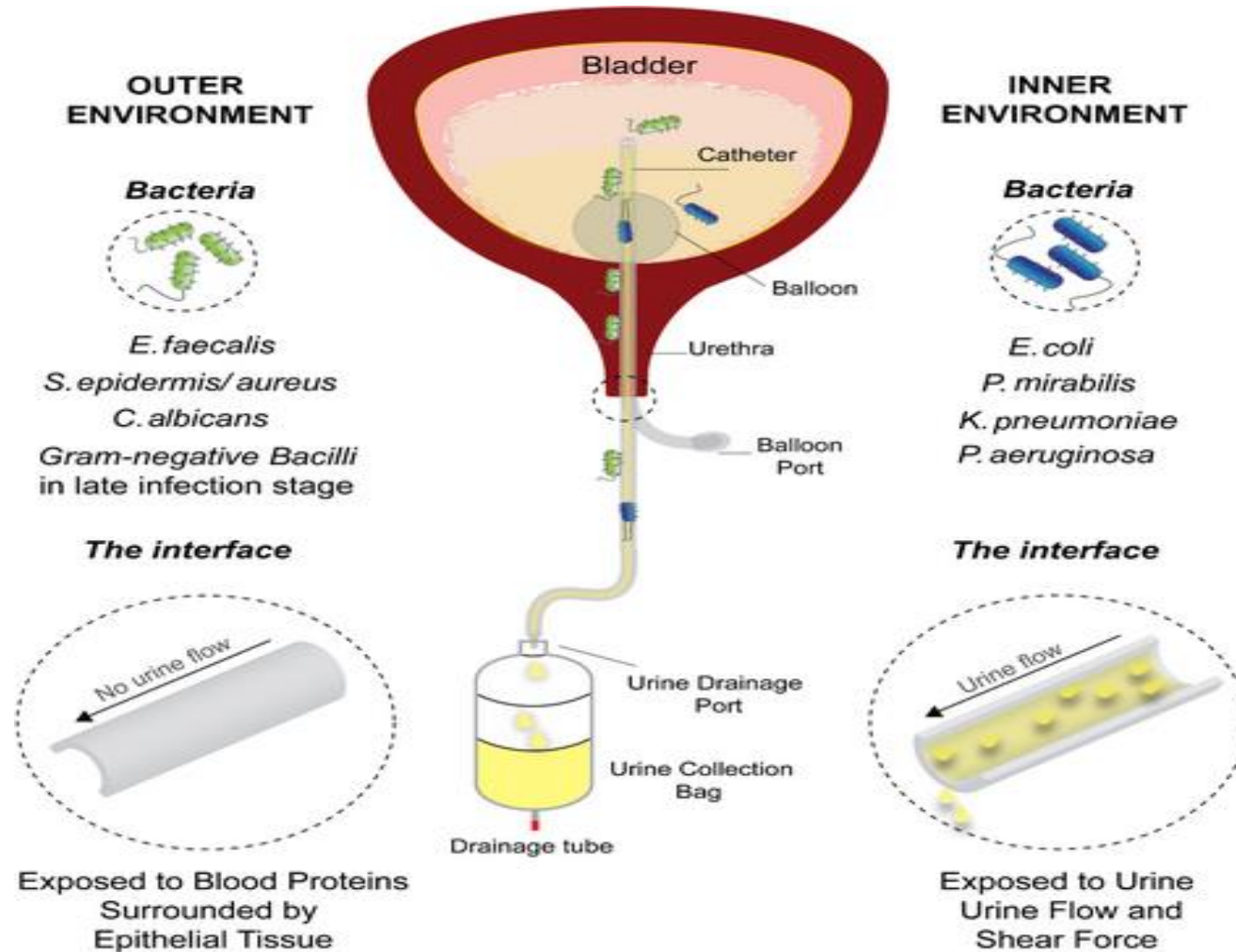
Etiology- Predisposing Factors

Catheter-associated urinary tract infections (CAUTI):

- UTI occurring in an individual whose urinary bladder is catheterized or has been catheterized within the past 48 hours.
 - CAUTIs are the most common nosocomial infections, and account for 1 million cases per year in the United States
 - They are the most common cause of secondary bloodstream infections.
 - The associated costs of preventable CAUTI are estimated to range from \$115 million to \$1.82 billion annually.




Etiology- Predisposing Factors



QUIZ-TIME



A 24-year-old female presents to your office with **burning urination, urgency and frequency**. She is **sexually active**. Urine cultures show **catalase-positive, gram-positive cocci**. The organism responsible for this patient's symptoms is most likely to be:

- A. Coagulase positive
- B. Beta Haemolytic
- C. Novobiocin resistant 
- D. DNase positive
- E. Yellow pigment producer

Thank you

to be continued...