Federal state budgetary educational institution of higher education "Volgograd state medical University" of the Ministry of health of the Russian Federation

Department of clinical laboratory diagnostics

LECTURE №6
Kidney diseases.
Clinical and biochemical analysis of urine. Physiological and pathological components of urine. Methods for its determination.

- 10% of adult population in industrialized countries have some nephrological pathology

- «Chronic kidney disease»
  - glomerulonephritis, pyelonephritis, polycystic kidney, hydronephrosis, urolithiasis

Causes for the development and progression of chronic kidney diseases:

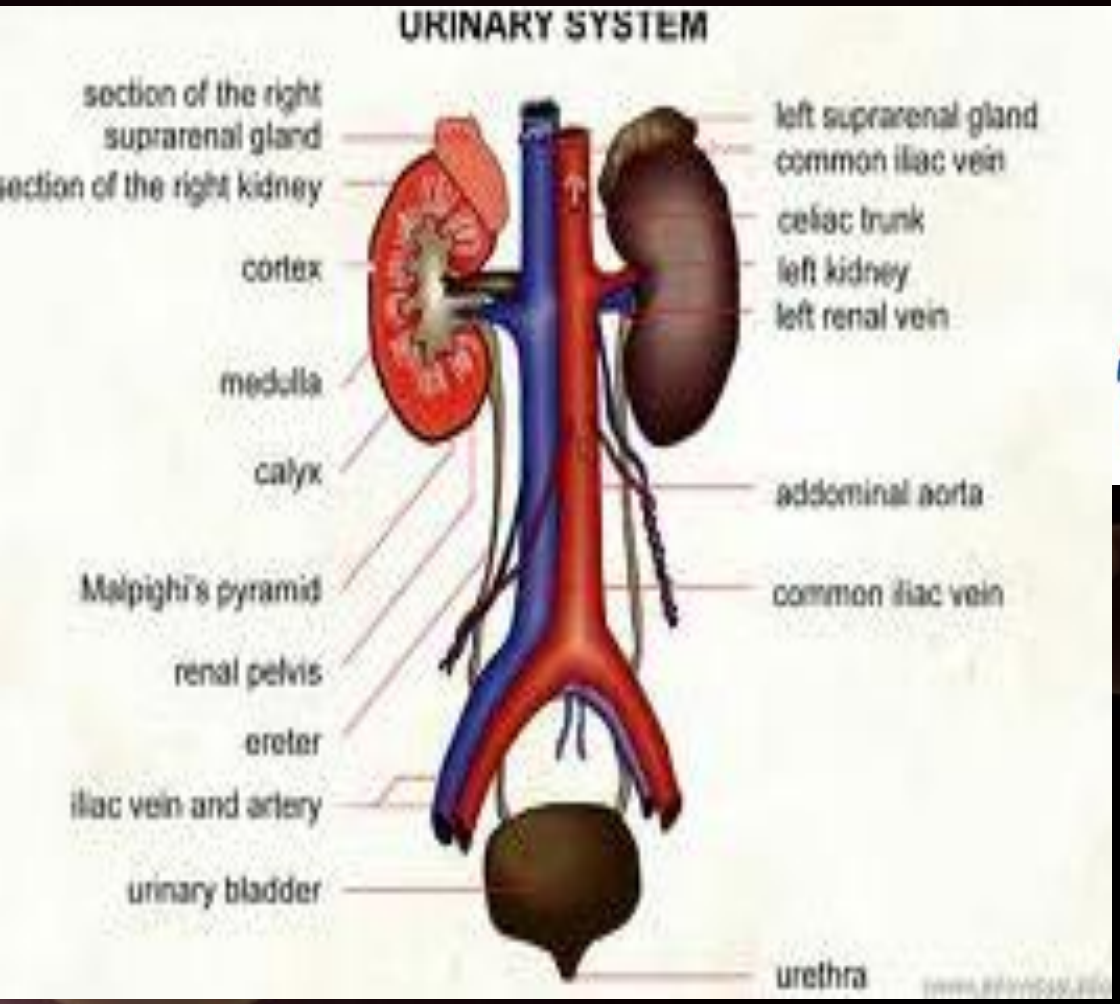
- infections
- certain medications
- alcohol and smoking
- the environment
- climate
- tradition food
- genetic features of populations

