COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI-22
SCHEME AND SYLLABUS FOR
MSC. DEGREE COURSE IN BIOTECHNOLOGY (MODIFIED 2020)
APPLICABLE W.E.F. 2020 ADMISSIONS

SEMESTER-I

Course subjects		**Instruction**				**Evaluation**		
Course no.	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**Pre requisites**	**Internal**	**End semester**	**Total**
20-303-0101	Metabolism and bioenergetics	4	C	3L+ 1P+1T	Nil	50	50	100
20-303-0102	Genetics	2	C	2L+ 0P +1T	Nil	50	50	100
20-303-0103	Molecular biology	3	C	3L+ 0P +1T	Nil	50	50	100
20-303-0104	Microbiology	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0105	Biostatistics and Principles of analytical techniques	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0106	Molecular Cell biology	4	C	3L+ 1P +1T	Nil	50	50	100
	TOTAL FOR SEM -I		**21C**		-	300	300	600

C-core; E-elective; All tutorial classes will be online

SEMESTER-II

Course subjects		**Instruction**				**Evaluation**		
Course no.	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**Pre-requisites**	**Internal**	**End semester**	**Total**
20-303-0201	Enzymology	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0202	Bioprocess Technology	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0203	Biosafety, Bioethics and IPR	2	C	2L+ 0P+ 1T	Nil	50	50	100
20-303-0204	Bioinformatics	3	C	2L+ 1P +1T	Nil	50	50	100
20-303-0205	Project Proposal Preparation and Presentation†	1	C	1L +0P+ 1T	Nil	100	-	100
20-303-0206	Critical Analysis of Classical Papers†	1	C	0L +1P+ 1T	Nil	100	-	100
20-303-0207	Cancer Biology	3	E	3L+ 0P+1T	Nil	50	50	100
20-303-0208	Plant Biotechnology	3	E	2L+ 1P+1T	Nil	50	50	100
20-303-0209	Nanobiotechnology	3	E	2L+ 1P +1T	Nil	50	50	100
20-303-0210	Neurobiology	3	E	2L+ 1P +1T	Nil	50	50	100
	TOTAL FOR SEM -II		**15C 12E**			400 200	200 200	600 400

C-core; E-elective; All tutorial classes will be online

SEMESTER-III

Course subjects		Instruction				Evaluation		
Course No.	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**Pre-requisites**	**Internal**	**End semester**	**Total**
20-303-0301	Recombinant DNA technology	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0302	Immunology and Immunotechnology	4	C	3L+ 1P +1T	Nil	50	50	100
20-303-0303	Biopharmaceuticals	3	C	2L+ 1P+1T	Nil	50	50	100
20-303-0304	Functional Genomics	2	E	1L+ 1P+1T	Nil	50	50	100
20-303-0305	Applications of Biotechnology-I (Industrial & Environmental Biotechnology)	4	E	3L+ 1P+1T	Nil	50	50	100
20-303-0306	Applications of Biotechnology-II (Medical & Animal Biotechnology)	4	E	3L+ 1P+1T	Nil	50	50	100
20-303-0307	Stem cell Biology & Regenerative Medicine	2	E	1L+ 1P+1T	Nil	50	50	100
	TOTAL FOR SEM -III		**11C 12 E**			150 200	150 200	300 400
Compulsory	Interdepartmental elective (for other department students)	3	IDE	3L+ 0P+0T		50	50	100

C-core; E-elective; All tutorial classes will be online

SEMESTER-IV

Course subjects		Instruction				Evaluation		
Course No.	**Course name**	**Credits**	**Core/ Elective**	**Hours/ week**	**Pre-requisites**	**Internal**	**End semester**	**Total**
20-303-0401	Innovation and Entrepreneurship for Biologists†	4	E	4	Nil	100	-	100
20-303-0402	Dissertation	12	**C**	-	-	200	200	400
	Comprehensive viva voce & Seminar	1	**C**	-	-	100	100	200
Total for semester IV			**13C 4E**			300 100	300	600 100
Compulsory	SWAYAM/ NPTEL Elective	3	E			100	-	100
GRAND TOTAL FOR M.Sc. BIOTECHNOLOGY PROGRAM			**60C 28E**			1200 500	800 400	2000 900

C-core; E-elective; All tutorial classes will be online

PROGRAM OUTCOMES FOR M.Sc. BIOTECHNOLOGY

After completing the program the MSc. Biotechnology students will be able to:

P.O.1. Demonstrate an in-depth understanding of the fundamental principles that underlie the field of Biotechnology, including Biochemistry, Molecular and Cellular Biology, Microbiology, Genetics and Genetic Engineering and other allied subjects.

P.O.2. Demonstrate a degree of mastery in the various fields of Biotechnology.

P.O.3. Show proficiency in performing various basic and advanced laboratory techniques employed in Biotechnology including analytical techniques.

P.O.4. Design and conduct biological experiments; analyze and interpret experimental data and perform troubleshooting if necessary.

P.O.5. Identify a problem using literature survey, formulate hypothesis, develop a research plan, execute the research plan, write the project report and communicate effectively through written, oral and visual methods.

P.O.6. Demonstrate analytical thinking and problem solving abilities enabling them to gain skillful job in industries and research labs

P.O.7. Identify and evaluate new business ideas in the field of life science and take it forward by creating a business plan and identifying funding source and executing the plan.

P.O.8. Communicate effectively; work in teams and lead in academic and non-academic situations.

COURSE REQUIREMENTS

Minimum credits to pass a semester	-16 credits
Maximum credits that can be taken per semester	-24 credits
Minimum credits to pass the M.Sc. program	-72 credits
At least one interdepartmental elective (level-2) (On or before semester III)	-3 or 4 credits
At least one elective course from SWAYAM/NPTEL (On or before semester IV)	-3 or 4 credits

Each credit earned requires 2.5 hours of study per week. This includes contact hours and self-study.
Each lab credit requires 3 hours of lab.

Internal evaluations for semester I to III

Exam Type	Course with lab (Marks)	Courses without Lab (Marks)
Internal Tests	30 (2 tests of 15 marks each)	45 (3 tests of 15 marks each)
Assignments	5	5
Practical Exam*	15	-
Internal Marks Total	50	50
End Semester Examination	50	50
Total Marks	100	100

45% marks is the Minimum required to pass end semester examination
50% minimum aggregate (internal + end semester) to pass each course

*****For all courses that contain laboratory Practicals, Laboratory evaluations are 100 % internal and will have a weightage of 15% (15 marks/100) of the total marks for the particular course.

20-303-0205, 20-303-0206, and 20-303-0401 evaluation will be completely internal
20-303-0205 Evaluation - One internal examination covering all modules (20 marks), Project Proposal Report (40 marks) and Proposal Defense (40 marks)
20-303-0206 Evaluation - Class assignments (50 marks) and presentation (25marks) and final review (25 Marks).
20-303-0401 Evaluation - Class assignments/activities (50 marks) and final presentation (50marks)

Pattern of question paper for end semester examination

The questions will be framed to test the students at all the learning levels planned for the particular OBE course.
Maximum marks=50
Part-A: (10) MCQs OR match the following OR very short answer questions - no choice (10 x 0.5 = 5 marks)
Part-B: Answer Any Ten out of Eleven short answer questions of 1.5 marks each (10 x 1.5 = 15 marks)
Part-C: Answer Any Five out of six long answer questions of 4 marks each. (5 x 4 = 20 marks)
Part-D: Answer any one out of three Essay type question of 10 marks (1x10 =10 marks)

DETAILED SYLLABUS

SEMESTER-I

20-303-0101 METABOLISM AND BIOENERGETICS (4C, 3L+1P+1T)

Course Description: This advanced course in biochemistry includes the study of bioenergetics and the metabolism of carbohydrates, amino acids, fatty acids, nucleic acids as well as Electron transport chain. In addition, understanding the regulation of metabolism and the inborn errors of metabolism are also included.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Comprehend various thermodynamic principles governing biochemical changes, Review bioenergetics, free energy, redox potential, biological oxidation (Understand Level)

L.O.2. Estimate energetics of catabolic degradation of intermediates in various metabolic pathways. (Apply Level)

L.O.3. Elucidate chemistry of various biomolecules and identify biomolecules (carbohydrate, fatty acid amino acid and nucleic acid) and Apply the understanding of metabolic pathways to biotechnological and biochemical research (Apply Level)

L.O.4. Illustrate carbohydrate, fatty acid amino acid and nucleic acid metabolic pathways and their regulation and indicate the implications of their abnormalities (Analyze Level)

MODULE I

Bioenergetics: Overview of thermodynamics, Relationship between G and Keq.; High energy compounds, standard free energy of hydrolysis of ATP, structural basis of the group transfer potential of ATP; Oxidation reduction potential, different types of oxidation reduction reactions.

Carbohydrate Chemistry & metabolism: Overview of Carbohydrate chemistry. Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis, Pentose phosphate pathway, Citric acid cycle, Glyoxalate cycle, Biosynthesis of Glycosamino glycans, Proteoglycans and Glycoproteins; Regulation of carbohydrate metabolism; Disorders of Carbohydrate metabolism.

MODULE II

Lipid Chemistry & metabolism: Overview of fatty acids and lipid chemistry. Biosynthesis of Fatty acids; Catabolism of fatty acids; Regulation of fatty acid metabolism; Metabolism of Ketone bodies; Synthesis of triacylglycerols; Phospholipid and glycolipid metabolism; Cholesterol metabolism and regulation; Eicosanoid metabolism- Prostaglandins, prostacyclins, Thromboxanes, Leukotrienes; Metabolism of lipoproteins; Inborn errors of lipid and lipoprotein metabolism.

MODULE III

Aminoacid Chemistry & metabolism: Overview of amino acids and protein. Protein degradation in cells: lysosomal events, role of ubiquitin and proteosomes; Catabolism of amino acid nitrogen - transamination, deamination, ammonia formation; urea cycle, regulation and disorders of urea cycle; Catabolism of amino acid carbon skeleton; Conversion of amino acids to specialized products: Histamine, Serotonin, epinephrine, nor-epinephrine and nitric oxide - function and metabolism; Metabolism of aromatic amino acids & Histidine, Cysteine and Serine; Inborn errors of amino acid metabolism.

MODULE IV

Nucleic acid Chemistry & metabolism: Overview of nucleic acids, Purines and Pyrimidines, Biosynthesis (*de novo* and salvage pathways) & catabolism of purines and pyrimidines; Regulation of purine and pyrimidine metabolism; Disorders of nucleic acid metabolism; Biosynthesis of nucleotide coenzymes; Inhibitors of nucleotide biosynthesis as chemotherapeutic agents.

MODULE V

Mitochondrial Metabolism: Ultra structure of mitochondria-anatomy, enzymes; Electron transport chain: thermodynamics of electron transport, components and different complexes, mobile electron carriers; proton transport during electron flow, inhibitors of electron transport chain.

Electron transport in other membrane system: microsomal electron transport chain; Oxidative phosphorylation–chemiosmotic model, ATP synthase (F_0F_1complex), proton gradient, rotational catalysis, shuttle systems to move reducing equivalents from cytosol to mitochondrial matrix; Regulation of oxidative phosphorylation

SUGGESTED LIST OF PRACTICAL LAB

1. Identification of carbohydrate (Sugars), amino acids/protein, cholesterol and triglycerides and nucleic acids
2. Estimation of carbohydrate (Sugars), protein, cholesterol and triglycerides and nucleic acids by spectroscopic analysis
3. Estimation of serum SGOT and SGPT, creatine kinase levels
4. Fluorescence spectroscopy to study effect of temperature and pH on protein structure. (L.O.4)
5. Estimate Tm (Effect of temperature on DNA)
6. Determination of catalase and cytochrome oxidase enzyme activity of various bacterial strains
7. Other biochemical like citrate utilization, indole, Conversion of lactose to acid, etc using bacterial strains

REFERENCES:

1. Voet, D. &Voet J. G. *Biochemistry* (2012). 4th edition, John Wiley and Sons
2. Stryer, Lubert*et al*., (2015).*Biochemistry*.8thedition.W.H. Freeman and Co.
3. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).*Principles of Biochemistry*.6th revised edition. Freeman and Co.
4. Devlin, Thomas. M. (2010).*Text book of Biochemistry with Clinical Correlations*- 7th edition. John Wiley & Sons.
5. Robert, K., Granner, D. K., & Mayes, P. A. M. (2003). Harper's illustrated biochemistry.
6. Grunwald, P. (2016).*Biocatalysis: Biochemical Fundamentals and Applications* .2nd reprint Edition. Imperial College Press.
7. Combs Jr, G. F., & McClung, J. P. (2016). *The vitamins: fundamental aspects in nutrition and health*. Academic press.
8. Lurton, R. (2010).*Clinical Biochemistry*.2nd Edition. Viva books.
9. White, Abraham. (2004).*Principles of Biochemistry*.6th edition. Tata Mcgraw-Hill.
10. Cooper T.G. (2015). *Tools of Biochemistry*.2nd edition, Wiley-Interscience
11. Sadasivam S. and Manickam A.(2009). *Biochemical Methods*, 2ndedn.New Age International Ltd Publishers.
12. Mu, P., & Plummer, D. T. (1988). Introduction to practical biochemistry. Tata McGraw-Hill Education.
13. Jayaraman J.(1992).*Laboratory manual in Biochemistry*.John Wiley.

