ZOO 362-COMPARATIVE ANIMAL PHYSIOLOGY

The study

MODULE	TOPIC
1.	**HOMEOSTASIS AS A CENTRAL CONCEPT IN PHYSIOLOGY** -
2.	**EXCRETION and OSMOREGULATION IN ANIMALS** - Major Excretory Organ [Kidney & types – Archinephros, Anamniote kidneys (Pronephros & Opisthonephros), Amniote Kidneys (Mesonephros & Metanephros) -Salt glands
3.	**INTEGRATING SYSTEMS:** **1**. **NERVOUS SYSTEM: [**CNS (Spinal cord & Brain), PNS (spinal nerves & cranial nerves-acousticolateralis system, branchial nerves, special sensory nerves, others) -**Autonomic N.S.** **-Sympathetic N.S.** **-Parasympathetic N.S.** **2. ENDOCRINE ORGANS:** (Pituitary, Thyroid, Parathyroid, Adrenal glands, Testes, Ovaries, Placenta) **3. SENSE ORGANS:** -Sight (eye); Hearing & equilibrium (ear), Olfactory (Nose), Taste (taste buds), Touch
3.	**MUSCULAR SYSTEM:** **-Voluntary versus Involuntary Muscles** **-Striated versus Non-striated muscles** **-Muscle cells and properties** **-Muscle functioning in movement, locomotion in animals**
4.	**REPRODUCTION:** -Reproductive Organs [Female organs (ovaries, oviducts), Male organs (testes, male ducts, copulatory organs, sperm types
PRACTICALS ON MODULES 1 - 4	
5.	**RESPIRATION:** **1. Respiratory Organs (**Nasal passages, Pharyngeal pouches & gills, swim bladder, lungs & air ducts, trachea & bronchi 2. **Respiration Types (** Pulmonary, Branchial, Cutaneous, Buccopharyngeal, Rectum & Cloaca) **3. Pharyngeal Derivatives** (Non respiratory – thyroid, thymus & parathyroid glands, tonsils, middle ear & Eustachian tube)
6.	**NUTRITION and DIGESTION SYSTEM: (GENERAL STRUCTURE)** **-Mouth and its associated structures (**lips, oral glands, tongue, teeth) -**Pharynx – Oesophagus, Stomach** (types & function)**, Intestine (**differentiation into distinct regions), **Digestive glands** (liver, pancreas)
7.	**BLOOD and CIRCULATION:** - Blood Vascular System (closed type), Lymphatic system, Blood & lymph, Blood forming tissues

	- Arterial System (Aortic Arches) - Venous system - Portal Circulation (hepatic, renal, hypophysio) - Fetal Circulation
8.	**BIOLUMINISCENCE IN ANIMALS**
9.	**CHROMATOPHORES and COLOUR CHANGE IN ANIMALS**
PRACTICALS ON MODULES 5 –	
CONTINOUS ASSESSMENT TEST (CAT)-ALL MODULES	

HOMEOSTASIS:

Homeostasis is a central concept in physiology that linked every other aspect of physiology together.

Homeostasis is the maintenance of stable *milieu interieur maintained* –the dynamic balance of multiple systems.

The essence of physiology is the maintenance of the stability of the internal environment –Homeostasis. All other system functioning is geared towards this end. A failure to achieve this by any animal will ultimately result in death.

The major mechanism of homeostasis is the **FEEDBACK MECHANISM:**

The two major types of feedback mechanism are NEGATIVE FEEDBACK and POSITIVE FEEDBACK mechanisms.

EXCRETION and OSMOREGULATION IN ANIMALS:

EXCRETION is the removal of wastes produced from metabolic activities.

IMPORTANCE:

- Nitrogenous waste products need to be removed because they are not further metabolised and therefore not of any use
- Nitrogenous wastes are toxic and their accumulation in the body is deleterious.

NITROGENOUS WASTES: These includes Ammonia, Trimethyl amine oxide (TMAO), Urea, Uric acid, Ornithine etc.

