

COURSES OF STUDIES

P.G. ZOOLOGY



Khallikote Unitary University

BERHAMPUR-760001

2023-24

COURSES OF STUDIES P.G. ZOOLOGY

SEMESTER	PAPER	SUBJECT	CREDITS	MARKS
I	Z-101	NON-CHORDATA AND TAXONOMY	4	80+20
	Z-102	ENVIRONMENTAL BIOLOGY AND BIOSTATISTICS	4	80+20
	Z-103	EVOLUTION AND ETHOLOGY	4	80+20
	Z-104	INSTRUMENTATION AND TECHNIQUES IN BIOLOGY	4	80+20
	Z-105	PRACTICAL	4	100
II	Z-201	CHORDATA	4	80+20
	Z-202	PHYSIOLOGY AND ENDOCRINOLOGY	4	80+20
	Z-203	MOLECULAR BIOLOGY AND GENETIC ENGINEERING	4	80+20
	Z-204	BIOTECHNOLOGY, APPLICATIONS OF BIOTECHNOLOGY, BIOETHICS AND BIOPHYSICS	4	80+20
	Z-205	PRACTICAL	4	100
III	Z-301	CELL AND INHERITANCE BIOLOGY	4	80+20
	Z-302	DEVELOPMENTAL BIOLOGY	4	80+20
	Z-303	CELL AND MOLECULAR BIOLOGY (CORE-ELECTIVE)	4	80+20
	Z-304	RESEARCH METHODOLOGY (APPLIED ELECTIVE)	4	80+20
	Z-305	PRACTICAL	4	100
IV	Z-401	CHEMICAL FOUNDATION, BIOCHEMISTRY AND INTERMEDIARY METABOLISM	4	80+20
	Z-402	MICROBIOLOGY AND IMMUNOLOGY	4	80+20
	Z-403	MOLECULAR GENETICS (CORE-ELECTIVE)	4	80+20
	Z-404	PROJECT	4	80+20
	Z-405	PRACTICAL	4	100

In 1st and 3rd Semester there will be 20 marks **Internal Assessment Examination** for each paper. There will be **Home Assignment** of 80 marks and 60 marks in 2nd semester and 4th semester respectively.

PG ZOOLOGY FIRST SEMESTER

101: Biology of Non-Chordata and Taxonomy

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Non-Chordata-I

1. Reproduction in Protozoa
2. Canal system in Porifera
3. Polymorphism in Coelenterata
4. Structure and affinities of Ctenophora
5. Organization of Bilateria

Unit II Non-Chordata-II

20 marks

1. Origin of Coelom and Coelomates
2. Metamerism and segmentation in Annelida
3. Excretory system in Annelida
4. Larval forms of crustaceans
5. Crustacean parasites

Unit III Non-Chordata-III

20 marks

1. Parasitic adaptation and host parasite relations in relation to human (Protozoa and Helminthes)
2. Respiration in Mollusca
3. Foot in Mollusca
4. Water vascular system in Echinodermata
5. Structure and affinities of Lobophorates

Unit IV Taxonomy

20 marks

1. History of taxonomy and new trends in taxonomy
2. Principles and theories of biological classification, hierarchical categories
3. Modern molecular methods in taxonomy
4. Species concept
5. Taxonomic procedures: Taxonomic collection, preservation, process of identification.

Internal Assessment

20 marks

Suggested Readings:

1. Busca, R, Moore W, Shuster SM. (2016) Invertebrates; OUP USA; 3rd edition
2. Hyman, L.H. (1967) *The invertebrates*, Vol. I: Protozoa through Ctenophora; Vol. II: Platyhelminthes and Rhynchocoela - The acoelomate Bilateria; Vol. III: Acanthocephala, Aschelminthes and Entoprocta - The Pseudocoelomate Bilateria; Vol. IV: Echinodermata - The coelomate Bilateria; Vol. V: Smaller Coelomate Groups - Chaetognatha, Hemichordata, Pogonophora, Phoronida, Ectoprocta, Brachipoda, Sipunculida - The Coelomate Bilateria; Vol. VI: Mollusca I - Aplacophora, Polyplacophora, Monoplacophora, Gastropoda, The coelomate Bilateria. Mc Graw-Hill Publishers,.
3. Kapoor, V. C. (2019). *Theory Practice Animal Taxonomy Bio*. India: CBS Publishers & Distributors
4. Kotpal, R. L. (2016) *Modern text book of Zoology: Invertebrates*. Rastogi Publications
5. Mayr, E. (2015). *Principles of Systematic Zoology*. United States: Scientific Publishers.
6. Ruppert, Edward E., and Robert D. Barnes (1994). *Invertebrate zoology*. Vol. 6. Fort Worth: Saunders College Publishing,

