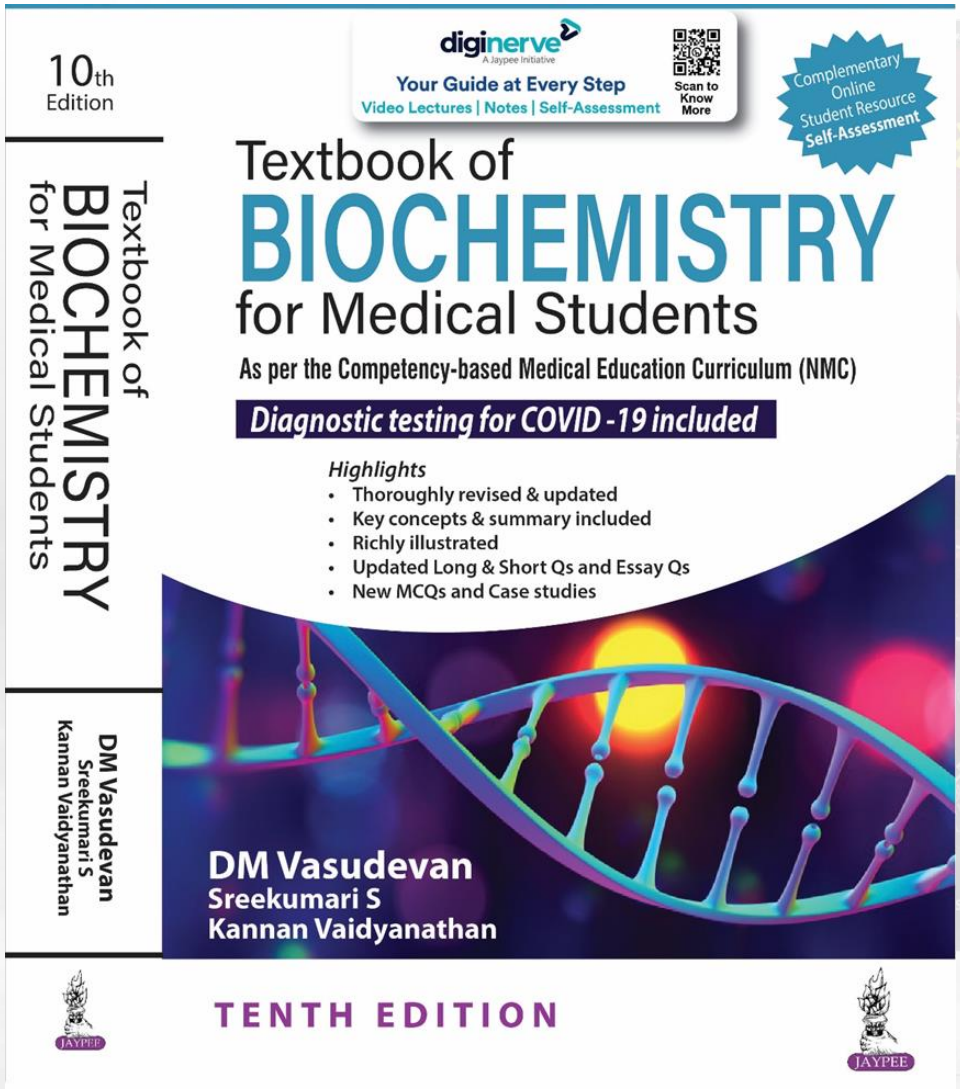
Chapter 22:

Kidney Function Tests



Textbook of

BIOCHEMISTRY

for Medical Students

By DM Vasudevan, *et al.*

TENTH EDITION

Functions of Kidney at a Glance

1. Excretion of nitrogenous wastes like urea, creatinine, uric acid, elimination of toxins, metabolites of drugs
2. Maintaining water balance
3. Maintenance of sodium balance
4. Maintenance of potassium balance
5. Excretion of hydrogen ions
6. Activation of vitamin D
7. Production of erythropoietin
8. Filtration: 180 liters/day of water with all sodium, chloride, sugar, amino acids
9. Reabsorption: 178.5 liters reabsorbed; all glucose and amino acids reabsorbed; most of sodium and chloride reabsorbed

Classification of Renal Function Tests

1. To screen for kidney disease

- Complete urine analysis
- Plasma urea and creatinine
- Plasma electrolytes

2. To assess glomerular function

- Glomerular filtration rate
- Clearance tests
- Glomerular permeability; Proteinuria

3. To assess tubular function

- Reabsorption studies
- Secretion tests
- Concentration and dilution tests
- Renal acidification

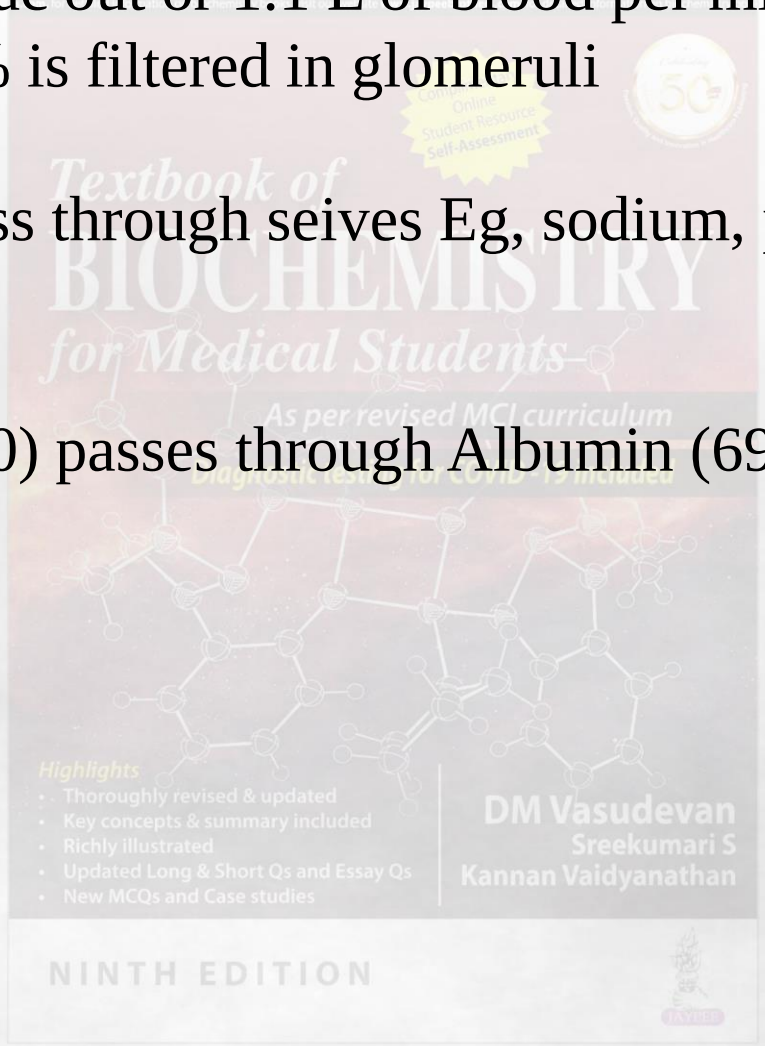
Handling of Solutes by the Renal Tubules (PCT = Proximal Convoluted Tubules; DCT = Distal Convoluted Tubules)

Compound	Mode of handling by tubules	Relative concentration
Creatinine	Not reabsorbed; secreted in small amounts	GF = Urine
Uric acid	90% is first absorbed in PCT; but later secreted in DCT	GF @ Urine
Urea	About 40% reabsorbed in PCT	GF > Urine
Sodium	Partially reabsorbed	GF > Urine
Glucose	Completely reabsorbed	GF >> Urine
Amino acid	Completely reabsorbed	GF >> Urine

About 20% of cardiac out or 1.1 L of blood per minute into kidneys of this, 10% is filtered in glomeruli

Small molecules pass through seives Eg, sodium, potassium, Glucose, insulin,

Hemoglobin (68,000) passes through Albumin (69,000) will not pass



Segment	Reabsorption of	Secretion
Proximal convoluted tubules	Na, Cl, HCO_3 glucose, amino acids, water (oblig)	H^+, NH_4^+
Loop of Henle	Na, Cl, Ca, Mg	
Distal convoluted tubules	Water (facultative)	H^+, K^+, NH_4, Uric acid

	Blood Urine level	Factors affecting
Urea	B= 15-40mg/dl U= 15-30 g/day	Glomerular filtration, Dietary proteins
Creatinine	B=0.7-1.4mg/dl (M) B=0.6-1.3mg/dl(F) U = 1-2 g/day	GFR, tubular secretion, muscle mass
Uric acid	B= 3 -7 mg/dl (M) B= 2 -5 mg/dl (F) U= 0.5 -0.8g/day	Tubular excretion, purine catabolism

Threshold Value of Some Common Substances Excreted Through Urine

Substance	Threshold value plasma level
Glucose	180 mg/dl
Lactate	60 mg/dl
Bicarbonate	28 mEq/L
Calcium	10 mg/dl

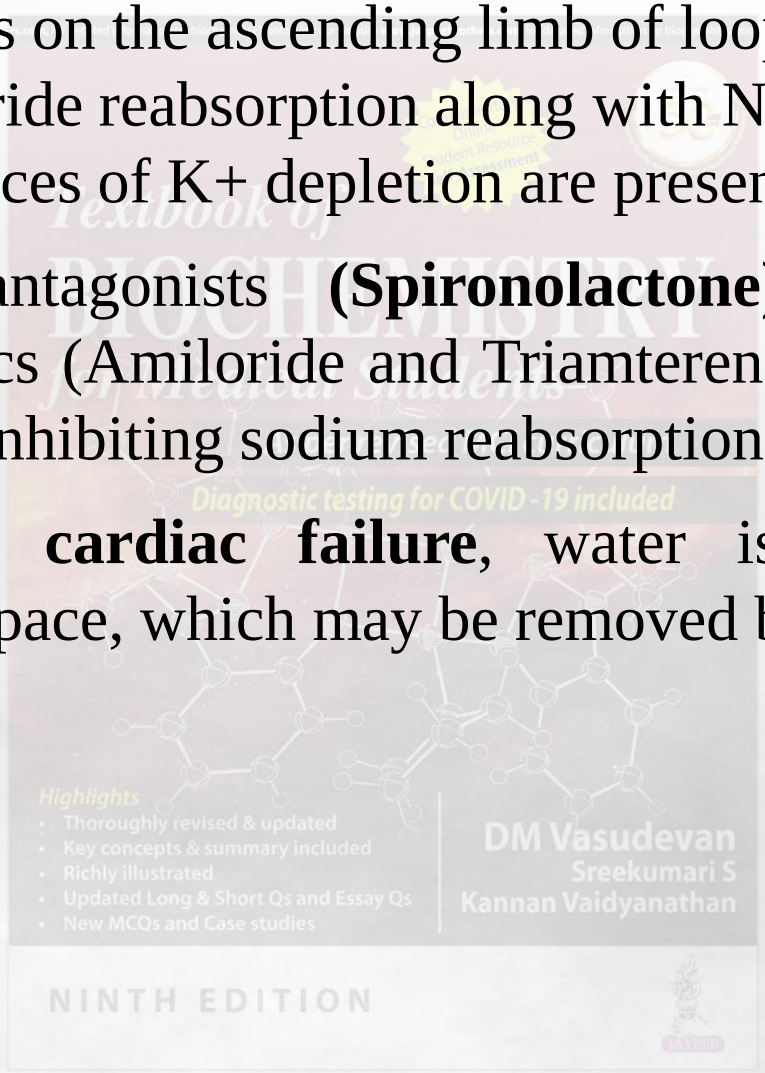
Clinical Applications of Diuretics

1. **Osmotic diuretics** act by interfering with reabsorption of solute so that more water is obligatorily excreted along with the solute. Osmotic diuretics mainly act at the proximal convoluted tubules, e.g. **mannitol**.
2. When carbonic anhydrase is inhibited, the dissociation of H_2CO_3 to H_2O and CO_2 is not taking place. Net effect is, decreased reabsorption of bicarbonate, sodium and water. Thus **acetazolamide**, a carbonic anhydrase inhibitor, will cause diuresis.
3. The **thiazide** group of diuretics act on distal convoluted tubules, inhibiting sodium reabsorption and therefore more water is excreted obligatorily.

Continued

Clinical Applications of Diuretics

4. **Frusemide** acts on the ascending limb of loop of Henle, inhibiting chloride reabsorption along with Na+ and water. So, chances of K+ depletion are present.
5. Aldosterone antagonists **(Spironolactone)** and potassium sparing diuretics (Amiloride and Triamterene) are also used as diuretics both inhibiting sodium reabsorption.
6. In **congestive cardiac failure**, water is accumulated in extravascular space, which may be removed by diuretics.



Constituents of Urine

Appearance	Significance
Clear	Normal urine is straw colored
Cloudy/ Opalescent	Urine turns cloudy on standing due to precipitation of phosphates on refrigeration. Presence of pus causes cloudiness.
High color	Concentrated urine, oxidation of urobilinogen to urobilin
Yellow	Bilirubinuria in jaundice; B-complex intake
Smoky red	Presence of blood
Brownish red	Hemoglobinuria
Orange	High levels of bilirubin; Rifampicin
Red	Porphyria; Ingestion of red beet
Black urine	Alkaptonuria; Formic acid poisoning
Milky urine	Chyluria

Abnormalities Detected in Dipstick

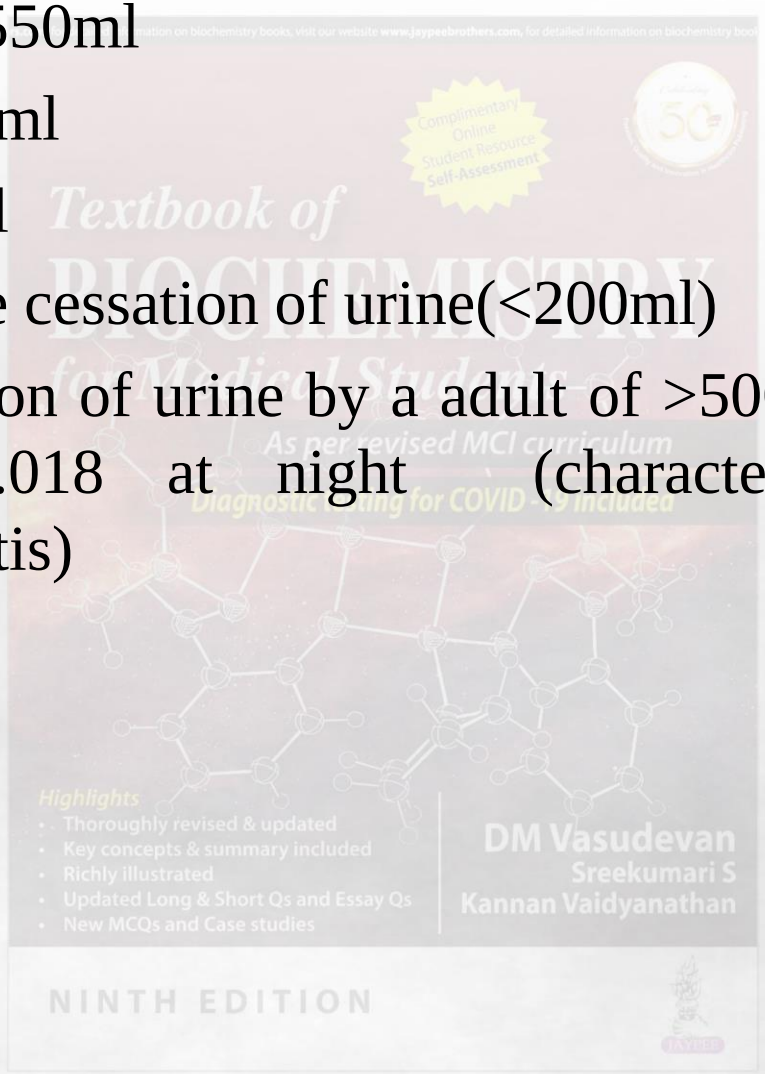
Test	Interpretations
1. Specific gravity 1.005-1.025	Low SG in renal tubular dysfunction; diabetes insipidus;. High SG in inadequate water intake; volume depletion
2. pH 5.5-6.5	Low pH in high protein diet and acidosis. Recent meal-alkaline tide High pH in low protein diet
3. Blood	Menstruation, traumatic catheterisation, Glomerulo-nephritis. Hemoglobinuria - hemolysis
4. Protein	Fever, exercise, orthostatic proteinuria; glomerulo-nephritis, urinary tract infection, tubular diseases
5. Glucose	Diabetes mellitus, Renal glycosuria; Fanconi's
6. Ketone Bodies	Diabetes mellitus Starvation
7. Bilirubin	Hepatitis, obstructive jaundice
8. Urobilinogen	Concentrated urine; hepatitis; intravascular hemolysis; low in obstructive jaundice
9. Bile salts	Obstructive jaundice
10. Nitrite	Urinary tract infection