OSMOREGULATION is the maintenance of constant osmotic conditions in the body, which involves regulation of water content and solute concentration of

body fluids, particularly of sodium, potassium and chloride ions or the mechanism to achieve this.

IMPORTANCE:

- Removal of unwanted by-products of metabolism
- Removal of toxic wastes
- Regulation of ionic concentration of body fluids within a narrow limit of concentration in the body fluid for proper cell functioning.
- Regulation of water content of body fluid
- Regulation of pH

ANIMAL BODY FLUID:

Animal body fluid are separated into INTRACELLULAR –fluid within the cells and EXTRACELLULAR – fluid which bathes the cells such as TISSUE FLUID or LYMPH. This separation is achieved by means of the cell membrane.

MODE OF CIRCULATION and BODY FLUIDS:

In animals with CLOSED CIRCULATION or closed vascular system – Annelids and Vertebrates, the presence of blood capillaries helps in separating the tissue fluid from blood plasma.

In animals with OPEN CIRCULATION – Arthropods, Molluscs – the tissue fluid is mixed with plasma thus forming HAEMOLYMPH.

N:B-

- Tissue fluid, Blood and Haemolymph all constitute the extracellular fluids and formed the INTERNAL ENVIRONMENT of the animal, which surrounds the body cells.
- Affecting the movement of water molecules in and out of the animal as a whole is the salt content/concentration of the EXTERNAL ENVIRONMENT or INTERNAL MEDIUM

OSMOTIC ENVIRONMENTS:

There are two major environments involved in osmoregulation namely:
INTERNAL ENVIRONMENT this includes as stated above blood, lymph or tissue fluid, haemolymph, coelomic fluid, pleural and peritoneal fluid, cerebrospinal fluid, synovial fluid, aqueous and vitreous humour. which had been dealt with above

EXTERNAL ENVIRONMENT – could either be AQUATIC and TERRESTRIAL environments.

Aquatic environment:

i. Sea water: 3.45%NaCl; 1000 mOsm; $\Delta\ ^0C$ is -1.88 ^0C approx. -2.0 ^0C; salinity is 29‰ to 35‰
ii. Freshwater: rivers, ponds, lakes, marshes, streams, run-offs. NaCl is 1% that of sea water; $\Delta\ ^0C$ is -0.02^0C; salinity is normally zero i.e. < 1.0‰
iii. Brackish Water: river mouths (deltas), mangrove swamps and lagoons, creeks and stream mix. Salinity varies from <3‰ to >35‰ depending on the season; $\Delta\ ^0C$ varies from -0.2^0C to -0.5^0C.
iv. Saline Waters: Great salt lake(Utah-USA), Dead Sea (Israel) – salinity varies from 50 to 250‰; $\Delta\ ^0C$ varies from -13.5^0C to -15.0^0C

Terrestrial Environment:

This environment poses two problems to animals living in them

i. Constant loss of water by evaporation from body surfaces
ii. Flooding (not so common problem)

COMPARATIVE ACCOUNT OF GROUPS OF AQUATIC ANIMALS

In their response to variation in the osmotic concentration of the surrounding water, there are four groups of aquatic animals

i. ISOSMOTIC FORMS
ii. HYPEROSMOTIC FORMS
iii. HYPOSMOTIC FORMS
iv. HYPER-HYPOSMOTIC FORMS

INTEGRATING SYSTEMS:

The integrating system is a large net which runs throughout the organisms body and connects all parts of the organism informationwise, either by electrical means or chemical transmitters or transducers.

The integrating system as a large machinery to ensure survival of the organism, consists of the following NERVOUS SYSTEM (Brain/Spinal Cord/Cranial nerves-CNS and Autonomic Nervous System); SENSE ORGANS (receptors); ENDOCRINE SYSTEM (neurosecretions)

Elements of Nervous System: Neurons and Neuroglia

Neurons are primary structural and functional unit of the nervous system which consists morphologically of CELL BODY which may be oval or irregularly star shaped. Each neuron has one to many DENDRITES; usually transmits impulses toward the cell body. In addition are the AXONS which transmits impulses away from the cell body. Most axons, and only axons, are ensheathed in lamellae derived from the cellular membranes of SCHWANN CELLS which enclose lipids and proteins and help to coat the axons, this coating is called MYELIN SHEATH. The portion of the axon coated by myelin is the AXON CYLINDER and the point between two Schwann cells where the myelin sheath is interrupted is called NODE OF RANVIER.