20-303-0102 GENETICS (2C, 2L-0P-1T)

Course Description: The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Describe fundamental molecular principles of genetics (Understand Level)
L.O.2. Describe the basics of genetic mapping and analyze crossing data (Analyse Level)
L.O.3. Explain the process of genetic mapping in bacteria and fungi and bacteriophage (Understand Level)
L.O.4. Analyse pedigree charts to come up with predicting genotype and probability of occurrence of particular genotype and phenotype (Analyse Level)
L.O.5. Explain the inheritance of complex traits (Understand Level)

L.O.6. Discuss the human disease genetics and inheritance of human diseases (Understand Level)

MODULE I

Mendelism and extensions of Mendelism, Epistasis, Pleiotropy, Polygenic inheritance, Sex-linked inheritance, extra-nuclear inheritance, chromosome theory of inheritance

MODULE II

Linkage and crossing over, Genetic mapping in – bacteria, bacteriophage, neurospora, yeast and drosophila; fine structure analysis; chromosome mapping and molecular mapping; Development of gene concept

MODULE III

Genomes and Genomics, Human genome project; functional genomics and reverse genetics; Comparative genomics

Human Disease Genetics: Pedigree analysis of Monogenic traits - Autosomal inheritance-dominant, recessive Sex-linked inheritance, Sex-limited and sex-influenced traits, Mitochondrial inheritance, OMIM number, Complications to the basic pedigree patterns- non penetrance, variable, expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations, mosaicism and chimerism, male lethality, X-inactivation; LOD score for linkage testing, genetic disorders

MODULE IV

Inheritance of complex traits: Complex traits, measuring and analyzing quantitative variation, narrow sense and broad sense heritability, QTLs and mapping QTLs, Human quantitative traits, Haplotype mapping and GWAS

The epigenome, including: epigene modifications, such as DNA methylation, histone modification, chromatin remodeling and non-coding RNAs; cellular maintenance of the epigenome; epigenetic control of gene expression, and epigenetics and development. X inactivation and genomic imprinting.

MODULE V

Population Genetics and Genetics of Evolution: Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness;
Darwin's theory of evolution; Genetic variation in natural populations; Molecular evolution; Speciation; Human evolution

REFERENCES

1. Introduction to Genetic Analysis, Griffith, AJF, Wessler SR, Carol SB and Dobley J., 11th edition, 2015, W.H. Freeman and Co.
2. Genetics: From Genes to Genomes, Hartwell LH, Goldberg ML, Fischer JA and Hood L., 6th edition, 2018, McGraw Hill.
3. Principles of Genetics, E.J. Gardner and D.P. Snustad, 7th edn, 2015, John Wiley and Sons
4. Genetics, Monroe W. Strickberger 3rd revised edition, 2008, Prentice Hall Pvt. Ltd
5. Essential Genetics- A Genomic Perspective- Daniel L.H, 4th edition, 2005 , Jones and Bartlett ,USA
6. Principles of Genetics, Robert H. Tamarin , 7th edition, 2007, Tata MaGraw-Hill
7. Genetics: a Conceptual Approach, Pierce, B. A., 6th edition, 2016 W.H. Freeman.
8. Evolutionary Genetics, Smith, J. M. 1999, 2nd edition, Oxford University Press.
9. Genetics : Analysis of Genes and Genomics, Hartle, L , 8th edition, 2011, Jones and Barlett, USA
10. Emery's Elements of Medical Genetics, Turnpenny P, and Ellard S, 15th edition, 2017, Elsevier
11. Molecular and Genetic Analysis of Human Traits, Maroni, 2001,Wiley-Blackwell
12. Approaches to Gene Mapping in Complex Human Diseases, Haines and Pericak, 2006, Wiley
13. Selected research papers to be given

20-303-0103 MOLECULAR BIOLOGY (3C, 3L-0P-1T)

Course Description: This course is intended to be an advanced course in molecular biology that builds on the basic undergraduate Molecular Biology course. The course is intended to focus more on the fundamental

principles of Molecular Biology than the vast information that is there in the field. At the end of the course students will be able to explain the principles underlying life at a cellular level. They will also be able to design appropriate experiments to test hypothesis regarding the inner workings of a cell. This course will also introduce students to the latest discoveries in the field by way of analysis of original journal articles and presentation by the students.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Describe the fundamental principles of replication and maintenance and gene expression and regulation in cells (Understand Level)
L.O.2. Design experimental strategies for testing molecular biological hypothesis (Analyse Level)
L.O.3. Analyse experimental data to explain the reasons for observed changes in gene expression and activity in cells (Analyse Level)
L.O.4. Select appropriate model systems for studying different molecular biological processes (Analyse Level)
L.O.5. Analyse and understand journal articles containing original research (Analyse Level)

MODULE I

Structure of Macromolecules: Bonds and interactions in Biology; Central Dogma; Structure of DNA and RNA; Structure of Proteins; Techniques in Molecular Biology

MODULE II

Maintenance of Genome: Genome structure, Chromatin and the Nucleosome; Replication of DNA, Extrachromosomal Replicons; Mutability and Repair of DNA, Homologous Recombination; Site specific recombination, Transposition of DNA

MODULE III

Transcription and Translation of Genetic Information: Mechanism of Transcription; RNA Splicing; Translation; The Genetic Code; The origin and early evolution of life

MODULE IV

Control of gene expression: Transcriptional regulation in prokaryotes; Transcriptional Regulation in Eukaryotes; Post-translational modifications

MODULE V

Regulatory RNAs; Gene Regulation in Development and Evolution; Systems Biology; Model Organisms in Molecular Biology

REFERENCES

1. Molecular Biology of the Gene,7th edition, Watson et al. 2013, CSHL Press (Primary Reference Book)
2. Genes XII, Lewin et. al., 2017, Jones and Bartlett Pub Inc.
3. Molecular Biology of the cell, Alberts, Bruce, 6th edition, 2014, Gorland Pub. Inc.
4. Biochemistry of Nucleic acids, -Roger L. P. Adams et al.,11th edition, 2007, Chapman & Hall
5. Molecular Cell Biology, Lodish, Baltimore et al., 8th edition, 2016, W.H.Freeman and Co.
6. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Meyers, Robert A, 2011 ed. Wiley, New Delhi.
7. Molecular Biology –David Clark and Nanette K Pazdernik, 2nd edition,2013, Academic press
8. Selected research papers to be given

20-303-0104 MICROBIOLOGY (4C, 3L+1P+1T)

Course description: This is an advanced course in microbiology. The course will detail molecular mechanisms of classification of bacteria and archaea and molecular Phylogeny. The course also includes the various transport mechanisms adopted by microbes and their molecular basis. The molecular basis of the nutrient cycles especially N-cycle will also be discussed. In addition the course will also include the molecular mechanisms underlying bacterial pathogenesis and antimicrobial resistance mechanisms. In addition, the course includes the role of

genomics, transcriptomics, metabolomics and proteomics at understanding the human microbiome, diversity and function in unique environments.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Develop strategies for molecular classification of microorganisms as well as construct phylogenetic trees (Analyze level)
L.O.2. Describe the mechanisms of various transport systems in microbes (Understand Level)
L.O.3. Describe mechanisms involved in nutrient cycling, especially N-cycle (Understand Level)
L.O.4. Analyze strategies to estimate pathogenesis (Analyze Level)
L.O.5. Develop strategies to understand antimicrobial resistance mechanisms in microbes trees (Analyze level)
L.O.6. Describe the impact of Human microbiome project (Understand Level)
L.O.7. Understand the role of genomics, transcriptomics and proteomics in enhancing knowledge about the microbial world today (Understand Level)

MODULE I

Molecular basis for Classification: of Archaebacteria, Eubacteria, cyanobacteria, Yeasts, fungi, microalgae, protozoans and viruses.
Phylogenetics and evolution.

MODULE II

Transport mechanisms in microbes and their regulation: Simple diffusion, facilitated diffusion, active transport and group translocation

MODULE III

Microbial transformation and molecular mechanism: Carbon, Nitrogen, Phosphorus, Sulphur, nitrogen cycles; Nitrogen fixation-leghaemoglobin,

MODULE IV

Pathogenesis: Role of horizontal gene transfer in pathogenesis; Pathogenecity islands, toxin genes, virulence genes,
Biofilms in disease; AMR genes in pathogenesis.
Human Bacterial diseases-Tuberculosis, leprosy, Cholera, Typhoid
Viral diseases: Polio, HIV, Hepatitis, Rabies, Influenza, H1N1, SARS, COVID19

MODULE V:

Metagenomics Principles: Soil metagenomics, human microbiome project-Understanding the Role of microbes in health and disease

SUGGESTED LIST OF PRACTICALS

1. Application of specific molecular markers like 16S rDNA/ 18S rDNA /COXa sequence amplification and analysis for molecular classification of microorganisms (L.O.1.)
2. Construction of phylogenetic tree to understand relatedness (L.O.1.)
3. Construct Antibiogram for analysis of antibiotic profile of given pathogens-Disk diffusion method (L.O.4. & L.O.5.)
4. Quantify the antibiotic sensitivity using liquid assay-MIC (L.O.4. & L.O.5.)
5. Amplify the R-gene using PCR techniques, confirm its presence by electrophoresis and analyze the sequence data (L.O.4. & L.O.5.)
6. Isolate and quantitate pure metagenomic DNA from soil sample. (L.O.7. & L.O.8.)
7. Analyze the given metagenomic data set using bioinformatics tools to identify resistome, diversity and function (L.O.7. & L.O.8.)

REFERENCES:

1. Pelczer J. Chen ECS., Krieg NR (1986).*Microbiology*, MC Grow Hill Company.
2. Gibson, D. T. (1984). *Microbial degradation of organic compounds*. Marcel Dekker Inc.

3. Adams, M. R., & Moss, M. O. (2000). *The microbiology of food preservation: In Food microbiology.*
4. Davis B.D.,Dulbecco R.,Eisen H N.and Ginsberg H S.(1990). *Microbiology*.4th edition,J. B. Lippincott company, Newyork.
5. Frazier, W. C., &Westhoff, D. C. (1988). Food microbiology 4th ed. *Tata McGraw-Hill Publishing Co. Ltd. New Delhi*.
6. Stanier,R.Y. (1987).*General Microbiology,* 5th Edition, Prentice Hall Macmillan Education Ltd.
7. White, D. (1996). *The physiology and biochemistry of prokaryotes: General Pharmacology*.
8. Ananthanarayan, R. (2005). *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan.
9. Pommerville, J. C. (2013). *Fundamentals of microbiology*. Jones & Bartlett Publishers.
10. Marjorie Kelly Cowan (2015).*Microbiology:A Systems Approach*,3rd edition, McGraw-Hill Higher Education.
11. Booth S J. (2010)*Microbiology*:*Pearls of Wisdom,* 2nd edition,Scientific book centre.

20-303-0104 BIOSTATISTICS AND PRINCIPLES OF ANALYTICAL TECHNIQUES (4C, 3L+1P+1T)

Course Description: Biostatistics topics include data and data types, tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. Bioanalytical technique introduces fundamental principles of various techniques employed in the field of Biotechnology like Microscopy, Radioisotope techniques, Chromatographic methods, Electrophoresis, Centrifugation techniques, Spectroscopic Techniques, Polymerase Chain Reaction (PCR), DNA sequencing, ELISA.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Understand the conceptual framework of basic methods of bio- statistical analysis. (Understand Level)
L.O.2. Develop a conceptual framework that integrates techniques and methods in biostatistics: thus student will learn that the principles of biostatistics are grounded in scientific learning. (Analyse Level)
L.O.3. Apply descriptive statistical techniques, commonly used, to summarize scientific data. (Apply Level)
L.O.4. Communicate the results of statistical analysis accurately and effectively to write technical reports and make technical presentation containing statistical results and work (Apply Level)
L.O.5. Explain the basic principles and applications of various techniques employed in the field of Biotechnology. (Understand Level)
L.O.6. Analyse the application of various techniques and retrieve knowledge independently to be able to present a scientifically sound solution for given application in the field of biotechnology. (Analyse Level)

MODULE I

Biostatistics I: Statistical data – types of data: primary, secondary, qualitative and quantitative - methods of collection: population, sample, sampling techniques - classification of data: frequency distribution and graphical presentation of data. Scales of measurements. Measures of central tendency - mean, median and mode. Measures of dispersion - Range, mean deviation, standard deviation, standard error and co-efficient of variation.

MODULE II

Biostatistics II: Probability: counting, Theorems of Probability; Probability distributions of discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, Experimental designs-simple and factorial. Sample size calculation

MODULE III

Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Dark-field; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy

Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle. nonlinear microscopy: multiphoton microscopy, tandem scanning (spinning disk) microscopes, advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy, Total Internal Reflection Microscopy; Near-Field Microscopy, Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-

Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM), Electron microscopy, AFM

MODULE IV

Principles and applications of advanced molecular Biology Techniques: Basic principles and applications of pH meter, Colorimeter, Spectrophotometers and Centrifuges

Chromatographic techniques- Paper chromatography, Thin layer chromatography, Column chromatography, Gas Chromatography, HPLC

Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray: 16S rRNA typing;

Diagnostic proteomics: SELDI-TOF-MS, 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, LCMS & NMR technological platforms. Metabolomics, lipidomics, metagenomics
X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering

MODULE V

Immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, microarrays, transgenic mice, gene knock outs//knock down.

SUGGESTED LIST OF PRACTICALS

1. Classify data collected by themselves using frequency table and represent it graphically.
2. Analyze data for mean, median and mode.
3. Analyse data for mean deviation, standard deviation, standard error and co-efficient of variation
4. Analyse a set of data for correlation and regression.
5. Determine probability for different types of events.
6. Test the significance of data using test t-, chi square test and ANOVA.
7. Analyse various statistical data by using MSExcel and SPSS software"
8. Micrometry and Haemocytometry
9. Calibrate the pH meter and test the pH of different sample solutions.
10. Estimate the concentration of the given sample (Beer-Lambert's law)
11. Prepare a plant extract and perform TLC
12. Gas chromatography and HPLC- demonstration.
13. Phase contrast, Fluorescence, Confocal and Electron microscopy- demonstrations.
14. Identify a specific protein marker expressed in a cell using Immunocytochemistry and microscopy techniques.

