



INDRASHIL UNIVERSITY

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A Life Sciences University

Sustained Excellence with Relevance



योग: कर्मसु कौशलम्

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DEPARTMENT OF BIOSCIENCES

PROGRAM STRUCTURE & DETAILED SYLLABUS

M.Sc. ANIMAL BIOLOGY 2019-2021



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SEMESTER – I			
Subject code	Subject Name	L-T-P	Credits
BIO 401	Cell Biology	3-1-0	4
BIO 402	Genetics	3-1-0	4
BIO 403	Macromolecular Structure & Function	3-1-0	4
BIO 404	Ecology & Evolution	3-1-0	4
BIO 405	Analytical Tools & Techniques (Lab)	0-0-12	6
	Total	12L+4T+12P	22
SEMESTER – II			
Subject code	Subject Name	L-T-P	Credits
BIO 406	Microbiology (Diversity and Systematics)	3-1-0	4
BIO 407	Molecular Biology	3-1-0	4
BIO 408	Enzymology	3-1-0	4
BIO 409	Metabolic Pathways	3-1-0	4
BIO 410	Analytical Tools & Techniques (Lab)	0-0-12	6
IU M 000	Basic Communication and Soft Skills	1-0-0	0
	Total	12L+4T+12P	22



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SEMESTER – III			
Subject code	Subject Name	L-T-P	Credits
BIO AB 501	Physiology (with emphasis on disease orientation)	3-1-0	4
BIO M-501	Immunology	3-1-0	4
BIO M 502	Reproduction and Developmental Biology	3-1-0	4
BIO M 503	Genetic Engineering	3-1-0	4
BIO M 504	Bioinformatics (Lab)	0-0-4	2
BIO AB 502	Biology Laboratory Techniques (Lab)	0-0-8	4
	Total	12L+4T+12P	22
SEMESTER – IV			
Subject code	Subject Name	L-T-P	Credits
BIO M 505	Stem Cells & Regenerative Medicine	3-1-0	4
BIO AB 503	Neuro-endocrinology	3-1-0	4
BIO AB 504	Research or Industrial Project/Viva	-	14
	Total	6L+ 2T	22

Credit to hours calculation:

Lecture: 1h = 1C

Practicals: 2h = 1C

Total Credits: 88



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SEMESTER - I

BIO 401 Cell Biology (L-T-P-C: 3-1-0-4)

Unit 1:

- Comparison of prokaryotic and eukaryotic cells
- General methods in cell biology
- Ultrastructure of plasma membrane
- Plant cell membrane-structure and function
- Cytoskeletal elements

Unit 2:

- Mitochondria- structure, biogenesis and evolution
- Mitochondria and male sterility
- Chloroplast –structure, organization, Function, Protein Import, Biogenesis, Genome and genetic manipulation
- Chloroplast mitochondrial interaction

Unit 3:

- Lysosomes- biogenesis, pathophysiology
- Peroxisomes, glyoxysomes
- Plant vacuoles
- Plant cell wall, Plasmodesmata
- Cell growth and division (mitosis, meiosis and cell differentiation)

Unit 4:

- Biosynthetic process in ER and Golgi Apparatus
- Vesicular Traffic from ER through Golgi Apparatus
- Trans Golgi Network, endocytosis and exocytosis
- Programmed Cell Death

Text Books:

1. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.

Reference Books:

1. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. "Molecular Biology of the Cell". Garland Science
2. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA
3. Latest review articles from Peer reviewed journals



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BIO 402 Genetics (L-T-P-C: 3-1-0-4)

Unit 1:

Mendelian Genetics and analysis: Extension of Mendelian analysis. Chromosomal basis of Inheritance. Chromosome characteristics: Chromosome structure, Euchromatin and heterochromatin, Coding and Non-coding sequences, transposons

Unit 2:

Genetic Recombination in Eukaryotes. Linkage and Crossing Over, Chromosome mapping, Tetrad analysis and Gene Conversion. Mutations and mutagenesis. Detection, Molecular basis and Applications. Chromosomal Changes: Number variation – Euploidy (auto and allo polyploidy), aneuploidy. Structural variations – Deficiencies, duplications, Inversions, translocations. Interaction of Genotype and Environment, Twin studies, genetic environment, non-genetic environment, phenocopies, penetrance and expressivity

Unit 3:

Gene expression regulation during differentiation and growth

Heterochromatinization in human beings and other mammals, dosage compensation, mechanism, sex chromatin, position effect

Unit 4:

Quantitative inheritance

Continuous traits – multigenic variability, dominance – additivity, norms of reaction

Non-Mendelian Inheritance; Plastid mutations – nature and mode of transmission

Mitochondrial traits – nature and mode of transmission; Applications

Unit 5:

Population Genetics: Genotype and allelic frequencies, the Hardy-Weinberg equilibrium, non-random mating, consequences of homozygosity, factors affecting gene frequencies, heterosis, mutation – effect on allele frequencies, migration and genetic drift

Developmental Genetics: Model system *Drosophila*, Genetic screen, Pattern formation, Maternal effect, Homoeotic transformations.

Reference Books:

1. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., Gelbart, W. M. An "Introduction to Genetic Analysis", W. H. Freeman & Company, New York.
2. Strickberger, M. W. "Genetics", latest Edition, Macmillan Publishing co., New York.
3. Gardner, E. J., Simmons, M. J. and Snustad, D. P. "Principles of Genetics", 8th Edition, John Wiley & Sons, New York.
4. "An Introduction to genetic analysis". Anthony A. J. F. Griffiths; Susan R. Wessler; Sean B. Carroll; John Deebly. 11th Edition
5. "Genetics: A Conceptual approach". Benjamin A. Pierce. latest Edition
6. "Genetics: analysis of genes and genomes". Daniel L Hartl; Maryellen Ruvolo. latest Edition.