102: Environmental Biology and Biostatistics

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Environmental Biology I

1. Concept of Ecosystem (emergent properties, biological levels of organization, structure and classification of ecosystems, ecological energetics, Gaia hypothesis and Cybernetics)
2. Leibig's law of minimum and concept of limiting factors, law of tolerance
3. Population ecology (Structure and dynamics)
4. Concept of meta-population, demes and dispersals, inter-demic extinctions

Unit II Environmental Biology II

20 marks

1. Community structure and its organization
2. Community dynamics (Succession), Niche segregation and species diversity
3. Major terrestrial biomes, theory of island biogeography and bio-geographical zones of India
4. Environmental stress and their management

Unit III System Ecology

20 marks

1. Ecomodelling
2. Green house effect, ozone depletion, global warming
3. Biodiversity and its conservation
4. Waste management and bioremediation, environmental management and Eco-auditing, Environmental education
5. Non conventional energy (nature, sources, production and utilization)

Unit IV Biostatistics

20 marks

1. Measurements of central tendency (mean, median, mode and standard deviation)
2. Probability distribution (normal, binomial and Poisson)
3. Test of significance (t-test, chi-square test)
4. Simple correlation and regression analysis
5. Analysis of variance
6. Elementary idea of skewness and kurtosis

Internal Assessment

20 marks

Suggested Readings:

1. Dash M.C., (2009) Fundamentals of Ecology. Mc GrawHill Ed India Pvt Ltd.
2. Miller, G. T., & Spoolman, S. (2014). *Essentials of ecology*. Cengage Learning.
3. Motulsky, H. (2010). *Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking*. United Kingdom: Oxford University Press.
4. Odum, E.P. and Barrett, G.W., (2018). *Fundamentals of Ecology*, 5th Edition
5. Smith and Smith (2015), *Elements of Ecology*, Global Edition; Pearson Education India;
6. Van Belle, G., Fisher, L. D., Heagerty, P. J., Lumley, T. (2004). *Biostatistics: A Methodology For the Health Sciences*. Germany: Wiley.

103: Evolution and Ethology

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 Marks

Unit I Evolution I

1. Modern synthetic theory of Evolution
2. Hardy Weinberg's law of genetic equilibrium, (Equilibrium destabilizing forces: Natural selection, mutation, genetic drift, recombination)
3. Animal distribution (Cosmopolitan, discontinuous, bipolar and isolated distribution) factors affecting animal distribution and its evolutionary significance.
4. Isolation and its mechanism
5. Fossilization and dating of fossils.

Unit II Evolution II

20 marks

1. Adaptive radiation
2. Evolutionary time scale (era, period and epoch)
3. Stages in primate evolution upto *Homo*
4. Concepts of neutral evolution including molecular divergence and molecular clocks
5. Evolutionary trees showing relationships among organisms, genes and genefamilies

Unit III Ethology I

20 marks

1. Concept of animal behavior, physiological basis of instinctive behavior, orientation and navigation in animals
2. Neural mechanism of learning
3. Physiological and biochemical basis of memory.
4. Reproductive behavior in vertebrates (Courtship and mating)
5. Social behavior in insects and primates.

