

UNIT – 3 REMEDIAL BIOLOGY

B. Pharmacy 1st Semester

POINTS TO BE COVERED IN THIS TOPIC

- ➤ EXCRETORY PRODUCTS AND THEIR ELIMINATION 
- ➤ NEURAL CONTROL AND COORDINATION 
- ➤ CHEMICAL COORDINATION AND REGULATION 
- ➤ HUMAN REPRODUCTION 

EXCRETORY PRODUCTS AND THEIR ELIMINATION

INTRODUCTION

Excretion is the biological process by which metabolic waste products are eliminated from the body to maintain homeostasis and prevent the accumulation of toxic substances. This process is essential for the survival of all living organisms as it helps maintain the proper chemical composition of body fluids.

MODES OF EXCRETION

AMMONOTELISM

- Animals that excrete ammonia as their primary nitrogenous waste are called ammonotelic organisms.
- Ammonia is highly toxic and requires large amounts of water for dilution.

- Common in aquatic animals like fish, tadpoles, and aquatic invertebrates.
- Ammonia is readily soluble and diffuses easily across gill membranes.

UREOTELISM

- Animals that excrete urea as their primary nitrogenous waste are called ureotelic organisms.
- Urea is less toxic than ammonia and requires moderate amounts of water for excretion.
- Common in mammals, adult amphibians, sharks, and some bony fish.
- Urea is synthesized in the liver through the ornithine cycle.

URICOTELISM

- Animals that excrete uric acid as their primary nitrogenous waste are called uricotelic organisms.
- Uric acid is the least toxic and requires minimal water for excretion.
- Common in birds, reptiles, land snails, and insects.
- Uric acid is excreted as a semi-solid paste, conserving water.

HUMAN EXCRETORY SYSTEM - STRUCTURE AND FUNCTION

The human excretory system consists of a pair of kidneys, ureters, urinary bladder, and urethra. This system is responsible for filtering blood, removing waste products, and maintaining water and electrolyte balance.

KIDNEYS

- Bean-shaped organs located in the retroperitoneal space.

- Each kidney measures approximately 10-12 cm in length.
- Covered by a tough fibrous capsule and surrounded by perirenal fat.
- **Gross Anatomy:**
 - Outer cortex containing glomeruli and convoluted tubules
 - Inner medulla containing loops of Henle and collecting ducts
 - Renal pelvis - funnel-shaped cavity collecting urine

NEPHRON - FUNCTIONAL UNIT OF KIDNEY

- Each kidney contains approximately 1 million nephrons.
- **Components of Nephron:**
 - **Renal Corpuscle:** Glomerulus + Bowman's capsule
 - **Renal Tubule:** Proximal convoluted tubule + Loop of Henle + Distal convoluted tubule
 - **Collecting Duct:** Final site of urine concentration

URETERS

- Muscular tubes connecting kidneys to urinary bladder.
- Length approximately 25-30 cm.
- Peristaltic movements propel urine towards bladder.

URINARY BLADDER

- Hollow muscular organ storing urine.
- Capacity ranges from 300-500 ml.
- Detrusor muscle controls bladder contraction.

URETHRA

- Tube carrying urine from bladder to exterior.
- Length differs between males (20 cm) and females (4 cm).

URINE FORMATION

Urine formation occurs through three main processes that take place in different parts of the nephron:

GLOMERULAR FILTRATION

- Blood is filtered at the glomerulus under pressure.
- Filtration pressure = Glomerular hydrostatic pressure - (Capsular hydrostatic pressure + Colloid osmotic pressure).
- **Glomerular Filtration Rate (GFR):**
 - Normal GFR: 120-125 ml/minute
 - Total filtrate formed: 180 liters/day
 - Only 1-2 liters excreted as urine

TUBULAR REABSORPTION

- Selective reabsorption of useful substances from filtrate.
- **Sites and Substances:**
 - **Proximal Convoluted Tubule:** 65% of filtrate, glucose, amino acids, sodium
 - **Loop of Henle:** Water and sodium chloride
 - **Distal Convoluted Tubule:** Sodium, chloride under hormonal control

- **Collecting Duct:** Final water reabsorption

TUBULAR SECRETION

- Active transport of waste substances from blood to urine.
- Substances secreted: hydrogen ions, potassium ions, creatinine, para-aminohippuric acid.
- Helps maintain acid-base balance and eliminate toxins.

RENIN-ANGIOTENSIN SYSTEM

The renin-angiotensin system is a crucial regulatory mechanism for blood pressure and fluid balance.

