University of Calcutta

Department of Physiology

Syllabus for admission test for enrolment to the Ph.D. Program

Admission test

Full Marks: 50

Duration of exam: 2 hr.

Distribution of marks and framing of questions:

1mark	10 questions	= 10 Marks
2 marks	10 questions	= 20 Marks
5 marks	2 questions	= 10 Marks
10 marks	1question	= 10 Marks
Total		50 Marks

Syllabus

Modules:

1. Cellular and Molecular Physiology
2. Systems Physiology
3. Advanced Physiology
4. Computer Applications and Biostatistics

1. Cellular & Molecular Physiology (15 marks)

a. Cellular organization, cell to cell communication and signalling

Membrane structure and function; Structural organization and function of intracellular organelles; Cell division & cell cycle; Cell signaling; Cellular communication; Cancer.

b. Biomacromolecules and their principles of interactions

Bonds in biochemical reactions; Molecular thermodynamics; Principles of colloidal chemistry; pH of body fluids; Conformation of proteins and polypeptides – Amino acid sequences; Secondary, tertiary, quarternary and domain structure of proteins; Reverse turns and Ramachandran plot; Helix-coil transition; Protein folding and its problems: Role of chaperons; Structure and stability of tRNA, rRNA and mRNA; Structural

polymorphism of DNA and RNA; Characteristics of viral, prokaryotic and eukaryotic DNA, circular DNA, superhelix and relaxed circles, pallindromes; Structural characteristics of polysaccharides, glycolipids, glycoproteins and peptidoglycans.

c. Enzymology

Structural basis of enzyme function: Active sites, Coenzymes, Activators, Inhibitors, Isoenzymes, Kinetics of enzyme action; Mechanism of enzyme action, Regulation of enzymatic activity, Rate limiting enzymes; Allosteric enzymes and their modulators; Mechanism of enzyme induction and repression; Technical approach to the study of enzyme activities; Purification and characterization of enzymes; Clinical enzymology, Diagnostic and therapeutic uses of enzymes.

d. Bioenergetics

Concepts of free energy and strategies of energy metabolism; High-energy biomolecules and coupling phenomenon, energy-rich bonds, weak interactions, group transfer, Biological energy transducers and bioenergetics; Oxidative phosphoryltion and mitochondrial function; Uncouplers and inhibitors of oxidative phosphorylation; Extramitochondrial electron transport chains; Oxygen toxicity and superoxide dismutase.

e. Metabolism

Carbohydrate metabolism; Lipid Metabolism; Amino Acid Metabolism; Amphibolic intermediates Nucleotide Metabolism; Membrane Metabolism;

f. Molecular biology

DNA as the molecule of information: DNA as the genetic material and its organisation, the law of DNA constancy and C-value paradox.

Perpetuation of DNA: DNA replication and its regulation; DNA-repair, DNA damage and repair, chromosome aberration: Transposons; somatic cell egentics; genome organization (in both prokaryotes and eukaryotes), the law of DNA constancy and C-value paradox.

DNA to Protein: Transcription, RNA-polymerases, Operon, m-RNA, Genetic-code, Protein biosynthesis & regulatory factors, Mechanism of action of inhibitors.

Molecular Organisation of eukaryotic genome: Packaging of eukaryotic DNA into chromosomes, nucleosomes, exons, introns, cis-acting and trans-acting regulatory elements, regulatory DNA sequences.

Regulation of gene expression, both prokaryotic and eukaryotic: Regulation of transcription, transcription factors, motifs, RNA splicing and post-transcriptional modification, catalytic RNA, Rearrangement of DNA, Antisense RNA.

