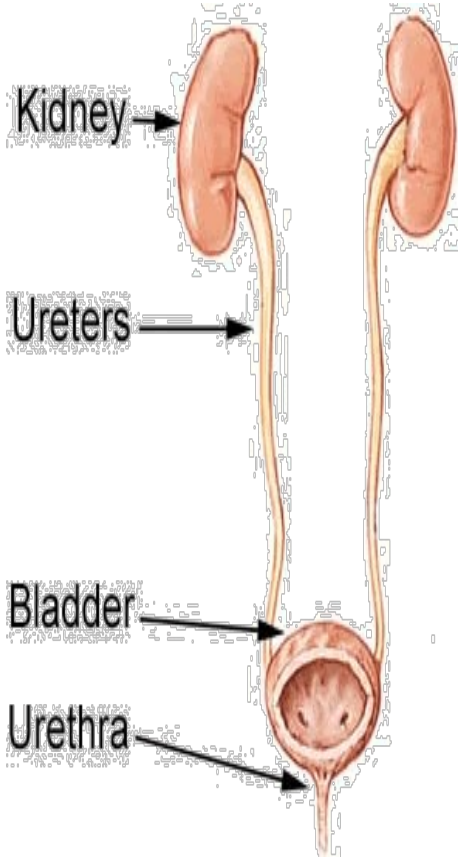
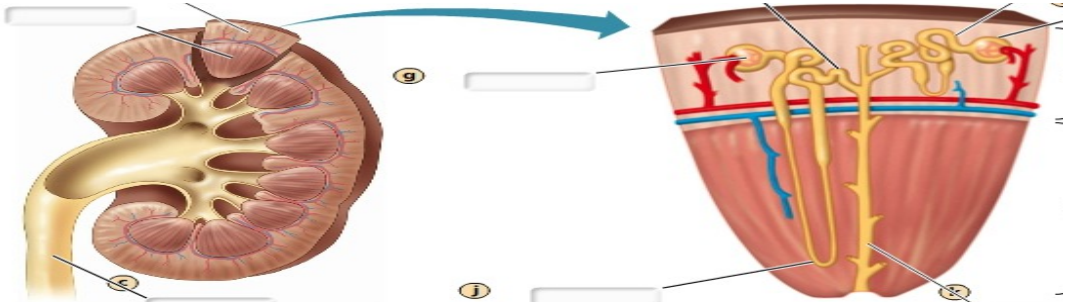
# Physical properties and detection of normal constituents of urine

# -Urinary system :

- The urinary system works with the lungs, skin and intestines to maintain the balance of chemicals and water in the body.
- The kidneys form urine, which passes through the ureters to the bladder for storage prior to excretion.
- Waste products are excreted selectively , electrolyte levels are controlled and pH (acid-base balance) is maintained by excretion of hydrogen ions .
- The composition of urine reflects **exchange** of substance between the nephron and blood in the renal capillaries.