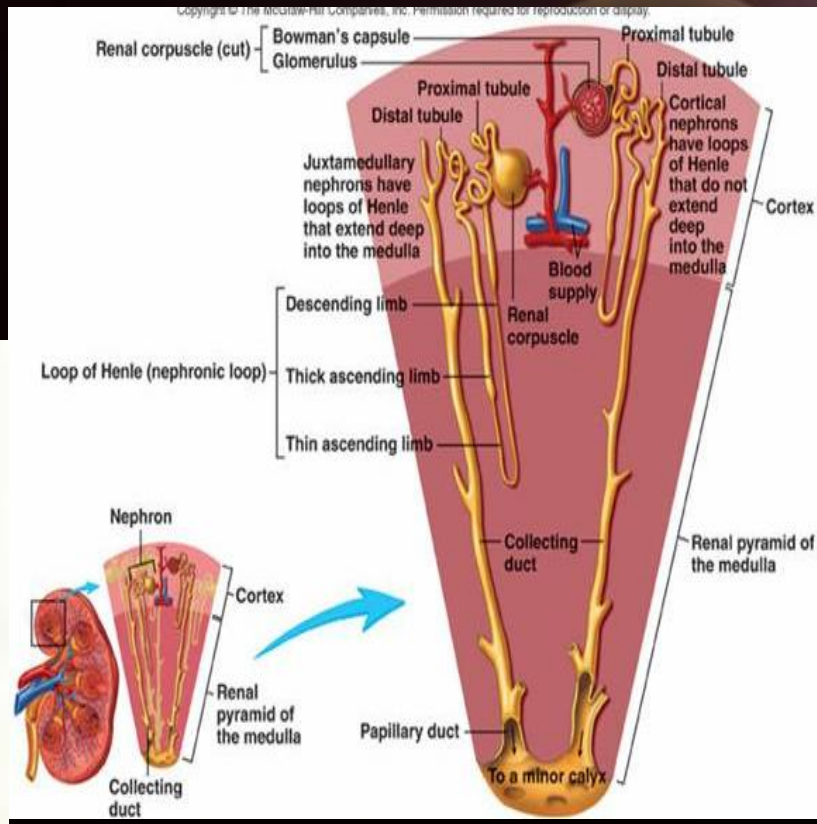
- arterial hypertension
- diabetes
- autoimmune diseases
- dyslipidemia
- obesity and metabolic syndrome

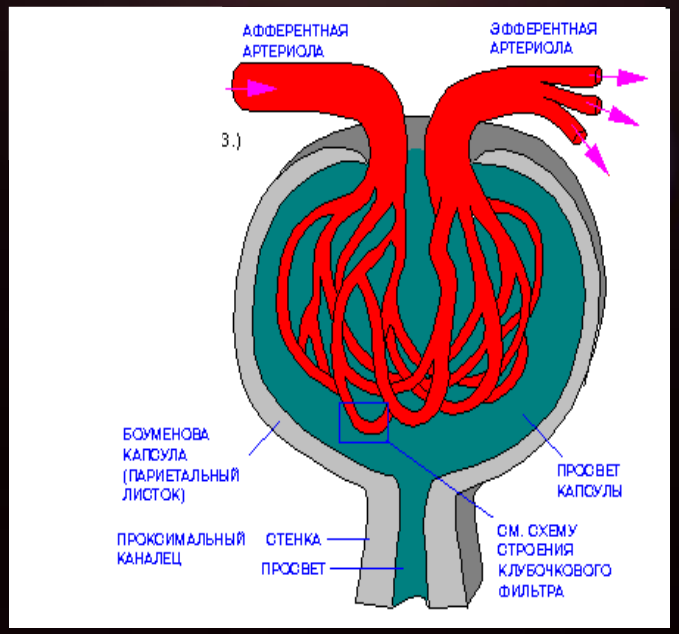
The kidneys are the main organs of excretion and osmoregulation

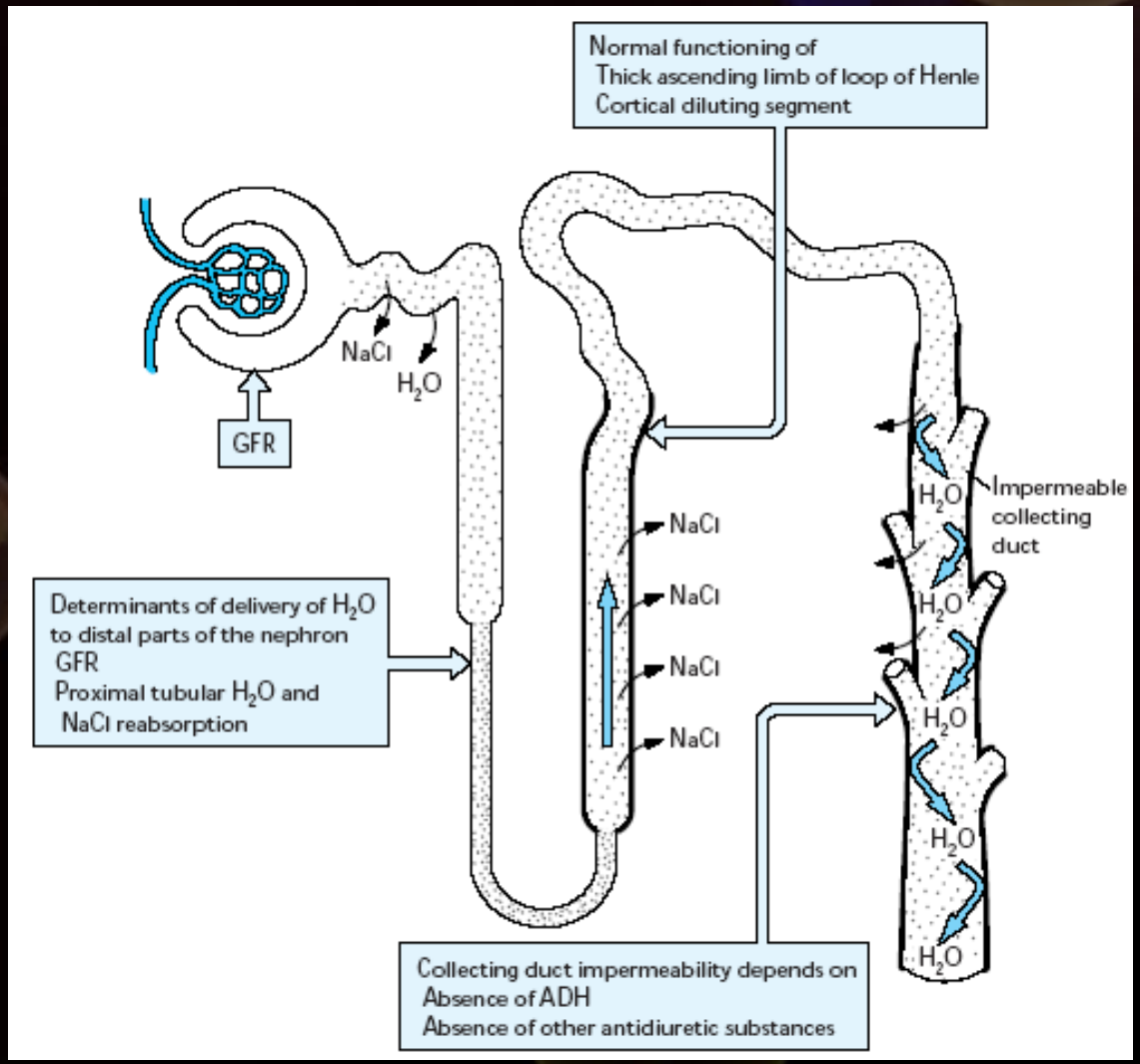
Their functions include:

- removal of waste products of metabolism and foreign substances from the body
- regulation of the chemical composition of body fluids by removing substances which exceed the current needs
- regulation of the water volume in the body fluids
- pH regulation of the body fluids


URINARY SYSTEM
section of the right suprarenal gland
section of the right kidney
cortex
medulla
calyx
Malpighi's pyramid
renal pelvis
ureter
iliac vein and artery
urinary bladder
left suprarenal gland
common iliac vein
celiac trunk
left kidney
left renal vein
abdominal aorta
common iliac vein
urethra


Renal corpuscle (cut)
Bowman's capsule
Glomerulus
Proximal tubule
Distal tubule
Proximal tubule
Distal tubule
Cortical nephrons have loops of Henle that do not extend deep into the medulla
Juxtamedullary nephrons have loops of Henle that extend deep into the medulla
Cortex
Blood supply
Renal corpuscle
Loop of Henle (nephronic loop)
Descending limb
Thick ascending limb
Thin ascending limb
Nephron
Cortex
Collecting duct
Renal pyramid of the medulla
Renal pyramid of the medulla
Papillary duct
To a minor calyx
Collecting duct


АФФЕРЕНТНАЯ АРТЕРИОЛА
ЭФФЕРЕНТНАЯ АРТЕРИОЛА
3.)
БОУМЕНОВА КАПСУЛА (ПАРИЕТАЛЬНЫЙ ЛИСТОК)
ПРОСВЕТ КАПСУЛЫ
ПРОКСИМАЛЬНЫЙ КАНАЛЕЦ
СТЕНКА
ПРОСВЕТ
СМ. СХЕМУ СТРОЕНИЯ КЛУБОЧКОВОГО ФИЛЬТРА


Normal functioning of
Thick ascending limb of loop of Henle
Cortical diluting segment
NaCl
H_2O
GFR
H_2O
Impermeable collecting duct
NaCl
NaCl
NaCl
NaCl
H_2O
H_2O
H_2O
H_2O
Determinants of delivery of H_2O to distal parts of the nephron
GFR
Proximal tubular H_2O and NaCl reabsorption
Collecting duct impermeability depends on
Absence of ADH
Absence of other antidiuretic substances

Glomerular filtration is a passive process of transition of plasma liquid part from the lumen of glomerular capillaries in the capsule through the renal glomeruli filter (capillary endothelium, basement membrane, the epithelium of the capsule). At the same time low-molecular substances are filtered with the plasma.

Ultrafiltration

- ✓ Glucose, water and urea pass into the filter in glomeruli
- ✓ Ultrafiltration rate is quite high - about 180 liters per day. However 99% of this filtrate is come back.
- ✓ Reabsorption of substances occurs in the tubules. There is an additional active removal of waste products.