Genomics and Proteomics: Definition of genome and proteome. Importance in modern biology.

g. Biotechnology

Concepts of Biotechnology: General & historical, aims, achievements and prospects. Microbial technology : Fermentation technology, production of ethanol, penicillin and other antibiotics, microbial-insecticides, enzymes, amino acids etc. and application in industry. Use of microorganisms in pollution control. Enzyme biotechnology: Immobilized enzymes and its application in industry. Principles of protein engineering. Biotechnology as applied to Immunology.

h. Human genetics

Organisation of human chromosomes; Inheritance; Genes in the Kinderds and in the individuals: Genetic variations, genetic factors in diseases, Pedigree analysis; Immunogenetics; Genes in Development and Differentiation; Population Genetics; Hardy-Weinberg equilibrium, mutation, selection, drift, gene flow, inbreeding, genetic diversity, races; Genetics disorders: Sickle cell anemia, hemophilia, thalassemia, cystic fibrosis, Huntington disease, Colour blindness, Phenylketonuria; Cancer Genetics; Molecular diagnosis of genetic disorders: Use of RE, RFLP, Oligonucleotide probes, DNA-probes, DNA blotting, etc. DNA fingerprinting and SNP analysis, Genetic screening and genetic counseling; The Human genome project (HGP): Implications and future prospects.

i. Physiology of excitable cells

Nerve : Axoplasmic flow and transport mechanism in the axons; Problem of nerve conduction with reference to single nerve fibre study; Nature of nerve fibre excitation and interpretation of action potential; voltage gated channels and gating currents. Voltage clamp of nerve fiber membrane and membrane currents. Patch clamp and unitary activity of membrane channels.

Neuro-Muscular Junction (NMJ) : Neuro-muscular transmission – Electrical and Biochemical events; Acetylcholine receptor – Protein and antigenic structure and its relevance to myasthenia gravis, structure-function relationship; Acetylcholine – Structure-function relationship, Metabolism and Regulation; Drugs acting at NMJ; Motor unit, MUAP, motor unit recruitment patterns.

Muscle: Protein components and contraction mechanism in different types of muscles. Excitation – contraction coupling, Role of fast and slow channels, Ca^{++} -binding protein including calmodulin, Muscle fibre types

2. Systems Physiology (15 marks)

a. Blood and Hemodynamics

Hematopoiesis; Erythrocytes; Hemoglobin, Iron-ferritin-transferin system, Leukocytes; Leukemia, Eosinophilia, Immuno deficiency diseases; Hemostasis & Thrombosis: Blood antigen, Blood transfusion technology, Applications of hematological techniques, other fluid systems of body; Haemodynamics: Fundamental concepts.

b. Cardiovascular Physiology

Evolution of Heart on a comparative basis. Anatomy and General Function: Electrical activity of Heart and Cardiac Efficiency : Autonomic Nervous System: Chemical and reflex action by receptor system; Cardiovascular homeostasis; Cardiovascular reflexes; Cardiac Metabolism and the role of neurohormones; Regional circulation; Applied Aspects Related to Cardiovascular System; Myocardial necrosis and Myocarditis: Molecular basis of Cardiac Hypertrophy, Heart failure and Ischaemic Heart Disease. Coronary bypass, coronary angioplasty; Cardiotoxins; Heart transplantation.

c. Respiratory Physiology

Basic Principles: Evolution of the atmosphere; Biological consequence of an oxidizing environment; Turnover rates of atmospheric gases; Evolution and adaptation; Morphology of lung: Elastic forces, lung volumes, Pressure/volume relationship of the lung and thoracic cage; measurement of compliance and lung volumes; elastic recoil of the lungs and thoracic cage; Principle of Lung function tests. Respiratory system resistance : Physical principles of gas flow and resistance; Respiratory system resistance; Factors affecting respiratory resistance; Muscular control of airway diameter; Work of breathing; Respiratory gas equation and alveolar air equation; Alveolar ventilation and perfusion ratio. Non-respiratory functions of the lung: the endocrine lung; Physiology of pulmonary diseases; Artificial Ventilation: Non-invasive ventilation; Lung transplantation; Respiratory system & Immune function. Respiratory functions in altered conditions: Respiratory function in pregnancy; The lungs before birth, Events at birth; Neonatal lung function; Respiratory distress syndrome; Sudden infant death; Respiratory function during exercise and sleep; Respiration in closed environments and space; Respiration in high altitude, Hypoxia, Hyperoxia and Oxygen toxicity.