Alterations in Urine Test Results

Test	False positive	False negative
SG	Contamination during collection and storage	None
pH	Increased while standing	
Blood	Bacterial peroxidase	Ascorbic acid, Nitrites
Protein	Fever, concentrated urine; cells; bacteria	Dilution of urine
Glucose	Oxidising agents	Ascorbic acid
Ketones	Captopril; M-Dopa	Prolonged keeping
Bilirubin	Rifampicin; Chlorpromazine	Ascorbic acid Sunlight
UBG	Alkaline urine Sulfonamides	Antibiotics; Sunlight
Esterase	Oxidising agents; Trichomonas	Ascorbic acid Tetracyclins, Cephalosporins, Nitrofurantoin
Nitrites		Ascorbic acid, Mycobacterium

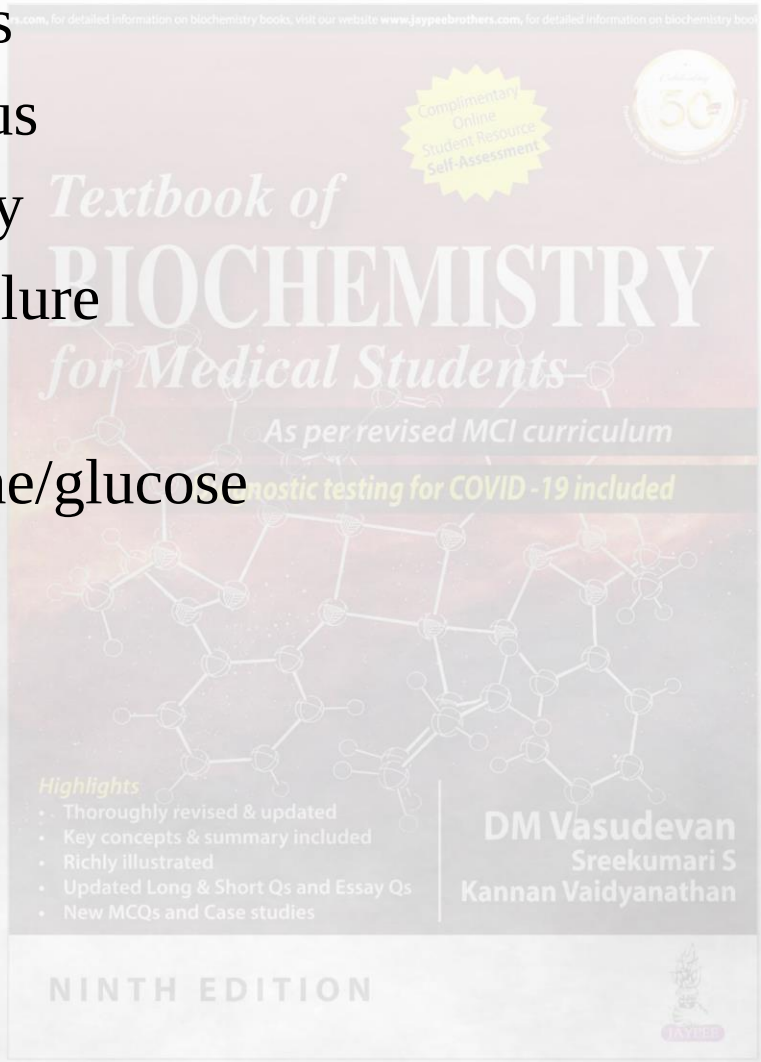
Urinary Volume

- Normal = 600-1550ml
- ***Polyuria-*** >2000ml
- ***Oliguria-***<400ml
- ***Anuria-***complete cessation of urine(<200ml)
- ***Nocturia-***excretion of urine by a adult of >500ml with a specific gravity of <1.018 at night (characteristic of chronic glomerulonephritis)



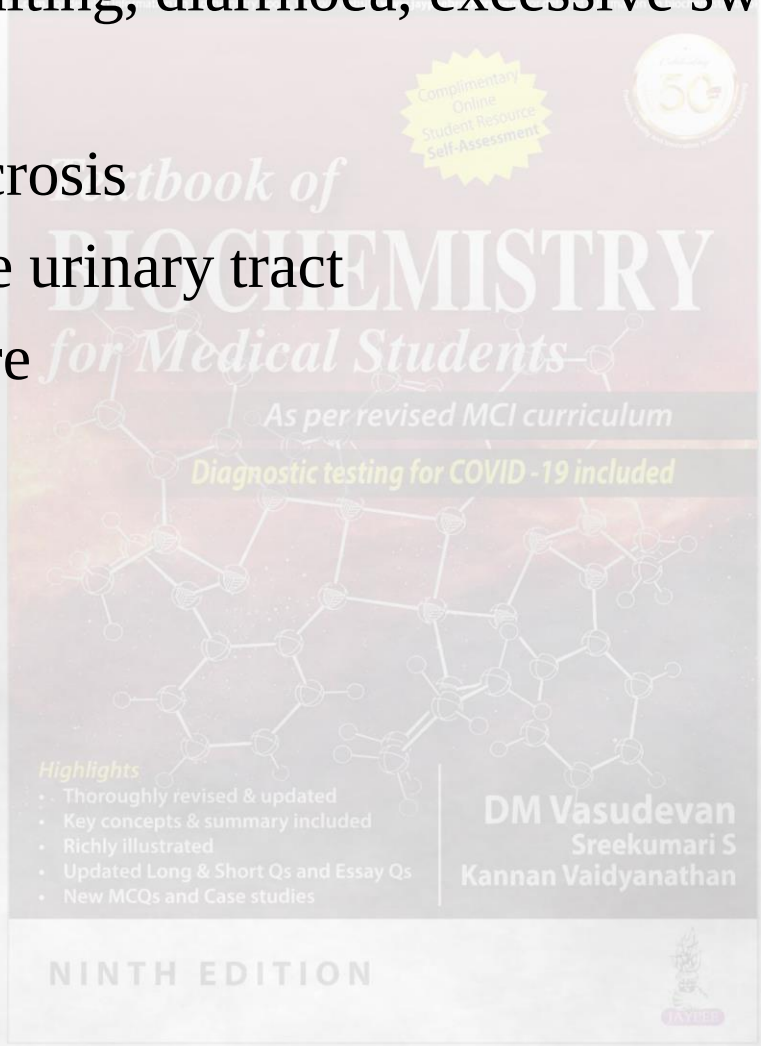
Causes of Polyuria

- Diabetes mellitus
- Diabetes insipidus
- Polycystic kidney
- Chronic renal failure
- Diuretics
- Intravenous saline/glucose



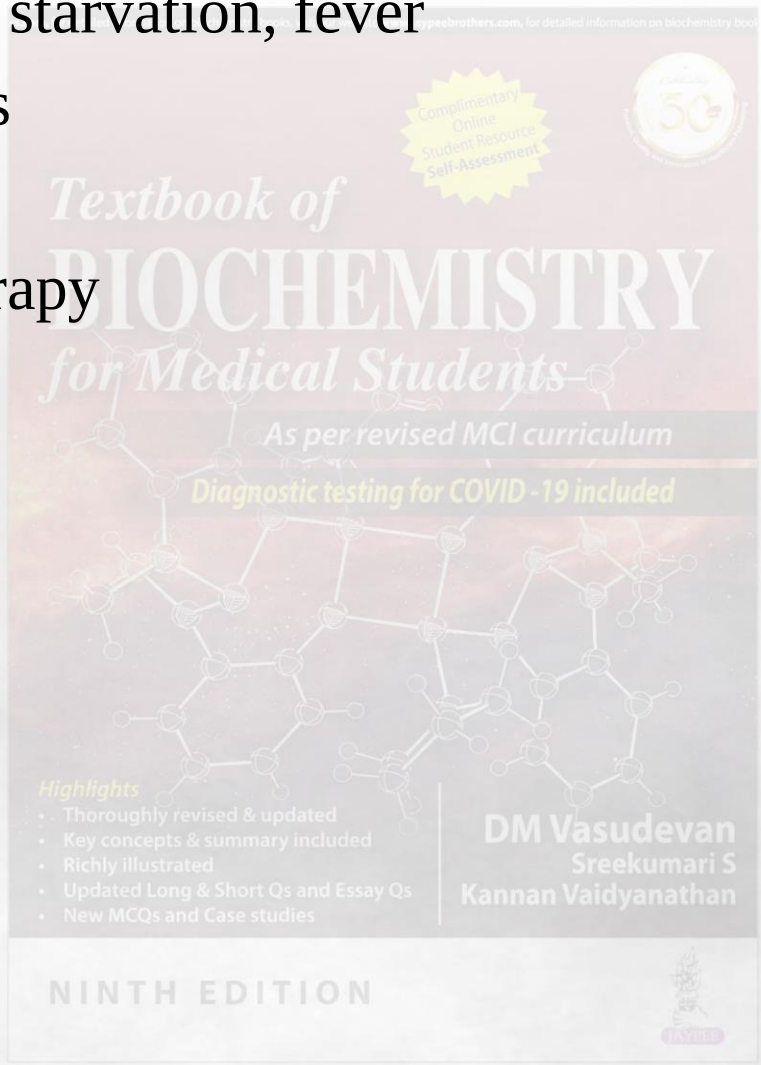
Oliguria

- Dehydration-vomiting, diarrhoea, excessive sweating
- Renal ischemia
- Acute tubular necrosis
- Obstruction to the urinary tract
- Acute renal failure



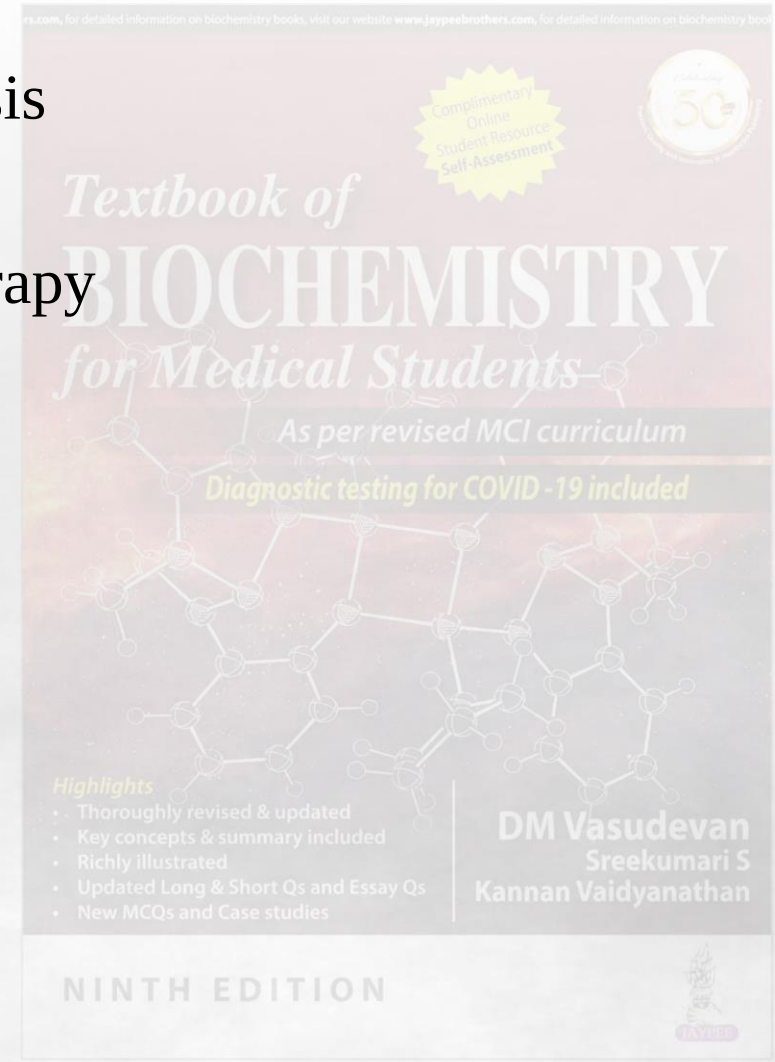
Acidic Urine

- Ketosis-diabetes, starvation, fever
- Systemic acidosis
- UTI- E.coli
- Acidification therapy



Alkaline Urine

- Strict vegetarian
- Systemic alkalosis
- UTI- Proteus
- Alkalization therapy

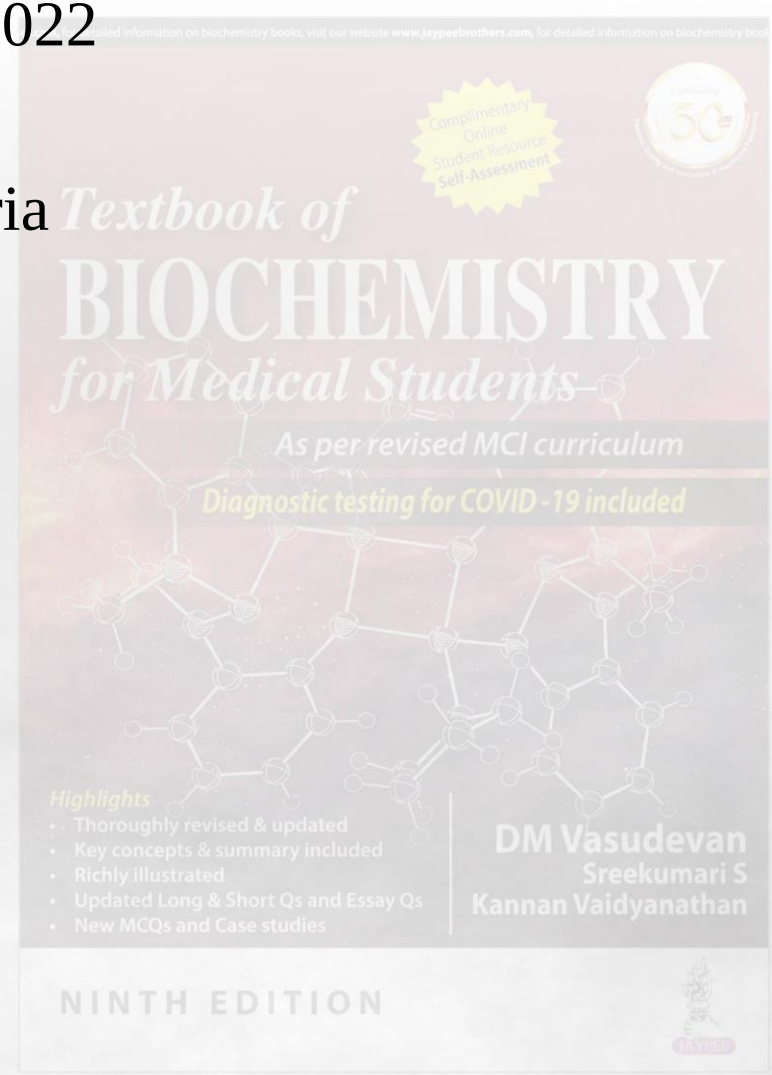


High Specific Gravity (Hyperosthenuria)

- Normal-1.016-1.022
- Causes

All causes of oliguria

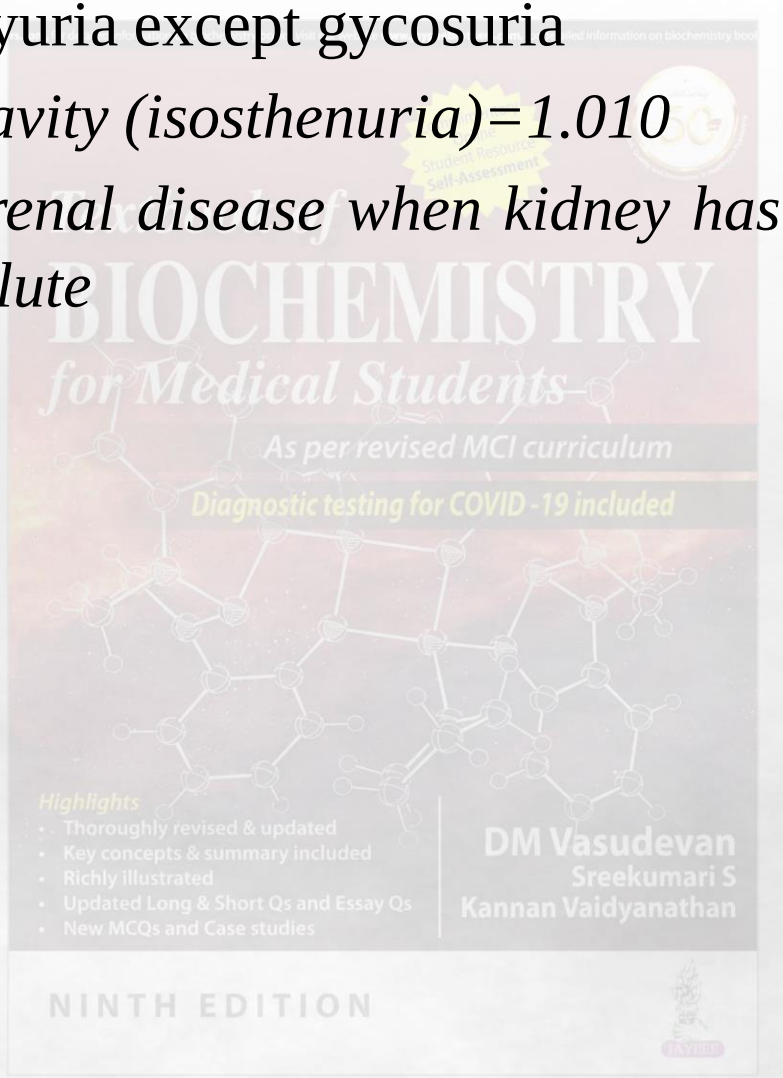
Gycosuria



Low Specific Gravity (Hyposthenuria)

