Medical Laboratory services-III

LEARNING GUIDE#49

Unit of Competence:-Performing Urinalysis and body fluid analysis

Module Title: - **Performing Urinalysis and body fluid analysis**

LG Code: - HLT MLT3 M10LO1-LG49

TTLM Code:-HLT MLT3 M10 0919v1

LO1. Identify concepts of urinalysis

	Learning guide #49	**Unit**	Performing Urine and Body Fluid analysis
		Module	Performing Urine and Body Fluid analysis

Welcome to the module "Performing Urine and Body Fluid analysis". This learner's guide was prepared to help you achieve the required competence in "**Medical laboratory services Level-III** This will be the source of information for you to acquire knowledge and skills in this particular occupation with minimum supervision or help from your trainer.

Summary of Learning Outcomes

After completing this learning guide, you should be able to:

LO1. Identify concepts of urinalysis

1.1. Anatomy and physiology of urinary system.

1.2. Metabolic products in urine

1.3. Testing methodology of urinalysis.

Learning-instructions

1. Read the contents of this Learning Guide. It is divided into sections that cover all the skills and knowledge that you need.
2. Read the information written in the "Information Sheet #1, #2, and # 3".
3. Accomplish the "Self-check #1on page 15 &16, #2 on page 20, and #3 on page 23
4. If you earned a satisfactory evaluation on self-check proceed to next learning Guide. However, if your rating is unsatisfactory, see your teacher for further instructions.
5. Read the "Operation Sheet" and try to understand the procedures discussed.
6. Practice the steps or procedures as illustrated in the operation sheet. Go to your teacher if you need clarification or you want answers to your questions or you need assistance in understanding a particular step or procedures

Instruction Sheet #1	Learning Guide #49

This learning guide is developed to provide you the necessary information regarding the

Following content coverage and topics –

LO1. Identify concepts of urinalysis

- Concept of renal physiology and anatomy are identified
- Metabolic products in urine are identified
- Testing methodology of urinalysis is identified

Learning Activities

1. Read the information written in the “Information Sheets”.
2. If you earned a satisfactory evaluation proceed to next module. However, if your rating is unsatisfactory, see your teacher for further instructions.
3. Read the “Operation Sheet” and try to understand the procedures discussed.
4. Practice the steps or procedures as illustrated in the operation sheet. Go to your teacher if you need clarification or you want answers to your questions or you need assistance in understanding a particular step or procedure

	Information sheet # 1	Learning Guide#49	Identify concepts of urinalysis
		Topic	Anatomy and physiology of urinary system.

1.1. Introduction to Basic Concepts in Urinalysis

Introduction: Dear trainees, this learning guide tries to explain to you that the basic concept and principles of Urine formation and urine analysis, starting from anatomy and physiology of kidney up to the renal Clearance and threshold analysis.

Objectives: At the end of this learning guide you will be able to:

- Describe anatomy of the kidney.
- Explain the physiology of the kidney and formation of urine.
- List composition of urine.
- Identify factors affecting composition of urine.
- Discuss clinical significance of urine analysis.
- Describe renal clearance and renal threshold.

Urinalysis

Urinalysis is a group of tests performed most frequently on random specimen. It is one of the most helpful indicators of health and disease.

Uses:

□□It is useful as a screening test for the detection of various endocrine or metabolic abnormalities.

□□It is also used to detect intrinsic conditions that may adversely affect the kidneys or urinary tract.

□□Generally, urinalysis provides useful information concerning the presence or absence of renal and other diseases.

- It is a very simple method for monitoring the course of a disease as well as the efficacy of treatment

1.1.1. Urinary system

The urinary system is also called the excretory system of the body because one of its functions is to remove waste products from the blood and eliminate them from the body.

- Composed of two kidneys, two ureters, one bladder and one urethra.
- The two human kidneys are the main structural part of urinary system, responsible for the formation of urine.
- Each kidney contains about a million filter units, called nephrons, designed for the synthesis of urine in our body.
- The urinary system consists of

• **Two kidneys**: this organ extracts wastes from the blood, balance body fluids and form urine.

• **Two ureters**: this tube conducts urine from the kidneys to the urinary bladder.

- ✓ Ureters are two tubes stretched from kidney to bladder.
- ✓ Function of ureters is to transport urine from the kidney to the bladder.
- ✓ The transport methods in ureters are by gravity and peristalsis (a rhythmic squeezing) of smooth muscle of ureters.

• **The urinary bladder**: this reservoir receives and stores the urine brought to it by the two ureters.

• **The urethra**: this tube conducts urine from the bladder to the outside of the body for elimination.

