Tribhuvan University
Institute of Science and Technology
M.Sc. Zoology (Semester System)
SEMESTER II
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Genomics and Proteomics **Credits: 3**
Course No: Zoo 569 **Lecture hrs: 48**
Nature of the Course: Theory **Full Marks: 75**
Pass Marks: 37.5

Course Objectives

- To impart advanced and innovative knowledge of present day in genomics and proteomics.
- To provide knowledge on some important techniques in genomics and proteomics.

Course Contents

A. Genomics **24 hrs**

1. **Concept:** DNA-Gene-Genome, Coining of the term genome, Coding and non-coding region of gene. Nuclear genome, Mitochondria genome, Chloroplast genome. (2)
2. **Genome compositions:** Repetitive and non-repetitive DNA, Properties of repetitive and non-repetitive DNA. (1)
3. **Genome:** Types of organisms and sizes of genomes (from viruses to human). (2)
4. **Genomics**: Basic concept of genomics and its history. (1)
5. **Human genome project:** History and significance, Highlights, Merits and demerits. (1)
6. **Types of genomics based on evolution:** Prokaryotic and Eukaryotic genomics. (2)
7. **Types of genomics based on organisms:** Human genomics, Animal Genomics, Plant Genomics, and Microbial Genomics. (2)
8. **Classification of genomics**: Functional genomics, Structural genomics, Comparative genomics, Biochemical genomics, Evolutionary genomics, Phylogenomics, Physiological genomics, Epigenomics, Metagenomics, Conservation genomics. (2)
9. **Genome Studying and Mapping** Studying DNA, Enzyme for DNA manipulation, DNA cloning, the Polymerase Chain Reaction (PCR), Genetic and physical Mappings. (2)
10. **Genome analysis: and evolution:** 1. Sequencing and its types. 2. Assembly, 3. Annotation 4. Sequencing pipelines and database. Genome evolution in the first 10 billion years, Human genome evolution in the last 5 million years. (4)
11. **Applications of genomics:** 1. Genomic medicine, 2. Synthetic biology and bioengineering 3.Convervation genomics. (1)
12. **Wildlife Genomics:** Introduction, Landscape genetics, Conservation genomics, Population genomics, Genetics for migration ecology, Disease ecology, Non-invasive and trace DNA, Population size estimates, Bottlenecks, Species identification, Individualization, Conservation and small

population management, Bar coding of important species, Molecular kinship reconstruction, Genetic diversity, Assessing impacts of disease on populations. (4)

B. Proteomics **24 hrs**

1. **Concept:** Central dogma: DNA-RNA-Protein interface. DNA as genotype and Protein as phenotype. Transcriptome, proteomics and "Omics" revolution. (2)
2. **Proteome Analysis: (1)** Protein-expression proteomics, (2) Structural proteomics, (3) Functional proteomics. (2)
3. **Methods of studying proteins** (4)

i. Protein detection with antibodies (immunoassays)

ii. Antibody-free protein detection: Detection methods and Separation methods.

iii. Hybrid technologies

iv. Current research methodologies

v. High-throughput proteomic technologies: Mass spectrometry and protein profiling, Protein chips and Reverse-phased protein microarrays

4. Protein structure, function and folding (10)

- **Basic concept: Biochemistry of Protein**: Amino acids and Khorana's dictionary of triplets. **Protein synthesis**: Biosynthesis and chemical synthesis
- **Protein structure:** Primary, secondary, tertiary and quaternary structures, Protein structure determination, protein sequence analysis, Computational prediction of protein structure.
- **Protein functions:** Cellular functions, Enzymes, Cell signaling and ligand binding, Structural proteins, Hormones.
- **Protein folding:** Process of protein folding: Primary, secondary, tertiary, and quaternary; Driving force of protein folding: Hydrophobic effect and Chaperones.
- **Computational methods for studying protein folding:** Energy landscape of protein folding and Modeling of protein folding.
- **Experimental techniques for studying protein folding:** X-ray crystallography, Fluorescence spectroscopy, Circular dichroism, Vibrational circular dichroism of proteins, Protein nuclear magnetic resonance spectroscopy, Dual polarisation interferometry, Studies of folding with high time resolution, Proteolysis, Optical tweezers.
- **Incorrect protein folding and neurodegenerative disease, Levinthal's paradox and kinetics.**

5. **Applications of proteomics:** 1. Post-translational modifications: (a) Phosphorylation, (b) Ubiquitination, (c) Additional modifications, (d) Distinct proteins under distinct settings 2. Protein-protein interactions, 3.Protein expression profiling, 4.Molecular medicine: Tuber metastasis, Renal disease diagnosis, Neurology, Urological cancer research, Antibody profiling for study and treatment of disease, Nutrition research, Diabetes research, Fetal and maternal medicine. (2)
6. **Research methodology:** DNA/protein sample collection, preservation, DNA extraction, Electrophoresis, DNA/Protein Analysis, Proposal, thesis, report and scientific paper writing. (4)

Suggested Readings:

Campbell, P.N. and Smith, A.D. (2000): **Biochemistry Illustrated.** Churchill Livingstone, A Division of Harcourt Publishers Limited, 1-3 Baxter's place, Leith Walk, Edinburgh EH1 3AF, UK.

Harisha, S. (2007): **Fundamentals of Bioinformatics.** I.K, International Publishing House Pvt Ltd, New Delhi, Banglore and Mumbai, India.

Lesk, A.M. ((2014): **Introduction to Bioinformatics.** Oxford University Press, Great Clarendon Street, Oxford, OX2 6DP, UK.

Wilson, K. and Walker, J. (1995): **Practical Biochemistry: Principles and Techniques**, Fourth Edition, Cambridge University Press, UK.

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Tribhuvan University
Institute of Science and Technology
M.Sc. Zoology (Semester System)
SEMESTER II
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Bioinformatics and Molecular Systems Biology **Credits: 3**
Course No: Zoo 570 **Lecture hrs: 48**
Nature of the Course: Theory **Full marks: 75**
Pass marks: 37.5

Objectives

- To impart advanced and innovative knowledge of present day in Bioinformatics and Systems Biology.
- To provide knowledge on some important tools of Biological data analysis in Bioinformatics and Systems Biology.