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BIO 403 Macromolecular Structure and Function (L-T-P-C: 3-1-0-4)

Unit 1: Introduction

The molecular logic of life: The chemical unity of diverse living organisms, Miller and Urey experiments on origin of life, composition of living matter. Macromolecules and their monomeric subunits. Evolutionary aspects of stereo specificity and structural interplay between biomolecules (RNA, DNA, Amino acids and sugars). Methods for the determination of macromolecular structure.

Unit 2: Proteins

Classification, structure and properties of amino acids, zwitter ion, rare amino acids, D-amino acids. Classification and properties of proteins, – Peptide synthesis: reactive ester method and Merrifield synthesis, sequencing of proteins,

Primary structure: Peptide conformation, N- and C- terminal, peptide cleavage

Secondary structure: α -helix, β -sheet, random coil, Ramachandran plot

Tertiary structure: Forces stabilizing, unfolding/ refolding experimentation.

Quaternary structures: Structure and function of hemoglobin.

Structure, coagulation and denaturation of proteins. Concepts of iso electric point and salting in and salting out. Structural and functional significance of Prions and viroids. Biologically active peptides, Oligomer formations -role in neurodegenerative diseases e.g., β -Amyloid etc.

Unit 3: Carbohydrates

Occurrence, classification, basic chemical structure, monosaccharides, aldoses, and ketoses, cyclic structure of monosaccharides, stereoisomerism, anomers and epimers. general properties and functions of polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins. Mucopolysaccharides, deoxy sugars, amino sugars, and sugar acids.

Unit 4: Lipids

Structure, distribution and biological importance of fats and fatty acids- essential (ω -3 and ω -6) and derived essential fatty acids- eicosanoids-prostaglandins, leukotrienes and lipoxins. Chemical properties and characterization of fats. Different dietary types of fatty acids, requirements, utilization and functions. Waxes, cerebrosides, gangliosides, phospholipids and proteolipids. Steroids and bile salts. Circulating lipids, Lipoproteins, chylomicrons, LDL, HDL, and VLDL. Pathological changes in lipid levels. Formation of micelles, monolayers, bilayer, liposomes and emulsions. Vitamins.

Unit 5: Nucleic acids

Nucleic acids as genetic information carriers, experimental evidence e.g., genetic transformation, Hershey-Chase experiments, action spectrum, etc. Structure and function of nucleotides. Primary, secondary and tertiary structure of nucleic acids, DNA forms and conformations, Denaturation of DNA. Unusual nucleic acid structures, Melting curves. Role of contemporary RNA enzymes: Ribozyme. Types of Synthesis methods of RNA and DNA. Sequencing methods. Diversity in RNAs-coding and non-coding RNAs, micro RNA etc



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Suggested Books:

1. "Principles of Biochemistry", Lehninger C Recent Edition.
2. "Biochemistry", L. Stryer, W.H. Freeman, San Francisco.
3. Schaum's "Outline Series of Theory and Problems of Biochemistry", Philip W. Kuchel and G.B. Ralston. Int. Ed., McGraw-Hill Book Co.
4. "Problem Approaches in Biochemistry". Wood and Hood
5. "DNA: The Secret of Life" by James D. Watson, Andrew Berry
6. "Review of Physiological Chemistry" by Harold A Harper, Lange Medical Publications Latest Edition.



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BIO 404 Ecology & Evolution (L-T-P-C: 3-1-0-4)

Unit 1:

Basic concepts of ecology and environment. Introduction to ecology - Ecosystems and allied concepts. The abiotic environment: Water, temperature, radiation, nutrient cycles. The biotic environment: producers, consumers and decomposers.

Unit 2:

Adaptations to the environment – Ecological niche and adaptation to variations and stress. Community and Population ecology. Biomes of the world. Natural resources – degradation and conservation. Human impacts on Natural Resources. Tools for natural resource degradation assessment and monitoring. Conservation- concepts and measures. Climate change.

Unit 3:

Origin of Life on Earth. Experiments of Miller. Chemical Evolution. What is Life? Biodiversity-definition and Measurement. Evolutionary ideas of Cuvier, Lamarck and Darwin. Contribution of RA Fisher, Haldane, Sewall Wright, Ernst Mayr. Modern synthesis. Evolution as an Emergent property. Concept of population, gene pool, gene frequency-conservation, allele frequency (Hardy-Weinberg equilibrium), Change in gene frequencies. Genetic drift, gene flow, genetic load. Adaptations and extinction. Osmotic regulation and excretion of nitrogenous waste, protective coloration, mimicry. Periodic and mass scale extinctions- possible causes.

Unit 4:

A brief and consensus account of Organic evolution of major groups of plants and animals on Earth. Geological eras and fossil evidence for Darwinian evolution. Human Evolution. Theory of Organic Evolution by Natural Selection. Adaptive significance of variations. Operative details of Natural Selection.. Concept of Species and Speciation. Isolation mechanisms, modes of speciation (allopatric, sympatric, peripatric), anagenesis&cladogenesis, levels of evolutionary change (micro & macroevolution). A brief account of Mendelian Genetics, Mutations, Statistical analysis of Genotype and Gene (allele) frequency in Populations. Sex selection and Kin selection. Morphological and Biochemical Adaptation- selected examples. Homology, Analogy and Homoplasy. Divergent and Convergent evolution. Comparative physiology of any one function.

