Program

M. Sc. (Master of Science) in Microbiology

Faculty of Sciences

[Revised 2016-2017]

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Programme Outcome

PO1. Provide education that helps to understand the fundamental and advanced concepts in the relevant field and prepare the students to communicate it effectively.

PO2. Instigate confidence to develop hypothesis, design experiments and interpret the results.

PO3. Prompt the students to work individually and synergistically.

PO4. Enable students to think independently and critically.

PO5. Make the students competent to identify their field of interest and find suitable employment in Industry and academia.

Programme Specific Outcome

The Postgraduate Program in Microbiology is focused on bacteriology, mycology, and virology along with other areas covering molecular biology, molecular genetics, evolution, and ecology, etc. The main objective of this course is to motivate the young talented students to and enhance the aptitudes and skills of students. The course also guides the students to apply the microbiology theories into areas that focus on live problems faced by the environment and industry. By the end of the course, students are having the ability to perform fermentation process development, media optimization, and bacterial strain improvement. Students are trained to have their own hypotheses and experimental design and to work on it during their final semester. The course covers the area of microbes such as bacteria, viruses, fungi, algae and its applications in the various food and dairy industry, agriculture , pharmaceuticals, water treatment plants, microbial waste management, etc. At the end of two years, students either get placements in different companies working in the area of microbiology or in any research lab across the globe.

Curriculum Structure

Semester 1			
Sl.No	**Course Code**	**Course Name**	**Credits**
1	BIO400	Cell Biology & Stem Cell Biology	3
2	BIO401	Molecular Biology	3
3	BIO419	Biochemistry	4
4	BIO497	Research Methodology	2
5	MIC407	Microbiology	2
6	MAT401	Biostatistics	3
7	CUL401	Cultural Education	1
8	SSD401	Soft Skills	1
9	MIC480	Microbiology - Lab	2
10	BIO482	Biochemistry - Lab	2
Total Credits			**23**

Semester 2			
Sl.No	**Course Code**	**Course Name**	**Credits**
1	BIO403	Molecular Genetics	3
2	BIO404	Ethics in Research & Intellectual Property Rights	2
3	BIO408	Recombinant DNA Technology	3
4	MIC402	Microbial Physiology	2
5	BIO418	Industrial Biotechnology	3
6	MIC411	Bacterial & Viral Pathogenesis	4
7	BIO481	Recombinant DNA Technology - Lab	2
8	BIO485	Industrial Biotechnology - Lab	2
9		MB Elective - 1	3
10	AVP401	Amrita Values Programme	1
11	SSD402	Soft Skills - II	2
Total Credits			**27**

MB Elective 1		

1	BIO464	Cancer Biology	3
2	BIO465	Phage Biology	3
3	BIO466	Cell Signalling	3
4	BIO467	Biomimicry	3
5	BIO424	Bioanalytical Techniques	3
6	BIO412	Molecular & Cellular Biophysics	3
7	BIO451	Neuroscience	3
8	BIO456	Advanced Biochemistry	3
9	BIO410	Advanced Discovery Biology	3
10.	BIO569	Regenerative Biology & Stem Cells	3

Semester 3

Sl.No	**Course Code**	**Course Name**	**Credits**
1	BIO514	Molecular and Cellular Immunology & Biology of Vaccines	4
2	BIO528	Advanced Pharmaceutical Biotechnology	3
3	MIC503	Food Microbiology	2
4	MIC505	Mycology	2
5	MIC506	Parasitology	2
6	MIC509	Environmental & Agricultural Microbiology	3
7	SSD501	Soft Skills-III	1
8		MB Elective - 2	3
9	BIO584	Immunology - Lab	2
10	MIC581	Food Microbiology - Lab	2
11		Open Elective	2
Total Credits			**26**

MB Elective 2			
1	BIO553	Nanobiotechnology	3
2	BIO550	Developmental Biology	3

3	BIO559	Molecular & Cellular Neuroscience	3
4	BIO552	Recent Trends in RNA Biology	3
5	BIO527	Mass Spectrometry & Proteomics	3
6	BIO568	Ecology & Evolution	3
7	BIO561	Glycobiology	3
8	BIO555	Matrix biology and Biomaterials	3
9	BIF514	Bioinformatics	3

Semester 4			
	Course Code	**Course Name**	**Credits**
1	MIC599	Dissertation/Thesis	10
Total Credits			**10**

TOTAL CREDITS FOR THE PROGRAMME	**86**

Course Objectives, Course Outcomes, Syllabus

Semester 1

BIO419 **BIOCHEMISTRY** **Credits 4**

Learning Objectives:

The course in Biochemistry deals with the structure and functions of the various biomolecules present in the cell. The course covers the metabolic aspects of various biomolecules and their regulatory aspects.

Syllabus:

Basic Concepts of Organic Chemistry: Principles of Chemical Bonding, Structure and Properties of water, **Acids and Bases,** Buffers **; Mechanism of Organic Reactions:** Chemistry of carbonyl compounds, Oxidation-Reduction reactions, Keto-enol Tautomerism, important functional groups in biochemistry, general types of reactions in biochemistry., Non-covalent interactions- Hydrogen bonds, Vander Waal's forces, Electrostatic & Hydrophobic interactions.

Carbohydrates: Carbohydrates: Introduction, Sources, Classification. Reactions of carbohydrates, Isomerism of carbohydrates, Fischer projections, Haworth structures, pyranose and furanose structures, Anomers, Epimers, Chair and boat conformations. Structure and functions of sugars, homo and heteropoly saccharides, glycoconjugates,

Lipids: Introduction, sources, Nomenclature, Classification. Properties & Functions. Steroids: Structure of steroid nucleus, biological role of cholesterol, fat soluble vitamins**,** Prostaglandins, Cyclooxygenase, Terpenes and terpenoids

Amino Acids and Proteins: Introduction, Classification optical isomerism, chemical properties, Acid-base properties- Peptide bond formation and properties. Levels of protein structure (brief mention of primary, secondary, tertiary & quaternary structures eg; collagen and hemoglobin), Ramachandran plot. Denaturation of proteins. Carbohydrate –protein covalent linkages, Membrane transport proteins. Enzymes, Kinetics, MM plot and LB Plot., Effect of pH on proteins and its role in chromatographic purification of proteins,

Nucleic Acids: Purines & Pyrimidines: Structures of purine and pyrimidine bases, nucleosides, nucleotides, RNA, & DNA (differences), base pairing schemes, keto -enol tautomerism of bases and its consequences, types of RNA: mRNA, rRNA, tRNA, aminoacyl tRNA synthetase, Secondary structure of DNA, Watson and Crick model. Denaturation of DNA , Spectroscopic properties of DNA, hyperchromic shift

Bioenergetics: Thermodynamics –First law of thermodynamics, second law of thermodynamics, Gibbs free energy, endergonic & exergonic reactions, Standard state free energy changes-$\otimes G$, $\otimes G^0$ and $\otimes G'^0$, Relationship between equilibrium constant and $\otimes G'^o$, Feasibility of reactions. Simple problems, ATP-Structure, properties and energy currency of the cell, Importance of Coupled reactions, High energy compounds, simple problems. **Introduction** to Metabolism - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways, Metabolism-Compartmentalization

Carbohydrate Metabolism: Introduction, Aerobic and anaerobic pathways: Glycolysis and its

regulation, Gluconeogenesis and its regulation. TCA cycle - Regulation, Glyoxylate cycle, amphibolic & anaplerotic reactions. Electron Transport chain, Oxidative phosphorylation, & production of ATP, Inhibitors of ETC and ATP synthesis, mechanism of 2,4-DNP, balance sheet of glucose oxidation, Oxidative stress., Pentose phosphate pathway (HMP shunt) & its regulation, Glycogen metabolism and regulation, Photosynthesis – 'light' and 'dark' reactions: Light reaction-structure of chlorophyll, Light harvesting complexes (LHC's) Photosystems PSI & II; Mechanism of energy production, - photophosphorylation, ancillary pigments. Dark reaction and regulation Calvin cycle, stoichiometry of carbon cycle, C4-pathway, CAM , efficiency of photosynthesis. Warburg effect, ^{18}F2-D-deoxyglucose in detecting tumors

