(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

(MAIN CAMPUS)

UNIVERSITY EXAMINATIONS 2019/2020 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE BACHELOR OF SCIENCE IN MEDICAL LABORATORY SCIENCES

COURSE CODE: BML 113

COURSE TITLE: FUNDAMENTALS OF PHYSIOLOGY

DATE: 4TH DECEMBER 2019 TIME: 9:00-11:00 AM

INSTRUCTIONS:
ANSWER ALL QUESTIONS IN SECTION A AND B, ONLY TWO IN SECTION THREE

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 6 Printed Pages. Please Turn Over

SECTION A: MULTIPLE CHOICE QUESTIONS (20 MARKS)

1. Which one of the following statements concerning serous membranes is **UNTRUE**
   (a) Serous membranes secrete fluids that fill the space between parietal and visceral membranes.
   (b) The parietal part of the serous membrane covers the internal organs
   (c) The peritoneal membranes line the abdominopelvic cavity and cover its organs
   (d) Retroperitoneal organs are found behind the parietal peritoneum

2. Identify a body plane that divides the body into the anterior and posterior parts
   (a) The transverse plane
   (b) The sagittal plane
   (c) The longitudinal plane
   (d) The frontal plane

3. Identify a component that is **NOT** directly involved in the maintenance of the integrity of DNA
   (a) DNA ligase
   (b) RNA polymerase
   (c) Topoisomerase
   (d) Histones

4. Select a statement which is **TRUE** of the ribosomes
   (a) Each ribosomal subunit is composed of a case of ribosomal DNA surrounded by ribosomal proteins.
   (b) Proteins are assembled in the ribosomes by translation of tRNA by ribosomal mRNA and a group of related proteins.
   (c) RNA molecules (tRNA and rRNA) play an important part in the catalytic activity of ribosomes.
   (d) The process of transcription occurs in the ribosomes.

5. The catabolic process involving the degradation of the cells own components through lysosomal machinery is called
   (a) Apoptosis
   (b) Cell signalling
   (c) Autophagy
   (d) Phagolysis

6. Which special proteins form small transmembrane passageways that enable solute molecules to cross the phospholipid bilayer.
   (a) The glycocalyx
   (b) External lipoprotein

(c) Permeases

(d) Peripheral proteins

7. All of the following are components that make up the extracellular fluid compartment except

(a) The interstitial fluid

(b) Plasma

(c) Transcellular fluid

(d) Cytosol

8. Which one of the following statements is **WRONG** with regard to the pineal gland

(a) It secretes hormone melatonin and is cone-shaped

(b) It causes drowsiness and increases body temperature through hormonal secretion.

(c) Its hormonal secretion enhances the production of cytokines in the immune system

(d) It is located near the corpora quadrigemina

9. Which group of hormones stimulates protein synthesis, promotes maturation of the nervous system and increases the rate of energy utilization from the body.

(a) Parathyroid hormones
(b) Gonadotrophic hormones
(c) **Thyroid hormones**
(d) Pituitary hormones

10. In the human digestive tract the gastric glands contain

(a) Argentaffen cells which secrete serotonin and histamine

(b) Pariental cells which secret gastrin

(c) Goblet cells which secrete hydrochloric acid

(d) Chief cells which secrete mucus

11. Identify the combination that **DOES NOT** entirely contain functions of the digestive system.

(a) Ingestion, mastication, defecation

(b) Peristalsis, deglutition, micturition

(c) Absorption, peristalsis, deglutition

(d) digestion, peristalsis, deglutition

12. After antigenic stimulation, T lymphocytes proliferate and differentiate to form the following clones of cells except.

(a) Memory T cells

(b) Suppressor T cells

(c) Plasma cells

(d) Cytotoxic T cells

13. In the vestibular apparatus that maintain equilibrium
    (a) Semicircular canals give information on linear acceleration
    (b) The utricle and saccule provide information about angular acceleration
    (c) The receptors for equilibrium are 20 to 50 kinocilia
    (d) The membranous labyrinth in the vestibular apparatus contains the endolymph

14. For pitch discrimination to occur in the hearing process, high sound frequencies are directly transmitted through.
    (a) The endolymph in the cochlea duct
    (b) The perilymph-containing scala vestibule
    (c) The perilymph-containing scala tympani
    (d) The vestibular membrane and the basilar membrane

15. As photoreceptors, the rods are known to
    (a) Absorb light maximally in the red region of the electromagnetic spectrum
    (b) Contain a pigment called rhodopsin that is responsible for colour vision.
    (c) Contain rhodopsin pigment that transmits light in the red and green regions of the visible spectrum.
    (d) Provide black and white vision under conditions of low light intensity.