- All causes of polyuria except gycosuria
- *Fixed specific gravity (isosthenuria)=1.010*

  Seen in chronic renal disease when kidney has lost the ability to concentrate or dilute



Chemical Examination

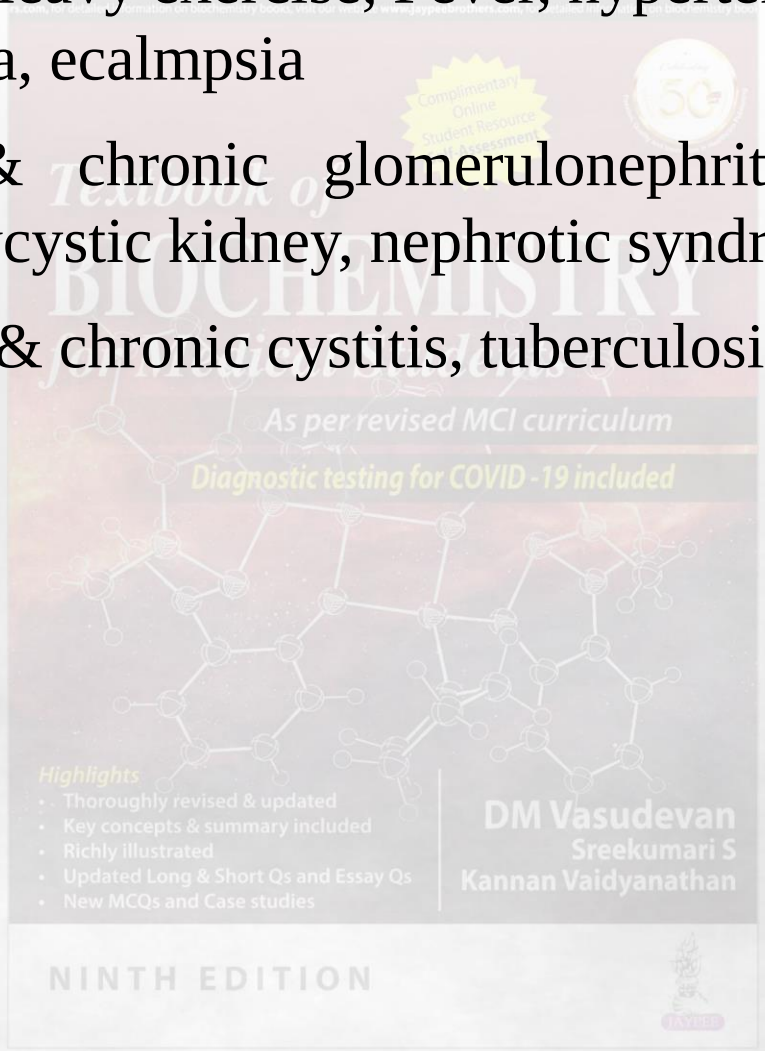
- Proteins
- Sugars
- Ketone bodies
- Bilirubin
- Bile salts
- Urobilinogen
- Blood

Tests for Proteins

- Test – HEAT & ACETIC ACID TEST
- Principle-proteins are denatured & coagulated on heating to give white cloud precipitate.
- Method-take 2/3 of test tube with urine, heat only the upper part keeping lower part as control.
- Presence of phosphates, carbonates, proteins gives a white cloud formation. Add acetic acid 1-2 drops, if the cloud persists it indicates it is protein(acetic acid dissolves the carbonates/ phosphates)

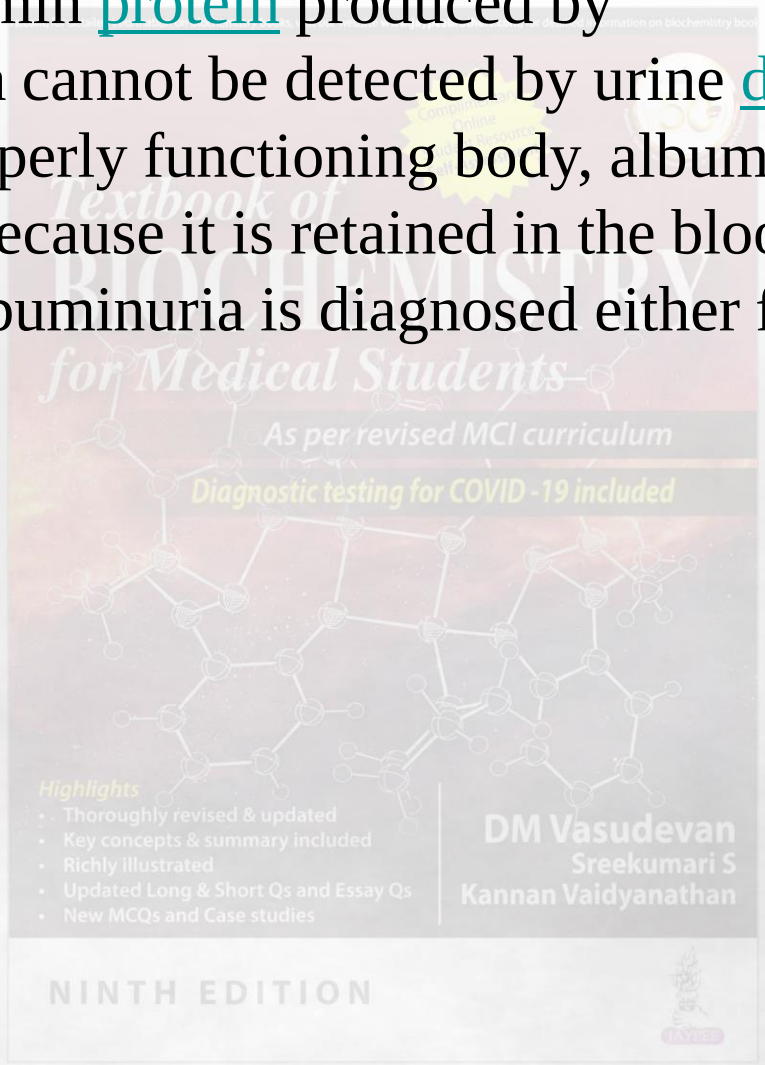
Causes of Proteinuria

- Prerenal causes-Heavy exercise, Fever, hypertension, multiple myeloma, ecalmpsia
- Renal –acute & chronic glomerulonephritis, Renal tubular dysfunction, Polycystic kidney, nephrotic syndrome
- Post renal- acute & chronic cystitis, tuberculosis cystitis



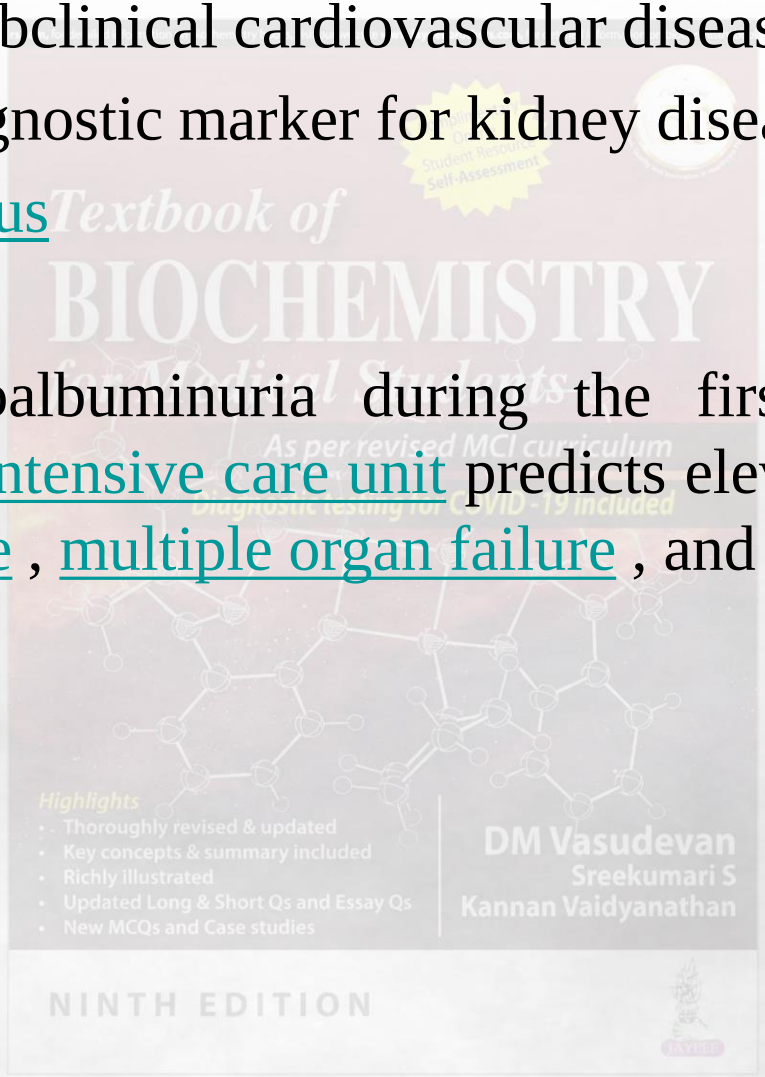
Microalbuminuria

- The level of albumin protein produced by microalbuminuria cannot be detected by urine dipstick methods. In a properly functioning body, albumin is not normally present in urine because it is retained in the bloodstream by the kidneys. Microalbuminuria is diagnosed either from a 24-hour urine collection



Significance of Microalbuminuria

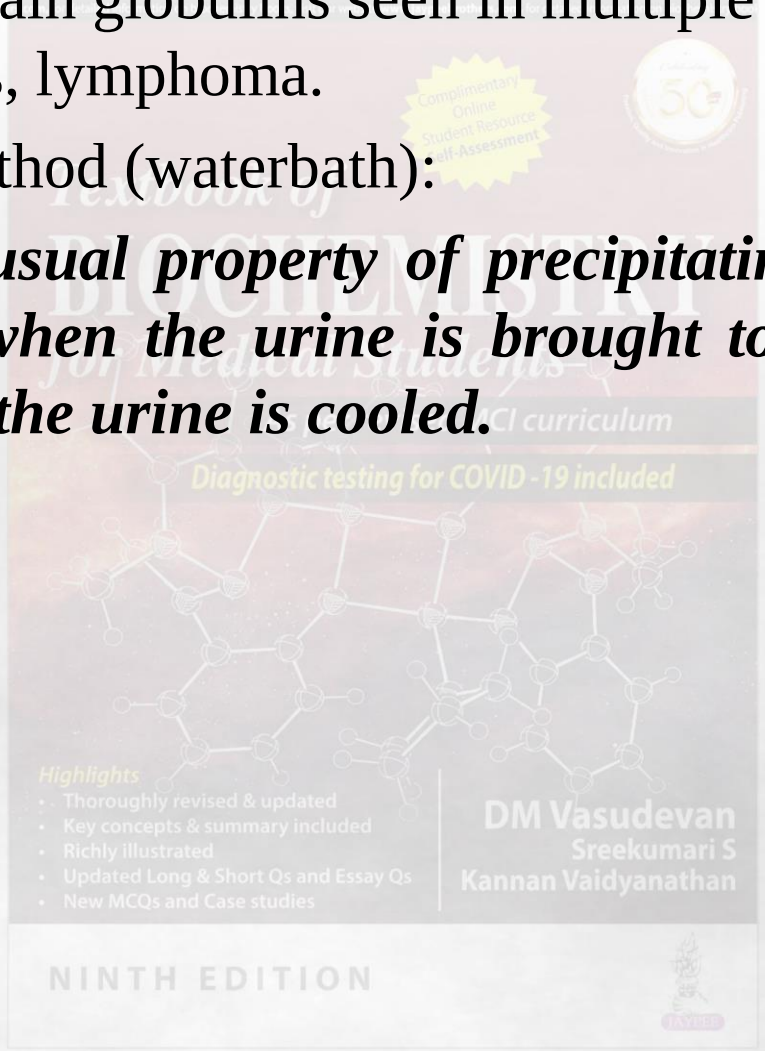
- an indicator of subclinical cardiovascular disease
- an important prognostic marker for kidney disease
- in diabetes mellitus
- in hypertension
- increasing microalbuminuria during the first 48 hours after admission to an intensive care unit predicts elevated risk for acute respiratory failure , multiple organ failure , and overall mortality



Bence Jones Proteins

- These are light chain globulins seen in multiple myeloma, macroglobulimias, lymphoma.
- Test- Thermal method (waterbath):

Proteins has unusual property of precipitating at 40^0 -60^0c & then dissolving when the urine is brought to boiling(100^0c) & reappears when the urine is cooled.



Test for Sugar

- **Test**-BENEDICT'S TEST(semiquantitative)
- **Principle**-benedict's reagent contains cuso4.In the presence of reducing sugars ***cupric ions*** are converted to ***cuprous oxide*** which is hastened by heating, to give the color.
- Method- take 5ml of benedict's reagent in a test tube, add 8drops of urine. Boil the mixture.

❖ Blue-green= negative

❖ Yellow-green=+(<0.5%)

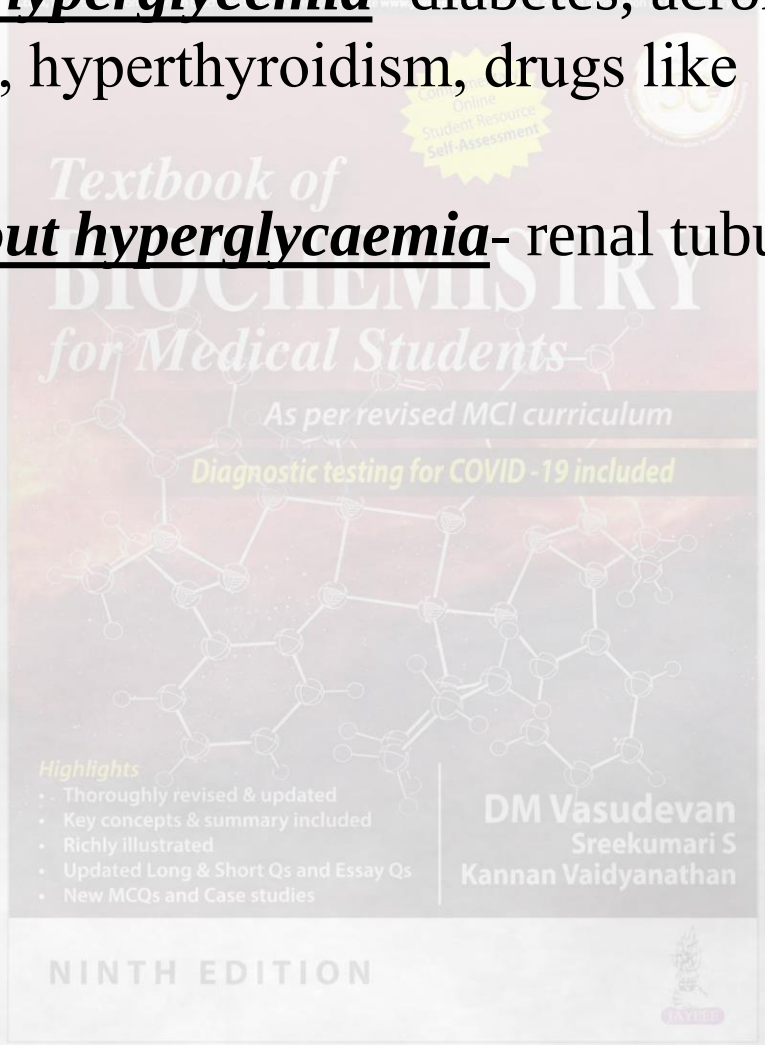
❖ Greenish yellow=++(0.5-1%)

❖ Yellow=+++(1-2%)

❖ Brick red=++++(>2%)