Lipid Metabolism: Biodegradation of fatty acids, beta – oxidations of saturated & unsaturated fatty acids.beta oxidation of odd chain fatty acids, ⌉-oxidation, 〈-oxidation Ketone bodies, production during starving and diabetes Biosynthesis of fatty acids – Acetyl-CoA carboxylase reaction, Fatty acid synthase complex, biosynthesis of palmitate, energetics, Regulation of fatty acid biosynthesis. Biosynthesis of triacylglycerols, Biosynthesis of cholesterol, regulation. Prostaglandins and thromboxanes

Amino Acid/ Nucleic Acid Metabolism: Overview of amino acid metabolism, fate of NH_4^+ and carbon skeleton. Urea cycle and regulation. Biodegradation of amino acids – deamination, transamination, decarboxylation, urea cycle including its regulation. Biosynthesis of amino acids, Disorders of amino acid metabolism (phenylketonuria, alkaptonuria, maple syrup disease, albinism). Metabolism of aromatic amino acids, His, Cys, Ser. Biologically active amines. Denovo and salvage pathways for purine synthesis. Recycling of Purine and Pyrimidine nucleotides by salvage pathways. Lesch-Nyhan syndrome & Gout.

REFERENCE:

1. Lehninger, Nelson and Cox, Principles of Biochemistry, 5th Edition, W.H.Freeman & Company,
2. Voet & Voet, Fundamentals of Biochemistry, 4th Edition.
3. Lubert Stryer, Biochemistry, 6 th Edition, W.H.Freeman and Company, 2007.
4. Graham Solomons and Craig B. Frhyle , Organic Chemistry, 8th Edition John Wiley and Sons, 2004.

Course outcome:

1. Students will be gaining knowledge about the elements present in biological system, important functional groups, concept of pH, pKa, buffers, non-covalent interactions

2. Students will be gaining in-depth knowledge about the structure and properties of various biomolecules including carbohydrates, amino acids, proteins, lipids and nucleic acids

3. Students will be exploring the different aspects of biochemical reactions including Bioenergetics, coupling of reactions, different kinds of biochemical reactions, various classes of enzymes, regulatory steps, enzyme regulation etc.

4. Will be able to understand major metabolic pathways of biomolecules, their energetic and regulatory aspects and associated metabolic disorders.

MIC407 MICROBIOLOGY Credits: 2

Learning Objectives:

To offer an understanding of microbial diversity, classification, nomenclature and taxonomy with an evolutionary framework.

Syllabus:

History- Spontaneous generation theory, Cell theory. Contributions of Antonie van leuwenhoek, Joseph Lister, Robert Koch, Louis Pasteur, Edward Jenner, John Tyndall, Sergei N. Winogradsky, Martinus W. Beijerinck, Selman A Waksman, Alexander Fleming, Paul Erlich, Fannie Hesse, Elie Metchnikoff, Carl woese, .

Broad outline of the three kingdom classification; diversity (Prokaryotic, eukaryotic, a cellular) and abundance of microorganisms. Habitat and ecological role of microorganisms; Types- Bacteria, archae, fungi, protist, helminthes, viruses.

Concepts, techniques and instrumentation- **Sterilisation and disinfection**- Definitions, Principles. Methods of sterilization- Physical methods (Heat, Filteration), Radiation and Chemical methods. Control of sterilization and Testing of sterility. Development of pure culture methods, culture media: types **Microscopy** – Principles, Light microscope, Phase Contrast, Dark field, Bright field, Fluorescent, NDIC Confocal, AFM and Electron microscope (TEM and SEM).**Staining-** Simple, Gram staining, Negative staining, Capsule staining, Spore staining, Flagellar staining, Nuclear staining and Acid fast staining **Biochemical identification methods :** IMViC test ,carbohydrate fermentation,Identification of gram postive bacteria **Maintenance and Preservation of cultures-** Short term– Slant, Stab, Mineral oil overlay- Long term– Lyophilization, Cryo preservation, Storage in sterile soil, Storage in silica gel.

Applications- Industry, Environment, Medicine, genetics, immunology, warfare, search for extraterrestrial life etc.

REFERENCE:

1. Prescott, L.M J.P. Harley and C.A. Klein 1995. Microbiology 2nd edition Wm, C. Brown publishers.
2. Michael J. Pelczar, Jr. E.C.S. Chan, Moel : Microbiology Mc Graw Hill Book R. Krieg, 1986 Company
3. Stainer R.Y. Ingraham J.L. Wheolis H.H and Painter P.R. 1986 The Microbial world, 5th edition. Eagle Works Cliffs N.J. Prentica Hall.

Course outcome:

1. This course comprises basic knowledge about microorganisms, their structure, composition and physiology of growth.

2. Students would be aware about the taxonomical classifications and nutritional grouping of microbes based on their habitat.

3. Students will have a better understanding of different techniques and instrumentation applicable in microbiology area including microscopy, sterilisation technique, biochemical identification methods etc.

4. Moreover, inclusions of wider applications of different fields of microbiology which includes medical food and industrial and biotechnological applications is also an added benefit.

MAT401 **Biostatistics** **CREDITS: 3**

Learning Objectives:

Biostatistics is a course offered to 1st semester M.Sc., (BT &MB). In this course a student will learn how to effectively collect data, describe data, and use data to make inferences and conclusions about real world phenomena. The theory of probability is a study of Statistical or Random experiments. Using these figures, it might be possible to estimate the possible level of prices at some future data so that some policy measures can be suggested to tackle the problems. Average is a value which is typical or representative of a set of data. On completion of the course, student should be able to

- Recognize the importance of data collection and its role in determining scope of inference.

- Demonstrate a solid understanding of interval estimation and hypothesis testing.
- Choose and apply appropriate statistical methods for analyzing one or two variables.
- Use technology to perform descriptive and inferential data analysis for one or two variables.
- Interpret statistical results correctly, effectively, and in context.

Syllabus:

Unit 1

Collection, Classification and Tabulation of data, Bar diagrams and Pie diagrams, Histogram, Frequency curve and frequency polygon, Ogives. Mean, median,mode, Standard deviation.

Unit 2

Probability theory: Random experiments, sample space, probability theory, conditional probability. Baye's theorem. Random variable,(.discrete and continuous), Probability density function(discrete and continuous), Distribution function for discrete random variable. Distribution function for continuous random variable, Joint probability distribution, Conditional and marginal distribution. Mathematical expectations: Introduction, The expected value of a random variable, moments, Moment generating functions, Product moments, Conditional expectations.

Unit 3

Standard distributions -: Uniform distribution. (Discrete and continuous). Exponential distribution Gamma distribution, Beta distribution. Binomial distribution, Poisson distribution, Normal distributions. Standard normal distributions.

Unit 4

Correlation and Regression analysis: Correlations and regressions-: Relation between two variables, scatter diagram, definition of correlations, curve fitting, principles of least squares, two regression lines, Karl Pearson's coefficient of correlation, Rank correlation, Tied ranks.

