



Deccan Education Society's
Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum
for 2 years M.Sc. Programme
as per guidelines of
NEP-2020

for
F. Y. M. Sc. (Biotechnology)
With effect from Academic Year
2023-2024

M. Sc. I Biotechnology
Course Structure

Semester	Paper Code	Paper Title	Credits
I	BTH -501	Cell Biology and Bacteriology	4
	BTH -502	Molecular Biology and Biochemistry	4
	BTH -503	Agricultural Biotechnology	4
	OR		
	BTH -504	Biostatistics	
	BTH -510	Research Methodology	4
	BTH -520	Biotechnology Practical I	2
	BTH -521	Biotechnology Practical II	2
	Total Semester Credits		20
II	BTH -551	Industrial Biotechnology and Bioinformatics	4
	BTH -552	Developmental Biology and Human Genetics	4
	BTH -553	Environmental Biotechnology	4
	OR		
	BTH -554	Clinical Research	
	BTH -560	OJT/FP	4
	BTH -570	Biotechnology Practical III	2
	BTH -571	Biotechnology Practical IV	2
	Total Semester Credits		20
Total PG-I Credits			40

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	3 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Program Outcomes (POs) for M.Sc.	
PO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	Critical Thinking and Problem solving: Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions
PO3	Social competence: Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise way and help reach conclusions in group settings.
PO4	Research-related skills and Scientific temper: Infer scientific literature, build a sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	Trans-disciplinary knowledge: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	Personal and professional competence: Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	Academic competence: (i) Gain strong foundation and knowledge in scientific fundamentals and acquire comprehensive understanding of the principles and practices of biotechnology including skill-based concepts, in an interdisciplinary course structure, provided by highly qualified and competent faculty. (ii) Acquire training in techniques/skills utilised in biotechnology and understand the scope and applications of biotechnology in well-equipped and state of the art laboratories. (iii) Achieve competence for higher studies, research and be employment ready in the domain of Biotechnology and allied fields. (iv) Demonstrate qualities of responsible biotechnologists that can work within the interdisciplinary framework of biotechnology and related fields
PSO2	Personal and Professional Competence: (i) Analyze and interpret data and provide solutions to basic problems relevant to biotechnology and related fields. (ii) Apply appropriate tools and techniques in biotechnology, combine experimental and computational approaches to design and perform experiments proficiently. (iii) Demonstrate and apply knowledge and skill in the design and development of solutions for relevant problems to cater to the requirements of biotechnology industries. (iv) Acquire good oral and written communication skills. (v) Experience the opportunity to curate/ manage or participate in a variety of co and extracurricular activities that will cater to the overall personality development.
PSO3	Research Competence: (i) Develop an interdisciplinary approach to conduct original research in various fields of Biotechnology and allied fields. (ii) Demonstrate appropriate skills in design of experiments with appropriate controls, critical thinking and result analysis. (iii) Apply statistical skills and computational tools to explore, analyse and authenticate biological data in experiments and research.
PSO4	Entrepreneurial and Social competence: (i) Implement skills and knowledge acquired in skill imparting and entrepreneurial courses in upcoming fields of Biotechnology. (ii) Develop a sense of social, ethical, environmental, and professional responsibility. (iii) Practise professional ethics in the conduct of science. (iv) Recognize the importance of Bioethics, IPR, entrepreneurship, Communication and management skills so to be ready to pursue future course of career

F.Y. M. Sc. Semester I		
BTH-501	Cell Biology and Bacteriology	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe structure and functions of eukaryotic cell and various organelles. Outline the techniques to study cell and its components.	
CO2	Discuss types and mechanism of transport across the membrane, illustrate mechanism of protein sorting and intracellular transport.	
CO3	Analyze the various cell signalling pathways and regulation of cell cycle. Evaluate pathways involved for and against cell death, abnormal behaviour leading to cancer.	
CO4	Categorize the molecular techniques for characterization of bacteria. Explain molecular basis of various events in the bacterial life cycle,	
CO5	Review metabolic diversity of bacteria, quorum sensing phenomenon, antimicrobial resistance and current trends in bacteriology.	
CO6	Revise bacterial growth, kinetics and specify the molecular adaptations of extremophiles.	

Unit. No.	Title of Unit and Contents	No. of hours
	Cell Biology	
I	Eukaryotic Cell structure and architecture: Plasma Membrane, Cell adhesion, Junctions, Cytoskeleton, Plant Cell Wall, Disorders associated with architecture malfunctions.	3
II	Structure and function of organelles of the eukaryotic cell and their interdependence: ER, Golgi, Mitochondria, Chloroplast, Vacuoles, Peroxisomes, Lysosomes, Nucleus. Organelle associated diseases and disorders Techniques to study the cells and its components: Patch-clamping technique, Fractionation of subcellular components, immuno-fluorescence technique and cell-sorting (FACS)	5
III	Transport across Cell membrane: Mechanism of transport: Ionophores, Maltoporin, K ⁺ channels, Cl ⁻ channels, Aquaporins, Transcellular transport. Types of transport: active and passive, secondary transport ATP driven Active transport: (Na ⁺ - K ⁺) ATPase, Ca ²⁺ ATPase, H ⁺ K ⁺ ATPase, group translocation, ABC transporters.	6

