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By: Prieti Gupta

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CONTENTS

PHYSIOLOGY

Question Bank – (Previous Year Solved Question Papers)

S.No. *Chapterwise Reference Book* *Page*

ANIMAL PHYSIOLOGY - I

ANIMAL PHYSIOLOGY - II

■ ■

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QUESTION PAPER

(June – 2019)

(Solved)

PHYSIOLOGY

Time: 2 Hours] *[Maximum Marks : 50*

Note: *Use separate answer sheets for* ***Part I*** *and* ***Part II.*** *Be brief and precise in your answers. Draw neat and labelled diagrams, wherever necessary.*

PART I
ANIMAL PHYSIOLOGY

Q. 1. ***(a)*** **Define the following terms:**

(i) **Micelles**

Ans. Micelles : Micelles are lipid molecules that arrange themselves in a spherical form in aqueous solutions. The polar head groups of micelles form the outside surface of the molecule, facing the aqueous environment, and their hydrophobic chains are clustered in the interior, where water is excluded since they are non-polar.

(ii) **Osmoconformers**

Ans. Osmoconformers: Osmoconformers are marine organisms that maintain an internal environment which is osmotic to their external environment. This means that the osmotic pressure of the organism's cells is equal to the osmotic pressure of their surrounding environment.

(b) **Fill in the blanks :**

(i) **Trypsin helps in the digestion of _____ of the food.**

(ii) **Arachnids exrete _____ .**

(iii) **Small sized animals have _____ metabolic rate than large sized animals.**

(iv) **_____ releases the secretion of ecdysone in insects.**

Ans. *(i)*Protein, *(ii)* nitrogen, *(iii)* higher, *(iv)* Prothoracic glands.

(C) **Expand the following :**

(i) **RQ**

Ans. Respiratory Quotient.

(ii) **ADH**

Ans. Antidiuretic hormone.

Q. 2. ***(a)*** **Describe the structure of a nephron in mammalian kidney.**

Ans. Ref.: See Chapter-4, Page No. 37, Q. No. 4.

(b) **What is glomerular filtration ?**

Ans. Glomerular filtration is the first step in making urine. Kidneys are able to filter our blood for excreting nitrogenous waste products. The filtrate that accumulates immediately after filtering the blood is called Glomerular filtrate.

Q. 3. ***(a)*** **Explain the process of clotting of blood.**

Ans. Ref.: See Chapter-3, Page No. 28, 'Clotting Mechanism'.

(b) **What is the role of lymphatic system in the body ?**

Ans. Ref.: See Chapter-3, Page No. 29, Q. No. 1.

Q. 4. ***(a)*** **Explain the hormonal mechanism involved inovulation in mammals.**

Ans. Ref.: See Chapter-8, Page No. 66, Q. No. 3.

(b) **Give the desert adaptations in Kangaroo rat.**

Ans. Kangaroo rats got their name because they have long back legs and can leap long distances. Both of these features allow them to thrive in dry and semi-dry climates, where vegetation is scarce and they need to cover a lot of ground to find food. They have a number of other adaptations for desert life. Despite living in the heat of the desert, kangaroo rats don't sweat. They also have very oily coats. Both of these adaptations prevent them from losing water.

Q. 5. Explain the mechanism of chemical and electrical synaptic transmission.

Ans. Ref.: See Chapter-9, Page No. 72, 'Chemical Synaptic Transmission' and Page No. 73, 'Electrical Synaptic Transmission'.

Q. 6. Write short notes on the following :

(a) **Oxygen dissociation curve**

Ans. Ref.: See Chapter-2, Page No. 18, 'Oxygen Dissociation Curves'.

***(b)* Tracheal Respiration**

Ans. Insects, and some other invertebrates, exchange oxygen and carbon dioxide between their tissues and the air by a system of air-filled tubes called tracheae, which is called tracheal respiration. Tracheae open to the outside through small holes called spiracles. In the grasshopper, the first and third segments of the thorax have a spiracle on each side. Another 8 pairs of spiracles are arranged in a line on either side of the abdomen. Spiracles open into large tracheal tubes. These, in turn, lead to ever-finer branches. The branches penetrate to every part of the body. At their extreme ends, called tracheoles, they may be less than 1 μm in diameter. Every cell in the insect's body is adjacent to, or very close to, the end of a tracheole. In some of the flight muscles of Drosophila the tracheoles even penetrate their T-tubules bringing oxygen right next to the mitochondria that power the muscle.