REFERENCES

1. Panse V .G. & Sukhatme, P.V (1967).Statistical Methods for Agricultural Workers, ICAR.
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19. Marimuthu R. 2011n Microscopy and Microtechnique. MJP Publishers
20. Prakash S.Bisen and Anjana Sharma. Introduction to instrumentation in life sciences. Publishers-Taylor and Francis Ltd. CRC press
21. Sivasankar B. Bioseparations; Principles and Techniques. Publisher: PHI Learning Pvt. Ltd
22. Selected Papers

20-303-0106 MOLECULAR CELL BIOLOGY (4C, 3L+1P+1T)

Course Description: This course will focus on understanding the structure and function of the cell, which is fundamental to all of the biological sciences. The advanced course in cell biology will focus on both Prokaryotic and Eukaryotic cell biology. The course will help to develop insight into the complexities of cell structure and function and the molecular events that mediate cellular processes, with specific focus on membrane structure and composition, transport and trafficking; the cytoskeleton and cell movement; and the integration of cells into tissues. In addition, the course will also cover important cellular processes such as cell cycle regulation, signal transduction, metabolic processes, and apoptosis and will attempt to relate defects in these various cellular processes to human diseases.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Develop a deeper understanding of cell structure and how it relates to cell functions. (Understand Level)
L.O.2. Describe the structure and function of biological membranes, and analyze cell-cell and cell- matrix interactions. (Analyze Level)
L.O.3. Outline the major processes of intracellular transport of proteins. (Analyze Level)
L.O.4. Describe how cells grow, divide and die, and how these important processes are regulated. (Analyze Level)
L.O.5. Describe the mechanisms that control cell signaling and how it regulates cellular functions. (Analyze Level)
L.O.6. Describe the dysregulation of key cellular processes and its role in various human diseases (Analyze Level)
L.O.7. Analyse a given theoretical problem/case, identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution (Apply Level)

MODULE I: The Dynamic Architecture and Composition of Cells
Structure and functions of cellular constituents, Membranes and cell architecture, Membrane trafficking, Ion channels and electrical properties of membranes, Transport of ions & small molecules, Protein transport into membranes and organelles, Vesicle trafficking; Vesicle Formation & Cargo Sorting, Vesicle Targeting and Fusion

MODULE II: Cells in Their Social Context
Microenvironment of the Cell, Cell communication, Cell polarity, Cytoskeleton-Microfilaments, Microtubules, intermediate Filaments, Actin Dynamics**,** Membrane Channels, receptor mechanisms of action, Cell-Cell Interaction, Cell-Matrix Interactions, Cell Migration and its Control Mechanisms

MODULE III: Cell Signaling and Signal Transduction
Ligands and surface receptors, GTP binding proteins, cAMP and Calcium signaling, Receptors and associated kinases, RTK signaling and other mechanisms, Major cell–cell signaling pathways—Wnt, TGF-β, Hedgehog (Hh), receptor tyrosine kinase (RTK), nuclear receptor, Jak/STAT, and Notch, Relationships between Signaling Pathways

MODULE IV: Cellular Growth Control and Regulation
Regulation of the cell division cycle, Regulation of DNA replication, Regulation of mitosis and meiosis, Cell cycle checkpoints, Factors Influencing Cell Growth and Survival*,* Cellular senescence, Molecular mechanisms of cell death; Autophagy-dependent cell death, Lysosome-dependent cell death, Apoptosis, necroptosis, Ferroptosis, Pyroptosis, Cellular senescence

MODULE V: Integrating Cells into Tissues
Epithelial tissue; types, characteristics and functions, Wound healing, Specialized connective tissues; Reticular, Blood, Bone, Cartilage and Adipose tissues, Muscle tissue; Cellular and molecular mechanism of muscle contraction, Nervous tissue; Basic structure and function of the nervous system, Neural conduction and synaptic transmission, Learning and memory

SUGGESTED LIST OF PRACTICAL LAB: LAB DEMONSTRATION:

1. Cell culture facilities in practice
2. Cell culture in vitro
3. Trypsination and methods for detachment of cells
4. Cell counting and reseeding
5. Cell imaging analysis of marker proteins for visualizing; various organelles, proliferation, apoptosis, cell matrix, differentiation and proteins involved in signal transduction
6. Cell cycle stages by FACS analysis

Practicals:

7. Histology
8. Tissue fixation
9. Tissue sectioning using cryostat
10. Visualization of the processed tissue samples
11. Immunocytochemistry

REFERENCES

1. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter; Molecular Biology of the Cell (6th Edition) by Garland Science; 2014
2. Chris A. Kaiser, Kelsey C. Martin, Harvey Lodish, Arnold Berk, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. ScottMolecular Cell Biology (8th Edition) by , Published by W. H. Freeman; 2016
3. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D.Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter; Essential Cell Biology (4th Edition) by Garland Science; 2013
4. Gerald Karp, Janet Iwasa, Wallace Marshall; Cell Biology (8th Edition); by Wiley; 2018
5. David E. Sadava; Jones & Bartlett Learning, Cell Biology: Organelle Structure and Function; 1993
6. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Angelika Amon; Kelsey C. Martin; W.H. Freeman; Molecular Cell Biology (8th Edition), 2016
7. Geoffrey M. Cooper, Robert E. Hausman; The Cell: A Molecular Approach (8th Edition) by Sinauer Associates; 2014
8. Jeff Hardin Gregory Paul Bertoni; Becker's World of the Cell, (9th Edition) by Pearson; 2015
9. Freshney, R. I. Culture of specific cell types. John Wiley & Sons, Inc.; 2005
10. Chris A. Kaiser, Kelsey C. Martin, Harvey Lodish, Arnold Berk, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. Scott, Molecular Cell Biology (8th Edition) by Published by W. H. Freeman; 2016
11. Julio E. Celis, Cell Biology: A Laboratory Handbook, Volumes 1, 2, 3; Edited by Academic Press, 1994

SEMESTER II

20-303-0201 ENZYMOLOGY (4C, 3L+ 1P +1T)

Course Description: This course on enzymology covers classification, naming, isolation and purification of enzymes. It also includes the structure and general properties of enzymes, mechanisms of enzyme catalysis, Enzyme kinetics, different types of enzyme inhibition, regulation of enzymes and applications of enzymes.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain principles underlying classification & nomenclature of enzymes and employ suitable methods for isolation and purification of enzymes from different sources. (Understand Level)
L.O.2. Discuss the structure and general properties of enzymes and their mechanism of action, (Understand Level)
L.O.3. Apply enzyme kinetics to study enzyme characteristics and analyze kinetic parameters to differentiate different types of enzyme inhibition.
L.O.4. Explain and evaluate the role of regulatory enzymes in the regulation of metabolic pathways. (Understand Level)

L.O.5. Discuss the applications of enzymes in medicine, industry and genetic engineering and also to design synthetic enzymes. (Understand Level)

MODULE I

Enzyme nomenclature and classification: The Enzyme Commission's system of classification and nomenclature; The six main classes of enzymes and their subclasses.

Extraction and Purification of Enzymes: Extraction of soluble and membrane bound enzymes; Purification of enzymes; Criteria of enzyme purity; Assay of enzymes; Zymography.

MODULE II

Structure and General properties of enzymes: Active site; Enzyme substrate complex; Reaction coordination diagram; Lowering of activation energy; Specificity of enzyme-Types of specificity, lock and key hypothesis, induced fit hypothesis and strain or transition state stabilization hypothesis; Mechanism of enzyme catalysis: Acid-base catalysis, covalent catalysis and metal ion catalysis ; Factors affecting enzyme activity; Isozymes; Coenzymes; Metalloenzymes; Membrane bound enzymes; Multienzyme complexes.

MODULE III

Kinetics of enzyme catalysed reactions: The relationship between initial velocity and substrate concentration - Michaelis-Menton, Lineweaver–Burk, Eadie-Hofstee and Hanes-Woolf equations and their applications; Pre-steady state kinetics, Fast kinetics to elucidate the intermediates and rate limiting steps; Kinetics of bisubstrate enzyme catalyzed reactions – Ping-pong and random order mechanisms

Enzyme inhibitors: types of inhibitors; Mechanism of enzyme inhibition –competitive, non–competitive, uncompetitive and mixed inhibition; Allosteric and irreversible inhibition; Hill equation.

MODULE IV

Regulatory enzymes and metabolic regulations: Allosteric enzymes- Properties, Sigmoid kinetics; Hill equation. Important metabolic pathways regulated by allosteric enzymes; Regulation of enzymes by covalent modification and zymogen activation.

Investigations of active site structure: methods of active site mapping.

MODULE V

Applications of Enzymes; Applications in medicine-diagnostic enzymes, therapeutic enzymes, Enzymes as reagents in clinical chemistry, Enzymes and inborn errors, Industrial applications of enzymes; Applications in genetic engineering/ gene editing.

Synthetic Enzyme: Ribozymes, Catalytic antibodies, Enzyme engineering (Protein engineering).

Enzyme Immobilization; Immobilization of enzymes and their applications, Kinetics of immobilized enzymes. Biosensors

SUGGESTED LIST OF PRACTICALS:

1. Extraction of an enzyme from animal/plant/microbial source.
2. Ammonium sulfate/Acetone precipitation of the extracted enzyme.
3. Purification of the enzyme by a suitable chromatographic techniques.
4. Determination of molecular weight by SDS PAGE.
5. Progress curve for the enzyme catalyzed reaction.
6. Assay of the enzyme to determine activity and specific activity
7. Effect of [S] on velocity: Michaelis-Menton Plot and Lineweaver-Burk plot- determination of Km and Vmax.
8. Determination of optimum pH of the enzyme.
9. Determination of optimum temperature.
10. Effect of inhibitors on enzyme activity.

REFERENCES

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2. Donald, F. C. (1992). Clinical Chemistry, A fundamental textbook. Saunders Company.
3. Uhlig, H. (2015). Industrial enzymes and their applications. John Wiley & Sons.

4. Palmer, T., & Bonner, P. L. (2007). Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier.
5. Chaplin, M.F.,Burke ,C.(1990). Enzyme technology.Cambridge University Press.
6. Grundwald, D. Peter. (2016). Biocatalysis: Biochemical Fundamental and Applications.2nd reprint Edition. Imperial College Press
7. Grunwald, P. (2009). Biocatalysis: biochemical fundamentals and applications. Imperial College Press.

20-303-0202 BIOPROCESS TECHNOLOGY (4C, 3L + 1P + 1T)

Course Description: This course gives the student an insight into bioprocesses for industrial applications. Differences between bio- and chemical processes, types of bioprocesses, screening for industrially important organisms, strain improvement strategies are all part of this course. In addition the kinetics of fermentation in batch and continuous mode, the mass transport processes, reactor design, types of reactors, process control and downstream processing of biological are included.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Differentiate chemical and biological processes (Understand Level)
L.O.2. Implement various methods of strain improvement of industrial organisms. (Apply Level)
L.O.3. Implement batch processes, as well as sterilization processes for application (Apply Level)
L.O.4. Differentiate between batch and continuous processes (Understand Level)
L.O.5. Explain mass and oxygen transfer processes in fermentation (Understand Level)
L.O.6. Explain process control and scale-up and also downstream processing (Understand Level)
L.O.7. Select processes such as solid state, submerged fermentation or immobilization for production (Analyze Level)
L.O.8. Apply different downstream processing for enzyme purification (Apply Level)

MODULE I
Basic principles of bioprocesses: Advantages of bioprocesses over chemical processes: Types of bioprocesses; Isolation and screening of industrially important microbes: improvement of strains for increased yield and other desirable characteristics-mutation and selection, Genetic recombination.

MODULE II
Kinetics of fermentation process: Design of fermentation media; Sterilization: thermal death kinetics, batch & continuous sterilization systems, Sterilization of air, fibrous filters; sterile filtration of biologicals.

MODULE III
Transport phenomenon in bioprocess: Mass transfer-Mass transfer coefficient for gases and liquids; Dimensionless groups - Reynolds no.; Mass transfer resistance; Rate of oxygen transfer; Oxygen transfer coefficient; Rheological properties of intermediates; Heat transfer – heat transfer coefficients, heat exchanger design.

MODULE IV
Reactor design and kinetics: Parts and their functions. Types of reactors; Auxiliary instrumentation of bioreactors; Microprocessor controlled fermentors.
Bioprocess control: on/ off control, online measurements; Monitoring variables such as temperature, aeration, agitation, pressure, pH, foaming; Computers in bioprocess control systems; Economic aspects of bioprocess.

MODULE V
Scale up and down stream processing of biological: Separation of cells, cell disruption and recovery; Direct extraction of products and metabolites; Large scale separation techniques like chromatographic and affinity techniques; membrane filtration –ultra filtration and reverse osmosis; Spray drying, drum drying & freeze drying.

SUGGESTED PRACTICAL LABS

1. Solid state fermentation for the production of wine
2. Solid state fermentation for the production of citric acid
3. Submerged fermentation for the production of α-amylase
4. Immobilization of whole cells for the production of enzyme
5. Immobilization of plant cells

REFERENCES

1. Sambamurthy, K. (2007). *Pharmaceutical engineering*. New Age International.
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
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7. Cassida L.E.J.R. (2015).*Industrial Microbiology*.New Age International.
8. Bisswanger, H. (2013).*Practical Enzymology*. 2ndedn. Wiley-VCH.
9. Gamborg, O. L. Plant cell, tissue, and organ culture: fundamental methods/OL Gamborg, GC Phillip, (eds.). *Springer lab manual*.
10. Ramdas, P.(2017).*Practical Biotechnology*,1st edn.Jaypee Publishers
11. Chrikjian& Jack, N. (2009).*Biotechnology Theory and Techniques*. Vol.I. and Vol.II CBS Publication.