COMPONENTS AND MECHANISM

- **Juxtaglomerular Apparatus:** Specialized cells in kidney producing renin.
- **Renin Release Triggers:**
 - Decreased blood pressure
 - Reduced sodium levels
 - Sympathetic nervous system activation

CASCADE REACTION

- Renin converts angiotensinogen → Angiotensin I
- Angiotensin Converting Enzyme (ACE) converts Angiotensin I → Angiotensin II
- **Effects of Angiotensin II:**
 - Vasoconstriction (increases blood pressure)

- Stimulates aldosterone release
 - Increases ADH secretion
 - Stimulates thirst sensation
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NEURAL CONTROL AND COORDINATION

DEFINITION AND CLASSIFICATION OF NERVOUS SYSTEM

The nervous system is a complex network of specialized cells that coordinate activities throughout the body by transmitting signals between different parts of the organism.

ANATOMICAL CLASSIFICATION

- **Central Nervous System (CNS):**
 - Brain and spinal cord
 - Processing and integration center
 - Protected by skull and vertebral column
- **Peripheral Nervous System (PNS):**
 - All nerves outside CNS
 - Connects CNS to rest of body
 - Includes cranial and spinal nerves

FUNCTIONAL CLASSIFICATION

- **Somatic Nervous System:**
 - Controls voluntary movements
 - Innervates skeletal muscles

- Single motor neuron pathway
- **Autonomic Nervous System:**
 - Controls involuntary functions
 - **Sympathetic Division:** Fight or flight response
 - **Parasympathetic Division:** Rest and digest response

STRUCTURE OF A NEURON

Neurons are the basic functional units of the nervous system, specialized for conducting electrical impulses.

Component	Structure	Function
Cell Body (Soma)	Contains nucleus and organelles	Metabolic activities, protein synthesis
Dendrites	Short, branched projections	Receive signals from other neurons
Axon	Long projection from cell body	Transmit signals away from cell body
Axon Terminal	End branches of axon	Release neurotransmitters
Myelin Sheath	Fatty covering around axon	Insulation, increases conduction speed

TYPES OF NEURONS

- **Sensory Neurons:** Carry information from receptors to CNS
- **Motor Neurons:** Carry commands from CNS to effectors
- **Interneurons:** Connect neurons within CNS

GENERATION AND CONDUCTION OF NERVE IMPULSE

RESTING POTENTIAL

- Membrane potential when neuron is not active.
- Approximately -70 mV inside relative to outside.
- Maintained by sodium-potassium pump.
- High K^+ inside, high Na^+ outside the cell.

ACTION POTENTIAL

- **Depolarization:**
 - Stimulus opens voltage-gated sodium channels
 - Rapid influx of Na^+ ions
 - Membrane potential becomes positive (+30 mV)
- **Repolarization:**
 - Sodium channels close, potassium channels open
 - K^+ efflux restores negative membrane potential
 - Brief hyperpolarization may occur

PROPAGATION OF IMPULSE

- **Unmyelinated Axons:** Continuous conduction
- **Myelinated Axons:** Saltatory conduction
 - Impulse jumps between nodes of Ranvier
 - Faster conduction velocity
 - Energy efficient

STRUCTURE OF BRAIN AND SPINAL CORD

BRAIN STRUCTURE The human brain weighs approximately 1.4 kg and contains about 86 billion neurons.

- **Forebrain:**
 - **Cerebrum:** Largest part, divided into two hemispheres
 - **Diencephalon:** Thalamus, hypothalamus, epithalamus
- **Midbrain:**
 - Connects forebrain and hindbrain
 - Contains visual and auditory reflex centers
- **Hindbrain:**
 - **Cerebellum:** Coordination and balance
 - **Pons:** Relay center for cerebellum
 - **Medulla Oblongata:** Vital functions control

SPINAL CORD STRUCTURE

- Cylindrical structure extending from medulla oblongata.
- Length approximately 45 cm in adults.
- **Gray Matter:** Cell bodies arranged in H-shape
- **White Matter:** Myelinated axons forming tracts
- **Central Canal:** Contains cerebrospinal fluid

FUNCTIONS OF BRAIN REGIONS

Brain Region	Primary Functions	Associated Disorders
Cerebrum	Consciousness, memory, reasoning, voluntary motor control	Stroke, epilepsy, dementia
Cerebellum	Balance, coordination, motor learning	Ataxia, tremors
Hypothalamus	Homeostasis, hormone regulation, circadian rhythms	Diabetes insipidus, sleep disorders
Medulla Oblongata	Cardiac, respiratory, vasomotor control	Respiratory failure, cardiac arrest