Unit IV Ethology II

20 marks

1. Homeostasis and Behavior
2. Hormones and pheromones influencing behavior
3. Altruism- Reciprocal Altruism, kin selection and inclusive fitness
4. Biological clock
5. Habitat selection and optimality in foraging

Internal Assessment

20 marks

Suggested Readings:

1. Alcock, J. (2013). Animal Behavior: An Evolutionary Approach. United States: Oxford University Press, Incorporated.
2. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
3. Hall, B. K., Hallgrímsson, B., Strickberger, M. W. (2014). Strickberger's Evolution. United States: Jones & Bartlett Learning.
4. Herron, J. C., Freeman, S. (2014). Evolutionary Analysis. United Kingdom: Pearson.
5. Manning A and Dawkins MS. An Introduction to Animal Behaviour. Cambridge University Press, USA.
6. Rastogi B.B., (2018). Organic Evolution, MedTech; 3rd edition

104: Instrumentation and Instrumental techniques

Full marks: 100 (80 + 20)

Duration: 3 hr

20 marks

Unit I Instrumentation

1. Microscopy-Principles Types: Phase contrast microscope, Transmission electron & Scanning Electron Microscope, Fluorescence Microscope
2. Chromatography- Principles and Types of Chromatography (Thin layer, Gas Chromatography, HPLC)
3. Centrifugation – General Principles & Types of Centrifugation.
4. Spectrophotometry – Laws of light absorption, Colorimeter, Principles and Functions of Spectrophotometer

Unit II Instrumental techniques I

20 marks

1. Electrophoresis – Principles & Types (Paper, SDS, Rocket Immuno)
2. Flowcytometry and Immunofluorescence microscopy.
3. *In situ* localization by techniques such as FISH, GISH
4. PET, MRI, FMRI & CAT

Unit III Instrumental techniques II

20 marks

1. Radioisotope techniques- Nature of radioisotopes
2. Isotopes in Biochemistry
3. Measurement of radioactivity(carbon dating, Geiger-Muller counting, liquid scintillation counting)

Unit IV Instrumental techniques III

20 marks

1. Principles of electrochemical techniques (electrochemical cells and reaction, potentiometry and voltmeter)
2. pH electrode, ion selective and gas sensing electrodes, and Clark type oxygen electrodes
3. Elementary idea about X-ray crystallography and NMR

Internal Assessment

20 marks

Suggested Readings:

1. Boyer, R. F. (2012). Biochemistry Laboratory: Modern Theory and Techniques. United Kingdom: Prentice Hall.
2. Campbell, I. (2012). Biophysical Techniques. United Kingdom: OUP Oxford.
3. Murphy, D. B., Davidson, M. W. (2013). Fundamentals of Light Microscopy and Electronic Imaging. United Kingdom: Wiley.
4. Serdyuk, I. N., Zaccai, N. R., Zaccai, J. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. (n.p.): Cambridge University Press.
5. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. (2018). United Kingdom: Cambridge University Press.

105: PRACTICAL

Full marks: 100

Duration: 6 hrs

1. Dissections:
 - i. Nervous system of Prawn, Cockroach, Earthworm
 - ii. Digestive system of Cockroach
2. Identification with comments:
 - i. Museum specimen (Invertebrate)
 - ii. Permanent slides (Invertebrates)
3. Mounting: Statocyst of prawn, ovary of earthworm, spermatheca of earthworm. Preparation of paramecium & euglena culture, some invertebrate microscopic specimens.
4. Ecology:
 - i. Determination of dissolved oxygen content of water samples by Wrinkler's method
 - ii. Determination of salinity and chlorinity of water samples
 - iii. Determination of soil pH and water holding capacity of soil
5. Biostatistics:

Calculation of:

 - i. Standard deviation
 - ii. Standard error
 - iii. t-test
 - iv. chi-square test
using suitable biological materials
6.
 - A.i. Construction of cladogram based on morphological characters
 - ii. Construction of phylogenetic trees on bioinformatics tools
 - B.i. Demonstration and working principle of centrifuge, colorimeter, spectrophotometer, chromatography, pH meter, electrophoresis and microtome
7. Viva voce
8. Practical record and Sessional work.

PG ZOOLOGY SECOND SEMESTER

201: CHORDATA

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I

1. Origin of Chordata
2. Salient features and affinities of protochordates.
3. Structural features and affinities of cyclostomes.
4. Electric organs of fishes
5. Structural features, distribution and affinities of Dipnoi and Latimeria.

