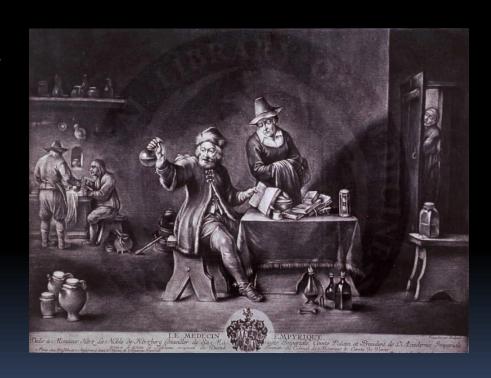
What is Urinalysis?

- Urinalysis or the analysis of urine – is one of the oldest laboratory procedures in the practice of medicine.
- It is a good test for assessing the overall health of a patient.



Courtesy of the National Library of Medicine

What is Urinalysis?

- It provides information about:
 - The state of the kidney and urinary tract.
 - Metabolic or systemic (non-kidney) disorders.
- Urinalysis can reveal diseases that have gone unnoticed because they do not produce striking signs or symptoms.
 - Examples include diabetes mellitus, various forms of kidney failure, and chronic urinary tract infections.

Urinalysis

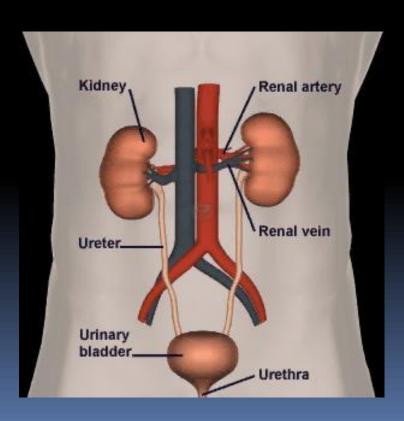


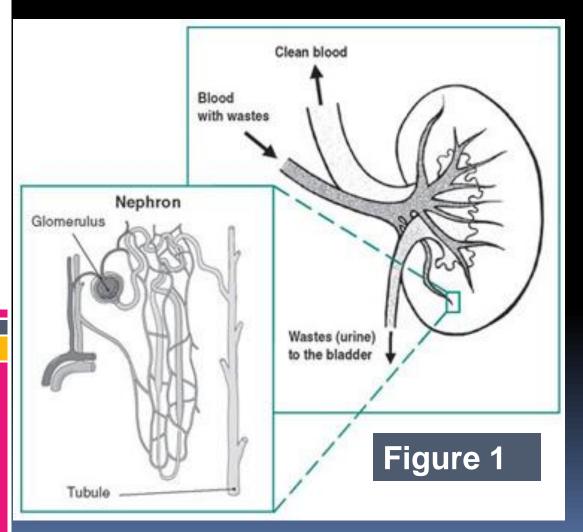
- Renal function tests, such as the urinalysis, are used to screen for the cause and the extent of renal dysfunction.
- Urinalysis consists of the following measurements:
 - Macroscopic exam
 - Chemical exam
 - Microscopic exam of the sediment

- Urine is composed of approximately 96% water and 4% dissolved substances derived from food or waste products of metabolism.
- The actual composition of urine varies, depending on diet, metabolism, general health of the body, and health of the kidney.
- Urinalysis is performed to assess the urine's composition as well as kidney function.

- Also recall the role of blood to bring nutrients and oxygen to cells of the body and to carry waste materials away from those cells.
- The kidney has the largest role in controlling the chemical composition of the blood in order to maintain proper cell function in the body.

 Recall the urinary system consists of two kidneys, two ureters and the bladder.





In the kidney, blood undergoes filtration and dialysis to separate waste compounds that will be removed from the body from those that will be returned to the circulating blood.

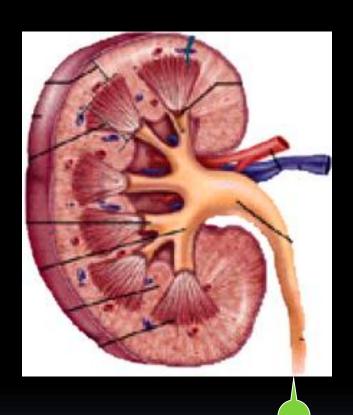
Purpose

- General evaluation of health
- Diagnosis of disease or disorders of the kidneys or urinary tract
- Diagnosis of other systemic disease that affect kidney function
- Monitoring of patients with diabetes
- Screening for drug abuse (eg. Sulfonamide or aminoglycosides)

- The processes of glomerular filtration and renal tubular reabsorption and secretion are can become affected when the kidney is compromised by disease.
- Loss of renal function can be caused by variety of conditions such as:
 - congestive heart failure
 - injury to the glomerulus or tubules caused by drugs, heavy metals and viral infections
 - diabetes, hypertension and kidney stones.

Functions of the Kidneys

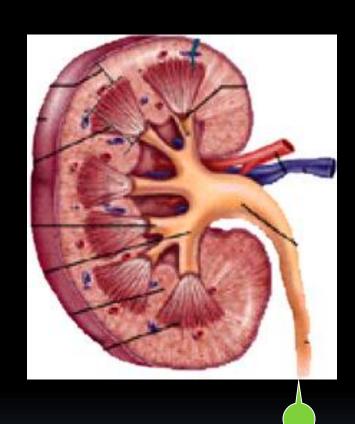
- 3) produce hormones
 - 1. renin
 - 2. erythropoietin
 - 3. calcitrol
- 4) regulate acid-base balance of the body fluids.
- 5) detoxify superoxides, free radicals, and drugs.



Functions of the Kidneys

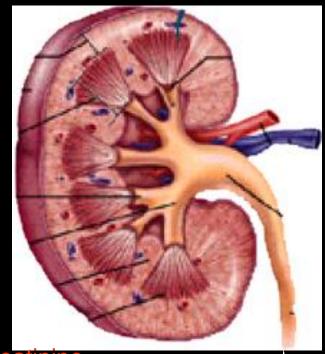
1) filter blood plasma, separate wastes, return useful materials to the blood, and eliminate the wastes.

2) regulate blood volume and osmolarity.



Functions of the Kidneys

1) filter blood plasma, separate wastes, return useful materials to the blood, and eliminate the wastes.



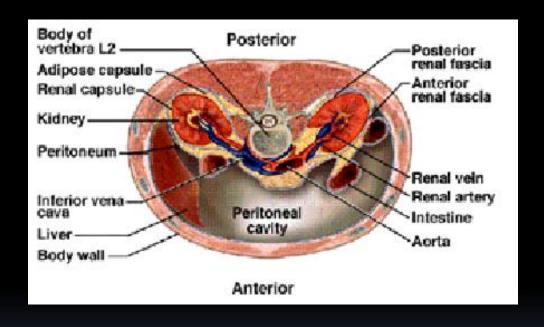
Toxic *nitrogenous wastes*

- ammonia, urea, uric acid, creatine, and

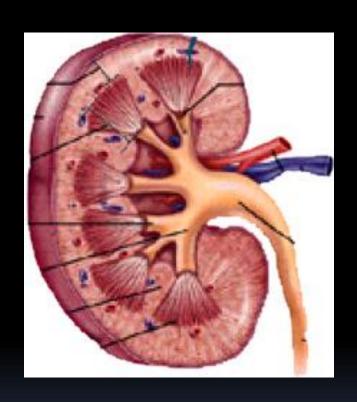
creatinine

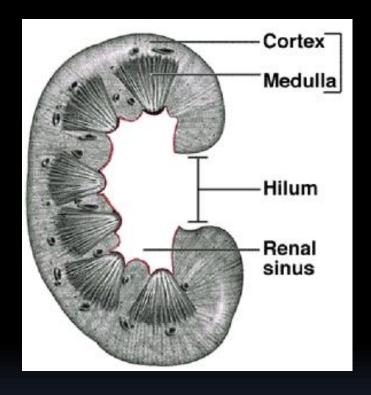
- cause diarrhea, vomiting, and cardiac arrhythmia, convulsions, coma, and death.

- The kidneys lie along the posterior abdominal wall



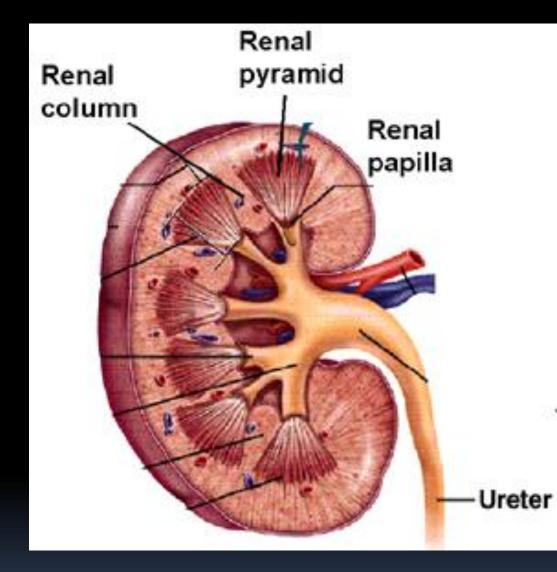
- The medial surface of the kidney is concave with a *hilum* carrying renal nerves and blood vessels.



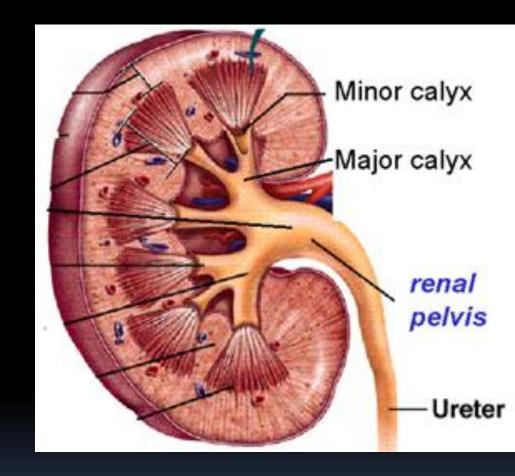


The renal parenchyma is divided into an outer *cortex* and inner *medulla*.

Extensions of the cortex (renal columns) project toward the sinus, dividing the medulla into 6-10 renal pyramids. Each pyramid is conical with a blunt point called the papilla facing the sinus.



The papilla is nestled into a cup called a *minor calyx*, which collects its urine. Two or three minor calyces merge to form a *major calyx*. The major calyces merge to form the *renal pelvis*.



The Nephron

- The kidney contains 1.2 million *nephrons*, which are the functional units of the kidney.

- A nephron consists of :

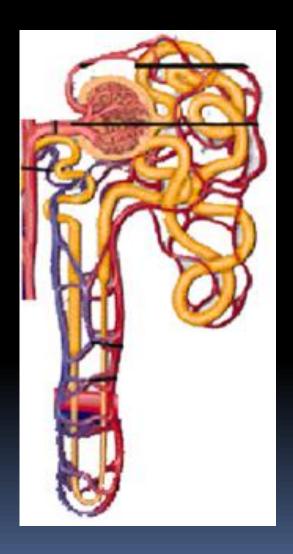
i. blood vessels

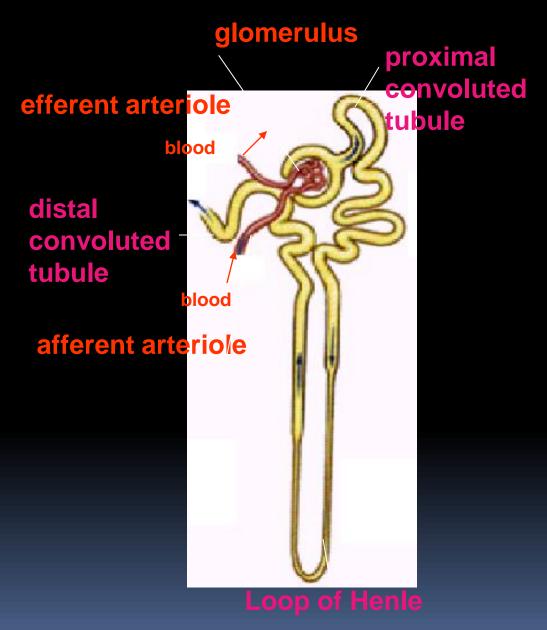
afferent arteriole glomerulus efferent arteriole

ii. renal tubules

proximal convoluted tubule loop of Henle distal convoluted tubule

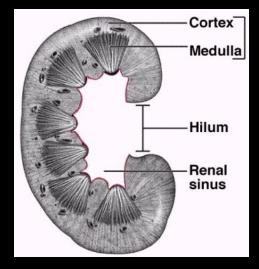
The Nephron

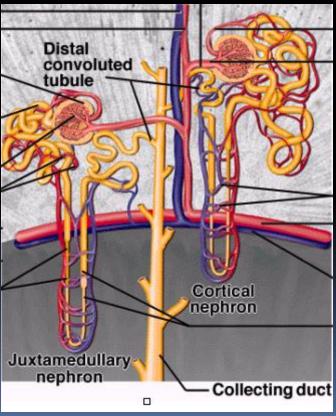




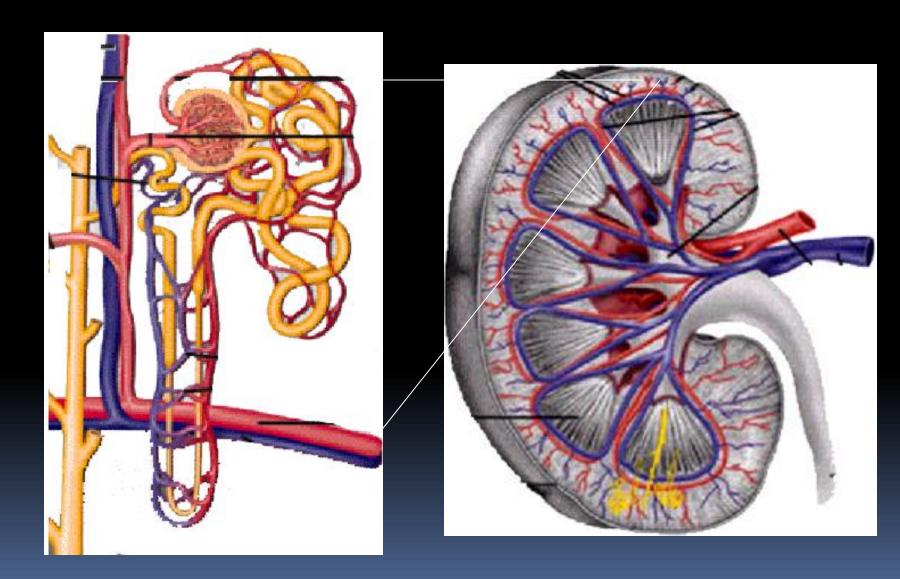
The Nephron

- Most components of the nephron are within the cortex.

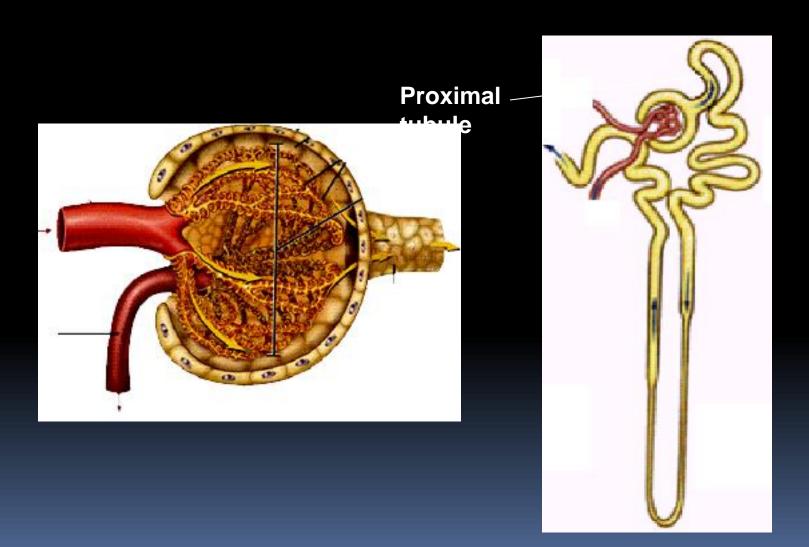




Nephrons are connected to renal artery/vein and ureter.



The glomerulus is enclosed in a two-layered glomerular (Bowman's) capsule.