	Neurotransmission: Voltage gated ion channels, Action potentials, neurotransmitters and their receptors.	
IV	Protein sorting and trafficking: Insertion of proteins in ER. Sorting of proteins to organelles- nucleus, mitochondria, chloroplasts, lysosomes Intracellular vesicular transport: Molecular mechanism of vesicular traffic, Vesicle trafficking of the secretory pathway, Receptor mediated endocytosis, synaptic vesicle function and formation. Disorders associated with protein trafficking.	5
V	Cell signalling: Signalling molecules and cell surface Receptors- GPCRs, RTKs Process of cell signalling, Importance of Ras Introduction to cell signalling pathways, electrical and synaptic signalling with examples.	5
VI	Cell Cycle and Cell Division: Mitosis, Meiosis, Cell Cycle regulation, checkpoints, significance of G_0 , pathways involved in regulation of cell cycle. Cell death and Cancer: Classic Apoptosis pathways and significance, important enzymes and proteins of apoptosis, pathways involved for and against cell death, tumor suppressors and oncogenes, inter-relation between cell cycle, cell death and cancer.	6
	Bacteriology	
VII	Molecular Basis of Bacterial cell division and structure Proteins involved in process of binary fission Genetic mechanism determining bacterial shapes Cytoskeleton in prokaryotes Cell Structure: Fimbriae, pili, axial filament, S layer, Glycocalyx (structure and significance) Structure and Assembly of Flagella, Motility and Chemotaxis (molecular mechanism) Cell wall (Overview) and mechanism of synthesis of peptidoglycan Endospore formation and Germination (mechanism describing role of sensor kinases and signalling pathways)	8

	Protoplast, Spheroplast, L forms, Mycoplasma (taxonomic significance)	
VIII	Bacterial Growth Generation time and Growth rate, specific growth rate (Problem solving) Kinetics of Batch, Fed batch and Continuous Culture Synchronous growth, Diauxic growth	5
IX	Metabolic Diversity of Bacteria Nutritional Classification and Metabolic diversity of bacteria with specific examples (Nutritional and Environmental) Extremophiles: Molecular adaptations of Extremophiles, Significance, and applications	5
X	Bacterial Taxonomy Overview of Classical methods, polyphasic approach Molecular techniques for characterization of bacterial genotype (Pattern and Sequence Based).	4
XI	Multidrug resistance in bacteria (cause and effect) Mechanisms of development of drug resistance, MDR, XDR Methicillin Resistant Staphylococcus aureus (MRSA), case studies Quorum Sensing in Bacteria: Significance in bacterial Virulence and antibiotic resistance (one example each) Possible approach for overcoming antibiotic resistance: Quorum Sensing Inhibitors Plasmid Curing Natural products Current Trends in Bacteriology	8

References:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., K Reiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. Introduction to Microbiology. 3rd Edition, (2004), Ingraham JL and Ingraham CA. Thomson Brooks / Cole.
5. Fundamental Principles of Bacteriology. 7th Edition, (1971) Salle AJ. Tata MacGraw Publishing Co. India
6. Microbiology, 4th edition (1990), Davis B.D., DeBacco, J.B. Lippincott Co. NY
7. Text book of microbiology 5th edition (1996), Ananthnarayana, R. and C.E, Jayaram Panakar, Orient Longman.

F.Y.M. Sc. Semester I		
BTH-502	Molecular Biology and Biochemistry	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the genome structure and organization, transposons and their types.	
CO2	Outline the basics of DNA damage and repair, examine the process of DNA replication and its regulation, analyse, and differentiate gene expression and its regulation in the processes in prokaryotes and eukaryotes.	
CO3	Specify the need for regulation of protein synthesis and elucidate its mechanism.	
CO4	Describe the techniques for protein structure determination and for protein-protein interaction studies.	
CO5	Discuss interaction of signalling, metabolic pathways and infer body's response to metabolically abnormal situations.	
CO6	Apply the concepts of enzymology and techniques for studying activity, kinetics, regulation.	

Unit. No.	Title of Unit Contents	No. of hours
	Molecular Biology	
I	Genome Structure and Organization: Definition and organization of viral, prokaryotic and eukaryotic genomes. Structure and function of chromatin, nucleosome, chromosome, centromere, telomere. Chromatin organization and remodelling, C value paradox and genome size, Cot curves, repetitive and non-repetitive DNA sequences, Pseudogenes.	3
II	Mobile DNA elements: Transposable elements, structure and their implications, Types of transposons with examples: replicative and non-replicative transposons, retrotransposons.	2
III	DNA damage and Repair: Types of DNA damage, basic DNA repair mechanisms in prokaryotes and eukaryotes, SOS response, recombination repair (Homologous and Non-homologous end joining).	7
IV	DNA Replication and Regulation: Mechanisms and regulation of DNA replication in prokaryotes and Eukaryotes.	4

V	Transcription and Regulation in Prokaryotes and Eukaryotes: Basic mechanism in prokaryotes and eukaryotes, Regulation of transcription including transcription factors, post-transcriptional processing and transport of RNA, Non-coding RNAs and its significance.	8
VI	Protein Synthesis and Regulation: Components, mechanism and regulation of protein synthesis, Genetic code and its ambiguity.	6
	Biochemistry	
VII	Protein Biochemistry: Primary, Secondary, Tertiary, Quaternary structure of proteins. Protein folding mechanisms - Molten globule, energy funnel, chaperon, Protein Misfolding and misfolding-related diseases. Protein Processing- Proteolytic cleavage (Pre, Pro, removal). Protein Modifications – Glycosylation, Phosphorylation, Lipids attachment, Glycolipids. Protein degradation – Lysosomal & proteosomal ubiquitination	7
VIII	Protein Structure and interactions: Structure determination: Databases, various structure determination techniques. Structure-function relationship, Techniques to study protein-protein and protein-small molecule interactions.	8
IX	Bioenergetics and Metabolism: Enthalpy, Entropy, Internal energy, Free energy, Laws of thermodynamics, Coupled reactions, Chemical equilibrium. Interaction networks of biomolecules in a cell. Study of key molecules which play a role as multiple regulators. Understanding complex disorders (Obesity, Diabetes)	5
X	Enzymology: Enzymes; Activity, Regulation, Kinetics, Action of inhibitors, Techniques for studying activity and kinetics.	10