20-303-0203 INTRODUCTION TO BIOETHICS, BIOSAFETY AND IPR (2C, 2L-0P-1T)

Course Description: This course introduces bioethics, biosafety and the IPR issues related to biotechnological research. It reviews ethical, legal and social issues and practices related to various applications of biotechnology including genetic testing and therapy, cloning, use of stem cells, etc. The practical aspects of performing responsible conduct of research will also be discussed. Discussion topics include biosafety issues regarding rDNA research as well as the various guidelines. The course will also discuss release of genetically modified organisms to the environment, its impact and safety issues. In addition the role of IPR and role of patent in biotechnology and procedures for patenting and protection of traditional knowledge will be discussed.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Understand the ethical, moral, social and legal issues underlying products and processes developed by biotechnology and microbiology (Understand Level)
L.O.2. Analyse and select appropriate biosafety measures for the conduct of experiments using various living organisms (Apply Level)
L.O.3. Explain the process of risk assessment analysis of the release of genetically modified organisms (Understand Level)
L.O.4. Identify potential ethical issues in the conduct of research experiments and to avoid committing unintentional research misconduct (Analyse Level)
L.O.5. Understand the process of applying for a provisional and complete patent through national and PCT mode (Understand Level)
L.O.6. Explain the various measures to protect to biodiversity and traditional knowledge from exploitation by unjust commercial interests (Comprehend Level)

MODULE I

Ethics and Bioethics: Freewill and Determinism, Morals and values, Theories of Ethics

Ethical, moral, social and legal issues in Biotechnological research: Relevance of regulation and control of research in biotechnology, societal obligations of a biotechnologist; Concerns relating to experimentation on animals, genetic engineering of plants and animals for food (GM foods), cloning, stem cell research, human gene therapy and genetic modifications, genetic testing and screening, human clinical trials and drug testing, bi-weapons program/bioterrorism.

MODULE II

Research Ethics: Responsible Conduct of Research; fabrication, falsification, and plagiarism; Authorship; Conflicts of Interest; Peer review and collaboration; Data and data management; Use of animal subjects and

animal protocols; Use of human subjects and IEC; Rigor and reproducibility, Research misconduct - case studies of major research misconduct.

MODULE III

Biosafety: Safety issues in different fields of Biotechnology, General Guidelines for recombinant DNA (rDNA) research**,** The Cartagena Protocol on Biosafety; NIH Guidelines; Guidelines for recombinant DNA research in India.

Classification of microorganisms according to pathogenicity; Containment facilities and Biosafety practices.

Risk Analysis and Assessment: Release of GM organisms to the environment- Environmental Impact Assessment and risk analysis. Safety assessment of GMO foods and human clinical trials; GLP and GMP

MODULE IV

Intellectual Property Rights (IPR): Different types of IPR, Patents – Origin and Treaties, Criteria for patentability, Issues of Patentability, PCT, Patent applications-rules and procedures, Impact of patents on the pharma sector, Patenting of life forms.

MODULE V

Protection of Traditional Knowledge: Plant variety protection, Registration of newer varieties, Rights and obligations: Farmers and breeders rights. Protection of biodiversity, Convention on Biodiversity and the Indian Biodiversity Act, Protection of Traditional Knowledge

REFERENCES

1. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Padma Nambisan, 2017, Academic Press.
2. Textbook of Research Ethics - Theory and Practice, Sana Loue, 2002, Kluwer Academic Publishers.
3. Bioethics - An introduction, Marianne Talbot, 2012, Cambridge University Press.
4. Intellectual property rights in agricultural Biotechnology, F. H. Erbisch and K. M. Maredia, 2nd edition, 2003, Cambridge University Press.
5. The Cambridge Textbook of Bioethics, Ed. Peter A. Singer, 2008, Cambridge University Press.
6. Biotechnology, Biosafety and Biodiverstiy, Sivamiah Shantharam, Jane F. Montegomery, 1999, Oxford & IBH Publ. New Delhi.
7. Genetically modified Food Sources, Safety Assessment and Control, Tutelyal, VA, 1st edition, 2013, Academic Press.
8. Bioethics: An Introduction to the History Methods and Practice, Jecker Nany S, Johsen Albert, Perlman, Robert A, 2nd ed., 2010, John & Bartlett, New Delhi.
9. Environmental Safety of Biotech and Conventional IPM Technology, Sharma, HC Dhillon, MK, Sahrawat, KN, 2012, Stadium Press LLC. USA.
10. Bioethics and Biosafety, Sathish MK, 2008, IK International.
11. Intellectual Property Rights, Neeraj Pandey and Khushdeep Dharni, 2014, PHI Learning, Pvt. Ltd.

20-303-0204 BIOINFORMATICS (3C, 2L + 1P+1T)

Course Description: This is an introductory course in bioinformatics. It includes the study of biological databases, primary and secondary databases and their importance; Sequence alignment and database search; phylogeny and Phylogenetic trees: Nucleotide sequence analysis: Tools and methods; Protein sequence analysis; and getting an idea of the various web resources available for scientific and research use.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Understand data handling (Understand Level)
L.O.2. Understand basic scripts in PERL, PYTHON (Understand Level)
L.O.3. Retrieve data (Sequences) from databases (Apply Level)
L.O.4. Execute the use of various tools for sequence alignment and database search

L.O.5. Construct molecular phylogeny and phylogenetic trees (Apply Level)
L.O.6. Understand basic tools used in proteomics (Understand Level)
L.O.7. Explain the structural analysis tools in genomics and proteomics. (Understand Level)

MODULE I

Introduction of Databases:-Concept of data, data models, data representation, mining, various types of databases, biological data and data analysis. Programming in PERL, PYTHON, Outline of Oracle, SQL, VB and Database management System (DBMS).

MODULE II

Biological Databases: Introduction to protein and nucleic acid databases; Sequence databases - Primary and secondary databases, composite databases, annotated databases, genomes and organism specific databases, protein databases, disease databases, small molecule databases, Toxicology Database.
NCBI, Entrez, file formats for sequence databases. Retrieval of biological data.

MODULE III

Sequence alignment and database search: Pair-wise sequence alignment, Multiple sequence alignment, Dot plots; Local and global alignment theory, Dynamic programming methods, FASTA and BLAST algorithms, database search using BLAST and FASTA; VAST, Similarity & distance, Similarity scores, Weight matrices, Heuristic method, Hidden Markov Models and their application in sequence analysis.

MODULE IV

Genomics and Proteomics:

Genomics: Phylogenetic analysis:-Evolution, elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, comparison of genetic sequence of organisms, phylogenetic analysis tools-Phylip, ClustalW.

Proteomics:-Protein sequence information, composition and properties, physicochemical properties based on sequence, sequence comparison, Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM250,BLOSUM62, ClustalW, Clustal Omega, BLASTp, Mascot

MODULE V

Structural Bioinformatics: Structural databases:- Protein Data bank (PDB), PIR, Nucleic Acid Data Bank (NDB),Molecular modeling Data Bank (MMDB).
Protein Structure Prediction:- D Primary structure analysis and prediction, Secondary structure analysis and prediction, motifs, profiles, patterns and fingerprints search.

SUGGESTED PRACTICAL LAB SESSION

1. **Biological Databases:**
   a) Retrieve the sequence of Human insulin gene from GenBank
   b) Retrieve the sequence of Human insulin from UniProt
2. Find the similarity between sequences using BLAST and FASTA
3. Align more than two sequences and find out the similarity between those sequences using CLUSTAL W
4. The phylogenetic relationships of nucleotide using MEGA

REFERENCES

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2. Gibas, C., & Jambeck, P. (2001). Developing bioinformatics computer skills. O'Reilly Media, Inc.
3. Moorhouse, M., & Barry, P. (2005). Bioinformatics biocomputing and Perl: an introduction to bioinformatics computing skills and practice. John Wiley & Sons.
4. Bergeron, B. P. (2003). Bioinformatics computing. Prentice Hall Professional.
5. WILLIAM R. PEARSON AND DAVID J. LIPMAN, (1988). Improved tools for biological sequence comparison. Proc. Natl. Acad. Sci. Vol. 85, pp. 2444-2448, April 1
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8. https://www.uniprot.org
9. https://www.ebi.ac.uk/Tools/msa/clustalo/
10. Sudhir Kumar, Koichiro Tamura, and Masatoshi Nei. 1993. MEGA: Molecular Evolutionary Genetics Analysis, version 1.01. The Pennsylvania State University, University Park, PA 16802.

20-303-0205 PROJECT PROPOSAL PREPARATION AND PRESENTATION (1C, 1L-0P-1T)

Course Description: The purpose of this course is to introduce the students to the scientific method and help students organize ideas, material and objectives for their dissertation. It is also intended to help students to begin the development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Understand and practice the scientific method and the source of scientific information (Comprehend Level)

L.O.2. Identify potential research area/problem for study by analysing gap in current knowledge by gathering and analysing scientific literature (Apply Level)

L.O.3. Critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis (Analyse Level)

L.O.4. Frame a hypothesis and device a research plan and methodology for testing the hypothesis/finding solution for the problem (Analyse Level)

L.O.5. Perform research design and planning after creating, analysing and critically evaluating different technical solutions (Analyse Level)

L.O.6. Write the Project Report containing all the technical details and budgeting requirements (Create Level)

L.O.7. Make a presentation and successfully defend it by communicating effectively (Create Level)

MODULE I

Scientific Methodology: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology

MODULE II

Source of Scientific Information: Journals (current and back volumes): Indexing journals, abstracting journals, research journals, review journals, e-journals; Impact factor; NCBI-Pub Med., Data Bank and Data Mining; INFLIBNET, INSDOC.

MODULE III

Process of Communication: Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences;

MODULE IV

Scientific communication: Presentation skills – formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

MODULE V

Scientific communication - Writing: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific

papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Project Proposal Preparation

Selection of research lab and research topic: Students should first select a lab (topic) wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Proposal Presentation

Oral Presentation: Students will have to present the their project proposal in front of the class and defend the research methodology, significance of the study, etc. and explain the anticipated results as well as answer the queries by the class members.

References

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2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. The Science of Scientific Writing. American Scientist, Gopen, G. D., & Smith, J. A., 1990, 550-558.
4. Speaking English Effectively, Mohan, K., & Singh, N. P., 2010, Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.
6. Research design, Qualitative, Quantitative and Mixed methods Approaches, John W. Creswell 2013, Sage publications Inc.
7. Debbie Holmes.2010. Research methods for the Biosciences: OUP Oxford
8. Research methods for the Biosciences, Gurumani N., 2011, MJP publishers
9. Research Methodology for Life sciences, Arumugam N., 2015, Saras Publications

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20-303-0206 CRITICAL ANALYSIS OF CLASSICAL PAPERS (1C, 0L-1P-1T)

Course Description: The objectives of this course are to familiarize students with classic literature to make them appreciate how groundbreaking discoveries were made without, necessarily, use of high-end technologies.

Students may be divided in groups of two and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. Each student will come to class after reading the paper and at the end of the semester each student will be asked to write a mini-review (3-4 pages long) on any one classical paper, other than the one he/she presented/discussed.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Appreciate the path-breaking work published in classical papers (Understand Level)

L.O.2. Apply data analysis tools and logical reasoning in the in-depth study and critical analysis of primary literature data (Apply Level)

L.O.3. Generate hypothesis from primary literature and anecdotal data (Analyze Level)

L.O.4. Ability to effectively summarize a compendium of research work or information (Create Level)

Sample Papers for Discussion

Molecular Biology

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from *Pneumococcus* type III.
Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58.
Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.

2. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56.
Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.

3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid
Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8
Note: In this one page paper Watson and Crick first described the structure of DNA double helix

4. Transposable mating type genes in *Saccharomyces cerevisiae*
James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483,1979
Note: This paper provided evidence for 'cassette hypothesis' of yeast mating type switches *i.e.* interconversion of mating types in yeast *(S. cerevisiae)* occurs by DNA rearrangement.

5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA.
Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82
Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"

6. *In vivo* alteration of telomere sequences and senescence caused by mutated
Tetrahymena telomerase RNAs
Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990
Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

Cell Biology

1. A protein-conducting channel in the endoplasmic reticulum
Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80
Note: This paper demonstrates the existence of a protein conducting channel

2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway
Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15
Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion

3. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum
Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45
Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC)

4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi
Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec; 39(2 Pt 1):405-16
Note: This paper describes setting up of an *in vitro* reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP *etc.*

5. A complete immunoglobulin gene is created by somatic recombination
Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14
Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.

6. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition

Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87
Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in *Drosophila* olfactory epithelium where a large family of odorat receptors is expressed.

7. Kinesin walks hand-over-hand
Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 **Note:** This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

Developmental Biology

1. Mutations affecting segment number and polarity in *Drosophila*
Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980
Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.

2. Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA
Anderson KV and Nusslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7
Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes

3. Hedgehog signalling in the mouse requires intraflagellar transport proteins
Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7
Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog ignaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it.

20-303-0207 CANCER BIOLOGY (3E, 3L-0P-1T)

Course Description: Cancer, defined by the uncontrolled cell division, is one of the major causes of deaths across the globe. The disease complexities in terms of its causes and types accentuates the requirement of increased understanding of the basic biology of cancer. The aim of this course is to provide an inclusive outline of the biology and pathology of cancer. The first part of the course would lay emphasis on the genetic and molecular basis of cancer by exploring the role of mutations, dysregulated signaling pathways and their implications in essential biological attributes like programmed cell death, cell proliferation and differentiation. The second part of the course is focus on clinical perspective where the student would familiarize with current diagnosis and treatment modules in the cancer clinic and learn about the advantages and disadvantages of advanced technologies. Critical reading and analysis of primary research papers pertaining to latest development in cancer biology will also be conducted.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain the role of deregulated cellular and molecular mechanisms in the development of cancer. (Understand Level)

L.O.2. Interpret genetic data and correlate gene mutations with the the development of cancer (Apply Level)

L.O.3. Formulate experimental setups to study the role of a particular gene in the development of cancer (Analyse Level)

L.O.4. Describe the various cancer diagnosis and prevention methods and the limitations of the present technologies (Understand Level)

L.O.5. Explain the most advanced modalities in cancer treatment (Understand Level)

L.O.6. Critically analyse research findings in cancer research publications (Analyse Level)

MODULE I

Introduction to cancer, its nature, types, etiology and incidence; Overview of the hallmarks of cancer; Mutations in cancer, Types of carcinogens; Stages of carcinogenesis; Oncogenes and tumor suppressor genes; Tumor viruses

MODULE II

Activation of oncogenes; Role/mechanisms of growth factors and receptors (with emphasis on tyrosine kinase receptors) in oncogenesis

Cytoplasmic signaling circuitry in cancer: Ras, Wnt and Jak-STAT signaling; negative and positive feedback control

Tumor suppressors: Rb and cell cycle control; p53 and regulation of apoptosis; Cancer syndromes; oncogene addiction

miRNAs and lncRNAs in cancer

MODULE III

Cellular senescence; cell immortalization and tumorigenesis; replication of telomere and telomerases; breakage-fusion-bridge cycle; structure of human telomerase holoenzyme; ALT mechanism

Multi-step tumorigenesis; Tumor promoting signals; Tumor stem cells

Genomic instability - Defects in DNA repair and their link to cancer; Driver and passenger mutations; Epigenetic changes in cancer

MODULE IV

Tumor Angiogenesis: Mechanism, Role of stromal and immune cells and tumor microenvironment, angiogenic switch, Hypoxia in cancer; Energy metabolism in cancer

Metastasis: Metastatic cascade and underlying mechanisms; EMT; CTCs and survival in circulation; Homing; Cancer dormancy

Tumor immunology: Tumor antigens; immune tolerance and immune evasion, immune editing

Tumor models for research: *in vitro* models – Trans-well, spheroids, hybrid, tumor microvessel models; *in vivo* tumor models – syngeneic and xenograft transplants, carcinogen induced, disease and target specific, transgenic, metastasis models

MODULE V

Cancer Diagnosis: Imaging methods - PET, MRI, CT, mammogram and others; Endoscopy methods; Biopsy and cytology tests; Biomarkers - genomic and proteomic tools; Staging of Cancer

Cancer Treatment: Surgery, Radio and chemo therapy; immunotherapies- check point inhibitors, T-cell transfer, Monoclonal Antibodies, immune-modulators, cancer vaccines; other targeted therapies; hormone therapy; stem cell transplant; precision medicine; Nano-medicines and nano-theranostic tools for cancer detection and therapy.

