# PHYSICAL PROPERTIES AND DETECTION OF NORMAL CONSTITUENTS OF URINE

# Urinary system:

- The **kidneys**, **ureters**, **bladder** and **urethra** make up the urinary system
- 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

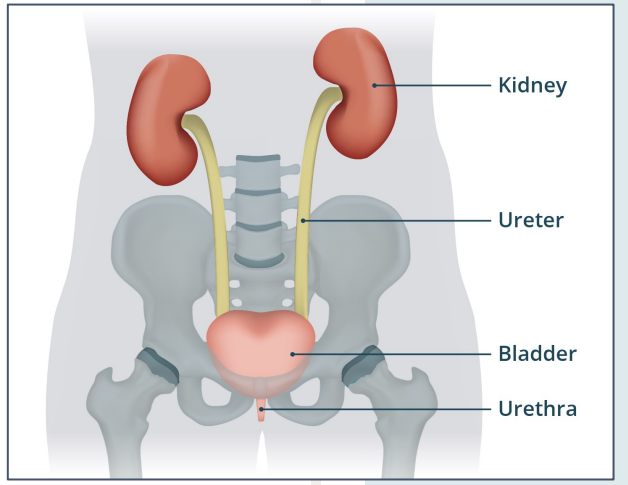



Figure 1. urinary system

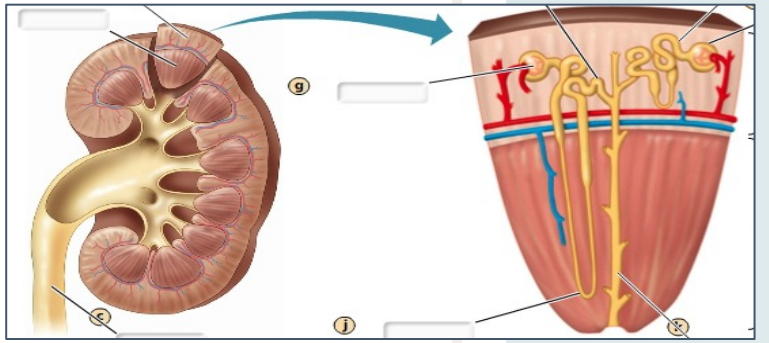


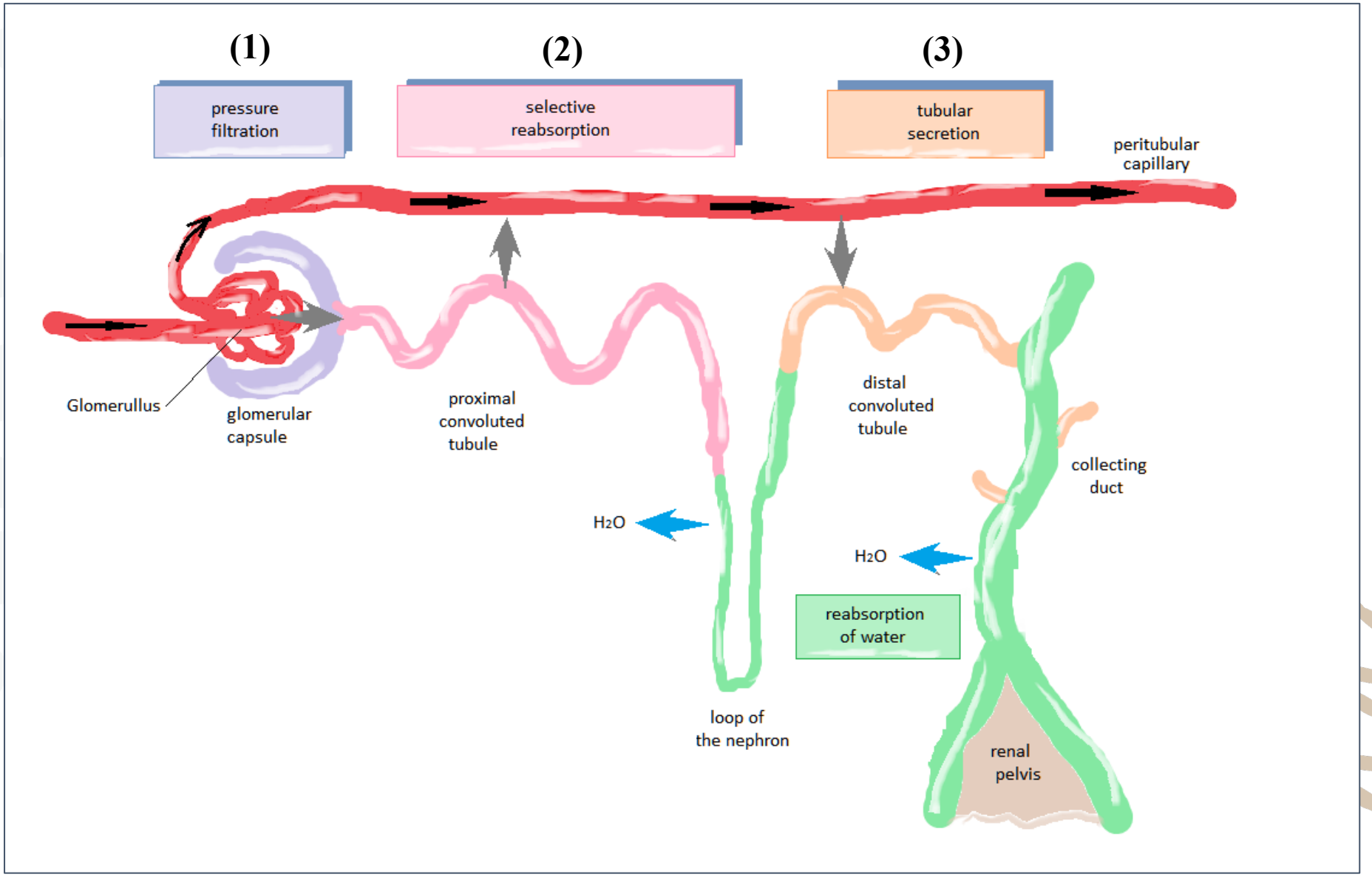
Figure 2. nephron structure

# 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



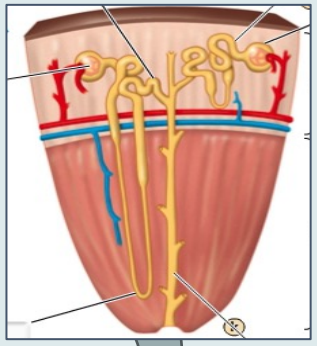