References

1. Genes XI, 11th edition (2012), Benjamin Lewin, Publisher - Jones and Barlett Inc. USA
2. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick. Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA
3. Molecular Biology, 5th Edition (2011), Weaver R., McGraw Hill Science. USA
4. Fundamentals of Molecular Biology, (2009), Pal J.K. and Saroj Ghaskadbi, Oxford University Press. India
5. Biochemistry: 4th Edition, (2011), Voet and Voet, John Wiley and Sons, Inc. Principles of Biochemistry, 7th edition (2017), Lehninger, Freeman W.H. and Company
6. Biochemistry, Berg J., Tymoczko J., Stryer L., 8th edition (2015), Freeman W. H. and Company
7. Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., John Wiley and Sons, New York

F.Y. M.Sc. Semester I		
BTH-503	Agricultural Biotechnology (Elective)	Credits:4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the concept of agriculture biotechnology as a science.	
CO2	Explain the different types of molecular markers used in agriculture biotechnology and discuss their applications in improvement of crop traits. Discuss DNA barcoding and clonal fidelity for selection of elite traits in crops.	
CO3	Apply the concept of RNAi and mutagenesis in crop biotechnology. Illustrate different methods for gene expression and profiling used to select for the elite crop varieties.	
CO4	Analyze and explain the importance of Eco-TILLING, and high-throughput genotyping techniques.	
CO5	Evaluate the genetics of resistance, 'R' genes and the use of genetic engineering techniques for developing disease resistance varieties.	
CO6	Devise new strategies to prevent spread of disease, to protect, improve and conserve the economically important agricultural plants. Develop and design new strategies for crop transgenics.	

Unit. No.	Title of Unit and Contents	No. of hours
I	Fundamental biotechnology: gene cloning, PCR: types and applications Introduction to DNA fingerprinting and profiling techniques: biochemical markers and DNA based (genic and random) markers; repertoire of DNA fingerprinting techniques Molecular markers: Molecular basis of dominant and co-dominant markers, RFLP, MAAP (Multiple Arbitrary Amplicon Profiling) and other PCR based markers (DNA Amplification Fingerprinting, Arbitrarily Primed PCR, RAPD, SSRs, STMS, SCARs, Inter-SSRs, AFLP, Intron spanning markers SNP based marker assays (CAPs, dCAPs, dHPLC, molecular beacons, 5'nuclease assay/Taqman assays)	20
II	Other applications of molecular markers: Genotyping tools as plant variety protection, DNA bar-coding technology, establishing clonal fidelity	8
III	Functional analysis of genes: RNA-mediated interference; gene knockoffs; site directed mutagenesis, insertional mutagenesis; Gene traps/ T-DNA insertion lines Gene expression: microarray profiling; SAGE; SNPs/variation; gene expression and transcript profiling; EST contigs;, allele/gene mining; synteny and comparative genomics Eco-TILLING (Targeting induced local lesions in the genome), high-throughput genotyping techniques: Diversity Array Technology (DARs), SNP and tiling arrays	16

IV	Plant pathology: Importance, definitions and concepts of plant diseases, Host pathogen interaction, recognition concept and infection, disease development- role of enzymes, toxins, defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.	16
-----------	--	-----------

References

1. Till, Bradley J., Troy Zerr, Luca Comai, and Steven Henikoff. "A protocol for TILLING and Ecotilling in plants and animals." *Nature protocols* 1, no. 5 (2006): 2465-2477.
2. Barkley, N. A., and M. L. Wang. "Application of TILLING and EcoTILLING as reverse genetic approaches to elucidate the function of genes in plants and animals." *Current genomics* 9.4 (2008): 212-226.
3. Varshney, Rajeev K., Kailash C. Bansal, Pramod K. Aggarwal, Swapan K. Datta, and Peter Q. Craufurd. "Agricultural biotechnology for crop improvement in a variable climate: hope or hype?" *Trends in plant science* 16, no. 7 (2011): 363-371.
4. Collard, B. C. Y., M. Z. Z. Jahufer, J. B. Brouwer, and E. C. K. Pang. "An introduction to markers, quantitative trait loci (QTL) mapping and marker-assisted selection for crop improvement: the basic concepts." *Euphytica* 142, no. 1-2 (2005): 169-196.
5. Madesis, Panagiotis, Ioannis Ganopoulos, Argiriou Anagnostis, and Athanasios Tsaftaris. "The application of Bar-HRM (Barcode DNA-High Resolution Melting) analysis for authenticity testing and quantitative detection of bean crops (Leguminosae) without prior DNA purification." *Food Control* 25, no. 2 (2012): 576-582

F.Y. M.Sc. Semester I		
BTH 504	BIostatISTICS (Elective)	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Recall the basic concepts in biostatistics.	
CO2	Interpret the pattern observed in the data.	
CO3	Carry out experiments to collect data.	
CO4	Analyse the collected data to test hypotheses	
CO5	Conclude the results obtained by testing the hypotheses.	
CO6	Formulate research questions using the acquired knowledge and skillset.	