Glomerular filtration rate is determined by:

- the value of rate renal blood flow
- intraglomerular hydrostatic pressure
- surface area of filtration

Ultrafiltration

- The concentration of creatinine in serum and urine collected during 24 hours is determining by the daily probe of Reberg

- GFR is measured by the method of Reberg-Tareev, which is based on the determination of endogenous creatinine clearance

A single probe of Reberg:

- Carry out in the morning before fluid intake and after emptying of bladder
- The patient drinks half a liter of water and donates blood after half an hour
- The patient collects urine half an hour later

Diuresis per minute is calculated:

A daily probe of Reberg	A single probe of Reberg
total volume of collected urine (ml) divided by 24 hours and by 60 minutes	single volume of collected urine (ml) divided by 60 minutes

The glomerular filtration rate is calculating by the formula:

GFR = Creatinine of urine (mmol/L) x diuresis per minute (ml/min) / creatinine level in blood serum (mmol/L)

Reabsorption

- Glucose, amino acids, proteins, urea, lactate, bicarbonate, inorganic phosphorus, chlorine, potassium and sodium reabsorbed in the lumen of the tubules.
- Potassium, sodium, magnesium and calcium reabsorbed in the loop of Henle and distal tubule.
- Secretion of potassium ions, hydrogen and ammonia is occurred in the proximal tubules.

Urine analysis is included determination of physical and chemical properties:

- ✓ color
- ✓ transparency
- ✓ reaction
- ✓ relative density
- ✓ proteins
- ✓ glucose
- ✓ ketones
- ✓ bilirubin
- ✓ urobilinogen
- ✓ urine microscopy

The four steps of urine analysis

- First step: urine collection
- Second step: visual examination
- Third step: chemical study by the test strip
- Fourth step: microscopy

Semi-automatic analyzer Urisys® 1100

- Portable analyzer for small laboratories.
- Enables to standardize and document the test results.
- Capacity - up to 70 tests per hour
- Outputs and prints the final result of 10 parameters with abnormal results displayed

Color of urine	Pathological conditions	Cause
Tawny	Congestive kidney, swelling, burns, diarrhea, vomiting	Increased concentration of dyes
Pale	Diabetes and diabetes insipidus, renal glycosuria, renal failure	Low concentration of dyes
Dark brown	Congenital anemia	Urobilinogenuriya
Dark (black)	Acute hemolytic kidney homogentisuria, black cancer	Hemoglobinuria, melanin
Red	Nephrolithiasis, renal infarction, lead anemia	Hematuria, uroporfirinuriya
Kind of "meat slops"	Acute exacerbation of chronic glomerulonephritis	Hematuria
Beer color, greenish-brown	Parenchymal jaundice	Bilirubinuriya, urobilinogenuriya
Greenish-yellow, brown	Mechanical jaundice	Bilirubinuriya
Whitish	Fatty degeneration	Lipuriya, pus, phosphate crystals
Milk	Lymphostasis kidney	Chyluria

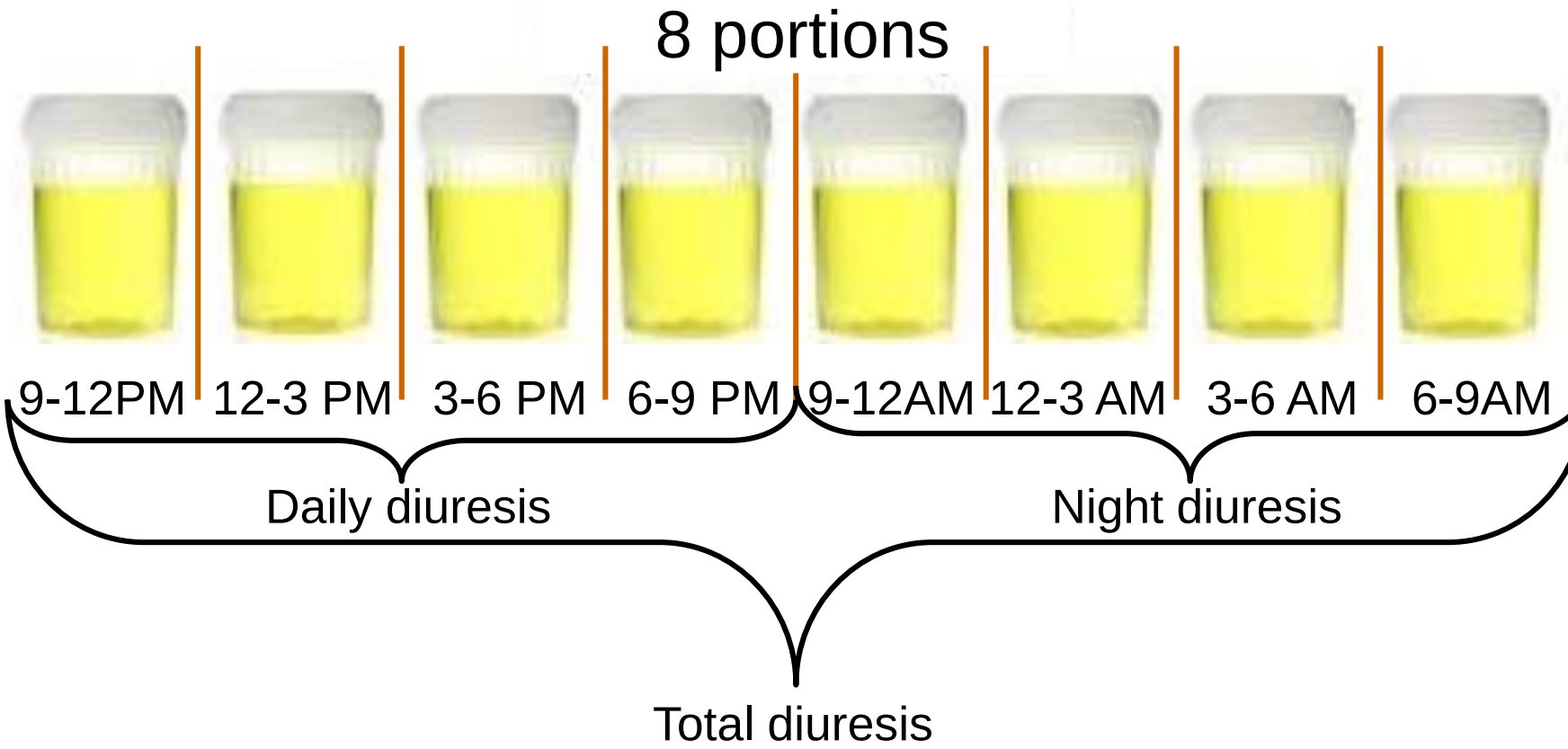
- Healthy adults produce from 0.6 to 2.0 liters of urine per day
- The ratio of the daily volume of urine output to the night one corresponds to 3 :1
- The increasing of night diuresis is called nycturia
- Conditions when the daily diuresis more than 2 liters is called polyuria
- When diuresis is less than 500 ml in day its called oliguria
- Oliguria can be subdivided to prerenal, renal and postrenal