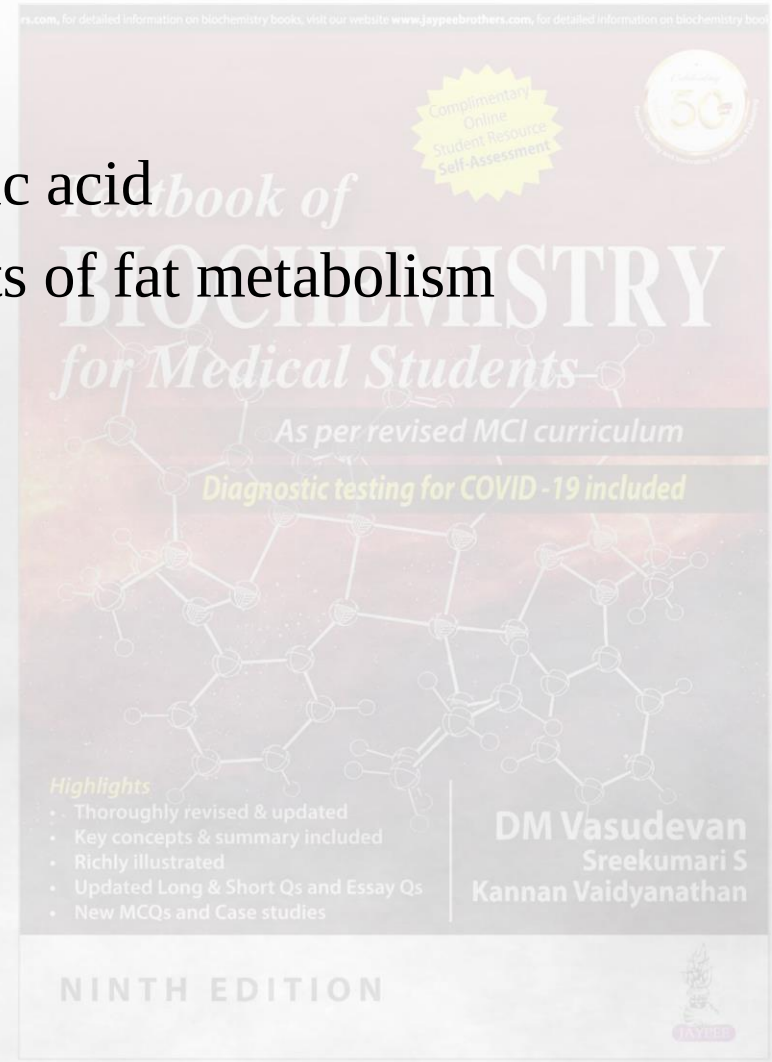
Causes of Glycosuria

- ***Glycosuria with hyperglycemia***- diabetes, acromegaly, cushing's disease, hyperthyroidism, drugs like corticosteroids.
- ***Glycosuria without hyperglycaemia***- renal tubular dysfunction



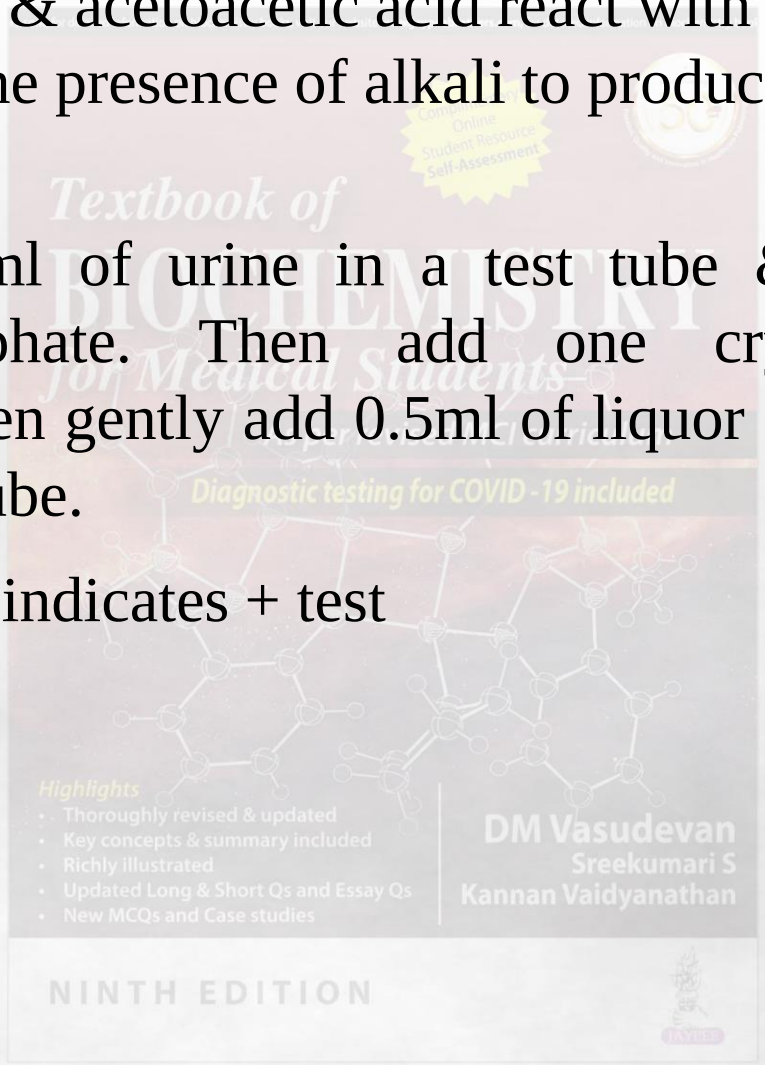
Ketone Bodies

- Acetone
- Acetoacetic acid
- β-hydroxy butyric acid
- They are products of fat metabolism



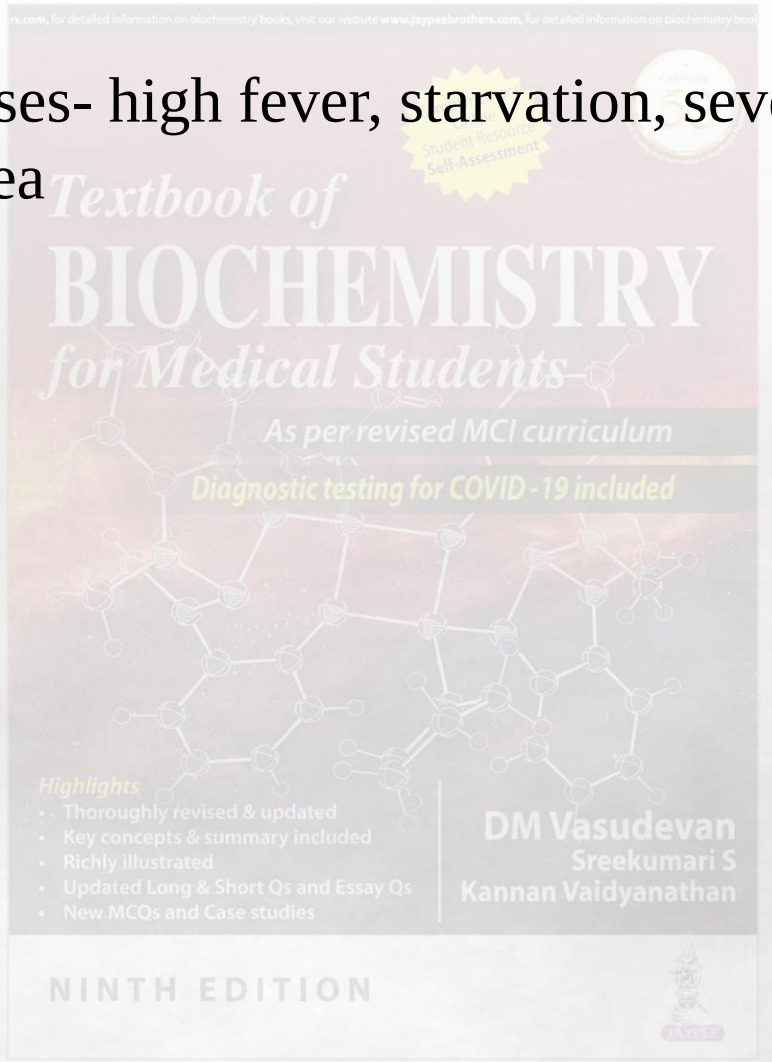
Rothera's Test

- Principle-acetone & acetoacetic acid react with sodium nitroprusside in the presence of alkali to produce purple colour.
- Method- take 5ml of urine in a test tube & saturate it with ammonium sulphate. Then add one crystal of sodium nitroprusside. Then gently add 0.5ml of liquor ammonia along the sides of the test tube.
- Change in colour indicates + test



Causes of Ketonuria

- Diabetes
- Non-diabetic causes- high fever, starvation, severe vomiting/diarrhoea

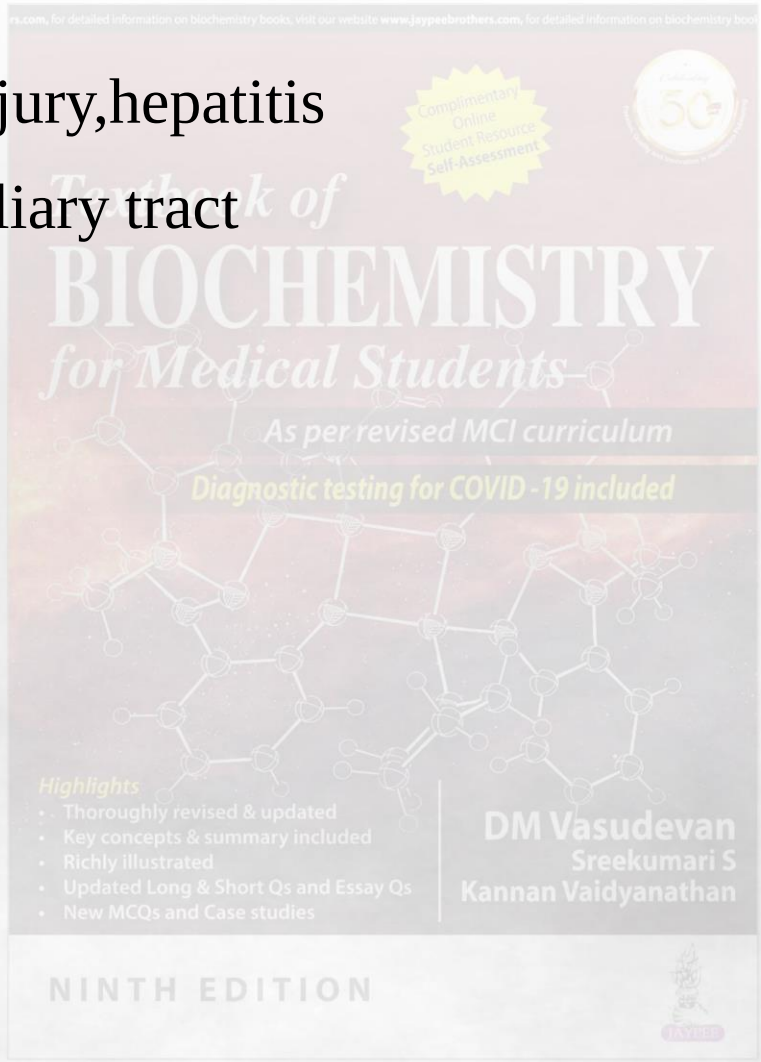


Bilirubin

- **Causes**

➢ Liver diseases-injury,hepatitis

➢ Obstruction to biliary tract



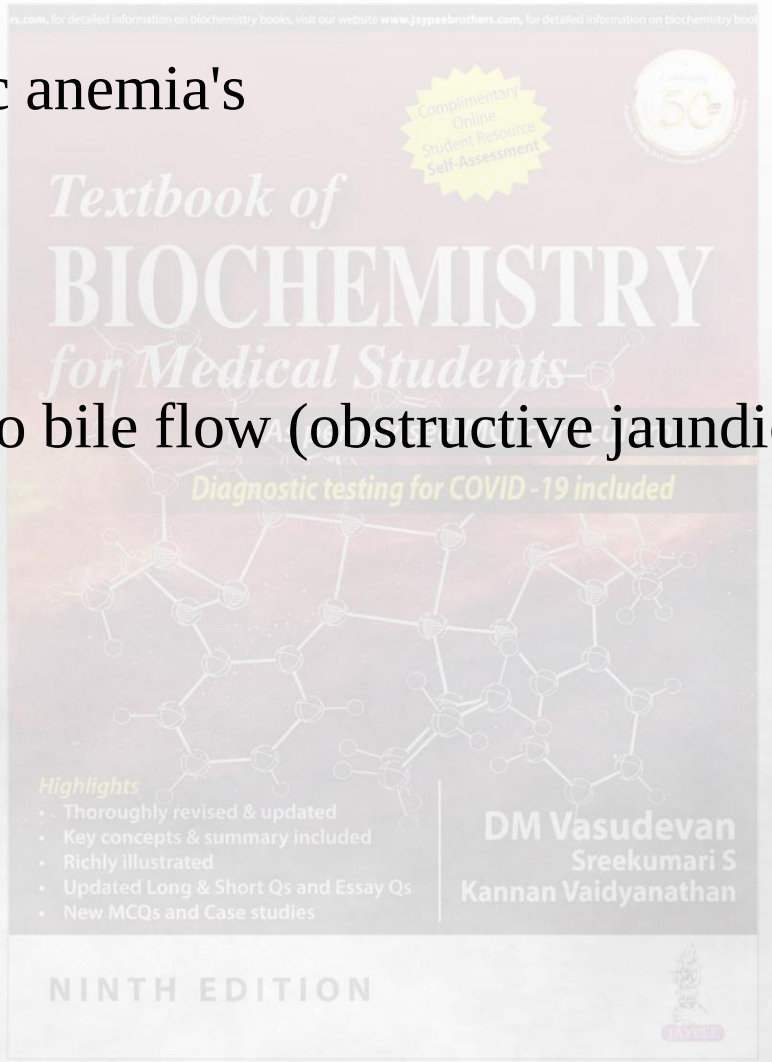
Urobilinogen

- Test- ehrlich test
- Causes-hemolytic anemia's

Bile salts-

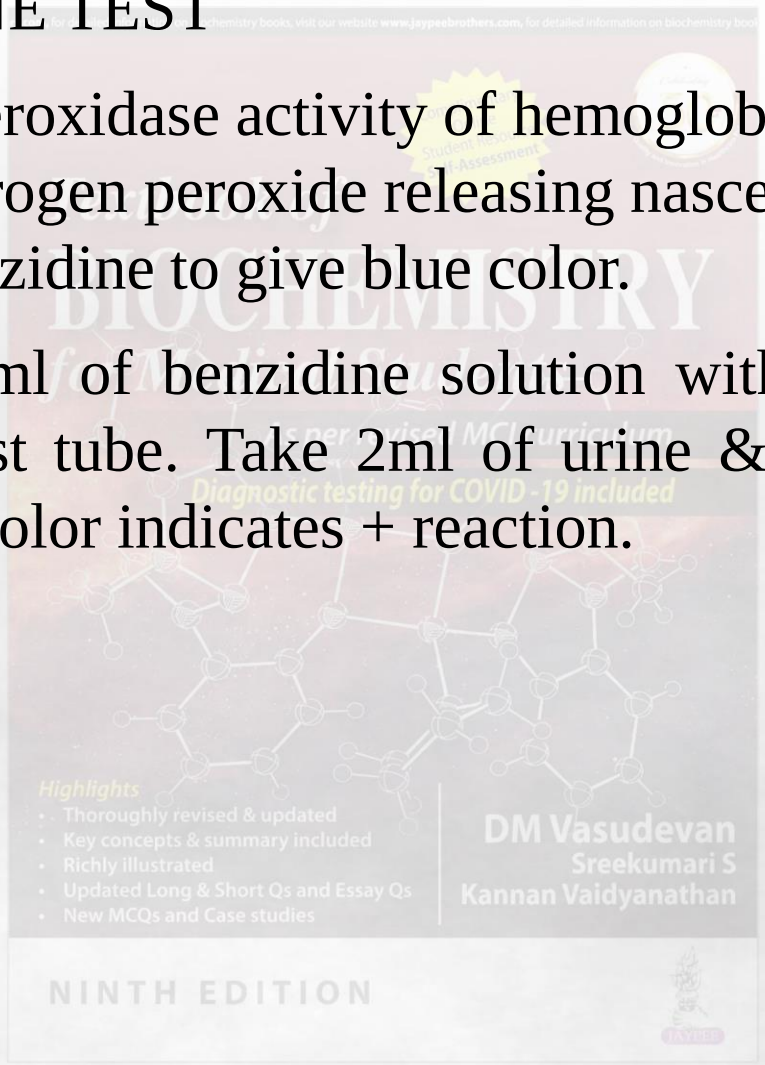
- Hay's test

Cause- obstruction to bile flow (obstructive jaundice)



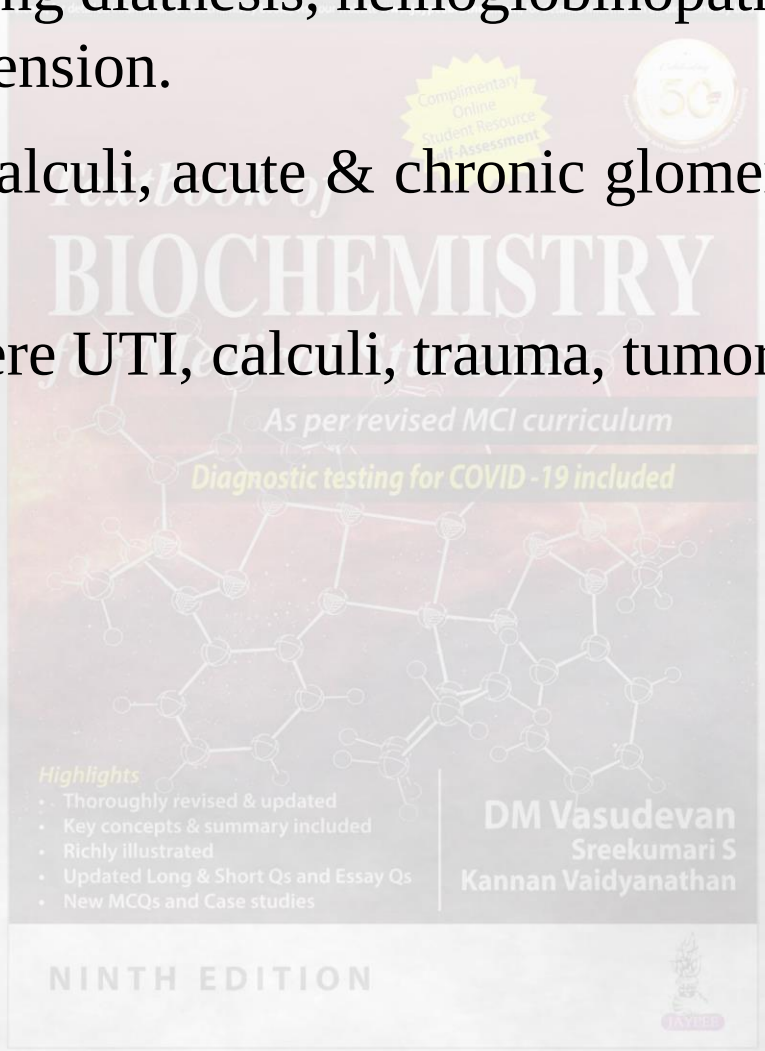
Blood in Urine

- **Test**- BENZIDINE TEST
- **Principle**-The peroxidase activity of hemoglobin decomposes hydrogen peroxide releasing nascent oxygen which in turn oxidizes benzidine to give blue color.
- **Method**- mix 2ml of benzidine solution with 2ml of hydrogen peroxide in a test tube. Take 2ml of urine & add 2ml of above mixture. A blue color indicates + reaction.