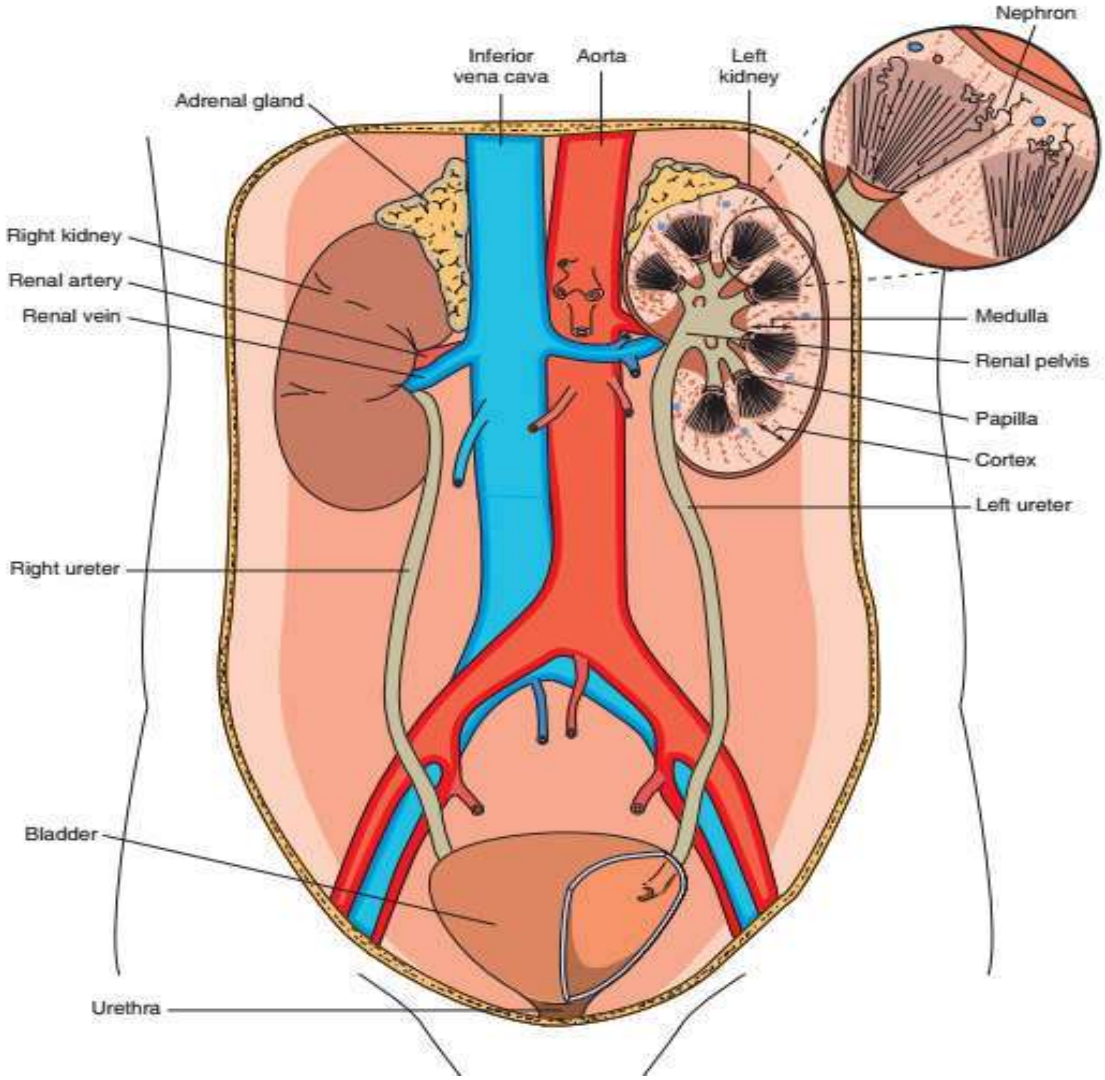

Figure 1.1:- Anatomy of the urinary system.

1.1.2. Anatomy of the kidney

Definitions:

- **Anatomy**: the word anatomy is derived from a Greek word "*Anatome*" meaning to cut up.
    - ✓ It is the study of structures that make up the body and how those structures relate with each other.
- **Kidneys**: are two bean shaped organs; it weighs about 150 gm each.

- **Location:** The kidneys are a pair of organs found along the posterior muscular wall of the abdominal cavity. Unlike the other abdominal organs, the kidneys lie behind the peritoneum. The ribs and muscles of the back protect the kidneys from external damage.
- **Structure**: The kidneys are bean-shaped with the convex side of each organ located laterally and the concave side media.

A. External Anatomy of the kidney

A pair of reddish brown, bean shaped organ located in the posterior wall of the abdominal region, one in each side of the vertebral column. They are protected at least partially by the last pair of ribs and capped by the adrenal gland. The bean shape of the kidney is medially concave and laterally convex.

On the medial concave border is the ***hilus*** (small indented area) where blood vessels, nerves & ureters enter and leave the kidney.

- kidneys are two bean shaped organs, about 150 gm each
- Urine forming units:
  - Cortex
  - Medulla (lobed: renal pyramids)
  - Cortex and medulla composed chiefly of nephrons and blood vessels
- About 25% of cardial out put Supplied to kidney through renal arteries (branches of descending aorta)
- Returns back by renal veins (branches of inferior vena cava)

Covering and supporting each kidney are three layers of tissue:

- **Renal capsule** – innermost, tough, fibrous layer
- **Adipose capsule** – the middle layer composed of fat, giving the kidney protective cushion.
- **Renal fascia** – is outer sub-serous membrane, connective tissue layer.