REFERENCES

1. Robert A Weinberg, The Biology of Cancer, 2nd Edition, Garland Publishing (Primary reference)
2. Lauren Pecorino Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, 4th Edition, 2016, Oxford University Press
3. Peter J Selby Margaret A Knowles, An Introduction To Cellular And Molecular Biology of Cancer by 4th Edition, 2005, Oxford University Press.
4. John E. Niederhuber, James O. Armitage, James H Doroshow, Michael B. Kastan, Joel E. Tepper, 6th Ed, Abeloff's Clinical Oncology, 2019, Elsevier.
5. Cancer Medicine, Waun Ki Hong, Robert Bast Jr, William Hait, Donald Kufe, Raphael Pollock, Ralph Weichselbaum, James Holland, Emil Frei, 2010, McGraw-Hill Education.
6. Eds: Sang Hyun Cho and Sunil Krishnan Cancer nanotechnology: principles and applications in radiation oncology, , 2013, CRC Press
7. Eds. Shannon Decker, Edward Sausville and Beverly A. Teicher, Tumor Models in Cancer Research 2nd edition, 2011, Humana Press

20-303-0208 PLANT BIOTECHNOLOGY (3E, 3L-1P-1T)

Course Description: This course will introduce the students to the exciting world of plant biotechnology. It will teach students the strategies to be employed in identifying the function of an unknown plant gene and how to isolate the gene and create transgenic plants. Various strategies such as Map based cloning and Marker assisted selection will be discussed in detail. It will help students to get a view of how plant biotechnology is applied to plant breeding. The various applications of biotechnology in crop improvement and production of value added products will be discussed using recent research papers. The students will get hands on practical training in plan tissue culture and genetic transformation also. Students are expected to study the literature and get well versed with the various strategies employed for crop improvement.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Perform plant tissue culture and to create new tissue culture protocols for their plant of interest (Create Level)

L.O.2. Device strategies for creating transgenic plants by identifying, cloning and expressing their gene of interest (Analyse Level)

L.O.3. Appreciate the latest developments in the field of plant biotechnology (Understand Level)

L.O.4. Formulate strategies for controlling gene expression in transgenic plants by selecting appropriate vector with promoter and regulatory elements (Analyse Level)

L.O.5. Explain the molecular mechanisms behind plant responses to biotic and abiotic stress (Understand Level)

L.O.6. Discuss the current scenario on production and regulation of GM crops in India (Understand Level)

MODULE I

Plant biotechnology-overview; uniqueness of plants; conventional methods of crop improvement- selection, mutation, polyploidy and clonal selection; inbred and commercial cultivars; Cisgenic and transgenic plants.

Plant Tissue Culture: Totipotency; organogenesis and somatic embryogenesis; plant growth regulators and cell culture media; Culture types- callus, cell suspension, anther, ovule, root, shoot tip and meristem cultures; Protoplast culture; Somaclonal variations.

Micropropagation of important food crops, medicinal and ornamental plants– methods and considerations; artificial seed.

MODULE II

Plant Genome analysis; Molecular Maps; Plant Functional genomics; Gene Isolation - gene tagging – Insertional mutagenesis (T-DNA, Transposon), subtractive cloning; Map based cloning, Chromosome walking and Chromosome jumping; QTL mapping.

Genetic Transfer to nucleus and plastids: vector systems, promoters, selection and reporter markers; different transfer methods – vector based (Agrobacterium mediated and virus mediated), direct methods (Biolistic, and others); Selection and regeneration of transformed plants.

Marker assisted selection/Genomic Selection, NIL, BSA, gene introgression and gene pyramiding,

MODULE III

Control of gene expression: Spatial-targeting specific tissue or organelles/temporal; transient versus stable expression; challenges in getting appropriate expression – gene silencing; removal of selection markers; control of Pollination – male sterility, Gene Use Restriction Technology (GURT).

Control of plant gene function: Mutagenesis, gene silencing and gene editing; Tools for analysis of gene expression; metabolic pathway engineering- use of systems biology- omics and synthetic biology

MODULE IV

Genetic Engineering strategies for crop improvement – nutrient quality (amino acid/protein, starch/sugar, oil content, vitamins), product quality (ripening, storage life, seedless, etc.) and herbicide resistance.

Biochemical and molecular basis of host plant resistance to biotic and abiotic stress. Strategies for developing crops resistant to insects, nematodes and pathogens (bacteria, fungi, and virus) attack. Biotechnological

approaches to developing crop plants resistant to abiotic stress (low or high temperature, deficient or excessive water, high salinity, heavy metals, and ultraviolet radiation).

Applications in improving ornamental plants and forest species.

MODULE V

Other Applications of plant biotechnology: Secondary metabolite production (alkaloids, drugs, hormones); Value added products - precursors for industrial products; Molecular Pharming-plantibody, edible vaccines; Carbon sequestration and biofuel production; Genetic engineering for enhancing – photosynthesis and nitrogen fixation; genetic diversity studies; gene editing for crop improvement

GM crops concerns – safety, horizontal gene transfer and transgene escape, ethical and legal issues; GMO – regulations in India and the world, current status and potential; risk analysis and management.

SUGGESTED LIST OF PRACTICALS

1. Making the stocks of cell culture media components and growth hormones
2. Perform ascetic culture - callus induction of Brassica
3. Study the effect of different explants on the callus induction
4. Induce rooting and shooting from callus culture
5. Study the effect of different growth hormones and their concentrations on callus induction, rooting and shooting
6. Perform axillary bud culture using coleus
7. Perform somatic embryogenesis using carrot cells
8. Perform gene transfer to Brassica leaf disks using Agroinfection
9. Assay for GUS activity in the transformed plant tissue

REFERENCES

1. Selected research papers to be given
2. Introduction to Plant Biotechnology, 3rd edition, Chawla H.S., 2009, Taylor and Francis.
3. Plant Biotechnology and Genetics: Principles, Techniques and Applications, C. Neal Stewart Jr., 2016, Wiley and Sons, New York
4. Plant Biotechnology - The Genetic Manipulation of Plants, 2nd edition, A. Slater, N. Scott and M. Fowler, 2008, Oxford University Press
5. Genetic Modification of Plants, Biotechnology in Agriculture and Forestry vol. 64 F Kempken, C Jung, 2010, Springer.
6. Principles of Plant Genetics and Breeding, George Acquaah, 2007, Blackwell Publishing, Malden, MA.
7. Plant Molecular Biology, 2nd edition, D. Grierson, S. N. Covey, , 2013 Chapman & Hall
8. Introduction to Plant Tissue Culture 3rd edition, Razdan, MK, 2016, Oxford University Press.
9. Agricultural Biotechnology, 3rd edition, Purohit, Kothari and Mathur, 2012, Agrobios.
10. Biochemistry and Physiology of Plant Hormones, 2nd edition, Thomas C. Moore, 2011, Narosa Publishing House
11. Plant biotechnology, S. Ignacimuthu, 1998, Oxford &IBH Pub.
12. Practices and New Experimental Protocols, in “Plant Tissue Culture” by B. N. Sathyanarayana, 2007, I.K International publishing House Pvt.
13. Plant cell culture, A Practical approach, 2nd Edition, Edited by R.A. Dixon and R.A. Gonzales, 1995, IRL Press.

20-303-0209 NANOBIOTECHNOLOGY (3E, 2L+1P+1T)

Course Description: The course will provide basic knowledge about the field of nanotechnology and its applications. The syllabus includes discussion about the different types of nanoparticles and techniques used to characterize them. The course will cover in detail about the different areas where nanotechnology is being applied in the medical field. Discussion will also include the translation of nano-based products and its challenges including nanotoxicology.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain the concept and advantages of using nanotechnology for medical/biotechnology applications (Understand Level)
L.O.2. Discuss about the types of nanoparticles being used for medical or biotech applications (Remember Level)

L.O.3. Explain the techniques used to characterize the nanoparticles (Understand Level)
L.O.4. Explain the different areas in biotechnology and medicine where nanotechnology can be applied (Understand Level)
L.O.5. Design a nanoparticle for a particle application. Eg: Targeted cancer cell drug delivery (Apply Level)
L.O.6. Analyze what are the different parameters that need to be considered for the development of a product for a particular biotech/medical application Eg: Development of a biosensor (Analyze Level)
L.O.7. Understand the current nanotechnology products in clinics/market and evaluate its advantages and limitations (Evaluate Level)
L.O.8. Design and synthesize a nanoparticle with a desired property/application. If possible design the nanoparticle so that it is better than an already marketed/translated product (Create Level)

MODULE I:
Introduction to Nanotechnology: Introduction to nano-size, Surface to volume ratio of nanoparticles, Nanoparticle fabrication: Top down and bottom up approaches, Introduction to Nanobiotechnology and nanomedicine.

MODULE II:
Characterization tools for nanoparticles: Electron microscopy – SEM, TEM/ Scanning probe microscopy - AFM, STM, Spectroscopic methods – Absorption and Emission Spectroscopy, Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, Raman spectroscopy, X ray crystallography, Electron diffraction pattern, Dynamic light scattering, Zeta potential analysis.

MODULE III:
Types of nanoparticles used for medical applications: Carbon based nanoparticles – Fullerenes & Carbon nanotubes, Quantum dots, Metallic and metal oxide nanoparticles, Polymeric and Protein nanostructures, DNA nanostructures, Dendrimers, Lipid based nanoparticles- Liposomes & solid lipid nanoparticles.

MODULE IV:
Medical nanotechnology: Nanoparticles for medical imaging; Nanoparticles for drug delivery – Targeted delivery, nanoparticles for crossing blood brain barrier; Nanotechnology for nerve regeneration; Nanotechnology in prosthesis; Nanotheranostics; Nano-biosensors; Nanoparticles in vaccines; Nanoparticles for gene delivery.

MODULE V:
Concerns and challenges: Nanotoxicology – Potential risks due to nanoparticles to human health, Techniques to asses toxicity, Translation of medical nanotechnology to clinical practice –Nanotechnology translated to clinical practice, Challenges in translation.

SUGGESTED LIST OF PRACTICALS

1. Synthesis of nanoparticles. (Any of the following: Silver nanoparticles, Iron oxide nanoparticle)
2. Measurement of size and surface charge of nanoparticle using DLS and zeta potential
3. Sample preparation for SEM
4. Synthesis of a nanoparticle with fluorescent property
5. Analysis of absorption spectrum of a nanoparticle solution

REFERENCES

1. Nanotechnology: Understanding Small Systems, Third Edition. Ben Rogers, Jesse Adams, Sumita Pennathur. 2017 by CRC Press
2. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Guozhang Cao Imperial College Press, 2004
3. Introduction to Nanoscience and Nanotechnology. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore. 2008 by CRC Press
4. Medical Nanotechnology and Nanomedicine Harry F. Tibbals. 2010 by CRC Press
5. Nanoparticles in Translational Science and Medicine, Volume 104, 1st Edition, 2011, Academic Press
6. Nanobiotechnology & Nanobiosciences, Claudio Nicolini, 2009, Pan Stanford Publishing, Ltd.

20-303-0210 **NEUROBIOLOGY** (3E, 2L+1P+1T)

Course Description: The course structure is aimed at providing in-depth knowledge of the molecular and cellular neurobiology by giving emphasis on human neurobiology. Course introduction focuses on neuroanatomy, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. During the later

stages of this course students get a chance to learn regarding more integrated functions of the nervous system like sensory processing and the programming of motor functions. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. The course also focuses on the neuroscience of brain diseases and also describes the current methods in neuroscience research.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Demonstrate a solid understanding of basic neuroanatomy and nervous system function on a molecular, cellular and systems level. (Understand Level)
L.O.2. Describe the structure and function of various cell types in the nervous system (Understand Level)
L.O.3. Describe how neurons are connected and it communicates in neuronal circuits that control our behaviour (Analyse Level)
L.O.4. Describe some of the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory. (Analyse Level)
L.O.5. Describe neurological disorders such as Alzheimer's disease, Parkinson's Disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke (Analyse Level)
L.O.6. Give an account for the current neurobiological techniques, such as brain histology, optogenetics, electrophysiology, CLARITY, behavioural analyses and transgenics. (Analyse Level)
L.O.7. Analyse a given theoretical problem/case, identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution. (Apply Level)

MODULE I
Organization of the nervous system: Organization of nervous system; CNS, PNS, Neuroanatomy, Meninges, Cerebrospinal fluid, Blood Brain Barrier, Neuron structure and classification, Glial cells: Structure and function of glial cells, Glial – Neuronal interplay, Neurotrophic factors, Neurogenesis; Birth and migration of neurons, Neural stem cells, Brain changes across the lifespan.