Unit 5

Parameter, Statistic, Null hypothesis, Alternative hypothesis, Critical region, Type1 Error, Type 11 Error, Level of significance, P-value and its applications. Test of Significance for Small samples: One sample t-test, Unpaired t test, Paired t-test. Chi-square Test: Test of goodness of fit, Test of Independence of attributes

Text books:

1. Fundamentals of Biostatistics. by Irfan A Khan.

2. An introduction to Biostatistics. by PSS Sunder Rao.

3. Introduction to the Practice of Statistics by Moore and McCabe

Reference:

1. Principles of Biostatistics. Marcello Pagano.

2. Course Manuals: S-PLUS Command Line Essentials, The Analysis of Microarrays

Course outcome:

CO1: To find r, ρ and study the nature of correlation and regression. Identify the different axiomatic approach.

CO2: To study and solve problems related to connectives under different situations.

CO3: To study the need of statistical approach Identify the different axiomatic approach.

CO4: To get a single value that describes the whole data and to study the variability of observation

CO5: Perform a two-sample t-test and interpret the results; calculate a 95% confidence interval for the difference in population means.

CO6: Select an appropriate test for comparing two populations on a continuous measure, when the two sample t-test is not appropriate

BIO401 MOLECULAR BIOLOGY CREDITS :3

Learning Objectives:

Basic knowledge in general molecular biology

Syllabus

Historical and Conceptual Background: Discovery of DNA as genetic material, Griffith's experiment, Hershy and Chase warring blender experiment, Chargaff's rule, Structure of DNA, RNA and Protein

Central Dogma in Detail, Gene Regulation: Basic mechanism of replication, transcription, translation, Gene regulation in prokaryotes and eukaryotes, positive regulation, negative regulation, attenuation, gene regulation in lambda phage life cycle, RNA processing and post transcriptional regulation

Transcriptional And Translational Regulation: Eukaryotic transcription factors, enhancers, silencers, insulators, chromatin structure and gene regulation, Translational regulation in prokaryote and eukaryotes, Post translational modification and protein stability.

REFERENCE:

1. Molecular biology of gene, J.D.Watson
2. Gene VIII, Benjamin Lewin
3. Molecular biology, David Freifielder

Course outcome:

1. History of molecular biology, Methods in Molecular Biology.
2. DNA-Protein interactions, Transcription in prokaryotes, Control of prokaryotic transcription, Transcription in Eukaryotes, Post transcriptional events, Transcriptional regulation, Translation and translational regulation, post translational modification, RNA and Protein export and its regulation.
3. Replication and enzymology, DNA damage and repair, Systems Biology, Bioinformatics.

BIO400 Cell Biology & Stem Cell Biology CREDITS: 3

Learning Objectives:

The course involves understanding the cocepts of protein sorting, apoptosis and circadian rythms. The course also includes the communication between different cells by understanding variousuch signaling pathways and their role in Cancer, Cell death and other pathological conditions in addition to the applications of stem cells. Students will gain in-depth knowledge in the fields of cell biology and stem cell biology.

Syllabus:

Cell- to -Cell Signaling: Hormones and Receptors, Intracellular signaling in Development and Disease Transport across Cell Membranes, Protein Sorting: Organelle Biogenesis and Protein secretion Stem Cell Biology, Cancer, Regulation of Cell Death; Apoptosis , Circadian Rhythms

REFERENCE:

1. "Molecular Cell Biology" 5th Edition by Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris Kaiser, Monty Krieger, Matthew Scott, Lawrence Zipursky and James Darnell. W.H Freeman and Company.
2. "Molecular Biotechnology" by B.R. Glick and J.J.Pasternak Third Edition, CBS Publishers.

Course outcomes:

1. Understand how the proteins synthesised in the cytosol are transported to different organelles

2. Understanding G protein signaling, receptor tyrosine kinase signalling and various other signaling mechanisms involved during the development of a organism which involves discussion of scientific articles.

3. Understand the role of circadian rhythms and apoptosis and their regulation in different pathological and physiological conditions.

4. Understand the basic concepts of stem cell biology with emphasis on the use of stem cell therapy to treat various disease conditions.

BIO497 **Research Methodology** **Credits: 2**

Learning objectives:

Basic knowledge in research methodology in life sciences.

Syllabus:

Meaning of scientific research, Objectives of scientific research, Scientific Methodology in terms of Research in Biology, Current trends in research methodology, Current areas of focus. Components of a scientific research article, Reading and understanding a research article. Presentation skills, Going beyond a research article: future perspectives. Student Presentations

Course outcomes:

1. Research Methodology in life sciences.
2. Literature Search: Use of databases, search engines: pubmed, Google Scholar; framing query with examples. Bibliometrics: Citation, Impact factor, Eigen factor.
3. Hypothesis as a framework for scientific projects. Alternatives of hypothesis driven research: hypothesis generating research.
4. Experimental Design: different experimental designs, controls, Taking measurements.
5. Data Analysis: Between-individual variation, replication and sampling. Common statistical tests.
6. Writing research hypothesis (grant).
7. Presenting research: oral and poster.
8. Use of common software tools: Microsoft Office™ (Powerpoint, Excel, Word); Mendeley; ImageJ. Use of social media in research: Mendeley, ResearchGate.

MIC480 **Microbiology Lab** **CREDITS: 2**

Learning Objectives:

To give a deep understanding to pure culture concepts and cultural characteristics.To perform staining procedures including differential and structural staining.To perform biochemical tests to identify microorganisms.To determine the antibiotic sensitivity analysis and determining their inhibitory concentration.Optimization factors related to microbial growth .

Syllabus:

Sterilization techniques-Dry heat, moist heat, filters sterilization and UV irradiation. Media preparation-Simple, selective and differential media. Pure culture technique-Serial dilution, pour plate, streak plate,spread plate. Staining techniques-Simple staining, Gram staining, acid fast staining, Negative staining, Spore staining. Biochemical reactions of microbes-IMViC, Carbohydrate fermentation, oxidase, catalase.Coagulase test, Decarboxylase test,Urease test ,Enumeration of microbes –serial dilution agar plate technique. Microscopic examination of living bacterial preparation. Studying the growth pattern of a microorganism., Determination of growth curve,Anaerobic culture techniques, Influence of environmental factors on microbial growth, Antibiotic sensitivity test;MIC and MBC determination.

REFERENCE:

Microbiology-A laboratory Manual-James G.Cappucino,Natalie Sherman.

Course outcome:

1. Students will gain Knowledge of bacterial and fungal cultivation and identification will enable the students to secure jobs in clinical/Pharmaceutical and Quality assurance industries

BIO482 BIOCHEMISTRY LAB CREDITS: 2

Learning Objectives:

This master's course provides a detailed knowledge about the basic as well as advanced research tools in biochemistry. The students will be meticulously explained on how a basic biochemistry research problem can be solved. The course includes tools/ instrumentation/methods like sonication, salt precipitation, dialysis, SDS-PAGE and experiments on characterization of enzymes/ proteins which comprises of velocity, quantitation of proteins, Specific activity, Km and Vmax (kinetics). Hands on training will be given for most of the above elements. Another aspect of the course includes isolation, purification and characterisation of phytochemicals. Students will be given hands-on

training on various instrumentation methods which includes sohxlet extraction, column chromatography, TLC , UV etc.

Syllabus:

Preparation of Laboratory Solutions and Buffers, Separation of plant pigments by column chromatography. Thin layer chromatography. Isolation of enzyme from a source by sonication. Ammonium sulphate precipitation and dialysis. Preparation of standard curve to find the velocity of the enzyme. Preparation of standard curve to find out the protein content and thereby the specific activity.. Effect of substrate concentration on Enzyme kinetics and determination of Km and Vmax by Michaelis Menton Plot and Lineweaver Burk plot. Structural studies of phycobiliproteins from spirulina using spectroscopic techniques. Protein purification by affinity chromatography. Polyacrylamide Gel Electrophoresis. Lab activity

References:

1. "Experimental Biochemistry", Beedu Sashidhar rao, Vijay Deshpande, I K International Pvt. Ltd., ISBN 81-88237-41-8.
2. Laboratory Manual in Biochemistry; J.Jayaraman, New Age International Private Limited.
3. Internet sources

Course outcomes:

1: Basic knowledge about some protein and phytochemical purification techniques by demonstration and hands on experience

2: Characterizing the proteins and phytochemicals biochemically by some analytical tools and experiments.