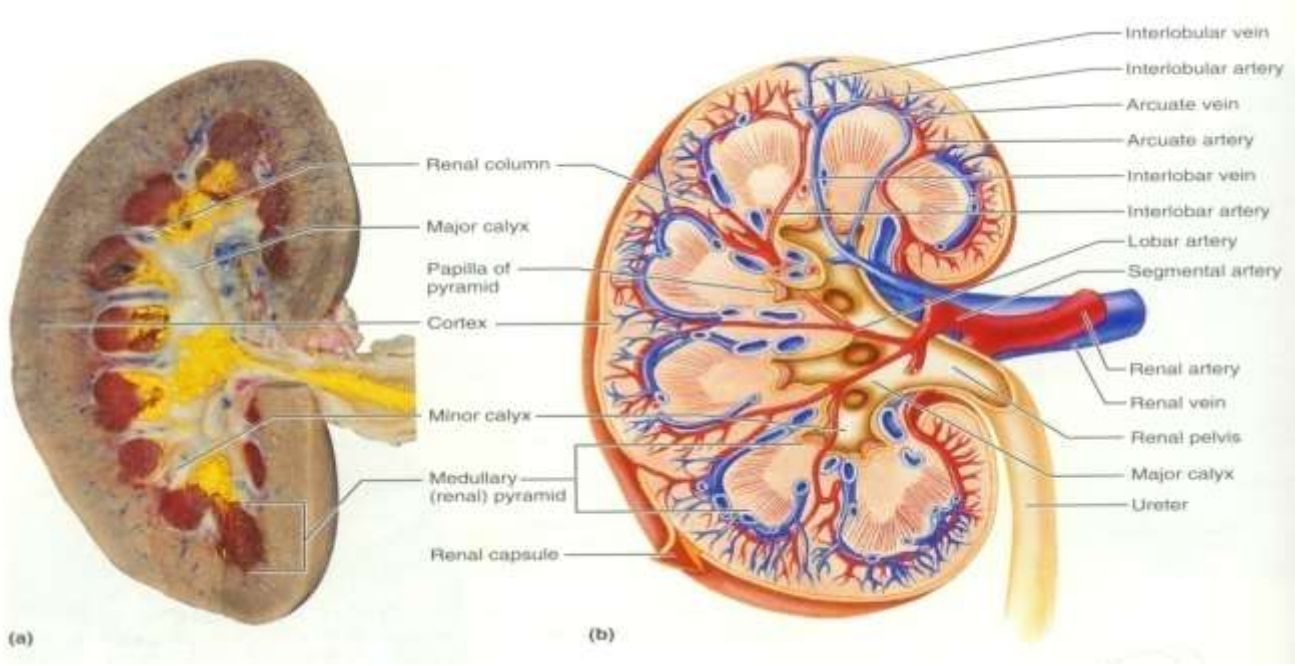

Figure 1.2 external and internal anatomy of kidney

B . Internal Anatomy of the kidney

- A sagital section of the kidney reveals three distinct regions called **pelvis**, **medulla** and **cortex** (from inside out).
- The **Renal pelvis** is the large collecting space within the kidney formed from the expanded upper portion of the ureters
- The **Renal medulla** is the middle portion of the kidney. It consists of 8 to 18 renal pyramids.
- The base of each pyramid is adjacent to the outer cortex. Pyramids contain tubules and collecting ducts of the nephron. Tubules involved in transportation and re-absorption of filtered materials.
- The **Renal cortex** is the outermost portion of the kidney. It has two regions the outer cortical and the inner juxtamedullary region.
- The cortical tissue that penetrates between pyramids forms ***Renal Columns***. The