Course Contents

A. Bioinformatics **24 hrs**

1. **Concept:** Bioinformatics and its use in the laboratory to study genomes, transcriptomes, and Proteomes. (1)
2. **Scoring matrices:** Introduction, The basics of scoring methods: 1. Initialization, 2. Fill or induction, 3. Track back. Types of scoring matrices, Relations between **PAM** and **BLOSUM.** (1)
3. **National Center for Biotechnology Information Entrez (NCBI Entrez):** Introduction, Public Databases at NCBI Entrez with its various modules for searches, Ten major databases of Bioinformatics. (1)
4. **Biological databases:** Introduction, the Origin of biological databases, Importance of computational databases, The database industry, The principle requirements on the public data services, **Types of biological databases: Primary databases:** 1.National Central for Biotechnology Information (NCBI), 2. European Molecular Biology Laboratory (EMBL), 3. DNA Data Bank of Japan (DDBJ), 4.Protein Information Resource (PIR), 5. Martinsried Institute for Protein Sequences (MIPS), 6.

SWISS-PROT, 7. TRANSLATED EMBL (Tr-EMBL), 8. NRL-3D. **Secondary databases**: 1.Domain Architecture databases, 2 Prosite, 3. Pfam, 4. Prints, 5.The Blocks Database. (3)

5. **Plasmid mapping and Primer design:** 1. Restriction mapping, 2. Primer design on the web, 3.Primer design programs and software (Web tools for primer design), 4. MacV ector, 5. OMIGA, 6. Vector NTI, 7. Gen Construction Kit. (2)

7. **Protein structure prediction and analysis:** Introduction, Anatomy of Amino Acids, Structure of the proteins: 1. Primary structure, 2. Secondary structure, 3. Tertiary structure, 4. Quaternary structure. **Methods of protein structure prediction**: Computational methods of protein structure prediction. Protein databases: 1.Protein structure databases, 2. Protein structure visualization databases, 3. Protein structure alignment database. Application of protein structure prediction. (3)

8. **Eavesdropping on the transmission of genetic information:** Identification of genes associated with inherited diseases, Genome-wide association studies, Genome sequence projects. (2)

9. **The genome of Homo sapiens:** Protein-coding genes, Repeat sequences, RNA, Single –nucleotide polymorphisms and haplotypes, Systematic measurements and collections of single-nucleotide polymorphisms, Ethical, legal, and social issues or implications (ELSI). **Genetic diversity in anthropology:** DNA sequences and languages, Genetic diversity and personal identification. **Comparative genomics of Eukarya.** (3)

10. **Drug discovery and development:** (1) **Insilico drug design:** Theory of drug design, Use of computers in drug design, Rational drug design software-state of the art, RACHEL software package, Development of a component specification language, Novel techniques to estimate legand-receptor binding. (2) The lead compound. Improving on the lead compound: quantitative structure-activity relationships, Bioinformatics in drug discovery and development, Molecular modeling in drug discovery. (3)

11. **Evolution and Phylogenetics:** Introduction, The basic processes of evolution, Phylogenetics, Molecular phylogeny in Bioinformatics, Methods of phylogenetic analysis: 1.Distance method (Pairwise method), 2. Neighbor Joining (NJ) method, 3. Maximum Parsimony method, 4. Maximum Likelihood Estimation method and 5. Other methods. Preparing sequence for phylogenetic analysis, Software for phylogenetic analysis, Bootstrapping. (3)

12. **Bioinformatics software and its applications:** List of bioinformatics softwares. (1)

13. **CCG Wisconsin Package:** Wisconsin package programs. (1)

B. Molecular Systems Biology **24 hrs**

1. **Concept and history:** Molecular systems biology as a tripartite confluence of system sciences, life sciences and information sciences, Mol.systems biology as holism vs. reductionism, Systems biology and "omics" as associated studies (Genomics, functional genomics, structural genomics, proteomics, functional proteomics, proteogenomics, metagenomics, neurogenomics, personal genomics, epigenomics, lipidomics, immunoproteomics, nutriproteomics, foodomics, nutrigenomics, transcriptomics, metabolomics, metabonomics, pharmacogenomics, pharmacomicrobiomics, toxicogenomics, psycogenomics, stem cell genomics, connectomics, microbiomics, cellomics, etc about 40. (3)

2. **Networks for Molecular systems biology:** Networks and graphs, Connectivity in networks, Dynamics, stability and robustness, Integrative genome-scale biology, Metabolic and regulatory networks, Evolution of genomes and biological networks, Clinical and translational systems biology, Synthetic biology and genome-scale biological engineering. (5)

3. **Some sources of ideas for mol. systems biology:** 1. Complexity of sequences, 2. Computational complexity, 3. Static and dynamic complexity, 4. Chaos and Predictability. (2)

4. **Metabolic pathways: Classification and Assignment of Protein function**: 1.The enzyme commission, 2.The gene ontology consortium protein function classification. **Catalysis by enzymes**: Active sites and co-factors. Protein–ligand binding equilibria, Enzym kinetics, Measurement of effectiveness of enzymes. **Databases of metabolic pathways:** EcoCyc and The Kyoto encyclopedia of genes and genomes. **Evolution and phylogeny of metabolic pathways:** Pathway comparison, **Alignment of metabolic pathways:** 1.Comparing linear metabolic pathways, 2. Comparing non-linear metabolic pathways: the pentose phosphate pathway and the Calvin-Benson cycle. **Dynamics of Metabolic networks:** 1. Robustness of metabolic networks, 2. Dynamic modeling of metabolism. (6)

5. **Gene expression and regulation**: **DNA microarrays and Mass spectrometry:** 1. Analysis of microarray data. 2. Genome sequence analysis by Mass spectrometry. **Protein complexes and aggregates**: Properties of protein-protein complexes. **Protein interaction networks**. **Regulatory networks:** 1. Signal transduction and transcriptional control, 2. Structures of regulatory networks, 3. Structural biology of regulatory networks. (5)

1. **The genetic switch of bacteriophage lamda:** 1.What are the characteristics of the switch that must be implemented by DNA-protein interactions? 2. The materials, 3. How to throw the switch. (2)

6. **The Genetic regulatory network of Saccharomyces cerevisiae:** Adaptibility of the yeast regulatory Network. (1)

Suggested Readings

Attwood, T.K. & Parry-Smith, D.J ((1999 and 2014): **Introduction to Bioinformatics** (Cell and Molecular Biology in Action Series) published by Prentice Hall, edited by DR. Ed Wood, Department of Biochemistry and Molecular Biology, University of Leeds, UK.