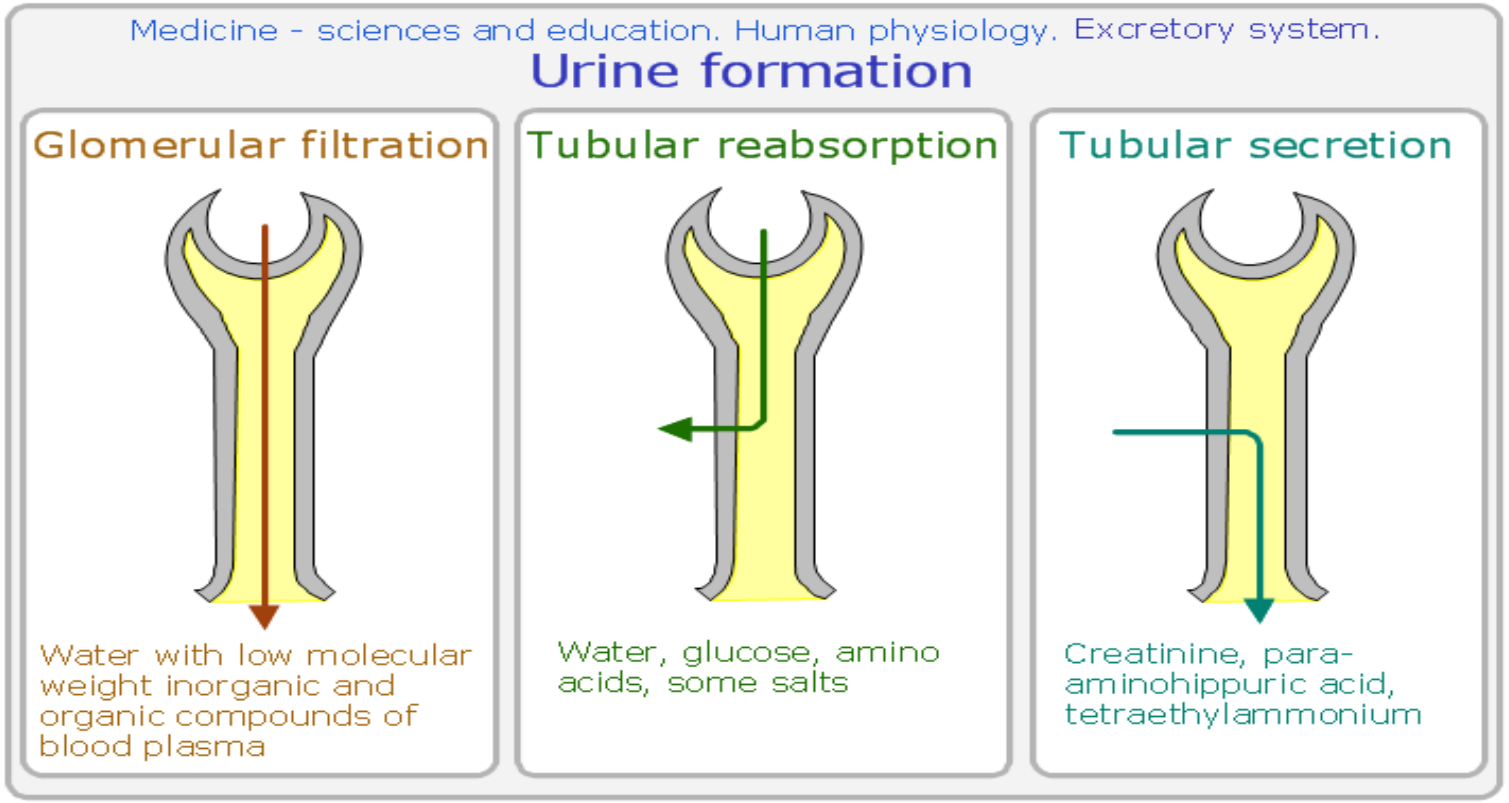


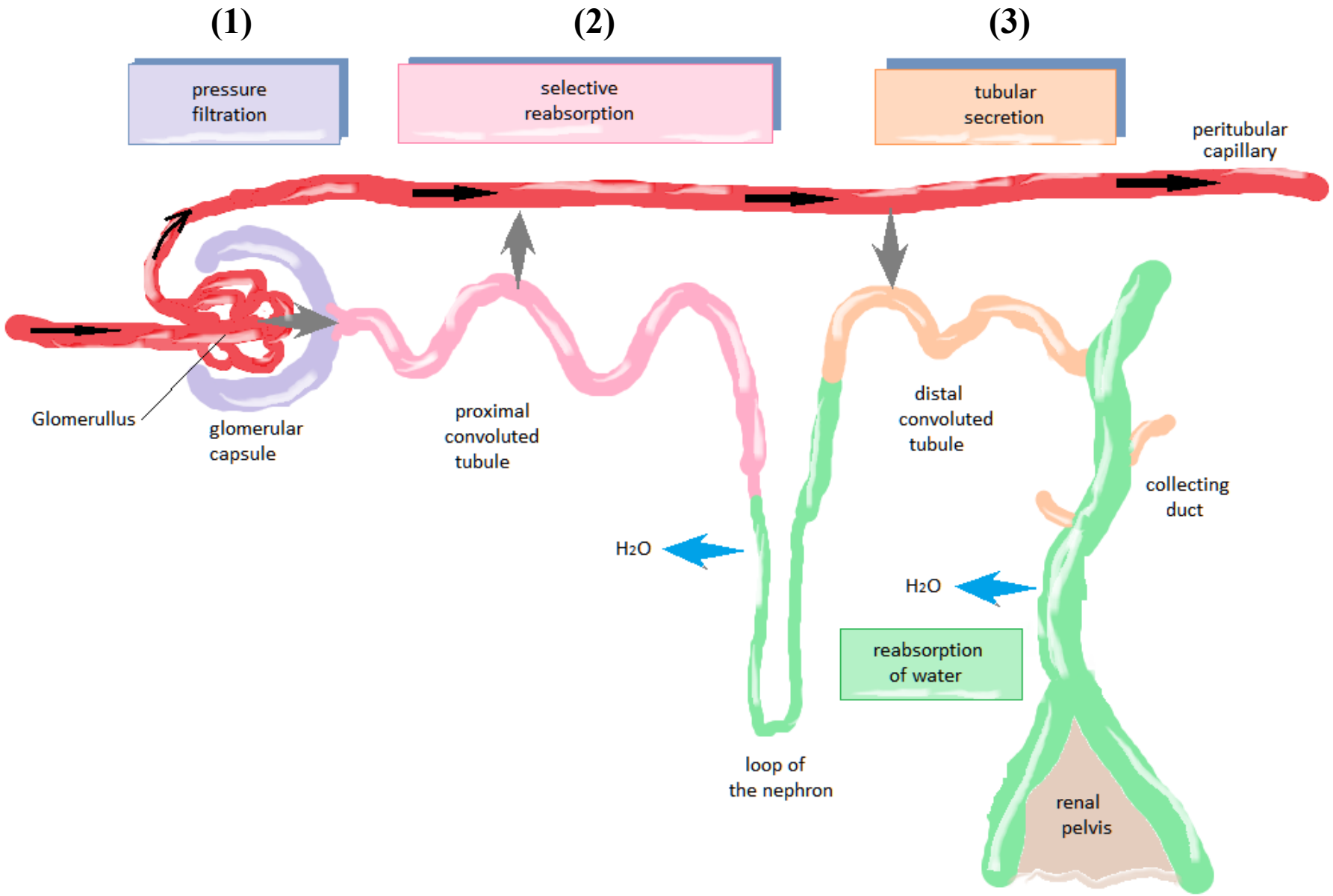
# -Urine Formation:

- There are three processes involved in the formation of urine:

1. Filtration.
2. Selective reabsorption.
3. Secretion.



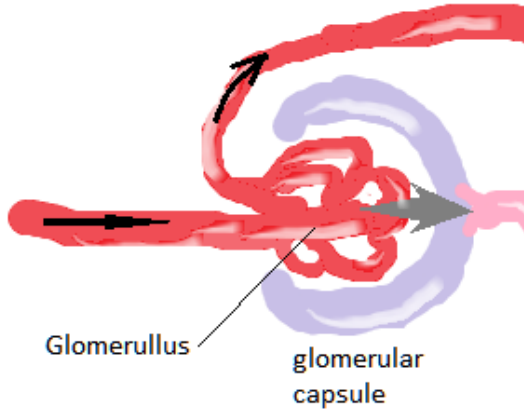
# The three processes of urine formation



# one: Filtration :

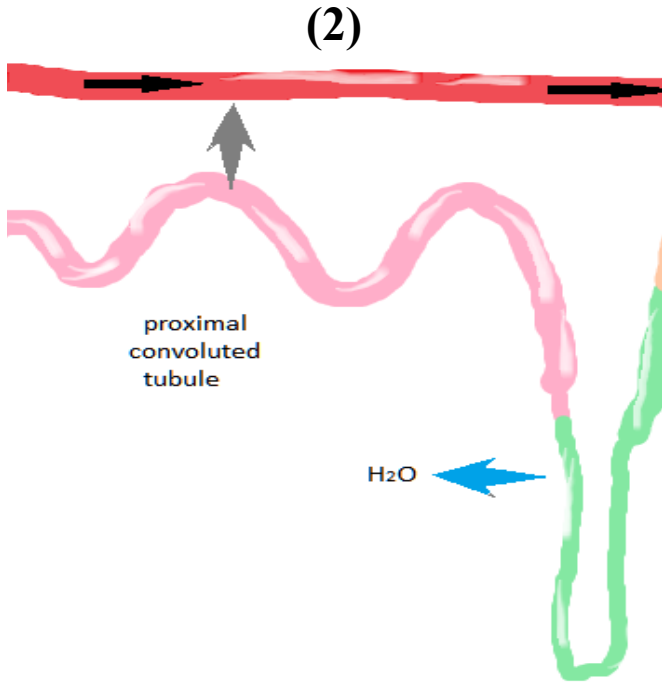
- This takes place through the semipermeable membrane of glomerulus and glomerular capsule (Bowman's capsule).
- Water and small molecules move from the glomerulus to the inside of the glomerular capsule.
- Molecules which have molecular weight **more than** 70,000 Dalton can not pass the glomerulus.
- Blood cells, plasma proteins and other large molecules are too large to filtrate (not filtrated).
- Inside the glomerular capsule now contains glomerular filtrate which is very similar in composition of plasma **except of plasma proteins and blood cells.**
- (Non-selective filtration occurs).

**(1)**



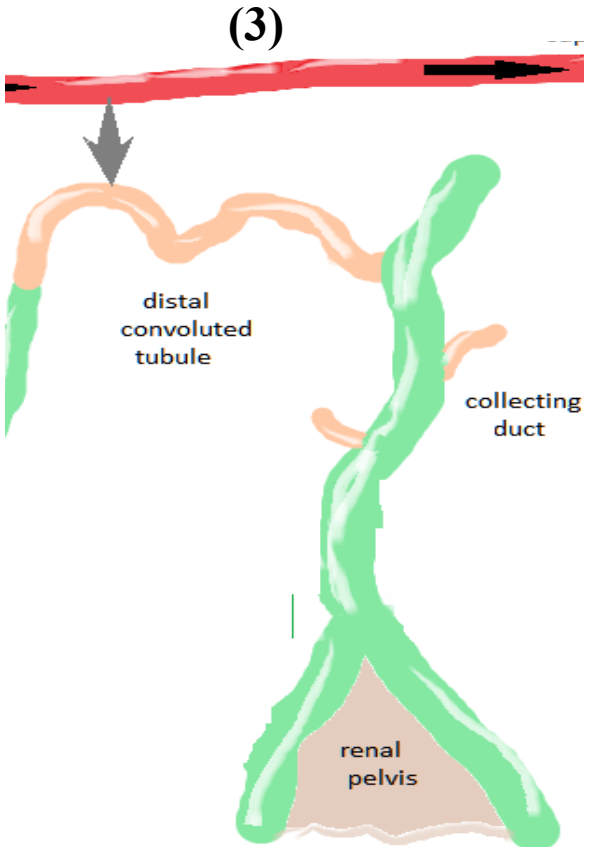
# two: Selective reabsorption:

- Is the process of restoration water and some solutes from the tubular fluid and returning them to the blood.
- **Reabsorption** is the movement of water and solutes from the tubule back into the blood.
- As molecules and ions are passively and actively reabsorbed from the nephron into the blood of the peritubular capillary network.
- Nutrients such as glucose and amino acids **return** to the peritubular capillaries almost exclusively at the proximal convoluted tubule.
- Every substance has a **maximum rate of transport.**



# three: Secretion:

- Is a second way by which substances are removed from blood and added to the tubular fluid.
- Is a process in which the renal tubule extracts chemicals from the capillary blood and secretes them into the **tubular fluid.**
- Hydrogen ions (H+), creatinine, and drugs such as penicillin are some of the substances moved by active transport from blood into the kidney tubule.
- Tubular secretion is now known to occur along the length of the kidney tubule.