- **Anuria** is complete termination of urine output
- **Dysuria** is disorder of urination
- **Pollakiuria** is a frequent urination
- **Ollakiuriya** is a rare urination
- **Enuresis** is involuntary urination

The relative density of urine depends on the concentration ability of the kidneys

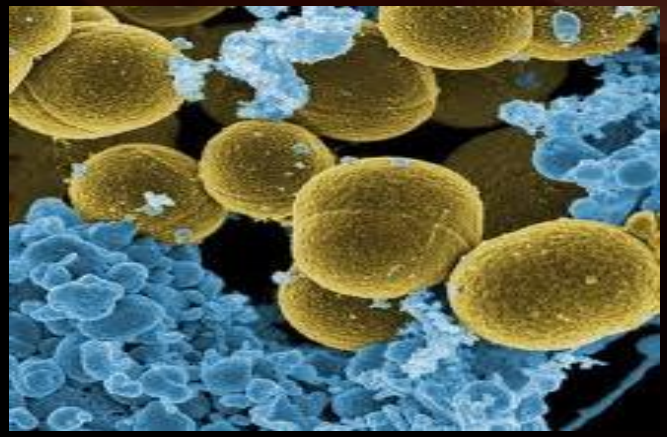
- The range of relative density of urine during the day should be from 1.003 to 1.028
- The reason of the renal concentration function violation can be better analyzed in dynamic
- Zimnitskiy method is used for this purpose

Zimnitskiy method



Mixed diet - urine pH 5.5-6.5

Vegetarian diet - neutral or alkaline urine



Urinary tract infection - alkaline urine

- **Normally glucose completely reabsorbed by the proximal tubule cells**
- **The maximal concentration of glucose in the blood, when there is no glycosuria, called the renal threshold**
- **The normal renal threshold of glucose in the blood is 10 mmol/L**

Proteinuria (detection of proteins in urine) is an important symptom of renal and urinary tract disease

Normally, the protein concentration in a single portion of urine is no more 0.033 g/L. In the daily portion its allowed up to 0.15 g/day

Protenuria can be functional and organic

Organic (pathological) proteinuria may be prerenal, renal and postrenal

Prerenal proteinuria is associated with increased synthesis of small proteins (myeloma)

Renal proteinuria is associated with damage of glomerulare and tubule (glomerulare and tubular type, respectively)

Postrenal proteinuria is happened when inflammatory exudates pass into urine (cystitis, prostatitis)

Glomerular types of proteinuria

- **highly selective** - low molecular weight proteins up to 70 kDa (albumin) in urine
- **selective** - molecular weight proteins up to 150 kDa in urine
- **nonselective** - high molecular weight proteins 800-900 kDa (immunoglobulins) in urine

Microscopic examination of urine sediment allows to distinguish its organic and inorganic parts.

- **The organic part represents by erythrocytes, leukocytes, cylinder and epithelium**