URINE FORMATION

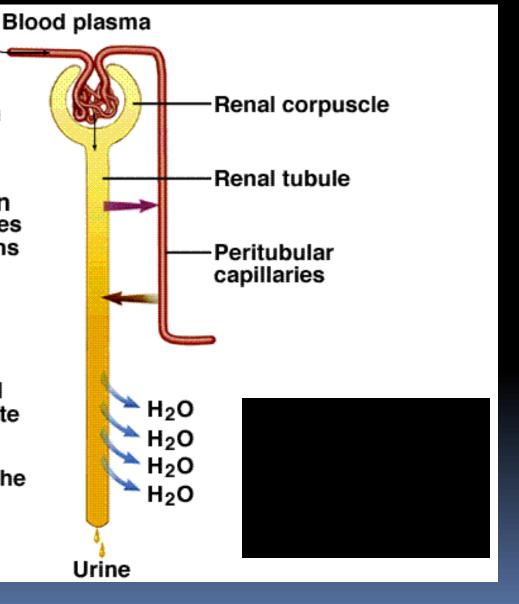
The kidney produces urine through 4 steps.

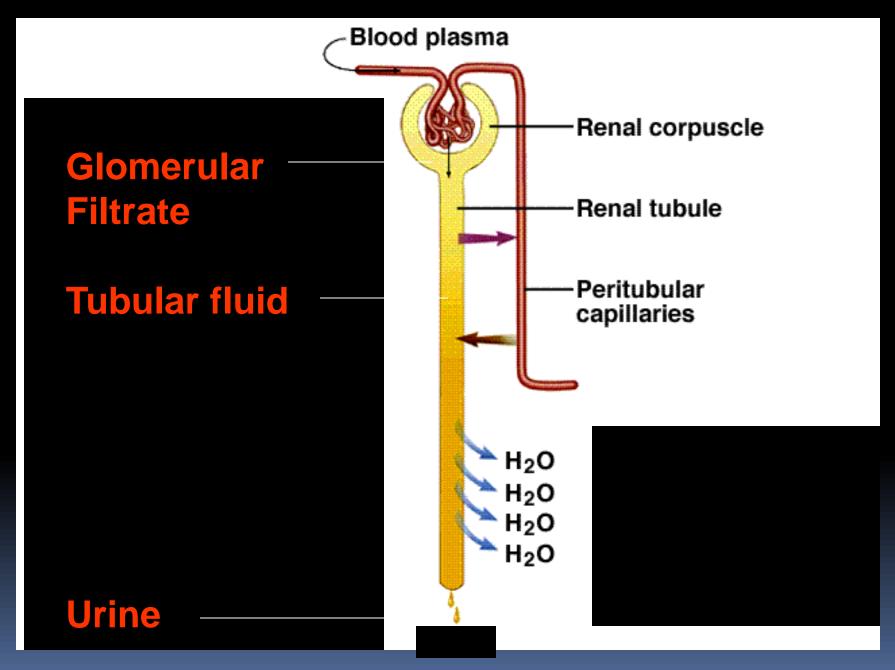
Glomerular filtration
 Creates a plasmalike
 filtrate of the blood

2 Tubular reabsorption Removes useful solutes from the filtrate, returns them to the blood

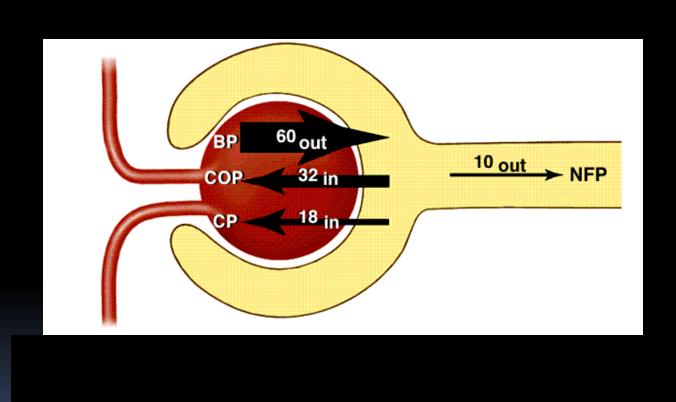
③ Tubular secretion Removes additional wastes from the blood adds them to the filtrate

Concentration
 Removes water from the urine, concentrates wastes



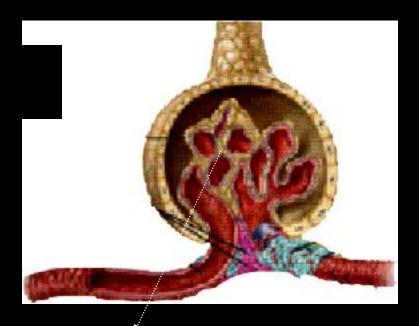


1) Glomerular Filtration



The Filtration Membrane

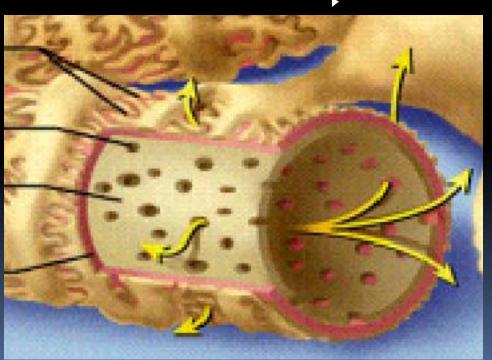
From the plasma to the capsular space, fluid passes through three barriers.



foot processes

fenestrated epithelium

basement membrane



The Filtration Membrane

Almost any molecule smaller than **3** nm can pass freely through the filtration membrane into the capsular space.



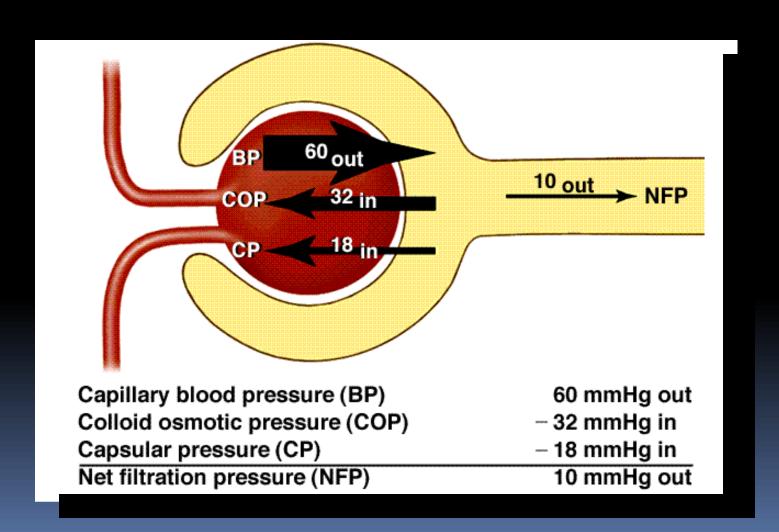
These include:

Water, electrolytes, glucose, amino acids, lipids, vitamins, and nitrogenous wastes

Kidney infections and trauma commonly damage the filtration membrane and allow *plasma proteins* or *blood cells* to pass through.

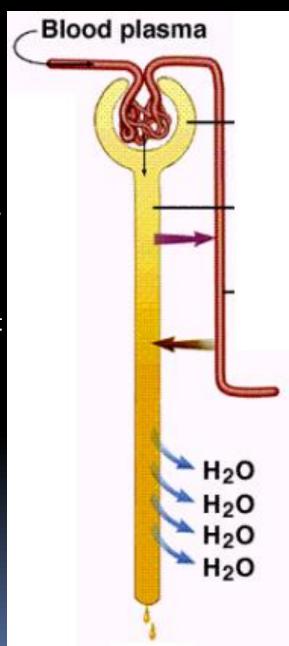
Filtration Pressure

Glomerular filtration follows the same principles that govern filtration in other capillaries.



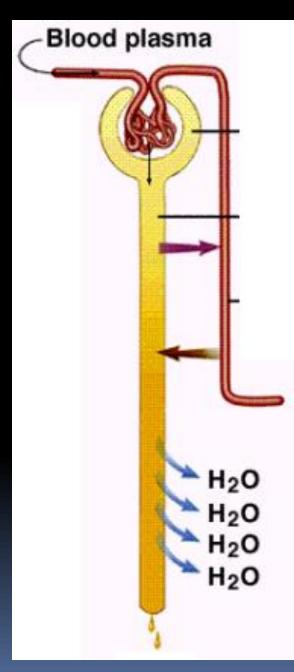
Glomerular Filtration Rate (GFR)

- is the amount of filtrate formed per minute by the two kidneys combined.
- For the average adult male, GFR is about 125 ml/min.
- This amounts to a rate of 180 L/day.
- An average of 99% of the filtrate is reabsorbed, so that 1-2 L of urine per day is excreted.



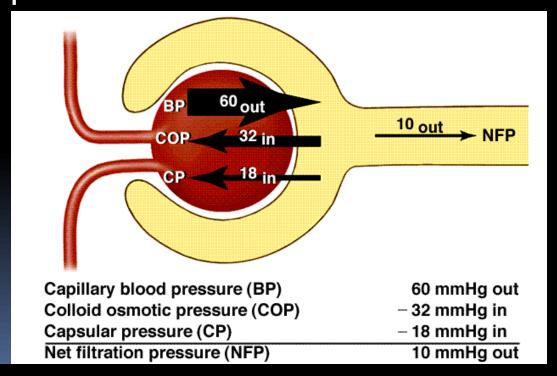
GFR must be precisely controlled.

- a. If GFR is too high
- increase in urine output
- threat of dehydration and electrolyte depletion.
- b. If GFR is too low
- insufficient excretion of wastes.
- c. The only way to adjust GFR from moment to moment is to change glomerular blood pressure.



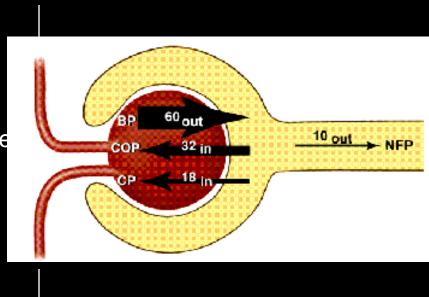
Renal Autoregulation

- the ability of the kidneys to maintain a relatively stable GFR in spite of the changes (75 - 175 mmHg) in arterial blood pressure.



The nephron has two ways to prevent drastic changes in GFR when blood pressure rises:

- 1) Constriction of the afferent arteriole to reduce blood flow into the glomerulus
- 2) Dilation of the efferent arteriole to allow the blood to flow out more easily.

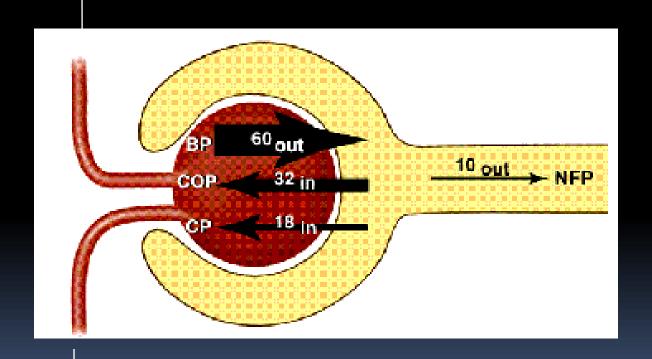


Change in an opposite direction if blood pressure falls

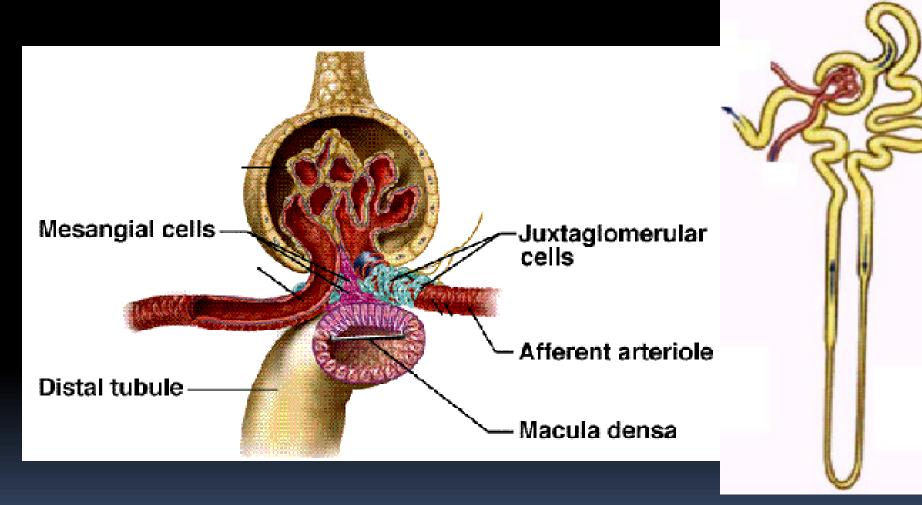
Mechanisms of Renal Autoregulation

- 1) myogenic response
- 2) tubuloglomerular feedback

1) myogenic response

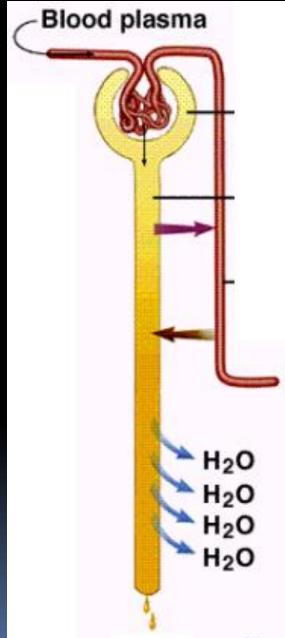


2) tubuloglomerular feedback

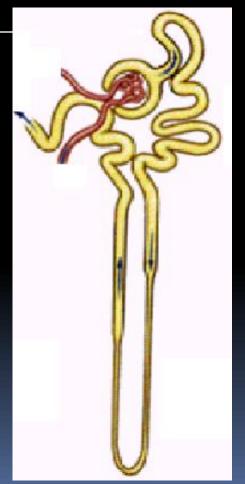


- 1) Glomerular Filtration
- 2) Tubular Reabsorption
- 3) Tubular Secretion
- 4) Concentrating Urine by Collecting Duct

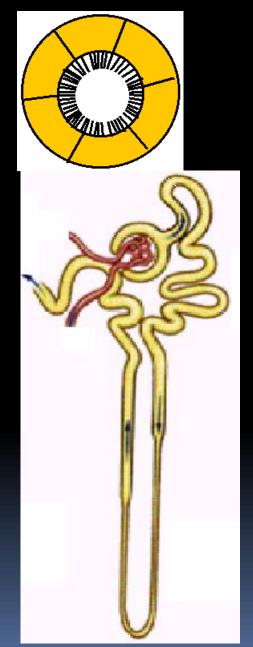
About 99% of Water and other useful small molecules in the filtrate are normally reabsorbed back into plasma by renal tubules.



Reabsorption in Proximal Convoluted Tubules



- The proximal convoluted tubule (PCT) is formed by one layer of epithelial cells with long apical microvilli.
- PCT reabsorbs about **65%** of the glomerular filtrate and return it to the blood.

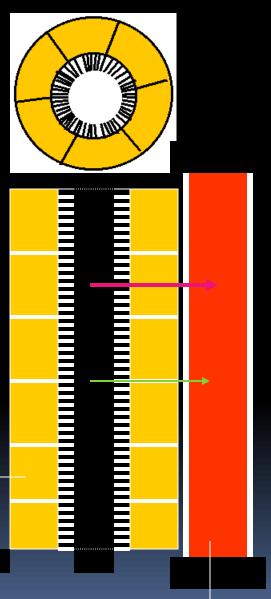


Routes of Proximal Tubular Reabsorption

- 1) transcellular route
- 2) paracellular route

PCT





Mechanisms of Proximal Tubular Reabsorption

- 1) Solvent drag
- 2) Active transport of sodium.
- 3) Secondary active transport of glucose, amino acids, and other nutrients.
- 4) Secondary water reabsorption via osmosis
- 5) Secondary ion reabsorption via electrostatic attraction
- 6) Endocytosis of large solutes

Osmosis

Water moves from a compartment of low osmolarity to the compartment of high osmolarity.

low osmolarity

high H2O conc.