renal columns composed of mainly collecting tubules

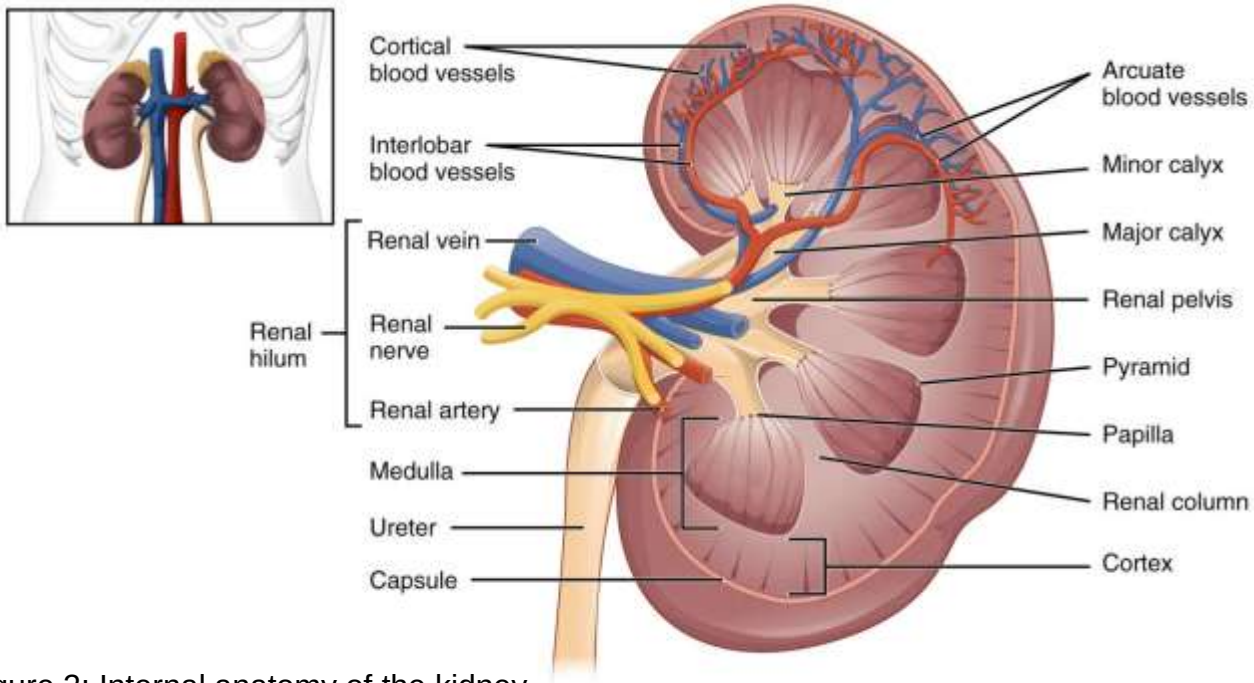

Figure 2: Internal anatomy of the kidney

The Nephron:

- It is the basic functional unit of the kidney.
- Each kidney contains approximately one million nephrons.
- Each nephron is an independent urine-forming unit.
- Each nephron consists of two parts: **renal corpuscle** and **renal tubule**
- **A renal corpuscle** (where blood plasma is filtered), has two components:
- The **glomerulus** (capillary network) and
- The **glomerular (Bowman's) capsule,** a double-walled epithelial cup that surrounds the glomerulus.
- **A renal tubule:** a tubule into which the filtered fluid passes. It consists of:

a. **Proximal convoluted tubule** is the part of the tubule attached to the glomerular capsule and

b. **Loop of Henle/nephron loop:** the tubule is tightly coiled.

c. **Distal convoluted tubule:** it is the parts that further away from the glomerular capsule.