Baldi, P and Brunak, S. (2003): **Bioinformatics: The Machine Learning Approach**. Published by Affiliated East-West Press Pvt. Ltd, 105 Nirmal Tower, 26 Barakhamba Road, New Delhi 110001.

Campbell, P.N. and Smith, A.D. (2000): **Biochemistry Illustrated.** Churchill Livingstone, A Division of Harcourt Publishers Limited, 1-3 Baxter's place, Leith Walk, Edinburgh EH1 3AF, UK.

Harisha, S. (2007): **Fundamentals of Bioinformatics.** I.K, International Publishing House Pvt Ltd, NewDelhi, Banglore and Mumbai, India.

Lesk, A.M. ((2014): **Introduction to Bioinformatics.** Oxford University Press, Great Clarendon Street, Oxford, OX2 6DP, UK.

Pangeni, R. P. (2007): **Concept on Bioinformatics**. Published by Sukunda Pustak Bhawan, Bhotahity, Kathmandu, Nepal.

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Tribhuvan University
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M.Sc. Zoology (Semester System)
SEMESTER II
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Related to Zoo 569 & 570 **Credits: 2**
Course No: Zoo 571 **Lecture hrs: 90**
Nature of the Course: Practical **Full marks: 50**
Pass marks: 25

Course Objectives

To impart practical knowledge on topics of Zoo 569 & 570.

Course Contents

Field and Laboratory works:

Genomics and Proteomics **Credit: 1**

1. DNA extraction methods: NaI Method and Phenol Chloroform Method, Operation of PCR, gel electrophoresis, and DNA cloning
2. Protein extraction, quantification, identification….?
3. Students will also learn how to analyze DNA and entire or section of genomes using computational biology.
4. Sequence comparison programs by the use of "Blast, GCG, MacVector or other useful programs" will also be carried out.
5. Eventually, the students will learn about the threats and issues of most endangered wild species leading to extinction and will take part in the protection and recover of these animals.

Bioinformatics and Molecular Systems Biology **Credit: 1**

1. Researching the background of the experiment: searching literature databases such as MEDLINE, or sequence databases.
2. Planning the experimental details, for example, using software to design PCR primers or identify good restriction enzymes for sub-cloning.
3. Collecting the experiment data, for example, using a computer attached to lab instrumentation.
4. Managing the experimental data, for example, assembling sequences from several DNA sequencing runs into one sequence.
5. Analyzing the experimental data, for example, analyzing the DNA sequence, identifying its function, etc.
6. Publishing the results: submitting a sequence to a sequence database, using a word processor to write a thesis or a paper.

7. Taking Homo sapiens as a model species and work on its functional genomics/proteomics or metabolic pathways to make an outcome oriented report.
8. Spanning systems biology, comparative functional genomics & bioinformatic analysis focusing on model organisms and phylogenetically related species.
9. Report writing on a model species based on system biology concept.

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Tribhuvan University
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M.Sc. Zoology (Semester System)
SEMESTER III
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Molecular Biochemistry **Credits: 3**
Course No: Zoo 625 **Lecture hrs: 48**
Nature of the Course: Theory **Full marks: 75**
Pass marks: 37.5

Course Objectives

- To impart advanced and innovative knowledge of present day in molecular biochemistry.
- To provide knowledge on some important techniques in molecular biochemistry.

Course Contents

1. **Basics of molecular biochemistry:** Concept and history of molecular biochemistry, Types of living cells, Marker enzymes, Metabolic functions of organelles, Shapes of some small molecules, Drawing chemical and molecular structures, 3-D molecular structure of organic compounds (Isomerism, stereoisomerism, and optical activity and resolution), Aromaticity a and natural aromatics, Chemical synthesis of biological molecules (Peptide synthesis and Oligonucleotide sysnthesis). (6)

2. **Introduction to proteins and peptides:** The role of amino acids in the cell, structure of amino acids, Asymmetry in biochemistry, Ionic properties of amino acids, Peptide structure and peptide bond, Ionic properties of peptide, Purification of proteins and determination of relative molecular mass, Methods for the determination of the amino acid sequence of proteins, Protein structural hierarchies, Protein denaturation and renaturation, Peptides, structure and biological activities. (4)
3. **Nucleic acids and protein synthesis:** Replication, transcription, and translation, Nucleic acid structure and synthesis, Biosynthesis of Proteins (translation), Protein targeting, Protein glycosylation. (3)
4. **Protein structure and function with hemoglobin and myoglobin as examples:** The properties of proteins, The folding of globular proteins, Structure and properties of myoglobin and hemoglobin, General principles of protein folding. **Specialized functions of Proteins:** Plasma proteins, Collagen, The immune system and the immunoglobulins, Proteins of molecular motors. (4)
5. **Structure and function of enzymes:** The properties of enzymes, Enzymes kinetics, Metabolic regulation and control, Enzyme phosphorylation and dephosphorylation, Second messengers,

Allosteric properties of enzymes, Metabolic control analysis, Genetic diversity of enzymes, Coenzymes and water-soluble vitamins. (3)