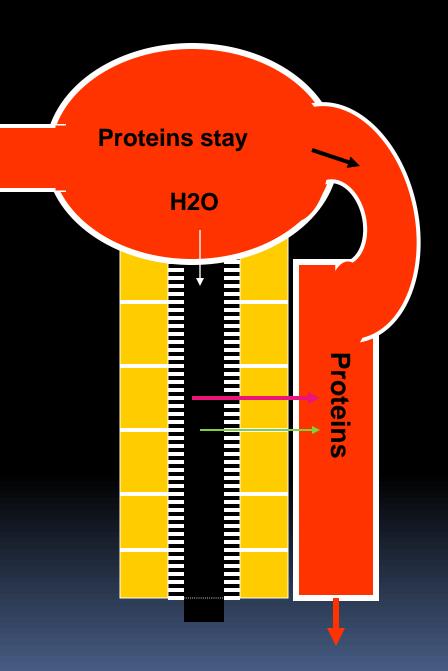
H20

high osmolarity

(low H2O conc.)

1) Solvent drag

- driven by high colloid osmotic pressure (COP) in the peritubular capillaries
- Water is reabsorbed by osmosis and carries all other solutes along.
- Both routes are involved.



2) Active transport of sodium

Sodium pumps (Na-K ATPase) in basolateral membranes transport sodium out of the cells against its concentration gradient using ATP.



There are also pumps for other ions



lumen

3) Secondary active transport of glucose, amino acids, and other nutrients

- Various cotransporters can carry both Na+ and other solutes. For example, the **sodium-dependent glucose transporter** (SDGT) can carry both Na+ and glucose.



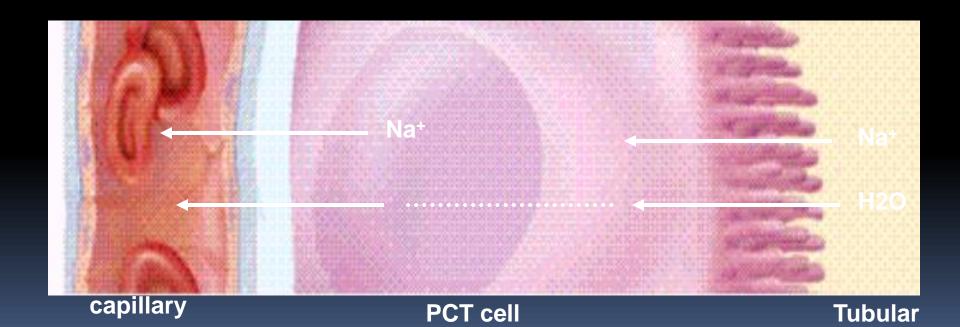
3) Secondary active transport of glucose, amino acids, and other nutrients

Amino acids and many other nutrients are reabsorbed by their specific cotransporters with sodium.



4) Secondary water reabsorption via osmosis

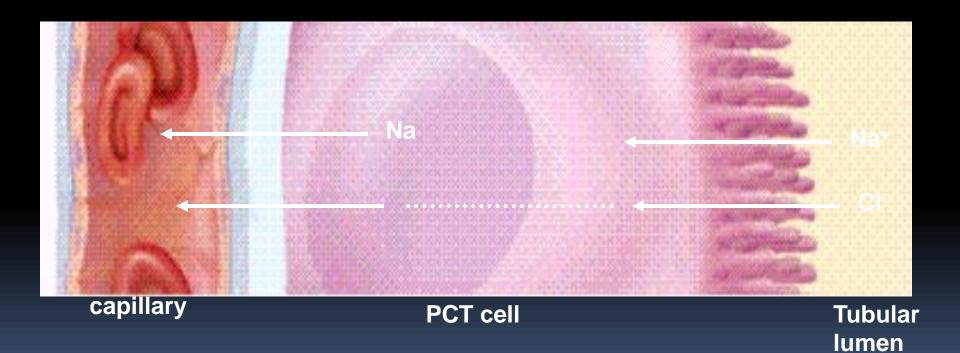
Sodium reabsorption makes both intracellular and extracellular fluid hypertonic to the tubular fluid. Water follows sodium into the peritubular capillaries.



lumen

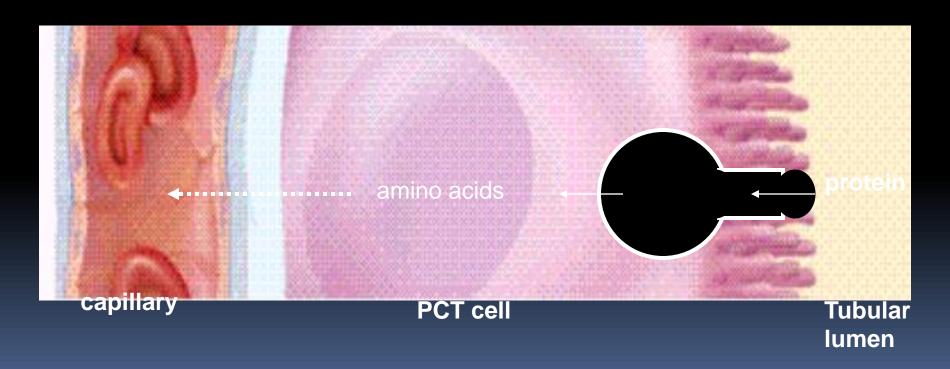
5) Secondary ion reabsorption via electrostatic attraction

Negative ions tend to follow the positive sodium ions by electrostatic attraction.



6) Endocytosis of large solutes

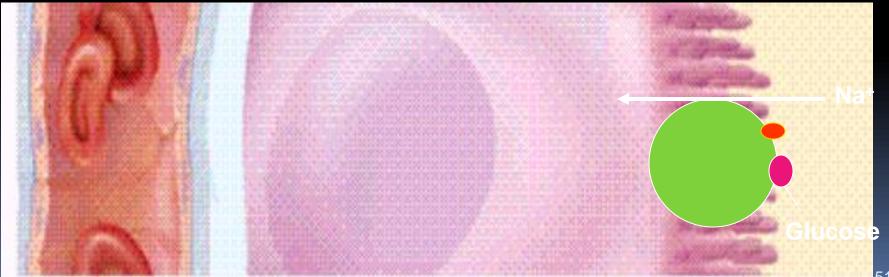
The glomerulus filters a small amount of protein from the blood. The PCT reclaims it by **endocytosis**, hydrolzes it to amino acids, and releases these to the ECF by facilitated diffusion.



The Transport Maximum

- There is a limit to the amount of solute that the renal tubule can reabsorb because there are limited numbers of transport proteins in the plasma membranes.
- If all the transporters are occupied as solute molecules pass through, some solute will remain in the tubular fluid and appear in the urine.

Example of diabetes

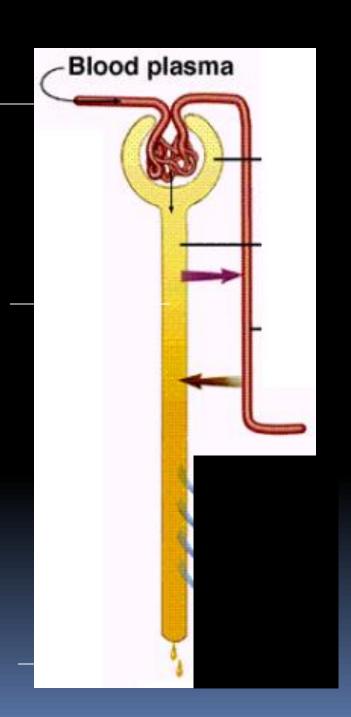


high glucose in blood

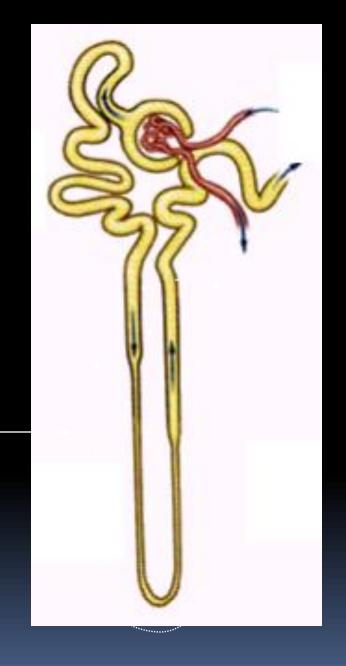
high glucose in filtrate

Exceeds Tm for glucose

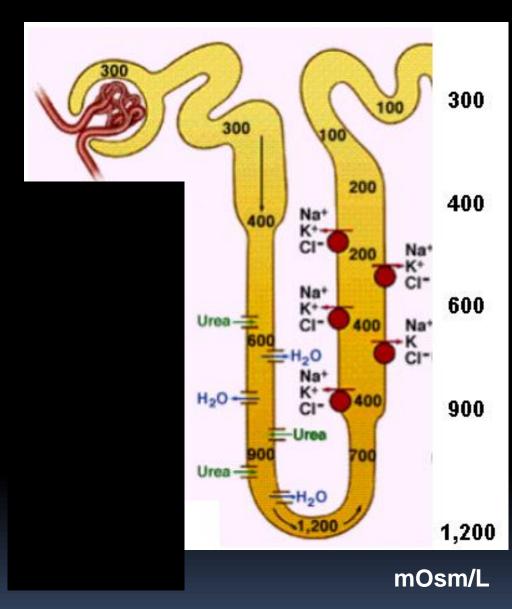
Glucose in urine



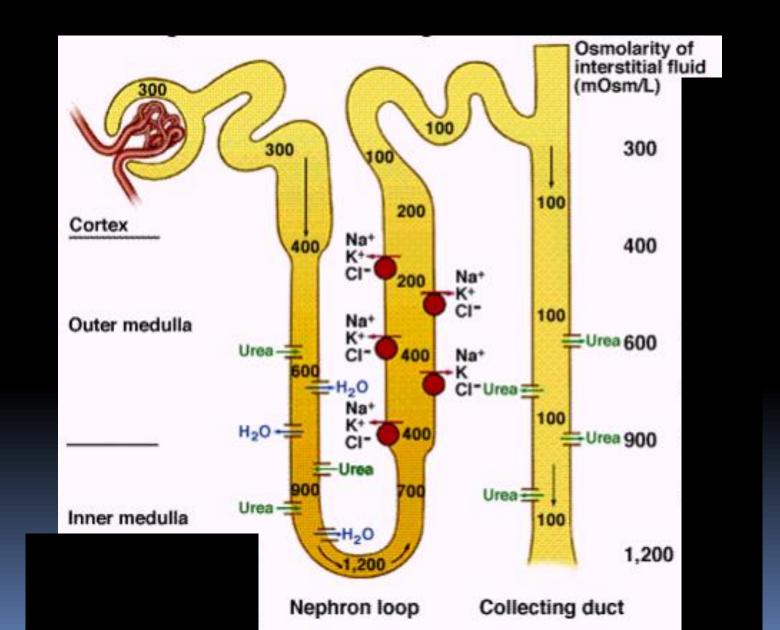
Reabsorption in the Nephron Loop

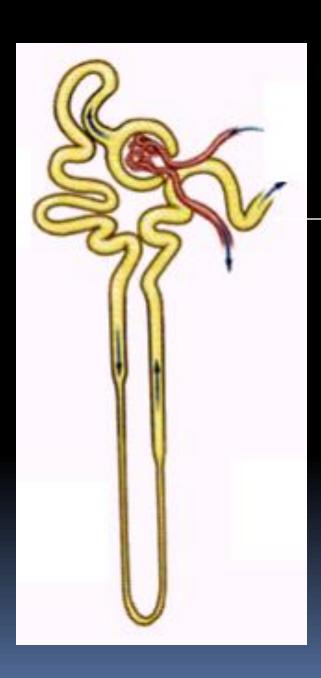


- The primary purpose is to establish a high extracellular osmotic concentration.
- The thick ascending limb reabsorbs solutes but is impermeable to water. Thus, the tubular fluid becomes very diluted while extracellular fluid becomes very concentrated with solutes.

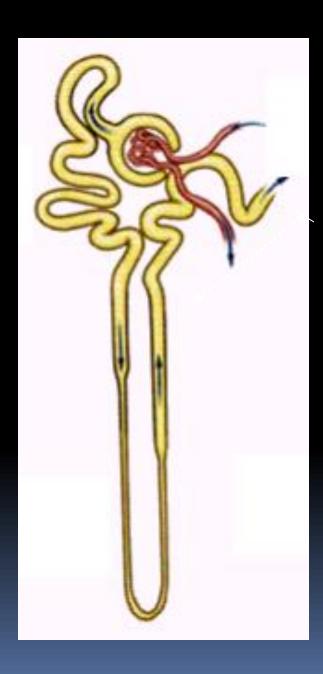


The high osmolarity enables the collecting duct to concentrate the urine later.

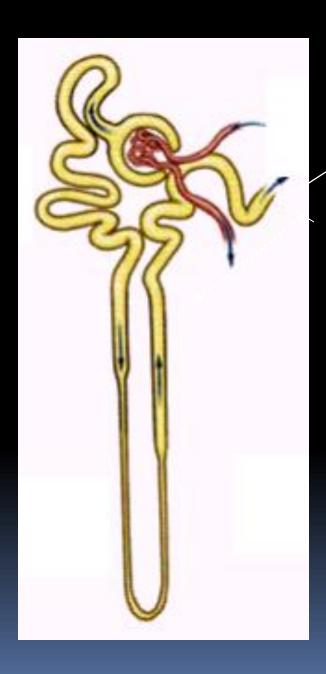




Reabsorption in Distal Convoluted Tubules

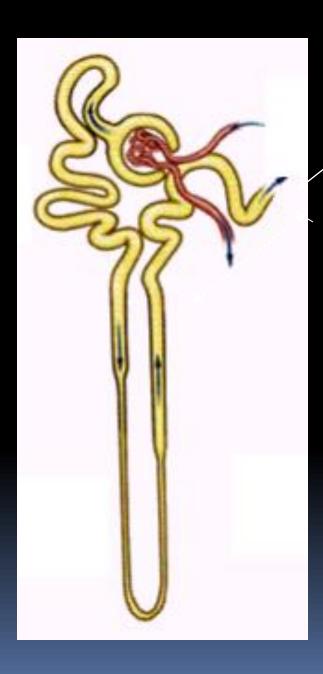


- Fluid arriving in the DCT still contains about 20% of the water and 10% of the salts of the glomerular filtrate.
- A distinguishing feature of these parts of the renal tubule is that they are subject to *hormonal control*.



Aldosterone

- a. secreted from adrenal gland in response to a ↓ Na+ or a ↑ K+ in blood
- to increase Na⁺ absorption and K⁺ secretion in the DCT and cortical portion of the collecting duct.
- c. helps to maintain blood volume and pressure.



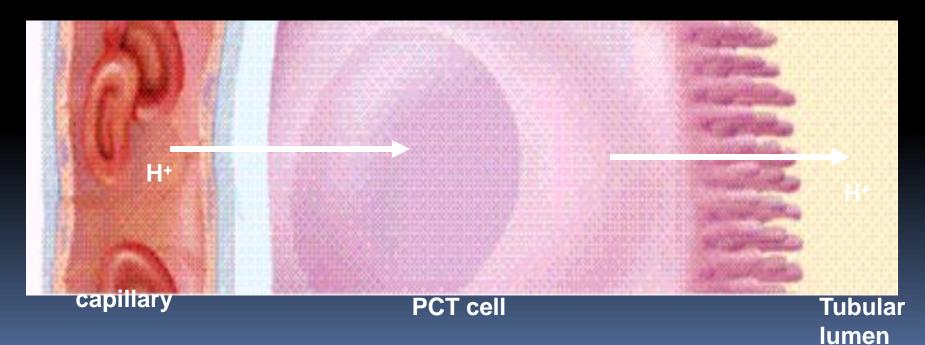
Atrial Natriuretic Factor

- secreted by the atrial myocardium in response to high blood pressure.
- It inhibits sodium and water reabsorption, increases the output of both in the urine, and thus reduces blood volume and pressure.

- 1) Glomerular Filtration
- 2) Tubular Reabsorption
- 3) Tubular Secretion
- 4) Concentrating Urine by Collecting Duct

Tubular Secretion

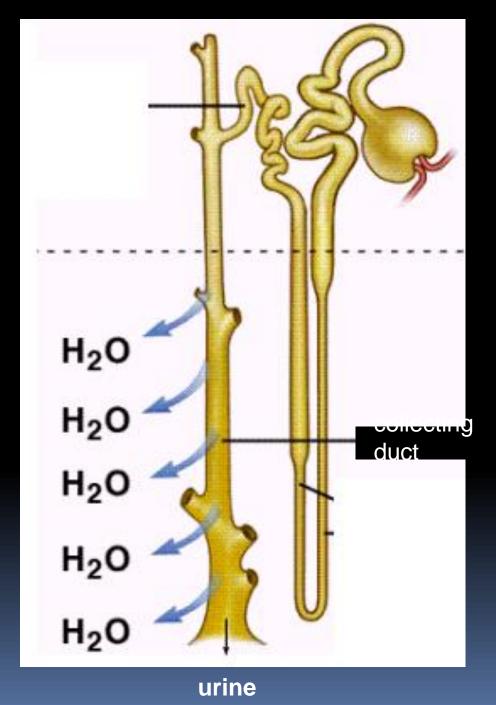
- Renal tubule extracts chemicals from the blood and secretes them into the tubular fluid.
- serves the purposes of waste removal and acid-base balance.