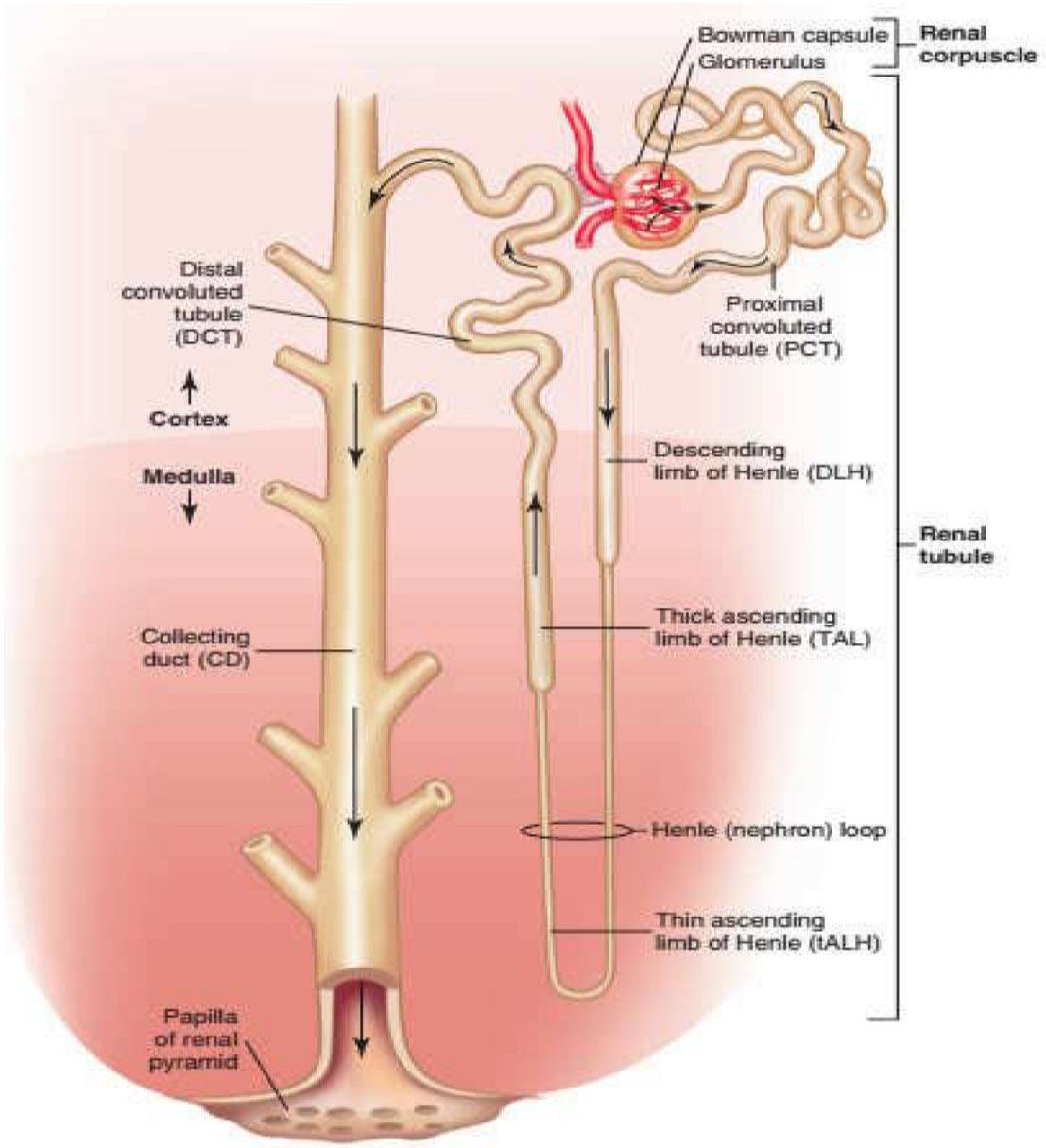

Figure 1.3: A diagram of a nephron tubules.

	Information sheet #1	Learning Guide#49	Identify concepts of urinalysis
		Topic	Anatomy and physiology of urinary system.

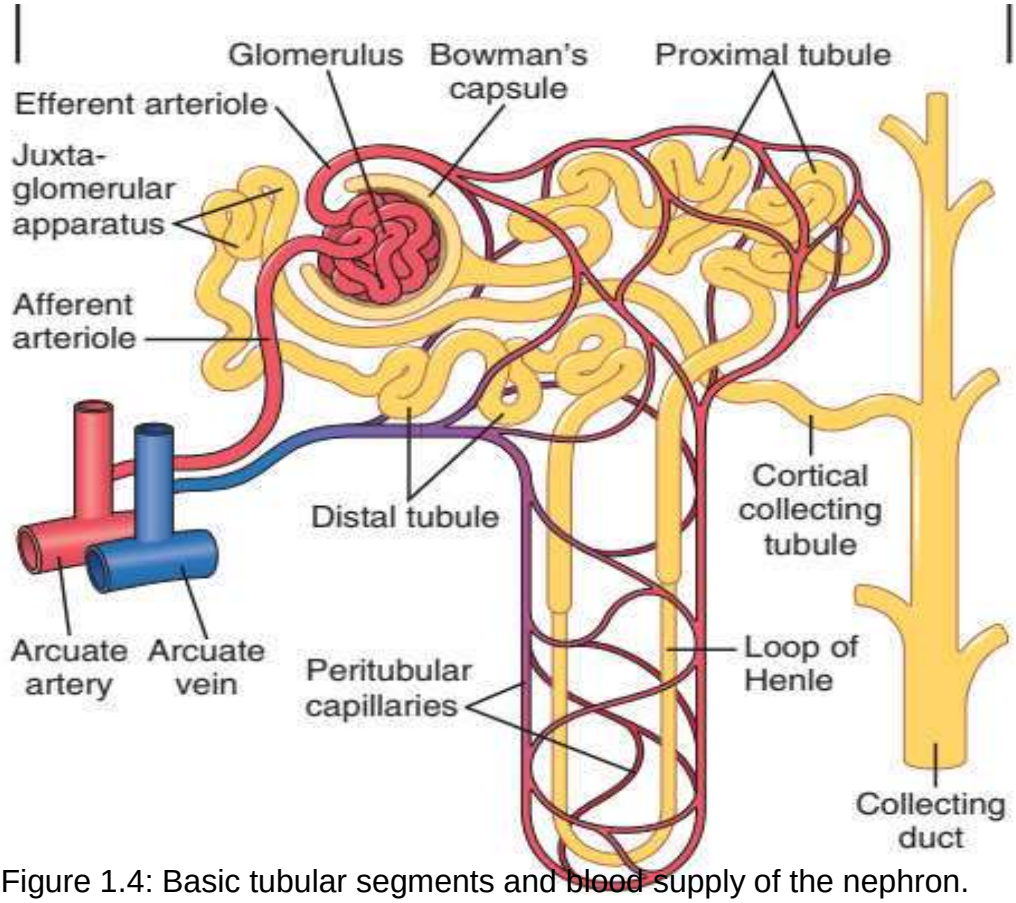

Figure 1.4: Basic tubular segments and blood supply of the nephron.

Blood Supply: Blood is supplied to the kidneys by renal artery and drainage is by renal vein.