Unit 5:

Basic ideas structure of bio macromolecules. Self-replicating molecules. RNA world. Cellular form of life. Prokaryote, Eukaryote and evolution of multi-cellular organisms. Comparison of primary structure of nucleic acids and proteins across members of a population, across species, genera, families, orders and classes. Dendrograms and Phylogenetic trees. Principles of construction. Concept of Molecular Clock. Evolution of enzymes and metabolic pathways towards functional efficacy or adaptation.



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Suggested Readings:

1. Odum, "Fundamentals of Ecology" (WB Saunders)
2. Ricklefy, "Fundamentals of Ecology" (WH Freeman)
3. Turk and Turk, "Environmental Science" (WB Saunders)
4. Clegg, CJ and DG Mackean (2000) "Advanced Biology-Principles and Applications", 2nd Edition, Hodder Education, UK
5. Mark Ridley (2004) "*Evolution*", 3rd Edition, Blackwell Publishing, UK Fritz of Capra and PL Luisi (2015) "The Systems View of Life- A Unifying Vision", Cambridge University Press, Chapters 7, 8, 9 and 10.



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BIO 405 Analytical Tools and Techniques (Lab) (L-T-P-C: 0-0-12-6)

1. Preparation of Various buffers 0.1 M NaCl, NaOH, Tris-HCL Phosphate and EDTA
2. Determination of pKa of amino Acids (Glycine)
3. Separation of Sugars (Glucose/Fructose/Starch/Cyclodextrin) by TLC
4. Quantitative estimation of protein by spectroscopic/Barford/BCA
5. To verify and validate Beer's Law and determine the molar extinction coefficient of NADH or Protein (Pure)
6. Isolation of Chloroplast by Sucrose gradient method from Spinach leaf
7. Study of Karyotyping in human normal/abnormal
8. Study of mitosis by using onion root tip
9. Problem on a) law of segregation, b) Independent assortment, c) Sex linked inheritance, d) population genetics
10. Determination of PI of amino acids by titration method
11. Working with Microscope and preparation of Slide.
12. Staining of nucleus and mitochondria and observation under microscope.



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SEMESTER - II

BIO 406 Microbiology (Diversity and Systematics) (L-T-P-C: 3-1-0-4)

Unit 1:

Historical developments: Discovery of microorganisms, Evolution of microbiology as a discipline Spontaneous Generation- Controversy, Germ theory of fermentation, Germ theory of disease. Whittaker's five-kingdom concept. Three-domain concept of Carl Woese, Microbiological techniques, Pure culture techniques, Enrichment, Anaerobic culturing
Discovery of microorganisms: Bacterial and fungal diversity, Culture techniques, Bacterial systematic.

Unit 2:

Different groups of Microorganisms and their general characteristics, Prokaryotic vs. Eukaryotic Organisation.

Characters used in microbial taxonomy (morphological, physiological, ecological, genetics protein content, nucleic acid sequence and base composition).

Unit 3:

Nutritional requirements of microorganisms: Nutritional types, Requirements, Uptake of nutrients, Design and types of nutrient media

Cell wall of bacteria and fungi, Gram+ve cell wall, Gram-ve cell wall, Cell wall of fungi and yeasts

Unit 4:

Microbial Ecology, Denitrification, Phosphate solubilization, Free-living nitrogen fixation, Plant-microbe interactions, Symbiotic nitrogen fixation, Mycorrhizae and Plant pathogens

Importance of microorganisms in medicine, agriculture, environment and industry

Unit 5:

General properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions, satellite virus.

Reference Books:

1. Microbiology Ed. Prescott.
2. Microbiology Ed. Torfora.
3. Microbiology Ed. Peltzar.
4. Microbiology Ed. Stanier.
5. Biology of Microorganisms Ed. M.T. Medican, J.M. Martiniko and J. Parker.



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BIO 407 Molecular Biology (L-T-P-C: 3-1-0-4)

Unit 1: Genetic material

Gene-definition-Structural differences between prokaryotic and eukaryotic genes- Genome: organization of prokaryotic genome- architecture of prokaryotic chromosome. Eukaryotic genome-Complexity-LINES,SINEs, Genome organization: C-value paradox, genome complexity; Cot value analysis, repetitive sequences, gene families

Recombination at the molecular level. Holliday model of homologous recombination – events at the molecular level; role of recA, recBC and chi sequences, Site- specific recombination – eg. bacteriophage λ ; FLP/FRT and Cre/Lox recombination

Unit 2: DNA Replication

DNA replication in prokaryotes and eukaryotes; Semiconservative and discontinuous mechanism of DNA replication – leading, lagging strand, Okazaki fragments, biochemistry of replication, DNA polymerases, helicase, primase, topoisomerase, processes of replication; initiation, elongation, termination, telomerase replicates the ends of chromosomes, rolling circle replication, mitochondrial DNA replication, M13 – rolling mechanism of replication, DNA repair – Nucleotide excision repair; Mismatch correction; SOS repair; Photoreactivation

Unit 3: Transcription

Prokaryotic and eukaryotic RNA polymerases, process of transcription; initiation, elongation and termination, transcription factors, other cis-trans elements, antibiotic inhibitors of transcription, RNA processing, Intron splicing, RNA editing, mRNA degradation

Regulation of gene expression; operon models- *lac*, *trp* and *his*, Bacteriophage lambda: a transcriptional switch; lytic and lysogenic cycle, influence of chromatin structure on transcription, nucleosome remodeling, RNA interference: miRNA, siRNA and piRNA

Unit 4: Translation

Genetic codon, protein synthesis; ribosome assembly, activation of amino acids, initiation, elongation and termination, proofreading and energetics of translation, antibiotics and toxins inhibitor of translation, post-translational modification of proteins; O and N-linked glycosylation, splicing, molecular chaperons, ubiquitin mediated protein degradation

Suggested Readings:

1. Lewin B. "Genes". Jones & Bartlett Publishers.
2. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. "Molecular Biology of the Cell". Garland Science.
3. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. "Molecular Biology of the Gene". Benjamin-Cummings Publishing Co.,
4. Freifelder D. "Molecular Biology".