SSD401 **Soft Skills** **CREDITS:1**

Syllabus:

Presentation Skills Speech techniques, content, purpose, strengths and weaknesses. Develop good listening and feedback skills. Resume Writing Purpose of Resumes, Resume Formats, Parts of the Resume. Group Discussion Type of GDs, Roles one could play, PESTLE analysis, Interview Skills Types

of Interviews, Behavioral interviews, STAR, HR questions

Course outcomes:

1. Become aware of personal speech habits and characteristics, Develop speech preparation and presentation techniques, audience awareness and self-awareness, Cultivate poise and self-confidence
2. Resume
3. understand the key skills and behaviours required to facilitate a group discussion, speak with confidence, exhibit leadership skills and make the group achieve the goals.
4. Competent to answer Behavioral and HR questions.

SEMESTER 2

BIO 403 **Molecular Genetics** **CREDITS: 3**

Learning objectives:

Genetics is the study of heredity and genes. The aim of this course is to strengthen the Mendelian principles along with other molecular genetics topics like recombination, pedigree analysis, transposons. This course will help students to venture in to the different areas of biomedical sciences.

Syllabus:

SYLLABUS:

Introduction: DNA, the carrier of genetic information, Classical (Mendelian) genetics: Inheritance of independent traits. Sex linked inheritance. Chromosome segregation in mitosis and meiosis. Structure of chromosomes, chromosomal variations and aberrations in number and structure. Genetic linkage, crossing-over, chromosome mapping. Genetic markers and distances. Genetic markers and mapping in humans, pedigree analysis and lod scores. Mapping by means of tetrad analysis in Neurospora and Saccharomyces. Genetics of bacteria and their phages. Mutation, mutagenesis, DNA damage and repair. Transposons and retroposons. Quantitative Genetics. Population and Evolutionary Genetics. Extrachromosomal inheritance. Genome editing technologies (CRISPR-CAS 9)

REFERENCE:

1 E.J.Gardner, M.J. Simmons and D.P.Snustad.1991"*Principles of Genetics*". Eighth edition John Wiley.

2 D.L. Hartl and E.W. Jones. "*Genetics, Analysis of Genes and Genomes*". Sixth edition. Jones and Bartlett Publishers.

Courseoutcomes:

1. To undertand the basic concept of Mendelian principles and learn its applicaion in different genetic experiments. This would help the students to solve the majority of the genetic problems.
2. To extrapolate the deviations from the standard mendelian laws in few cases and learning the mechanisms.
3. To learn the undelying genetic mechanisms that regulate sex determination and clinical cases leading into chromosome abnormalities.
4. To understand the principles of linkage, recombination and chromosome mapping to establish the physical and genetic connection between two neighbouring genes.
5. Learning how DNA repair mechansms restore the integrity following the DNA damage.
6. Applying statistical methods to obtain probabality and genetic ratios in the Mendelian crosses

BIO404 Ethics in Research & Intellectual Property Rights CREDITS: 2

Learning Objectives: The main objective is to make students aware of the rights for protection of their inventions. Innovations/creativity is useful for the society and it's very important to protect these innovations. The course is designed with a view to create IPR consciousness; and familiarize the learners about the documentation and administrative procedures relating to IPR. Another objective is to enable the students to understand the importance of ethics in research in relation to human rights. And the values of ethical principles.

Syllabus:

Intellectual Property, Patents, Trademarks, Copyright, Design Registration, TRIPS Agreement, Geographical Indication, TKDL , Prior Art and Patent Infringement , Biopiracy, Pharmaceutical Patenting, Generic Drugs, Bioequivalence, Pharmacovigilance, Ethics in Research, Case studies related to pharmaceutical patenting and Evergreening

REFERENCES

1. Cook, Trevor (2002), A Users guide to Patents, Butterworths, London
2. Benthly L,and Sherman B,(2001),Intellectual property law, Oxford University Press
3. Wegner, Harold (1994), Patent Law in biotechnology, chemicals & pharmaceuticals, Stockton, chipperham
4. Bruce Lehman, President, International Intellectual property Institute, The Pharmaceutical Industry and the Patent system.

Couse outcomes:

1: Introduction to IPR. Learn the Importance of IPR. Different types of IP protections. A. Patents: their definition, granting, infringement, searching & filing. B. Copyrights: their definition, granting, infringement, searching & filing. C. Trademarks: role in commerce, importance, protection, registration. D. Design Registration: Industrial Designs and Design Patents, its protection.

2: Pharmaceutical patenting: Introduction of Pharmaceutical patenting in India (TRIPS agreement). Learning about different aspects of a drug that you can patent. What is ever greening strategy? Importance of Bioequivalence tests for Generic drugs. .Advantages of generic drugs for developing countries.

3: Geographical indications: Definition and protection of a GI, GI as a part of IP, international protection, Examples of GI protected products. Bio piracy of traditional knowledge. Prevention of Bio piracy.

4: Case studies in IPR. Understand the importance of having an IP management strategy to protect innovative products from facing infringements. Famous examples of Patent infringements were discussed.

5: Ethics in research. Fundamental to understanding and applying ethical principles and guidelines is the concern for and protection of the human rights of the participants. Moral principles that constitute the basis for ethics in research.

BIO408 RECOMBINANT DNA TECHNOLOGY CREDITS 3

Learning Objectives: Basic aspects of genetic engineering, DNA amplification & manipulation

Syllabus:

Enzymology of Genetic manipulation, Genome Editing, Cloning Vectors and Method of Transformations, Gene Isolation Approaches, Gene expression in heterologous system, Techniques used in genetic engineering, Plant, animal transgenics for biotechnological application and gene therapy, Mutagenesis, Knock-in, Knock-out, conditional knock-outs, Regulation of gene expression, cDNA arrays, gene silencing by RNAi, dominant negative approach, in vivo and in vitro protein protein interactions, bacterial and yeast one, two and three hybrids, phage display, GST pull down, co-immunoprecipitation, Far Western blot, FRET, Biacore; DNA, RNA – protein interactions, Applications of genetic engineering

REFERENCE:

1. Brown, T. (2010). *Gene cloning and DNA analysis: an introduction*. John Wiley & Sons.
2. Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics*. Wiley. com.
3. Howe, C. J. (2007). *Gene cloning and manipulation*. Cambridge University Press.

Course outcomes:

1. Students learn the transformation methods, genomic DNA isolation, Plasmid DNA isolation, restriction digestion of Plasmid and genomic DNA, elution of DNA by low melting gel agarose, Ligation, insert analysis, isolation of RNA, PCR, Recombinant protein expression, purification and refolding.

MIC402 Microbial Physiology CREDITS –2

Learning objectives: To give deeper insights into microbial growth, reproduction and metabolism. Bacterial signal transduction processes is been extensively looked upon.

Syllabus:

Over view of prokaryotic cell- structure &functions, Cell wall synthesis**,** Membrane transport in bacteria-simple, group translocation, ABC transporters, Protein export in bacteria –Type1, 2, 3, 4, Protein export pathways & antimicrobial therapy, Iron transport- siderophores , Siderophores &

antimicrobial therapy ,Bacterial cell shape - bacterial cytoskeleton

Cell division- molecular mechanisms involved in formation of Z-ring, Cell division machinery & antimicrobial therapy, Two component signal transduction in prokaryotes----- Chemotaxis ,flagella assembly and synthesis Quorum sensing& biofilms , Quorum sensing & antimicrobial therapy , Sporulation inducing signals & events in sporulation , Osmolarity porin regulation in E.coli (Omp system) Phosphate assimilation in E.coli (Pho system),Nitrogen fixation in Klebsiella& Rhizobiumn(Ntr system).Multiple drug resistance and efflux pumps.Inclusion bodies:magentosomes and relevance.