***(c)* Mechanism of muscle contraction.**

Ans. Ref.: See Chapter-6, Page No. 47, 'Mechanism of Muscle Contraction'.

***(d)* Excitation of heart**

Ans. Ref.: See Chapter-3, Page No. 25, 'Excitation of Heart'.

PART II
PLANT PHYSIOLOGY

***(a)* Fill in the blanks of the following :**

***(i)* A very low concentration of _____ can lead to the closure of the stomata.**

***(ii)* _____is the most mobile nutrient in plants.**

Ans. *(i)* Potassium ions, *(ii)* Potassium.

***(b)* Choose the correct alternative from the words given within brackets :**

***(i)* Stomata allow entry of (H_2O/CO_2) necessary for the photosynthesis.**

***(ii)* (NH^+_4/NO^-_3) is the most preferred form of nitrogen by the plants.**

Ans. *(i)* CO_2, *(ii)* NO_3.

***(c)* Define the following :**

***(i)* Apoplastic pathway**

Ans. The apoplastic pathway is one of the two main pathways for water transport in plants, the other being symplastic pathway. In apoplastic transport, water and minerals flow in an upward direction via the apoplast to the xylem in the root.

***(ii)* Imbibition**

Ans. The absorption of water by the solid particles of an adsorbent causing it to enormously increase in volume without forming a solution is called imbibition. Solid substances or adsorbents which take part in imbibition are called imbibants, e.g., seeds, dry wood.

***(iii)* Stomatal Frequency**

Ans. Stomatal frequency can be defined as the number of stomata present per unit area of a leaf. Determination of stomatal frequency and the total area of stomata covered in a leaf are the essential prerequisite to assess the rate of water loss through stomata. Water stress results in a greater stomatal frequency.

Q. 8. Trace the transfer of electron from water to $NADP^+$ during light reaction in photosyn-thesis with proper diagram.

Ans. Ref.: See Chapter-13, Page No. 108, 'Photoreduction–Production of Reducing Power–NADPH' and 'Photophosphorylation–Production of ATP'.

Q. 9. Describe the function of essential elements in plants with proper examples.

Ans. Ref.: See Chapter-12, Page No. 96, 'Functions of Essential Elements'.

Q. 10. Describe the effect of auxin and cytokinin on plant growth and development.

Ans. Ref.: See Chapter-16, Page No. 135, 'Auxins' and Page No. 139, 'Cytokinins'.

Q. 11. *(a)* Discuss how plants responds towards biological stress

Ans. Ref.: See Chapter-18, Page No. 154, 'Biological Stress'.

***(b)* Describe the importance of heat-shock proteins in plants.**

Ans. Ref.: See Chapter-18, Page No. 158, 'The Heat-Shock Response'.

Q. 12. Write short notes on the following :

***(a)* Red Drop**

Ans. Ref.: See Chapter-13, Page No. 110, 'Red Drop'.

***(b)* Munch Pressure Flow Model**

Ans. Ref.: See Chapter-14, Page No. 123, 'Munch Pressure Flow Model'.

***(c)* Gifted species for nitrogen fixation**

Ans. Ref.: See Chapter-15, Page No. 126, 'The Gifted Species'.

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Sample Preview of The Chapter

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PHYSIOLOGY

ANIMAL PHYSIOLOGY-I

Nutrition, Feeding, Digestion

1

INTRODUCTION

Nutrition, feeding and digestion are the important mechanisms of physiology of an organism as animal obtain their energy supply from these functions. There are various adaptations in animals for obtaining food, which includes absorption through body surface, filter feeding, mucous trapping, sucking, biting, chewing etc. depending upon the nature of food required. The study of nutrition involves both the need for food to provide energy and the need for specific food components such as amino acids, vitamins, minerals etc. Feeding is the ingestion or intake of food, while digestion is defined as the breakdown of complex food molecules into simpler constituents. Digestion can be intracellular or extracellular. In this chapter, we will describe the various feeding strategies adopted by the animals regarding to the nature of available food. The process of absorption of food, the mode of digestion and energy metabolism will also be discussed in this chapter.

CHAPTER AT A GLANCE

NUTRITION

All animals are heterotrophs i.e. they depend on plants and other animals to obtain their food. Food components consist of proteins, carbohydrates, fats, water, minerals and vitamins required by all animals in same or different proportions. A balanced diet of nutrients is required by all the heterotrophic animals to survive, growth and meet their energy demands for all the physiological regulation.