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BIO 408 Enzymology (L-T-P-C: 3-1-0-4)

Unit 1: Enzymes

General characteristics of enzymes, role of co-factors, nomenclature, IUB enzyme classification (specific examples), The story of James B. Sumner and Urease; active sites and induced fit theory, measurement and expression of enzyme activity, enzyme assay. Definitions of IU, Katal, enzyme turnover and specific activity. Criteria for purity of enzymes. Correlation between the rates of enzyme turnover and structure and function of enzymes. Effect of pH, Temperature on Enzyme structure and function.

Unit 2: Kinetics of Enzyme Action

Concept of ES complex, active site, specificity, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of K_m & V_{max} and their physiological significances. Importance of K_{cat}/K_m . Kinetics of zero & first order reactions. Significance and evaluation of energy of activation. Collision & transition state theories. Michaelis – pH functions & their significance. Reversible and irreversible inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics. Suicide inhibitors, enzyme activators.

Unit 3: Mechanism of Enzyme Action

Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain & distortion theory. Chemical modification of active site groups. Site directed mutagenesis of enzymes. Mechanism of action of chymotrypsin, lysozyme, glyceraldehyde 3-phosphate dehydrogenase, aldolase, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase. Multienzyme system – Occurrence, isolation & their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Unit 4: Enzyme Regulation

General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modifications of enzymes. Mono cyclic and multi cyclic cascade systems with specific examples. Feedback inhibition and feed forward stimulation. Allosteric enzymes, qualitative description of “concerted” & “sequential” models for allosteric enzymes. Half site reactivity, Flipflop mechanism, positive and negative co-operativity with examples like aspartate transcarbamoylase & phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots.

Unit 5: Enzyme Technology

Introduction to enzyme engineering, Large scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods. Effect of partition on kinetics and on changes in pH and hydrophobicity. Enzymatic reactions in organic solvents. Industrial applications of immobilized enzymes: other applications in synthetic organic chemistry, industry, food technology, medicines. Synzymes



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Suggested Readings:

1. "Fundamentals of Enzymology" by Price and Stevens
2. "Enzymology" by Dixon and Webb
3. "Enzymes" by Palmer
4. "Textbook of Medical Physiology" by Guyton. A.C., H. Sanders
5. "Physiological chemistry" by HA Harper.



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BIO 409 Metabolic Pathways (L-T-P-C: 3-1-0-4)

Unit 1:

Metabolism as a defining property of living state. Thermodynamic principles and steady-state condition of 'living'. Methods of metabolic investigations. Metabolic pathways-linear and cyclic. Catabolism and anabolism. Phases I, II and III of catabolism.

Unit 2:

Major pathways of carbohydrate, amino acid, lipid and nucleotide metabolism. Biosynthesis of monosaccharides, fatty acids, amino acids and nucleotides. Secondary metabolites-biosynthesis and degradation. Role of metabolism in biomass production and energy homeostasis.

Unit 3:

Metabolic profile of adipose, neural, hepatic, skeletal muscle, and steroidogenic tissues.

Unit 4:

Integration and regulation of metabolic pathways in relation to cellular and organ functions. Evolution of metabolic pathways and adaptive significance, if any. Metabolic engineering for specific product production. Metabolic regulation during embryogenesis and development.

Suggested Readings:

1. Garrett and Grisham, "Biochemistry", 5th Ed. BRROKS/COLE Cengage Learning. 2013.
2. RL Foster, "Nature of Enzymology"
3. "Annual Review of Biochemistry"



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BIO 410 Analytical Tools and Techniques (Lab) (L-T-P-C: 0-0-12-6)

1. Isolation of microorganism from soil (Serial dilution method)
2. Gram Staining method
3. Testing of water by coliform test
4. Bacterial growth assessment by turbidometry
5. Isolation of genomic/plasmid DNA and gel electrophoresis
6. DNA/RNA purity and quantification by Nanodrop
7. Restriction digestion and cloning in bacteria
8. Purification of protein/enzyme (Lipoxygenase) by ammonium sulphate precipitation and dialysis
9. Column Chromatographic purification /molecular weight determination of protein by Gel electrophoresis
10. Determination of specific activity of enzymes
11. Effect of pH and temperature on enzyme activity
12. Determination of K_m and V_{max}
13. Isolation and assay of acid phosphatase from sweet potato (Optional)
14. Antibacterial assay by Disk plate method



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IU M 000 Basic Communication and Soft Skills (L-T-P-C: 1-0-0-0)

Unit 1: Fundamentals of Communication

- Importance of Communication
- Importance of Interpersonal Communication
- Process of Communication
- Flows and Types of Communication

Unit 2: Barriers to Communication

- Definition
- Types of Barriers

Unit 3: Listening

- Hearing & Listening
- Types of Listening
- Do's and Don'ts of Effective Listening