Figure 3. schematic representation of urine formation processes

# Step 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)**

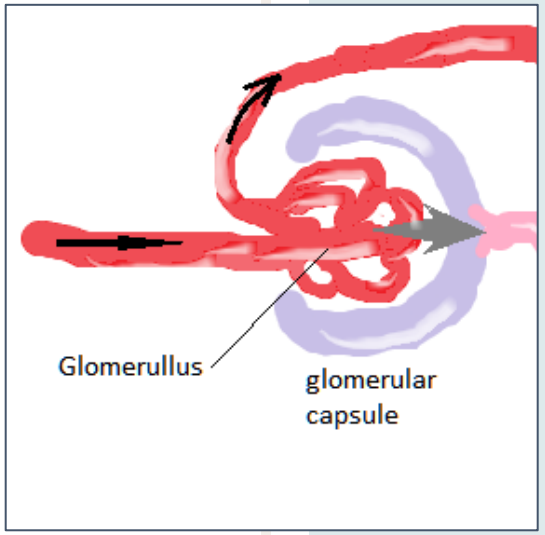



Figure 4. Filtration

# Step 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.
- Nutrients such as glucose and amino acids **return** to the peritubular capillaries almost exclusively at the proximal convoluted tubule.

💡Why is this step referred to as a selective reabsorption?