Proteins

Proteins are essentially required for growth and are synthesised in the cells. Proteins are composed of 20 different amino acids in various combinations. Some of the amino acids are formed in the body, while the others have to be supplied through diet. The amino acids that are synthesised in the body are called **non-essential amino acids** while those that have to be supplied through diet are known as **essential amino acids**. Different organisms require different essential amino acids. In order to determine which amino acid is essential and which is non-essential, the method of deletion experiments is adopted. In this method, the growth and health of the animal is observed by removing a single nutrient from the diet. By this method it was found out that 9 amino acids are essential for the growth of human beings. The requirement of essential amino acids depends on the synthetic ability of the body cells of an organism. Organisms like mammals, that require many essential amino acids have a marked synthetic disability, while bacteria has marked synthetic ability as it require a few essential amino acids.

Carbohydrates

The maximum required energy of animals i.e. 55-75% is obtained from the carbohydrates. In case, if dietary intake of carbohydrates is low, then energy is obtained from the fats and proteins.

Drosophila is an exception, as it cannot fly in the absence of carbohydrates even though it uses stored fat for other metabolic processes.

There is no essential carbohydrate due to availability of variety of hexose sugars like glucose, fructose, mannose, and galactose as interchangeable sources of energy, but growth of certain animals will be better on one type of sugar than on another. The preference of certain insects for a certain carbohydrate can be called an essential or **preferred nutrient**. For example, maltose is the **preferred nutrient** for locusts as it enhanced its growth.

Lipids

Lipids or fats are in all the animal tissues as essential components of cell membrane. The majority of lipids in biological systems function either as a source of stored metabolic energy or as structural matrices and permeability barriers in biological membranes. In healthy, well-fed

humans only about 2 per cent of the energy is derived from the metabolism of protein. Large amounts of lipids are stored in tissue. In higher animals and humans, tissue consisting of fat cells and is widely distributed over the body–mainly under the skin, around deep blood vessels, and in the abdominal cavity and to a lesser degree in association with muscles. The functions of lipids include insulation, padding, synthesis of steroid hormones and carriers of fat soluble vitamins.

Cholesterol is a lipid (fat) produced by the cells, vital for normal body function but its excess in humans can be a cause for the development of atherosclerosis or hardening of arteries. The insects cannot synthesise cholesterol from their precursors. Therefore, it must be supplied in their diet. Three fatty acids–**linoleic, liolenic** and **archidonic** are considered essential fatty acids as these are not synthesised. Generally, animals have a better synthetic ability for lipids than for amino acids.

Vitamins

The diet containing only carbohydrates, fats and proteins is not a balanced diet. Vitamins are essential although these are required in small quantities in the range of milligrams or micrograms. The vitamins act as coenzymes in various metabolic reactions. The synthetic ability for vitamins also varies among different animal species and those, which cannot synthesise are called essential vitamins. The requirement of these vitamins must be fulfilled through its dietary sources. For instance, most animals can synthesise ascorbic acid but humans cannot. Some vitamins are fat soluble like A, D, E and K and the others are water soluble like B or C. The fat soluble vitamins are stored in the fat deposits of the body but water soluble vitamins must be supplied continually as they are lost through urine. The vitamins, their sources and functions and also the deficiency diseases are mentioned in the table 1.1 below.

Minerals and Trace Elements: Normally, 96% of the total weight of a mammal is composed of oxygen, carbon, hydrogen and nitrogen. The remaining nearly 4% is composed of calcium, phosphorus, potassium, sulphur, sodium, chlorine and magnesium. Out of known 90 naturally occurring elements, the 26 elements are known to be necessary in humans. The role of some important minerals is given in the table 1.1 on Page 3.