NEURILEMMA is a second transparent sheath that is external to myelin sheath covering portion of axons outside of the brain and spinal cord. This membrane is also formed by the Schwann cells.

NEUROGLIA (=NERVE + GLUE): About half of the bulk of the brain is neuroglia and these cells are responsible for various functions, including potassium transport, nutrition, excretion, regeneration and repair.

Nerve impulse and synapse:

A nerve impulse is an electrical phenomenon that passes as a wave along the surface membrane of a nerve fibre. The crucial difference is that there 30x more potassium on the inside of the resting membrane and about 10x more sodium on the outside. The potassium leaks out through the membrane, but in some unknown way the membrane resists the entrance of sodium. The result is that there is a difference in electric potential across the membrane, with the inside negative. When the fibre is locally excited, the membrane briefly allows sodium to rush in, and the inside of the membrane changes to a positive potential. A tiny eddy of current is set up between the excited portion and adjacent portions of the membrane and the impulse is propagated along the fibre, switching charges ahead and restoring them behind as it travels. How the membrane pumps the sodium out is not well understood. **Check Sodium-Potassium Pump**

Synapse: The functional union of an axon of one neuron with a dendrite or nerve cell body of another neuron is called a SYNAPSE. Some neurons have only a few synapse while others have thousands. A synapse transfers impulses impulses only

in the direction away from the axon and only if a threshhold level of excitation is achieved.

Others: Tracts, nerves and ganglia

Some divisions of the System:

- Central nervous system (The brain and Spinal Cord)
- Peripheral nervous system (All other nerves and ganglia)
- Autonomic nervous system
- Afferent (Sensory) fibres
- Efferent (Motor) fibres

Reflex Arc: Simple stereotype movement in response to sensory stimuli. One input, no alternative pathways, the behavioural response involves no coordination of effector cells, no central neural control. Examples: the knee-jerk reflex, hand withdrawal response to heat. It can involve single cells, 2 cells or 3 cells, sensory neuron, interneuron and motor neuron.

Invertebrate nervous system: This is the simplest nervous system and are majorly NERVE NETS.

NUTRITION and DIGESTION SYSTEM:

FOOD

Food is required by animals to provide energy, for growth and replacement of worn-out tissues, proper health of individual.

The six classes of substances which must be taken in by animals to satisfy the three requirements above are water, carbohydrates, proteins, lipids, vitamins and mineral salts. All are called food substances and may be in solid or liquid form.

FEEDING MECHANISMS IN ANIMALS:

A. Macroscopic/Macrophagous feeding
B. Microscopic/Microphagous feeding
C. Fluid feeding

GROUPS OF ANIMALS BASED ON WHAT IS FED UPON:

A. Herbivores
B. Carnivores

DIGESTION: The enzymatic hydrolytic degradation of complex food substances is called digestion. Polysaccharides are broken down in stages to monosaccharides, proteins to amino acids and lipids to glycerol and fatty acids

TYPES OF DIGESTION:

1. **Intracellular**
2. **Extracellular**

DIGESTIVE ENZYMES:

1. **Carbohydrate splitting Enzymes**
2. **Protein Splitting Enzymes**
3. **Lipid Splitting Enzymes**
4. **Other Digestive Enzymes**

BLOOD AND CIRCULATION:

Why Circulation?

- Diffusion alone is not adequate for transporting substances over long distances
- The circulatory system solves this problem by bulk transport between the aqueous environment (interstitial fluid or plasma) surrounding cells and the organs that exchange gases, absorb nutrient and dispose of wastes.
- Transportation of metabolic wastes products from point of production to point of final removal
- Transportation of oxygen to cells where needed
- Transport of hormones from endocrine glands to target cells
- Circulation of heat around the animals' body.