**(2)**

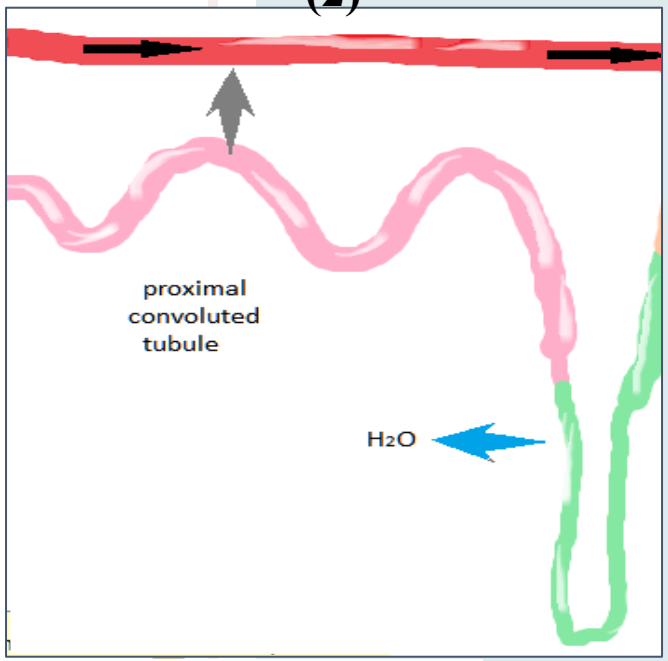



Figure 5. Selective reabsorption

# Step 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.

**(3)**

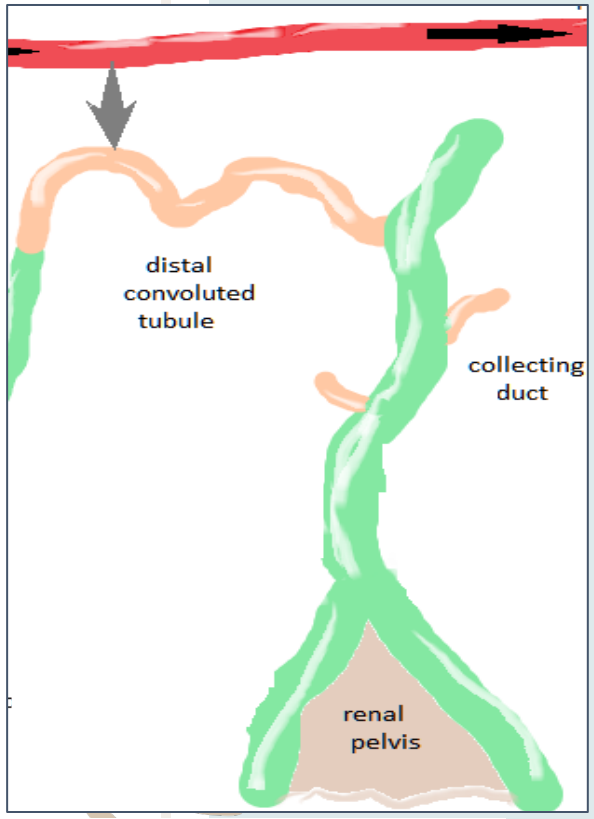



Figure 6. Secretion

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%