Unit II

20 marks

1. Origin and evolution of amphibia.
2. Structural peculiarities and affinities of gymnophiona.
3. Origin of reptilia
4. Adaptive radiation in reptiles
5. Structure and affinities of *Sphenodon*

Unit III

20 marks

1. Flight adaptation and Migration in birds
2. Plumage and coloration in birds
3. Prototheria and Metatheria
4. Aquatic mammals
5. Adaptive radiation in mammals

Unit IV

20 marks

1. Origin and evolution of Heart, Kidney and Brain.
2. Respiratory organs in vertebrates
3. Receptor organs in vertebrates
4. Integuments and its derivatives in vertebrates

Home assignment

20 marks

Suggested Readings:

1. Hickman, C. P. (2014). Integrated Principles of Zoology. United Kingdom: McGraw-Hill Education
2. Kotpal RL (2016). Modern Textbook of Zoology –Vertebrates; Rastogi Publications -Meerut
3. Pough, F. H., Janis, C. M., Heiser, J. B. (2013). Vertebrate Life. United Kingdom: Pearson.
4. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.

202: Physiology and Endocrinology

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Physiology I

1. Structure of haemoglobin and its role in O₂ and CO₂ transport.
2. Cardiac cycle and its regulation.
3. Breathing and its regulation, Exchanges of gases.
4. Mechanism of urine formation, acid-base balance.
5. Ultra structure and mechanism of muscle contraction in skeletal muscle.

Unit II Physiology II

20 marks

1. Mechanism of Nerve conduction and synaptic transmission.
2. Thermoregulation in Homeotherms and Poikilotherms.
3. Pheromones with special reference to insects and mammals.
4. Stress physiology- Concepts of stress, strain, and Elastic and Plastic strain.
5. Stress tolerance, stress avoidance, stress resistance.

Unit III Endocrinology I

20 marks

1. Chemistry & functions of the hormones secreted by the endocrine glands
Pituitary, thyroid, adrenal, pancreas, gonads, pineal, thymus & gastrointestinal hormones

Unit IV Endocrinology II

20 marks

1. Mechanism of hormone action
2. Chemical messengers, hormones & their feedback system
3. Hypothalamic control of adeno-hypophysial function
4. Neurotransmitters and neuropeptides (type, synthesis and mode of action)

Home assignment

20 marks

Suggested Readings:

1. Bentley, Peter John (1998). *Comparative vertebrate endocrinology*. Cambridge University Press,
2. Hadley, Mac E (2007). *Endocrinology*. Pearson Education India,
3. Hall, John E., and Michael E. Hall. *Guyton and Hall textbook of medical physiology e-Book*. Elsevier Health Sciences, 2020.
4. Norris, D., Carr, J. A. (2020). *Vertebrate Endocrinology*. Netherlands: Elsevier Science.
5. Tortora, G.J. & Grabowski, S. (2006). *Principles of Anatomy & Physiology*. XI Edition John Wiley & sons.

203: Molecular biology and Genetic Engineering

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Molecular Biology I

1. Nucleic acids as genetic material
2. Replication of DNA
3. Concept of gene as recon, muton and cistron, split gene, jumping gene, overlapping gene
4. Gene regulation: Operon concept, Negative and positive regulations

Unit II Molecular Biology II

20 marks

1. Transposons
2. DNA damage & repair
3. RNA synthesis & processing. Factors for RNA synthesis, Editing, Splicing & polyadenylation of nascent RNA
4. Mechanism of protein synthesis

Unit III Genetic Engineering I

20 marks

1. Isolation and sequencing of gene or a DNA segment (Maxam & Gilbert's method and Sanger's method)
2. Protein sequencing
3. DNA chip technology and microarrays.

Unit IV Genetic Engineering II

20 marks

1. Gene cloning (Strategies of gene delivery, gene replacement, gene regulation and silencing) Gene library.
2. RFLP, RAPD, AFLP analysis and their applications in the field of genetic engineering
3. Protein engineering in microbes.

Home assignment

20 marks

Suggested Readings:

1. Alberts, Bruce.(2017) *Molecular biology of the cell*. Garland science,.
2. Brown, T. A.,(2007) *Genomes* . New York: Garland Science Publishers,
3. Green, M. R., & Sambrook, J.(2012) *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Karp, Gerald, Janet Iwasa, and Wallace Marshall(2020). *Karp's Cell and Molecular Biology*. John Wiley & Sons,
5. Lodish, Harvey F., Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde L. Ploegh, Kelsey C. Martin, Michael B. Yaffe, and Angelika Amon.(2021) *Molecular cell biology*. New York: WH Freeman,.
6. Old, R. W., Primrose, S. B., & Twyman, R. M.(2011.) . *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.