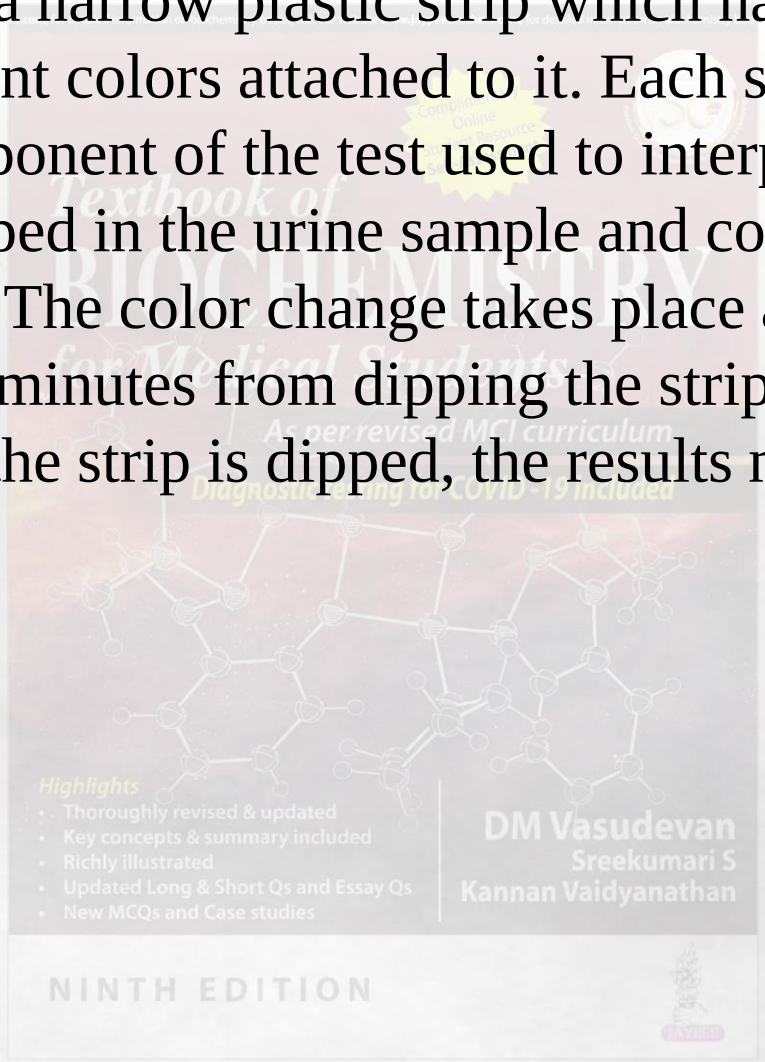
Causes of Hematuria

- **Pre renal**- bleeding diathesis, hemoglobinopathies, malignant hypertension.
- **Renal**- trauma, calculi, acute & chronic glomerulonephritis, renal TB, renal tumors
- **Post renal** – severe UTI, calculi, trauma, tumors of urinary tract

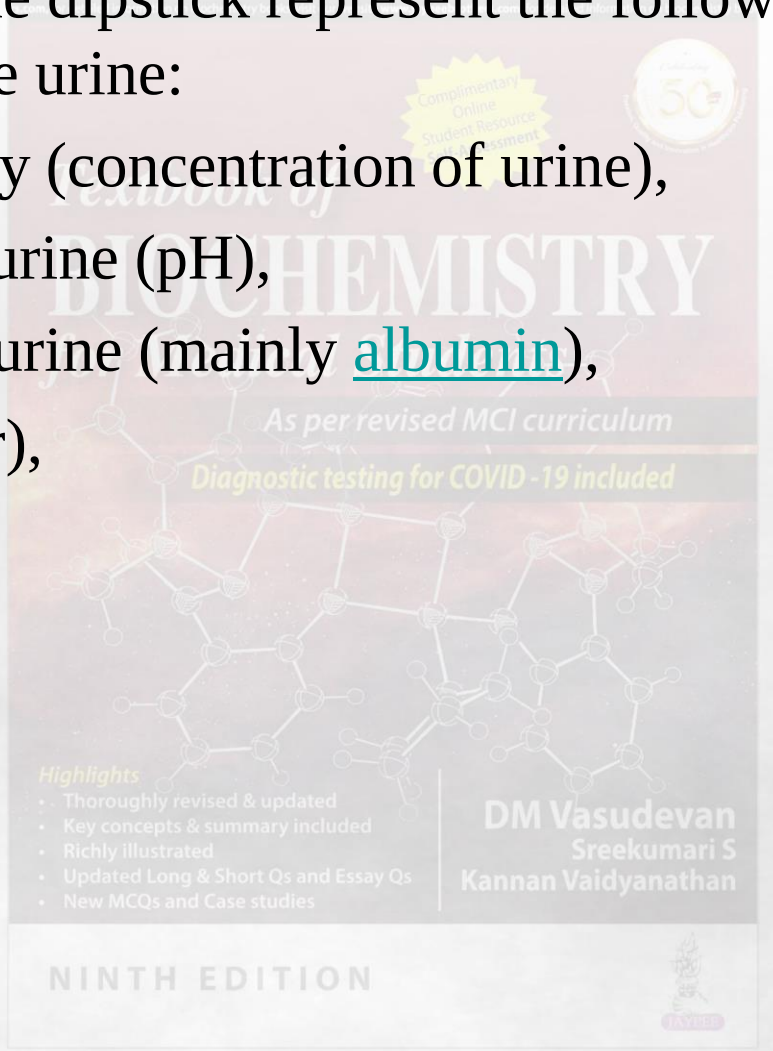


Urine Dipsticks

- Urine dipstick is a narrow plastic strip which has several squares of different colors attached to it. Each small square represents a component of the test used to interpret urinalysis. The entire strip is dipped in the urine sample and color changes in each square are noted. The color change takes place after several seconds to a few minutes from dipping the strip. If read too early or too long after the strip is dipped, the results may not be accurate.



- The squares on the dipstick represent the following components in the urine:
  - specific gravity (concentration of urine),
  - acidity of the urine (pH),
  - protein in the urine (mainly albumin),
  - glucose (sugar),
  - ketones
  - blood
  - bilirubin and
  - urobilinogen

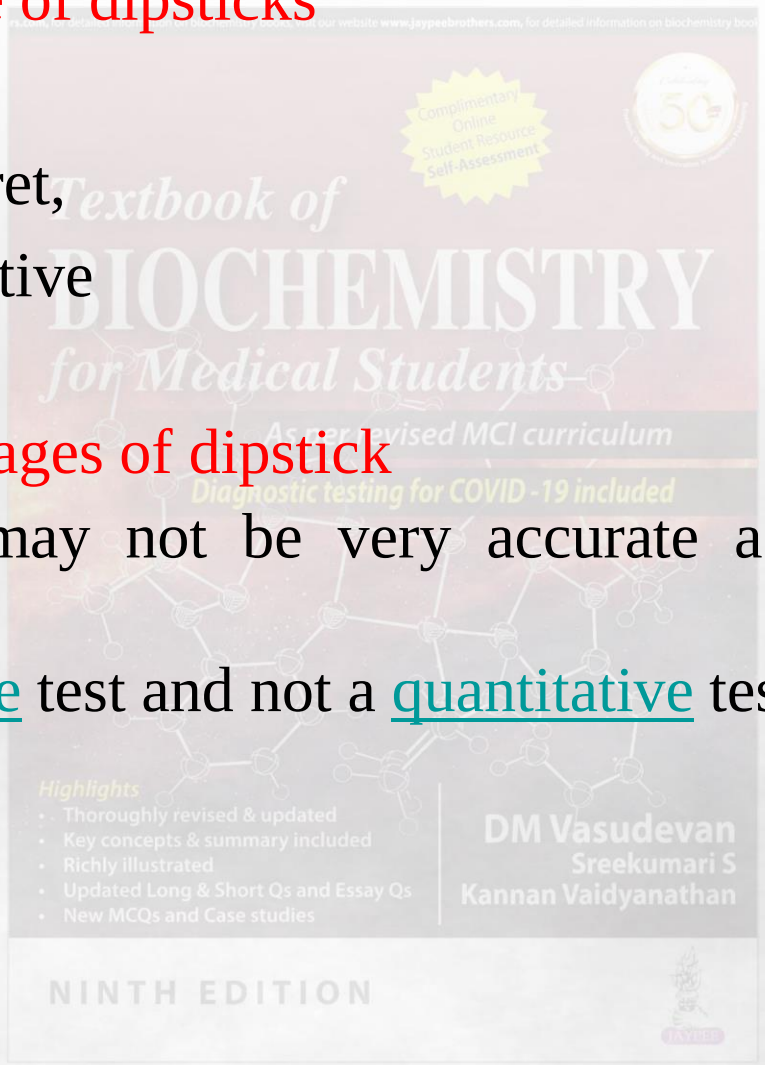


The main advantage of dipsticks

1. convenient,
2. easy to interpret,
3. and cost-effective

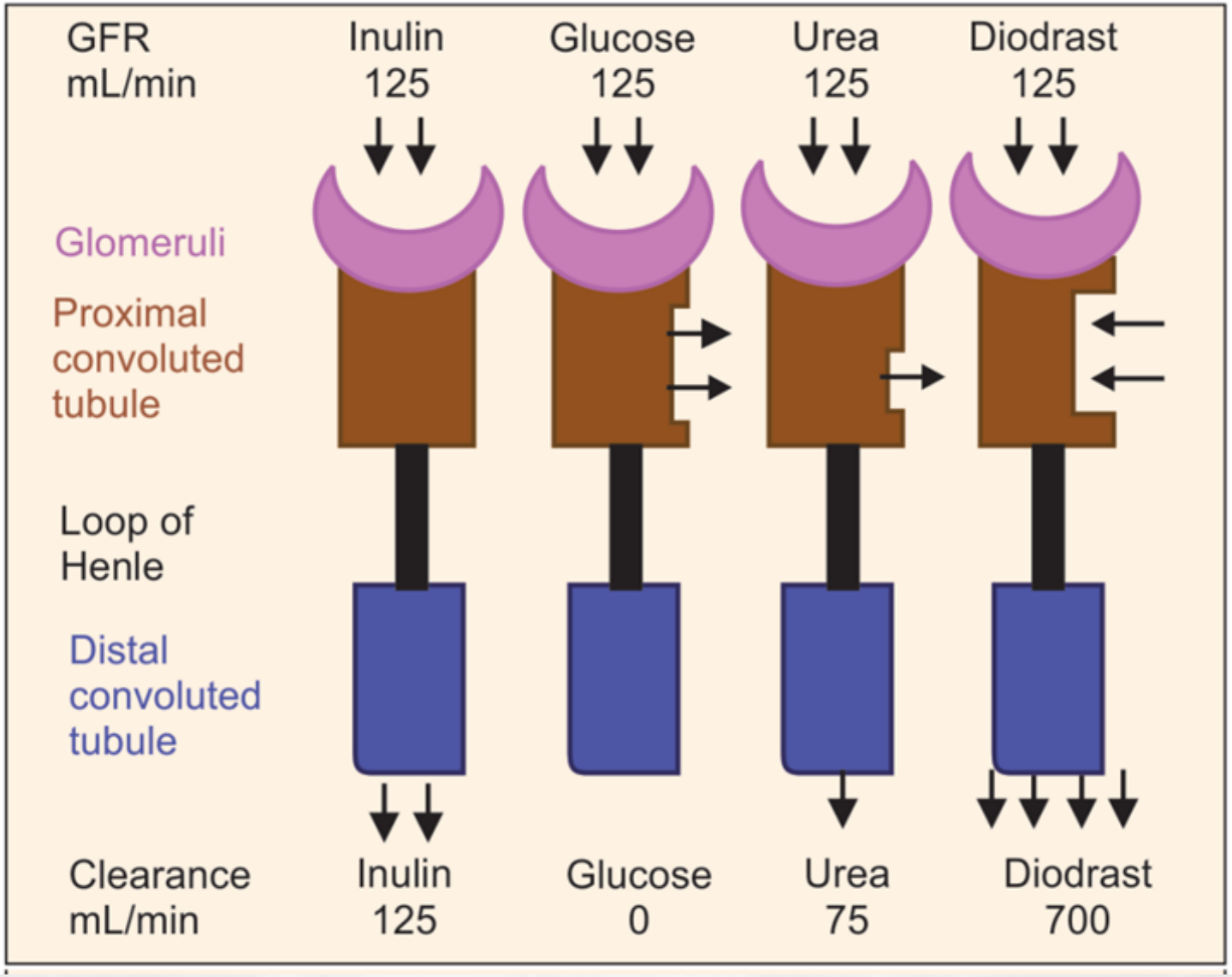
The main disadvantages of dipstick

1. Information may not be very accurate as the test is time-sensitive.
2. It is qualitative test and not a quantitative test.



Common Tests to Assess Kidney Function

Constituent	Blood level or urine excretion	Factors affecting urinary excretion
Urea	B = 15-40 mg/dl U = 15-30 g/day	Protein catabolism Renal blood flow
Creatinine	B = 0.7-1.4 mg/dl(M) B = 0.6-1.3 mg/dl(F) U = 1-2 g/day	GFR, tubular secretion, age, sex, muscle mass
Uric acid	B = 3-7 mg/dl (M) B = 2-5 mg/dl (F) U = 0.5-0.8g/day	Purine catabolism, tubular excretion
Sodium	B = 135-142 mmol/L	State of hydration, dietary sodium
Potassium	B = 3.5-5 mmol/L	Dietary potassium, acid base balance
Calcium	B = 9-11 mg/dl	PTH, calcitonin


GFR
mL/min
Inulin
125
Glucose
125
Urea
125
Diodrast
125
Glomeruli
Proximal
convoluted
tubule
Loop of
Henle
Distal
convoluted
tubule
Clearance
mL/min
Inulin
125
Glucose
0
Urea
75
Diodrast
700

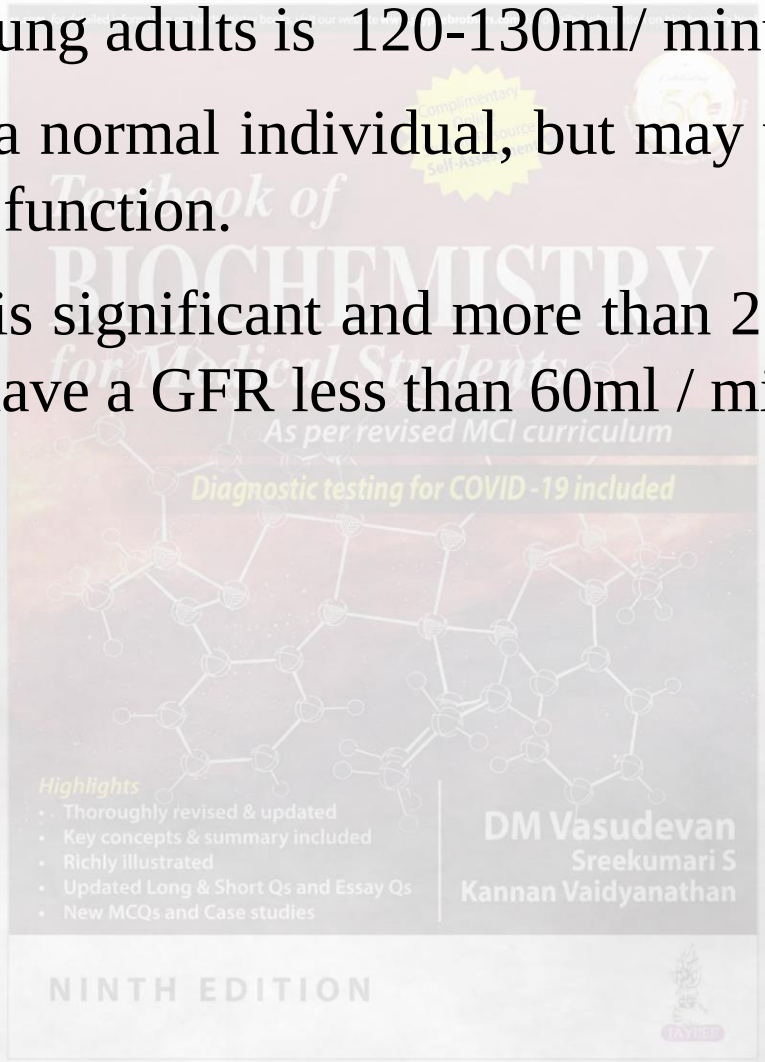
Relationship of GFR with Clearance

Mechanism	Result	Example
Substances filtered; neither reabsorbed nor excreted	GFR = clearance	Inulin Creatinine
Substance filtered; reabsorbed and excreted	GFR ≅ clearance	Uric acid
Substances filtered; partially reabsorbed	Clearance < GFR	Urea
Substances filtered; secreted but not reabsorbed	Clearance > GFR	Diodrast, PAH

Normal GFR for young adults is 120-130ml/ minute/1.73 sq.M.