1. The renal arteries branch directly from the abdominal aorta and enter the kidneys through the renal hilus.
2. Inside our kidneys, the renal arteries diverge into the smaller afferent arterioles of the kidneys.
3. Each afferent arteriole carries blood into the renal cortex, where it separates into a bundle of capillaries known as a glomerulus.
4. From the glomerulus, the blood recollects into smaller efferent arterioles that descend into the renal medulla.
5. The efferent arterioles separate into the peritubular capillaries that surround the renal tubules.
6. Next, the peritubular capillaries merge to form veins that merge again to form the large renal vein.
7. Finally, the renal vein exits the kidney and joins with the inferior

vena cava, which carries blood back to the heart.

	INFORMATION SHEET # 1	Learning Guide#1	Identify concepts of urinalysis
		Topic	Anatomy and physiology of urinary system.

1.1.3. Physiology of the Kidney and Formation of Urine

1.1.3.1. Physiology of the Kidney

The kidneys perform their most important functions by filtering the plasma and removing substances from the filtrate. The kidneys clear unwanted substances from the filtrate by excreting them in the urine while returning substances that are needed back to the blood.

Kidneys homeostatic functions:

- Excretion of metabolic waste products and foreign chemicals
- Regulation of water and electrolyte balances
- Regulation of body fluid osmolality and electrolyte concentrations
- Regulation of arterial pressure
- Regulation of acid-base balance
- Regulation of erythrocyte production
- Secretion, metabolism, and excretion of hormones
- Gluconeogenesis

Group Discussion Point

- Discuss on physiologic role of the kidney excretion of **waste materials and foreign chemicals**.

Hint:

Excretion of metabolic waste products, foreign chemicals, drugs, and hormone metabolites:

- The kidneys are the primary means for eliminating waste products of metabolism that are no longer needed by the body. These products include urea (from the metabolism of amino acids), creatinine (from muscle creatine), uric acid (from nucleic acids), end products of hemoglobin breakdown (such as bilirubin), and metabolites of various hormones.

Regulation of Erythrocyte Production:

- The kidneys secrete erythropoietin, which stimulates the production of red blood cells by hematopoietic stem cells in the bone marrow

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Group Activity• Discuss how our kidney produce and excrete urine.

INFORMATION SHEET # 1	Learning Guide#49	Identify concepts of urinalysis
	Topic	Anatomy and physiology of urinary system.

1.1.4. Formation of Urine

Urine is formed by the three physiological processes that are:

- ✓ Glomerular filtration
- ✓ Tubular re-absorption
- ✓ Tubular secretion

And is collected by the collecting duct and passes into bladder through ureters and then comes out through urethra.

The blood enters the glomerulus of each nephron by passing through the afferent arteriole into the glomerular capillaries. The capillary walls in the glomerulus are highly permeable to water and the low molecular-weight components of the plasma.

They filter through the capillary walls and the closely adhering membrane of Bowman's capsule into Bowman's Space from where the plasma ultra filtrate passes into the tubule where re-absorption of some substances, secretion of others, and the concentration of urine occur.

Many components of the plasma filtrate such as glucose, water, and amino acids, are partially or completely reabsorbed by the capillaries surrounding the proximal tubules. In the distal tubules, more water is reabsorbed and potassium and hydrogen ions are secreted.

The Loop of Henle and the system of collecting tubules are the principal sites where the urine is concentrated as a mechanism for conserving body water.

- One of the main function of kidney:
  - ☐ selective absorption of substances necessary for our body
  - ☐ Removal of waste products and surplus substances, that would be harmful to our body in the form of urine.
- The formation of urine by the kidneys achieved by three phase processes:
  - ☐ Simple filtration
  - ☐ active and passive reabsorption
  - ☐ secretion

Discussion question?

List urine constituents that indicate abnormality of the kidney function.

1. _____
2. _____
3. _____

self-check #1	Written Test

Self-Check

Multiple Choices: Choose the correct answer from the given choices.

1. Which one of the following is the functional unit of the kidney?
   A. Bowman's capsule B. Cortex C. Nephron D. Medulla
2. The urinary system has the following functions except
   A. Synthesis of proteins
   B. Excretion of metabolic waste product
   C. Regulation of water and electrolyte balance
   D. Regulation of red blood cell production
3. ---------Tube conducts urine from the kidneys to the urinary bladder?
   A. Urethra B. Ureter C. Proximal tube D. Collecting duct
4. Identify wrong statement about external anatomy of the kidney?
   A. Located in the posterior wall of the abdominal region
   B. The bean shape of the kidney is medially convex and laterally concave
   C. Capped by the adrenal gland
   D. They are protected at least partially by the last pair of ribs
5. The site in the external portion of the kidneys where blood vessels, nerves & ureters enter and leave the kidney are--------?
   A. Renal fascia B. Hilus C. Renal corpuscle D. Renal pelvis
6. ------- is the large collecting space within the kidney formed from the expanded upper portion of the ureters?
   A. Renal cortex B. Renal medulla **C.** Renal pelvis D. Renal capsule
7. ----------Is a double-walled epithelial cup that surrounds the glomerulus?
   A. Bowman's capsule C. The glomerulus
   B. renal corpuscle D. capillary network
8. A sagital/inner section of the kidney reveals three distinct regions. Which alternatives show those regions from outer to inner in sequences?
   A. Pelvis→Cortex→Medulla C. Pelvis→ Medulla → Cortex
   B. Cortex→Medulla→ Pelvis D. Medulla→ Pelvis→ Cortex