61

- 1) Glomerular Filtration
- 2) Tubular Reabsorption
- 3) Tubular Secretion
- 4) Concentrating Urine by Collecting Duct

- 1. The collecting duct (CD) begins in the cortex, where it receives tubular fluid from numerous nephrons.
- 2. CD reabsorbs water.

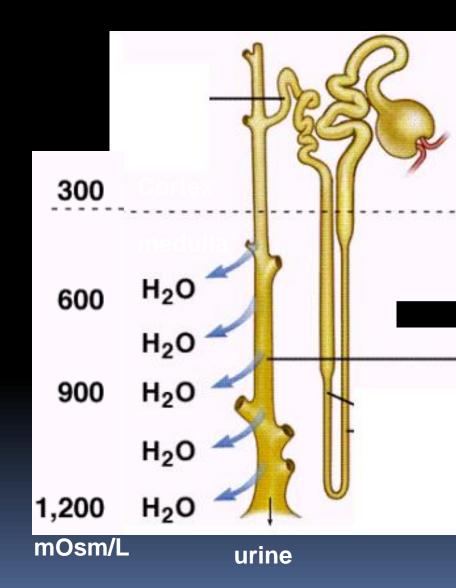


1. Driving force

The *high osmolarity* of extracellular fluid generated by *NaCl* and *urea*, provides the driving force for water reabsorption.

2. Regulation

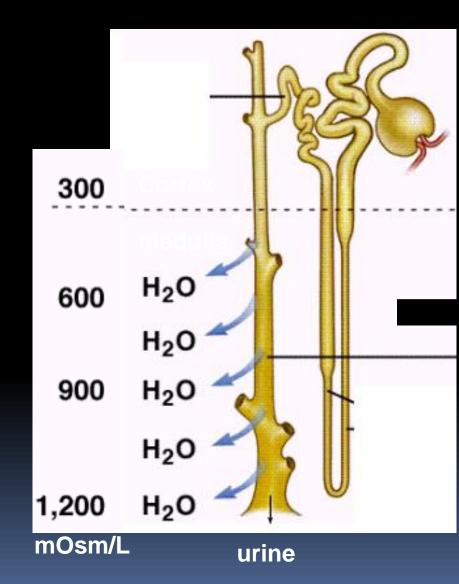
The medullary portion of the CD is *not permeable to NaCl but permeable to water*, depending on ADH.



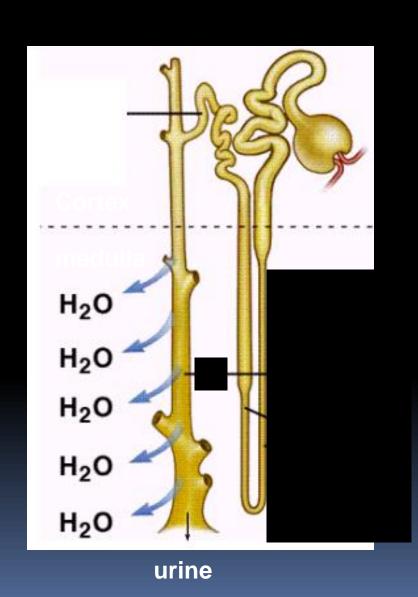
Control of Urine Concentration depends on the body's state of hydration.

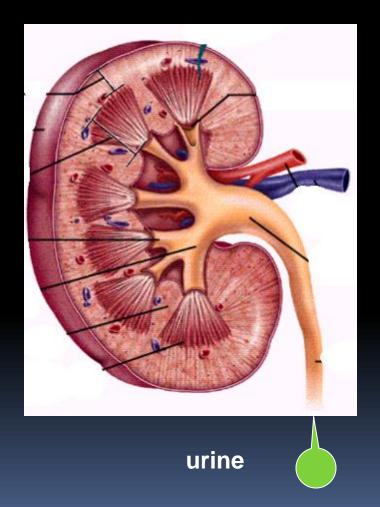
a. In a state of *full hydration*, antidiuretic hormone (ADH) is not secreted and the CD permeability to water is low, leaving the water to be excreted.

b. In a state of *dehydration*, ADH is secreted; the CD permeability to water increases. With the increased reabsorption of water by osmosis, the urine becomes more concentrated.



No more reabsorption after tubular fluid leaving CD





Collection of urine specimens

- The first voided morning urine (the most common)
- Random urine (for emergency)
- Clean-catch, midstream urine (for urine culture)

Attention

Need to be examined within 1 hour

Urine Properties

Composition and Properties of Urine

Fresh urine is *clear*, containing *no blood cells* and *little proteins*. If cloudy, it could indicate the presence of bacteria, semen, blood, or menstrual fluid.

Examination of the physical properties including....

- Color
- Clarity (or transparency)



- Color normal
 - yellow (straw to amber)
- Color abnormal (due to disease, drugs or diet)
 - pale to colorless
 - amber (dark yellow)
 - orange
 - pink or red
 - green
 - brown or black

- Clarity (or transparency) normal
 - clear
- Clarity abnormal (due to insoluble elements such as cells, crystals, etc.)
 - hazy
 - cloudy
 - turbid



Left to right: Straw, clear; yellow, clear; yellow, hazy; yellow, clear; redorange, clear; brown, hazy.

Appearance

- Including color and clarity
- Color: normally, pale to dark yellow (urochrome)

Abnormal color:

some drugs cause color changes

1. red urine: causes: hematuria

hemoglobinuria

myoglobinuria

2. yellow-brown or green-brown urine: bilirubin

cause: obstructive jaundice

Red Urine

- Microscopic Hematuria
 - Urinary tract source
 - •Urethra or bladder
 - Prostate
 - •Ureter or kidney
 - Non-Urinary tract source
 - Vagina
 - Anus or rectum

- Pseudohematuria (non-hematuria related red urine)
 - Myoglobinuria
 - Hemoglobinuria
 - Phenolphthalein <u>Laxatives</u>
 - Phenothiazines
 - Porphyria
 - Rifampin
 - Pyridium
 - Bilirubinuria
 - Phenytoin
 - Pyridium
 - Red diaper syndrome
 - Foods (Beets, Blackberries, Rhubarb)



Red Urine

- Causes of Asymptomatic Gross Hematuria by <u>Incidence</u>
- Acute Cystitis (23%)
- Bladder Cancer (17%)
- Benign Prostatic Hyperplasia (12%)
- Nephrolithiasis (10%)
- Benign essential hematuria (10%)
- Prostatitis (9%)
- Renal cancer (6%)
- Pyelonephritis (4%)
- Prostate Cancer (3%)
- Urethral stricture (2%)

Appearance

Clarity: normally, clear Abnormal color: cloudy urine Causes: 1. crystals or nonpathologic salts phosphate, carbonate in alkaline urine (dissolve---add acetic acid) uric acid in acid urine (dissolve---warming to 60°C) 2. various cellular elements: leukocytes, RBCs, epithelial cells

Urine volume

- The average adult : 1000ml to 2000ml/24h
- Increase
 - polyuria---more than 2000ml of urine in 24 hours
 - 1. physiological states: water intake, some drugs, intravenous solutions
 - 2. pathologic states: diabetes mellitus, diabetes insipidus

Urine volume

Decrease

- Oliguria---less than 400ml of urine in 24 hours

 Anuria---less than 100ml of urine in 24 hours
 - 1. prerenal: hemorrhage, dehydration, congestive heart failure
 - 2. postrenal: obstruction of the urinary tract (may be stones, carcinoma)
 - 3. renal parenchymal disease: acute tubular necrosis, chronic renal failure

Specific gravity (SG)

- Reflect the density of the urine
- Range of 1.001 to 1.040
- Increase: Dehydration \ Fever \ Vomiting Diarrhea
 Diabetes Mellitus and other causes of Glycosuria \ Congestive Heart Failure \ Syndrome Inappropriate ADH
 Secretion (SIADH) \ Adrenal Insufficiency

failure (urine volume↓ and SG↑)

Decrease: diabetes insipidus (urine volume↑ and SG ↓)

<u>Urine</u> PH

- Normal PH
 - The average is about 6 Range from 5~9 (depends on diet)
- Higher PH---alkaline urine
 - 1.drugs: sodium bicarbonate
 - 2. classic renal tubular acidosis
 - 3.alkalosis (metabolic or respiratory)
- Lower PH---acid urine
 - 1.drugs: ammonium chloride
 - acidosis (metabolic or respiratory)

Substance	Blood Plasma (total amount)	Urine (amount per day)
Urea	4.8 g	25 g
Uric acid	0.15 g	0.8 g
Creatinine	0.03 g	1.6 g
Potassium	0.5 g	2.0 g
Chloride	10.7 g	6.3 g
Sodium	9.7 g	4.6 g
Protein	200 g	0.1 g
HCO ₃ -	4.6 g	0 g
Glucose	3 g	0 g

Protein in urine

Reference value

Qualitative method: negative

Quantitative method: less than 150mg of

protein in 24 hours

 Urine proteins come from plasma protein and Tamm-Horsfall (T-H) glycoprotein

- Proteinuria---more than 150mg proteins in urine in 24 hours or qualitative test is positive
- Proteinuria quantification (depend on the amount of protein)
 - heavy proteinuria----> 4.0g/24 hours moderate proteinuria----1.0~4.0g/24 hours minimal proteinuria----< 1.0g/24 hours

Qualitative categories of proteinuria

- Glomerular proteinuria:
 - glomerular diseases damage glomerular basement membrane but tubular function is normal
 - 2.selective proteinuria---chiefly albumin nonselective proteinuria
 - 3.heavy proteinuria
 - 4. disease: acute glomerulonephritis

Tubular proteinuria

- 1.Renal tubular disease damage tubular function but glomerular is normal
- 2. Moderate proteinuria
- 3. disease: pyelonephritis

Overflow proteinuria

Excess levels of a protein in the circulation, hemoglobin, myoglobin, etc. The renal function is normal

Overflow Causes

- Hemoglobinuria
- Myoglobinuria
- Multiple Myeloma
- > Amyloidosis

Proteinuria Causes

- Glomerular Causes (Increased glomerulus permeability)
- Primary Glomerulonephropathy
 - Minimal Change Disease
 - IgA Nephropathy
 - Idiopathic membranous Glomerulonephritis
 - Focal segmental <u>Glomerulonephritis</u>
 - Membranoproliferative Glomerulonephritis
 - Heavy metals
- Tubular Causes (Decreased tubular reabsorption)
- Hypertensive nephrosclerosis
- <u>Uric Acid</u> nephropathy
- Acute hypersensitivity
- Interstitial Nephritis
- Fanconi Syndrome
- Heavy metals
- Sickle Cell Anemia
- NSAIDs
- Antibiotics

- Secondary Glomerulonephropathy
 - Diabetes Mellitus (Diabetic Nephropathy)
 - Systemic Lupus Erythematosus (Lupus Nephritis)
 - Amyloidosis
 - Preeclampsia (Pregnancy Induced Hypertension)
 - Infection
 - HIV Infection
 - Hepatitis B
 - Hepatitis C
 - Poststreptococcal Glomerulonephritis
 - Syphilis
 - Malaria
 - Endocarditis
 - Lung Cancer
 - Gastrointestinal Cancer
 - Lymphoma
 - Renal transplant rejection

- Overflow Causes (Increased low MW protein production)
- Hemoglobinuria
- Myoglobinuria
- Multiple Myeloma
- Amyloidosis

Glucose in urine

- Reference value
 - Qualitative method: negative
- Glycosuria--- qualitative test is positive
 - 1.hyperglycemia: diabetes mellitus
 - Cushing's syndrom
 - 2.without hyperglycemia: renal tubular dysfunction, such as pyelonephritis

Ketones in urine

Including three ketone bodies:

acetoacetic acid 20% acetone 2%

β-hydroxybutyric acid 78%

- The products of fat metabolism
- Reference value:

qualitative method: negative

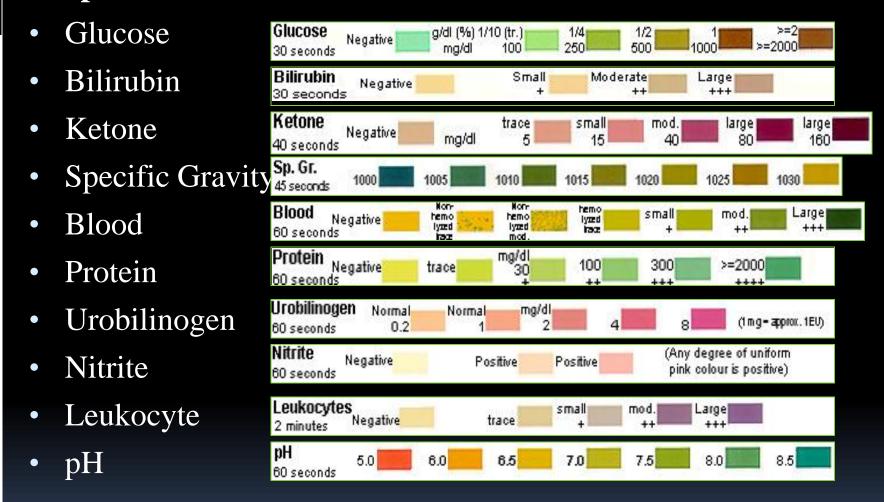
Ketonuria--- qualitative test is positive

Ketonuria

- 1. diabetic ketonuria
- 2. nondiabetic ketonuria:

Hyperemesis of pregnancy
Patients accompanied by vomiting or diarrhea

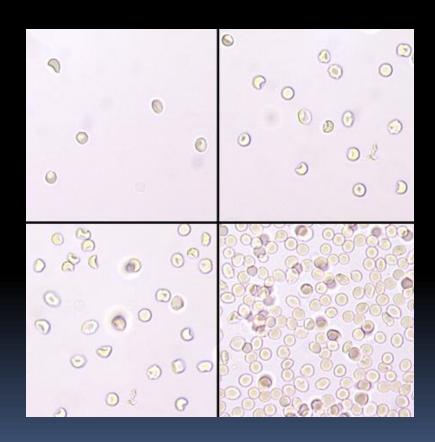
Strip include the tests:



- A variety of normal and abnormal cellular elements may be seen in urine sediment such as:
 - Red blood cells
 - White blood cells
 - Mucus
 - Various epithelial cells
 - Various crystals
 - Bacteria

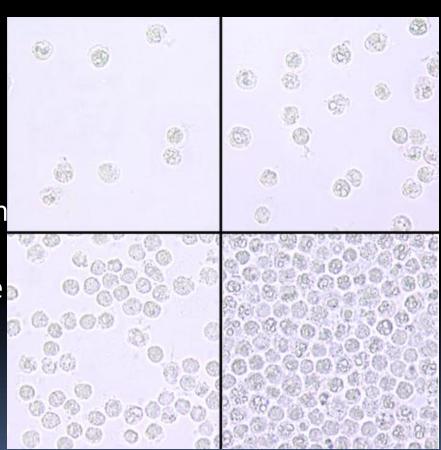
- The urine specimen is centrifuged and the liquid portion is poured off.
- The concentrated cellular sediment





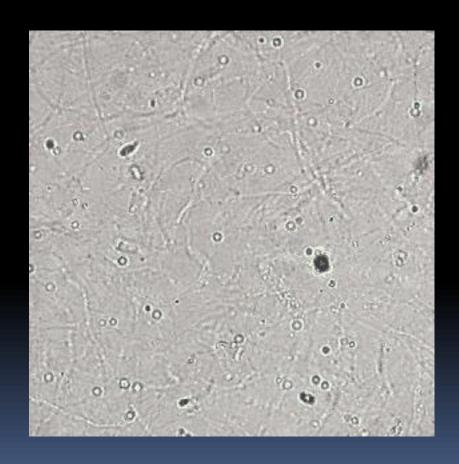
- Red blood cells
 - presence of a few is normal
 - higher numbers are indicator of renal disease
 - result of bleeding at any point in urinary system

- White blood cells
 - a few are normal
 - high numbers indicate inflammation or infection somewhere along the urinary or genital tract



Mucus

- look like long, ribbonlike threads
- common finding in urine sediment
- secreted by glands in the lower urinary tract



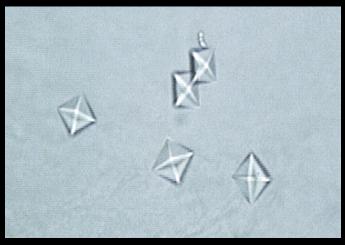


- Epithelial cells
 - cells are large and flat
 - normal cells that line the urinary and genital tract or renal tubules

NORMAL CRYSTALS

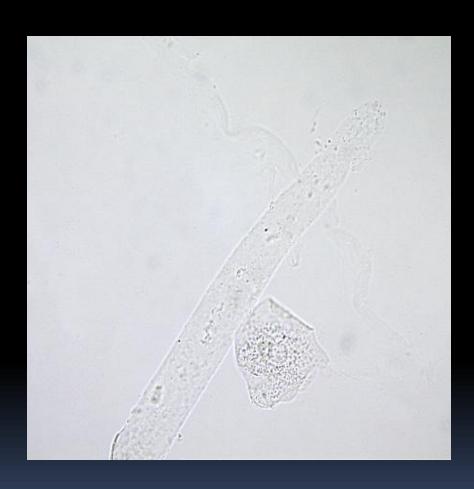


 A variety of normal and abnormal crystals may be present in the urine sediment.