- In the end, **urine contains :**

1-Substances that have undergone glomerular filtration (step one) but have not been reabsorbed (step two).

2-Substances that have undergone tubular secretion (step three).

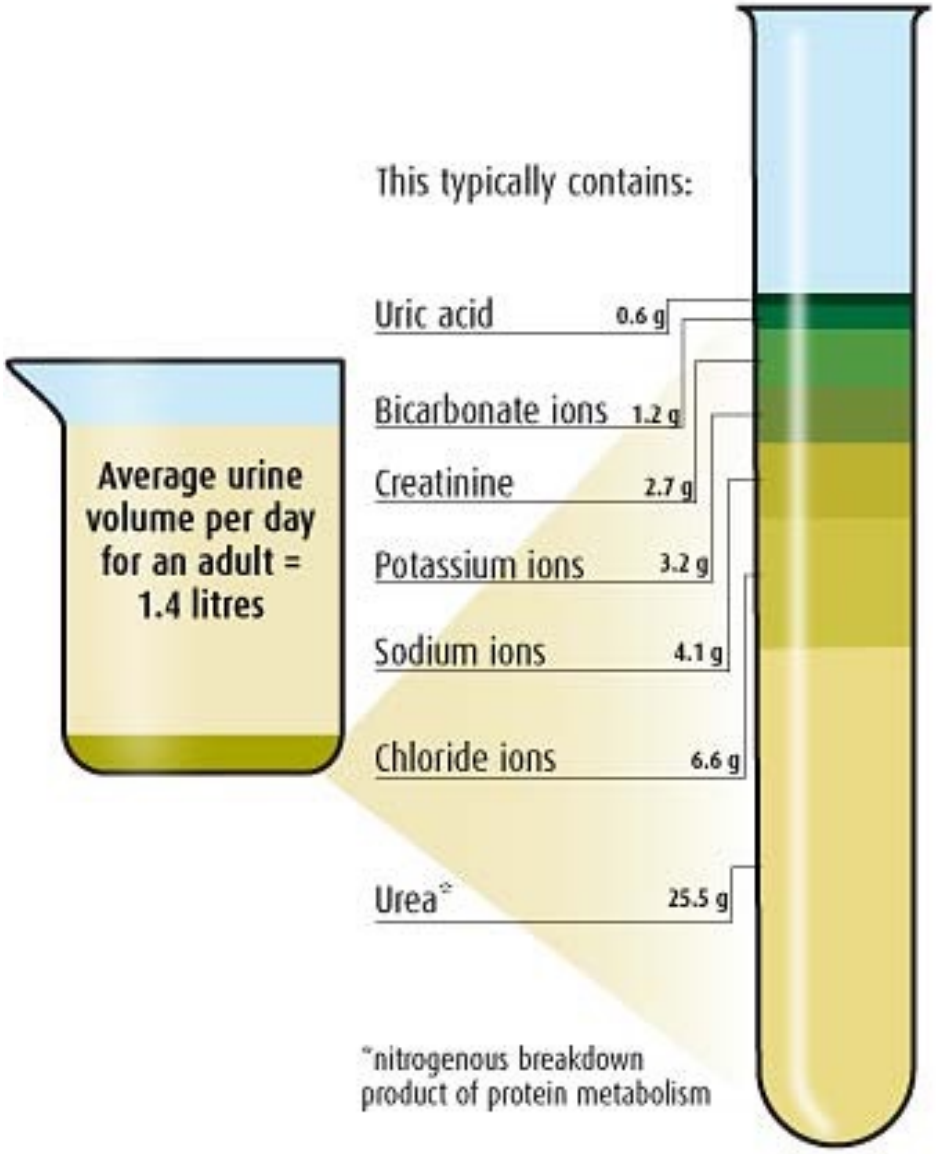
# Glomerular filtrate VS Urine

| Constituent | Daily Excretion | |
|---|---|---|
| | Glomerular Filtrate | Urine |
| Water | 130,000 ml | 1500 ml |
| Sodium | 20,000 mmol | 150 ml |
| Albumin | 4 g (60 µmol) | 0.04 g (6 µmol) |
| Urea | 900 mmol | 400 mmol |

# -Composition of Normal Urine:

- Water 96%
- Urea 2%
- Uric acid
- Creatinine
- Oxalate
- Ammonia
- Sodium
- Potassium
- Chloride
- Phosphate
- Sulphate

2%



# -Urinalysis:

- Urinalysis (UA) is one of the most frequently ordered tests.

- Two unique characteristics of urine specimens :

1- Urine is readily available and easily collected specimen.

2- Urine contains information about many of the body's major metabolic functions, and this information can be obtained by simple laboratory tests.

## -Laboratory testing for routine urinalysis (types of testing):

- First, the **physical characteristics** of the urine are noted and recorded .
- Second , a series of **chemical tests** is run . A chemically impregnated dipstick can be used for many of these tests.
- Third, the urine sediment is examined under **microscopic** to identify components.