204: Biotechnology, Applications of Biotechnology, Bioethics and Biophysics

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Biotechnology

1. Recombinant DNA technology-Enzymes used in r-DNA technology, Molecular tools and their applications, Restriction enzymes, DNA & RNA markers
2. Cloning vectors (plasmids, phasmids, cosmids and bacterial artificial chromosome (BAC), Yeast artificial chromosome (YAC)
3. Blotting techniques (Southern, Northern and Western blotting)
4. PCR technology and its application (Basic PCR, Anchored PCR, Inverse PCR and Asymmetric PCR)

Unit II Applications of Biotechnology

20 marks

1. Cloning and transgenic animals.
2. DNA fingerprinting
3. Anti-sense RNA technology
4. Organic waste management (Concept and resource recovery through biological and non biological processes) and Vermicomposting (Concept, characteristics and present status)

Unit III Bioethics

20 marks

1. Ethical problems in biotechnology: Intellectual property rights (IPR), Intellectual property protection (IPP)
2. Bioethical concerns of rDNA technology
3. Patenting of genes and DNA sequences
4. International conventions relating to patents

Unit IV Biophysics

20 marks

1. Intermolecular forces: Dipoles, Dielectric constant, Dipole movement, Ionic bonding, Hydrogen bonding, Vanderwaal's force
2. Colloidal system, Properties of colloids, Emulsion, Suspension, Adsorption & Ultrafiltration
3. Electromagnetic radiation and its interaction with living organisms with reference to UV & Visible radiations
4. Oxidation-Reduction Equilibrium, Equilibrium Constant & Redox Potential
5. Theories of Reaction rate and the energy activation

Home assignment

20 marks

Suggested Readings

1. Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub.
2. Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
3. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Goel, D., Parashar, S. (2013). *IPR, Biosafety and Bioethics*. India: Pearson Education India.
5. Nambisan, P. (2017). *An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology*. United Kingdom: Elsevier Science.
6. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.
7. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.
8. Phillips, R., Kondev, J., & Theriot, J. (2009). *Physical Biology of the Cell*. New York: Garland Science.
9. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.

205:PRACTICAL

Full marks: 100

Duration: 6 hrs

1. Dissections:
 - i. Cranial nerves of *Scoliodon*
 - ii. Brain of Chick
 - iii. Study of feathers and beaks of birds
2. Identification with comments:
 - i. Museum specimen (Vertebrate)
 - ii. Permanent histological slides (Chordates)
 - iii. Study of bones (Frog, Varanus, Fowl and Rabbit)
3. Physiology:
 - i. Estimation of haemoglobin concentration of blood of toad/human
 - ii. Estimation of R.B.C. and W.B.C. in human blood
 - iii. Differential counting of leucocytes in Toad/ Human blood
 - iv. Isolation and identification of the pure culture of Bacteria and fungi
 - v. Staining of Gram-positive and Gram negative Bacteria.
4. a. Estimation of DNA and RNA
b. Demonstration of agarose gel electrophoresis and PAGE
5. Preparation of histological slides of vertebrates
6. Viva voce
7. Practical record and Sessional work.

THIRD SEMESTER

301: Cell and Inheritance biology

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Cell Biology I

1. Molecular organization & functions of plasma membrane
2. Ultrastructure and functions of mitochondria
3. Chemistry and functions of lysosome
4. Compartmentalization and functional significance of golgi apparatus
5. Dynamics of endoplasmic reticulum

Unit II Cell Biology II

20 marks

1. Structure and function of ribosome and site of protein synthesis
2. Nucleus: Structure and Function, nucleolus
3. Giant chromosomes (Polytene and Lampbrush)
4. Molecular mechanism of cell division: Mitosis (behavior of chromosomes),cytokinesis, meiosis- events and mechanism

Unit III Inheritance Biology I

20 marks

1. Concept of gene: allele, multiple allele, pseudoallele
2. Pleiotropism, Penetrance and Expressivity
3. Gene interactions
4. Linkage and linkage maps
5. Crossing over

Unit IV Inheritance Biology II

20 marks

1. Structural and numerical abnormalities in chromosomes
2. Eugenics, Euphenics
3. Human chromosome analysis- Karyotype analysis, banding pattern
4. Heredity of twins

Internal Assessment

20 marks

Suggested Readings:

1. Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition
2. Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication
3. Griffiths, A. J. F. (2008). Introduction to Genetic Analysis. United Kingdom: W.H. Freeman and Company
4. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition
5. Fletcher H. and Hickey I. (2015). Genetics. IV Edition. GS, Taylor and Francis Group, New York and London.
6. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.