d. Neurophysiology

Central Nervous system: Modern techniques for studying nervous mechanism including neuroimaging. Neuro- & gliogenesis, neuronal

migration. Myelination and dysmyelinating conditions. Structure and functions of neuroglia. Neural Plasticity. Higher order functions of Cerebral Cortex, Dominant Cortex, Laterality. Cognition, Learning and Memory- cellular and Molecular basis. Structure activity relationship (neural circuitry) of cerebellum, Vestibular apparatus and its functions, Regulatory function of cerebellum with special reference to autonomic function. Neurophysiological basis of decerebrate rigidity and role of higher centres in the regulation of muscle tone. Importance of basal ganglia in the regulation of automatic movements. Modern concept of hypothalamic functions. Neurological disorders of brain- general cellular events; Mechanism of development of degenerative diseases - Alzheimer's, Parkinson's Disease, ALS etc. Thalamo cortical projections and its influence on evoked cortical activity, Brain Waves, Sleep, wakefulness.

e. Sensory physiology

Sensory modalities, Sensory receptors, Sensory circuits, and Sensory perception.

Chemical senses: Taste system – Receptor organs – distribution, ultramicroscopic structures, innervation, replacement of cells and formation of taste buds; Taste qualities and substances evoking primary taste sensations - membrane mechanisms of transduction; Sensory processing; Taste pathways; Taste behaviour. Olfactory system – Olfactory epithelium and receptors, turnover and regeneration of olfactory receptor cells; Olfactory bulb; Odour responses, coding of olfactory informations, spatial patterns, plasticity, neurotransmiters; odour transduction; Central olfactory connections; Psychophysics – Anosmia and directional smelling; Olfaction and behaviour.

Visual Sense: Structures of retina and sensory transduction; Visual pathway, Visual cortex and cortical processing; Colour vision – retinal and neural mechanisms, binocular and stereoscopic perception; Psychophysical measurements of visual performance; Higher functions in vision – Neural encoding, recognition of objects, space perception and selective processes in perception.

Auditory Senses : Organ of corti-ultramicroscopic structure, cochlear mechanics, sensory transduction and processing; Functions of auditory system – Frequency analysis and its discrimination; pitch; Intensity processing – factors determining loudness, discrimination of loudness, loudness adaptation, masking, auditory fatigue; Processing of speech; Perception of sounds in space.

f. Gastrointestinal Physiology

Histomorphology; Digestive juice and regulation of its secretion; Role of hepatobilliary systems in GI functions; Gastrointestinal hormones and their interplay; Immune function of GI Tract; Central control of gastrointestinal functions; Diseased conditions and their management (Ulcer, Malabsorption and Diarrhoea); Cancer of the GI Tract.

g. Renal Physiology

Anatomy and histomorphology of kidney; renal blood flow; Methods of study of renal tubular function. Tubular transport mechanisms and trans-tubular potential. Counter current multiplier and exchanger systems; renal regulation of sodium-ion-exchange, body fluid volume. Neural and Endocrine control of renal functions; Non-excretory functions: renin-angiotensin system, erythropoietin system, biosynthesis of dihydroxychole-calciferols, guanidoacetate and prostaglandins; Pathophysiological aspects and renal failures.

h. Endocrinology and Reproductive Physiology

Functions of hormones, interaction of hormones. Chemistry of Hormones: Chemical nature, synthesis, storage, release, transport and degradation of steroids, amines and peptide hormones. Cytokines and growth factors. Hormonal regulation of metabolism: Carbohydrate, protein, lipid, water, minerals/electrolyte. Disorders of endocrine fumctions.