Patient Name:_____

Age:_____ ❑ M ❑ F

Physician's Name:_____

Collection Date:_____ Test Date:_____ Tester's Initials:_____

**Physical Characteristics:**

Color: ❑ colorless ❑ yellow ❑ amber ❑ other ❑ orange ❑ green ❑ red

Appearance: ❑ clear ❑ hazy ❑ cloudy ❑ turbid

**Chemical Measurements:** (circle one)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| urobilinogen (mg/dL) | normal | 2 | 4 | 8 | | | |
| glucose (mg/dL) | neg | 50 | 100 | 250 | 500 | 1000 | |
| ketone (mg/dL) | neg | trace/5 | +/15 | ++/40 | +++/80 | ++++/160 | |
| bilirubin | neg | | + | ++ | +++ | | |
| protein (mg/dL) | neg | trace | | +/30 | ++/100 | +++/300 | ++++/2000 |
| nitrite | neg | pos (any pink color is considered positive) | | | | | |
| leukocytes | neg | trace | + | ++ | +++ | | |
| blood | neg | trace | moderate | trace | +/small | ++/mod | +++/large |
| | | Non-Hemolyzed | | Hemolyzed | | | |
| pH | 5 | 6 | 6.5 | 7 | 8 | 9 | |
| specific gravity | 1.000 | 1.005 | 1.010 | 1.015 | 1.020 | 1.025 | 1.030 |