302 :Developmental Biology

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I

1. Molecular events of pre and post fertilization
2. Fate map and morphogenetic movements during gastrulation (neuralcrest and primordial germ cell migration)
3. Basic concept of development- potency,commitment,specification,induction and competence)
4. Eye lens induction and limb development in amphibia

Unit II

20 marks

1. Axes and pattern formation in (a) *Drosophila*, (b) amphibia, (c) chick
2. Growth and growth curves
3. Metamorphosis (progressive, retrogressive)
4. Hormonal regulation of metamorphosis

Unit III

20 marks

1. Placentation in mammals
2. Oestrus and menstrual cycle
3. Infertility, multiple ovulation, *invitro* fertilization and embryo transfer, embryo sexing
4. Regeneration

Unit IV

20 marks

1. Apoptosis and its role in development
2. Cellular differentiation and differential gene regulation
3. Environmental regulation of normal development
4. Concept and applications of stem cell

Internal Assessment

20 marks

Suggested Readings

1. Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.
3. Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).
4. Wolpert L (2010). Principles of Development. II Edition, Oxford University Press.

303: Cell and Molecular Biology(core-elective)

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit-I Molecular Cytology I

1. Chromatin organization (Euchromatin, heterochromatin, nucleosome concept)
2. Constitution of eukaryotic genome, C-value paradox, Repetitive and Non-repetitive DNA sequences
3. Meiotic abnormalities and non-disjunction of chromosome, mis-division of centromere
4. Cell cycle-control, mechanism, role of cyclin dependent kinase

Unit-II Molecular Cytology II

20 marks

1. Transport across cell membrane
2. Cell adhesion, cell junction
3. Cell signaling: Cell surface receptors, secondary messenger systems
4. Cell signaling: MAP kinase pathways, signaling from plasma membrane tonucleus

Unit-III Molecular Cytology III

20 marks

1. Prokaryotic & eukaryotic transcription and their regulation
2. Post translational modification
3. Protein targeting-mitochondrial, peroxisomal, nuclear encoded proteins
4. Protein sorting

Unit-IV Cancer Biology

20 marks

1. Biology of cancer cell
2. Genetic basis of cancer: Protooncogene, Viral and cellular oncology
3. Tumor suppressor genes from human, structure, function and mechanism of action of PRB and p53 tumor suppressor gene
4. Role of carcinogens and DNA repair in cancer

Internal Assessment

20 marks

Suggested Readings

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., Roberts, K., Walter, P. (2013). Essential Cell Biology. United States: CRC Press.
2. Arnold Berk , Chris A. Kaiser, Harvey Lodish , Angelika Amon , Hidde Ploegh, Anthony Bretscher, Monty Krieger Kelsey C. Martin(2016) Molecular Cell Biology. 8th edition
3. Cooper, G. M., Hausman, R. E. (2019). The Cell: A Molecular Approach. United Kingdom: Oxford University Press.
4. Krebs, J. E., Lewin, B., Goldstein, E. S., Kilpatrick, S. T. (2014). Lewin's Genes XI. Japan: Jones & Bartlett Learning
5. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.

304:Research Methodology

Full marks: 100 (80 + 20)

Duration: 3 hrs

Unit I

20 marks

1. Types of radio-isotopes used in biology
2. Genomics & its application to health.
3. Protein and nucleic acid extraction
4. Protein and nucleic acid purification
5. X-ray diffraction analysis and Mass spectroscopy.

Unit II

20 marks

1. Definition, Objectives, Emerging areas and Applications of Bioinformatics
2. Biological database and its management
3. *In-silico* primary characterization of protein sequences and protein structure prediction.
4. Genome analysis.
5. Biological datamining.