Table 1.1: The Vitamins and their characteristics

Name, Formula, and Solubility	Important Sources	Functions	Results of Deficiency or absence in humans, except as noted
Lipid-soluble Vitamins:			
A ($C_{20}H_{30}O$) anti-xerophthalmic	Plants form (carotene, $C_{40}H_{56}$) in green leaves, carrots, etc; is changed in liver to animal from ($C_{20}H_{30}O$), present in fish-liver oil (shark); both forms in egg yolk, butter, milk	Maintains integrity of epithelial tissues, especially mucous membrane; needed as part of visual purple in retina of eye	Xerophthalmia (dry cornea, no tear) secretion), phrynoderma (toad skin) night blindness, growth retardation, nutritional croup (hoarseness) in birds
D ($C_{28}H_{44}O$), antirachitic	Fish-liver oils, especially tuna, less in cod; beef fat; also exposure of skin to ultraviolet radiation	Regulates metabolism of calcium and phosphorus; promotes absorption of calcium intestine; needed for normal growth & mineralisation of bones	Rickets in young (bones soft, yielding, often deformed); osteomalacia (soft bones),
E or tocopherol ($C_{29}H_{50}O_2$), antisterility	Green leaves, wheat-germ oil and other vegetable fats, meat, milk	Antioxidative; maintains integrity of membranes	Sterility in male fowls and rats, degeneration of testes with failure of sperm-togenesis, embryonic growth disturbances, suckling paralysis and muscular dystrophy in young animals Blood fails to clot.
K ($C_{31}H_{46}O_2$), antihemorrhagic	Green leaves, also certain bacteria, such as those of intestinal flora	Essential to production of prothrombin in liver; necessary for blood clotting	
Water-soluble Vitamins			
B complex Thiamine (B_1) ($C_{12}H_{17}ON_4S$), antineuritic	Yeast, germ of cereals (especially wheat, peanuts, other leguminous seed), roots, egg yolk, liver, lean meat	Needed for carbohydrate metabolism; thiamine pyrophosphate an essential coenzyme in pyruvate metabolism (stimulates root growth in plants)	On diet high in polished rice, beriberi (nerve inflammation); loss of appetite, with loss of tone and reduced motility in digestive tract; cessation of growth; polyneuritis (nerve inflammation) in birds

Name, Formula, and Solubility	Important Sources	Functions	Results of deficiency or absence in humans, except as noted
Riboflavin (B_2) ($C_{17}H_{20}O_6N_4$)	Green leaves, milk, eggs, liver, yeast	Essential for growth; forms prosthetic group of FAD enzymes concerned with intermediate metabolism of food and electron-transport system	Cheilosis (inflammation and cracking at corners of mouth), digestive disturbances, 'yellow liver' of dogs, curledtoe paralysis of chicks, cataract
Nicotinic acid, or niacin ($C_6H_5O_2N$), antipellagric	Green leaves, wheat germ, egg yolk, meat, liver, yeast	Forms active group of nicotinamide adenine dinucleotide, which functions in dehydrogeneration reactions	Pellagra in humans and monkeys, swine pellagra in pigs, blacktongue to perosis in birds
Folic acid ($C_{19}H_{19}O_6N_7$)	Green leaves, liver, soyabeans, yeast, egg yolk	Essential for growth and formation of blood cells; co-enzyme involved in transfer of single-carbon units in metabolism	Anaemia, haemorrhage from kidneys, and sprue (defective intestinal absorption) in humans; nutritional cytopenia (reduction in cellular elements of blood) in monkeys; slow growth and anaemia in chicks and rats
Pyridoxine (B_6) ($C_8H_{12}O_2N$)	Yeast, cereal grains, meat, eggs, milk, liver	Present in tissues as pyridoxal phosphate which serve as co-enzyme in transamination and decarboxylation of amino acids	Anaemia in dogs and pigs; dermatitis in rats; paralysis (and death) in pig, rats and chicks; growth retardation
Pantothenic acid ($C_9H_{17}O_3N$)	Yeast, cane molasses, peanuts, egg yolks, milk, liver	Forms coenzyme A, which catalyzes transfer of various carboxylated groups and functions in carbohydrate and lipid metabolism	Dermatitis in chicks and rats, graying of fur in black rats, 'goosestepping' and nerve degeneration in pigs
Biotin (vitamin H) ($C_{10}H_{16}O_3N_2S$)	Yeast, cereal grains, cane molasses, egg yolk, liver, vegetables, fresh fruits	Essential for growth; functions in CO_2 fixation and fatty acid oxidation and synthesis	Dermatitis with thickening of skin in rats and chicks, periosisin birds
Cyanocobalamin (B_{12}) ($C_{63}H_{90}N_{14}O_{14}PC_0$)	Liver, fish, meat, milk, egg yolk, oysters, bacteria and fermentations of streptomyces; synthesised only by bacteria	Formation of blood cells, growth; coenzyme involved in transfer of methyl groups and in nucleic acid metabolism	Pernicious anaemia, slow growth in young animals; wasting disease in ruminants
C, or ascorbic acid ($C_6H_8O_6$)	Citrus fruits, tomatoes, vegetables; also produced by animals (except primates and guinea pigs)	Maintains integrity of capillary walls; involved in formation of 'intercellular cement'	Scurvy (bleeding in mucous membranes, under skin and into joints) inhumans and guinea pigs

Source: *T.L. Storer, R.L. Usinger, R.C. Stebbins, and J.W. Nybakken, General Zoology, 6th ed., McGraw-Hill, New York, 1979.*