Unit. No.	Title of Unit and Contents	No. of hours
I	Descriptive statistics: • Data Collection • Data organisation: Biological variables, frequency distributions, graphical visualization of data • Measures of central tendency: mean, median, mode • Measures of central dispersion: range, standard deviation, quartiles • Skewness, Kurtosis	15
II	Probability: • Basic probabilities – addition, multiplication, independence of events. • Probability Distributions and their applications: Binomial distribution, Poisson distribution, Normal/Gaussian distribution • Central Limit theorem	20

III	Statistics in research: ● Sampling: Sample size, Sampling strategies and Sampling distributions ● Experimental design: Randomization, Replication, Blinding, Control ● Hypothesis Testing: Hypothesis Formulation-Null hypothesis, Alternate hypothesis, Rationale of hypothesis testing ● Examples of parametric and non-parametric tests: Comparison of means, Z-test, t-test, Chi-square test, ANOVA ● Std. error, Confidence limits, Significance, Type I and Type II errors ● Regression ● Correlation ● Examples from biological research	25
-----	--	----

References:

1. Robert Bartle., and Donald Sherbert. Introduction to real analysis.4th ed. Illinois, USA: John Wiley& Sons, Inc., USA, 2011.
2. Chap T. Le. Introductory Biostatistics. 1st ed. New Jersey, USA: John Wiley& Sons, Inc., USA, 2003.
3. Antony N Glaser. High-Yield™ Biostatistics. Maryland, USA: Lippincott Williams and Wilkins, USA, 2005.
4. Edward Batschelet. Introduction to Mathematics for Life Scientists. 3rd ed. Berlin, Germany: Springer-Verlag Berlin Heidelberg, Germany, 1979.

E -Resources

1. Online Statistics Education: A Multimedia Course of Study (<http://onlinestatbook.com/>).

F.Y. M.Sc. Semester I		
BTH-510	Research Methodology	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Learn the various aspects of the research process, framing useful research questions, research design, data collection, analysis, writing and presentation.	
CO2	Understand the research problem, methods/techniques to be adopted, Explain Regulatory affairs and guidelines from Indian regulatory bodies.	
CO3	Apply statistical tools for analysing the data while performing their research, Illustrate the Biosafety levels, risk assessment and characterization.	
CO4	Develop skills in qualitative and quantitative data analysis and presentation, Describe the ethical aspects related to Biotechnology.	
CO5	Analyse for fitting, errors in the measurements and able to draw conclusions from the analysed data.	
CO6	Review scientific articles related to the subject so as to gain a critical understanding of their contents and prepare a written and oral presentation of scientific articles.	

Unit. No.	Title of Unit and Contents	No. of hours
I	History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications.	12
II	Statistical analyses and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, non-response and methods of recovering the missing response, Various software for statistical analysis. The module will consist of case studies of the research performed in various subjects using statistical methods, Error and noise analysis, curve fitting.	12
III	Literature search, selection of research topic (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, effective verbal and non-verbal communication, field data collection, safety in field.	12
IV	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology.	12
V	Biosafety, Bioethics and Regulations: <u>Biosafety:</u> Introduction; historical background; biosafety levels, introduction to biological safety cabinets; definition of GMOs, principles of safety assessment of transgenic plants , sequential steps in risk assessment; concepts of familiarity and substantial	12

	equivalence; risk – environmental risk assessment, risk characterization and development of analysis plan; risk assessment of transgenic crops. <u>Bioethics:</u> Introduction, ethical conflicts in biological sciences, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, Bioethics in research – cloning and stem cell research, Agricultural biotechnology - environmental risk, public opinion, Protection of environment and biodiversity, biopiracy <u>Regulations:</u> Regulatory affairs, role of regulatory professional, Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; International regulatory bodies	
--	---	--

References:

1. ‘History of the Scientific Methods’ by Martin Shuttleworth, <https://explorable.com/history-of-thescientific-method>.
2. ‘National ethical guidelines for biomedical and health research involving human participants (ICMR 2017).
3. Handbook for Institutional Biosafety Committee (IBSC), 2020.
4. An introduction to statistical analysis in research, K Weaver et. al., Wiley publications, 2017.

F.Y. M.Sc. Semester I		
BTH-520	Biotechnology Practical I Practical in Cell Biology and Bacteriology	Credits: 2 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Determine the steps of isolation of mitochondria and lysosomes by sucrose density gradient centrifugation technique and test for SDH and acid phosphatase activity.	
CO2	Specify the phenomenon of programmed cell death during limb development in chick embryo.	
CO3	Explain effect of drugs on cell division.	
CO4	Analyse growth rate of bacteria under varying conditions. Identify bacterial pathogens, test antibiotic sensitivity.	
CO5	Determine different in vitro culture systems and analyse the effect of different factors on growth and development.	
CO6	Design and perform extraction of bioactive principles from plant sources.	

Unit. No.	Title of the Experiment	No. of hours
	Cell Biology	
1	Isolation of mitochondria and lysosomes by sucrose gradient centrifugation and analysis of fractions by assay of SDH and Acid phosphatase activity respectively	3
2	Programmed cell death during limb development In Chick	2
3	The effect of drugs like colchicine on cell division	2
4	Visit to facility for Cell sorting and Cell-cell communication studies	1
	Bacteriology	
5	Effect of environmental parameters on bacterial growth curve and generation time.	1
6	Extraction of bioactive principles from plant and estimation of its antimicrobial activity using standard guidelines (CLSI)	2
7	Demonstration of Bacterial diversity in Winogradsky's column	2
8	Isolation and identification of bacteria from given sample	2

F.Y. M .Sc. Semester I		
BTH-521	Biotechnology Practical-II Practical in Molecular Biology and Biochemistry	Credits: 2 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Outline the concept and need of RNA isolation from prokaryotic and eukaryotic systems. Tell the important steps and precautions necessary for RNA isolation.	
CO2	Explain the technique of PAGE and use it to analyse histones	
CO3	Carry out agarose gel electrophoresis to determine mononucleosome size by isolation of nuclei and chromatin	
CO4	Carry out enzyme isolation. Explain how to optimize enzyme assay conditions and determine the factors affecting enzyme activity	
CO5	Describe steps in protein purification.	
CO6	Perform biophysical and biochemical characterization of partially purified protein.	