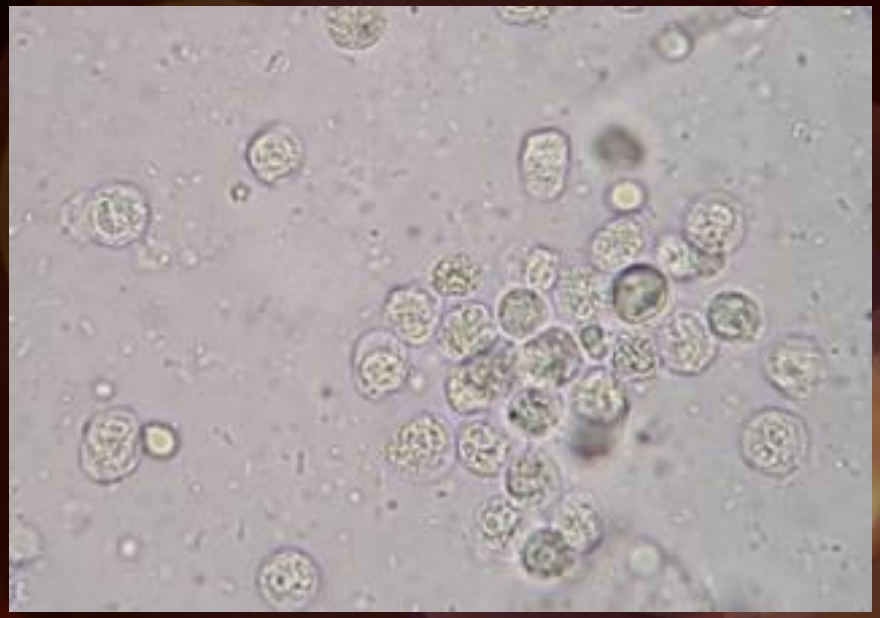
- **The inorganic part represents by salts of different chemical nature**

Erythrocytes in urine is pathological bladder syndrome

Causes:

- Prerenal (pathology of blood coagulation and liver disease with violation of the synthesis of clotting factor)
- Renal divided on glomerulus (glomerulonephritis) and nonglomerulus (polycystic kidney and damage of renal tubular)
- Postrenal (damage of pelvis, ureter and bladder)

Leukocytes in urine



Normally, urine sediment microscopy detected single leukocytes in each field of view

Causes of increase leukocytes in urine:

-infectious processes in the kidney (pyelonephritis) and urogenital tract (urocystitis and urethritis)

Cylinder cylinders in urine. Cylinders are a repetition of the configuration renal tubules consisting of proteins and glycosaminoglycans (hyaline)

Methods of quantification:

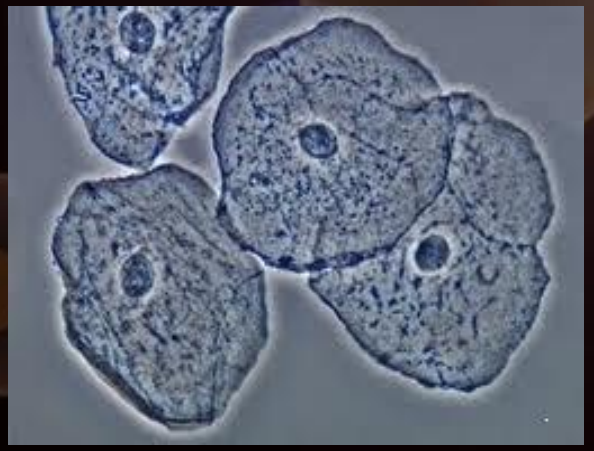
- **The method of Addis Kakovskogo (counting of erythrocytes, leukocytes, and cylinders in the volume of daily urine)**
- **The method Nechiporenko (counting of erythrocytes, leukocytes, and cylinders in 1 ml of urine)**

Types of epithelial cells

Squamous epithelial cells:

Keratinized (skin)

Non-keratinized (distal



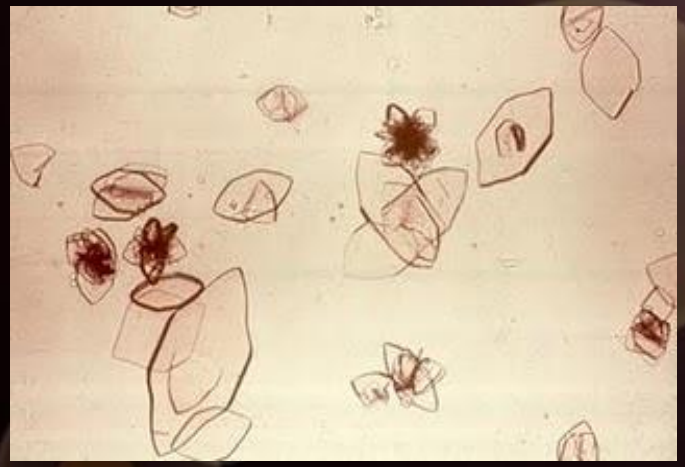
Transitional epithelial cells (pelvis, ureters, bladder and proximal urethra)

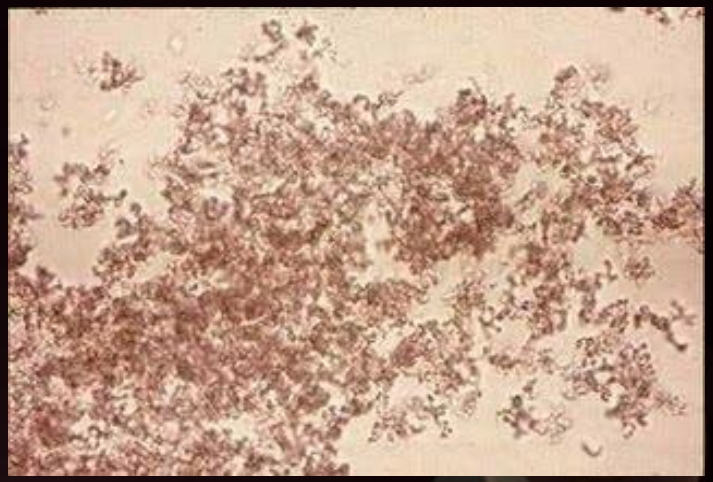
Renal tubular epithelial cells

The inorganic part of urine sediment consists of different salts

- The urine pH is acidic (less than pH=7): amorphous urate
- The urine pH is alkaline (more than pH=7): amorphous phosphate
- The calcium oxalate may occur in acidic, neutral or alkaline urine