**Microscopic Examination:**

WBC_____/HPF Crystals_____ Parasites_____

RBC_____/HPF Bacteria_____ Spermatozoa_____

Casts_____/LPF Yeast_____ Artifacts_____

Epithelial Cells_____/HPF Other_____

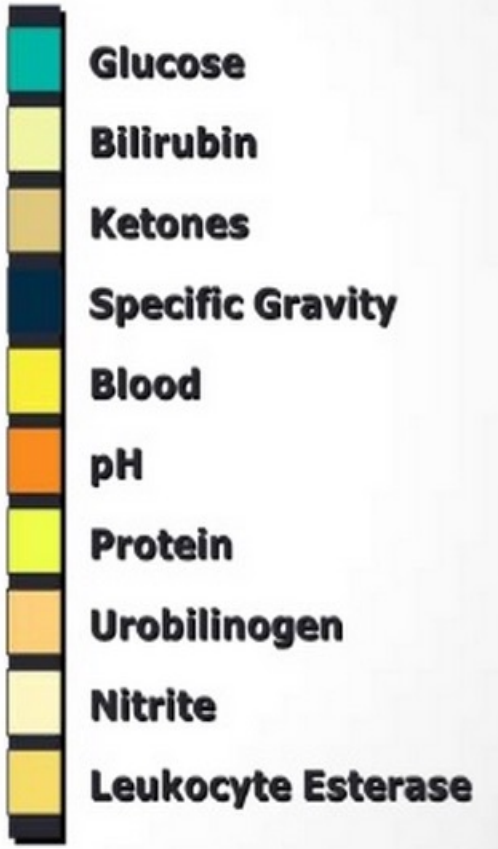
Physical characteristics

Chemical tests

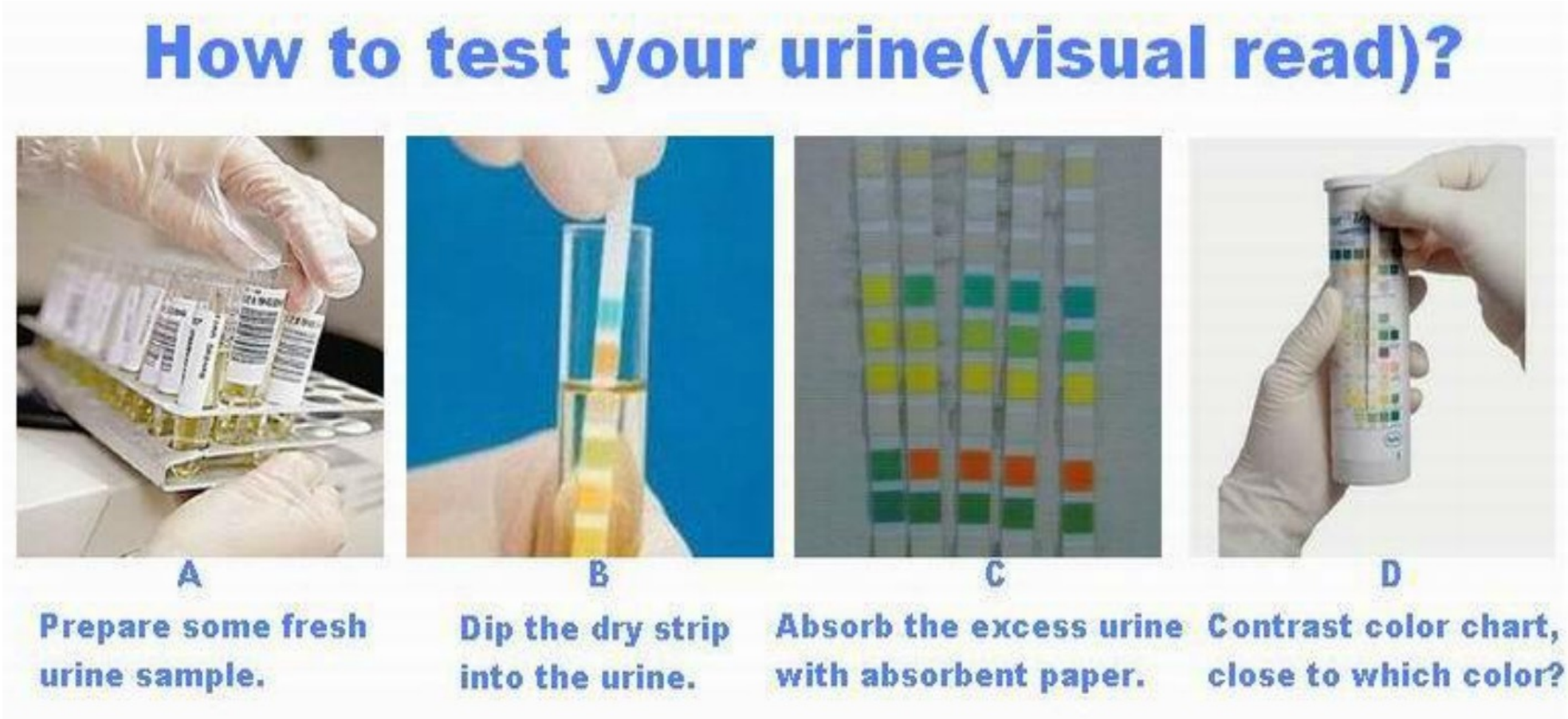
Microscopic examination

# Urine dipstick / Urine test strips:

- The test strips consist of a ribbon made of absorbent microfiber cellulose pads attached to it.
- Each pad contains the dried **reagents** needed for a **specific test** that react with the compounds present in urine producing a characteristic colour.
- The depth of color produced relates to the concentration of the substance in the urine.
- It provides quick **Semi-quantitative determinations** of pH, protein, glucose, ketones, bilirubin, hemoglobin (blood), nitrite, leukocyte , urobilinogen, and specific gravity.
- Color changes then matched to the control chart at the correct time after each stick is dipped into the urine specimen.



# Urine dipstick / Urine test strips




How to use urine test strips : https://youtu.be/g_4PiTezF6s

# Simple Examination of the Urine

## Physical Examination

Volume, Specific gravity, Color, Appearance, odor, pH

## Chemical Examination

### Organic

Uric acid, Creatinine

### Inorganic

Chloride, Phosphate, Bicarbonate, Sulphate, ammonia.

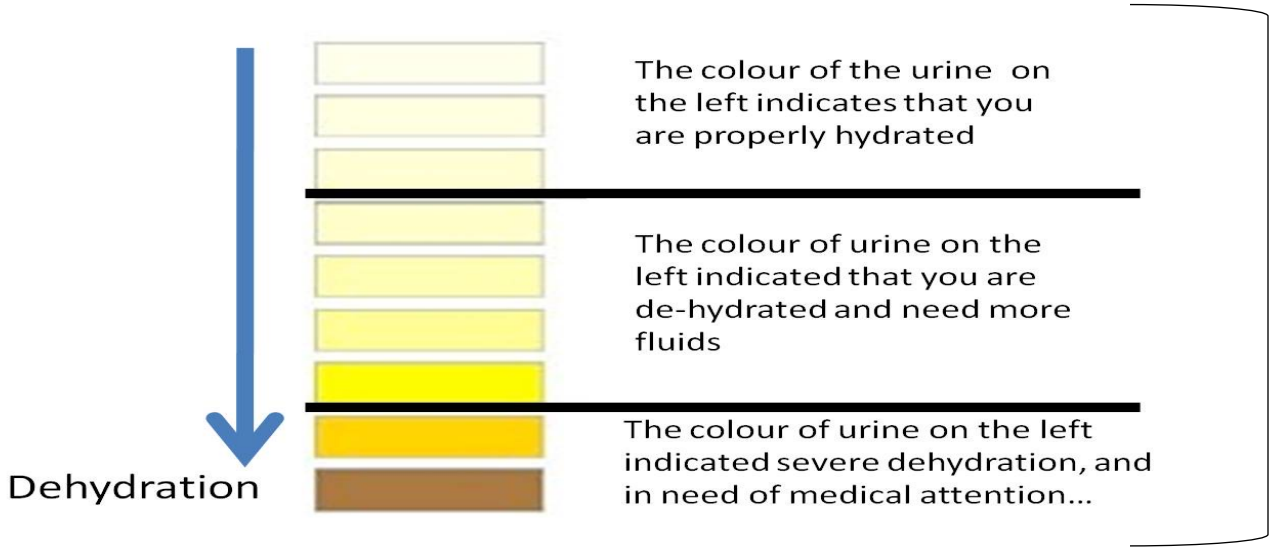
# Physical Examinations:
# 1- Volume:

- The daily output of urine on an average diet and normal fluid intake is between 800-2500 ml with an average of 1500 ml/day.
- Effected by : 1) Physiological factors. 2) Pathological factors.

| Polyuria | Oliguria | Anuria |
|---|---|---|
| • More than 2500 ml/day.<br>• Diabetes mellitus.<br>• Chronic renal insufficiency. | • Below 500 ml /day.<br>• In case of deficient intake of water or excessive loss of fluids by other routs like hemorrhage or as diarrhea and vomiting. | • Below 100 ml /day.<br>• Stones or tumors in the urinary tract can also cause it by creating an obstruction to urinary flow. |

# 2- Colour :

- Normally, Urine is amber in color due to the presence of urobilin (urochrome).
- Pale urine has a **low** specific gravity, a dark line has a **high** specific gravity ( a **direct relationship** between the colour and the specific gravity).
- **Coloured urines** occur in certain diseases or metabolic disorders, and after the administration of many drugs.