6. **Carbohydrate structures and their inter-conversions:** Monosaccharides and disaccharides, Polysaccharides, Inter-conversions of monosaccharides. (2)
7. **Nitrogen metabolism:** Protein breakdown and excretion of nitrogen, The supply of amino acids, Catabolism of essential amino acids and the formation of adrenaline, histamine, thyroxine and serotonin, The biosynthesis and metabolism of heme and chlorophylls. (3)
8. **Oxidative catabolism of glucose and fatty acids:** ß-Oxidation and glycolysis, The citric acid cycle, The electron transport chain, Oxidative phosphorylation, Other mitochondrial topics. (2)
9. **Carbohydrate and Lipid metabolism in the fasting and absorptive states:** Metabolism in the fasting state, Glycogen and its degradation, Gluconeogenesis, Ketone body formation and utilization, Control of the blood glucose concentration in health and disease, The process of absorption, Glycogenesis, Lipogenesis. (4)
10. **Plasma lipoproteins, cholesterol metabolism and atherosclerosis**: Plasma lipoproteins and cholesterol metabolism, Elevated blood lipids and atherosclerosis, Metabolism of triacylglycerols. (3)
11. **The action of hormones and other effectors in regulating glycogen and glucose metabolism, ketogenesis and lipogenesis:** Whole body interactions, The regulation of glycogen metabolism, Regulation of glycolysis and gluconeogenesis, Regulation of lipid metabolism. (3)
12. **Phopholipids, other lipid substances and complex carbohydrates:** Phospholipids, Lipid-soluble vitamins, Other lipid compounds, complex carbohydrates. (2)
13. **Biomembranes, receptors and signal transduction:** The basis of membrane structure, Membrane receptors, G-proteins, Cell signaling systems, Receptor traffic, The cytoskeleton, Membrane transport, Cell adhesion. (3)
14. **Spectroscopic techniques, Mass spectrometric techniques, Chromatographic techniques: (1) Spectroscopic techniques:** Concept and history, Theory, Properties of electromagnetic radiation, Interaction with matters, spectrum, the types of Spectroscopy, applications **(2) Mass spectrometric techniques**: Concept and history, Components or parts of a mass spectrometer, Creating ions, Mass selection, Analysers, Detectors, Tandem mass spectrometry, Common mass spectrometer configurations and techniques Separation techniques with Chromatography combined with mass spectrometry, Data and analysis, and applications, **(3) Chromatographic techniques:** Concept and history, Theory, Distribution coefficients, modes of chromatography, Performance of chromatography, quantification, internal and external standards, Types and applications. (6)

Suggested Readings

Campbell, P.N. and Smith, A.D. (2000): Biochemistry Illustrated. The 4th edition, Churchill Livingstone, 1-3 Baxer's Place, Leith Walk, Edinburgh EH1 3AF, UK.

Fisher, J. and Arnold, J.R.P. (2002): Instant Notes in Chemistry for Biologists. Viva Books Private Limited, New Delhi, Mumbai , Chennai , India.

Hames, B.D; Hooper, N.M. and Houghton, J.D. (1998): Instant Notes in Biochemistrys. Viva Books Private Limited, New Delhi, Mumbai , Chennai , India.

Jain, J.L.; Jain, S.; Jain, N. (2016): Fundamentals of Biochemistry. Publised by S. Chand & Company Pvt. Ltd.7361, Ram Nagar, New Delhi-110-055, India.

Vargas, J.E.; Caughey, A.B.; Tan, A.; Li, J.Z. (2004): Blueprints Notes and Cases : Biochemistry, Genetics and Embryology. Blackwell Publishing, first Indian reprint.

Verma, A.S.; Das, S.; Singh, A. (2014): Laboratory Manual for Biotechnology. S.Chand & Company Pvt. Ltd. Ram Nagar, New Delhi -110 055, India.

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Tribhuvan University
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M.Sc. Zoology (Semester System)
SEMESTER III
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Molecular Immunology **Credits: 3**
Course No: Zoo 626 **Lecture hrs: 48**
Nature of the Course: Theory **Full marks: 75**
Pass marks: 37.5

Course Objectives

- To impart advanced and innovative knowledge of present day in molecular immunology.
- To provide knowledge on some important diagnostic techniques in molecular immunology.

Course Contents

1. **The nature of immunity:** Concept, Variolation and vaccination, Cardinal feature of immune responses (Biological recognition systems), Recognition and defence: a minimal model. Immunological recognition (T and B lymphocytes), Immunological defence, an overview of immune system, Immunopatholog. (3)
2. **Antigen recognition**: Factors governing innunogenicity (Nature of the antigen, Expose to the antigen, Nature of the recipient, Receptor-antigen interactions), Antigen receptors of B and T lymphocytes, Antigen recognition by B and T lymphocytes, The HLA systems and its proteins (The structure of HLA molecules, The HLA complex of genes, HLA polymorphism). (5)
3. **Lymphocyte development and differentiation:** B cell development, B cell activation and maturation, T-cell development and education, T-cell subpopulation (Large granular lymphocytes). (2)
4. **Lymphocyte interactions and the lymphoid systems:** Cytotoxic T cells (Helper T cells, Costimulation of lymphocyte activation), The lymphoid system, Lymphocyte recirculation and homing, Lymphocyte selection and maturation (Regulation of lymphocyte responses), Laboratory methods (Identification and isolation of lymphocytes, Stimulation of lymphocytes). (4)

5. **Cytokines:** Sources and functions of immunological cytokines (Activation of cells of the immune system, TH1 Versus TH2 cells, Haemopoesis, Inflammation, Cytostatic, cytotoxic, and anti-viral activities), The cytokine network, Cytokines and therapy. (2)

6. **Immunoglobulins:** Structure (Variable and constant domains, The antigen-combing site, Affinity and avidity), Classes and sub-classes (IgG, IgA, IgM, IgD, IgE), Triggering of effector systems, Immunoglobulin genes (The origin of diversity, Allelic exclusion and clonal selection, Isotype switching, T cell receptor genes), Exploiting the properties of immunoglobulins (Laboratory methods, Monoclonal antibodies from hybridomas). (4)