Unit 4: Effective Presentation

- Patterns & Methods of Presentation, Oral Presentation
- How to prepare presentation
- Effective ways to deliver the presentation
- How to prepare multi-media presentation
- Difference between C.V & Resume, types of resume

Unit 5: Corporate Etiquettes

- Non-verbal Communication
- E-mail etiquette, telephone etiquette, dining etiquette
- Office meeting etiquettes, dress etiquette

Text Books:

1. Soft Skills for Everyone by Jeff Butterfield, Cengage publication
2. Technical Communication; Principles and Practice" by Meenakshi Raman & Sangita Sharma (Oxford University Press)
3. "Communication Skills" by Dr. Sanjay Kumar and Dr. Pushp Lata, Oxford University Press

Reference Books:

1. Personality Development and Soft Skills by Barun K Mitra
2. Business Correspondence and Report writing"- R C Sharma and Krishna Mohan, Tata McGraw Hill, 8th Ed.2015



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SEMESTER - III

BIO AB 501 Physiology (with emphasis on disease orientation) (L-T-P-C: 3-1-0-4)

Unit 1: Digestive and Respiratory Systems

Nutrition and digestion: Types of nutrition encountered in animal kingdom. Principles of coordination of secretions in the alimentary canal. Regions of the digestive tract. Movements of the gastrointestinal tract. Salivary and gastric secretions. Pancreatic secretions. Liver and biliary systems. Functions and secretions of small and large intestines. Enzymes of the alimentary canal: factors controlling the rates of enzyme reaction. Gastrointestinal hormones. s Biochemistry of digestion and assimilation of carbohydrates, proteins and lipids. Diseases associated with Digestion: Gastritis. Gastric Atrophy. Pancreatitis. Steatorrhea. Hepatitis.

Respiration: Respiratory system in mammals; ventilation and dead space; lung capacities; gas exchange; nervous coordination of respiration. A comparative account of respiratory apparatus and pigments. –Transport of respiratory gases in mammals - Nature of haemoglobin and Myoglobin; transport of oxygen; oxygen equilibrium curves. - Transport of carbon dioxide. Artificial respiration. Effects of exercise on respiration. Carbonmonoxidepoisoning, Pneumonia, Pneumothorax, Pulmonary tuberculosis, Emphysema.

Unit 2: Cardiac and Muscular Physiology

Blood circulation; Types of hearts in animals; double circulation of mammals; chambers of the mammalian heart; cardiac muscle and its properties. The origin and conduction of the heartbeat, mechanical events during heartbeat, heart output and its regulations. Cardiac cycle. Coronary circulation. Fetal circulation. Pressures encountered within the circulatory system, Exchange between capillaries, tissues and the lymph, Blood: Cellular components of the blood; Blood coagulation (XIII factors). Lymphatic system and Lymph. Cardiac murmur. Arrhythmia, Hemorrhage. ECG.

Muscle and body movement: Types of muscles, Detailed structure of skeletal muscle; ultra-structure of muscle proteins and their inter relationship; Sarcomere and t-tubule system. Physiology of muscle contraction - sliding filament theory. Role of Ca^{2+} and ATP in muscle contraction. Electromyogram and disorders of skeletal muscle. Endurance of the muscle.

Unit 3: Renal Physiology and Skin

Excretion: Types of kidneys; detailed structure of mammalian kidney. 1hr. Nephron and the mechanism of urine formation; counter current multiplier System and its role in urine concentration. Acid- base regulation; role of the kidney in the maintenance of pH.1hr - Nitrogenous excretory substances in the urine of mammals: Urea - Krebs' ornithine cycle; Ammonia; Creatinine. Dialysis and artificial kidney.

Skin and temperature control: Structure of mammalian skin. Modification of skin in non-mammalian vertebrates. - Classification of animals on the basis of their ability to regulate body temperatures, Thermal neutral zone. Hypothalamus - a thermostatic organ.



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Adaptations of animals living in extremely cold and warm environments; torpor; Hibernation; Aestivation.

Unit 4: Experimental Physiology

Experimental Physiology: Study of apparatus. Examination of fresh blood. Hemocytometry, Hematocrit, TLC, DLC, ESR, Viscosity of blood, Osmotic fragility of RBCs. Breath holding time, Spirometry, Pulmonary function test. Electrocardiography 2hrs. Exercise Tolerance Test, Color vision, Tuning fork tests of hearing, Electroencephalography, Pregnancy diagnosis tests. Oral Glucose tolerance test. Twitch, Tetanus, Fatigue.

Seminars and assignments and quiz.

Text Books:

1. D. Randall, Warren W. Burggren, K. French, R. Eckert, (2002) "Animal Physiology", Illustrated Ed., W H Freeman & Co.
2. William S. Hoar, (2008) "General and Comparative Physiology", 3rd Ed., Phi Learning Pvt. Ltd.
3. Arthur J. Vander, James H. Sherman, Dorothy S. Luciano, (2000) "Human Physiology", 8th Ed., Me Graw Hill.
4. Knut Schmidt-Nielsen, (1997) "Animal Physiology: Adaptation and Environment", 5th Ed., Cambridge University Press.
5. CL Ghai (2013) "A Text Book of Practical Physiology", Jaypee Brothers Medical Publishers (P) Ltd, New Delhi.



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BIO M 501 Immunology (L-T-P-C: 3-1-0-4)

Unit 1:

Molecular components of immune system-antibodies, complement, T-cell receptors, MHC/HLA complex antigens etc. Structure, function and generation of antibodies, regulation of immune response, signal transduction, autoimmunity, and immune tolerance.