GFR is constant in a normal individual, but may vary among people with normal kidney function.

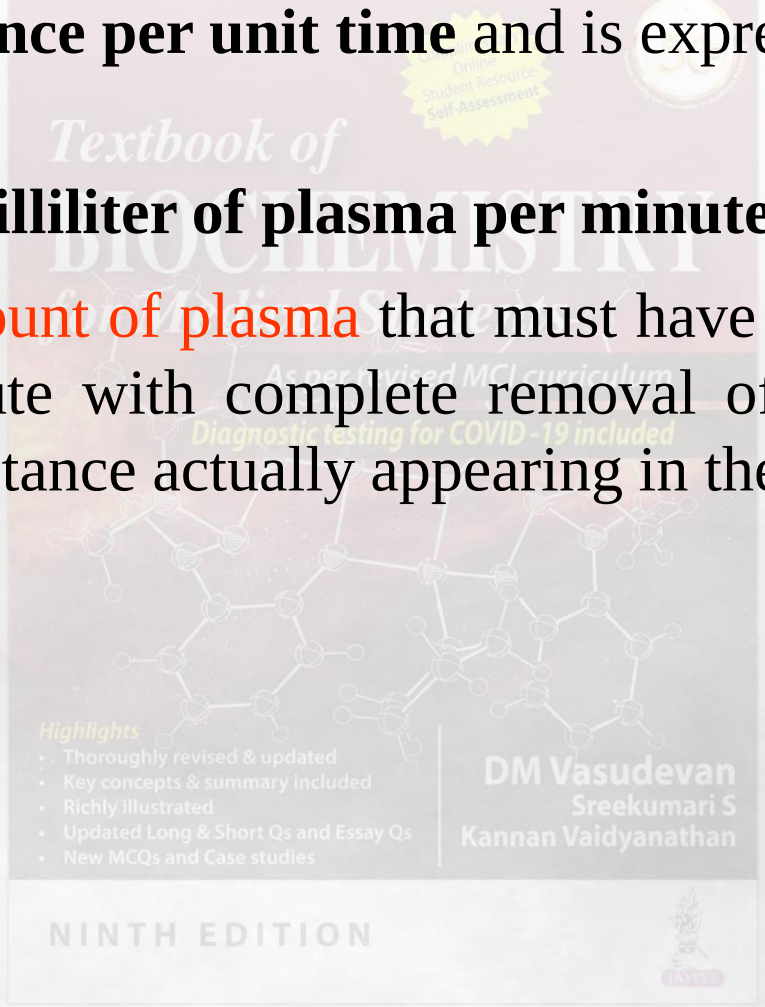
A decline with age is significant and more than 25% of people older than 70 years may have a GFR less than 60ml / minute.



Clearance is defined as the quantity of blood or **plasma completely cleared of a substance per unit time** and is expressed as milliliter per minute.

It is expressed as **milliliter of plasma per minute** (not as g or mg).

It estimates the amount of plasma that must have passed through the glomeruli per minute with complete removal of that substance to account for the substance actually appearing in the urine.



$$\text{Clearance} = \frac{\text{mg of sub excreted per minute}}{\text{mg of subst per ml of plasma}}$$

$$C = \frac{U \times V}{P}$$

where U = concentration of the substance in urine;

P = concentration of the substance in plasma or serum and

V = the ml of urine excreted per minute. The value is expressed as ml / minute.

Advantage of Creatinine

Endogenously produced compound

Constantly produced

Constantly excreted

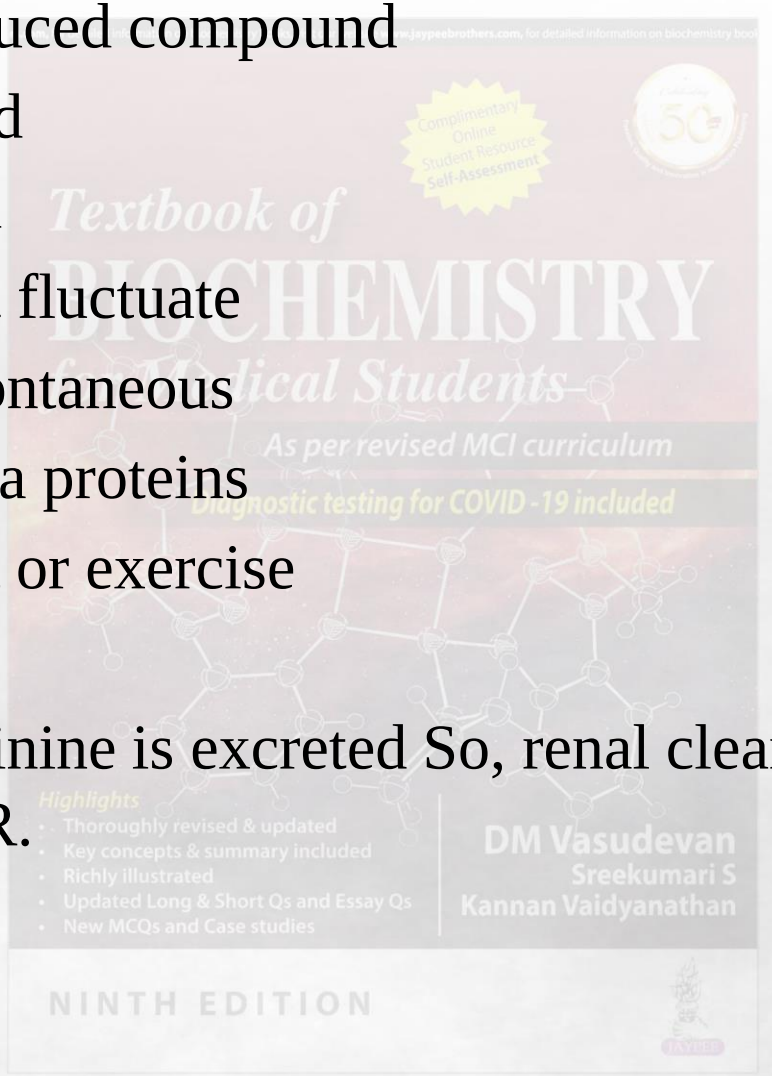
Blood level will not fluctuate

Non-enzymatic, spontaneous

Not bound to plasma proteins

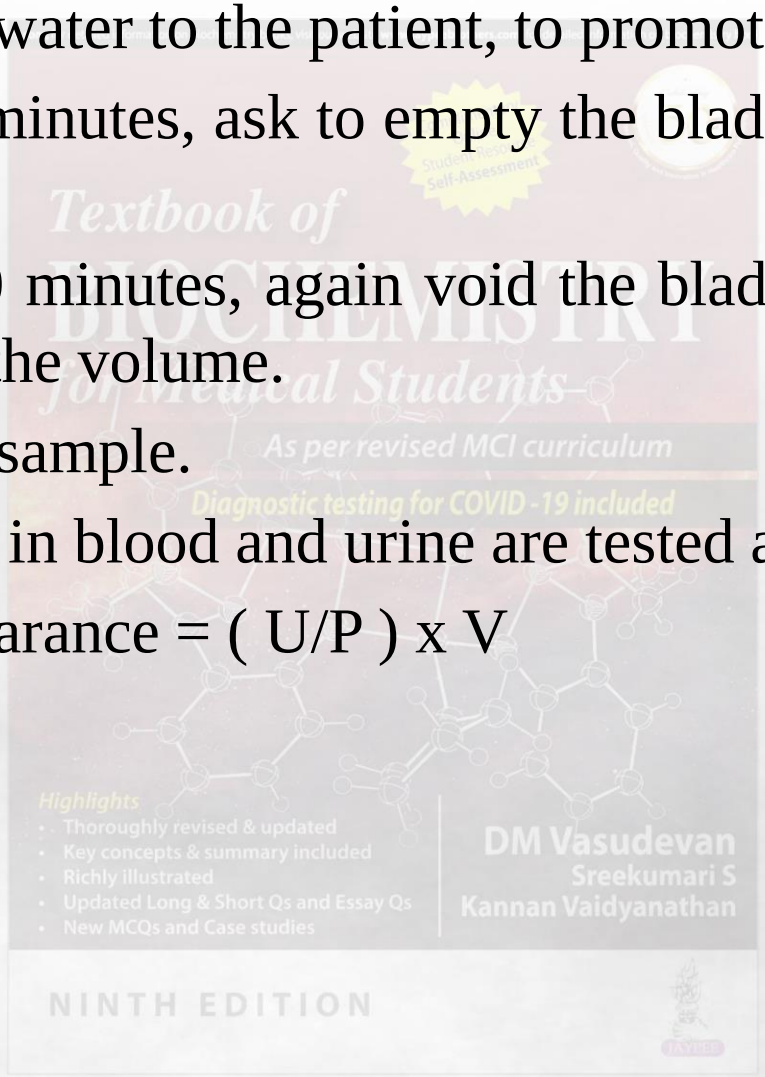
Not affected by diet or exercise

Entire filtered creatinine is excreted So, renal clearance of creatinine is a measure of GFR.



Procedure for Creatinine Clearance Test

- Give 500 ml of water to the patient, to promote good urine flow.
- After about 30 minutes, ask to empty the bladder and discard the urine.
- Exactly after 60 minutes, again void the bladder and collect the urine, and note the volume.
- Take one blood sample.
- Creatinine level in blood and urine are tested and calculated.
- Uncorrected clearance = (U/P) x V



Creatinine clearance corrected for surface area could be calculated as

$$\frac{U \times V \times 1.73}{P \times A}$$

Normal Reference Values

	Serum creatinine	GFR
Adult male	0.7 -1.4 mg/dl	95-115 ml/mt
Adult female	0.6-1.3 mg/dl	85- 110 ml/mt
Children	0.5 -1.2 mg/dl	

Factors reducing serum creatinine	Factors increasing serum creatinine
Low muscle mass	**Old age**
Malnutrition	**Renal diseases**
Medicines	Glomerulonephritis
Thiazide	Pyelonephritis
Vancomycin	Renal failure
	Urinary obstruction
	Congestive cardiac failure
	Medicines Amphoteracin B Captopril Cephalosporins Kanamycin

Grading of Chronic Kidney Disease

State	GFR	Grade
		ml/mt/1.73M^2
Minimal damage with normal GFR	1	>90
Mild damage with slightly low GFR	2	60-89
Moderately low GFR	3	30-59
Severely low GFR	4	15-29
Kidney failure	5	<15

Estimated GFR (eGFR)

A simpler technique of estimating creatinine clearance and there by GFR is by using serum creatinine level. This would eliminate the need for timed urine collections.

Cockcroft-Gault equation.

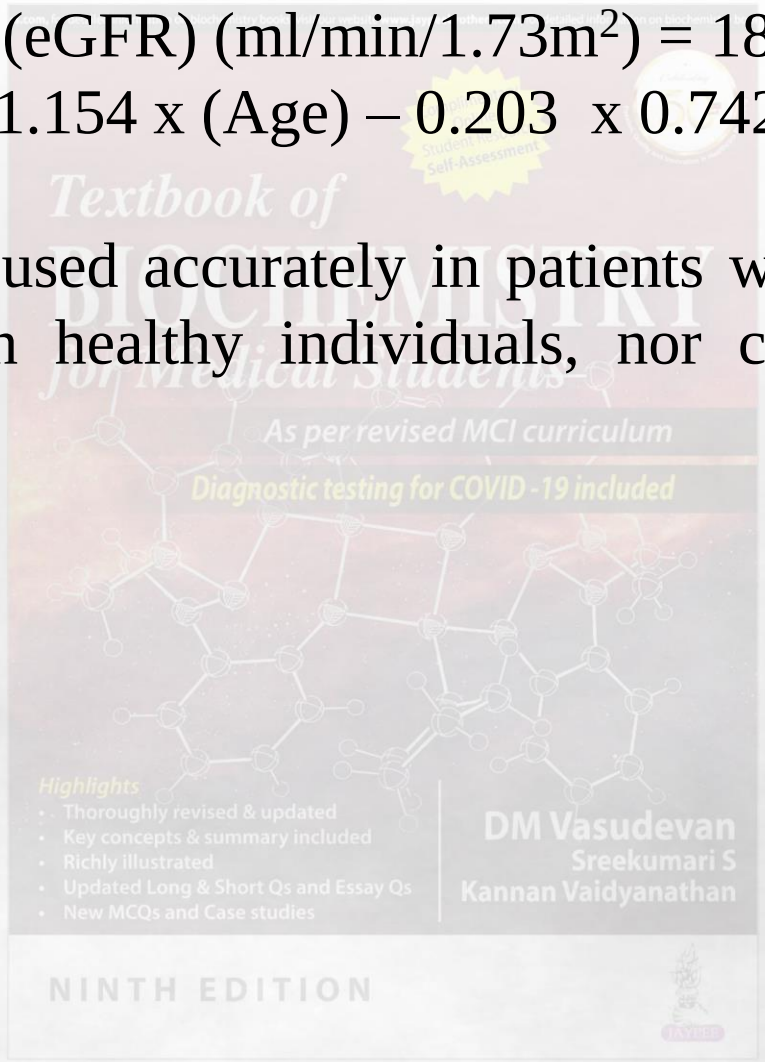
Ccr = (140--age in years) x weight in Kg (0.85 in females) / 72 x Pcr in mg/dl

The factor 0.85 is used in females assuming that they have 15% less muscle mass. The issue of overestimation cannot be eliminated by this calculation.

MDRD (Modification of Diet in Renal Disease) Equation is more Accurate

The estimated GFR (eGFR) (ml/min/1.73m^2) = 186 x (Creatinine / 88.4) -1.154 x (Age) – 0.203 x 0.742 (if female)

eGFR can only be used accurately in patients with chronic kidney disease and not on healthy individuals, nor children and obese people.

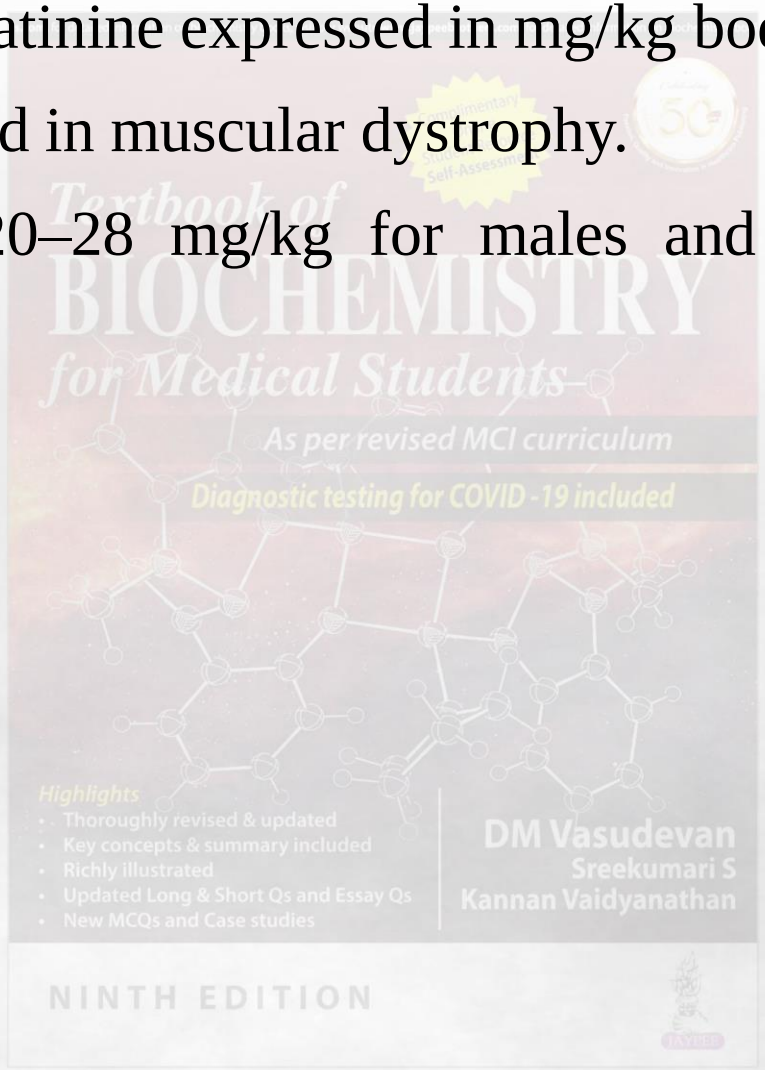


Creatinine co-Efficient

It is the urinary creatinine expressed in mg/kg body weight.