7. **Complement:** The classical pathway (C3 conversion, Solubilization of immune complexes), The alternative pathway, The membrane attack pathway (Inadequate regulation of complement activation: Hereditary angio-oedema, Paroxysmal nocturnal haemoglobinuria, Nephritic factor, Complement polymorphisms and deficiencies). (2)

8. **Phagocytes:** Macrophages, Neutrophils, Common features of phagocyte responses (Chemotaxis, Target recognition, Ingestion, Killing and degradation: Oxygen-dependence and oxygen-independence mechanisms, Deficiency disorders). (2)

9. **Mast cells, basophils and eosinophils:** Triggering of mast cells and basophils, Mast cell mediators (Preformed mediators, Secondary mediators, Cytokines), Eosinophils (Eosinophil products, Hypereosinophilic syndrome). (2)

10. **Killer cells:** Mechanism of target cell recognition (Cytotoxic T cells, Large granular lymphocytes, Antibody–dependent cellular cytotoxicity), Mechanism of target cell killing (Secreted proteins, Membrane ligands), Cooperation between killer cells and interferons). (2)

11. **Basis of immunodiagnostics:** Introduction, The immunoglobulin molecule, Isotypes, Allotypes, Idiotypes, Binding of Immunoglobin to antigen, Importance and scope of immnodiagnotics. (2)

12. **The antigen-antibody reaction:** Introduction, Antigen-antibody binding, Kinetics of antigen-antibody reaction. (1)

13. **Immunoprecipitation, agglutination and complement fixation:** Introduction, Precipitation, Single linear immunodiffusion, Single radial immunodiffusion, Immuno quantum plate system, Double Diffusion test, Immunoelectrophoresis, Reversed immunoelectrophoresis, Immunoelectrofocussing, Cross-over electrophoresis, Rocket immunoelectrophoresis, Two-dimensional electrophoresis, Enzymo-immunodiffusion, Special double diffusion tests, Immunosedimentation, Immunorheophoresis, Agglutination (diagnostic tests), Complement fixation tests, Recent development. (5)

14. **Isotopic and Non-isotopic Immunoassays**: Introduction, Radioimmmunoassay (RIA), Manufacture and use of RIA kit, Non-isotopic immunoassays, Enzyme immunoassay, Enzyme linked immunosorbent assay (ELISA), Clinical application of ELISA), Fluoroimmunoassay, Luminescent immunoassay, Recent development. (3)

15. **Immunocytochemical techniques:** Introduction, immunofluorescence, Gold labeling, Cell separation techniques, immunosensors, Recent development. (2)

16. **Case studies in immunology:** MHC Class I and II Deficiencies, AIDS, Allergic asthma, Kidney Graft in IDDM, Systemic Lupus Erythematosus, Drug-Induced Serum Sickness, Multiple Myeloma.(7)

Suggested Readings

Peakman, M. and Vergani, D. (1997): Basic and Clinical Immunology. Churchill Livingstone, produced by Longman Asia Ltd, Hong Kong, NPCC/01.

Rastogi, S.C. (1996): Immunodiagnostics: Principles and Practices. Published by New Age International Pvt. Ltd, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002. India.

Reeves, G. and Todd, I. (1996). Lecture notes on Immunology. Blackwell Science, Third edition, Printed and bound in Great Britain, Alden Press Limited, Oxford and Northampton, UK.

Rosen, F.S. and Geha, R.S. (1996): Case studies in Immunology: A Clinical Companion. Churchill Living stone, Robert Stevenson Huse, 1-3 Baxter's place, Leith Walk, Edinburgh, EH1 3AF, UK.

Verma, A.S.; Das, S.; Singh, A. (2014): Laboratory Manual for Biotechnology. S.Chand & Company Pvt. Ltd. Ram Nagar, New Delhi -110 055, India.

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Tribhuvan University
Institute of Science and Technology
M.Sc. Zoology (Semester System)
SEMESTER III
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Molecular biology and Bionanotechnology **Credits: 3**
Course No: Zoo 627 **Lecture hrs: 48**
Nature of the Course: Theory **Full marks: 75**
Pass marks: 37.5

Course Objectives

- To impart advanced and innovative knowledge of present day in molecular biology.
- To impart advanced and innovative knowledge of present day in bionanotechnology.
- To provide knowledge on some important techniques in molecular biology and bionanotechnology.

Course Contents

A. Molecular Biology **24 hrs**

1. **Prokaryotic and eukaryotic chromosome structure:** Prokaryotic chromosome structure, Chromatin structure, Eukaryotic Chromosome structure, Genome complexity. (2)
2. **DNA replication:** DNA replication-an overview, Bacterial DNA replication, Eukaryotic DNA replication, the genetic code and tRNA structure and function. (2)
3. **DNA damage, repair and recombination:** Mutagenesis, DNA damage, DNA repair, The clinical importance of DNA repair mechanisms, Recombination. (2)
4. **Gene manipulation and cloning vectors:** DNA cloning-an overview, Preparation of Plasmid DNA, Restriction enzyme and electrophoresis, Ligation, transformation, and analysis of recombinants. Design of plasmid vectors, Bacteriophage vectors, Cosmids and YACs, Eukaryotic vectors. (2)

5. **Molecular techniques:** DNA extraction, Electrophoresis, PCR-RFLP, PCR-SSCP, PCR-DNA-PAGE, RT-PCR and PCR-sequencing. (2)

6. **Gene libraries, screening, analysis cum uses of cloned DNA:** Genomic libraries, cDNA libraries, Screening procedures, Characterization of clones, Nucleic acid sequencing, Polymerase chain reaction, Organization of cloned genes, Mutagenesis of cloned genes, Applications of cloning. (2)