Stress physiology --- effect of oxygen toxicity, pH, osmotic pressure, heat shock etc on bacteria Adaptations in thermophiles, halophiles, alkaliphiles , acidophiles , Extremophiles – adaptations & significance in biotechnology

References

1. Prescott's Microbiology 8th Edition

2. Microbial Physiology -Moat & Foster.

3. Web resources (Reviwes/articles)

Course outcomes:

1. Students gain deeper insights to secretion of proteins in bacteria which sheds light on antibiotic efflux mechanisms and conjugation mechanism.
2. Gain knowledge based on microbial transport mechanism across membranes.
3. Gain knowledge on concept of cell division in microbes and indepth mechanism. To concrete evidences on different methods of microbial communication methods with special empasis to quorum sensing and biofilm formation.
4. Students learn the complex physiological process of bacteria with special reference to their motility patterns

BIO418 Industrial Biotechnology CREDITS: 3

Learning objectives:

To provide fundamental insights of the principles, practice and key concepts relevant to industrial biotechnology and build a foundation for more advanced studies in bioprocess technology.They will

learn how to relate the growth properties of an organism to its production aspects.Students are made aware of how to commercially exploit microorganisms for their processes and products that are of major economic, environmental and social importance.

Syllabus:

An Introduction To Fermentation Processes: Microbial biomass, Microbial enzymes, Microbial metabolites, Recombinant products,

Transformation processes: The Isolation, Preservation And Improvement Of Industrially Important Micro-Organisms: Screening methods, Storage at reduced temperature, Storage in a dehydrated form, The selection of induced mutants, use of auxotrophs, resistant mutants, revertant mutants, Modification of the permeability, use of recombination systems, protoplast fusion techniques

Fermentation Systems : Batch culture, Continuous culture, Fed-batch culture, Kinetics of growth and product formation. Design Of A Fermenter: Basic functions of a fermenter for microbial or animal cell culture, Aseptic operation and containment, Body construction & components, Sensor probes, different types of fermenters, fermenters for animal cell culture, instrumentation and control

Media For Industrial Fermentations : Typical media, Medium formulation, The addition of precursors and metabolic regulators to media, Antifoams
Sterilization: The design of batch sterilization processes, Calculation of the Del factor during heating and cooling, HTST, The scale up of batch sterilization processes , Filter sterilization of air, Sterilization of fermenter exhaust air, The theory& design of depth filters.

The Development Of Inocula For Industrial Fermentations: Criteria for the transfer of inoculums, The development of inocula for bacterial processes, The development of inocula for mycelial processes

Aeration And Agitation: Determination of KLa values, Fluid rheology, Factors affecting KLa values in fermentation vessels, Power number, Reynold's number, Scale-up and scale-down, Scale-up of aeration/agitation regimes in stirred tank reactors, The scale-up of air-lift reactors, Scale-down methods

Downstream Processing: Filtration, Centrifugation, Cell disruption, Liquid-liquid extraction, Chromatography, membrane processes, Drying, Crystallization, Whole broth processing, effluent treatment

Fermentation Economics: Space requirements, capital investment, Raw materials, highest-yielding strain, automation, Recovery and purification procedures, Heat and power, effluent discharge, safety guidelines and regulations.

Industrial Products And Process: Microbial enzymes, Fuels and industrial chemicals, Health care products, Food and beverage fermentations, Food additives and supplements, Microbial biomass production ,biotransformation.

REFERENCES:

1. Principles of Fermentation Technology Second Edition PETER F. STANBURY, ALLAN WHITAKER, STEPHEN J. HALL .Elsevier Science Ltd

2. Industrial Microbiology: An Introduction. Michael J. Waites, Neil L. Morgan, John S. Rockey Gary Higton. Blackwell Science Ltd

3. Modern Industrial Biotechnology & Microbiology. Nduka Okafor, SCIENCE PUBLISHERS, Edenbridge Ltd.,

4. Microbial Technology .Vol 1&2 H.J. Peppler and D. Perlman. Academic Press.

5. Industrial Microbiology . L E Casida Jr. John Wiley and Sons I

Course outcomes:

1. By the end of the course students will be able to develop an undestanding of the various aspects of the fermentation technology.
2. Understand principles underlying the design of fermenter, fermentation process and downstream processing.
3. They will also understand the importance of strain improvement and screening of industrially important organisms.
4. The students also will get exposed to various technologies and processes for industrial waste treatment.

MIC411 BACTERIAL AND VIRAL PATHOGENESIS CREDITS: 4

Learning objectives:

The course introduces the basic concepts and molecular aspects of Bacterial and Viral Pathogenesis. Helps students to extrapolate those concepts in explaning the pathogenesis and pathology of

different bacterial and viral pathogens.

Syllabus:

Importance Of Bacterial Pathogenesis, Host Immunity, Normal Microbiota.

Skin and Mucosa the first line of defence , innate immunity, antibodies and T cells.

Host pathogen interaction : Bacterial strategies for evading / surviving in host,Toxins and other toxic virulence factors. Delivery of virulence factors, Virulence regulation. Identification of virulence factors: Measuring infectivity and virulance, Bacterial drug resistance

Pathogenesis Of Representative Organisms, *Staphyllococcus aureus, Streptococcusn spp,* Clostridum spp *Escherichia coli, Salmonella spp, Pseudomonas aeruginosa*. Mycobacterium, Spirochetes

Background Information Of Viral Pathogenesis, Representative Organisms DNA: virus replication strategies, RNA virus replication strategies. Influenza virus and Para influenza viruses. SARS and respiratory viruses. Measles, mumps and rubella viruses. Herpes virus. Enteroviruses. Pox viruses. Retroviruses, HIV and retroviral therapy. Oncogenic viruses. Hepatitis viruses. Brief account on plant viral diseases.

REFERENCES:

1. Virology, Flint.
2. Microbiology, Ananthanarayanan, Panicker.
3. Virology, James jay.
4. Bacterial Pathogenesis: A Molecular Approach (Paperback) by A. A. Salyers and D. D. Whitt.
5. Principles of Bacterial Pathogenesis by Eduardo A. Groisman.

Course outcomes:

1. To understand the pathogenesis from the perspective of the etiological agents.
2. Bacterial and viral virulence factors.
3. The host responses to bacterial and viral infections.
4. Discussions on specific bacterial and viral pathogens.
5. Discussion of emerging diseases

BIO481 Recombinant DNA Technology – Lab CREDITS: 2

Learning Objectives:

To provide fundamental insights of the principles, practice and key concepts relevant to genetic engineering

Syllabus:

Transformation methods, genomic DNA isolation, Plasmid DNA isolation, restriction digestion of Plasmid and genomic DNA, insert analysis, isolation of RNA, PCR, RT-PCR, Recombinant protein expression, purification and refolding.

REFERENCES:

1. Sambrook, J., Russell, D. W., & Russell, D. W. (2001). Molecular cloning: a laboratory manual (3-volume set).
2. Amrita University Virtual Lab. http://amrita.vlab.co.in/?sub=3

Course outcomes:

1: Understand the principles and techniques for competent cell preparation and bacterial transformation 2: Learn to isolate Plasmid DNA from transformed bacteria and genomic DNA from different biological samples
3: Learn to quantify, perform restriction digestion and analysis of the digested DNA.
4: Understand the principle and perform polymerase chain reaction
5: Learn recombinant protein expression, purification and refolding
6: Perform RNA isolation and analysis

BIO485 Industrial Biotechnology lab CREDITS: 2

Learning objective:

To provide hands on experience on isolating and evaluating the industrially potential of microorganisms from various sources. This course helps students to work with small scale fermentors and learn their basic working principle.