Unit III

20 marks

1. Introduction to research methodology: Definition, characteristics, objectives, nature, classification, flowchart, identification of the problems.
2. Research design: Definition, classification, features, factors, types and criteria.
3. Methods of data collection.
4. Hypothesis: Types, sources, characteristics, advantages, hypothesis testing.

Unit IV

20 marks

1. Computer application in research, networking, internet
2. MS Office: Word, Excel, Powerpoint.
3. Research report and preparation- report drafting, reference to footnotes, table and charts.
4. Preparation of bibliography and indexing, diagrammatic presentation.

Internal Assessment

20 marks

Suggested Readings:

1. Campbell, I. (2012). Biophysical Techniques. United Kingdom: OUP Oxford.
2. Kothari, C. R. (2004). Research Methodology: Methods and Techniques. India: New Age International (P) Limited.
3. Lesk, A.M. (2002). Introduction to Bioinformatics. Oxford University Press
4. Mount, D. W. (2001). Bioinformatics: Sequence and Genome analysis. Cold Spring Harbor, NY: Cold Spring Harbour Laboratory Press
5. Panneerselvam, r. (2014). Research methodology. India: PHI Learning.
6. Serdyuk, I. N., Zaccai, N. R., Zaccai, J. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. (n.p.): Cambridge University Press.

305: PRACTICAL

Full marks: 100

Duration: 6 hrs

1. Permanent cytological preparation to demonstrate the mitotic and meiotic chromosomes of onion root tip and grasshopper testis
2.
 - a. Identification and comment on cytological preparations- different stages of mitosis and meiosis
 - b. Study of permanent embryological slides of *Amphioxus*, Frog and Chick
3. Karyotypic analysis of mitotic chromosomes
4. Preparation of permanent embryological slides of frog and chick embryo of different hours of incubations.
5. Study of growth of anuran tadpole larva of different days.
6. Viva voce
7. Practical record and Sessional work.

FOURTH SEMESTER

401: Chemical Foundation, Biochemistry & Intermediary Metabolism

Full marks: 100 (80 + 20)

Duration: 3 hrs

Unit I Chemical Foundation

20 marks

1. pH, buffer and pKa (Derivation of Henderson-Hasselbalch equation and its importance, principles of buffer, determination of pH of buffer, role of buffers in pH regulation with examples and pKa)
2. Structure and classifications of monosaccharides
3. General structural features and classification of polysaccharides, structure and significance of glycolipids, glycoproteins, proteoglycans
4. A broad outline classification of lipids
5. Chemistry of nucleic acids

Unit II Biochemistry

20 marks

1. Structure, classification and properties of amino acids
2. Structure and classifications of proteins, Ramachandran plot
3. A broad classification of enzymes, coenzymes and vitamins
4. Mechanism of enzyme action and regulation of enzyme activity
5. Enzyme kinetics: Michaelis-Menten equation, Determination of K_m and V_{max}

Unit III Intermediary Metabolism

20 marks

1. Oxidative Phosphorylation & ATP Generation.
2. β - Oxidation
3. General reactions of amino-acid metabolism (Decarboxylation, Transamination, Deamination and Transmethylation)
4. Intermediary metabolism of carbohydrate, lipid, and amino acid and its regulation (feedback and hormonal)

Unit IV Biochemical process

20 marks

1. Photochemical process of Bioluminescence (mechanism, kinetics of light production)
2. Biosynthesis of fatty acids and tri-glycerides, cAMP: structure and function
3. Regulation of body glucose by insulin and glucagon
4. Degradation of tryptophan and phenylalanine

Home assignment

20 marks

Suggested Readings:

1. Berg, J. M., Tymoczko, J. L., Gatto, G. J., Stryer, L. (2015). Biochemistry. United States: W. H. Freeman.
2. Murray, R. K. (2009). Harper's Illustrated Biochemistry, 28th Edition. United Kingdom: McGraw-Hill Education.
3. Nelson, D. L., Cox, M. M. (2017). Lehninger Principles of Biochemistry. India: W. H. Freeman
4. Voet, D., Voet, J. G., Pratt, C. W. (2018). Voet's Principles of Biochemistry. United States: Wiley.