Unit 2:

The effector mechanisms of innate immune system, pattern recognition, complement system, antimicrobial peptides, and cytokine products in response to viral, bacterial and parasitic pathogens. Antigen processing and presentation.

Unit 3:

Adaptive immune response-antigen recognition, lymphocyte activation, humoral and cell mediated immunity, immunological memory, and physiological and pathological aspects of inflammation.

Unit 4:

Immune dysfunctions-autoimmunity, immunodeficiency, different types of hypersensitivity, alloantigen and transplantation rejections.

Unit 5:

Applications of antibodies-antigen-antibody interactions *in vitro* and *in vivo*, RIAs and ELISAs, complement based assays, monoclonal and polyclonal antibodies, and FvSc antibodies, Abzymes, Immunocytochemistry, enzyme-Ab & drug-Ab conjugates, Immuno-affinity chromatography, immunoprecipitations and interactome studies. Immuno therapies-Potential and prospects in cancer therapy.

Suggested Readings:

1. Goldsby et.al "Immunology", 7thedn, WH Freeman & company.
2. Janeway et.al, "Immunobiology", 8thedn, Garland Publishing.
3. Ramesh, SR. "Immunology", McGraw Hill Education (India), New Delhi.



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BIO M 502 Reproduction and Developmental Biology (L-T-P-C: 3-1-0-4)

REPRODUCTIVE BIOLOGY

Unit 1: Structure and Function Reproductive System

- 1) Testis: Leydig and Sertoli cells, Epididymis and accessory reproductive glands, hormonal regulation of spermatogenesis and spermiogenesis, biochemistry of semen, Y- 15 specific probes, Assessment of sperm functions, inhibin and androgen binding proteins, capacitation of spermatozoa. Structure of Spermatozoa.
- 2) Ovary, influence of hormones on development of ovarian follicles and oogenesis, reproductive cycles: estrous and menstrual cycles; oocyte maturation, structure of ovum. ovulation, atresia and corpus luteum formation, pregnancy and lactation, implantation and placentation.
- 3) Hormonal and chemical regulation, recent advances in contraception research, immunological methods in contraception

Unit 2: Sex Determination and Artificial Fertilization

- 1) Genetic sex- gonadal sex-somatic sex, Sex determination and differentiation, germ cell development and differentiation, Hormonal regulation of reproduction and puberty through differential gene expression.
- 2) Estrus synchronization; super ovulation, semen collection, evaluation, storage: cryopreservation, assisted reproductive technology, *in vitro* fertilization, Intra-cytoplasmic sperm injection (ICSI) and Intra-cytoplasmic morphologically selected sperm injection (imsi), gamete intra fallopian transfer (gift), zygote intra fallopian transfer (ZIFT), Tubal embryo transfer (TET), preservation of endangered species by biotechnological methods.

DEVELOPMENTAL BIOLOGY

Unit 3: Fertilization and Basic Concepts of Developmen

- 1) Basics of Fertilization. Acrosome reaction, fast and slow block to polyspermy, zygote formation. Potency, commitment, specification (autonomous, regulative and syncytial), induction, competence, determination and differentiation, morphogenetic gradients, cell fate and cell lineages, genomic equivalence and the cytoplasmic determinants, imprinting. Patterns and molecular mechanism of cleavage

Unit 4: Early Embryonic Development

- 1) Blastula formation, gastrulation patterns, concept and functions of primary organizer, neural induction, differential gene expression during formation of germ layers. Formation and differentiation of neural tube, differentiation of neurons, specification and regionalization of neural crest cells and their derivatives.
- 2) Axes and pattern formation in *Drosophila*, amphibia and chick, derivatives of ectoderm, mesoderm and endoderm. Organogenesis- vulva formation in *Caenorhabditis elegans*; eye lens formation, formation of somite, limb development.



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Suggested Readings:

1. Wilson J.D. "Text Book of Endocrinology". Saunders Publishers.
2. Schatten H and Constantinescu G.M. "Comparative Reproductive Biology". Blackwell Publishers, UK
3. Joy K.P, Krishna A, Haldar C. "Comparative Endocrinology and Reproduction". Narosa Publishers, Delhi.
4. Stephen Nussey and Saffron Whitehead. "Endocrinology-An Integrated Approach", Oxford: BIOS Scientific Publishers.
5. Kenneth S. Polonsky, P. Reed Larsen, Henry M. Kronenberg. Williams Textbook of Endocrinology, Elsevier.
6. R. G. Edwards, "Human Reproduction", Oxford Univ. Press
7. G. Litwack, Biochemical actions of Hormones, Academic press
7. Gilbert S.F. "Developmental Biology", 10th Edition, Sinauer Associates, Inc., Publishers Sunderland, Massachusetts, USA.
8. Slack J. M. W. "Essential Developmental Biology", Wiley-Blackwell.
9. T. Subramonium (2013) "Molecular Developmental Biology",



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BIO M 503 Genetic Engineering (L-T-P-C: 3-1-0-4)

Unit 1:

Overview of genetic engineering, Generation of DNA fragments: Mechanical shearing, restriction endonucleases (REs), use of REs in molecular cloning, PCR technology and its application in recombinant DNA technology, cDNA synthesis – strategies for isolation of full length cDNAs, chemical synthesis of a DNA fragment.