CEREBRUM FUNCTIONS

- **Frontal Lobe:** Executive functions, personality, motor control
- **Parietal Lobe:** Sensory processing, spatial awareness
- **Temporal Lobe:** Auditory processing, memory, language
- **Occipital Lobe:** Visual processing

CEREBELLUM FUNCTIONS

- Maintains balance and posture
- Coordinates voluntary movements
- Motor learning and adaptation
- Cognitive functions (recent research)

HYPOTHALAMUS FUNCTIONS

- Temperature regulation

- Hunger and thirst control
- Circadian rhythm maintenance
- Hormone secretion control
- Emotional responses

MEDULLA OBLONGATA FUNCTIONS

- Cardiovascular control center
 - Respiratory control center
 - Reflex centers (coughing, sneezing, vomiting)
 - Relay station for ascending and descending tracts
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CHEMICAL COORDINATION AND REGULATION

ENDOCRINE GLANDS AND THEIR SECRETIONS

The endocrine system consists of ductless glands that secrete hormones directly into the bloodstream to regulate various body functions.

MAJOR ENDOCRINE GLANDS

- **Pituitary Gland:**
 - **Anterior Pituitary:** Growth hormone, prolactin, ACTH, TSH, FSH, LH
 - **Posterior Pituitary:** ADH, oxytocin
- **Thyroid Gland:** Thyroxine (T4), triiodothyronine (T3), calcitonin
- **Parathyroid Glands:** Parathyroid hormone (PTH)
- **Adrenal Glands:**

- **Adrenal Cortex:** Cortisol, aldosterone, androgens
- **Adrenal Medulla:** Epinephrine, norepinephrine
- **Pancreas:** Insulin, glucagon, somatostatin
- **Gonads:**
 - **Testes:** Testosterone
 - **Ovaries:** Estrogen, progesterone

FUNCTIONS OF HORMONES SECRETED BY ENDOCRINE GLANDS

GROWTH AND DEVELOPMENT HORMONES

- **Growth Hormone (GH):**
 - Stimulates growth of bones and muscles
 - Promotes protein synthesis
 - Regulates metabolism
- **Thyroid Hormones (T3, T4):**
 - Control basal metabolic rate
 - Essential for normal growth and development
 - Regulate body temperature

METABOLIC REGULATION HORMONES

- **Insulin:**
 - Lowers blood glucose levels
 - Promotes glucose uptake by cells
 - Stimulates glycogen synthesis

- **Glucagon:**
 - Raises blood glucose levels
 - Stimulates glycogen breakdown
 - Promotes gluconeogenesis
- **Cortisol:**
 - Increases blood glucose
 - Anti-inflammatory effects
 - Stress response hormone

WATER AND ELECTROLYTE BALANCE

- **Aldosterone:**
 - Regulates sodium and potassium balance
 - Controls blood volume and pressure
 - Acts on kidney tubules
- **Antidiuretic Hormone (ADH):**
 - Regulates water reabsorption in kidneys
 - Concentrates urine
 - Maintains blood osmolarity

CALCIUM HOMEOSTASIS

- **Parathyroid Hormone (PTH):**
 - Increases blood calcium levels
 - Stimulates bone resorption
 - Enhances calcium absorption in intestines

- **Calcitonin:**

- Decreases blood calcium levels
- Inhibits bone resorption
- Promotes calcium deposition in bones

REPRODUCTIVE HORMONES

- **Follicle Stimulating Hormone (FSH):**

- Stimulates follicle development in ovaries
- Promotes spermatogenesis in testes

- **Luteinizing Hormone (LH):**

- Triggers ovulation in females
 - Stimulates testosterone production in males
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HUMAN REPRODUCTION 🧑

PARTS OF FEMALE REPRODUCTIVE SYSTEM

The female reproductive system is designed for the production of eggs, fertilization, and nurturing of developing offspring.