402: Microbiology and Immunology

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit I Microbiology I

1. Virus- general characters and classification, Molecular architecture of a bacteriophage, Reproduction in virus with special reference to lysogeny and lytic cycles.
2. Bacterial-Molecular organization, growth, nutrition and reproduction in bacteria
3. Other microbes-A brief outline study of Mycoplasma, slime molds, yeast and cyanobacteria
4. Microbial genetics-Transformation, Transduction, Conjugation and recombination

Unit II Microbiology II

20 marks

1. Subviral pathogenic entities (Viroids, Virusoids and prions)
2. Microbial diseases, host microbe relationship
3. Microbial toxins – types, mode of action, virulence and pathogenesis
4. Role of microbes in industry and agriculture

Unit III Immunology I

20 marks

1. Types of immunity: Innate, acquired, passive, active, humoral and cell-mediated immunity concepts; self and non-self
2. Lymphoid organs: (origin, function) and cells of the immune system
3. Antigen, Hapten and Superantigen
4. Immunoglobulin: Structure, Distribution & function. Interaction between antigens and antibodies(antigen-antibody complex; antibody-mediated complemented activation)

UNIT- IV Immunology II

20 marks

1. MHC: Types and their role in antigen presentation
2. Autoimmune disorders
3. Complement system
4. Immuno response during bacterial (tuberculosis), parasitic (malaria) & viral infection (HIV)

Home Assignment

20 marks

Suggested Readings:

1. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology*. London: Gower Medical Pub.
2. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.
4. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology*. New York: Garland Science.
5. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press
6. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology (5th ed.)*. New York: McGraw-Hill.
7. Willey, J. M., Sherwood, L., Woolverton, C. J. (2008). Prescott, Harley, and Klein's *Microbiology*. Spain: McGraw-Hill Higher Education.

403: Molecular Genetics

Full marks: 100 (80 + 20)

Duration: 3 hrs

20 marks

Unit-I Molecular Genetics I

1. Molecular basis of gene mutation
2. Detection of mutation by AMES test.
3. Physical and chemical mutagenesis
4. Site directed mutagenesis

Unit-II Molecular Genetics II

20 marks

1. Transposable elements in prokaryotes and eukaryotes
2. Mutation induced by transposons
3. Multifaceted disorders-Artherosclerosis, diabetes mellitus, huntington's chorea
4. Ageing and senescence.

Unit-III Molecular Genetics III

20 marks

1. Molecular mechanism of sex determination in *Drosophila* and man
2. Multiple factor inheritance
3. Extra chromosomal inheritance- mitochondrial and maternal inheritance
4. Polygenic inheritance and QTL mapping

Unit-IV Epigenetics

20 marks

1. Epigenetics and environment
2. Genomic imprinting and epigenetics
3. Epigenome and epigenomics
4. Histone code, DNA methylation and epigenetics

Home Assignment

20 marks

Suggested Readings:

1. Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication
2. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
3. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
4. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition
5. Lewin B. (2013). Gene XI, Jones and Bartlett.
6. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.

404: PROJECT WORK

Full marks: 100

405: PRACTICAL

Full marks: 100

Duration: 6 hrs

1. Biochemistry:
 - i. Quantitative estimation of protein, ascorbic acid, glycogen content by colorimetric/spectrophotometric method
 - ii. Preparation of buffers (acetate/phosphate)
 - iii. Separation of amino acid by paper chromatography
2. Enzyme kinetics and mechanism of enzyme action (Urease- Effect of temperature, pH and substrate concentration).
3.
 - i. Sterilisation and Preparation of media for microbial culture
 - ii. Staining of *Lactobacillus* from curd
 - iii. Staining of gram +ve and gram -ve bacteria
4. Preparation of cytological slides to demonstrate mitotic chromosomes following flame dried Giemsa staining
 - a. Bone marrow cells of bird/ mammal
 - b. Kidney/gill epithelia of fish
5.
 - a. Sequence retrieval and analysis from GenBank, NCBI
 - b. Protein structure retrieval and visualization (PDB)
6. Viva voce
7. Practical record and Sessional work.

NOTE: 1st and 3rd Semester-Internal (40marks) + Home Assignment (40marks)