16. Which one of the following statements is **TRUE** with regard to the eyes ability to transduce energy in the electromagnetic spectrum into nerve impulses?
    (a) Only electromagnetic energy with wavelengths between 200 and 400 nanometres (nm) comprises visible light.
    (b) Individuals without lenses can see light within the infrared region of the spectrum
    (c) The ultraviolet wavelength of light is only felt as heat by the eyes
    (d) The yellow colour of the lens has the ability to filter out the high energy ultra violet light.

17. Identify a regulatory measure which **DOES NOT** apply with regard to the inhibition of catecholamine neurotransmitters.
    (a) Enzymatic degradation by acetylcholinesterase
    (b) Re-uptake of the catecholamines at the presynaptic end
    (c) Enzymatic degradation by MAO (monoamine oxidase) from the presynaptic knobs
    (d) Enzymatic degradation by COMT (Catecholamine -0- methyl transferase) from the post synaptic knob.

18. Which receptors are usually stimulated by the release of chemicals from damaged tissue cells leading to pain sensation.
    (a) Chemoreceptors
    (b) Nocioreceptors

(c) Mechanoreceptors

(d) Extreroreceptors

19. Which one of the following is **NOT** a direct homeostatic function of the kidney

(a) Maintaining carbohydrate metabolism

(b) Regulation of blood pH

(c) Re-absorption of substances like water and sodium ions into the blood

(d) Excretion of urea and other wastes

20. The human B lymphocytes

(a) Are manufactured in the bone marrow and then processed in the thymus gland

(b) Play the role of antibody (immunoglobulin) mediated immunity

(c) Differentiate to form suppressor cells and plasma cells on encountering antigens

(d) Require Antigen Processing Cell (APC) mediation in order to be sensitized by antigen

SECTION B: SHORT ANSWER QUESTIONS [40 MARKS]

1. Describe the hearing process, organization and roles played by the vestibular apparatus in the perception of equilibrium **(5 marks)**

Sound waves are funneled by the pinna into the external auditory meatus which channels sound into the eardrum. Vibrations are then transmitted to the middle ear ossicles; the maleus, incus and stapes.

From the stapes, the vibrations are transmitted to the oval window of the cochlea. These vibrations displace the endolymph within the cochlea duct and produce pressure waves in the perilymph-containing scala vestibule and scala tympani.

These movements displace the round window. High sound frequencies are transmitted directly through the vestibular membrane and through the basilar membrane for pitch discrimination.

Pressure waves of the perilymph are transmitted to the sensory nerve endings through hairs (cilia) in the organ of corti leading to hearing sensations.

2. With examples, outline positive and negative feed back homeostatic regulation mechanisms **(4 marks)**

Positive feedback mechanisms are designed to accelerate or enhance the output created by a stimulus that has already been activated e.g. blood platelet accumulation, which in turn, causes blood clotting in response to a break in blood vessel lining, release of oxytocin to intensify contractions that accompany child birth

Negative feedback mechanisms reduce the output of activity of any organ or system back to its normal range of functioning e.g. regulation of blood pressure through vasodilation or vasoconstriction, thermoregulation by increasing or reducing the rate of sweating

3. With the aid of a diagram, explain the mechanisms that occur in salutatory impulse conduction **(4 marks)**

This refers to the jumping of depolarization from node to node in myelinated axons in a rapid process that enables myelinated fibers to conduct up to 50 times faster than the fastest unmylinated fibers. The following diagram illustrates the conduction of a salutatory nerve impulse:

4. Describe the electrical and contractile activities of skeletal muscles (use diagrams) **(5 marks)**

The electrical events in skeletal muscles and the ionic fluxes underlying them are similar to those in neurons although there are quantitative differences in timing and magnitude. Ionic distribution across the muscle fiber membrane is similar to that across the nerve cell membrane.
Muscle fiber membrane membrane depolarization usually starts at the motor end plate, the specialized structure under the motor nerve ending; the action potential is transmitted along the muscle fiber and initiates the contractile responses through the binding of calcium to troponin C followed by the formation of crosslinkages between actin and myosin that results in the sliding of thin (actin) filaments on thick (myosin) filaments causing shortening.
In relaxation calcium is released from troponin C followed by the cessation of interactions between actin and myosin.

5. Describe any two sleeping disorders **(4 marks)**

Insomnia: the subjective problem of insufficient or nonrestorative sleep despite an adequate opportunity for sleep. Occurs at one time or another in almost all adults. It can be relieved by sleeping pills like benzodiapenes. Persistent insomnia can be fatal.