Embryology of the gonads and the genital ducts. Function of mammalian testis: Spermatogenesis; Sertoli cells – germ cells – Leydig cells interaction; functions of sertoli cells and Leydig cells. Structure of Sperm: Histology, Biochemistry and capacitation of spermatozoa. Functions of mammalian ovary: Folliculogenesis, Ovogenesis, Ovulation, Luteinization and Luteolysis. Biological action of gonadotropins on gonads. Feed-back control of gametogenesis and endocrine functions of gonads. Pineal glands and Photoperiods – gonadal functions. Fertilization: Molecular mechanism of fertilization; acrosomal reaction; chemical, mechanical and immunological method of controlling fertility; in vitro fertilization, preservation of gamates and embryotransfer. Implantation: Decidualization, function of placenta and foeto-placental unit, placental hormone (synthesis, control, role in foetal life and bioassay of HCG). Parturition and Lactation: Regulation of parturition and lactation. Onset of Puberty: Reproductive cycles and its hormonal regulation. Principle and Techniques of fertility regulation in male and female.

3. Advanced Physiology (15 marks)

a. Exercise and Sports Physiology

Classification of physical exercise, sports, workloads etc. Hematological changes during graded muscular exercise. Heart rate, blood pressure, pulmonary ventilation, ventilation equivalent, VE Max, VO_2Max; Alveolar ventilation at different state of breathing. Lactic acid concentration and O_2 debt. Nutrition in sports and exercise. Cardiorespiratory changes in sedentary and trained persons during exercise. Concept of Physical fitness. Physiological effects of doping / drug abuse.

Physician's Interest in the Physiology of Exercise; Dynamic Physical Examination; Principles of safety in Physical Activity and sports; Management of Illness and Injury sustained in Exercise Activities; Rehabilitation procedures.

b. Work Physiology & Ergonomics

Assessment of Physiological and mental stress; Evaluation of physiological fatigue during over-load job in extreme environment.

System Design; Work Study and Method Study; Ergonomics in Safety; Anthropometry: Definition of Anthropometry; Static & Dynamic Anthropometry; Application of Anthropometry in design development.

Design Ergonomics, Human error and its relation with psychological condition during operation; Decision making and cognitive ability; Cost-effective study and improvement of individual productivity;

c. Immunobiology

Antigenicity and immunogenicity, Cellular and molecular interaction during induction of immune responses, basic structure of antibody, immunodiagnostics, immunity to infectious diseases, vaccine development, immune response to inflammatory reaction and role of interleukins

d. Microbial Physiology

General Microbiology: Different types of microbes, classifications; morphology, structure, classification, reproduction and physiology of bacteria. Microbial fermentation; antibiotics; organic acids and vitamins; microbes in decomposition and recycling processes; symbiotic and asymbiotic N2-fixation; microbiology of water, air, soil and sewage: microbes as pathological agents in man; general design and applications of biofermenter and biofertilizer. Man-microbe interactions: Commensals, beneficials, parasites and pathogenic microbes. Microbial Pathogenecity: Germ theory of disease, Infectious diseases and its control. Microbial Flora: Normal microbial flora of humans on the skin, in the Gastro-

intestinal tract, Respiratory tract, Urino-genital tract etc. and their role in health and disease.

e. Molecular Neurophysiology, Applied Neurophysiology & Advanced Electrophysiology

Molecular basis of neural induction, differentiation of neurons and glia, and generation of neuronal diversity. Molecular basis of growth cone motility and axon guidance. Neurotrophin signaling. Molecular basis of neurodegenerative and demyelinating diseases.

Self stimulation behavior and pleasure stimulus; Neurophysiology of learning, attention and memory; Epilepsy and its management, kindling and inhibition; Postural and vestibular reflexes (human studies); Biofeedback, galvanic skin resistance (GRS) and autonomic reflexes; startle reflexes, analgesia and analgesics and emotional behavior; Neuroimmunology.