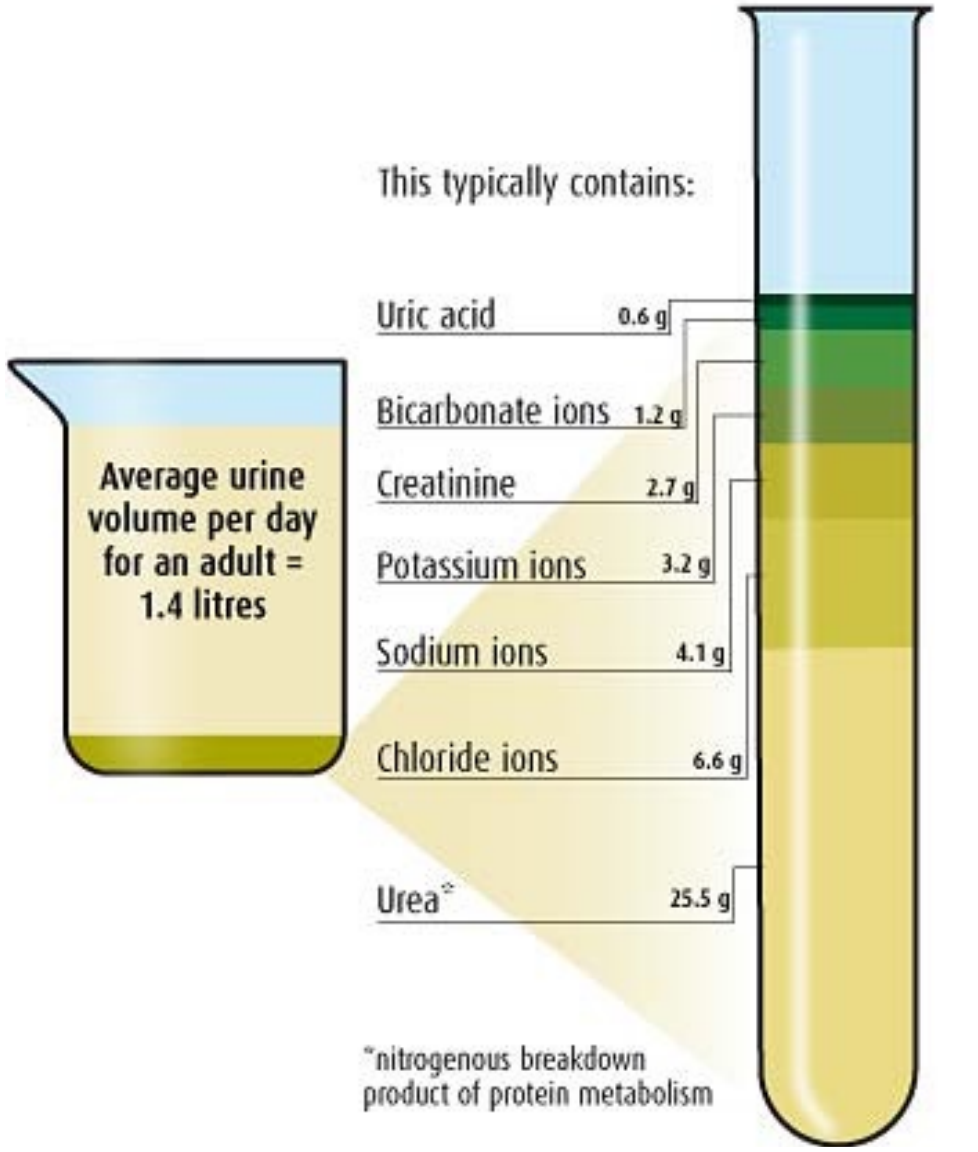



Figure 7. Composition of Normal Urine

# 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

Figure 8. Urine Analysis Report

# 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.

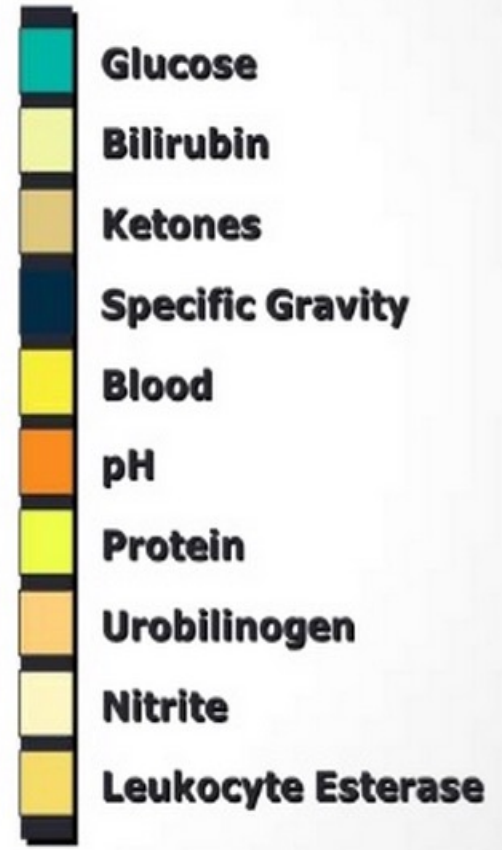