- Crystals of calcium oxalate
 - colorless octahedron
 - found in acid urine
- Crystals of triple phosphate
 - colorless, "coffin-lid" prism
 - common finding; not clinically significant



- Hyaline Casts
 - colorless and fatter than mucus
 - a few are normal
 - may be increased after strenuous exercise
 - form when protein solidifies in the nephron

Hyaline cast & epithelial cell, 40x objective

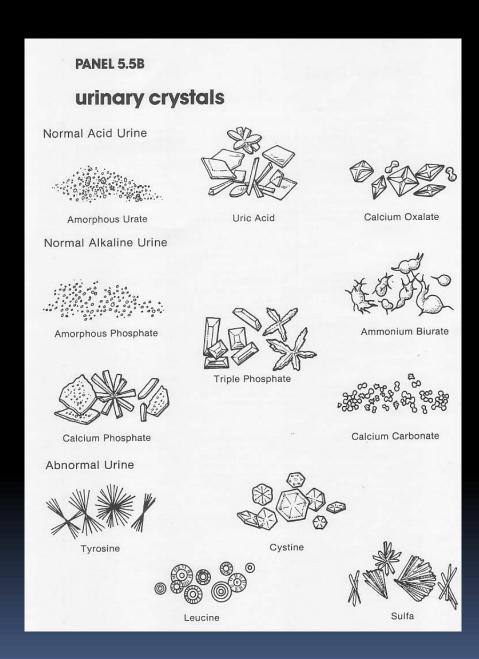
PANEL 5.5A

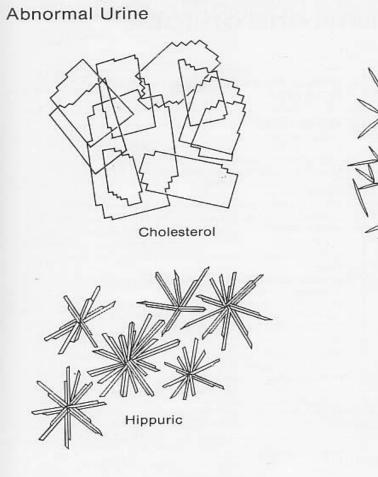
urinary crystals

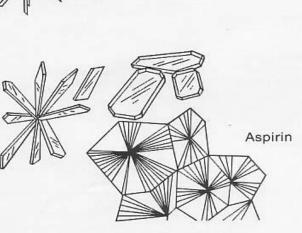
TYPE OF URINE	TYPE OF CRYSTALS	DESCRIPTION OF CRYSTALS	SIGNIFICANCE WHEN FOUND IN URINE
Normal Acid Urine	amorphous urate	colorless or yellow-brown granules (pink macroscopically)	nonpathologic
	uric acid	occur in many shapes; may be colorless, yellow- brown or red-brown; and square, diamond-shaped, wedge-shaped, or grouped in rosettes	usually nonpathologic; in large numbers, may indicate gout
	calcium oxalate	octahedral or dumbbell-shaped; possess double refractive index	usually nonpathologic; may be associated with stone formation
Normal Alkaline Urine	amorphous phosphates	small, colorless, granules	nonpathologic
	triple phosphates	colorless prisms with three to six sides ("coffin-lids") or feathery shaped like fern leaves	usually nonpathologic; may be associated with urine stasis or chronic urinary tract infection
	ammonium biurate	yellow-brown "thorny apple" appearance or yellow-brown spheres	nonpathologic
	calcium phosphate	colorless prisms or rosettes	usually nonpathologic; may be associated with urine stasis or chronic urinary tract infection
	calcium carbonate	usually appear colorless and amorphous; may be shaped like dumbbells, rhombi, or needles	usually nonpathologic; may be associated with inorganic calculi formation

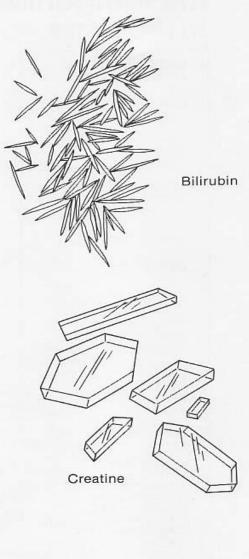
PANEL 5.5A (cont.)

TYPE OF URINE	TYPE OF CRYSTALS	DESCRIPTION OF CRYSTALS	SIGNIFICANCE WHEN FOUND IN URINE
4	tyrosine	thin, dark needles, arranged in sheaves or clumps; usually colorless, but may be pale yellow-brown	liver disease or inherited metabolic disorder
*	leucine	yellow-brown spheres with radial striations	liver disease or inherited metabolic disorder
Abnormal Urine	cystine	clear, hexagonal plates	cystinuria
	hippuric acid	star-shaped clusters of needles, rhombic plates, or elongated prisms; may be colorless or yellow-brown	usually nonpathologic
	bilirubin	delicate needles or rhombic plates; red-brown in color; birefringent	bilirubinuria
	cholesterol	colorless, transparent plates with regular or irregular corner notches	chyluria, urinary tract infections, nephrotic syndrome
	creatine	pseudohexagonal plates with positive birefringence	destruction of muscular tissue due to muscular dystrophies, atrophies, and myositis
	aspirin	distinctive prismatic or star-like forms; usually colorless; show positive birefringence	Ingestion of aspirin or other salicylates
	sulfonamide	yellow-brown dumbbells, asymmetrical sheaves, rosettes, or hexagonal plates	ingestion of sulfonamide drugs
	ampicillin	long, thin, clear crystals	parenteral administration of ampicillin
	x-ray media	long, thin rectangles or flat, four-sided, notched plates	x-ray procedure with contrast media



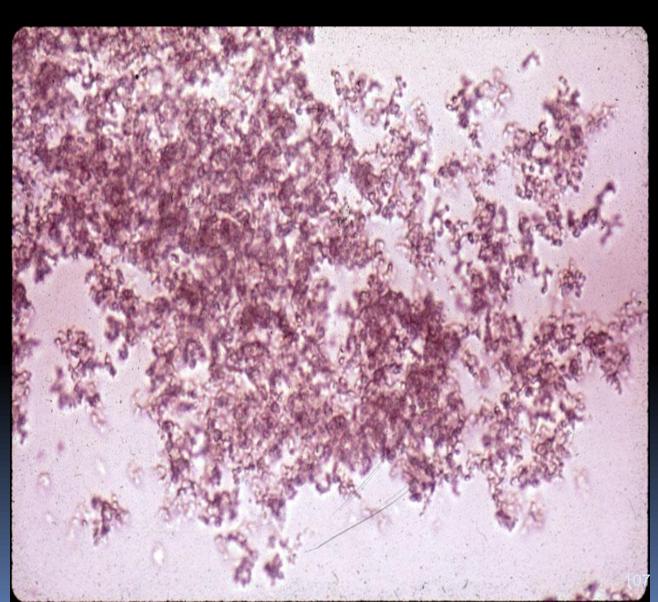






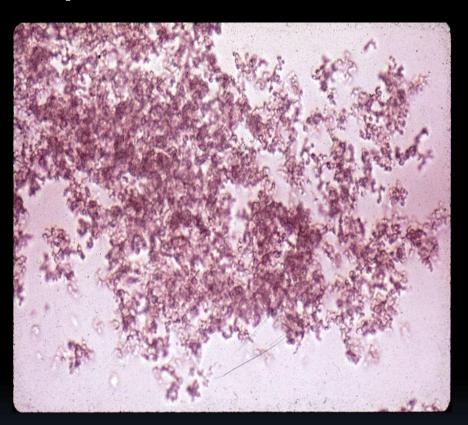
Amorphous Urates

Brown or colorless granules Na or K Sediment in spin down tube may have brick red color



Amorphous Phosphates

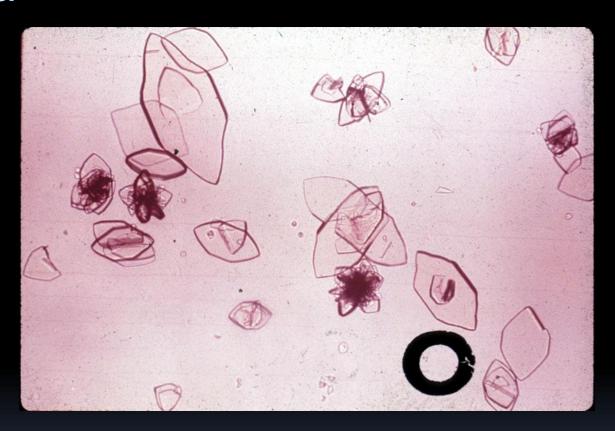
- Ca or Mg
- Found in Basic urine
- Dissolves in Acetic Acid



Acid urine Yellowish Brown Ovals with pointed Ends



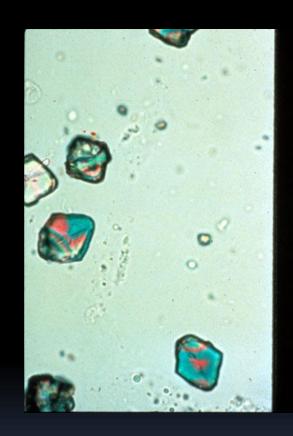
Yellowish
Brown
Ovals with
pointed Ends



Birefringence under polarized light

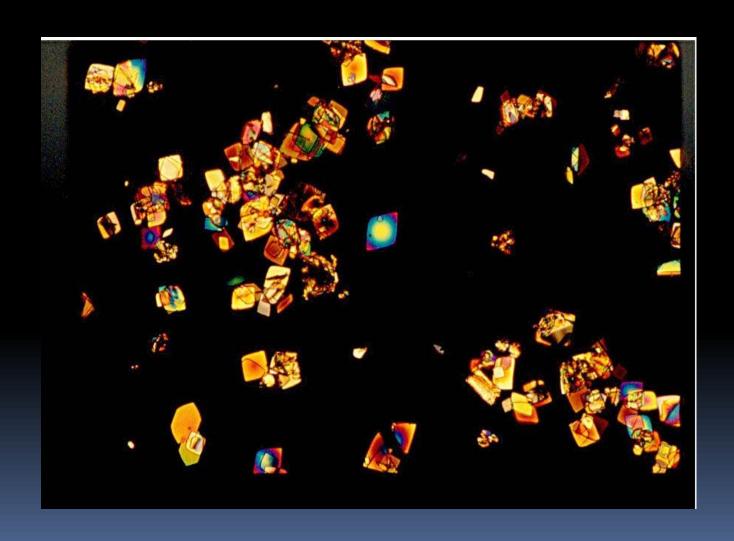


Sometimes associated with gout





Uric Acid Polarized



Uric Acid Rosette Form

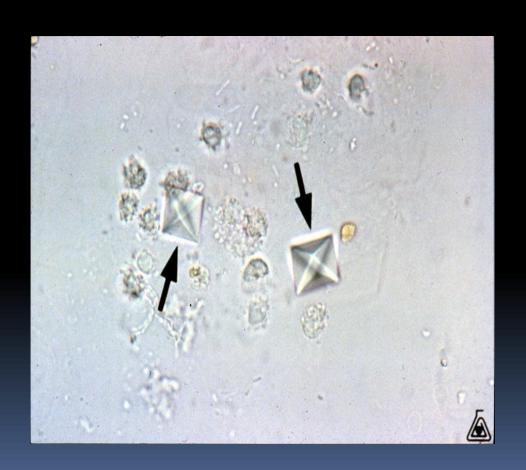
Many Forms

"Great Imposters"



Calcium Oxalate

- Common
- pH acid or neutral
- Envelope or dumb bell shaped
- Oval May be mistaken for RBC
- Ca Ox soluble in HCl Insoluble in acetic acid
- RBC lyse in acetic acid



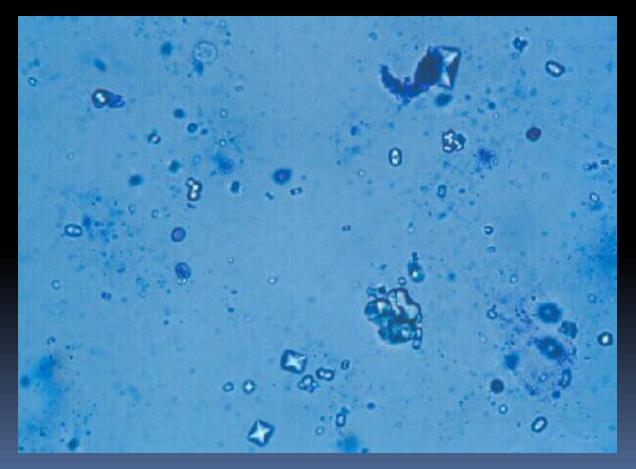
Calcium Oxalate and Epi



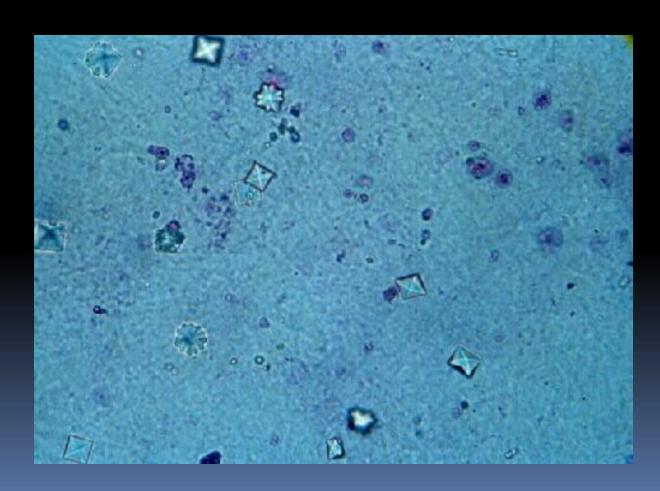
Calcium Oxalate



Calcium oxalate dihydrate and monohydrate (dumbbell and ring forms) - x400 magnification.



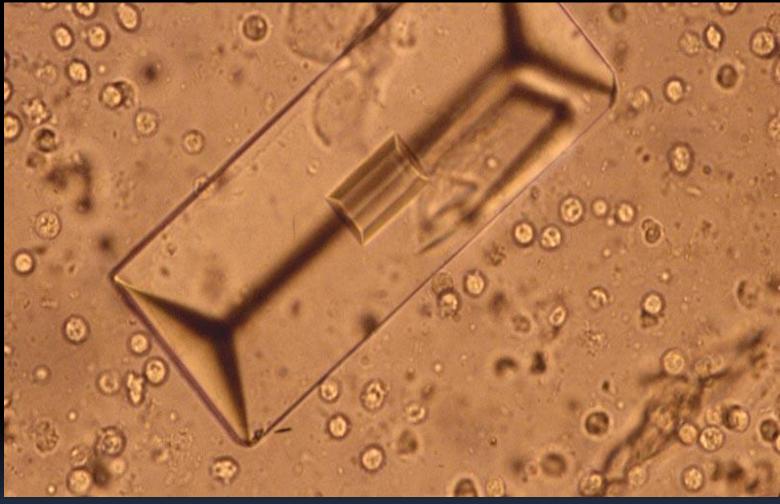
Calcium oxalate dihydrate, various octahedral forms...