EXTERNAL GENITALIA (VULVA)

- **Mons Pubis:** Fatty tissue covering pubic bone
- **Labia Majora:** Outer folds of vulva
- **Labia Minora:** Inner folds surrounding vaginal opening
- **Clitoris:** Sensitive erectile tissue
- **Vestibule:** Area containing urethral and vaginal openings

INTERNAL REPRODUCTIVE ORGANS

- **Vagina:**
 - Muscular tube connecting external genitalia to uterus
 - Length approximately 10-12 cm
 - Acidic environment (pH 3.8-4.5)
- **Uterus:**
 - Pear-shaped muscular organ
 - **Endometrium:** Inner lining that sheds during menstruation
 - **Myometrium:** Smooth muscle layer
 - **Perimetrium:** Outer covering
- **Fallopian Tubes (Oviducts):**
 - Transport eggs from ovaries to uterus
 - Site of fertilization
 - Length approximately 10-12 cm
- **Ovaries:**
 - Oval-shaped organs producing eggs and hormones
 - Contain follicles at various stages of development
 - Produce estrogen and progesterone

PARTS OF MALE REPRODUCTIVE SYSTEM

The male reproductive system is designed for the production, maturation, and delivery of sperm.

EXTERNAL GENITALIA

- **Penis:**
 - Male organ of copulation
 - Contains erectile tissue (corpora cavernosa and corpus spongiosum)
 - Urethra passes through corpus spongiosum
- **Scrotum:**
 - Pouch containing testes
 - Maintains temperature 2-3°C below body temperature
 - Essential for sperm production

INTERNAL REPRODUCTIVE ORGANS

- **Testes:**
 - Oval-shaped organs producing sperm and testosterone
 - Contain seminiferous tubules
 - Located in scrotum
- **Epididymis:**
 - Coiled tube attached to testis
 - Site of sperm maturation and storage
 - Length approximately 6 meters when uncoiled
- **Vas Deferens:**
 - Tube carrying sperm from epididymis to urethra
 - Length approximately 45 cm
 - Part of spermatic cord
- **Accessory Glands:**

- **Seminal Vesicles:** Produce fructose-rich seminal fluid
- **Prostate Gland:** Produces alkaline prostatic fluid
- **Cowper's Glands:** Produce pre-ejaculatory fluid

SPERMATOGENESIS AND OOGENESIS

SPERMATOGENESIS Spermatogenesis is the process of sperm formation occurring in the seminiferous tubules of testes.

- **Duration:** Approximately 74 days
- **Location:** Seminiferous tubules
- **Stages:**
 - **Mitotic Phase:** Spermatogonial divisions
 - **Meiotic Phase:** Primary and secondary spermatocytes
 - **Differentiation Phase:** Spermatids → Spermatozoa

HORMONAL CONTROL

- **FSH:** Stimulates Sertoli cells, supports spermatogenesis
- **LH:** Stimulates Leydig cells to produce testosterone
- **Testosterone:** Essential for spermatogenesis and male characteristics

OOGENESIS Oogenesis is the process of egg formation occurring in the ovaries.

- **Duration:** Begins during fetal development, completed at fertilization
- **Location:** Ovarian follicles
- **Stages:**

- **Multiplication Phase:** Oogonial divisions (fetal period)
- **Growth Phase:** Primary oocyte growth
- **Maturation Phase:** Meiotic divisions

FOLLICULAR DEVELOPMENT

- **Primordial Follicle:** Contains primary oocyte
- **Primary Follicle:** Surrounding follicular cells develop
- **Secondary Follicle:** Antrum formation
- **Graafian Follicle:** Mature follicle ready for ovulation

MENSTRUAL CYCLE

The menstrual cycle is a recurring process preparing the female body for pregnancy.

Phase	Duration (Days)	Key Events	Hormonal Changes
Menstrual	1-5	Endometrial shedding	Low estrogen and progesterone
Follicular	1-13	Follicle development	Rising FSH and estrogen
Ovulation	14	Egg release	LH surge
Luteal	15-28	Corpus luteum formation	High progesterone

MENSTRUAL PHASE (1-5 days)

- Shedding of endometrial lining

- Menstrual flow contains blood, endometrial tissue, and mucus
- Low levels of estrogen and progesterone

FOLLICULAR PHASE (1-13 days)

- FSH stimulates follicle development
- Rising estrogen levels
- Endometrial proliferation begins

OVULATION (Day 14)

- LH surge triggers ovulation
- Release of mature egg from Graafian follicle
- Fertile period for conception

LUTEAL PHASE (15-28 days)

- Corpus luteum forms from ruptured follicle
- High progesterone prepares endometrium for implantation
- If pregnancy doesn't occur, corpus luteum degenerates

HORMONAL REGULATION

- **Hypothalamic-Pituitary-Ovarian Axis**
- **GnRH:** Released from hypothalamus
- **FSH and LH:** Released from anterior pituitary
- **Estrogen and Progesterone:** Released from ovaries
- **Feedback Mechanisms:** Positive and negative feedback control hormone levels