Expt. No.	Title of the Experiment	No. of hours
1	Isolation of genomic DNA from different sources.	2
2	Characterization of DNA by spectrophotometric assay, electrophoresis, and Melting Temperature (T_m).	1
3	Isolation of chromatin, histone and characterization.	2
4	Isolation and analysis of RNA from prokaryotes and eukaryotes.	1
5	Detection of mRNA.	2
6	Extraction, purification, and characterization of an enzyme: Solvent fractionation, Salt fractionation, Dialysis, Column chromatography; Ion exchange and/or Gel filtration, SDS-PAGE, Generation of purification table; determination of total activity, total protein, specific activity, purification fold, percent yield. Enzyme kinetics; determination of K_m , V_{max} , K_{cat}	5

F.Y. M.Sc. Semester II		
BTH-551	Industrial Biotechnology and Bioinformatics	Credits: 4 Hours: 60
CO1	Define and integrate fundamentals and applications of biological and engineering principles to microbial systems required in Fermentation Industry	
CO2	Explain the upstream and downstream processes for successful operation of bioprocess	
CO3	Apply knowledge to explain production processes of various products	
CO4	Differentiate between bioinformatics tools and techniques and how to use them for the analysis of the biological experimental data..	
CO5	Compare various databases and various methods for the data retrieval, data storage, and data mining and use that data for the further analysis	
CO6	Design <i>In-silico</i> experiments for the protein modeling and drug discovery process.	

Unit. No.	Contents	No. of Hours
I	Introduction to fermentation and Basic aspects of Bioengineering: Introduction to Industrial Biotechnology and Bioprocess engineering, Fermentation, types Overview of bioreactor design: - Design aspects of Stirred tank reactor and non- mechanically agitated bioreactors - Animal and Plant Cell Bioreactor, immobilized cell reactors. New designs of Bioreactors. Kinetics of operation of bioreactors: - Batch, Fed Batch and Continuous Processes Concept of growth linked and non-growth linked products Aeration and agitation of fermentation broth: Mass transfer: Concept of mass transfer, Molecular diffusion and role in bioprocess, Two – film theory, Convective mass transfer, volumetric mass transfer (KLa), Liquid-Solid, Liquid-Liquid and Gas- liquid mass transfer equations and significance in bioprocess. Aeration: Oxygen Uptake in cell cultures, Oxygen transfer from gas bubble to Cell. Gas hold up, KLa importance, Factors affecting KLa. Fermentation Broth rheology – Newtonian and Non - Newtonian fluids, significance in bioprocess Bulk Mixing: Power requirement for mixing Power number, Reynolds number, Flow regimes in fermentation tank (Laminar, turbulent and transition),	10

	Correlation between mass transfer coefficient and operating variables. Mass and Energy balance	
II	Medium Sterilization: - Kinetics of thermal death of cells and spores (Del factor, Design organism) - Design of Batch and continuous thermal sterilization - Filter Sterilization (Air and Medium)	3
III	Overview of methods for online and off line monitoring of Bioreactors Scale Up and Scale Down: - Scale up with constant parameters like oxygen transfer rate, mixing, shear stress, flow regime, Reactor volume, etc. - Scale-up methods by currently used rules-of-thumb viz. constant P/V, KLa - Various approaches to scale-up including regime analysis. Scale Down: - Approaches and Importance	2
IV	Strain Improvement: Recombinant Methods, non-recombinant (Mutagenesis, fusion, recombination etc.)	2
V	Downstream Processing: Removal of insoluble: Centrifugation, Sedimentation, Filtration Product Isolation: - Cell Lysis methods for intracellular products, Solvent extraction, - Aqueous two phase, Supercritical fluid extraction, Adsorption, Product Purification: - Chromatography and other techniques for product purification with examples	5

VI	Commercial Production and Recovery of: ● Alcoholic Beverages: Beer ● Amino Acids: Glutamic Acid ● Food and Dairy products: Cheese ● Microbial Cells: Yeast as food and food supplement ● Enzymes: Restriction Enzymes ● Bio based Polymers: Xanthan Gum ● Recombinant products: Vaccine or any other ● Quality control and Quality Assurance(Roles and Responsibilities)	5
VII	Sequence Analysis: Various File Formats for Bimolecular Sequences: ● GenBank ● FASTA Basic concepts of sequence analysis: ● Global Pairwise Sequence Alignment ● Local Pairwise Sequence Alignment ● Needleman and Wunsch, ● Smith and Waterman algorithms for pairwise alignments ● Gap penalties ● Use of pairwise alignments for analysis of Nucleic acid and Protein sequences and interpretation of results. Databases Searches : ● BLAST ● FASTA Multiple Sequence Alignment: ● The need for MSA	3

	Basic concepts of various approaches for MSA (e.g. progressive, hierarchical, iterative etc.).	
VIII	Concept of Phylogeny: • Molecular Phylogeny • Various Methods of Phylogenetic Tree Construction Scoring matrices: • Basic concept of a scoring matrix Substitution Matrices PAM and BLOSSUM series.	6
IX	Protein Structures Study: • Biophysicochemical Properties • Secondary Structure of protein (alpha helices & beta sheets) • Motifs and Domains • Tertiary and Quaternary Structure of the Protein. Computational Methods for Protein Structure Prediction: • Energy- and fragment-based methods • Evolutionary covariation to predict 3D contacts • Comparative protein modeling • Homology modeling • Protein threading Side-chain geometry prediction	8
X	Structure Databases: • PDB – Protein Databank • NDB-Nucleotide Databank • PubChem Molecular visualization: Protein conformation and visualization tool • RASMOL • SPDBViewer • Cn3D • Jmol	4

XI	Virtual Drug Discovery: Role of bioinformatics in drug discovery Target discovery Lead discovery Docking Prediction of drug quality.	4
-----------	--	----------

References:

1. Pauline M. Doran, Bioprocess Engineering Principles (2nd Edition) Academic Press, 2013
2. E. M. T. El-Mansi., Jens Nielsen, David Mousdale and Ross P. Carlson. Fermentation Microbiology and Biotechnology. 4th ed. London : CRC press, 2019.
3. Michael L. Shuler, Fikret Kargi , Matthew DeLisa , Bioprocess Engineering: Basic Concepts, 3rd Edition, Prentice Hall, 2017.
4. BIOTOL series, Bioreactor Design and Product Yield. UK: Butterworth-Heinemann, 1992
5. Casida, L. E., Industrial Microbiology. 2nd ed. New Delhi: New age International, 2019.
6. Indian Pharmacopia and British Pharmacopia (Latest Edn).
7. Peppler, H. J., D. Perlman. Microbial Technology, Vol I and II, 2nd ed. New York: Academic Press, 1979
8. Peter F. Stanbury., A. Whittaker and S. Hall. Principles of Fermentation Technology. 3rd ed., Springer 2016
9. Prescott, S.C. and Dunn, C. G. Industrial Microbiology. 4th ed.: New Delhi., CBS Publishers, 2004.
10. Crueger, W. and Crueger, A. A Text Book of Industrial Biotechnology. New Delhi, Panima, 2005.
11. . David Mount, Bioinformatics Sequence and Genome Analysis 2nd ed., University of Arizona, Tucson, 2004
12. Jin Xiong, Essentials Bioinformatics, 1st ed., Cambridge University Press, New York 2006
13. H. wood, T.K. Parry smith DJ, Introduction to Bioinformatics, Pearson education Asia 2001.

F. Y. M.Sc. Semester II		
BTH-552	Developmental Biology and Human Genetics	Credits: 4 Hours:60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the processes in early development and apply the concepts in human development.	
CO2	Discuss the different cellular organizations during development that lead to development of multicellular organisms from a zygote.	
CO3	Illustrate different techniques and advancements to study developmental Biology and review different biomedical tests	
CO4	Explain Mendel's laws of inheritance and understand genetic aberrations	
CO5	Evaluate principles of genetic linkage and chromosome mapping.	
CO6	Prepare a report on the nature of various genetic disorders, their diagnosis and testing techniques.	

Unit. No.	Title of Unit and Contents	No. of Hours
	Developmental Biology	
I	Gametogenesis and Early Development: · Oogenesis and Spermatogenesis: · Human Embryonic development till first eight weeks · Hormonal Regulation and Molecular Factors involved. · Cleavage, Embryo Implantation, Gastrulation · Discussion on abnormalities in early development · Emphasis on Human Development	15
II	Late Development: · Organogenesis, Extra Embryonic Membranes · Birth	5
III	Overview of techniques to study Developmental Biology: · Genetic analysis of developmental processes · Techniques of fluorescence microscopy · Cell transplantations · Transgenic techniques · RNAi and knock-down of developmental genes · Life-imaging of morphogenetic processes · Cell migration and intracellular transport of mRNAs and proteins · Basic techniques of molecular cloning and protein techniques	5
IV	Applications and Clinical Significance: prenatal testing to determine developmental abnormalities in embryo and foetal development. Biomedical applications like IVF, toxicity testing etc.	5
	Human Genetics	
V	Genetic traits: Monogenic traits and inheritance patterns (autosomal, sex-linked inheritance, sex limited and mitochondrial inheritance) Quantitative Genetics: Polygenic traits and mode of inheritance, analysis of variation: genetic and environmental factors, heritability, inbreeding and consequences, coefficient of	5

	inbreeding and consanguinity Pedigree analysis in humans: Symbols, construction of pedigree, molecular genetic data.	
VI	Cytogenetics: Karyotyping, Classical karyotyping (banding techniques). Molecular karyotyping (FISH, M-FISH, SKY, QF-PCR and mBAND). Various karyotyping symbols used in human genetics	5
VII	Chromosomal aberrations and syndromes: Changes in chromosomal number: euploidy, aneuploidy, polyploidy, mosaics, trisomy, and monosomy. Changes in chromosomal structure: translocation, inversion, duplication, deletion. Autosomal and sex-linked disorders. Abnormal karyotype and its implications. Chromosomal abnormalities in cancer.	5
VIII	Environment and the genome: Imprinting and epigenetics, Genetics of cancer (Oncogenes and tumour suppressor genes), Genetics of aging (gerontology)	5
IX	Clinical detection of chromosomal abnormalities and molecular genetic analysis approaches: Clinical tests to detect genetic disorders, amniocentesis, CVS, ultrasound, detection of alpha-fetoprotein. Application of molecular methodologies in genetic analysis, gene-based therapeutic approaches, mapping human genome, polymorphism and population analysis-SNPs and genotyping using sequence analysis and microarrays. Ethics and limitations.	5
X	Mendelian genetics in random mating populations and discrepancies in human population: Human population and gene pool concepts, modes of speciation, genotype and allele frequencies, variation, Hardy-Weinberg's laws, genetic equilibrium, X-linked loci, departure from equilibrium.	5
XI	Genetic traits: Monogenic traits and inheritance patterns (autosomal, sex-linked inheritance, sex limited and mitochondrial inheritance) Quantitative Genetics: Polygenic traits and mode of inheritance, analysis of variation: genetic and environmental factors, heritability, inbreeding and consequences, coefficient of inbreeding and consanguinity Pedigree analysis in humans: Symbols, construction of pedigree, molecular genetic data.	5
XII	Cytogenetics: Karyotyping, Classical karyotyping (banding techniques). Molecular karyotyping (FISH, M-FISH, SKY, QF-PCR and mBAND). Various karyotyping symbols used in human genetics	5
XIII	Chromosomal aberrations and syndromes: Changes in chromosomal number: euploidy, aneuploidy, polyploidy, mosaics, trisomy, and monosomy. Changes in chromosomal structure: translocation, inversion, duplication, deletion. Autosomal and sex-linked disorders. Abnormal karyotype and its implications. Chromosomal abnormalities in cancer.	5