Urate can to appear in urine after physical activity, meat diet, fever and urine acid diathesis, gout, leukemia



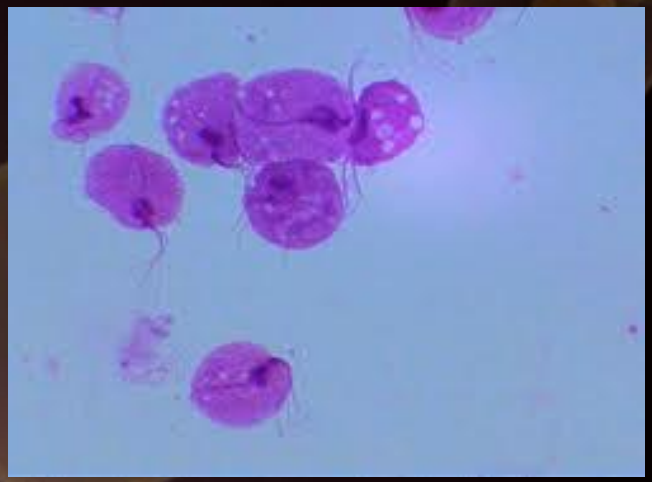


Phosphate can to appear in urine of healthy persons after eating large meals in result decreased the acidity of urine

Calcium oxalate can appear in urine by eating foods rich in oxalic acid. The presence of calcium oxalate in urine is characteristic of urolithiasis

Urine is usually sterile, but sometimes bacteria or yeast can migrate from the skin of the urethra to the urinary tract, causing a urinary tract infection

Yeast (for example Candida albicans) can appear in urine after prolonged treatment antibiotics

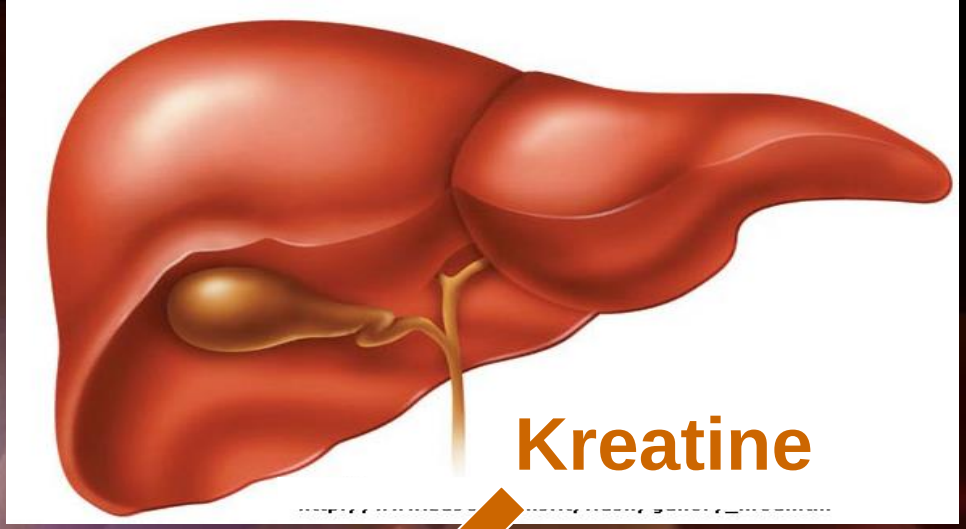


Trichomonas vaginalis is a pathogen that causesurogenital sexually transmitted diseasesfor men and women

Physiological components of urine are urea, creatinine, creatine and uric acid

The concentration of urea in the blood from 2.5 to 8.3 mmol/L is physiologically acceptable

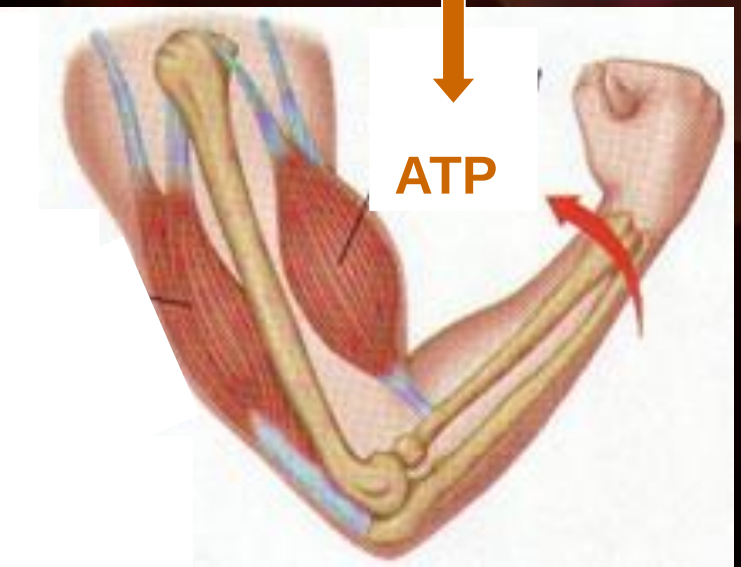
Increasing of urea concentration in the blood with clinical syndrome of intoxication is called uremia