MODULE II
Propagation of nerve impulses and molecular mechanisms of neurotransmission: Biological and electrical proporties of neurons, Ionic Basis of the Resting Membrane Potential, Ionic Basis of the Action Potential, Molecular Mechanisms of Action Potential Generation, Propagation of Action Potentials, Synaptic Transmission, Neurotransmitters; chemistry, synthesis, storage, release and uptake, Ionotropic Neurotransmitters Receptors, Metabotropic Neurotransmitters Receptors and Postsynaptic Mechanisms, Synaptic Integration, Long-Term Potentiation and Depression, Spike-Timing Dependent synaptic Plasticity, Hebb's Postulate

MODULE III
Neural Control Systems: Sensory Systems; The Visual System, Audition, Vestibular Sensation and Chemical Senses, Movement and Motor Control, Neural control of; Immune, Cardiovascular, Endocrine and Enteric nervous systems

MODULE IV
Complex Brain Functions and Brain Disorders: Circadian Rhythms, Sleep; Brain Waves and Sleep Stages, Neurobiology of Emotion, Reward and Addiction, Learning and Memory; Cognitive development, Visual Recognition, Language, Short-term, long-term and Working Memory
Neurodegenerative disorders; Alzheimer's, Parkinson's, Huntington's and Prion Diseases Amyotrophic Lateral Sclerosis, Epilepsy, Psychotic disorders, Schizophrenia, Bipolar disorder

MODULE V
Neurobiology Techniques: Neuronal cell culture, Animal behavior analysis in Neuroscience, Electrophysiology Whole Brain Imaging; fluorescence, functional magnetic resonance imaging (fMRI), positron emission tomography (PET), Electrochemical techniques; exocytosis measurements, fast-scan cyclic voltammetry, Calcium imaging, Optogenetics, CLARITY

SUGGESTED LIST OF PRACTICAL LAB

Lab demonstration:
1. Culturing and Passaging of neuronal cell line
2. Culturing and Passaging of primary cells isolated from mice/rat brain
3. Isolation and culturing of neural stem cells from mice/rat brain
4. FACS sorting of stem cells

Practical:

1. Mice/Rat brain perfusion
2. Brain fixation
3. Tissue processing
4. Tissue Sectioning using cryostat
5. Atlas-based identification of brain regions
6. Immunohistochemistry of the brain sections

REFERENCES

1. Principles of Neural Science (5th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2012
2. Neuroscience (6th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2017
3. Neuroscience: Exploring the brain (4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2015
4. Basic Neurochemistry. Molecular, Cellular and Medical aspects (8th Edition) by George J. Siegel, Bernard W.Agra noff, R. Wayne Albers, Stephen K. Fisher& Michael D. Uhler.; 2011
5. From Neuron to Brain (5th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2012
6. Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994
7. Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991
8. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015
9. Molecular Neuroscience: A Laboratory Manual by Rusty Lansford; Cold Spring Harbor Laboratory Press; 2014
10. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014

SEMESTER III

20-303-0301 RECOMBINANT DNA TECHNOLOGY (4C, 3L + 1P + 1T)

Course Description: This is an advanced course dealing with the tools and techniques involved in manipulating DNA. The various modules elaborate the different enzymes, the types of vectors used, the expression systems, the heterologous host systems used as well as the various cloning strategies and the processes involved therein. In addition techniques such as PCR, blotting, site directed mutagenesis, gene transfer and various screening strategies are also included.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Elaborate the different enzymes, vectors, as well as cloning strategies (Comprehension Level)
L.O.2. Apply the different enzymes used in rDNA technology (Apply Level)
L.O.3. Use different types of vectors for cloning (Apply Level)
L.O.4. Produce a genomic DNA library and screening for recombinants (Create Level)
L.O.5. Construct a probe and do blotting techniques (Create Level)
L.O.6. Apply site directed mutagenesis technique (Create Level)
L.O.7. Employ different types of PCR techniques for gene amplification and clone the amplicon (Apply Level)
L.O.8. Demonstrate heterologous gene expression (Apply Level)
L.O.9. Compare various genome editing tools (Analyze Level)

MODULE I

Enzymes in rDNA technology: Restriction–modification systems, Deoxyribo nucleases: exonucleases and endonucleases, Restriction enzymes-type-I, II, and III. S1 Nucleases, DNA Ligases, Alkaline phosphatase, DNA polymerase.

MODULE II

Cloning strategies: Shot gun cloning, amplicon cloning, cDNA cloning and its advantages and disadvantages.

Construction of genomic DNA and cDNA libraries: Cloning Vectors -plasmids, lambda phage, SV40, Phagemids; Construction of artificial chromosome vectors-BAC & YAC; Expression systems and their applications.

MODULE III

Recombinant DNA-tailing, cohesive ends: Use of linkers, blunt end methods; *In vitro* packaging, Host vector systems; Probe construction; recombinant selection and screening; Southern hybridization, Colony hybridization, Plaque hybridization.

MODULE IV

Applications: PCR: RT-PCR, Inverse PCR, Nested PCR, LAMP; Molecular Markers - RAPD, RFLP, DNA finger printing, microsatellites and mini satellites, SNPs, ESTs, Barcoding;

Site directed mutagenesis;

Gene transfer in animals and plants: direct gene transfer and molecular chimeras Microinjection, electroporation, biolistics, direct gene transfer using PEG, calcium chloride, calcium phosphate; Vector mediated gene transfer-Agrobacterium mediated transfer.

MODULE V

Heterologous protein expression in prokaryote and Eukaryotes- Expression in *E. coli*, yeasts and mammalian cells; Advantages and disadvantages of the various expression systems; cloning of genes into vectors; production and subsequent characterization of the recombinant protein.

Genome editing strategies: CRISPR-Cas, TALENS, ZFNs, engineered nucleases, meganucleases; MAGE; Applications

SUGGESTED PRACTICAL LAB SESSION

1. Isolation of genomic DNA (Bacteria, bacteriophage, plant and rat liver) and Isolation of metagenomic DNA
2. Isolation of plasmid DNA from transformed *E.coli*
3. Restriction digestion and analysis of DNA
4. Isolation of total RNA and cDNA library construction(Demo)
5. Preparation of competent cells and Transformation in *E.coli*
6. Construction of genomic DNA library
7. PCR Techniques – BOX, ERIC, Nested
8. Real time PCR (demonstration)
9. LAMP (demonstration)
10. DNA sequencing (demo by industrial visit)

References:

1. Winnaker, E.L. (2003). *From Genes to Clones*. India. VCH Panima Educational Book Agency.
2. Karcher, S.J. (1995). *Molecular Biology-A Project Approach* (1st ed.). Academic Press.
3. Primrose, S.B. (2006). *Principles of Gene manipulation and Genomics* (7th ed.). Blackwell Scientific Publications.
4. Lodish, H., Berk, A, *et al*. (2016). *Molecular Cell Biology* (8th ed.). W.H. Freeman.
5. Watson, J.D. (2007). *Molecular Biology of the Gene* (6th ed.). Pearson.
6. Lewin, B., Goldstein, E.S., *et al.* (2014). *Genes–XI*. Jones and Bartlett Publishers.
7. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular cloning: a laboratory manual (No. Ed. 2). Cold spring harbor laboratory press.
8. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (1987). Current protocols in molecular biology New York. NY: Wiley.
9. Freshney, R. I. Culture of animal cells, a manual of basic technique.
10. Kumar, A., Garg, S., Garg N. (2012). Biochemical Test, Principles and Protocols. India: Viva books.
11. Sawhney, S. K., & Singh, R. (Eds.). (2000). Introductory practical biochemistry. Alpha Science Int'l Ltd.
12. Gradwohl, R. B. H., Sonnenwirth, A. C., & Jarett, L. (1980). Gradwohl's clinical laboratory methods and diagnosis. Mosby.

20-303-0302 IMMUNOLOGY AND IMMUNOTECHNOLOGY (4C, 3L + 1P + 1T)

Course Description: This course is intended to provide a solid grounding in immunology, starting with the basic concepts and proceeding to a deeper understanding of the mechanisms of immune functioning. Special emphasis is given to the 'team-work' in immune responses. The course also underscores how the system can go wrong, and how it can be corrected or managed using innovative technology. The recent enhanced appreciation of the preeminence of the innate immune system, the importance of the intestinal immune system, and the immunomodulatory potential of the gut microbiota are also highlighted. The course also points out the tremendous scope for basic and applied immunological research.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Define/recognize the fundamental organization and associations of the immune system. (Understand Level)
L.O.2. Explain/describe/discuss how the immune system functions in a 'team-work' fashion, and how it is regulated. (Understand Level)
L.O.3. Explain/describe/discuss how the immune system can go wrong, and what types of immuno-pathologies result. (Understand Level)
L.O.4. Apply appropriate strategies, techniques, and technologies in the management of immune system disorders. (Apply Level)
L.O.5. Analyze the intricate regulatory mechanisms of the immune system in specific clinical conditions such as hypersensitivities, immunodeficiencies, and autoimmune diseases. (Analyze Level)
L.O.6. Assess the feasibility of adopting or adapting technologies from other disciplines in the correction and/or management of deranged immune systems. (Evaluate Level)

MODULE I
Introduction to the Immune System: Historical landmarks, branches, broad divisions of immune system, antigens vs. immunogens, haptens and carriers, epitopes and paratopes. Hematopoiesis, Theories on immune system functioning; Cells and molecules of the immune system, Inflammation: cellular and molecular events, acute and chronic inflammation, contribution to hypersensitivity and autoimmune reactions; Overview of comparative immunology; Overview of psycho-neuro-endocrino-immunology (PNEI); Overview of the circadian – immune connection; Overview of ecoimmunology.

MODULE II
Humoral and Cell-mediated immune responses: Structure and functions of primary and secondary lymphoid organs; Development, maturation, and functions of T- and B lymphocytes, molecular markers of T- and B-lymphocytes; structure and functions of antibodies, monoclonal vs. polyclonal antibodies, primary and secondary immune responses, clonal selection and clonal expansion, effector cells of the immune system and their specific roles; Generation of receptor diversity (BCR and TCR), subsets of T- and B- cells; Complement: the 3 pathways, regulatory molecules, disorders of the complement system.

MODULE III
Strategies of immune functioning: MHC/HLA: its structure, functions, and role in antigen presentation, disorders of antigen processing and presentation, relative risk associated with specific MHC haplotypes; Lymphocyte trafficking and interaction at the germinal centers, role of HEV in lymphocyte trafficking; Immune responses against bacteria, fungi, parasites, viruses, and prions; Immune evasion strategies of pathogens.

MODULE IV
Clinical immunology: Immunodeficiencies; Hypersensitivity reactions; Autoimmune diseases; Transplantation immunology; Tumor immunology

MODULE V
Immunoprophylaxis and Immunotechnology: Nanotechnology and its applications in immunology; Hybridoma technology and its applications in medicine; Vaccines: their development, and applications in medicine; Immune

manipulation of the intestinal immune system, and the gut microbiota Consolidated immunotherapeutic strategies with respect to hypersensitivity, autoimmunity, transplantation, immunodeficiencies, and tumor immunology.

SUGGESTED LIST OF PRACTICALS

1. Differential white cell count **(M.1)**
2. Haemagglutination (Direct and Indirect) **(M.1)**
3. Immunodiffusion (Ouchterlony, Mancinii) **(M.2)**
4. Complement fixation test**(M.2)**
5. Coombs' test **(M.2)**
6. Basic immunoelectrophoresis **(M.2)**
7. Rocket immunoelectrophoresis **(M.2)**
8. Western blotting **(M.4)**
9. ELISA **(M.4)**
10. HLA typing (immunological and PCR-based)**(M.4)**

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20-303-0303 BIOPHARMACEUTICALS (3C, 2L+1P+1T)

Course Description: This course introduces the basic principles of drug action and the principles of pharmacodynamics and pharmacokinetics. Techniques for drug development: Drug design, targeting & delivery; Drug discovery and development: Lead development, Preclinical and clinical studies, Pharmaceuticals derived from plants, microorganisms, fungi and marine organisms; Production of recombinant products and Good manufacturing practices (GMP) are the other topics covered.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Discuss the basic principles of drug action and the principles of pharmacodynamics and pharmacokinetics. (Understand Level)
L.O.2. Explain the application of various techniques for drug development: Drug design, targeting & delivery (Understand Level)
L.O.3. Devise strategies for drug discovery and development and to evaluate drugs derived from different sources. (Apply Level)
L.O.4. Describe the production of recombinant biopharmaceutical products such as hormones, thrombolytic agents, antiviral agents and recombinant vaccines. (Understand Level)
L.O.5. Explain Good manufacturing practices (GMP) and design standard operating procedures (SOPs) for the production of biopharmaceuticals. (Understand Level)

MODULE I

Basic principles of drug action: Drug receptor interactions, Basis of dose-response curves - reversible irreversible antagonist, partial agonists, Stimulation of second messenger systems and pharmacology of ion channels, Principles governing pharmacokinetics and pharmacodynamics ; Pharmacogenetics.

MODULE II

Techniques for drug development: Drug design, targeting & delivery, Techniques for measuring receptor binding and its uses in new drug development, Techniques used in assay of drugs, Determination of molecular structures, and the quantification of drugs in the body, Application of nano materials in targeted drug delivery, molecular medicine

MODULE III

Pharmacognosy: Importance of natural drug substance, Drugs from natural plant products, Pharmaceuticals derived from microorganisms, fungi, marine organisms: antibiotics, antivirals, anticancer, antiallergic and antitumor compounds, production methods.

Phases of Drug Development: drug discovery, preclinical studies; Clinical studies; review by regulatory authority and post market drug safety monitoring.

MODULE IV

Production of recombinant products: Insulin, human growth hormone, erythropoietin, interferon, recombinant vaccines, Food vaccines, Pharming, Monoclonal antibody based therapeutic agents.