Syllabus:

Isolation and screening of microorganism producing amylases from soil. Environmental isolation of protease producing microorganisms. Isolation of phosphate solubilizing bacteria. Isolation of free living nitrogen fixers from soil (Azotobacter). Isolation of rhizobium from root nodules.

Isolation of antibiotic producing actinomycetes from soil. Determination of alcohol production by immobilized yeast cells. Sulphite oxidation method. Determination of mixing time and reynolds number in fermentor. Ionotrophic gelation of E.coli using calcium alginate beads.

Reference:

1. Microbiology, A Laboratory Manual-James Cappuccino, Natalie Sherman.
2. Manual of Industrial Microbiology and Biotechnology-Arnold L Demain , Julian E Davies

Course outcomes:

1. Understand various methods of screening industrially important microorganisms from different sources
2. Understand the working of small scale fermenter and also determine the aeration efficiency of the fermenter
3. Understand the technique of immobilization of cells like yeast and E.coli.

SSD 402 **Soft Skills II**

Credits:1

Learning objectives:

The objective of this course to give students training and experiences that will allow them to be successful in their second year and beyond. There are two components in this course. Verbal skills that equips you with vocabulary skills, Essential Grammar, write Cover letter and SOPs

Syllabus:

Cover Letter Skills, key words, action words**.** S V Agreement Subject, Pronoun, Verb, To write grammatically correct sentences. Modifier Adjectives and Adverbs. Clauses Noun, clause, Relative clauses etc. Punctuation Punctuation marks, Tenses Time, Tenses, Reading and Comprehension Language,pronunciation, SOP

Course outcome:

1. They will be able to write a Cover Letter
2. To write grammatically correct sentences
3. Enrichment of vocabulary and knowledge, and fluency

Elective **1**

CREDITS: 3

BIO466 **Cell Signaling**

Learning Objectives:

The course includes extensive study on different cell signaling pathways and the recent advancements in contributing to various disease conditions. The course involves discussion of recent scientific papers related to each of these signaling pathways.

Syllabus:

Basics of animal communications including the different kinds of signals, Principles of Cell Signaling Systems, Classification of signaling mechanism, Techniques used to understand cell signaling in the laboratory, Growth Factor/ Receptor Tyrosine Kinases (RTKs), Receptor serine threonine kinase, Cytokine Receptors, Other enzyme-linked receptors, G Protein Signaling, Significance of toxins like cholera and pertussis in understanding GPCR-mediated cell signaling, Nobel lectures in G protein and RTK signaling, Signaling involved in taste, vision and smell, Cross-talk between GPCR and RTK signaling pathways, Signal Transduction Through Ion Channels, Signals with Long-Term Consequences (Cell cycle and its control, Apoptosis and Cytoskeletal remodeling), Signaling in developmental pathways like Wnt, Notch and Hedgehog, Signaling in plants- Auxin, Ethylene and Phytochromes, Prokaryotic Signaling, Signaling involved in Circadian rythm in Humans, Drososphila and Cyanobacteria, Recent Advances in Signaling Research and diseases.

Books and References:

1. The Biochemistry of Cell Signalling, Ernst J.M. Helmreich (2005) Indian edition, Oxford University Press.
2. Molecular Biology of the Cell. Alberts B. et al.,(2008) 5thedition. Garland Science.
3. The Cell: A Molecular Approach, 4th Edition, Geoffrey M. Cooper and Robert E. Hausman
4. Journal papers: reviews and research articles

Course outcomes:

1. Understanding G protein signaling in depth which involves discussions on the noble lectures in the field.

2. Extensive study on Receptor tyrosine kinases and their signaling with respect to disease conditions like Cancer.

3. Study of other signaling pathways involved during various developmental stages with detailed discussions of scientific articles pertaining to each of the signaling pathways.

4. Involves understanding various signaling mechanism in plants.

5. Trained to design experiments and interpret data based on the discussions on each signaling pathway which would help them develop scientific critical thinking skills.

BIO464 Cancer Biology

Learning objective:

This course covers in detail the molecular mechanism of cancer development with emphasis on tumor viruses, oncogenes, tumor suppressor genes, cell cycle and its control and other hallmarks of cancer. It also covers the molecular approaches to cancer diagnostics and treatment. More recent advances in cancer stem cells and cancer epigenetics are also discussed.

Syllabus

The Development and Causes of Cancer,Tumor Viruses, Oncogenes, Tumor Suppressor genes, Cell cycle and its control, Apoptosis, Telomeres, cellular immortalization and tumorigenesis, Cancer Stem Cells, Angiogenesis and Metastasis, Cancer Epigenetics, Molecular Approaches to Cancer Treatment, Prevention, assessing risk, diagnostics and treatment

REFERENCES:

1. The Biology of Cancer, 2nd Edition, Robert A. Weinberg
2. Molecular Biology of the Cell. Alberts B. et al.,(2008) 5thedition. Garland Science.
3. The Cell: A Molecular Approach, 4th Edition, Geoffrey M. Cooper and Robert E. Hausman
4. Journal papers: reviews and research articles

Course outcome:

After concluding this course students will be able to

1. describe the six hallmarks of cancer,

2. describe different causes of cancer development

3. explain the role of mutations in cancer formation

4. Can give example of oncogene and it's role in cancer development

5. explain cell cycle and its regulation and dysregulation in cancer giving example of tumor suppressor proteins

6. the extrinsic and intrinsic pathways of apoptosis

7. describe the mechanism of angiogenesis

8. factors that control metastasis in cencer cells

9. role of diet and epigenetics in cancer

10. describe about the properties of cancer stem cells

11. Interpret data published in scientific journal articles and present cancer biology articles from reputed journals

BIO451 **Neuroscience**

Learning Objective: This course deals with the study of structure and function of nervous system and how information is transmitted from one part to the other with emphasis on physiology, development, anatomy etc.

Introduction to Neuroscience, History of Neuroscience, Neuroanatomical planes, parts of Central Nervous system, Neurons and glia, **Neurophysiology basics**, resting potential, action potential, Synaptic transmission, types of synapses, behavior of neuron, initiation and propagation of action potential, Ion Channels and properties, Learning and plasticity at the synapse, **Neurophysiology and Neuron Simulation Virtual Labs**, Hodgkin-Huxley neuron, patch clamp physiology, electrophysiological techniques, basic protocols in neuroscience, **Vision**, **Olfaction, Hearing, Motor system, Cerebellum, Brain disorders, Neural basis of Consciousness.**

REFERENCE:

1. Kandel, E.R., Schwartz, J.H., Jessell, T.M., & Siegelbaum, S.A. (2013) Principles of Neural Science. 5th Edition. McGraw-Hill Professional. ISBN: 978-0071390118.
2. Neuroscience, 3rd ed, edited by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel La Mantia, James O. McNamara, and S. Mark Williams. 2004. ISBN -

0-87893-725-0

Reference text books:

1. Neuroscience Online, the Open-Access Neuroscience Electronic Textbook! http://neuroscience.uth.tmc.edu/, UT Austin
2. The Synaptic Organization of the Brain, 4th Edition, Gordon Shepherd (Editor), Oxford University Press.

Course outcome:

Students who complete this course will have a deeper understanding on the nervous system

BIO424 BIOANALYTICAL TECHNIQUES

Learning Objective: To give advanced knowledge on instrumentation to isolate, purify and characterize biomolecules such as proteins and nucleic acids.