Figure 9. Urine dipstick

# Urine dipstick / Urine test strips:

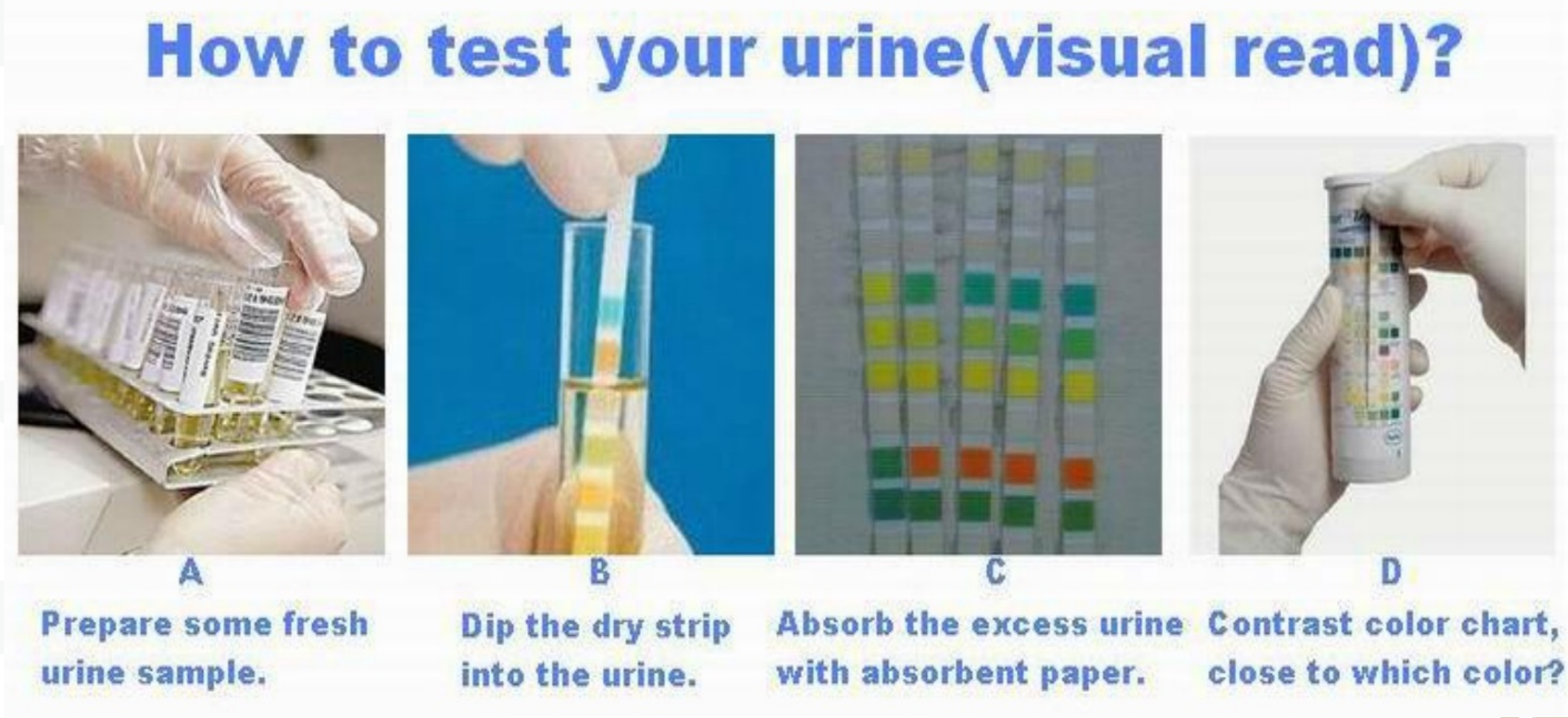



Figure 10. Urine dipstick usage guide

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<br>• 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. |