Note:- Satisfactory point is above four (>4)
Not-satisfactory point is below four (<4)

Answer sheet

1. ———
2. ———
3. ———
4. ———
5. ———
6. ———
7. ———
8. ———

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	Information sheet # 2	Learning Guide#49	Identify concepts of urinalysis
		Topic	Metabolic products in urine

1.2.1. Composition of Urine

- Urine
  - A fluid extracted by the kidneys, pass through the ureters, stored in the bladder, and discharge through the urethra.
  - in the presence of disease conditions, depending on the abnormality, the urine will have abnormal constituents.

Normal urine

- Freshly voided urine from healthy individuals is clear and pale yellow in color
- Having aromatic odor from volatile organic acids, and specific gravity about 1.024
- .It is slightly acidic (pH 5.0 to 6.0) and contains 95 % water.
- Normal urine contains
  - Creatinine, uric acid, urea, few epithelial cells, 2-3 leukocytes/HPF and amorphous urates (in acidic urine) and amorphous phosphates (in alkaline urines).
  - Urine also have electrolytes like sodium, chlorine; and hormones, like aldosterones, vitamins and drug metabolic products in a very small quantities.
- Those substances considered as normal components of urine because they are waste product of our body metabolism, and their means of elimination from the body is mainly through urine.
- Abnormal compositions of urine
  - Sugar, Proteins, Bilirubin, ketone bodies, different hormones & electrolytes in higher concentration.
  - Urine sediments, such as high number of leukocytes, red blood cells, different kind of Casts, parasites, bacteria's, and yeasts.

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Table:- Summary of composition of urine

Normal Urine Constituents	**Abnormal Urine Constituents**
Water (about 95% of urine)	Glucose
Urea	Blood cells
Creatinine	Bile pigments
Uric acid	Protein, nitrite
Electrolytes	Cast, Crystals
Normal Urine Constituents	Parasites
	Microorganisms

1.2.2. The Factors Affecting the composition of Urine

- Diet and nutritional status
- Condition of body metabolism
- Ability of kidney function
- Level of contamination with pathogenic microorganism or even non-pathogenic microorganism.

Group Activity:

Explain how the above factors affect the composition of urine

1.2.3. Renal Clearance and Renal Threshold

Renal Clearance: Renal Clearance value indicates the degree to which a substance is removed from the blood by excretion in the urine.

- Clearance is usually defined as the blood volume that contains the

quantity of a substance excreted in the urine per minute.

- **Renal Clearance value**:
  - indicates the degree to which a substance is removed from the blood by excretion in the urine.
- **Clearance** :
  - the blood volume that contains the quantity of a substance excreted in the urine per minute.

GFR : Rate at which glomerular filtrate is formed

- About 120 ml of glomerular filtrate is produced per minute.
- The rate at which the glomerular filtrate is formed is known as the **glomerular filtration rate** (GFR).

❑ CREATININE CLEARENCES

- Creatinine is a substance present in the filtrate, which is not reabsorbed (however, this is some tubular secretion of creatinine).
- Therefore the clearance of creatinine from the plasma is 120 ml per minute.
- Hence creatinine clearance is used clinically to give an approximate indication of glomerular filtrate rate and, therefore, as a test of kidney function. When the filtration rate falls, the concentration of creatinine in the plasma rises.
- The creatinine clearance test expresses the volume of blood containing the amount of creatinine excreted by the kidney in one minute.
  - ➢ The creatinine clearance (Crcl) is calculated by collecting a 24 hrs urine specimen and a blood sample as well within the urine collection time.
  - ➢ Creatinine is then determined in both urine and serum and the creatinine clearance calculated in milliliters per minute (ml/minute).

Crcl (ml/minute) = $\frac{U \times V}{S}$

- ✓ Where, U= Urine Creatinine Concentration in mol/l
- ✓ V= Volume of urine in ml per 24 hrs
- ✓ S= Serum Creatinine Concentration in mol/l
- ✓ **Normal Range:** The normal Crcl value usually ranges between 110 – 140 ml/minute.

❑ **N.B**

- — Why is creatinine clearance most often used to monitor GFR?
- — Creatinine freely filtered by glomerulus
- — Creatinine not 'rehandled' by tubules
- — Creatinine is an endogenous substance
- — Amount of creatinine produced per day is constant
- — Amount of creatinine produced is proportional to muscle mass

❖ **Renal Threshold:**

- ✓ The renal threshold of a substance refers to the highest concentration of a substance, which is present in the blood before it is found in the urine.
- ✓ A substance such as glucose is a high threshold (160-180ml/dl), because it is completely absorbed from the glomerular filtrate and is only found in the urine, when the blood glucose level is markedly raised.
- ✓ Urea and creatinine, however, are always present in the urine independent of the blood level because very little, if any, of these substance is reabsorbed.