Syllabus:

Ultracentrifugation: Theory, Determination of purity of samples, Determination of conformational changes, Study of molecular aggregates using analytical ultracentrifuges equipped with fluorescence detection.

Fundamentals of Chromatography, van Deemter curve, Ion exchange chromatography, Gel filtration chromatography, Reversed-phase chromatography, Ion-pair chromatography, Hydrophilic interaction liquid chromatography, Affinity chromatography, High performance liquid chromatography, Fast protein liquid chromatography, Supercritical Fluid chromatography, UHPLC, Gas chromatography.

Primary structure determination of proteins: Amino acid composition, End group analysis. UV-Visible Spectroscopy: Principle, Instrumentation, Applications, Fluorescence Spectroscopy: Principle, Instrumentation, Applications,Circular Dichroism, Isothermal titration calorimetry, Differential scanning calorimetry, Atomic force microscopy, Infrared spectroscopy, Nuclear magnetic resonance spectroscopy.

REFERENCES:

1. Biochemistry by Voet and Voet
2. Protein Purification Techniques by Simon Roe

3. Protein Purification by Robert K. Scopes
4. Analytical Biochemistry by David Home and Hazel Peck
5. Physical Biochemistry by David Sheehan
6. Fundamental of analytical chemistry by Douglas Skoog and Donald West
7. Practical Biochemistry by Keith Wilson and John Walker

Course outcome:

1: Introduce the basic concept and principles of bioanalytical techniques

2: Learn how to extract and isolate molecules from different biological sources

3: Learn how to purify biomolecules using basic and advanced chromatographic techniques

4: Learn how to structurally characterize biomolecules using electrophoretic and spectroscopic techniques

BIO410 Advanced Discovery Biology

Learning Objectives:

To give an exposure to recent advances and trends in different aspects of discovery biology and the drug design and development process

Syllabus:

Fundamental Principles of Pharmacology, Principles of Chemotherapy, Principles of Toxicology, Drug Discovery, Design and Development, Drug receptor interactions, IPR in Pharma/Biotech industry, FDA rules and regulations for the approval of new drugs, Major companies in the pharmaceutical industry Molecular Diagnostics, Current trends in Pharma/Biotech industry

REFERENCES:

1. Pharmaceutical Biotechnology by Daan J. A. Crommelin, et al

2. "Principles of Pharmacology by D. Golan, A. Tashjian, E. Armstrong, J.Galanter, A.W.Armstrong, R. Arnaout and H.Rose. 2005, Lippincott Williams and Wilkins.

3. Goodman and Gilman's The Pharmacological Basis of Therapeutics Book by J.Hardman, Lee Limbird and A.G. Gilman.

Course outcome:

1: Understanding the basic process of drug development

2: What is pharmacophore mapping

3: Understanding the concept of I.C.50, Rational drug design, Quantitative Structure Activity Relationship (QSAR)

4: Principles of Pharmacokinetics, Pharmacodynamics

5: Understanding Pharmacogenomics

6: Biomarker Discovery

7: G-Protein coupled Drug Discovery

8: Basic principles of CRISPR-Cas gene editing

9: Principles of Immunooncology"

BIO456 ADVANCED BIOCHEMISTRY

Learning objective: The course being offered as an elective intends to apply the knowledge Biochemistry to uunderstand the various molecular mechanisms in the cell. The course deals with biochemical calculations in different aspects and is addressed with analytical and problem solving approach.

Syllabus:

Biochemical calculations [pH, buffers, molar/normal solutions, dilutions] Molar/Normal solutions, Acids and Bases, Laboratory Buffers, Practice Problems ,Chemistry of Biological molecules, Practice problems, Kinetics of enzyme catalysed reactions, Order of reactions, Kinetics of zero, first and second order reactions, half-life, MM plot and LB plot, kinetics of inhibition, Practice problems, Vitamins, Enzyme Catalysis, mechanisms and SAR/, Organic chemistry of enzyme action and inhibition, Membranes and Membrane transport Structure and chemistry of membranes, Transport across membranes, Kinetics and mechanism of transport, Biochemistry of the reception and transmission of extracellular information, Signal transduction pathways , Neurotransmission , Integration and Regulation of Mammalian Metabolism with clinical correlations

REFERENCE:

1. Lehninger, Nelson and Cox, Principles of Biochemistry, 4th Edition, W.H.Freeman & Company, 2004.
2. Voet & Voet, Fundamentals of Biochemistry, 3rd Edition, Wiley, 2004.
3. Garret and Grisham Biochemistry 3rd edition
4. Thomas Devlin, Biochemistry with clinical correlations 7th edition
5. Segel I .H, Biochemical Calculations, Wiley and Sons, 2nd Edition,

Course outcome:

1. Demonstrate an understanding of the fundamental principles, including scientific reasoning to solve problems, apply laboratory orientated numerical calculations, chemistry, srtructure and function of biomolecules.

2. Students will gain knowledge in reaction kinetics, kinetics of enzyme catalysed reactions, enzyme catalysis mechanisms, Structure activity relationships and drug designing

3. Will be able to understand the principles behind membrane transport, mechanisms involved in neurotransmission.

4. Will be demonstrating their understanding in relevant research areas in biology through presentations, problem solving etc.

BIO465 PHAGE BIOLOGY CREDITS: 3

Learning Objective:

Advanced knoweldge in bacteriophages and their application

Syllabus:

History of phage biology, Classification and Characterization, Ecology & Evolution, biochemistry and physiology, Bacteriophage and bacterial virulence. Applications: Therapeutics (human & veterinary), agriculture, aquaculture, sanitation. Genome engineering. Phage display library and other molecular biology applications.

REFERENCES:

Flint, S. J., Enquist, L. W., Racaniello, V. R., Skalka, A. M., Flint, S. J., Enquist, L. W., ... & Skalka, A. M. (2008). Principles of Virology, (Volume I and Volume II).

Kutter, E., & Sulakvelidze, A. (Eds.). (2004). Bacteriophages: biology and applications. CRC Press.

Calendar, R., & Abedon, S. T. (2005). The bacteriophages. Oxford University Press.

Reference Books:

Clokie, M. R. & Kropinski, A.M. (2009). Bacteriophages: methods and protocols, volume 1: isolation, characterization, and interactions (Vol. 1 and 2). Humana Press Inc.

Lobocka, M., & Szybalski, W. T. (Eds.). (2012). Bacteriophages (Vol. 82 & 83). Academic Press

Course outcome:

1. Students will be able to apply the knowledge in modern biology & applications of bacteriophages in therapy & environmental remediation with special emphasis on antibiotic resistance issues

BIO467 BIOMIMICRY CREDITS: 3

Learning Objective:

The course is intended to provide an insight into the fact that nature can offer solutions to the problems faced by human as nature has a 'bench work' experience of 3.8 billion years. The course will introduce methods and methodologies to gather information about a function, mechanism, ecosytem etc of a particular biological entity and adopt them to solve a choosen problem. In a nut shell it is to ponder what the nature has to offer as solution to a given problem. Above all the overarching objective is make the students appreciate the function and structure principles of biology that are developed in context to its immediate environment without spuriously affecting the other entities and the habitat.

Syllabus:

The background- Innovation inspired by nature. The pioneers- Janine M. Benyus, Dayna Baumeister etc. How and why nature can be Model, Measure and Mentor to solve problems. Biomimetic solutions to food scarcity and energy crises; manufacturing in a benign and sustainable manner; nature as a repertoire of drugs and pharmacological strategies; nature as paradigm to process and store information; ecological concepts in city planning and buisness. Individual Mini projects (conceptual) to identify a problem and derive solutions from nature.