# Physical Examinations:

## 2. Color

- 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

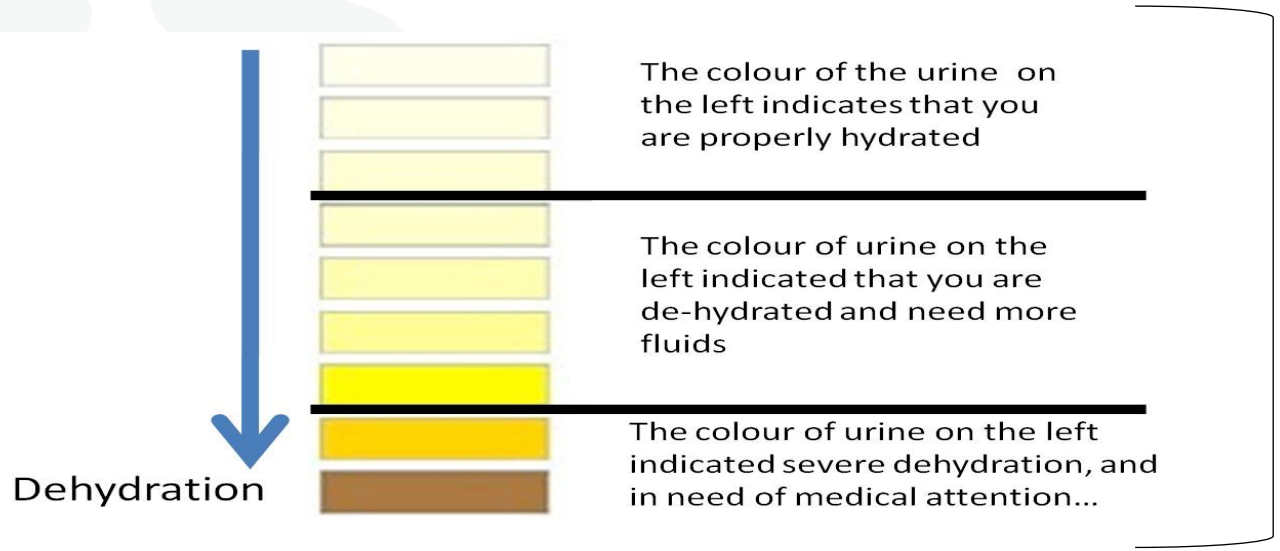



Figure 11. Urine color chart

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


Figure 12. Urine color chart

# Physical Examinations:

**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.

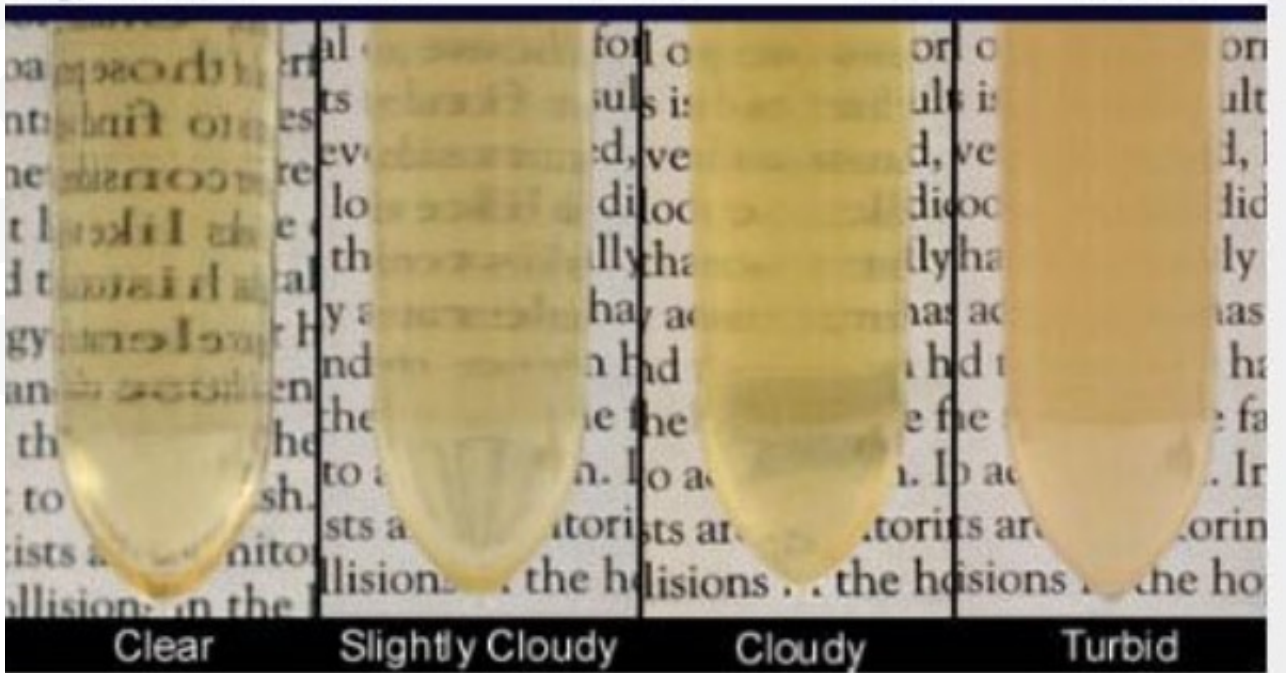



Figure 13. Urine Turbidity Scale

# Physical Examinations:

## 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) odour **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, diarrhea 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.

# Physical Examinations:

## 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**.

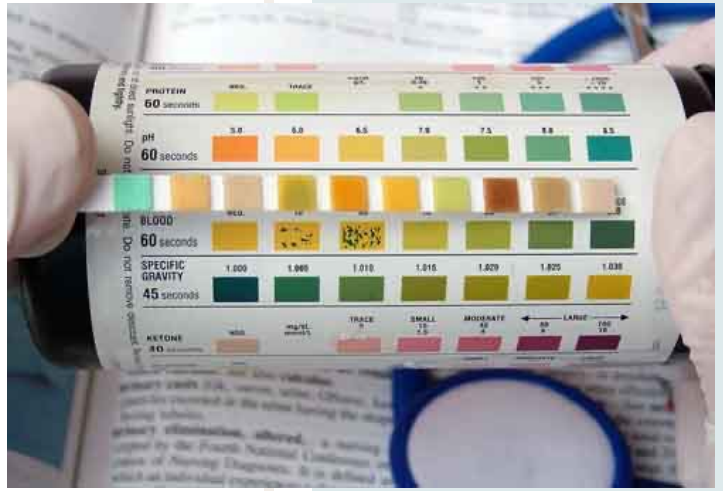