Unit 2:

Vectors used in molecular cloning. a) Plasmids – general concepts, eg. pUC, pBlueScript, pGEM vectors; Expression vectors; pMal, GST-based, pET vectors; b) Bacteriophage λ vectors – λ gt10, λ gt11, λ ZAP and replacement vectors - EMBL c) Phagemids - M13-derived vectors, d) cosmids - Artificial chromosome vectors (YACs; BACs); d) Other viral vectors: SV-40, Vaccinia, Baculovirus & retroviral vectors.

Unit 3:

Cloning strategies & Introduction of recombinant DNA into hosts: a) Other enzymes used in cloning - DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase b) cloning strategies – basic concepts of cohesive and blunt end ligation; directional cloning, use of linkers and adaptors; c) Homopolymer tailing, d) T-vectors and cloning of PCR products, e) Introduction of recombinant DNA into suitable hosts - transformation, conjugation, transduction, transfection, particle bombardment techniques, f) Ti plasmids and *Agrobacterium*-mediated transformation.

Unit 4:

Construction and screening of genomic libraries: a) Construction of genomic and cDNA libraries using for eg. λ gt11, λ ZAP vectors, b) Screening: DNA probe based screening - molecular hybridization techniques: Preparation of nucleic acid probes by nick translation, random primer labeling and end labeling, hybridization techniques for identification of clones with gene of interest, c) Screening by antibody-based methods: induction of protein expression, immunodetection, radioactive and chemiluminescent methods of detection. Characterization of cloned genes: a) Sequencing of DNA- Sanger's enzymatic method and Gilbert's chemical sequencing method; automated DNA sequencing; next generation sequencing b) Identification of promoters and regulatory elements – promoter reporter fusions c) Site directed mutagenesis.

Unit 5:

Expression of recombinant proteins. a) Protein expression in *E. coli* as a host - Factors influencing the expression of recombinant proteins. Purification of recombinant proteins - His-tag, GST-tag, MBP-tag etc.; commercially available *E. coli* hosts for expression of recombinant proteins, b) examples of alternate expression systems – yeast, *Baculovirus*, mammalian systems and plants. Genome editing, Zinc fingers, TALEN's, CRISPR/Cas9. Ethics and patentability.



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Suggested Readings:

4. Primrose, Twyman and Old. "Principles of Gene Manipulation". Blackwell Science.
5. Sambrook J and Russell D. "Molecular Cloning: A laboratory Manual". Cold Spring Harbor Laboratory Press.
6. Lewin B. "Genes". Jones & Bartlett Publishers.
7. Alberts B, Bray D, Lewis J, Raff M, Roberts K, and Watson J.D. "Molecular Biology of the Cell". Garland Science.
8. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M and Losick R. "Molecular Biology of the Gene". Benjamin-Cummings Publishing Co.,
9. Freifelder D. "Molecular Biology". Narosa Publishing House.



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BIO M 504 Bioinformatics (Lab) (L-T-P-C: 0-0-8-4)

1. Nucleic acid sequence databases: DDBJ, GenBank, NCBI
2. Protein Sequence Databases: PIR, UNIPROT
3. Protein Structure Database: PDB, MMDB
4. Specialized genomic resources- ENTREZ – genome, gramene, SRA
5. Sequence Alignment: BLAST variants and FASTA variants
6. Gene prediction: PFAM, GENESCAN, FGENESH, GLIMMER
7. Tools for primer designing – Primer3, Genefisher, FastPCR
8. Multiple Sequence Alignment: Clustal X, Clustal W
9. Phylogenetic Analysis: MEGA
10. Protein Modelling- SWISS Model, Modeller, I TASSER
11. Docking: Auto Dock, Swiss Docking
12. Test of significance – t-test – F-test and 2-test – correlation and regression analysis – ANOVA – data transformation
13. Factorial experiments – split-plot design – strip plot design
14. Statistical analysis using MS Excel, SYSTAT/SPSS, SAS/IRRISTAT.

Suggested Readings:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
3. Pevsner, J. (2009). Bioinformatics & Functional Genomics. Wiley- Blackwell, New Jersey.
4. Janus, M. Bujnicki. (2004). Practical Bioinformatics. Springer.
5. Durbin, R., Eddy .S.R, Krough A and Mitchison, G. (2004). Biological Sequence Analysis. Cambridge University Press.
6. Sharma. K.V.S. (2010). Statistics Made Simple: Do it yourself on PC, Prentice Hall of India, New Delhi.
7. Darren George and Paul Mallery, (2007), SPSS for Windows Step by Step – A Simple Guide and Reference, Pearson Education in South Asia.
8. SYSTAT/SPSS User's Guide and User's Manual.
9. SAS/ IRRISTAT User's Guide and User's Manual.



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BIO AB 502 Biology Laboratory Techniques (Lab) (L-T-P-C: 0-0-8-4)

1. Purification of protein/enzyme and protein estimation using BSA standard
2. Preparation PCR reaction and amplification.
3. Purification of PCR product from agarose gel.
4. Isolation, restriction digestion and ligation
5. Competent cell preparation, transformation and calculation of transformation efficiency
6. Screening of recombinant DNA using antibiotics marker and blue/white.
7. Analysis of recombinant DNA using restriction digestion
8. Southern/Northern blotting techniques
9. Preparation of antigens, immunization and methods of bleeding, serum separation and storage.
10. Antibody titre by ELISA method.
11. Double diffusion, Immuno electrophoresis and Radial immuno diffusion.
12. Complement fixation test.
13. Isolation and purification of IgG from serum or IgY from chicken egg.
14. Blood smear identification of leucocytes by Giemsa's stain.
15. Separation of mononuclear cells by Ficoll-Hypaque.
16. Differential leucocyte count under microscope.