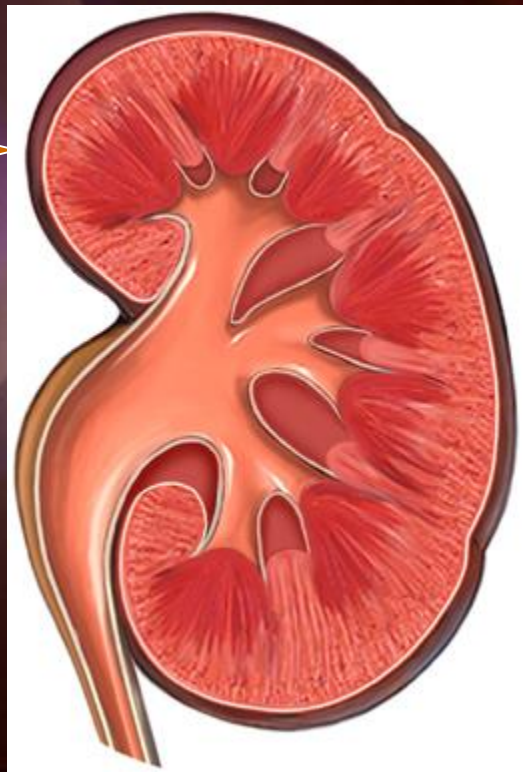
Kreatine

Creatine phosphate

ATP



Creatinine



The concentration of creatinine in the blood -- for adult males from 80 to 140 μmol/L - for adult females from 60 to 110 μmol/L - children from 20 to 100 μmol/l is physiologically acceptable

Increased serum creatinine levels are seen in:

- Impaired renal function
- Chronic nephritis
- Urinary tract obstruction
- Muscle diseases such as gigantism, acromegaly, and myasthenia gravis
- Congestive heart failure
- Shock

Decreased creatinine levels may be seen in:

- the elderly
- persons with small stature
- decreased muscle mass
- inadequate dietary protein

Uric acid is the end product of metabolism proteins. Normal values range between 3.5 and 7.2 mg/dL

Hyperuricemia may be due to:

- Hypoparathyroidism
- Gout
- Nephrolithiasis
- Renal failure
- Leukemia
- Diabetes
- Purine-rich diet
- Chemotherapy-related side effects
- Alhoholism
- Acidosis

Hypourecemia may be due to:

- Wilson`s disease
- Low purine diet
- Fanconi syndrome

There are following syndromes of renal disease:

- urinary
- nephrotic
- hypertonic
- nephritis
- acute renal failure
- chronic renal failure
- renal tubular dysfunction syndrome

Urinary syndrome is characterized by:

- proteinuria
- hematuria
- leukocyturia
- cylindruria
- In the absence of extrarenal signs

Nephrotic syndrome is characterized by:

- generalized edema
- massive proteinuria (greater than 3.5 g/day)
- hypoproteinemia and hypoalbuminemia (less than 20 g/L)
- hyperlipidemia (cholesterol above 6.5 mmol/l)

Hypertonic syndrome is associated with diffuse lesions of the kidneys

In the clinic, this is characterized by:

- increasing of blood pressure

In laboratory this is characterized by:

- Increased blood creatinine and urea levels
- Reduced glomerular filtration rate

Acute renal failure - a syndrome characterized by sudden azotemia - rapid excretory disfunction of kidneys

Acute renal failure is of characterizide by:

- Elevated urea and creatinine in blood
- Oliguria
- Disorders of water and electrolyte balance
- Disorders of acid-base balance

Nephritic syndrome is characterized by:

- **hematuria** (blood in the urine)
- **proteinuria** (protein in the urine) - small amounts of protein are lost in the urine, but this is usually trivial (<3.5 g/day)
- **hypertesion** (high blood pressure)- mild
- **uremia** - due to retention of waste products

Variable renal insufficiency:

- **azotemia** (elevated blood nitrogen)
- **oliguria** (low urine output <400 mL/day)

Chronic renal failure - gradual and permanent violation of kidney function. So, that kidney can no longer support normal homeostasis.

Chronic renal failure is characterized by:

- Increased serum creatinine or protein in the urine
- Accumulation of urea (azotemia and uremia)
- High blood pressure
- Accumulation of potassium in the blood (hyperkaliemia)
- reduction in synthesis of erythropoietin (anemia)
- Overloading the liquid volume
- Hyperphosphatemia

Tubular disfunction (tubulopathy) –

damage of the tubular function in normal or some decreased glomerular filtration

Tubular disfunction is characterized by:

- **Polyuria**
- **Renal glucosuria**

Conclusion:

The understanding of pathophysiological processes that happen in the kidneys can clearly identify the needs for a laboratory study