Calcium Oxalate



Coffin Lid

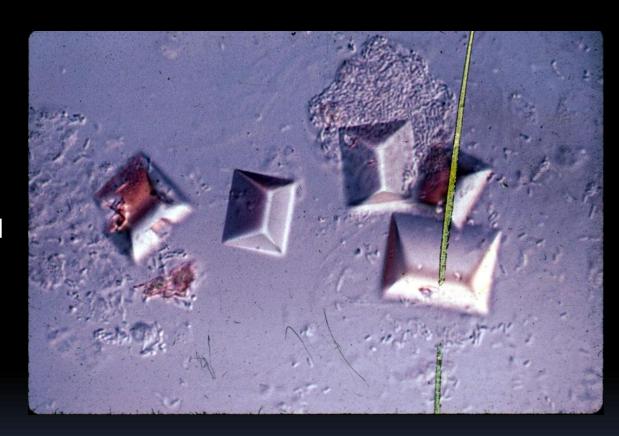


Triple Phosphate

AKA Ammonium Magnesium Phosphate

Found in Basic or Neutral urine

Soluble in Acetic Acid



Triple Phosphate

Irregular plates

"Sheets of Ice"

Rosetts

Associated with Cystitis and Urine retention



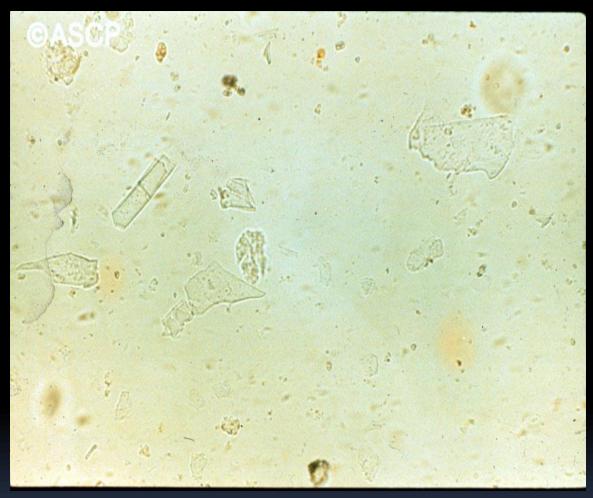
Calcium Phosphate Crystals

Irregular plates

"Sheets of Ice"

Rosettes

Associated with Cystitis and Urine retention



Calcium Phosphate Crystals

Irregular plates

"Sheets of Ice"

Rosettes

Associated with Cystitis and Urine retention



Calcium Phosphate Crystals

Spheres or Dumb-bell forms

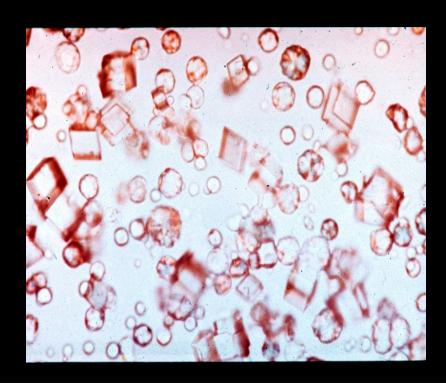
Birefringent



Calcium Carbonate Crystals

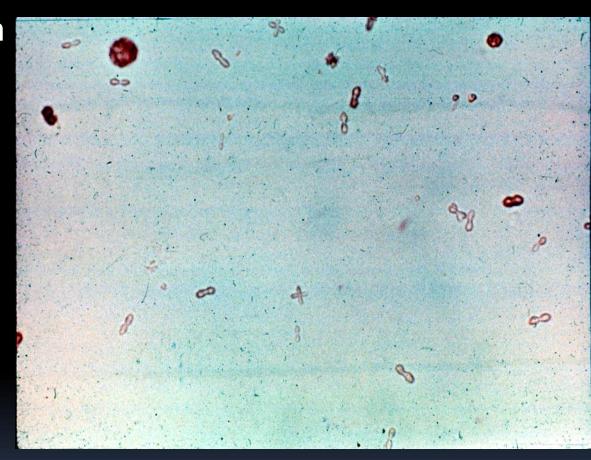
Calcium Carbonate

Rhombohedral form



Calcium Carbonate

Dumbbell form

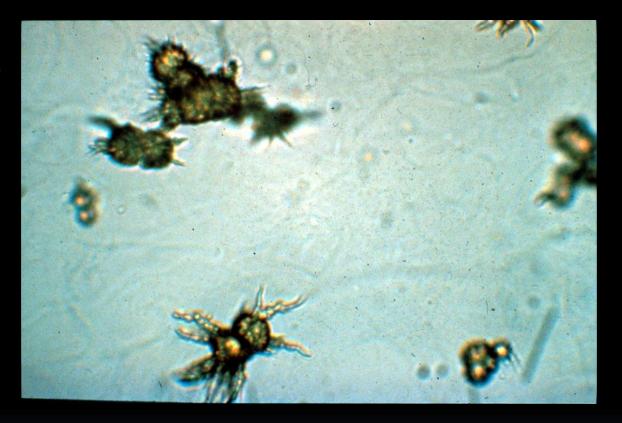


Alkaline urine Only urate found in alkaline urine

Yellow brown spheres with horns

Thorn apple

Soluble in Acetic Acid



Ammonium Biurate Crystals

Ammonium Biurate



Ammonium Biurate

- pH alkaline
- Thorn apple



Abnormal Crystals

- All are found in acidic urine
- Indicate pathologic condition

Needle shaped fine and silky appearance

Liver disease due to hepatitis, hepatocellular poisons

Leukemia's Typhoid fever and smallpox

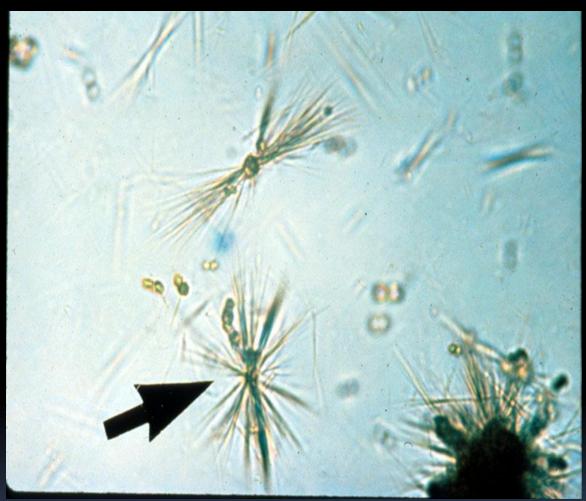


Tyrosine

Needle shaped fine and silky appearance

Liver disease due to hepatitis, hepatocellular poisons

Leukemia's Typhoid fever and smallpox



Tyrosine

Spheres, Yellowbrown concentric rings

Birefringence

Pseudo Maltese Cross

Maple syrup disease

Liver Disease



Leucine

Spheres, Yellowbrown concentric rings

Birefringence

Pseudo Maltese Cross

Maple syrup disease

Liver Disease



Leucine

Thin colorless hexagonal plates

Birefringent in polarized light

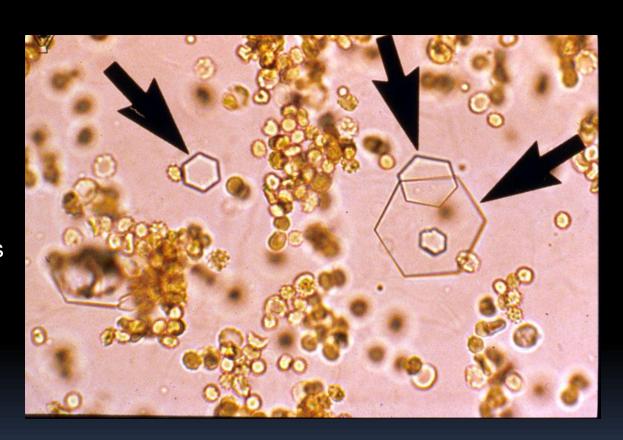
Hereditary metabolic disorders involving renal transport of various amino acieds



Thin colorless hexagonal plates

Birefringent in polarized light

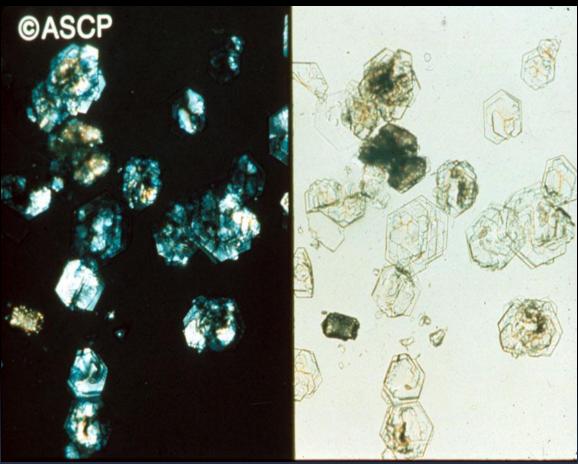
Hereditary metabolic disorders involving renal transport of various amino acieds

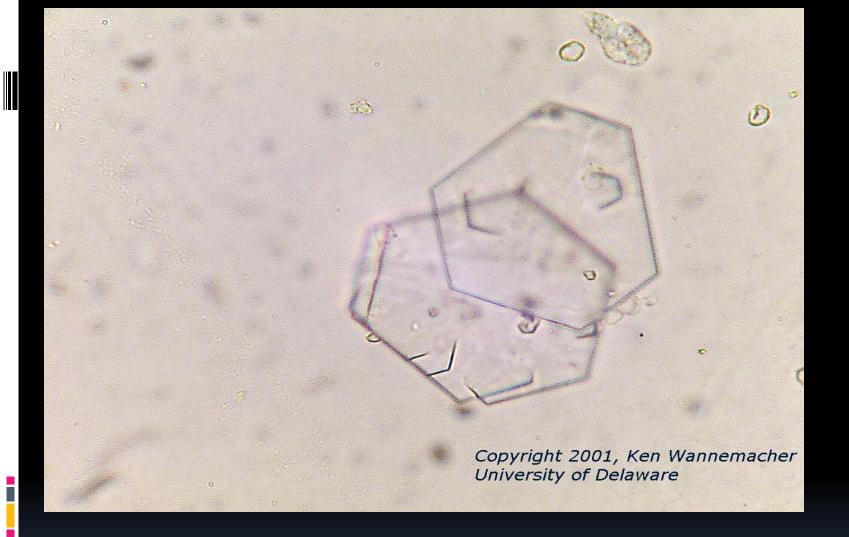


Thin colorless hexagonal plates

Birefringent in polarized light

Hereditary metabolic disorders involving renal transport of various amino acids





Cystine • Acid Urine



Cholesterol

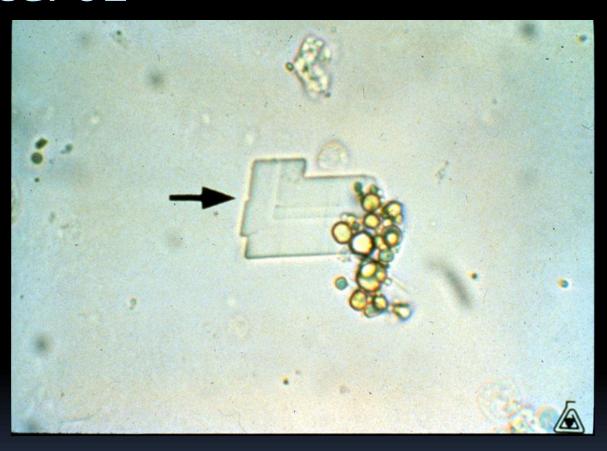
id Urine

gular or irregular plate h Notched corner

efringent under larized light

rious renal diseases

phrotic Syndrome or ner condition where ere is a deposition of ds in Kidney



Cholesterol

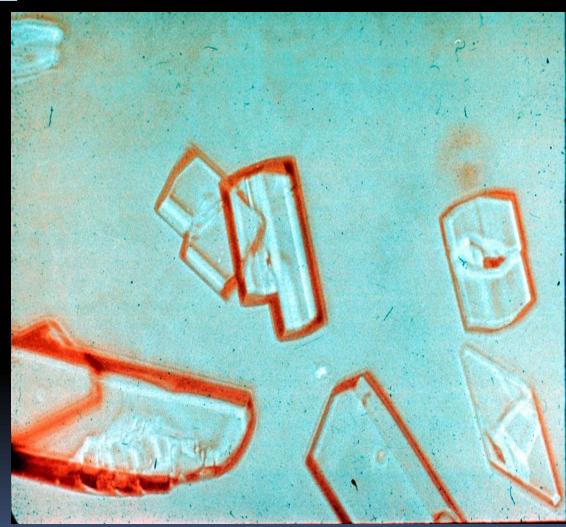
Acid Urine

Regular or irregular plate with Notched corner

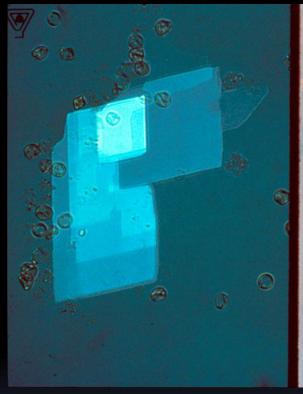
Birefringent under polarized light

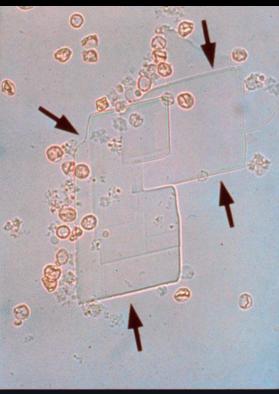
Various renal diseases

Nephrotic
Syndrome or other
condition where
there is a deposition
of lipids in Kidney



Cholesterol

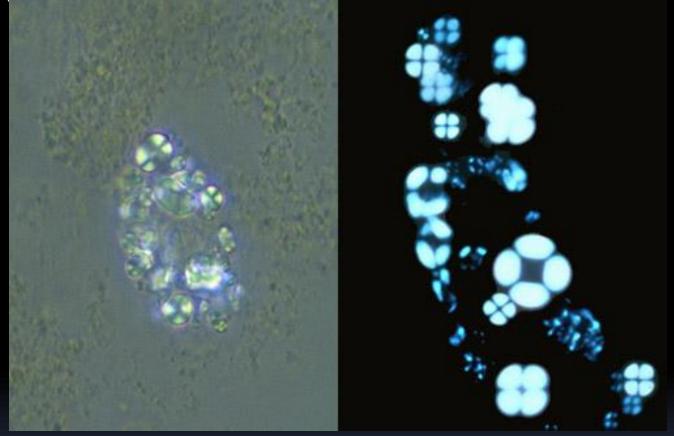




Oval Fat Bodies



Oval Fat Bodies Polarized





Fiber

Fatty Cast Polarized



Corpora amylacea



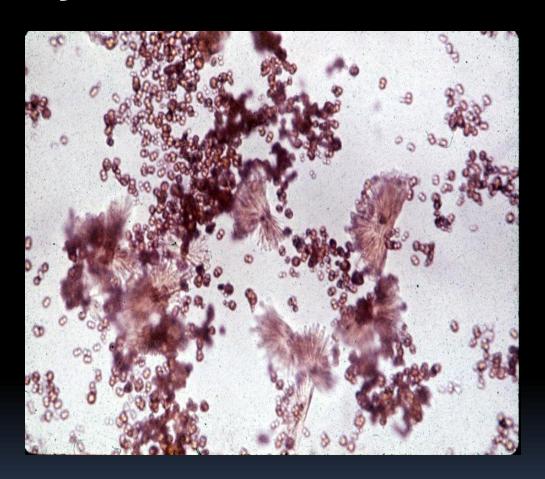
Crystalline Artifact

SterheimerMalbin Stain



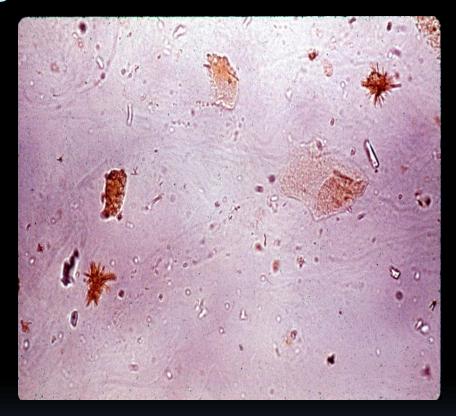
Bilirubin Crystals

- Acidic Urine
- Pigmented yellowish Brown Granules
- Pathologic appear in a wide variety of hepatobiliary and hematopoietic diseases



Bilirubin Crystals

- Acidic Urine
- Pigmented yellowish Brown Granules
- Pathologic appear in a wide variety of hepatobiliary and hematopoietic diseases



Summary

- Urinalysis in an important clinical diagnostic test.
- Urinalysis can reveal diseases that have gone unnoticed because they do not produce striking signs or symptoms.
- Urinalysis provides information about the kidney, urinary tract, and systemic (non-kidney) disorders.
- The results of the macroscopic, chemical and microscopic analysis must be interpreted together to arrive at a proper diagnosis.