XIV	Environment and the genome: Imprinting and epigenetics, Genetics of cancer (Oncogenes and tumour suppressor genes), Genetics of aging (gerontology)	5
XV	Clinical detection of chromosomal abnormalities and molecular genetic analysis approaches: Clinical tests to detect genetic disorders, amniocentesis, CVS, ultrasound, detection of alpha-fetoprotein. Application of molecular methodologies in genetic analysis, gene-based therapeutic approaches, mapping human genome, polymorphism and population analysis-SNPs and genotyping using sequence analysis and microarrays. Ethics and limitations.	5
XVI	Mendelian genetics in random mating populations and discrepancies in human population: Human population and gene pool concepts, modes of speciation, genotype and allele frequencies, variation, Hardy-Weinberg's laws, genetic equilibrium, X-linked loci, departure from equilibrium.	5

References:

1. Developmental Biology, Tenth Edition. Scott F. Gilbert; ISBN 10: 0878939784 ISBN 13: 9780878939787; Publisher: Sinauer Associates, Inc., 2013
2. Langman's Medical Embryology, Twelfth edition. Thomas W Sadler; Langman, Jan; ISBN: 9781451113426/1451113420; Publisher: Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins, c2012.
3. Principles of development, Third edition. Lewis Wolpert; ISBN: 9780199275373 (alk. paper); Publisher: Oxford; New York: Oxford University Press, c2007.
4. Pasternak, An Introduction to Molecular Human Genetics, Fitzgerald, 2000
5. Gersen & Keagle, The Principles of Clinical Cytogenetics, Humana, 1999
6. Strachan & Read, Human Molecular Genetics, Wiley, 1999
7. Strickberger MW, Genetics, Prentice Hall-India, 2006 5. Hartl DL, Jones EW, Genetics: analysis of genes and genomes, Jones and Bartlett, Massachusetts)

F. Y. M.Sc. Semester II		
BTH-553	Environmental Biotechnology (Elective- I)	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Specify the Global and regional threats to the environment.	
CO2	Illustrate the role of biotechnology in controlling pollutants of the environment.	
CO3	Analyze the methods of environmental monitoring and sample analysis.	
CO4	Describe the role of remote sensing in environmental monitoring.	
CO5	Outline the concept of GIS and explain its application in environmental studies.	
CO6	Determine the significance of EIA and EQAM. Articulate environmental laws, policies, audits and ethics.	

Unit. No.	Title of Unit and Contents	No. of hours
I	Global and regional threats to the environment pollution • Concept, Sources, impacts, and measurement of Air, water, noise, soil, solid waste, and radiation pollutants. • Industrial pollution and safe disposal of effluents with case study and field visit. • Recycle, Reuse and Recovery. Biomedical waste and its management.	10
II	Bioremediation, Biotransformation and Biodegradation: • Bioremediation; In situ and Ex situ bioremediation; • Constraints and priorities of bioremediation; Evaluating Bioremediation; Bioremediation of VOCs. • Biodegradation; Factors affecting process of biodegradation; Methods in determining biodegradability; Contaminant availability for biodegradation. • Xenobiotics; Persistence and biomagnification of xenobiotic molecules; Microbial interactions with xenobiotics; • Phase I and Phase II reactions; Cyt P 450 mediated reactions; Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation. Environmental monitoring and sample analysis: • Sampling of air and water pollutants; Monitoring techniques and methodology, pH, Dissolved Oxygen (DO); Chemical oxygen demand (COD); Biological Oxygen Demand (BOD); Speculation of metals, monitoring & analysis of CO₂, NO₂,	20

	CO ₂ , SO ₂ ; Pesticide residue; Phenols and petrochemicals.	
III	Principles of Remote sensing, its applications in Environmental Monitoring: • Concept of Remote sensing; EMR & its interaction with matter; Aerial Photography: Types, Camera, Elements of photo interpretation (Aerial Photography/image recognition) • Sensors & platforms; IRS satellites & their sensors; Application of remote sensing in environmental studies. Geographical Information System (GIS) Concept of GIS • Types of Geographical Data; Data Structure; Vector and Raster data: their Advantages and Disadvantages; Input, verification, storage and output of geographical data; Importance of Geographical Information System in environmental studies	10
IV	Environmental management: • Environmental management Plan: scope, EMP preparation, Need of EMP Environmental Impact Assessment: • (EIA): Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies; Environmental Impact Assessment Techniques-Ad-hoc method, checklist method, overlay mapping method, network method, simulation and modeling technique, matrix method, and system diagram technique; Merits and Demerits of EIA studies. Environmental Quality Assessment and Monitoring: What is environmental quality? Quality of environment for life on earth and man; Deterioration of environmental quality with reference to anthropogenic impact; Methods of assessment of environmental quality; Short term studies/surveys; Rapid assessment; Continuous short and long term monitoring, bioindicators and Biomarkers for monitoring. ISO 14000, Environmental audits and ethics Environmental Laws and Policies.	20

References:

1. Bruce Rittman, Perry L. McCarty, Environmental Biotechnology: Principles and Applications, 2nd edition, McGraw-Hill, 2000.
2. Indu Shekhar Thakur (2006) Environmental Biotechnology: Basic Concepts and Applications, I. K. International Pvt Ltd, 2006.
3. Gareth M. Evans and Judith C. Furlong (2003) Environmental Biotechnology Theory and Application, John Wiley & Sons Inc.
4. Alan H. Scragg (2006) Environmental Biotechnology, 1st edition, Oxford University Press
5. S.K. Agarwal (2007) Environmental Biotechnology, APH Publishing Co-operation, New Delhi

F.Y. M.Sc. Semester II		
BTH-554	Clinical Research (Elective- II)	Credits: 4 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Discuss and analyses the new drug development process and discuss regulatory and ethical requirements.	
CO2	Design a basic protocol for the conduct of scientific enquiry and the interpretation of the data obtained.	
CO3	Demonstrate competency in clinical methods, including accurately reporting observations, analysis and understand clinical management practice.	
CO4	Specify the principles of Pharmacovigilance.	
CO5	Describe and employ the drug regulatory affairs and ethical requirements.	
CO6	Demonstrate critical thinking skills to improve employment opportunities.	