Table 1.2: Physiological role of important minerals

Elements	Physiological Role	Deficiency Disease	Source
Sodium (Na)	Main extracellular positive ion; Regulates plasma volume, acid-base balance; nerve and muscle function	Unknown on normal diet, Secondary in illness or injury	Table salt, salt added to prepared food
Potassium (K)	Major intracellular positive ion; nerve and muscle function; acid base balance	Secondary to illness, injury or diuretic therapy; paralysis, mental confusion muscular weakness	
Calcium (Ca)	Component of bones, teeth; regulation of nerve, muscle function; blood clotting	Children–rickets Adults–ostomalacia	Dairy products, beans, leafy vegetables
Phosphorus (P)	Bone formation, part of DNA, RNA, ATP, etc.; energy metabolism	Children–rickets Adults–ostomalacia	Phosphate food additives
Magnesium (Mg)	Bone and teeth; carbohydrate metabolism	Secondary to malabsorption or diarrhoea, alcoholism	Leafy green vegetables
Chlorine (Cl)	Major extracellular negative ion; osmotic and acid-base balance; stomach acid	In infants fed on salt free formula; secondary to vomiting, diuretic therapy, renal disease.	Table salt

The 15 additional elements are also required but their total combined amount in mammalian body is less than 0.01% of the body weight, hence these are known as trace elements. Some of these trace elements are essential for the normal growth of one organism may not be required for others. The physiological role of trace elements is described in the following table.

Table 1.3: Physiological Role of Essential Trace Elements

Elements	Physiological Role	Deficiency Disease	Source
Iron (Fe)	Component of haem group in haemoglobins, cytochromes	Anaemia	Iron cookware
Copper (Cu)	Needed to make haemoglobin, bone, part of cytochrome	Anaemia, secondary to malnutrition, Monkey's syndrome	
Iodine (I)	Component of thyroid hormone	Children; cretinism Adults: goitre, hyperthyroidism, myxedema	Iodised salt, seafood
Manganese (Mn)	Needed in urea formation, protein metabolism, glycolysis, citric acid cycle	Unknown in humans	
Cobalt (Co)	Constituent of vitamin B_{12}, RBC formation	B_{12} deficiency	Foods of animal origin
Zinc (Zn)	Essential constituent of many enzymes, needed for normal senses of smell and taste	Hypogonadism, growth failure, impaired wound healing, decreased taste and smell	
Molybdenum (Mo)	Constituent of some enzymes	Secondary to parenteral nutrition	
Flourine (F)	Hardness of teeth	Dental caries	Drinking water
Selenium (se)	Needed in fat metabolism	Marginal deficiency where salt content is low, secondary to parenteral nutrition	
Chromium (Cr)	Needed in glucose metabolism	Impaired glucose tolerance	

Water

Water constitutes up to 95% of the fresh weight of some animals. It must be taken by drinking, through food and in small quantities by metabolic processes as it is lost through sweat, excretion and evaporation from the respiratory surfaces.

FEEDING MECHANISMS

The feeding mechanisms depend on the nature of the food required as food can be obtained by the animals in different ways. Each and every mechanism for obtaining food is difficult to discuss in detail but the following table describes the basic principles on which the different feeding mechanism operate in animal groups according to the type of food available.

Table 1.4: Feeding methods classified according to type of food

Type of food	Method of feeding	Animals using the method
Small particles	Digestive vacuoles	Amoeba, Radiolarians
	Use of cilia	Ciliates, Sponges, Bivalves, Tadpoles
	Mucous traps	Gastropods, Tunicates
	Tentacles	Sea cucumbers
	Filter feeding	Small Crustanceans, Herrings, Baleen Whales, Flamingoes, Petrels
Large food masses	Ingestion of inactive masses	Detritus feeders, Earthworm
	Scraping, chewing, boring	Sea urchins, Snails, Insects, Vertebrates
	Capture and swallowing of prey	Coelentrates, Fishes, Snakes, Bats, Birds
Fluid or soft tissue	Sucking plant sap, nector	Aphids, Bees, Humming-birds
	Ingestion of blood	Leaches, Ticks, Insects Vampire bats
	Sucking of milk or Similar secretions	Young Mammals, Young Birds
	External digestion	Spiders
	Uptake from body surface	Parasites, Tapeworm
Dissolved organic solution	Uptake from dilute solution	Aquatic invertebrates
Symbiotic supply of nutrients	Intracellular symbiotic algae	Paramecium, Sponges, Flatworms, Corals, Hydras, Clams.