Blood is a connective tissue with cells (red blood cell, leucocytes, platelets) suspended in fluid plasma (90% water, 7% protein), tissue fluid or lymph (0.85% prot. In man)

The Organs: Heart, arteries, veins

Types of Circulation:

- Open Circulation
- Closed Circulation

Types of Heart:

- Linear fish type – two chambered, consists of a ventricle and an atrium blood circulation is single circulation.

- 3-Chambered heart – 2 atria, 1 ventricle; found in amphibians and reptiles but the ventricle in reptiles is partially partitioned except crocodilians where it is fully partitioned
- 4- Chambered heart – 2 atria, 2 fully partitioned ventricle; found in crocodiles, birds, mammals – double circulation goes hand in hand with the advent of 4 chambered heart.

RESPIRATION:

Oxygen is required by aerobic animals in order to form ATP energy during oxidative phosphorylation process which is coupled with the electron transport system or respiratory chain reactions in the cells. Oxygen comes from external medium (air or water). It is therefore necessary for animals with a circulatory system to have a permeable part of the body surface covering where oxygen can diffuse into the circulatory system and carbon dioxide diffuse out of it. This are of the body surface is termed respiratory surface consisting of very thin layer of epithelium separating the circulating fluid from the external medium.

Respiratory Surface:

1. **Vascularized outgrowths of body wall projecting into water –Gills**
2. **Invagination of body surface leading to a highly branched in-growths – Lung or Trachea**

Types of gills:

1. **Scaphognathites, mastigobranchs, podobranchs, arthrobranchs, pleurobranchs - in crabs**
2. **Ctenidia – Molluscs**
3. **Papullae – echinoderms**
4. **Blood gills – larvae of Trichoptera, Chironomidae**
5. **Blood gills - fishes**

Tracheal system, Book lungs and Vertebrate Lungs:

1. **Tracheae – in air breathing arthropods**
2. **Book lungs or lung books – found exclusively in some members of the arachnids**
3. **Lungs – are found primarily in terrestrial vertebrates**

Mechanism of gaseous exchange in animals is called VENTILATION

BIOLUMINISCENCE IN ANIMALS:

Bioluminescence is the production and emission of light by a living organism. It is a form of luminescence or "cold" light emission. Less than 20% of this light generates thermal radiation.

PURPOSE:

1. Counterillumination camouflage
2. Attraction
3. Repulsion
4. Communication
5. Illumination

APPLICATION IN SCIENCE:

1. Genetic engineering – luciferase systems, reporter genes
2. Bioluminescence imaging
3. Symbiosis, quorum sensing
4. Investigation of photophores by individual designers

BIOLUMINESCENT ORGANISMS:

Arthropods – Firefly, Molluscs- *Quantula striata,* Marine invertebrates, Fish, Microorganisms.

Bioluminescence in Firefly:

$LH_2 + ATP + O_2 \xrightarrow{\text{luciferase } Mg^{2+}}$ Light + PP + AMP + L(o)

CHROMATOPHORES AND COLOUR CHANGE:

Chromatophores are specialised effector cells that contain pigments. The dispersion of the pigments reversibly alter the colour of the animal or determine the intensity of the colouration of the animal.

Chromatophores are found in varieties of animals such as Cnidarians, Annelids, Insects, Crustaceans, Echinoderms, Fishes, Reptiles and Amphibians, Cephalopod Molluscs.

Melanophore are melanin containing chromatophore (black pigments)

Xanthophores yellow pigments

Erythrophores red pigments

Leucophores white pigments
Iridophores Iridescent pigments.
Location: epithelia of the skin, sometimes found in the deeper tissues
Morphology: A single chromatophore cell contains only one type of pigment.
Chromatosome: Cluster of several chromatophores forming an organ and contains two or more differently coloured pigments.
Types:

1. **Monochromatic chromatosomes**
2. **Polychromatic chromatosomes**

Colour Change and Chromatophores:

1. **Physiological Colour Change:**
2. **Morphological Colour Change**