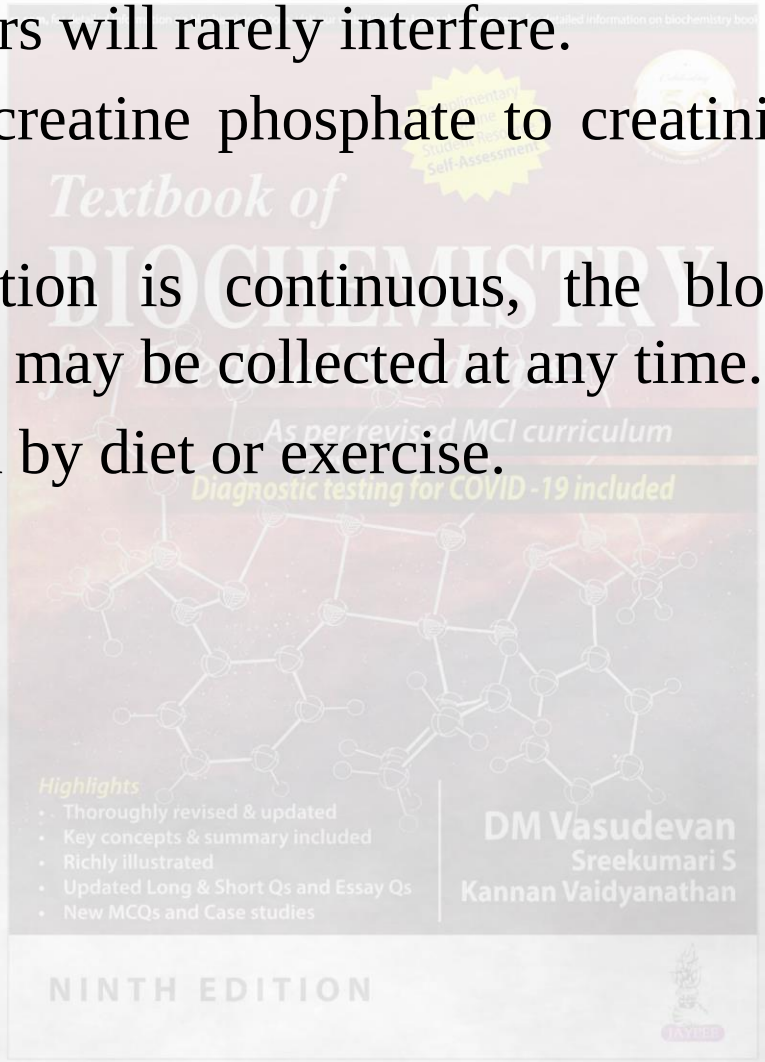
The value is elevated in muscular dystrophy.

Normal range is 20–28 mg/kg for males and 15–21 mg/kg for females.



Advantages of using Creatinine Clearance Test as a GFR Marker

1. Extrarenal factors will rarely interfere.
2. Conversion of creatine phosphate to creatinine is spontaneous, nonenzymatic.
3. As the production is continuous, the blood level will not fluctuate. Blood may be collected at any time.
4. It is not affected by diet or exercise.



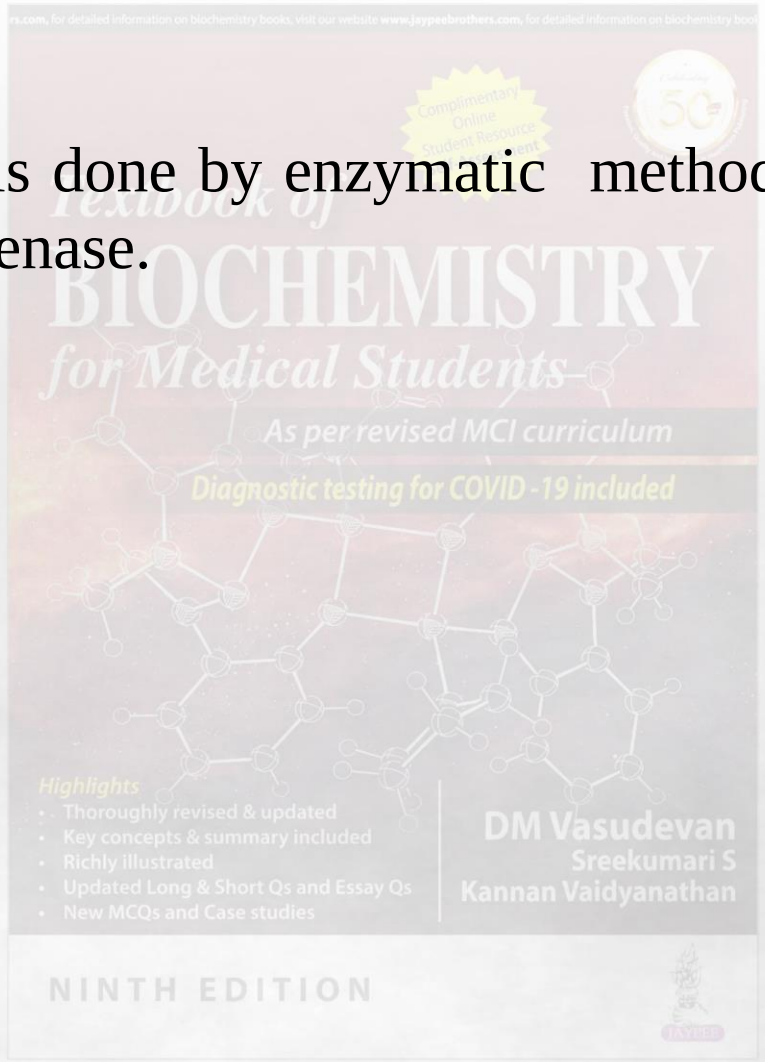
Disadvantages of Creatinine

1. Creatinine is filtered by glomeruli, and actively excreted by the tubules. Of the total excretion, about 10% is tubular component.
2. When the GFR is reduced, the secretion component is increased, and will viciate the results. The creatinine clearance is said to overestimate GFR by about 10-20ml/mt .
3. When GFR is severely reduced, extra-renal excretion increases. Then the major route becomes the degradation by intestinal bacterial flora.
4. Early kidney failure is not detected
5. Other prerenal, renal and postrenal causes will influence creatinine value.

Normal Serum Urea Level

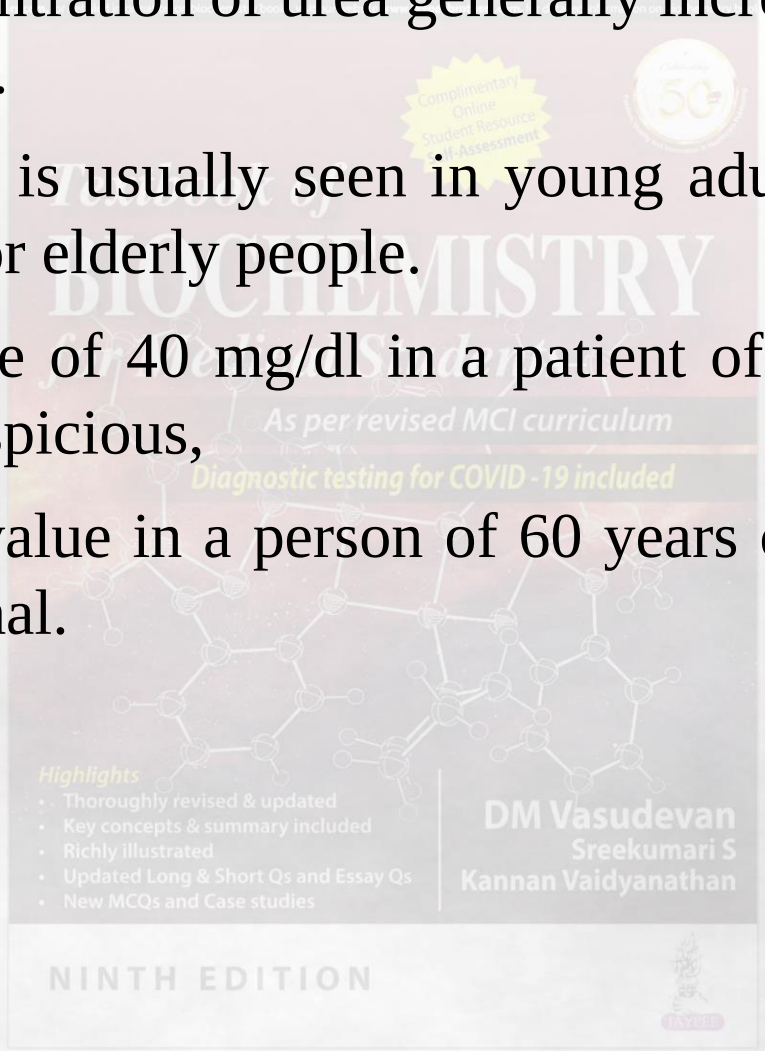
20 to 40 mg/dL.

Estimation of urea is done by enzymatic method using urease and glutamate dehydrogenase.



Urea is the end-product of Protein Metabolism

- The serum concentration of urea generally increases as the age advances.
- The lower range is usually seen in young adults and the upper limit is normal for elderly people.
- Therefore a value of 40 mg/dl in a patient of 25 years may be considered as suspicious,
- while the same value in a person of 60 years can be considered as perfectly normal.



Causes for Increased Blood Urea

1. Pre-renal conditions

   Dehydration: Severe vomiting, intestinal obstruction, diarrhea. Diabetic coma and severe burns.

   Fever and severe infections

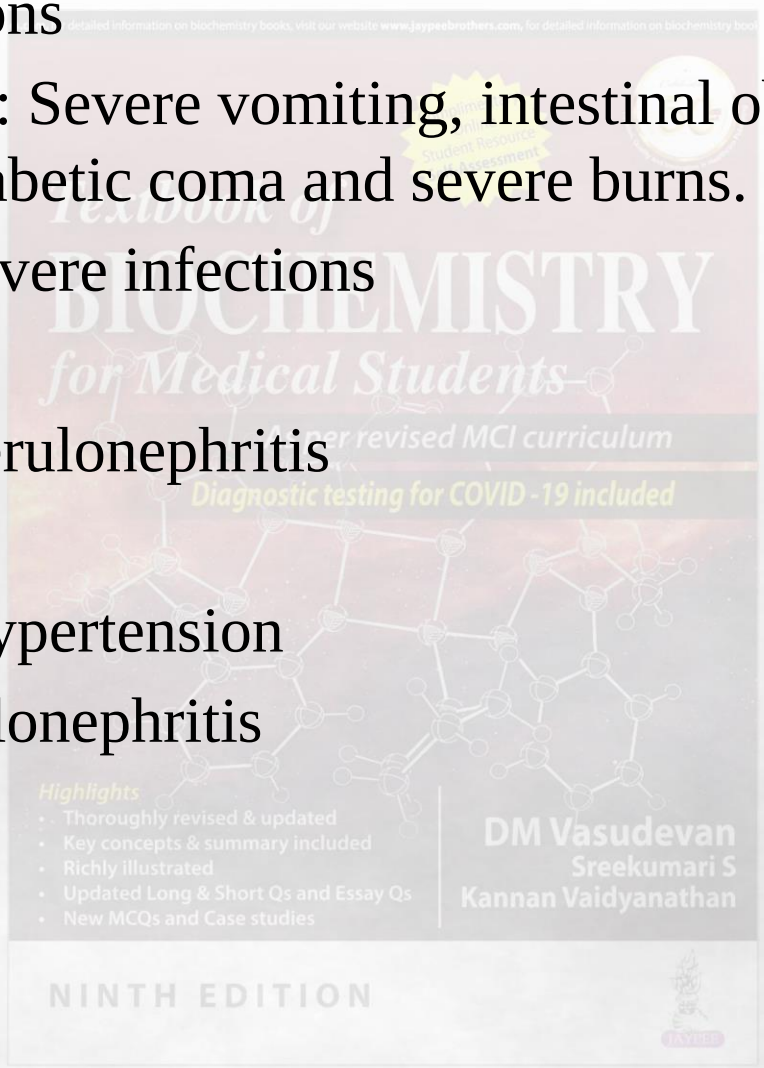
2. Renal diseases

   Acute glomerulonephritis

   Nephrosis

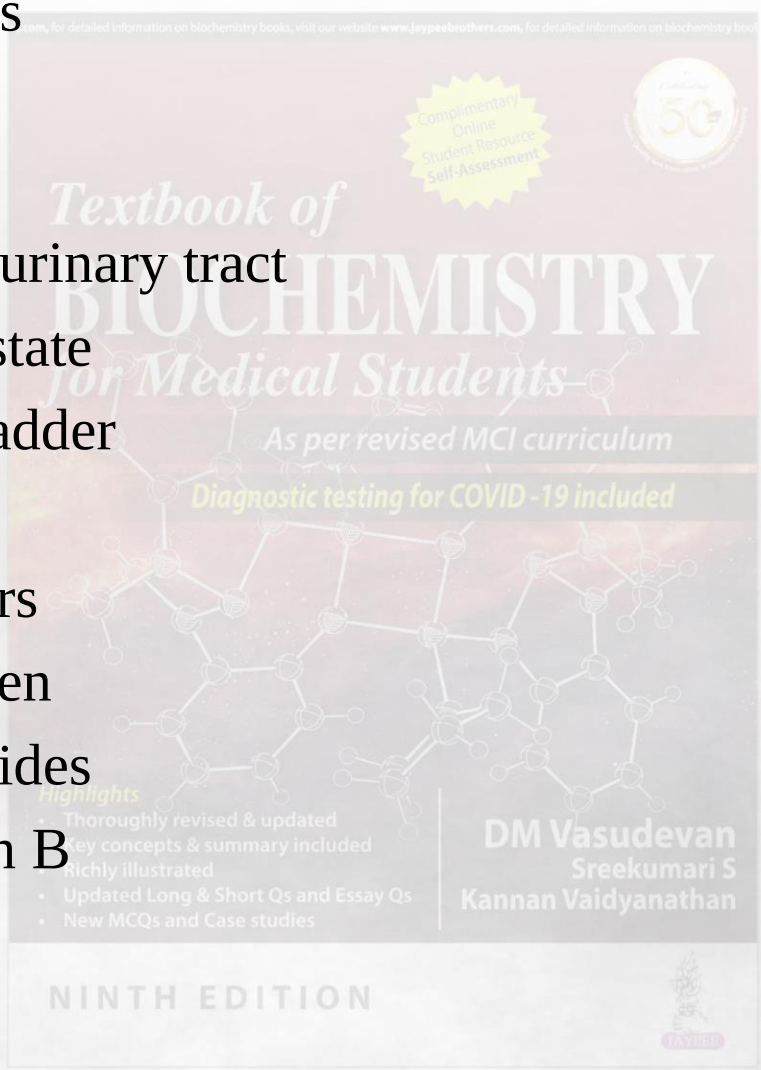
   Malignant hypertension

   Chronic pyelonephritis



Causes for Increased Blood Urea

1. Pre-renal conditions
2. Renal diseases
3. Post-renal causes
    - Stones in the urinary tract
    - Enlarged prostate
    - Tumors of bladder
4. Medications
    - ACE inhibitors
    - Acetaminophen
    - Aminoglycosides
    - Amphoteracin B
    - Diuretics
    - NSAIDs