MODULE V

Good manufacturing practices (GMP) for the production of recombinant biopharmaceutical products and the establishment of standard operating procedures (SOPs) for a production process, certification of pharmaceutical products

SUGGESTED LIST OF PRACTICALS:

1. Feeding and handling of laboratory animals.
2. Routes of administration of drugs in laboratory animals.
3. Collection of blood from laboratory animals.
4. Sacrifice of animals and collection of tissues.
5. Anti-inflammatory activity studies using paw edema model.
6. Antibacterial activity assay by disc diffusion.
7. *In vitro* antioxidant activity assays.
8. Preparation of Chitosan nanoparticles for drug delivery.
9. Quantification of drugs using hyphenated techniques.
10. Extraction, separation and quantification of alkaloids, flavanoids and terpenoids from plant *sources.*

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20-303-0304 FUNCTIONAL GENOMICS (2E) (1L+ 1P+1T)

Course description. In this course, we use the genomics approach to understand the proteome, predict protein structure from DNA sequence data, understand protein-protein interactions, and the use of different tools for the analysis of genomic data sets. In addition, this course also includes the methods for gene annotation to gene prediction.

Learning outcomes of the course: After completing the course the student will be able to
L.O.1. Understand Protein sequencing, Nucleic acid sequencing and their analysis. (Understand)
L.O.2. Analyze Gene expression, and establish genomic library. (Analyze)
L.O.3. Design primer for a specific marker gene (Create)
L.O.4. Describe proteins interaction, activity, modification and function. (Understand)
L.O.5. Apply Protein modelling and molecular dynamics methods to study structure from sequence (Apply)
L.O.6. Discuss the Design drugs from data of functional genomics and proteomics (Understand)
L.O.7. Analyze the metagenomics data of soil microbiome for resistome, diversity and function (Analyze level)
L.O.8. Analyze the transcriptomics data of soil for expression of resistance components (Analyze level)

MODULE I
Visualization and protein structure prediction: Protein structure prediction for known folds and unknown folds (secondary structure prediction, prediction of transmembrane regions, homology modeling); Online modeling servers (e.g.-SWISSMOD), Molecular visualization software-kinemages and chemscape, Chime molecular visualization, Rasmol, pymol, Discovery Studio.

MODULE II
Structural proteomics: Methods of sequence based protein prediction. Definition of protein families - protein families and classification, SCOP and CATH, patterns, profiles, sequence vs family comparison. Homology modeling, prediction of protein structure from sequences, functional sites, FSSP, 3Dee

MODULE III
Protein folding: Protein folding problem, protein folding classes, protein identification and characterization:- AACompIdent, TagIdent, PepIdent and MultiIdent, PROSEARCH, PepSea, PepMAPPER, FindPept, Predicting transmembrane helices.

MODULE IV
Tools and methods in genomics: Stand-alone packages for sequence alignment- Bioedit, MEGA, Submitting DNA sequence in genbank - bankIt, Sequin, tbl2asn, Primer designing, Tools for primer designing.
Gene ontology and annotation; Prediction of genes and protein coding regions, Conserved sequence pattern discovery; Tools for gene prediction; Whole genome analysis; Gene mapping; Genome sequencing strategies, Next Generation Sequencing platforms, analysis, Metagenomics - MGRAST.

MODULE V
Drug designing: Introduction, Structure-based drug designing approaches: Target Identification and Validation, receptor mapping, active site analysis and pharmacophore mapping, Grid maps. Introduction to docking methods to generate new structure; Tools and Molecular docking programs: AutoDock, Dock, HEX, Cheminformatics.

SUGGESTED LIST OF PRACTICALS

1. Find the secondary and tertiary structure of the given protein sequence. (L
2. Design primer for mitochondrial COX1 gene (L.O.3)
3. Analyze the metagenomics data of soil microbiome for resistome, diversity and function (L.O.7)
4. Analyze the transcriptomics data of soil for expression of resistance components (L.O.8)
5. Design drugs for a given cancer marker as receptor (L.O.6)
6. Docking of the given ligand on receptor and find the interactions (L.O.6)

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20-303-0305 INDUSTRIAL & ENVIRONMENTAL BIOTECHNOLOGY (APPLICATIONS OF BIOTECHNOLOGY - I) (4E, 3L+1P+1T)

Course Description: This course gives an overview of the various biotechnology based industries and the biotechnologically produced product. The course also discusses briefly the production process of various products like cheese, enzymes, antibiotics, vaccines, amino acids, citric acid, biogas, hydrogen production etc. The student will also get an insight to Microbial interactions; microbes in biodegradation of organic compounds, microbes in waste management including Liquid waste and Solid waste, Bioremediation of environmental pollutants and microbes and mineral recovery.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain large scale production of fermented food products (Understand Level)
L.O.2. Perform spawn preparation and mushroom cultivation in a small scale (Apply)
L.O.3. Analyse bread making, milk and milk product processing
L.O.4. Discuss the application of Microbes in production of antibiotics, vitamins, and vaccines (Understand Level)
L.O.5. Explain Microbial production of polysaccharides, alcohol, amino acids, enzymes, etc (Understand Level)
L.O.6. Produce Biopesticides and biofertilizers (Pseudomonas) in small scale (Apply)
L.O.7. Discuss Biogas, biodiesel and fuel cells/hydrogen production (Understand Level)
L.O.8. Explain strategies of bioremediation (Understand Level)

MODULE I

Industrial Food products: Industrial production of Cheese, bread, mushroom, wine, vinegar, Probiotics, Prebiotics, Neutraceuticals

Industrial Pharmaceuticals: Penicillin, Streptomycin, Cephalosporin. Microbial production of vaccines - bacterial and viral; Toxoid production. Microbial production of vitamins-B12 , riboflavin, and gibberellins, Fermented Ayurvedic medicines.

MODULE II

Microbial polysaccharides: Xanthan gum, chitin, chitosan, Microbial production of industrial chemicals - alcohol, lactic acid, citric acid, Microbial production of amino acids- Glutamic acid, L- lysine

Microbial production of enzymes: Proteases, amylases, invertase, pectinases, Enzyme immobilization and their applications in food and other industries

MODULE III

Processes and Applications: Biopesticides - Bacillus thuringiensis, Trichoderma, Baculoviruses; Biofertilizers - Rhizobium, Azolla, Acetobacter, Anabaena, Mycorrhizae, Phosphate solubilizing bacteria

Biofuels : Biogas production, methane, bioethanol, biodiesel / Fuel cells - hydrogen production

MODULE IV

Strategies of microbial degradation and bioremediation; Environmental effects on microbial degradation of polysaccharides and organic compounds - microbial degradation of cellulose, lignocellulose, paper, textiles, leather, rubber, emerging contaminants and xenobiotics, Kinetics of biodegradation; Bioremediation of organic and inorganic pollutants; Remediation Technologies

MODULE V

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper).
Solid waste management: composting, anaerobic digestion& bio methanation
Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides.
Microbes and mineral recovery: Bioleaching of copper, gold and uranium.

SUGGESTED PRACTICAL LAB SESSION

1. Prepare spawn of Pleurotus sp
2. Cultivate oyster mushroom for household use
3. Industrial visit to Milma and Modern bread
4. Production of Pseudomonas biofertilizer in talc powder
5. Visit waste management plants

REFERENCES

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20-303-0306 ANIMAL BIOTECHNOLOGY AND MEDICAL BIOTECHNOLOGY (APPLICATIONS OF BIOTECHNOLOGY-II) (4E, 3L + 1P + 1T)

Course Description: This is an elective course on Animal and Medical biotechnology. The former part of this course will introduce the basic concept /principles involved in animal cell and tissue culture, the requirements of media, growth characteristics in culture and cell-cell communication. The latter half of the course elaborates the human genome project, molecular basis of human diseases and the molecular diagnosis of genetic diseases. The course also gives an insight to diagnostic techniques and pharmacogenomics as well as personalized medicine.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Explain the basic principles and terminologies involved in animal cell and tissue culture. (Understand Level)
L.O.2. Seed and maintain animal cells culture (Apply Level)
L.O.3. Design cell culture experiments (Apply Level)
L.O.4. Troubleshoot problems related to the 2D cell attachment, growth and proliferation (Analyse Level)
L.O.5. Solve issues related to in vitro contaminations (Apply Level)
L.O.6. Explain the techniques involved in Genetic Engineering of animals ((Understand Level)
L.O.7. Design small animal experiments used commonly in research (Apply Level)
L.O.8. Discuss the impact of human genome project on medical practice ((Understand Level)
L.O.9. Devise molecular diagnostic techniques for confirming the disease (Apply Level)
L.O.10. Explain genetic screening for single gene diseases its therapeutics and gene therapy (Understand Level)
L.O.11. Discuss the use of DNA probes for diagnosis in epidemiology and forensic science (Understand Level)
L.O.12. Explain the use of Pharmacogenomics in personalized medicine (Understand Level)

MODULE I

Animal cell culture- Principles involved and Characteristics of cells in Culture

History related to development in animal cell cultureLaboratory design and practices, Sterilization techniques, Identification and Characterization of contaminations and use of antibiotics for its control (bacterial, viral and mycoplasma). Cell Culture media- synthetic media and serum, conditioning of media, Cell counting and viability assay-MTT, LDH and Alamar assay. Cryopreservation of animal cells, Explant isolation and culture, Growth phases of cell in culture, Cell to cell interactions, contact inhibition, anchorage dependency, cell-cell communication, cell senescence.

MODULE II

Animal tissue culture-Technique and Applications

Primary and secondary cell culture, Cell Differentiation, Techniques in cloning of cells. 3D cell culture, Organ culture, Artificial skin, blood and tissues, Hybridoma technology, Production of bioactive compounds and growth hormones, Propagation of viruses, Tissue culture vaccines, Assisted Reproductive Technology (ART) and In vitro fertilization.

MODULE III

Use of animals as experimental model and Genetic Engineering of animals

Techniques and vectors used for genetic engineering; Small Animals used in research- Rat, mice, rabbit, zebra fish. Knockout animals and disease models, Application of Transgenic animals for biopharming, xeno-transplantation, gene therapy, developing hypoallergenic pets and glo fish, Super pig and transgenic salmon as food and RIDL mosquitoes for vector control.

MODULE IV:

Introduction to molecular medicine and medical biotechnology

Current scenario and future prospects, Impact of discovery of DNA on medical practice; Human Genome Project; Gene hunting, Molecular basis of human diseases (hereditary, infectious, chronic and auto immune diseases, epigenetics)

MODULE V

Molecular technology and diagnostics

Molecular diagnosis of genetic diseases - genetic screening for single gene diseases, Complex pre-disposition symptoms using molecular technologies i.e. genetic markers, PCR based diagnostics, Array-based diagnostics and Nucleotide polymorphisms; Genetic testing in Forensic Science - MLP and SLP Technology; Mitochondrial DNA, Y Chromosome analysis, DNA probes for diagnosis in epidemiology and forensic science; Pharmacogenomics and personalized medicine.

Genetic diseases and treatment -Spinal Muscular Atrophy (SMA),; Huntington's disease, etc; antisense oligonucleotides therapies

PRACTICAL LAB SESSIONS

1. Demonstrate the skill to maintain cell lines in culture with and without antibiotics.
2. Maintenance and Handling of Small Animals based on CPCSEA guidelines
3. Forensic Case study and presentation of crime solved using molecular technology and diagnostics.

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26. Edited: Murray Moo-Young, University of Waterloo, Canada Section 5: Medical Biotechnology and Healthcare 17th July 2019; Comprehensive Biotechnology - ScienceDirect.html, Elsevier **Book ISBN:** 9780444640468
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20-303-0307 STEM CELL BIOLOGY AND REGENERATIVE MEDICINE (2E, 1L + 1P +1T)

Course Description: Stem cell research and regenerative medicine is one of the fastest growing areas of biomedical research worldwide. Stem cells are specialised cells which are undifferentiated and capable of self-renewal and have the potential to develop into differentiated cell types. Stem cells act as organisms reserve cells that replaces specialised cells that are damages or lost during the development. During this course we explore several aspects of stem cell biology like the microenvironments or the niches that are required to maintain stem cells, asymmetric cell division, the genes required for stem cell fate, and the use of stem cells for medical/therapeutic applications. In addition, students will also get an insight into stem cell transplantation and tissue engineering in regenerative medicine and the ethical issues involved in this field of research.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Describe different types of stem cells and their specific characteristics and how they differ from fully differentiated cells. (Understand Level)
L.O.2. Gain knowledge of the intrinsic and extrinsic factors important for stem cell renewal and differentiation. (Analyze Level)

L.O.3. Evaluate the validity of applications of stem cells for regenerative medicine and the possible problems that need to be overcome. (Analyze Level)
L.O.4. Apply techniques based on the use of Embryonic/Fetal, Induced pluripotent and Adult stem cells for regenerative medicine applications to human diseases. (Apply Level)
L.O.5. Evaluate the ethical issues associated with Embryonic/Fetal, Induced pluripotent, Adult stem cells and stem cell therapy with a global bioethics perspective. (Analyze Level)
L.O.6. Analyse a given theoretical problem/case study, identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution. (Apply Level)

MODULE I
Origin of stem cells: Origin of stem cells in organogenesis, Properties of Stem cells, Cell fate determination, Cell potency, Embryonic stem cells, Adult/Tissue-specific stem cells, Induced pluripotent stem cells (iPSCs), Cord blood stem cells and amniotic fluid stem cells, Developmental plasticity, Dedifferentiation, Transdifferentiation, Somatic Cells by Nuclear Transfer

MODULE II
Tissue-specific/Adult stem cells: Hematopoietic Stem Cells, Mesenchymal Stem Cells, Neural Stem Cells, Epithelial Stem Cells, Skin Stem Cells, Cardiac stem cells, Stem Cells in the Pancreas and Liver, Other tissue specific stem cells, Cancer stem cells
MODULE III
Regulation of Stem Cell Fate and Function: Stem cell niche, Morphogens and growth factors, Control of gene expression, Epigenetic regulation, Positional identity and polarity in regeneration, Cellular differentiation and environmental insults/Stress, Morphallaxis, Epimorphosis

MODULE IV
Tissue Engineering and Regenerative Medicine: Three-dimensional cell culture, Organ culture, Organotypic culture, Animal models of stem cell research, Preclinical study design, Engineered scaffolds and matrices, Bioprinting of organs and tissues, Assessing potential stem cell risks and complications, Stem cell therapeutic efficacy and stability, Tumorigenicity

MODULE V
Stem cells from the laboratory to the clinic: Modes of cell and tissue delivery, Biobanking of stem cells, *In vivo* regeneration of tissues by cell transplantation, Immunoisolation techniques, Regulatory perspectives, good laboratory/manufacturing practice (GLP/GMP), Ethical considerations in regenerative medicine, Studies of patients treated with stem cells.