Summary

- Although urinalysis is easily performed with reagent test strips, the results are dependent on:
 - correct technique
 - an understanding of the limitations and interference's
- Thus, technologists and technicians performing these tests must be properly trained, especially in correctly recognizing microscopic elements.

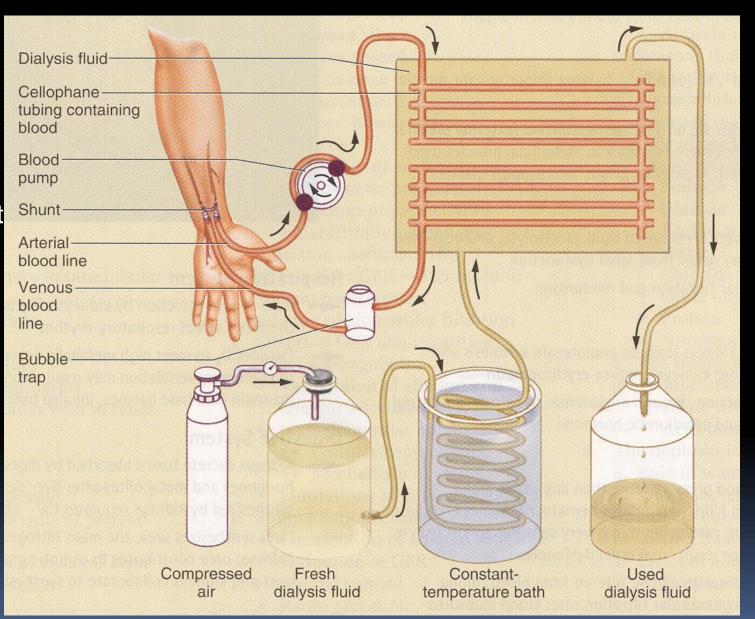
Hemodialysis

artificially clearing wastes from the blood

1) Dialysis machine

- efficient

- inconvenient



I- Physical Characteristics:

- direct visual observation.
- Normal fresh urine: Color: pale or dark yellow-amber, clear.
- Vol:750 2000 ml/24hr.
- Physical examination involves:
 - 1. Color
 - 2. Transparency
 - 3. Odour
 - 4. Volume
 - 5. pH
 - 6. Specific gravity

1- Color:

- Many things affect urine color, including fluid balance, diet, medicines, and diseases.
- Color intensity of urine correlates to concentration.
- Darker color means more concentrated sample.
 - Amber yellow Urochrome (derivative of urobilin, produce from bilirubin degradation, is pigment found in normal urine).
 - Colorless due to reduced concentration.
 - Silver or milky appearance Pus, bacteria or epithelial cells
 - Reddish brown Blood (Hemoglobin).
 - Yellow foam Bile or medications.
 - Orange, green, blue or red

2- Transparency:

- Urine is normally clear. Bacteria, blood, sperm, crystals, or mucus can make urine look cloudy.
- Is classified as clear or turbid.
- In normal urine: the main cause of cloudiness is crystals and epithelial cells.
- In pathological urine: it is due to pus, blood and bacteria.
- Degree of cloudiness depends on: pH and dissolved solids
 - Turbidity: may be due to gross bacteriuria,
 - Smoky appearance: is seen in hematouria.
 - Thread-like cloudiness: is seen in sample full of mucus.

3- Odour:

Odour has little diagnostic significance.

- 1. Aromatic odour----> Normal urine due to aromatic acids.
- 2. Ammonia odour----> On standing due to decomposition of urea.
- 3. Fruity odour----> Diabetes due to the presence of ketones.
- ❖ Urine does not smell very strong, but has a slightly "nutty" odor. Some diseases cause a change in the odor of urine. For example, an infection with *E. coli* bacteria can cause a bad odor, while <u>diabetes</u> or starvation can cause a sweet, fruity odor.

4- Volume:

- Is important part of assessment for fluid balance and kidney functions.
- Adults produce from 750ml-2500ml / 24h, with the average of about 1.5L per person.
- For RUA, a 10ml-12ml of sample is optimal for accurate of analysis

5- pH:

- pH 5.0 6.0 6.5 7.0 7.5 8.0 8.5 60 seconds
- pH measure acidicity or alkalinity (basic) of urine
- Normal urine pH: 4.5-8.
- Increased <u>acidity</u> in urine: due to <u>diabetes</u> or medications.
- Urine sample must be fresh (why?)
 (on standing urine become <u>alkaline</u> as a result of ammonia liberation due to urea decomposition).
- A urine pH of 4 is strongly acidic, 7 is neutral (neither acidic nor alkaline), and 9 is strongly alkaline.
- Sometimes the pH of urine is affected by certain treatments. For example, your doctor may instruct you how to keep your urine either acidic or alkaline to prevent some types of kidney stones from forming.



6. Specific Gravity (SG):

- measures the amount of substances dissolved in urine.
- also indicates how well kidneys are able to adjust amount of water in urine.
- higher SG: more solid material is dissolved in urine
- When you drink a lot of fluid, your kidneys make urine with a high amount of water in it which has a low specific gravity. When you do not drink fluids, your kidneys make urine with a small amount of water in it which has a high specific gravity.

Normal Chemical Constituents of Urine:

Organic: urea, uric acid, creatinine

Inorganic: Cl⁻, PO₄⁻³, HBO₃, NH₄, SO₄⁻²

1- Urea:

1ml urine + 3ml NaOCL (sodium hypochlorite) ==>Evolution of N2 gas.

2- Uric acid UA:

1ml urine + 0.5 ml 10% NaOH +1ml Folins reagent ===> Blue color.

3- Creatinine:

- 1ml urine + drops Picric acid + drops NaOH ====> red color ppt.

Note: if reaction is acidified with HCL, the color changes to yellow.

4- Chloride:

- 1ml urine + drops $HNO_3 + 1$ ml $AgNO_3 ===>$ white ppt of AgCL

5- Phosphate:

1ml urine + 1ml conc. HNO₃ + 1ml NH₄-molybdate===>Yellow color.

6- Carbonate:

1ml urine + drops conc. $HCL == \frac{Na_2CO_{ente}}{2}HCL == > H_2O + 2NaCL + CO_2$

7- Ammonia:

- Make urine alkaline with NaOH. Close the tube with a cork containing another side tube dipped in Nessler's reagent. Heat the urine and then notice the evolving of NH3 in Nessler's reagent
- Detect NH3 by its odour.
- 1ml urine + 1ml phenol + 1ml NaBr =====> Blue color.

8- Sulphates:

- 1ml urine + 2 drops conc. HCL + few drops BaCL2 ===> White ppt of BaSO4. SO4 + BaCL2 ====> BaSO4 + 2CL-

Chemical characterstics

- Protein. Protein is normally not found in the urine. Fever, hard exercise, pregnancy, and some diseases, especially kidney disease, may cause protein to be in the urine.
- Glucose. Glucose is the type of sugar found in blood. Normally there is very little or no glucose in urine. When the blood sugar level is very high, as in uncontrolled diabetes, the sugar spills over into the urine. Glucose can also be found in urine when the kidneys are damaged or diseased.
- Nitrites. Bacteria that cause a urinary tract infection (UTI) make an enzyme that changes urinary nitrates to nitrites.
- Leukocyte esterase (WBC esterase). Leukocyte esterase shows leukocytes (white blood cells [WBCs]) in the urine.
- Ketones. When fat is broken down for energy, the body makes substances called ketones (or ketone bodies). These are passed in the urine. Large amounts of ketones in the urine may mean a very serious condition, diabetic ketoacidosis, is present. A diet low in sugars and starches (carbohydrates), starvation, or severe vomiting may also cause ketones to be in the urine.

Using Reagent Strips

- BRIEFLY dip the strip in urine.
- Colors are matched to those on the bottle label at the appropriate times.
- Timing is critical for accurate results.



Chemical Examination

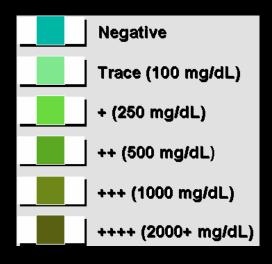
- Reagent strips are used only once and discarded.
- Testing
 - Perform within 1 hour after collection
 - Allow refrigerated specimens to return to room temperature.
 - Dip strip in fresh urine and compare color of pads to the color chart after appropriate time period.
 - Instruments are available which detect color changes electronically

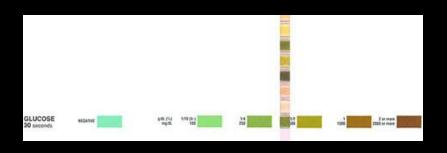
Reagent Strips





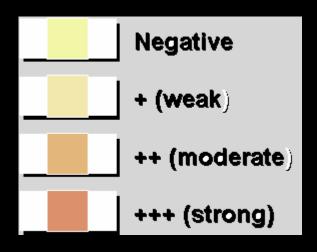
Glucose

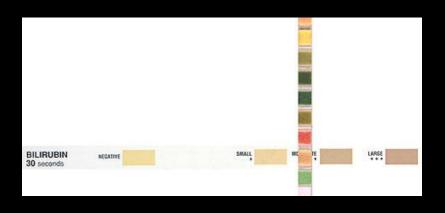




- Presence of glucose (glycosuria) indicates that the blood glucose level has exceeded the renal threshold.
- Useful to screen for diabetes.

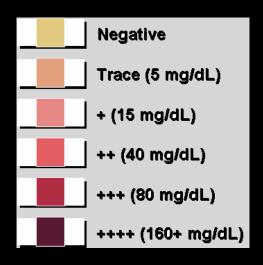
Bilirubin

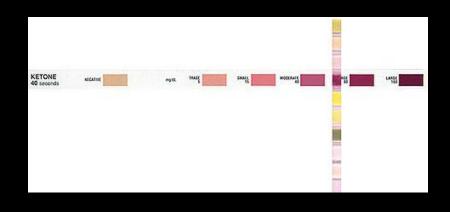




- Bilirubin is a byproduct of the breakdown of hemoglobin.
- Normally contains no bilirubin.
- Presence may be an indication of liver disease, bile duct obstruction or hepatitis.
- Since the bilirubin in samples is sensitive to light, exposure of the urine samples to light for a long period of time may result in a false negative test result.

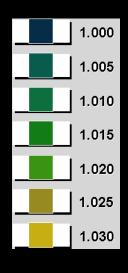
Ketones

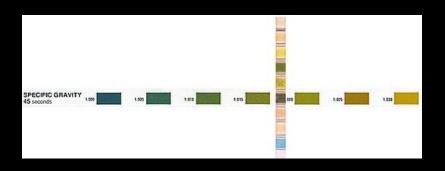




 Ketones are excreted when the body metabolizes fats incompletely (ketonuria)

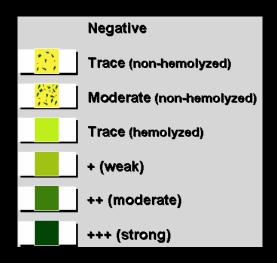
Specific Gravity

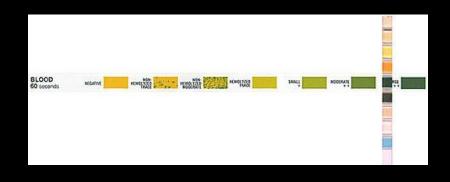




- Specific gravity reflects kidney's ability to concentrate.
- Want concentrated urine for accurate testing, best is first morning sample.
- Low specimen not concentrated, kidney disease.
- High first morning, certain drugs

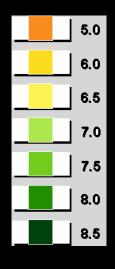
Blood

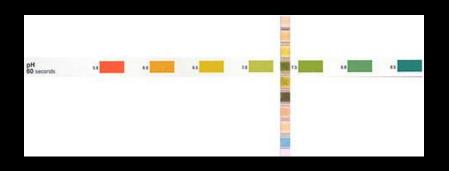




- Presence of blood may indicate infection, trauma to the urinary tract or bleeding in the kidneys.
- False positive readings most often due to contamination with menstrual blood.

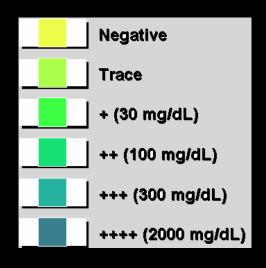
Ph

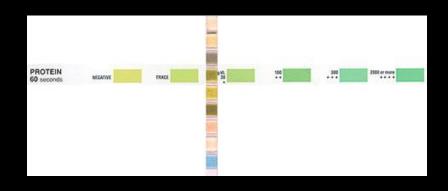




pH measures degree of acidity or alkalinity of urine

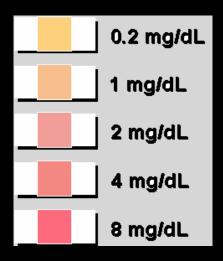
Protein

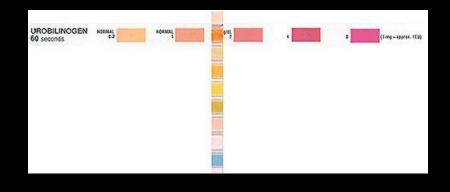




- Presence of protein (proteinuria) is an important indicator of renal disease.
- False negatives can occur in alkaline or dilute urine or when primary protein is not albumin.

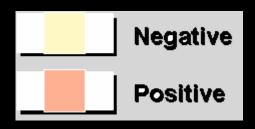
Urobilinogen

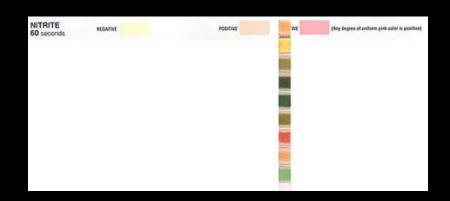




- Urobilinogen is a degradation product of bilirubin formed by intestinal bacteria.
- It may be increased in hepatic disease or hemolytic disease

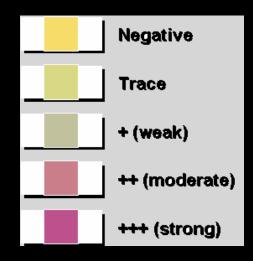
Nitrite





 Nitrite formed by gram negative bacteria converting urinary nitrate to nitrite

Leukocytes



- Leukocytes (white blood cells) usually indicate infection.
- Leucocyte esterase activity is due to presence of WBCs in urine while nitrites strongly suggest bacteriuria.

Normal Values

- Negative results for glucose, ketones, bilirubin, nitrites, leukocyte esterase and blood.
- Protein negative or trace.
- pH 5.5-8.0
- Urobilinogen 0.2-1.0 Ehrlich units

Handling and Storage of Strips

- Handling and Storage
 - Keep strips in original container
 - Do not touch reagent pad areas
 - Reagents and strips must be stored properly to retain activity
 - Protect from moisture and volatile fumes
 - Stored at room temperature
 - Use before expiration date

Procedure

- Dip strip briefly, but completely into well mixed, room temperature urine sample.
- Withdraw strip.
- Blot briefly on its side.
- Keep the strip flat, read results at the appropriate times by comparing the color to the appropriate color on the chart provided.







Sources of Error

- **Timing** Failure to observe color changes at appropriate time intervals may cause inaccurate results.
- **Lighting** Observe color changes and color charts under good lighting.
- QC Reagent strips should be tested with positive controls on each day of use to ensure proper reactivity.
- Sample Proper collection and storage of urine is necessary to insure preservation of chemical.