7. **Recombinant DNA technology:** Introduction, Restriction enzymes, Gel electrophoresis, Enzymatic method of DNA sequencing, Southern blotting and prenatal testing for sickle cell anemia, Isolating a human gene with DNA cloning, polymerase chain reaction (PCR), Producing a protein from a cloned gene, Site-directed mutagenesis and transgenic animals, methods of transgenic animals. (2)

8. **Mutations of the DNA sequence**: Silent mutations, Missense mutations, Nonsense mutations, Frameshift mutations, Translocation mutations, RNA splicing mutations, Transposable element mutations, Trinucleotide repeat mutations. (1)

9. **Molecular oncology:** Proto-oncogenes, Oncogenes, and anti-oncogenes: Definiations, Designations, Classification of oncogenes, Mechanism of action of the ras proto-oncogene, Anti-oncogenes (tumor-suppressor genes), Molecular pathology of colorectal cancer, Phases of cell cycles, Control of cell cycle, Stages of M phase. (3)

10. **Mitochondrial genes:** Introduction, Gene products that are encoded by mitochondrial DNA (mtDNA), Other mitochondrial proteins, Mitochondrial diseases. (2)

11. **Receptors and signal transduction:** Ion channel-linked receptors, G-protein-linked receptors, Enzyme-linked receptors, Steroid hormone (intracellular) receptors, Receptors types, Nitric oxide (NO), Receptor-mediated endocytosis. (2)

12. **Recent trends in molecular biology:** Molecular ethnobiology and gene geography; Telomere, molecular aging, and longevity; Apoptosis; Molecular epidemiology of genes and diseases. (2)

B. Bionanotechnology **24 hrs**

1. **Fabulous world of bionanotechnology:** History and concept of bionanotechnology, Nature as the bionanotechnologist, Unique properties of bionanomaterials, Benefits and classification of bionanomaterials (DNA, Amyloid fibrils, Actin filaments, Aromatic peptides, Bateriophages, Minerals, Viruses, Enzymes and nucleic acids). (2)

2. **Basics of Bionanotechnology:** Nanomaterials, bionanomaterials, biosensors, bionanosensors, nanodevices, bionanoelectronics, bionanomechanics, biological machines, molecular motors, mechanism of transport, nanoparticles, nanoscale phenomena, new nanotools, peptoid nanosheet, cantilever array sensor, nanophotonics. (2)

3. **Different types of nanostructures: Concept, Shapes, and structures of nanomaterials:** 1. Size effect on shape of materials, 2. Size effect on electronic properties (Magic numbers), 3. Nanopods, nanocones, nanotetradpods, nanoparticles, 4. Nanocombs and nanowalls, 5. Nanotubes, naowires and naoislands, 6.Nanoflowers, nanobrushes, nanotowers, and nanocastles. **Quantum Dots and semiconductors nanoparticles.** (2)

4. **Biomachines in action:** The Unfamiliar world of bionanomachines., Negligible gravity and inertia at the nanoscale., Atomic granularity in nanomachines Thermal motion as a significant force at the nanoscale, Requirement of Water environment for bionanomachines, Modern biomaterials. Composition of most natural bionanomachines as proteins, Lipids for infrastructure and Polysaccharides in specialized structural roles. Evolution and Significant limitations on the properties of natural biomolecules. (3)

5. **Bionanomaterial sysnthesis routes: 1. Botton-up approaches:** Sol gel method, Thin-film grown (Physical vapor deposition and Chemical vapor deposition), Molecular beam epitaxy, Spray conversion processing, Wet chemical synthesis, Self-assembly, **Hydrothermal growth** **2. Top-down approaches:** Mechanical alloying and mechanochemical methods, Equal channel angular pressing, High pressure torson, Accumulative roll bonding, Nanofrabication and nanolithography, **Ball milling** **3. Consolidation of nanopowers**, **4. Green synthesis of nanoparticles.** (4)

6. **Tools to characterize nanomaterials: 1. Spectroscopic techniques, 2. X-ray diffraction and scattering techniques** (Single crystal XRD, Powder XRD, Small angle X-ray scattering), **3.Microscopic techniques:** Optical microscopic techniques:-Fluorescence microscope, Confocal microscope, Dark field and bright field microscope, Phase contrast microscope), Electron microscopic techniques, Scanning probe microscopy. (3)

7. **Applications of Bionanotechnology**: 1.Electronics and nanoeletronics (Metal oxide semiconductor field effect transistor, Solid state quantum effect devices, Molecular electronics, Spintronics, Novel optoelectronic devices), 2. Nanosensors and nanoprobes (Micro and nano-electromechanical systems (MEMS/NEMS), Nanosensors, Plasmonic based nanoprobes, Optical nanosensors,, SQUID based magnetic nanosensors, Biosensors, Microcantilever based sensors, Electronic nose, Electronic tongues), 3. Nanocatalysts, 4. Food and agriculture industry, 5. Personal care products (cosmetics) and consumer goods, 6. Structure and Engineering, 7. Automibile industry, 8. Water treatment and environment, 9. Nano-medical applications (Drug discovery, Prosthetics and impants, Diagnostics), 10.Textiles, 11. Paints, 12. Energy sector applications, 13.Space applications, 14. Nanotechnology in defense. 15. Structural applications. (2)

8. **Bionanotoxicoloty and Concerns/Challenges and Opportunities of Bionanotechnology 1.** Health, Environment and Ecological issues of nanomaterials: Health risks of nanomaterials, Impact of nanomaterials on environment, Ecological nanotoxicoloty, Health and environmental issues of some nanomaterials. **2.** Biocompatibility and toxicity in nanoparticles, Cytotoxicity in nanoparticles, Neurotoxicity in nanoparticles, Nanoparticles in living systems. (3)

9. **Future of bionanotechnology:** Future, A Timetable for bionanotechnology., Lessons for molecular nanotechnology. Three case ttudies (Case study: Nanotube synthase, Case ttudy: A General nanoscale assembler, and Case study: nanosurveillance), Ethical considerations, Respect for life, Potential dangers. Final thoughts. (3)

Suggested Readings

Agarwal, V.K. (2017): Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S.Chand and Company Ltd, Ram Nagar, New Delhi-110-055, India.