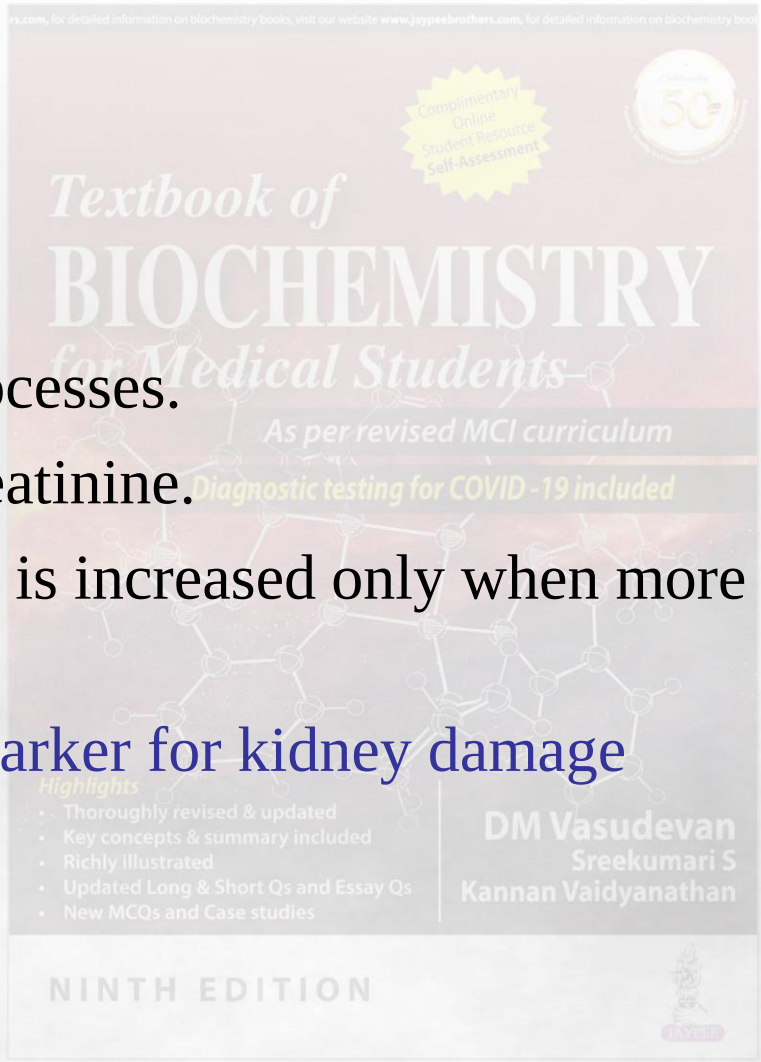


Cystatin C

- High concentrations in biological fluids: breast milk, tears, saliva, semen
- Expressed in virtually all organs of the body.
- The most abundant extracellular Cysteine protease inhibitors.
- Inhibits lysosomal cathepsines, metalloproteinases, proteases of parasites and microbes
- It allows a more precise testing of kidney glomerular function
- Stable production rate and free filtration by kidney glomeruli
- Constant production rate; not vary in concentration during an acute-phase reaction
- Cystatin C is a more precise test of kidney function (GFR) than serum creatinine levels

Cystatin C

- Not depended on
- age,
- sex,
- muscle mass or
- inflammatory processes.
- So,better than creatinine.
- [Creatinine level is increased only when more than 50% renal damage]
- Sensitive early marker for kidney damage



Cystatin C

Normal blood level : 0.8 to 1.2 mg /L

Only 20% of patients had elevated serum creatinine, whereas 76% had elevated serum cystatin C levels.

Cystatin C is significantly ($P < 0.05$) more sensitive than creatinine cystatin C is significantly ($P < 0.05$) more sensitive than creatinine

Serum creatinine does not increase until the GFR has moderatey decreased (about 40 ml/min/1.73 m^2).

This insensitivity to small to moderate decreases in GFR in the so called creatinine blind GFR area (40–70 ml/min/1.73 m^2)

Since there is no tubular secretion of Cystatin C, it is extremely sensitive to small changes in GFR in the earliest stages of CKD.

Advantages of Cystatin C

Unaffected by non-renal factors

Muscle Mass

Weight Height

Gender

Less inter-individual variation

than creatinine

Sensitive to changes in the so-called creatinine blind GFR(40–70 ml/ min/ 1.73m2).

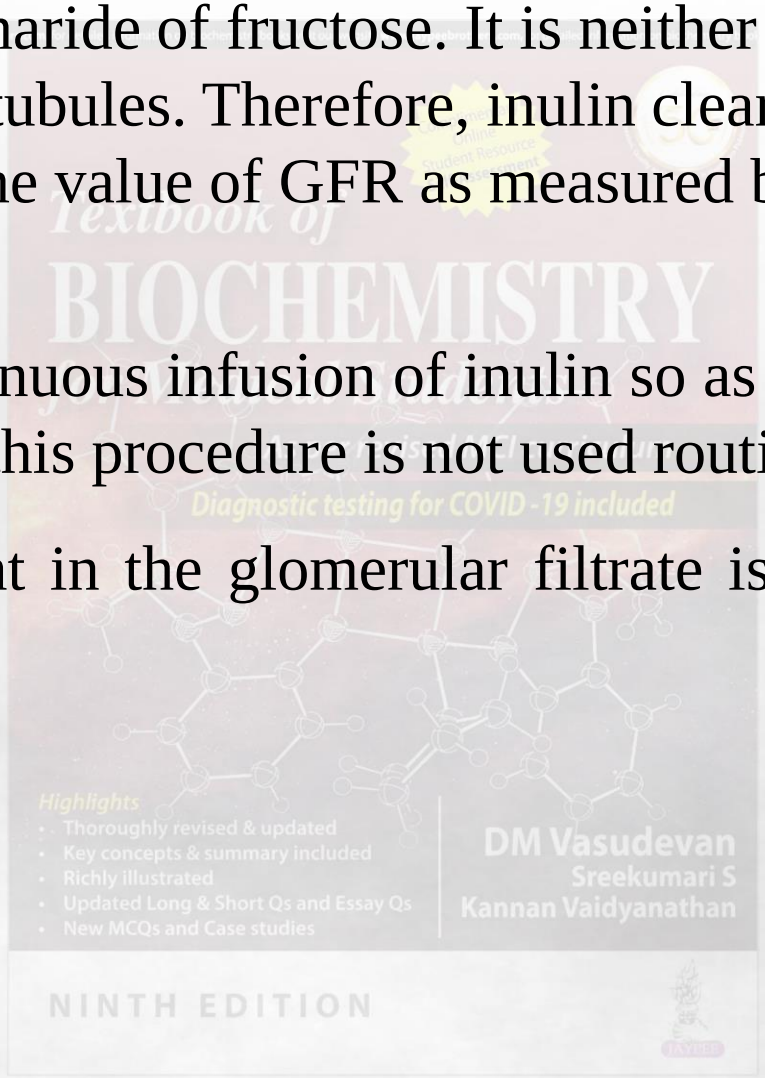
Enables early detection and treatment of CKD.

Inulin Clearance

Inulin is a polysaccharide of fructose. It is neither absorbed nor secreted by the tubules. Therefore, inulin clearance is a measure of GFR. The value of GFR as measured by inulin clearance is 125 mL/min.

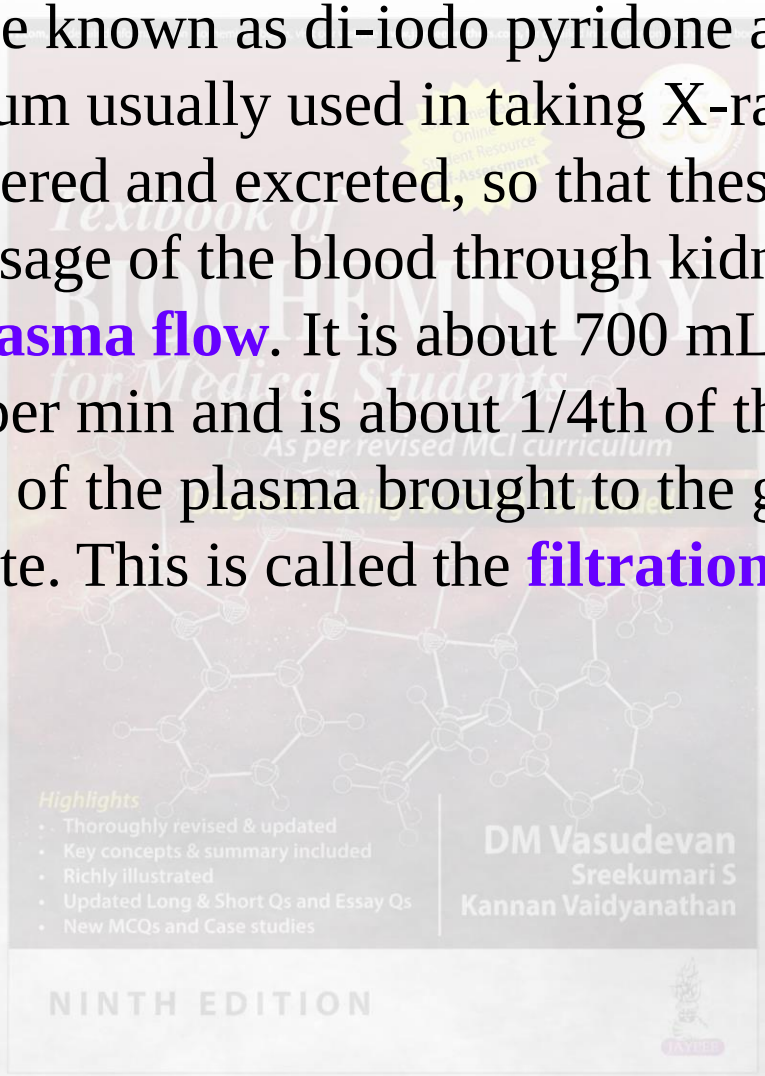
The test needs continuous infusion of inulin so as to keep the plasma level adequate. So, this procedure is not used routinely.

40% of urea present in the glomerular filtrate is reabsorbed in the tubules.



Diodrast Clearance

Diodrast is otherwise known as di-iodo pyridone acetic acid. It is a contrast medium usually used in taking X-ray of urinary tract. Diodrast is filtered and excreted, so that these substances are removed by one passage of the blood through kidney. It is a measure of **renal plasma flow**. It is about 700 mL of plasma or 1,200 mL of blood per min and is about 1/4th of the total cardiac output. About 1/5th of the plasma brought to the glomeruli becomes the glomerular filtrate. This is called the **filtration fraction.**

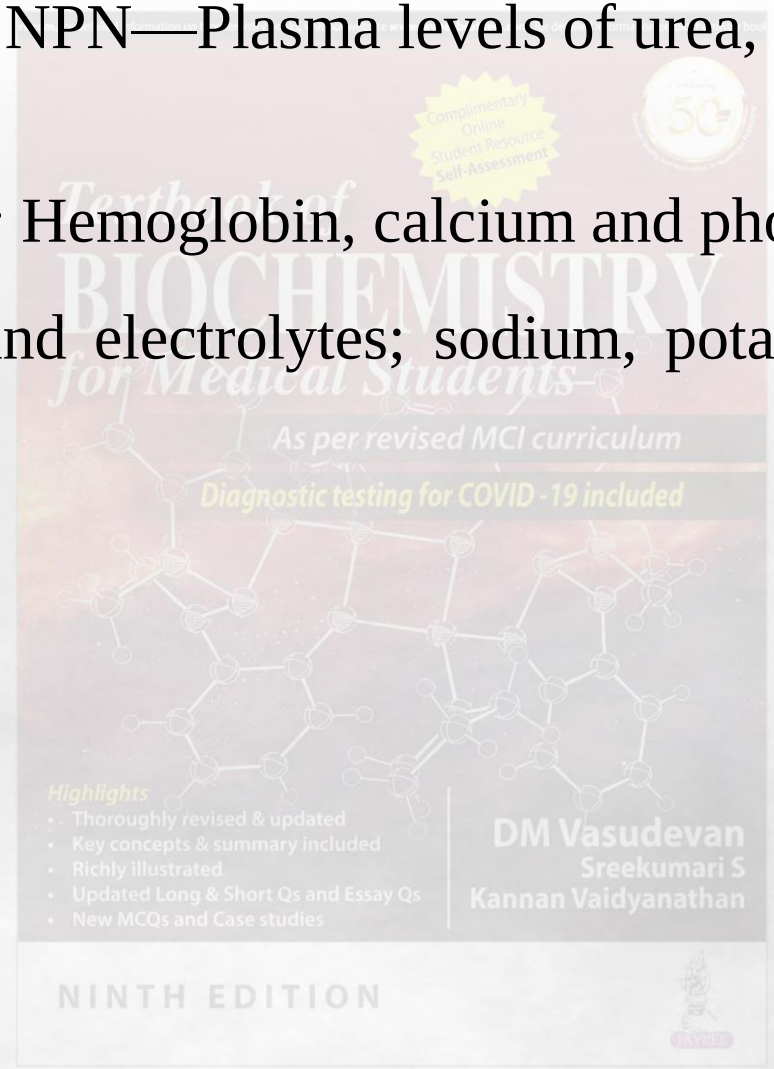


Parameters for Residual Renal Function

Excretory function: NPN—Plasma levels of urea, creatinine, uric acid

Endocrine function: Hemoglobin, calcium and phosphate

Homeostasis: pH and electrolytes; sodium, potassium, bicarbonate and chloride

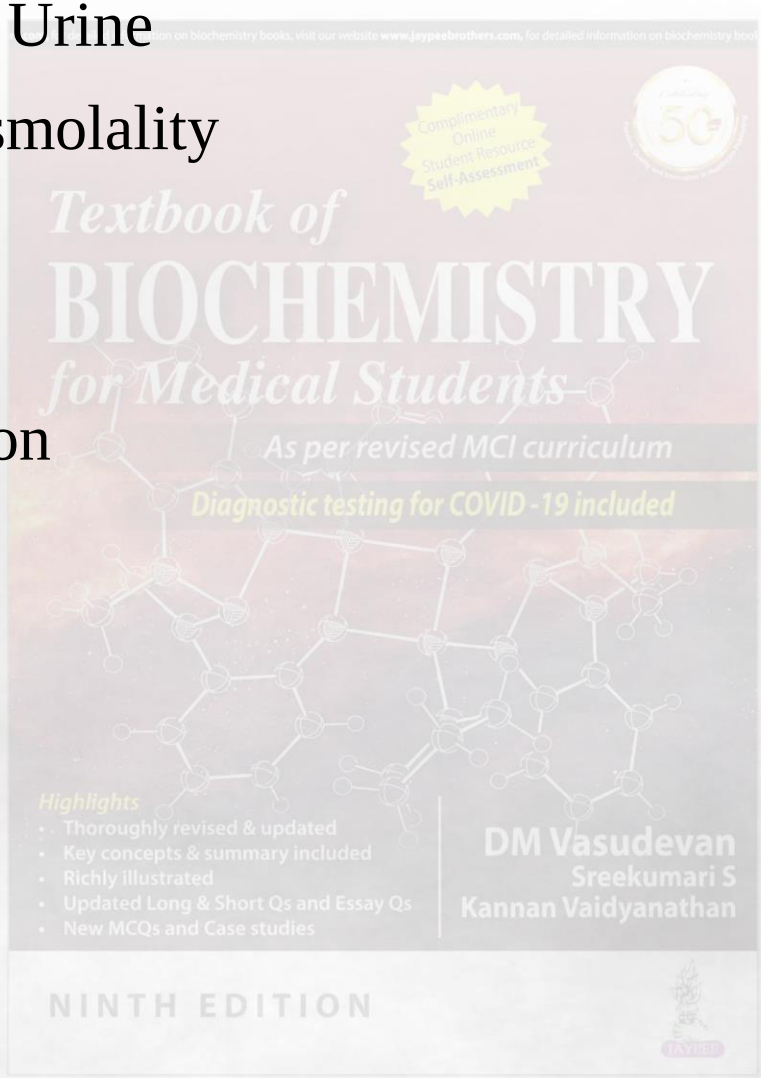


Indications for Quantitation of Proteinuria

1. Diagnosis of nephrotic syndrome: Nephrotic syndrome is a triad of edema, hypoalbuminemia and proteinuria > 3 gm/day. 24 hrs urine protein, creatinine clearance and sodium should be measured for planning appropriate treatment.
2. Prognosis of progressive renal disease: It is a marker for assessing the progressive loss of renal function in renal disease; diabetic nephropathy, chronic glomerulonephritis, reflux nephropathy. Treatments that reduce proteinuria (like anti-hypertensive drugs) decrease rate of progression.
3. Diagnosis of early diabetic nephropathy: Early stages of diabetic nephropathy are characterised by increase in GFR, micro-albuminuria and hypertension.

Tests for Tubular Function

- Specific Gravity of Urine
- Measurement of Osmolality
- Concentration Test
- Dilution Tests
- Urinary Acidification



Summary of Renal Function Tests

Glomerular dysfunction		Tubular dysfunction	
Serum urea	↑	Urine concentration	↓
Serum creatinine	↑	Dilution test abnormal	
Inulin clearance	↓	Uric acid excretion	↓
Creatinine clearance	↓	Blood uric acid	↑
Urea clearance	↓		
PAH clearance	↓	Acidification of urine	↓
Proteinuria present	↓	Amino aciduria present	
Urine volume	↓	Urine volume	↑
Specific gravity	↑	Specific gravity	↓
Serum phosphate	↑	Serum phosphate	↓