Self check #2	Written exam

Instruction: Choose the correct answer from the given choices.

1. Which substance is used to evaluate renal clearance?
   A. Blood cell B. Cast C. Creatinine D. Protein
2. One of the following substances is not found in normal urine?
   A. Creatinine B. Electrolyte
   C. Protein D. Urea
3. Among the following alternatives which one contains normal constituents of urine only?
   A. Glucose, Electrolytes, Blood cells C. Uric acid, Urea, Creatinine
   B. Creatinine, Urea, Parasites D. Protein, nitrite, Bile pigments
4. If water intake is decreased, the kidney will protect the body from excessive retention of water by eliminating a larger volume of urine than normal and viseversa.
   A. True B. False C. Uknown
5. Which substance is used to evaluate renal clearance?
   A. Blood cell B. Cast C. Creatinine D. Protein

Note:- Satisfactory point is above three (>3)
Not-satisfactory point is below three (<3)

Answer sheet

1. ———
2. ———
3. ———
4. ———
5. ———

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	Information sheet #3	Learning Guide#49	Identify concepts of urinalysis
		Topic	Testing methodology of urinalysis.

1.3. Testing methodology of urinalysis.

In the diagnostic medical laboratory urine specimens can be analyzed by using different methods of examnation. Some of this methods may includes

- Phyical examination
- Chemical examination
- Microscopic examination
- Microbiological examination (Cultiring methods) and…etc.

1.3.1. Type of Examination in Routine Urinalysis

1.3.1.1. Physical Examination of Urine includes

- ✓ □ Volume _ PH
- ✓ □ Color _ Appearances
- ✓ □ Odor _ specific gravity

1.3.1.2. Chemical Examination of Urine

- Glucose Ketones Urobilinogen blood
- Protein Bilirubin nitrite leukocyte esterase

1.3.1.3. Microscopic Examination of Urine

- RBCs _ Yeasts
- WBCs _ parasites
- Epithelial cells _ crystals
- Casts
- Bacteria

1.3.1.4. Microbiological examination (Cultiring methods)

- Possible pathogens may includes

✓ Gram positive	Gram negative
✓ Staphylococcus	Escherichia coli
✓ saprophyticus	Proteus species
✓ Haemolytic streptococci	Pseudomonas aeruginosa
	Klebsiella strains
	*Salmonella Typhi
	*Salmonella Paratyphi
	*Neisseria gonorrhoeae

1.3.2. Categories of Urine Tests

According to their degree of accuracy urine tests are grouped into three broad categories:

- Screening tests
- Qualitative tests
- Quantitative tests

1.3.2.1. **Screening tests** tell only whether a substance is present or absent, and the results are reported as positive or negative. They are done on random specimen.

1.3.2.2. **Qualitative tests** give rough estimate of the amount of substance present. They are also called semi-quantitative tests. The results of qualitative tests can be graded as negative, trace, +1, +2, +3 or +4.

1.3.2.3. **Quantitative tests** determine accurately the amount of the substances to be tested. However, since they are time consuming, they are not included in routine urinalysis. Most common quantitative tests performed in urinalysis laboratory are those for sugar and for protein.

The results of a quantitative test are usually reported in milligrams per deciliter, gram per deciliter, and per liter. For quantitative test, a complete 24-hour urine specimen is needed.

An appropriate preservative should be added to the container or the specimen should be stored in refrigerator.

Self check #3	Written exam

Instruction 1:- Say true or false for each of the following questions

1. Screening tests give rough estimate of the amount of substance present.
2. Most common quantitative tests performed in urinalysis laboratory are those for sugar and for protein.
3. Qualitative tests tell only whether a substance is present or absent, and the results are reported as positive or negative.
4. Quantitative tests determine accurately the amount of the substances to be tested.
5. The results of qualitative tests can be graded as negative, trace, +1, +2, +3 or +4.

Instruction #2:- Choose the best possible answer among the given alternatives

1. Physical Examination of Urine includes all of the following except?
   A. Volume C. Specific gravity
   B. Color D. Leukocyte esterase
2. Which of the following alternatives includes only Chemical Examination of Urine?
   A. Glucose, Ketones, Specific gravity C. Urobilinogen, blood, Odor
   B. Protein, Bilirubin, nitrite D. Volume, PH, leukocyte esterase
3. Microscopic Examination of Urine may include all of the following except?
   A. RBCs and WBCs C. Yeasts & Crystals
   B. Parasites & Epithelial cells D. PH, & leukocyte esterase
4. If Microbiological examination is performed on urine specimen possible outcome may includes?
   A. Staphylococcus & Escherichia coli C. saprophyticus & Proteus species
   B. Hemolytic streptococci & Pseudomonas aeruginosa D. All

Note:- Satisfactory point is above five (>5)
Not-satisfactory point is below five (<5)

Answer sheet

Instruction 1

1. ———
2. ———
3. ———
4. ———
5. ———

Instruction 2

1. ———
2. ———

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3. ———
4. ———

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