The more that your body is dehydrated , the more the urine is dark

# Change in the color or odour is a warning sign!

**Pale yellow or clear**
- healthy and hydrated

**Bright yellow**
- an excess of B vitamins

**Red**
- blood in urine
- eating beetroot or blackberries

**Purple**
- porphyria, a rare metabolic disorder

**Brown**
- certain antipsychotic drugs
- certain antibiotics
- phenytoin (Dilantin)
- sennoside laxatives

**Green**
- drugs containing phenol
- some antidepressants
- dyes in food
- biliverdin, a bile pigment
- certain infections

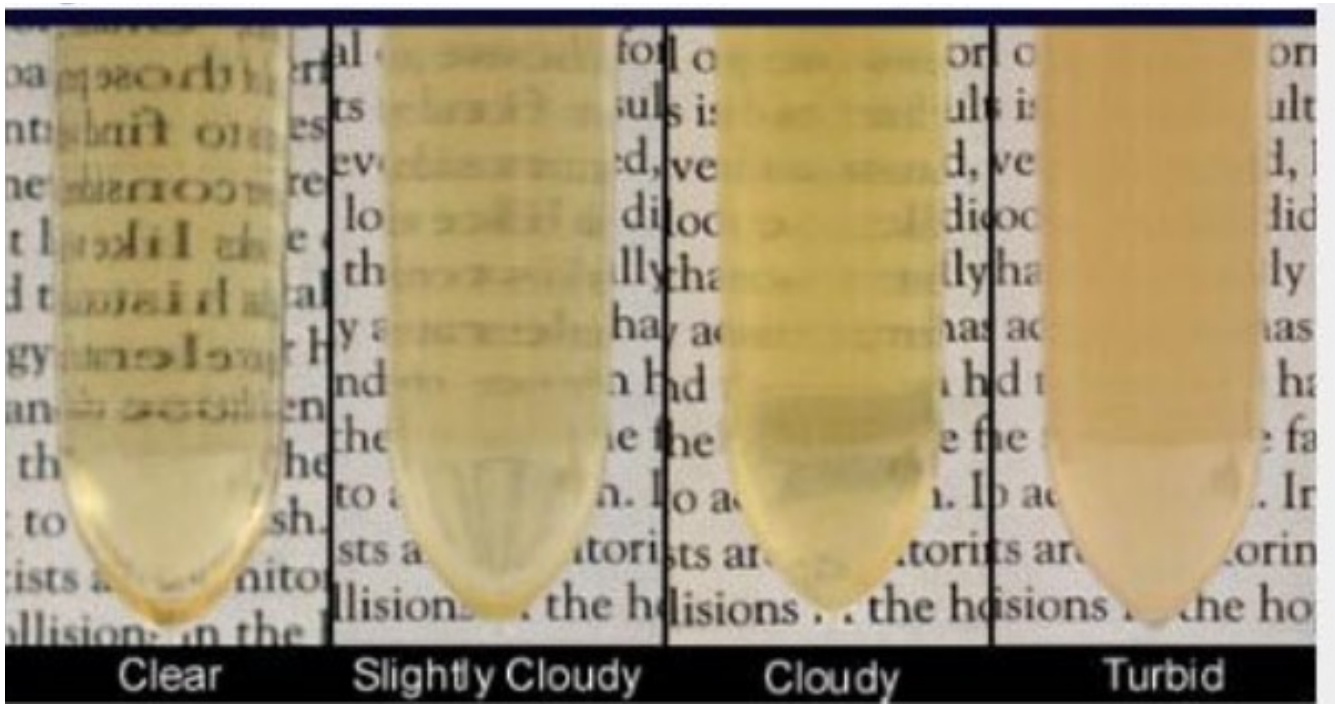
**Orange**
- dehydration
- certain drugs and medications
- dietary factors, such as eating lots of carrots

# 3- Appearance :

- Normal urine is clear.

- **Urine clarity is typically classified as:** clear, mildly cloudy, cloudy, or turbid.

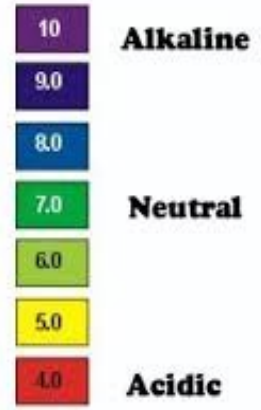
➔**Note:** cloudy or turbid urine can indicate dehydration, urinary tract infection or presence of RBCs, WBCs, epithelial cells or bacteria.



# 4- Odour:

- Normally Urine smells **aromatic** due to the presence of volatile organic acids.
- The urine of patients with diabetes ketoacidosis may have a fruity (acetone) odor **because of ketosis**.
- Urine which is infected with Gram-negative organisms often has a distinctive unpleasant smell (fish-like odour).
- Certain drugs impart a typical odour.