Unit. No.	Title of Unit and Contents	No. of hours
I	Introduction to clinical research Drug Development Process: Overview of Drug Development Process including clinical trials phases	2
II	Protocol Designing: Definition of protocol, its importance and purpose. Protocol format: Chapters (Headings) and broad contents of protocol Important scientific and administrative aspect included protocol Introduction to Research Methodology Protocol writing team and role of each member Clinical trial design: Types of study designs Sampling, sample size, randomization, Inclusion and Exclusion criteria Phases of clinical trial & Types of trials	12
III	Good Clinical Practice (GCP)-ICH E6: Ethical Principles and their origin Ethics in clinical research: As per ICMR & GCP Ethics committees: Roles & responsibility of IEC and IRB Ethics in relation to vulnerable groups & special situations Responsibilities of Sponsors, Investigators & Regulators ICH: Purpose, regulations & guidelines Informed consent and Informed consent form Essential Documents	12

IV	Drug Regulatory Affairs (Clinical Trial) Regulatory Authority in India (DCGI & CDSCO) Schedule Y of Drugs & Cosmetics Act International Scenario of Regulatory Aspects: FDA, CFR,	6
V	Clinical Safety and Pharmacovigilance: Definitions of AE, ADR, SAE, Recording & reporting: Objectives & Importance Pharmacovigilance: International procedures Pharmacovigilance in India	10
VI	Monitoring and its role in clinical trials CRF and other source documents relevant to monitoring	4
VII	Clinical Data Management	2
VIII	Practical for Protocol Design, CRF Design and source	12

References:

1. Maloy, S.R.; Cronan, Jr., Freifelder D.; Microbial Genetics, 2nd edition (2009), Narosa book distributors Pvt. Ltd., New Delhi.
2. Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L.; General Microbiology; 5th Edition (1987), Macmillan Press Ltd.
3. Snustad, Simmons, Principles of genetics, 6th Edition (2011), John Wiley & Sons, Inc.
4. Hartl, D. L., Jones, E. W., Genetics-Analysis of genes and genomes, 8th Edition, (2011), Jones and Bartlett learning
5. Snyder, L. and Champness, W. Molecular Genetics of Bacteria, 3rd Edition (2007), ASM press.
6. Gardner, Simmons, Snustad. (2006), Principles of Genetics, 8th Edn. John Wiley & Sons. Inc. New York.

F.Y. M. Sc. Semester I		
BTH-570	Biotechnology Practical - III Practical in Industrial Biotechnology and Bioinformatics	Credits: 2 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the preparation and study of fermented foods	
CO2	Perform Solid State Fermentation and recovery of a product and sterility check of a product	
CO3	Apply and execute Lab Scale to Bench Top Fermentation Process Study the large-scale manufacturing process by visit	
CO4	Differentiate various methods for data retrieval from Biological databases and Perform Pairwise and Multiple Sequence alignment and analysis.	
CO5	Compare between various methods for phylogenetic tree construction to understand evolutionary relations. Compare the different Bioinformatics Software tools for the prediction of protein structure	
CO6	Design the Molecular Docking using AutoDock and Molecular visualization of docked complexes (using Pymol or Chimera)	

Expt. No.	Title of the Experiment	No. of hour
1	Lab Scale to Bench Top Fermentation Process: a. Screening and identification (Genus Level) of any one production strain (enzyme /antibiotic / or any other) from soil samples. b. Optimization of different parameters of the isolated organism (conventional and Statistical design) c. Scale up to Lab Bench Fermenter (Setting up fermenter for production) Recovery and quantification of the product	3P
2	Solid State Fermentation: a. Lab scale production b. Recovery and estimation of a product	1P
3	Preparation and study of fermented foods/ Yeast Biomass production, quality check and application.	1P
4	Sterility check of injectables	1P
5	Visit to Fermentation industry	1P

7	Sequence alignment and Database Similarity searching: - BLAST - FASTA Multiple Sequence Alignment by Using the Tools: - Clustal Omega - T-COFFEE - MUSCLE	2P
8	Phylogenetic analysis using Phylip or Mega	1P
9	Basic Structure visualization: - SwissPDB Viewer - Deep View (Performing basic tasks like Selecting and Displaying structures, Colouring, Measuring distances and labeling)	1P
10	Prediction of protein tertiary structure using any method - MODELLER - SWISS Model	1P
11	Molecular Docking: - AutoDock Or - AutoDock Vina Molecular visualization of docked complexes: - Pymol Or - Chimera	2P

F.Y. M .Sc. Semester I		
BTH-571	Biotechnology Practical - IV Practical in Developmental Biology and Genetics	Credits: 2 Hours: 60
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the early chick embryo staging.	
CO2	Explain the developmental stages of Chick and compare with human developmental stages.	
CO3	Establish shell less culture.	
CO4	Carry out Toxicity testing.	
CO5	Interpret the inheritance patterns	
CO6	Perform barr body staining.	

Expt. No.	Title of the Experiment	No. of hours
1	Early chick embryo staging	4
2	Tracking and study of developmental stages of Chick and comparison with human developmental stages	2
3	Establishment of shell less culture	2
4	Toxicity testing (Window technique)	2
5	Inheritance patterns: Case studies and pedigree analysis, population survey of a genetic disorder/ trait	3
6	Staining of Barr body from buccal epithelial cells.	1
7	Lab visit	1