Microelectrodes, brain stem auditory evoked potential, power spectrum analysis of EEG, cognitive negative variation.

f. Stress Physiology

Oxidants, oxidative stress, oxidative damage, antioxidants. Enzymatic and non-enzymatic antioxidants. Mechanisms of actions. Fenton-reaction, Haber-Weiss reaction. Stress-induced disorders and role of antioxidants in ameliorating these disease situations.

g. Molecular Endocrinology And Neuro-Endocrinology

Mechanism of hormone actions: Membrane bound and intercellular receptors; steroid hormone-receptor interactions; membrane bound hormone-receptor interactions; second messenger in hormone action/signal transduction; recycling of receptors. Hormones in immune responses: Autoimmune endocrine disorders. Non-Conventional Endocrine Molecules in Health & Disease

Neuroendocrinology: Hypothalamus as neuroendocrine organ, process of neurosecretions and neurosecretory materials, synthesis, transport, release, functions and control of neurosecretory materials.

Chronobiology: Zeitgebers, Cellular mechanisms of clock, Human Circadian Rhythm and its mechanism of control- cellular and molecular mechanisms; The SCN, photic and non-photic entrainment pathways, Jet Lag, shift-work.

h. Nutritional Biochemistry and Dietetics

Nutritional survey, assessment, counselling. National & International bodies – their role in community nutrition- ICDS, Mid day meal, Immunization programme. Food guide pyramid, food groups, exchange

list. Meal planning, serving portion, mode of feeding. Nutrition in paediatrics & geriatrics. Nutrition in under-nutrition (PCM) & over nutrition (obesity). Nutrition in metabolic (Diabetes mellitus & Gout) & Systemic (Cardiovascular, Renal) disease. Nutrition in stress, cancer, space.

i. Principles Of Environmental Physiology

The Environment: Physical environment; biotic environment; biotic and abiotic interactions; Habitat and niche; Species interactions; Community ecology; Ecological succession; Ecosystems; Biogeography; Applied ecology; Environmental pollution; global environmental change; biodiversity-status; Conservation biology;

Environmental Pollution and its control: Air, Water, Radiation and Thermal, Noise Pollution.

j. Space & Aviation Physiology

Atmospheric requirements of Man in space; Waste removal and/or storage; Human tolerances to stresses in space including space flight: Acceleration, Deceleration, Weightlessness, Thermal Extreme, High 'g', Ionizing Radiation, Meteorites; The Cabin Atmosphere (Space Craft): Nutritional problems, Isolation & Sensory Deprivation; General Medical Emergencies.

k. Biomedical Instrumentation

Basic Idea on Electronic Instruments : Transducers: Temperature, Force and Pressure Transducer, Pulse Sensor, Optical Transducer, Optical Fibre Sensors, Electrochemical Sensors, Position Transducer. Cathode Ray Oscilloscope, Chart Recorder, Ultraviolet Recorder, Fibre Optic Recorder, Magnetic Tape Recorder, Computer Data Logging.

Structural and Analytical Instruments: Electrophoresis - Agarose, Polyacrylamide; Chromatography – Ion Exchange, Affinity, HPLC, GLC; X-ray crystallography, NMR spectroscopy.

Bio-medical Instrumentation: CT scan, ultrasonography, MRI, pulmonary function analyzer, biomedical telemetry.

4. Computer Applications and Biostatistics (5 marks)

Basic Architecture of Computer

Software and Programming Language: Machine Language; Assembly Language; High Level Language; (FORTRAN, COBOL, C++, UNIX, BASIC), Statistical packages.

Simulation & Modeling of Physiological Problems.

Some utility softwares for life sciences research

Application of Computer for Solving Physiological Problems

Testing of Hypothesis; Probability Distributions; Nonparametric Statistics; Correlations; Regressions; Analysis of Variances

Applications of Statistical principles in physiological problems.