Dudek, R.W. (1999): High-Yield Cell and Molecular Biology. Lippinchott Williams and Wilkins. AWolters Kluwer Company, 351 East Washington Square, Baltimore, Maryland 21201-2436, USA.

Goodsell, D.S. (2004): Bionanotechnology: Lessons from Nature. Wiley-Liss, Inc, Hoboken, New Jersey, USA.

Latchman, D. (1997): Basic Molecular and Cell Biology. BMJ Publishing Group, Latimer Trend and Company Limited, Plymouth, UK.

Murty, B.S; Shanker, P; Raj, B; Rath, B. B; Murday, J. (2016): Textbook of Nanoscience and Nanotechnolgy. Published by University Press (India) Private Limited, 3-6-747/1/A & 3-6-754/1, Himayatnagar, Hyderabad 500 029, Telangana, India.

Neupane, B.B; Pandey, B; Giri, B; Joshi, M, K.(2016): A Textbook of Nanoscience and Nanotechnology: Fundamentals, Applications and Experiments. Heritage Publishers and Distributors Pvt. Ltd. Bhotahity, Kathmandu, Nepal.

Choudhary, S. (2008): The Current State of Bionanotechnology. Eliezer Geisler (Illinois Institute of technology, USA) and Nilmini Wickramasinghe (Illinois Institute of technology, USA).

Turner, P.C; McLennan, A.G; Bates, A.D.: and White, M.R.P. (1998). Instant Notes in Molecular Biology. Bios Scientific Publishers Limited, 9 Newtec Place, Magdalen Road, Oxford OX4 1RE, UK. Published by Viva Books Private Limited, 4325/3, Ansari Road, Daryaganj, New Delhi-110-002.

Rao, M.S.R; and Singh, S. (2016): Nanoscience and Nanotechnology: Fundamentals for Frontiers. . Wiley India Pvt. Ltd, 4435-36/7, Ansari Road, Daryaganj, New Delhi 110002, Reprint Edition.

Rastogi, S.C. (2001): Cell and Molecular Biology. New Age International Pvit Ltd, 4835/24, Ansari Road, Daryaganj, New Delhi -110-002, India.

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Tribhuvan University
Institute of Science and Technology
M.Sc. Zoology (Semester System)
SEMESTER III
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Applied Medico-genomics **Credits: 3**
Course No: Zoo 628 **Lecture hrs: 48**
Nature of the Course: Theory **Full marks: 75**
Pass marks: 37.5

Course Objectives

- To impart advanced and innovative knowledge of present day applied medico-genomcs.
- To provide knowledge on some important diagnostic techniques in applied medico-gennomcs.

Course Contents

1. **Forensic Science:** Origins of forensic science, Early methods, Toxicology and ballistics, Anthropometry, Fingerprints, Uhlenhuth test (antigen–antibody precipitin test), body fluid analysis, blood pattern interpretation, investigation of assaults and sexual offences, Human osteology. (5)
2. **DNA profiling:** Alec Jeffreys and DNA testing, Applications of DNA Fingerprinting, DNA technologies used in molecular forensic investigation (Restriction Fragment Length Polymorphism-RFLP, PCR analysis, STR analysis, Mitochondrial DNA analysis, Y-chromosome analysis**), Sixteen Core STR loci** (DNA markers/identifiers)with their chromosomal positions (D8S1179, D21511, D7S820, CSF1PO, D3S1358, THO1, D13S317, D16S539, D2S1338, D19S433, VWA , TPOX , D18S51, AMELOGENIN, D5S818, FGA). **Forensic DNA typing:** Five steps of DNA fingerprinting in the laboratory (Isolation of DNA, Cutting, sizing, and sorting/Quantifying, PRC and then Transfer of DNA to nylon, Typing/Probing, DNA fingerprint/Interpretation), DNA fingerprint in a family, DNA fingerprint in a rape case. (5)
3. **Pharmacogenomics:** Concept and history, Drug metabolizing enzymes: Cytochrome P450s, The vitamin K epoxide reductase complex subunit 1 (VKORC1), Thiopurine methyltransferase (TPMT), Predictive phenotypes and metabolic activities (Ultra-Rapid Metabolizer, Extensive Metabolizer, Intermediate Metabolizer, Poor Metabolizer), Pharmacogenomic biomarkers and Drug labeling, Reduction of polypharmacy in pharamacogenomics, Challenges of Pharamacogenomics, Future of Pharmacogenomics, Applications of pharmacogenomics. (5)
4. **Personalized medicine:** Development, methods, Challenges, Applications of Personalized medicine. (2)
5. **Precision medicine:** Precision medicine initiative, Development, Methods, Progress and Challenges, Applications of precision medicine, Difference between Personalized medicine and precision medicine. (2)
6. **Molecular medicine:** Development, Methods, Trends in molecular medicine, Challenges, Applications of molecular medicine. (2)
7. **Genomic Detection, prognosis and treatment of inborn errors of metabolism**: **(a) Carbohydrate metabolism (Glycogen storage disease):** Type I to VII, but more focus on Type I (Von Gierkes Disease), Type II (Pompe's disease), Type III (Limit Dextrinosis), and Type VI (Her's disease),

Pentosuria, Galactosuria. **(b) Protein metabolism:** Alkaptonuria, Phenylketonuria. **(c). Lipid metabolism:** Niemann-Pick disease, Tay-Sach's disease, Gaucher's disease. **(d) Nucleic acid metabolism:** Lesch-Nyhan syndrome, Hereditary Xanthinuria. (7)