Figure 14. Urine dipstick analysis

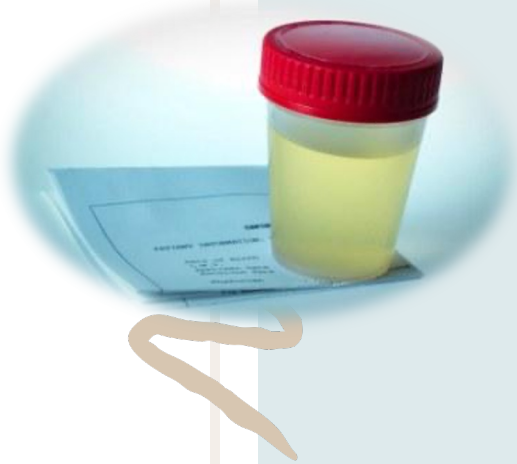
# Practical Part

# 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:

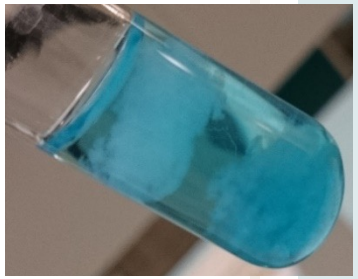
**Principle:** Each test based on the chemical properties of the substance.

**1- Organic:**

**A. Uric acid:**

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:

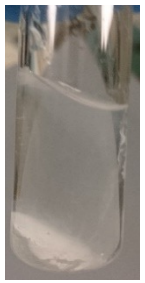
**2- Inorganic**

**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.

# Chemical Examinations:

**2- Inorganic**

**D. Sulphate:**

-Method:

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

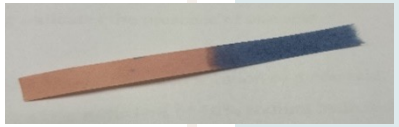
➔ A white precipitate sulphate is precipitated as of **barium sulphate** is formed.

**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 |