Sleepwalking (somnambulism) and nocturnal enuresis and night-terrors occur during arousal from slow wave sleep. Sleep walking is more common in children than adults and predominant in males, lasting several minutes, at times. Somnambulists walk with their eyes open and avoid obstacles, but when awakened cannot recall their episodes. *Sleep apnea:* caused by obstruction of the airway during sleep. It leads to loss of sleep, tiredness and poor performance during daytime. Subjects should avoid sleeping on their backs, avoid hypnotics and alcohol.

3. Outline the mechanism of body fluid balance and blood pressure regulation by the RAAS (Renin Angiotensin Aldosterone System) **(10 marks)**

The RAAS is a hormone system that regulates blood pressure and water (fluid) balance. When the blood volume is low the juxtaglomerular cells in the kidneys secrete renin directly into the circulation. Plasma renin then converts angiotensinogen released by the liver into angiotensin I. Angiotensin I is subsequently converted into angiotensin II by the enzyme angiotensin converting enzyme (ACE) found in the lungs.

Angiotensin II is a potent vasoactive peptide that causes blood vessels to constrict, resulting in increased blood pressure. Angiotensin II also stimulates the secretion of the hormone aldosterone from the adrenal cortex. Aldosterone stimulates increased renal reabsorption of water and sodium into the blood. This increases the volume of fluid in the body, which also increases blood pressure.

If the RAAS is too active, blood pressure will be too high. Drugs that interrupt different steps in the RAAS can be used to lower blood pressure. These drugs are one of the ways of controlling: high blood pressure

(hypertension), kidney failure and harmful effects of diabetes.

4. Discuss antigen a processing and presentation pathways of the immune system **(8 marks)**

The antigen processing and presentation pathway for cytosolic and nuclear proteins is different from that of extracellular and membrane proteins.

Endogenously produced proteins are digested in proteasome complexes, sometimes after coupling to ubiquitin, and they are combined with MHC class I proteins in the endoplasmic reticulum (ER) before external display. With their TCR complexes cytotoxic killer T cells detect internally derived peptide antigens complexed with MHC class I molecules on the surfaces of virus infected or mutated, malignant, abnormal or damages cells, and this triggers cytotoxic killing.

Endogenously uptaken proteins enter the cytoplasm by endocytosis and are digested in the lysosomes or endosomes and combined with MHC class II proteins before externalization. With their TCR complexes helper T cells detect peptide externally derived peptide antigens complexed with MHC class II molecules on the surfaces of antigen presenting cells, such as macrophages, B cells and dendritic cell and this triggers activation, and differentiation into cytokine producing T cell subsets.

Diagram:

			Cell surface
Cytosolic and nuclear proteins	ubiquitin	Proteosome complex	Peptide MHC class I complex

			Cell surface
Extracellular proteins	ubiquitin	Proteosome complex	Peptide MHC class I complex
Membrane proteins			

SECTION C: LONG ANSWER QUESTIONS [40 MARKS]

1. Explain the stages involved in urine formation and key outcomes of proper kidney functioning **(20 marks)**

Filtration: This takes place between the semipermeable walls of the glomerulus and the glomerular capsule (water and the following molecules pass through: mineral salts, amino acids, keto acids, glucose, some hormones, creatinine, urea, uric acid, some toxins, some drugs). These are the constituents of the glomerular filtrate, some of which are reabsorbed back into circulation. The following blood constituents remain in the glomerular capillaries: leukocytes, erythrocytes, platelets, plasma proteins, and some drugs.

Filtration is assisted by the build up of a capillary hydrostatic pressure caused by the narrowness of the efferent arteriole in comparison to the afferent arteriole.

Selective reabsorption: This process alters the composition and volume of the glomerular filtrate during passage through the convoluted tubules, medullary loop and collecting tubule. This process enables reabsorption, into the blood, of filtrate constituents needed to maintain fluid and electrolyte balance and blood pH. Active transport using chemical energy at carrier sites transports substances against their concentration gradients. Glucose and amino acids are normally completely reabsorbed and do not appear in urine.

Substances reabsorbed by active transport include: sodium, potassium, phosphate and chloride ions. Sodium and chloride ions can still be absorbed by active or passive mechanisms depending on the site at the nephron. Hormones regulating reabsorption include: Parathyroid hormone; from parathyroid glands, and calcitonin from the thyroid gland together regulate the reabsorption of calcium and phosphates, Antidiuretic hormone (ADH); from the posterior lobe of the pitutitary gland increases the permeability of the distal convoluted tubules and collecting ducts, increasing the reabsorption of water, Aldosterone; secreted by the adrenal cortex and increases the reabsorption of sodium and secretion of potassium, Atrial natriuretic peptide (ANP); secreted by the atria of the heart in response to stretching of the atrial wall, decreases reabsorption of sodium and water in the proximal convoluted tubules and collecting ducts. It also inhibits the secretion of ADH and aldosterone.