8. **Genomic Detection, prognosis and treatment of Monogenic disorders: Autosomal dominant disorders** (Marfan syndrome, Neurofibromatosis). **Autosomal recessive disorders** (Sickle cell disease, Cystic fibrosis). **X-linked dominant disorders** (Xg blood group, Vitamin D-resistant rickets). **X-linked recessive disorders** (Muscular dystrophy, Hemophilia A and B). **Y-linked disorders (**Male fertility**). Mitochondrial inheritance (**Leber's hereditary optic neuropathy-LHON). **Genomic imprinting** (Prader-Willi syndrome via father and Angelman syndrome via mother). (6)
9. **Genomic Detection, prognosis and treatment of polygenic/multi-factorial disorders:** Atherosclerosis, Autoimmune diseases, Cancers, Diabetes mellitus, Hypertension , Obesity, Peptic ulcer disease, Spina bifida. (4)
10. **Genomic detection, prognosis and treatment of neurodegenerative diseases:** Alzheimer's disease, Parkinson's disease, Huntington's Disease, Creutzfeldt-Jakob Disease (Prion disease), Amyotrophic lateral sclerosis (ALS), Multiple sclerosis (MS), Epilepsy, Schizophrenia. (4)
11. **Trinucleotide repeats:** Type I of CGG repeat in Fragile X syndrome, Type II of CAG repeat in Huntington disease and Type III of CTG repeat in Myotonic dystrophy. (1)
12. **(12) Treatment of Genetic diseases:** Surgery for Phenotype, Molecular therapy, Changing metabolism with drugs, Removal of excess substrates, Providing missing products, Vitamins for coenzymes, Induction of enzyme synthesis, Enzyme modification, Enzyme replacement, DNA replacement. (1)
13. **Molecular diagnosis of infectious diseases-Viruses**: Introduction, Sample collection and preparation, Detection of virus (PCR methods, Non-PCR methods, Molecular epidemiology, Quantitative viral estimation, Measurement of antiviral resistance, Detection of novel agents of disease, Commercial systems). (2)
14. **Molecular diagnosis of infectious diseases-Bacteria, fungus and Protozoa:** Introduction, Specimen collection and preparation, Identification (Mycobacteria, Other bacteria, Genotypic methods vs. Phenotypic methods), Commercial systems, Typing of isolates (Epidemiology, Chromosomal DNA, Plasmid DNA, Repetitive DNA, Phylogeny), Antimicrobial resistance, Novel and noncultivatable bacteria, Fungi, Protozoa. Future prospects. (2)

Suggested Readings

Dhar, P. K. (1997): Human genetics. Jaypee Brothers, Medical Publishers (P) Ltd, B-3 EMCA House, 23/23B Ansari Riadm Daryaganj, Post Box. 7193, New Delhi 110002, India.

Jeffery, S.; Booth, J.; Myint, S. (1999): Molecular Diagnosis. Bios Scientific Publishers Limited, 9 Newtec Place, Magdalen Road, Oxford OX4 IRE, UK. World Wide Web home page: http:/www.hios.co.uk/

Harrison, G.A.; Tanner, J.M.; Pilbeam, D.R.; Baker, P.T. (1990): Human Biology: An Introduction to human Evolution, Variation, Growth and Adaptability. Reprinted by ELBS: English Language Book Society/Oxford University Press, Walton Street, Oxford OX2 6DP, UK

Seashore, M.R.; and Wappner, R.S. (1996): A Lange medical book on Genetics in Primary Care & Clinical Medicine. First Edition, Prentice –Hall International , Inc.USA.

Strachan, T. and Read, A.P. (1996): Human Molecular Genetics. Bios Scientific Publishers Limited, 9 Newtec Place, Magdalen Road, Oxford OX4 IRE, UK. World Wide Web home page: http:/www.hios.co.uk/

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Tribhuvan University
Institute of Science and Technology
M.Sc. Zoology (Semester System)
SEMESTER III
GENOMICS AND MOLECULAR BIOLOGY

Course Title: Related to Zoo 625 & 626 **Credits: 2**
Course No: Zoo 629 **Lecture hrs: 90**
Nature of the Course: Practical **Full marks: 45**
Pass marks:

Course Objectives

To impart practical knowledge on topics of Zoo 625 & 626.

Course Contents

Molecular Biochemistry **Credit: 1**

1. Performing qualitative tests for Carbohydrate.
2. Estimation of Blood glucose.
3. Solubility test for Lipid
4. Extraction of Lipid
5. Estimation or Isolation of Protein
6. Estimation of Nucleic acid
7. Performing some practical related to the enzymatic activities in the lab.
8. Studying the use and function of spectroscopy, spectrometry and chromatography in the available institution.

Laboratory: Molecular Immunology **Credit: 1**

1. Antigen and antibody reactions.
2. Antigen preparation with complete adjuvant.
3. Antigen preparation with incomplete adjuvant.
4. Identification and isolation of lymphocytes.
5. Conducting Eliza test

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Tribhuvan University

Institute of Science and Technology

M.Sc. Zoology (Semester System)

GENOMICS AND MOLECULAR BIOLOGY

SEMESTER III

Course Title: Related to Zoo 627 & 628 **Credits: 2**
Course No: Zoo 630 **Lecture hrs: 90**
Nature of the Course: Practical **Full marks: 50**
Pass marks: 25

Course Objectives

To impart practical knowledge on topics of Zoo 627 & 628.

Course Contents

Molecular biology and Bionanotechnology **Credit:1**

1. Performing the following molecular techniques: DNA extraction, Electrophoresis, PCR-RFLP, PCR-SSCP, PCR-DNA-PAGE, RT-PCR and PCR-sequencing etc.
2. Studying the detailed structure of some protein of interest using visualization software.
3. Visualizing the cytoskeleton actins protein in some cell lines of interest using fluorescence microscope
4. Counting the number of axons in differentiated neural cell using bright field microscope.
5. Studying the morphology of blood cells by bright field microscope.

Applied Medico-genomics **Credit:1**

1. Taking some measures on different ethnic groups i.e. anthropometry.
2. Conducting some praticals on fingerprints.
3. Carrying out Uhlenhuth test.
4. Detecting some genomic basis for monogenic diseases in general.
5. Detecting some viruses, bacteria, fungi and protozoa in the collected samples of interest.

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