# 5- pH:



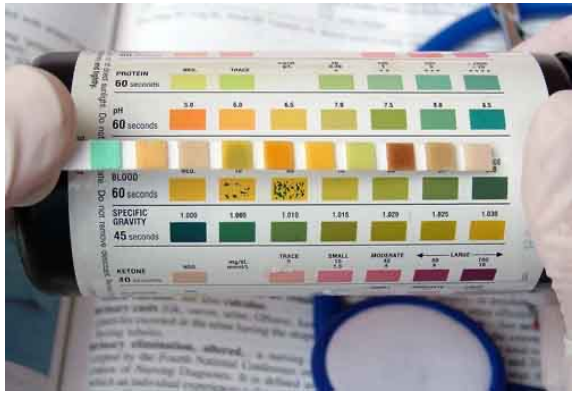

- On a normal mixed diet the urine is **usually acid**, generally varying in pH between **5.5 and 8.0**, with a **mean of 6 in 24 hours.**

**- Acidic Urine :**

- Diabetic ketosis, urinary tract infection, diarrheal and starvation.

**- Alkaline Urine:**

- A vegetarian diet which causes a tendency to alkalosis.
- It may also be grossly increased by bacterial infection of the urinary tract.



# 6- Specific gravity (SG):

- The normal specific gravity (correctly called relative density) of a pooled 24 hour urine sample is between **1.010 and 1.025.**
- There are **direct relationship** between concentration of substance in urine (concentration of urine) and SG.

➔The concentration of urine is highest in the a morning specimen (overnight urine) and is lowest in a specimen passed an hour after much fluid has been taken.

# Practical Part

# -Objectives:

1. Simple physical examination of urine.
2. To detect some of the normal organic constituents of urine (Qualitative) .
3. To detect some of the normal inorganic ions present in urine (Qualitative) .

- **Note:**

All the examination in 24 hour collection of urine.

# Physical Examinations:

## method:

### 1- Volume:

-Measure the volume of the 24 hour collection of normal urine.

### 2- Odour:

- State whether it is normal urine like ammonical, or not.

### 3- Colour:

- Visually examine its colour.

### 4- Appearance:

- State whether it is clear, cloudy or whether deposits or precipitates are present.

### 5- pH:

- Record the pH of the sample by test strips.

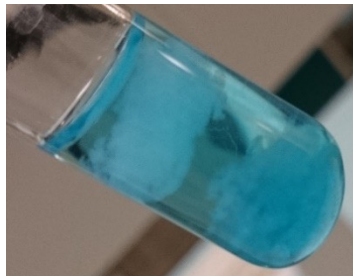
### 6- Specific gravity:

- Record the specific gravity of the sample by test strips

# Chemical Examinations:

**Principle:** Each test based on the chemical properties of the substance + test strip.

## 1- Organic:



### A. Uric acid:

- Uric acid is the end product of purine metabolism.

-Method:

1. To 2 ml of urine add 1 ml of Bendect reagen.
2. Then heated in a boiling water bath for three minutes .
3. Changes to the white precipitate indicates the presence of uric acid.

### B. Creatinine:

-Method:

1. To about 5 ml of urine add a few drops of a saturated solution of picric acid.
2. On rendering the solution alkaline with a few drops of 10% sodium hydroxide solution, a deep red color or orange due to creatinine picrate appears.
3. On acidification, with 2N HCl, the color changes to yellow.

# Chemical Examinations cont':
# 1- Inorganic:

**A. Chloride:**

-Method:

Add 5 ml of Urine +5 drops of 2N nitric acid+ 2N silver nitrate solution

➔A white precipitate of **silver chloride** is formed (Silver chloride is precipitated in the presence of nitric acid and silver nitrate).

**B. Phosphate:**

-Method:

Add 5 ml of urine +5ml nitric acid+4 ml of ammonium molybdate, then heat in water bath.

➔ A yellow crystalline precipitate of **ammonium phospho-molybdate** appears.

**C. Bicarbonate:**

-Method:

Add 4 drops of concentrate hydrochloric +5 ml of urine.

➔ A slight effervescence occurs due to **$CO_2$ evolution**. Test the gas evolved with lime water.

**D. Sulphate:**

-Method:

To Acidify add 10 ml of urine with 1ml dilute hydrochloric acid + 4 drops of 5% barium chloride solution

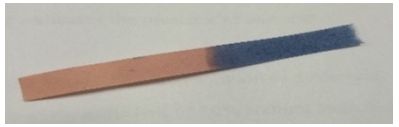
➔ A white precipitate sulphate is precipitated as of **barium sulphate** is formed.

**E. Ammonia:**

-Method:

Add 1 ml of 10% sodium hydroxide solution +5 ml or urine, then heat in water bath.

➔ The evolved **ammonia** may be detected its occur in confirmed by turning the moist red litmus paper to blue.



# Summery:

| Physical examination | |
|---|---|
| The normal constituent of 24 hour urine | |
| **Volume** | 800-2500 ml with an average of 1500 ml |
| **Color** | Amber in color |
| **Appearance** | Clear |
| **Odour** | Urine like |
| **pH** | 5.5 - 8.0, with a mean of 6 |
| **Specific gravity** | 1.010 - 1.025 |
| **Chemical examination** | |
| Chemical | Positive result |
| **Uric acid** | White precipitate |
| **Creatinine** | Deep orange color |
| **Chloride** | White precipitate |
| **Phosphate** | Yellow precipitate |
| **Bicarbonate** | $CO_2$ bubble appeared |
| **Sulphate** | White precipitate |
| **Ammonia** | Litmus paper turns to blue |