Abnormal Urine Constituents include:

1- Proteinurea:

- is the presence of abnormal amount of protein in urine.
- Urine of healthy individual contains no protein due to:
 - ✓ In normal physiology, small M.wt. proteinsis reabsorbed by kidney tubules (proximal tubule)
 - ✓ large M.wt of protein so it can't pass through kidney tubule to urine. unless kidney tubule has damage.
- The main protein in urine is albumin therefore, proteinuria=albuminuria

Microalbuminuria:

- Is the presence of small amounts of albumin in urine.
- It is very important in detection of early stage of nephronpathy and in diagnosis of DM complication (nephropathy).
- High protein in urine makes urine looks foamy.
- Associated with face or feet abnormal odema, due to disturbance of liquid balance in body due to protein loss.

Detection:

- Qualitative test: using a reagent test strip.
- Quantitative test: depends on volume and time of urine (protein conc. in urine may vary with time and volume)
- Most assays are performed on urine sample of 12-24h.

Reference value:

• Quantitative for 24-h urine:

Male: 1-4 mg/dl Female: 3-10 mg/dl Child: 1-10mg/dl

Qualitative reference value: Normal = Negative

2- Glucoseurea:

- is the presence of abnormal conc. of glucose in urine.
- Normally, glucose is reabsorbed by active transport in proximal tubule and therefore doesn't appear in urine.
- If the blood glucose level exceeds the reabsorption capacity of kidney tubules (renal threshold), glucose will appear in urine.
- **Renal threshold of glucose:** is around 160 mg/100 ml.

• Glucosuria indicates that **glucose concentration in blood** exceeds this amount and the kidneys are unable to reabsorb it efficiently.

Glucosuria occurs in DM, which characterized by:

- hyperglycemia,
- usually polyurea (increased volume of urine),
- high SG
- urine may be light in color.

3- ketourea:

- is the presence of abnormal amount of ketone bodies in urine.
- Body normally uses carbohydrates as source of energy.
- If carbohydrate source depleted or there is defect in carbohydrate metabolism, body use fat as a source of energy.

- Fat metabolism is occurred for certain time, at certain point, fatty acid utilization occurs incompletely results in production of intermediate substances (keton bodies).
- Three ketone bodies: acetone, acetoacetate, β– hydroxybutayric acid

- Normally ketone bodies are removed by liver.
- elevated levels of keton bodies in blood and urine cause acidosis which leads to coma and death.

Ketourea is common in uncontrolled DM (why?)

• because diabetic patient has high blood glucose but can't use by cells, so lipids are used as source of energy.

Ketourea present in:

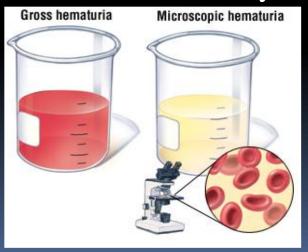
- Disease
- Nutrition
- Vomiting for long time
- Results effected by: diet and drugs

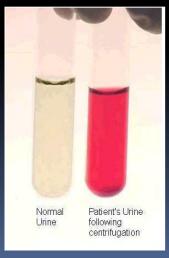
Normal values: negative test result is normal.

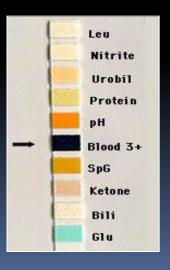
Small: < 20 mg/dl Moderate: 30-40 mg/dl large > 80 mg/dl

4- Haematourea:

- It is the presence of red blood cells (RBCs) in the urine.
- Can't detected by the naked eye so detection by strip or microscope as anucleated cells
- Positive result may be: normally: no pathological cause abnormally: due to stones or tumers.
- Need other confirmatory test.

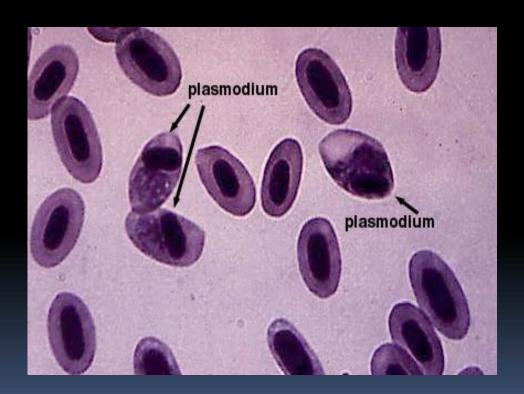






5- Hemoglobinuria:

- Presence of heamoglobin in urine due to rupturing of RBCs
- This may occur in malaria, typhoid, yellow fever, hemolytic jaundice and other diseases.



6- Bilirubin (Bile):

- Result from hemoglobin breakdown
- Elevated in hepatitis and jaundice (biliary duct obstruction).

7- Nitrite:

- used for screening for bacteria.
- Normal urine contain nitrate but not contain nitrites.
- In the presence of bacteria, the normally present nitrate in the urine is reduced to nitrite.

```
nitrate <u>reduction</u> nitrite
''nink''
```

Positive test indicates presence of more than 10 organisms/ml.

8- Urine leucocytes:

- This test detects any microbial infection in the body.
- Depends on esterase method:

```
Esterase + Ester --- 3-0H-5-phenyl pyrrole diazonium salt pink -purple color neutrophils strip
```

+ve result: means more than 5 leucocytes/hpf. (high power field)

- If urine stand long time leucocytes lysis and more intense reaction occur.
- False positives: occurs with vaginal contamination, presence of glucose, albumin, ascorbic acid
- False negative: large amounts of oxalic acid can inhibit the reaction.

9- pH:

 Phosphates will precipitate in an alkaline urine, and uric acid will precipitate in an acidic urine

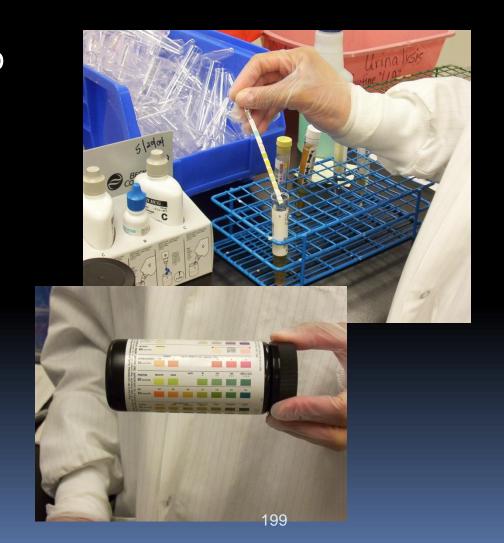
10- SG:

- The specific gravity is a convenient index of urine concentration.
- It measures density and is only an approximate guide to true concentration.
- High SG is due to protein, glucose and other substances



- The presence of normal and abnormal chemical elements in the urine are detected using dry reagent strips.
- These plastic strips contain absorbent pads with various chemical reagents for determining a specific substance.

- When the test strip is dipped in urine the reagents are activated and a chemical reaction occurs.
- The chemical reaction results in a specific color change.



After a specific amount of time has elapse, this color change is compared against a reference color chart provided by the manufacturer of the strips.



Chemical Reaction Chart



 The intensity of the color formed is generally proportional to the amount of substance present.



Typical Substances Tested & Significance

- pH partial assessment of acid base status; alkaline pH indicates old sample or urinary tract infection
- Specific Gravity state of kidney and hydration status of patient
- Protein primarily detects protein called albumin;
 important indicator in the detection of renal disease
- Glucose primarily detects glucose (sugar); important indicator of diabetes mellitus

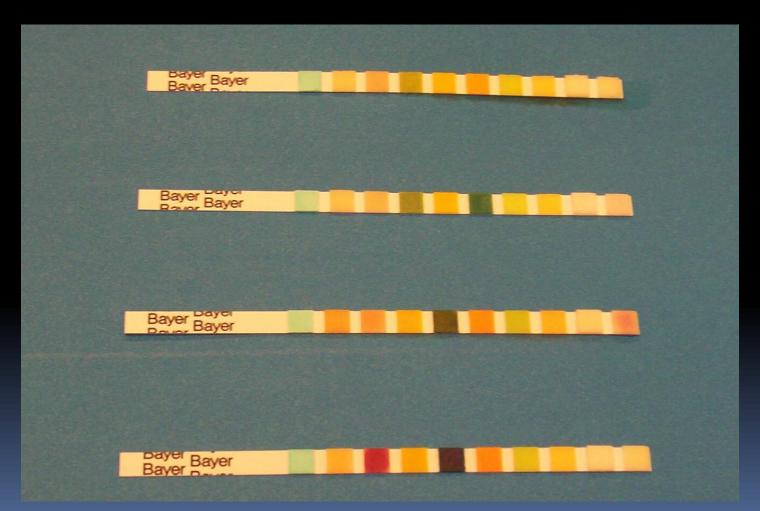
Typical Substances Tested & Significance

- Blood red blood cells, hemoglobin, or myoglobin (muscle hemoglobin); sensitive early indicator of renal disease
- Ketone normal product of fat metabolism; increased amounts seen in diabetes or starvation (extreme dieting)
- Bilirubin detects bilirubin (a product of red cell breakdown); indicator of liver function
- Urobilinogen another by-product of red cell breakdown; increased amounts seen in fever, dehydration, hemolytic anemia and liver disease

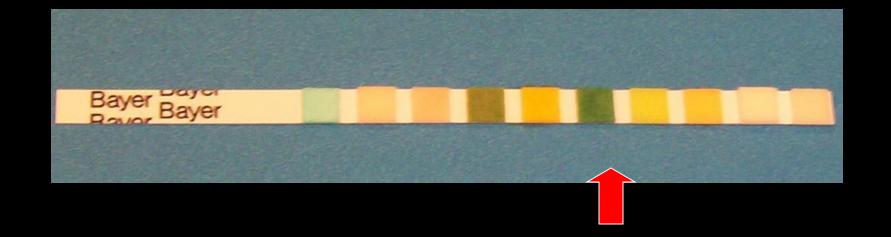
Typical Substances Tested & Significance

- Nitrite certain bacteria convert normal urine nitrate to nitrite; indicator of urinary tract infection
- Leukocyte Esterase detects esterase enzyme present in certain white blood cells (e.g, neutrophils, monocytes); indicator of urinary tract infection

Example Chemical Analysis Results ...



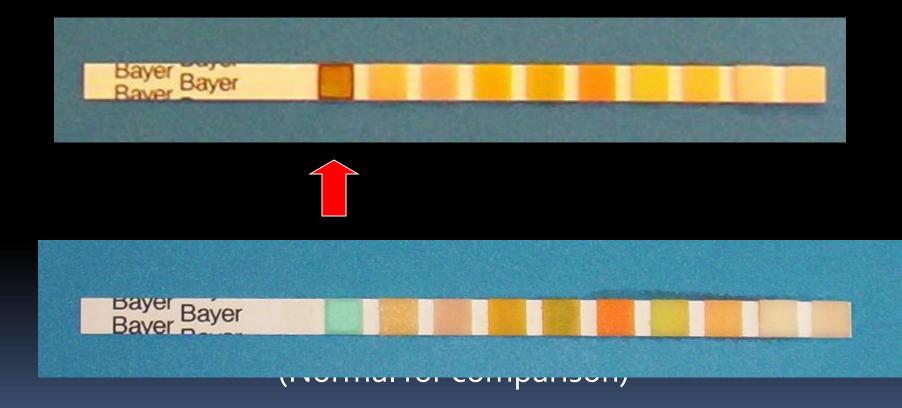
Elevated pH (alkaline)



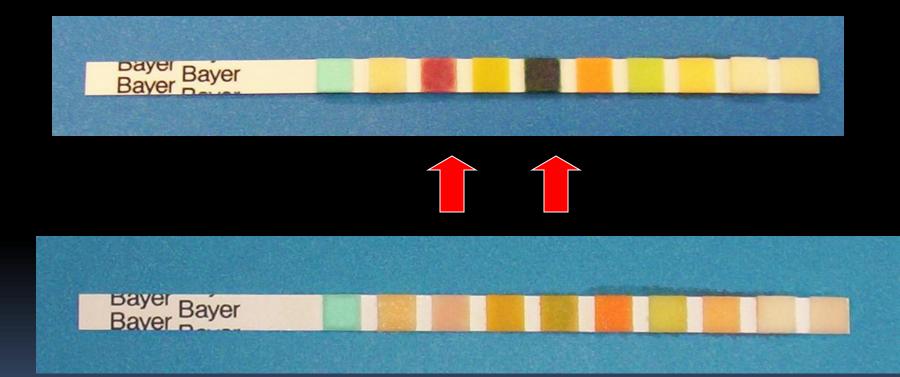
Bayer Bayer

(Normal for comparison)

Positive Glucose

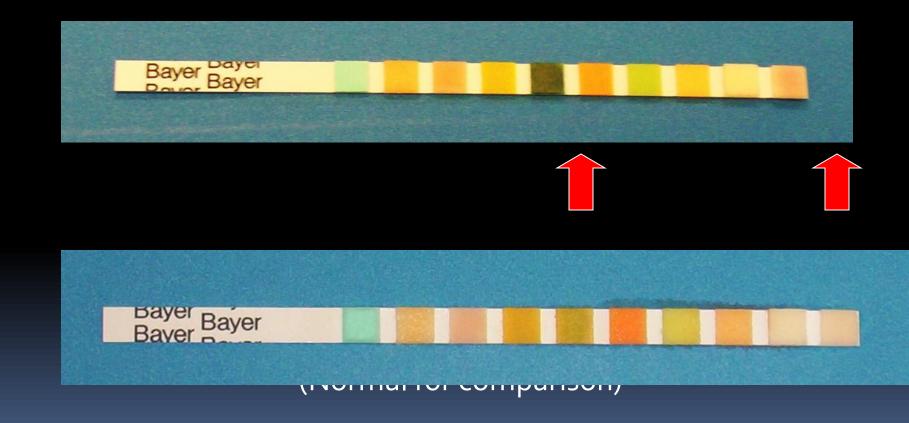


Positive Blood & Ketones



(Normal for comparison)

Positive Blood and Leukocyte Esterase

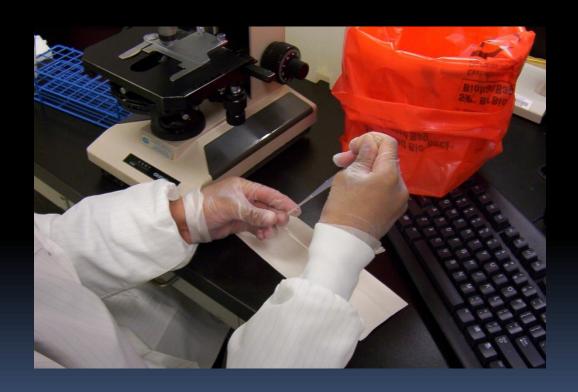


- Most commonly used procedure for the detection of renal and/or urinary tract disease.
- This exam consists of reviewing the solid material suspended in the urine - both chemical and cellular.



- Requires a well-trained laboratory professional who is:
 - skilled in the use of various microscopic techniques such as bright field and phase microscopy
 - able to distinguish normal or contaminating items from abnormal, pathologic elements
 - knowledgeable of the clinical significance of each finding and its relationship to the chemical and physical analysis

.... is then placed on a microscope slide, covered with a coverslip and



... viewed under a microscope.



- The urine specimen is centrifuged and the liquid portion is poured off.
- The concentrated cellular sediment



An additional note ...

- The chemical and microscopic analysis of urine can be performed manually or with automated analyzers.
- In many laboratories, abnormal automated findings are confirmed by manual techniques.





Who performs urinalysis testing?

- In most clinical laboratories, urinalysis is performed by medical laboratory professionals called:
 - Medical Laboratory Technicians or Clinical Laboratory Technicians (MLT/CLT)
 - Medical Technologists or Clinical Laboratory Scientists (MT/CLS)

What education is required to be a laboratory

- Associate's degree OTESSIONAL! Medical Laboratory Technician (MLT)
 - Clinical Laboratory Technician (CLT)
- Bachelor's degree
 - Medical Technologist (MT)
 - Clinical Laboratory Scientist (CLS)
- For more info, visit our web site at www.medlabcareers.msu.edu



Laboratory science careers are rated among the best!

- Website manager
- Actuary
- Computer systems analyst
- Software engineer
- Mathematician
- Computer programmer
- Accountant
- Industrial designer
- Hospital administrator
- Web developer
- Paralegal assistant

- Parole officer
- Meteorologist
- Technical writer
- Medical secretary
- Medical technologist
- Financial planner
- Medical laboratory technician
- Astronomer
- Historian