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SEMESTER - IV

BIO M 505 Stem Cells and Regenerative Medicine (L-T-P-C: 3-1-0-4)

Unit 1: Basic Introduction to Stem Cells

1) Cellular potency, lineage commitment, cellular development, differentiation, dedifferentiation & trans differentiation, Cell cycle control, Immortal DNA strand hypothesis, Asymmetric cell division, telomerases in relevance to stem cell development and differentiation.

2) Embryonic stem cells, Adult stem cell (epithelial stem cells, mesenchymal stem cells, neural stem cells, hematopoietic stem cells, cardiac stem cells), Regulatory mechanisms in Embryonic and adult stem cells, Cancer stem cells, Markers, molecular and evolutionary mechanisms addressing origin and maintenance of cancer stem cells.

Unit 2: Characterization & Reprogramming of Stem Cells

1) Isolation, purification and characterization of tissue specific stem cells using flow cytometry, dynabeads and colony forming assays, *in vitro* differentiation assays to understand its commitment to specific tissue lineages, possible usage of Gene editing technologies – (TALEN, CRISPR Cas9) to rectify the defect, Mining of Bioinformatics resources related to Stem cells (Next generation sequencing; DNA-seq, RNA-seq, ChIP-seq etc. Utility of genome browsers (UCSC), ENCODE & stemformatics). Generation of induced pluripotent cells from somatic cells, Transcription factor used and molecular mechanism involved in iPSCs reprogramming. iPSCs commitment to different cell lineages to harness its regenerative potential.

Unit 3: Basics of Regenerative Medicine

Introduction and principles of regenerative medicine, fundamentals of cell based therapies, Nanotechnology in cell based therapies. Cellular interactions with the microenvironment in context of tissue regeneration, Biomaterials and scaffolds, Polymers and cell--substrate interactions, Cell–Substrate Interactions, Nanotechnology as a tool for biomaterial control.

Unit 4: Applications & Policy matters on Stem Cells Research Therapy

Cell and tissue based regeneration, Cell--Based Repair for Cardiovascular Regeneration and Neovascularization, Blood regeneration, Hepatocyte transplantation, Principles of bone tissue engineering, Scaffolding design criteria for bone tissue engineering, Nano-fibrous scaffolds for Bone tissue engineering, Skin and vasculature tissue engineering. Regulations and ethics in stem cell research; Regulatory approvals, Ethical considerations, GMP facilities.

Suggested Readings:

1. Lanza R, Gaerhart J, Hogan B, Melton R, Thomas D, Thomas J, and Wilmut S. “Essentials of Stem Cell Biology”. Elsevier Inc.
2. Stillman B, Stewart D and Grodzicker T, “Control and Regulation of Stem Cells”.
3. Tursen Kursad, “Stem Cell Biology and Regenerative Medicine”, Humana Press



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BIO AB 503 Neuro-endocrinology (L-T-P-C: 3-1-0-4)

Unit 1: Introduction

To cellular and molecular basis of nervous system and its uniqueness. Neural Development: a. Turning embryonic stem cells into neurons b. Glial guided neuronal migration, path finding, and axon guidance. The Macroscopic Organization of the Brain: a. Functional anatomy of the brain b. Cellular heterogeneity of nervous system c. Blood Brain Barrier and its disorders. Synaptic Transmission: Electrical and Chemical transmission. Neurotransmitters (synthesis, storage and function) Disorders of synaptic transmission.

Unit 2: Cognitive Neuroscience

a. Role of limbic system in cognition, b. Cellular and molecular basis for learning and memory c. Synaptic plasticity. Special aspects of brain metabolism: a. Brain specific genes, DNA, RNA and protein synthesis b. Amino acid transport. Molecular aspects of neurological dysfunction and neuro degeneration: a. Mechanism of apoptosis and special aspects of neuro degeneration b. Neurodegenerative diseases: Alzheimer's Disease, Parkinson's Disease, Creutzfeldt-Jakob Disease (CJD), Amyotrophic Lateral Sclerosis (ALS), Epilepsy, Schizophrenia. c. Cerebrovascular Diseases: Stroke, Arteriosclerosis, Arterio Venous Malformations (AVMs), Aneurysms

Unit 3: Endocrinology - I

Structure of Endocrine – the glands: Macroscopic and histological. Nature and attributes of hormones; A brief study of the role of hormones and regulation of the hypothalamus, pineal, pituitary, thyroid, parathyroid, supra-renal and pancreatic glands, Endocrine Testis and Ovary and Prostate gland.

Unit 4: Endocrinology - II

Disorders caused due to the hypo and hyper secretions of the endocrine glands. Feedback control of the hormone production and its release. The mechanism of action of lipid soluble and water soluble hormones. The concept of “Second Messenger” and its role in hormone function. Menstrual cycle, Ovulation, Menopause, Infertility, Fertility control, Mammary glands and lactation. Biological rhythms and its management.

Reference Books:

1. Endocrinology An integrated approach – Stephen Nussey and Saffron Whitehead BIOS Scientific Publishers Ltd.
2. Wilson J.D. “Text Book of Endocrinology”. Saunders Publishers.
3. An introduction to neuro-endocrinology Michael Wilkinson and Richard E. Brown Cambridge university press.
4. Hand book of Neuro endocrinology - George fink, Donald Pfaff, Jon Levine Elsevier.

BIO AB 504 Research or Industrial Project/Viva (L-T-P-C: 0-0-0-14)