SUGGESTED LIST OF PRACTICAL LAB
Lab demonstration:

1. Culturing and Passaging of stem cells from rat blood
2. Culturing and Passaging of stem cells from rat bone marrow
3. FACS sorting of stem cells
4. Culturing of stem cells on 3D scaffolds
5. Stem cell analysis using microscopy techniques

Practicals:

1. Neural stem cell isolation from mice brain
2. Passaging and maintaining neural stem cell cultures
3. Analysis of neurospheres
4. Characterisation of stem cells using various markers

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8. Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies; (1st Edition) Alain A. Vertes, Nasib Qureshi, Arnold I. Caplan, Lee E. Babiss; Wiley-Blackwell; 2015
9. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
10. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1). Academic Press; 2013

SEMESTER IV

20-303-0401 INNOVATION AND ENTREPRENEURSHIP FOR BIOLOGISTS (4E, 2L-2P-0T)

Course Description: The objective of this course is to expose the students to the field of innovation and entrepreneurship with a specific focus on life science. Student will also be familiarized with the process of developing a life science enterprise. In this course you will learn the tools and trades of becoming an entrepreneur. Course will teach you the various aspects of entrepreneurship; from the fundamentals of selecting an idea and developing a product or process; Preparing a business plan to Identifying and securing investors; setting up a company to meeting the regulatory requirements. Student teams will perform various activities of entrepreneurship: from identifying a market need after market survey and coming up with a solution to making a business plan and pitching to investors.

This course is conducted jointly by Department of Biotechnology and School of Management Studies at CUSAT and outside resource persons experienced in life science entrepreneurships and soft-skill training who will be invited for discussion/workshops. This course will be conducted in workshop mode. Case studies will be included with active participation. The practical component will include case studies, discussions, brainstorming, presentations, etc.

Learning Outcomes (LO) of the course: After completing the course the student will be able to:

L.O.1. Describe the various programmes and opportunities for entrepreneurship in life science in India (Understand)
L.O.2. Apply innovation tools such as ideation and design thinking for generating innovative ideas (Apply)
L.O.3. Analyse real time data to explore and establish relationships in the areas of entrepreneurship decisions (Analyse)
L.O.4. Identify potential funding sources and how to sell the idea for successful funding (Apply)
L.O.5. Evaluate various business ideas in the field of life science and select the most appropriate one on the basis of opportunity identification, opportunity evaluation and feasibility studies (Evaluate)
L.O.6. Generate new bio-entrepreneurship ideas and create business plans and proposals for starting business or business expansion/diversification. (Create)

MODULE I

Innovation and entrepreneurship: Invention-innovation differences; Types of innovation; creativity; innovation ecosystem; challenges of innovation management; steps in innovation management; technology and innovation-new business models. State and scope of life science innovations and entrepreneurship in India and the world; unique opportunities and challenges of Bio-entrepreneurship.

MODULE II

Entrepreneurship: Definition, traits, characteristics, qualities and functions of entrepreneurs; Entrepreneurial Behaviors and entrepreneurial motivation; Entrepreneurship Theories; Entrepreneurship types: Social entrepreneurship and Technology entrepreneurship, Family business; Startup landscape and innovation hubs; Innovation in Indian context.

MODULE III

Entrepreneurship: Role in economic development. Entrepreneurial climate in India; Ease of doing business, Government support for entrepreneurship, Start-up India Programme, Pradhan Mantri Mudra Yojana, Assistances for Biotech enterprises, BIRAC/BIG, Business Incubation and other schemes. MSME Policy: various schemes and support.

MODULE IV

Idea generation: Design thinking, customer journey mapping, Idea evaluation; lean startup; Business plan: elements-technical-marketing-financial, preparation of Business plans.

Sources of Finance: Venture capital, angel investment, crowd funding. Mechanics of setting of new enterprises – forms of business organization.

MODULE V

Protection of Intellectual Property Rights, Patent, Trademark and Copyrights. Managerial problems of new enterprises; production purchasing, financing labor and marketing problems.

PRACTICALS

Case studies, Discussion, Brainstorming, Presentations, etc.

REFERENCES

1. Innovation and Entrepreneurship, Drucker, Peter, 1985, Heinemann, London.
2. Patterns of Entrepreneurship Management, Kaplan, J.M and Warren A.C., John, 2013, Wiley & Sons Inc.
3. Entrepreneurship Development and Small Business Enterprises, Charantimath Poornima M, 2018, Pearson.
4. The Lean Start Up, Ries, Eric, 2011, Crown Publishing, USA.
5. Entrepreneurial Policies and Strategies- The Innovator's Choice, Manimala, Mathew J, 1999, SAGE Publications.
6. The IDEATE Method, Identifying High-Potential Entrepreneurial Ideas, Cohen, Dan Pool, Greg & Neck, Heidi, 2020, SAGE Publications.
7. Managing Innovation and Entrepreneurship, Kearney, Claudine & Hisrich, Robert D, 2013, SAGE Publications.
8. Biotechnology Entrepreneurship - Starting, Managing, and Leading Biotech Companies, Ed. Craig Shimasaki, 2014, Academic Press.
9. Art of the Start 2.0, Guy Kawasaki, 2015, Portfolio.
10. A Biotech Manager's Handbook - A Practical Guide, Eds. M O'Neill M M Hopkins, 2012, Woodhead Publishing
11. Innovation, Commercialization, and Start-Ups in Life Sciences, James F. Jordan, 2014, CRC Press.
12. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences, Adams, D. J., & Sparrow, J. C., 2008, Bloxham: Scion.

20-303-0402 DISSERTATION (12C)

COMPREHENSIVE VIVA VOCE AND SEMINAR (1C)

Description: This course covering 3-5 months will be conducted by the students in the department or in other research institutions in India or aboard. THE AIM of the dissertation is to allow the student to apply all the theoretical and analytical practices learnt over the previous three semesters to work independently / or with supervision on a research project under the guidance of the concerned project supervisor.

On completion of this course the student will be able to:

1. Conduct literature survey in the concerned field of research and identify and concentrate on a research / industry related problem in the specified field.
2. Apply required theory and experiments on the problem
3. Construct a project proposal through extensive study of the literature and / or discussion with learned resource persons in academy or industry

4. Create an action plan of the project work to be carried out through deliberations.
5. Realize various steps involved in completing a project work like literature survey, methodology adopted (field study / survey / experiments / numerical work), analysis of the data to arrive at final results and conclusions.
6. Analyze the data generated and discuss in context of current status
7. Prepare, Present and defend self-prepared report, verified by the project guide to a peer audience.

- The dissertation work can include experimental, computational, field based, human study, clinical study, industry related or other research projects. The project work shall be reviewed periodically and at the end of the semester each student need to submit a project report as per the format given below.
- At the end of the semester, each student shall submit a project report comprising of the following.

    a. Introduction
    b. Objectives.
    c. Literature Review.
    d. Application and feasibility of the project.
    e. Project implementation action plan.(Materials and methods)
    f. Detailed documentation of the work done including figures, tables, diagrams, etc (Results/outputs and discussion)
    g. Summary
    h. Future scope and conclusions
    i. References

- The thesis should be written in English about the research that the master degree candidate conducted independently. The thesis will be evaluated based on the regulations of the University, program and laboratory that the candidate belongs to and the following criteria.

    1. A title clearly identifies the topic of the thesis.
    2. An introduction (background, objective), methods, results, discussion, figures, tables and references are presented in a standard thesis style.
    3. Relevant research is critically investigated and analyzed in the background and objective.
    4. Methods are described in detail, so it is clear why they were selected for the research.
    5. Data are shown accurately and clearly in the text using figures and tables.
    6. Results are interpreted critically and discussed in reaching logical conclusions.
    7. The thesis includes original and creative findings.
    8. References are listed completely and accurately and with careful attention paid to research ethics, including plagiarism and proper citation.

- The end semester evaluation of the project will be by a team comprising of 3 internal examiners including senior faculty members. The HOD will act as the Convener of the Committee. The final evaluation of the project shall include the following.

    1. Presentation of the work
    2. Oral examination
    3. Demonstration of the project against objectives
    4. Quality and content of the project report

Additional information for the students/instructors/supervisors

The dissertation will be organized to contain the following

1. Cover page with the
    i. Title of the research work in ALL CAPS Arial 12 font
    ii. Name of the student, registration no.
    iii. Name of affiliated department, university
2. The inner page will also include all the above
3. Certificate from the HOD
4. Evaluation sheet with the names of the reviewers/examiners
5. Certificate from the Supervisor
6. Certificate from student
7. Acknowledgements-no more than one page
8. List of contents
9. The dissertation will have an
    a. Introduction
    b. Objectives.
    c. Literature Review.
    d. Application and feasibility of the project.
    e. Project implementation action plan.(Materials and methods)
    f. Detailed documentation of the work done including figures, tables, diagrams, etc (Results/outputs and discussion)
    g. Summary
    h. Future scope and conclusions
    i. References
    j. appendix can show supplemental data, etc
    k. certificates from IBSC/IAEC/HEC as per case

The following criteria may be applied when assessing a dissertation. The grade assigned depends on the level to which the standards have been met.

Definition of research scope and goals

- The research scope has been suitably defined, in the form of a clear and erudite noteworthy research question
- The objectives of the thesis clearly are stated
- Evidence of intellectual enquiry towards research query from an initial phase in the dissertation

Grasp of the topic

- The student demonstrates a knowledgeable grasp of the topic and understanding of the scope of research
- The student demonstrates understanding of the relevant theoretical literature
- The student demonstrates skills in making use of literature and other relevant sources of information for advancing research goals

Methods, conclusions

- The student demonstrates an ability to devise suitable investigation designs for attainment of project goals
- The student demonstrates capability to apply the chosen methods
- The dissertation contains references to the relevant scholarly publications in the field
- The dissertation presents well-founded conclusions drawn from the results
- The dissertation answers the research question(s) presented

Contribution to knowledge and thesis structure

- The dissertation is relevant to the set goal and arrives at an answer to the research question
- The dissertation is a well-organized logical whole
- The dissertation rigorously develops and offers research-based arguments and analysis that substantiates, modifies, challenges or in other ways adds to the current understanding of the relevant subject/issue

Presentation and language

- The dissertation is proofread, edited, and technically of the high standard expected of scholarly outputs
- The dissertation is written in a coherent, formal style and forms a well-ordered whole
- The dissertation observes the conventions and practices of the chosen referencing style (any style can be used, as long as it is used consistently and correctly)

INTER-DEPARTMENTAL ELECTIVE CREDITS: SEMESTER: **ODD**

20-303-0308: BASIC NEUROSCIENCE 3E (3L +0P +1T)

Course Description: One of the most challenging and interesting problems in the field of biology is to understand the Human brain. According to the society for neuroscience; brain is the most complex living structure in the entire universe. This basic course in Neuroscience will introduce students to the fundamentals of brain function and review the current scientific understanding of brain's inner workings. The course starts by introducing basic neuroanatomy, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. This course aims to attract students from a wide range of backgrounds by providing some insights into the issues and advantages pertaining to interdisciplinary research in the realm of neuroscience.

Learning objectives of the course: After completing the course the student will be able to:

L.O.1. Develop an understanding of the interdisciplinary nature of neuroscience.
L.O.2. Describe major areas of neuroscience with basic understanding of the fundamental concepts of neurobiology.
L.O.3. Describe the basic classes of cells found in the central nervous system and understand the basic human brain organization.
L.O.4. Describe some of the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory.
L.O.5. Describe neurological disorders such as Alzheimer's disease, Parkinson 's disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke.
L.O.6. Analyse a given theoretical problem/case study, identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.

MODULE I

Organization of the nervous system: The parts of the nervous system: The human brain and spinal cord, Basic neuroanatomy: Neural differentiation and regionalization of the brain, Cells of the nervous system, Organization of sensory and motor systems.

MODULE II

Propagation of nerve impulses and molecular mechanisms of neurotransmission: Chemical and electrical transmission, Neurotransmitters and neuropeptides- chemical nature and mode of action, Neuronal excitability, Signal generation and propagation, Synapses and nerve circuits, post synaptic mechanisms of signal integration.

MODULE III

Sensory and Motor Neuroscience (Basic introduction: functionalities of human Brain): Visual information processing, Somatosensory system, Motor system, Chemoreception, Auditory system, Pain, Addiction, Sleep, Depression

MODULE IV

Neuronal Plasticity, Learning, and Memory: Neurogenesis, Stem cells in the Brain, Neural basis of perceiving, learning and remembering, Neural cell migration, Axonal pathfinding, Brain changes across the lifespan

MODULE V

Neuro-degenerative disorders and regenerative approaches: Causes for neurodegeneration, Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, Psychiatric disorders, Traumatic Brain Injury and Stroke, Treatment strategies for neurodegenerative diseases**;** Neuroimaging, Biomarkers for early identification, Stem cell transplantation.

REFERENCES

1. Principles of Neural Science (5th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2012
2. Neuroscience (6th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2017
3. Neuroscience : Exploring the brain (4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2015
4. Basic Neurochemistry. Molecular, Cellular and Medical aspects (8th Edition) by George J. Siegel, Bernard W.Agra noff, R. Wayne Albers, Stephen K. Fisher& Michael D. Uhler.; 2011
5. From Neuron to Brain (5th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2012
6. Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994
7. Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991
8. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015