Tubular Secretion: Substances not required and foreign materials e.g. drugs like penicillin and aspirin may not be cleared from blood by ultrafiltration because of the short time they remain in the glomerulus. Such substances are cleared by secretion into the convoluted tubules and secreted from the body in the urine. Tubular secretion of hydrogen ions is important in the maintenance of normal blood pH.

Composition of urine: 96% water, 2% urea, 2% uric acid, creatinine, ammonia, sodium, potassium, chlorides, phosphates, sulphates, oxalates. Urine is usually clear and amber due to the presence of urobilin, a bile pigment secreted by kidneys. The pH of normal urine is about 6.0 (between 4.5 and 8) and a healthy adult passes 1000 ml to 1500 ml of urine per day.

Key outcomes of proper kidney functioning include: water balance regulation, electrolyte balance regulation, sodium and potassium balance regulation, regulation of blood pressure by the RAAS, regulation of calcium and phosphate balance, and control of pH balance.

2. Explain the compartmentalization of the body fluids **(20 marks)**

Fluid compartments of the human body are broadly categorized into two main categories:
The intracellular fluid compartment makes up to 60-65% of body water
The extracellular fluid makes up 35-40% of body water
The intracellular fluid is found within the bilayered plasma membrane and is the cytoplasmic matrix in which cellular organelles are suspended, and chemical reactions take place. It is also called cytosol and under ordinary conditions it remains in osmotic equilibrium with the extracellular fluid. Many chemical reactions and metabolic pathways take place in the cytosol and it is primarily a solution of potassium, organic ions and proteins.

The extracellular fluid compartment is made up of the following types of fluid subcompartments that are found outside body cells:

The interstitial fluid/tissue fluid is a solution that bathes and surrounds the body cells and is the main component of the extracellular fluid. It is found in the interstitial spaces, also called tissue spaces.It consists of water solvent containing amino acids, sugars, fatty acids, co-enzymes, hormones, neurotransmitters, salts as well as cellular waste products

Plasma circulates as the extracellular fluid component of blood. It is the straw-coloured liquid component of blood in which the blood cells in whole blood are normally suspended. It makes up about 55% of the total blood volume. It is an intravascular fluid that is mostly water (93%) and contains dissolved proteins, glucose, clotting factors, mineral ions, hormones, carbon dioxide. It serves as the protein reserve of the human body and plays a vital role in intravascular osmotic effects that keep electrolyte balance in check, prevents the body from infection and blood disorders

Transcellular fluid is the portion of body water contained within the epithelial lined spaces. It is the smallest component of the extracellular fluid and forms 2.5% of the total body water. Examples of transcellular fluids: cerebrospinal fluid, ocular fluid, joint and bladder urine. Sodium chloride and bicarbonate ions are some of the electrolyte present in the transcellular fluid whose composition changes dramatically from time to time.

2. Explain properties and Excitation mechanisms that take place in skeletal muscles **(20 marks)**

These are made up of building blocks called muscle fibers or myofibers arranged in parallel between the tendinous ends so that the force of contraction of the units is additive.

Skeletal muscles mostly begin and end in tendons. Each muscle fiber is a single cell, multinucleated, long, cylindrical, and surrounded by a cell membrane, the sarcolemma. Muscle fibers contain myofibrils, made up of individual filaments, made up of contractile proteins.

Contractile mechanisms in skeletal muscles depend on the proteins tropomyosin, troponin (troponin T, troponin I and troponin C), actin, alpha-actinin, and myosin.

Muscle fibrils have a sarcotubular system which is made up of a T system, and sarcoplastic reticulum. The T system which is continuous with the sarcolemma, functions in the rapid transmission of action potential from the cell membrane to all the muscle fibrils. The sarcoplastic reticulum functions in movement of calcium ions and muscle metabolism.

Electrical events in skeletal muscles and the ionic fluxes underlying them are similar to those in nerves, although there are quantitative and qualitative differences in timing and magnitude. Ionic distribution across the muscle fiber membrane is similar to that across the nerve cell membrane.

Muscle fiber membrane depolarization normally starts at the motor end plate; the specialized structure under the motor nerve ending; the action potential is then transmitted along the muscle fiber and it initiates the contractile response through causing the binding of calcium ions on troponin C followed by the formation of cross linkages between actin and myosin that result in the sliding of thin filaments

on thick filaments producing shortening. In muscle relaxation, calcium ions are released from troponin leading to the cessation of interactions between actin and myosin.

A muscle twitch is a single action potential that causes a brief contraction followed by a relaxation. An isometric contraction is a contraction that occurs without an appreciable decrease in the length of the whole muscle. The hydrolysis of ATP yields the energy requirements for muscle contraction to occur.