Essential reading

1. Biomimicry- Innovation Inspired by nature, Janine M. Benyus..

2. Biomimicry resource handbook from Biomimicry 3.8

Web resource

http://biomimicry.net

http://biomimicry.org

http://www.asknature.org

Course outcome:

1. To help students look at nature as a model, mentor and measure.

2. To introduce to the students the overarching general principles of biological systems.

3. Biomimetic solutions to food scarcity and energy crises; manufacturing in a benign and sustainable manner; nature as a repertoire of drugs and pharmacological strategies.

4. nature as paradigm to process and store information; ecological concepts in city planning and business.

BIO 412 Molecular and Cellular Biophysics CREDITS: 3

Learning Objective:

The course in molecular and cellular biophysics is meant to introduce biophysics as a course in biosciences applying the theoretical language of physics to aid functional understanding of molecular and cellular processes.

Syllabus:

Molecular structure in biological systems: states and forces, hydration, movement, structure formation, self-assembly, mechanical properties, energetics. Membrane transport and diffusion: Brownian motion, random walks, Fick's law, diffusion coefficients and the diffusion equation, electrodiffusion, equilibrium potentials and the Nernst equation, the Goldman-Hodgkin-Katz equation.

Membrane transport and diffusion: Ohm's law, the resting membrane potential, the action potential, voltage clamp recording, Na+ and K+ currents in axons, activation and inactivation of Na+ currents, gating charge and gating currents. An introduction to ordinary differential equations (ODEs), the electrical circuit model of the plasma membrane (PM), membrane conductance, capacitance, and time constants, comparing numerical and analytical solutionsto ODEs. The Hodgkin-Huxley (HH) model of the action potential, current-voltage relations, the current balance equation, voltage-dependent variables of the HH model, the two kinetic processes that control Na+

conductances, and the “delayed rectifier” K+ conductance.

Voltage-and ligand-gated ionic currents, transporters, and pumps: The superfamily of voltage-gated channels, voltage-gated Ca2+ channels, potassium channels and chloride channels, and ligand-gated channels of fast chemical synapses.

Whole cell behavior: neuron Integration, Propagation, saltatory conduction, Neuron synapse, synaptic plasticity, Structure of the synapse, Electrochemical transduction, Postsynaptic integration and information processing.

REFERENCE:

1. Meyer B. Jackson, Molecular and cellular biophysics, Cambridge University Press, 2006, ISBN: 978-0-521-62470-1.
2. Christof Koch, Biophysics of Computation, Oxford University Press: New York, New York, 1999.
3. BertilHille, Ionic Channels of Excitable Membranes, 3rd ed., Sinaur, 2001.

Course outcome:

1. To understand physical laws underlying biological systems
2. To understand timining and role in biological systems
3. To understand Neuronal biophysics

BIO569 **Regenerative Biology & Stem Cells** **CREDITS: 3**

Learning objective:

This is an interdisciplinary course at the interface of the cutting-edge fields: stem cell research and regenerative medicine and bioengineering. The course covers how adult stem cells are specified into different cellular fate during health and disease, different model organisms used to study adult stem cell biology, role of extracellular niche and other molecular signaling pathways regulating stem cell fate decision. Course covers induced pluripotent stem cells, stem cell treatment using engineered stem cells and disease modelling using IPSCs. Course includes a discussion component where we discuss recent research advances in the field and ethics and policies in stem cell research.

SYLLABUS:

Embryonic stem cells and Induced pluripotent stem cells, Disease modelling using induced

pluripotent stem cells, Introduction to regenerative medicine, Adult stem cells and regeneration, Zebra fish and mammalian heart regeneration. Adult Neurogenesis, Hematopoietic stem cells, Cellular factors influencing tissue regeneration during tissue injury, Cell interactions with the microenvironment in tissue regeneration, Molecular signalling regulating stem cell proliferation and differentiation. Notch Signalling, Wnt signalling, Hedgehog signalling, FGF, LIF- smad, Protein Kinase A

Stem cells and tissue engineering (Stem cell based therapies), Stem cell derived skin tissue and cartilage, Bone marrow transplantation, Umbilical cord blood stem cells and its therapeutic use, Experimental stem cell therapies in heart diseases, spinal cord injury, Boosting one's own stem cells: stem cells and aging, Ethics and Policies in stem cell research. Paper Presentations and discussions on recent advances in stem cell biology

References:

1. Mostly based on Research and Review articles from journals in stem cells and regenerative biology and medicine
2. Essentials of Stem Cell Biology by Robert Lanza and Anthony Atala
3. The Cell Biology of Stem Cells by Eran Meshorer and Kathrin Plath
4. Advances in Stem Cell Therapy by Nagwa El-Badri

Course outcome:

1. understanding of various types of stem cells in the human body and their potential in regenerative medicine
2. Have knowledge about the molecular signaling pathways and the extra celluar niche regulating stem cell fate.
3. Have knowledge about different basic biomaterials in regenerative medicine.
4. understand induced pluripotent stem cells, stem cell treatment using engineered stem cells and disease modelling using IPSCs.
5. Develop research aptitude by having discussions based on current research papers.
6. Identify and critically address a scientific question in regenerative medicine
7. Develop critical thinking and problem-solving skills.

SEMESTER 3

BIO514 Molecular & Cellular Immunology & Biology of Vaccines Credits: 4

Learning Objectives:

This is an advanced level immunology course providing development and function of the immune

system during health and diseases states of the body. We emphasize the molecular and cellular aspects of the immune system and response. Course covers innate and adaptive immune response and its components, Antibody and T cell receptor structure, function, molecular development and its genetics, Major histocompatibility complex, antigen presentation, B cell and T Cell activation and signaling, effector mechanisms, biology of vaccines, hypersensitivities, autoimmunity, immunodeficiency diseases, tumor and immunology. Course also aims to develop research aptitude in immunology by having discussions based on current research papers.

Syllabus:

Historical perspectives in Immunology, Host-pathogen interactions, Cells and Organs of the immune system, Antigens (properties), Antibodies (types and functions), immunoglobulin genes (antibody diversity generation), Monoclonal antibody production and applications, Antigen-antibody interactions and applications, Innate immune responses (early and induced, cells and functions), The complement system (classical, alternative and MBL pathway), Major Histocompatibility Complex (genes and function), MHC restriction and antigen presentation (cytosolic and endocytic), T-cell receptor (structure, function and diversity), T-cell biology – T-cell development, activation and effector functions, B-cell biology – B-cell development, activation and effector functions, Biology of Vaccines and Immunization, Advanced Topics, Cytokines (types and functions), Hypersensitive reactions (type I, II, III, IV), Advanced topics: Mucosal Immunity, Autoimmunity, Immunodeficiency diseases, Tumor and Transplantation immunology.

REFERENCE:

1. Immunology, Kuby, by Kindt, Goldsby, Osborne, Sixth Edition.

2.Immunobiology, The Immune system in Health and Disease, Seventh Edition by Janeway, Travers et al, Garland Publishing, 2008.

Research articles and reviews from select journals

1. Journal of Immunology
2. Nature reviews Immunology
3. Annual review of Immunology

Course outcome:

1. Understand immune response in our body, both innate and adaptive, to different pathogens, tissue injury and cancer.
2. Understand what happens if our immune system overreacts to foreign substances

(hypersensitivities and allergies)

3. Understand what happens if our body recognize self as non-self (autoimmunity)
4. Understand the biology of different vaccines against infectious agents and cancer and solutions to produce better vaccines.
5. Develop research aptitude in immunology by having discussions based on current research papers.
6. Develop critical thinking and problem-solving skills.

BIO528 Advanced Pharmaceutical Biotechnology Credits: 3

Learning Objective:

To provide an understanding about the basic concept of drug discovery & designing, mechanism of action of different drugs, pharmaco dynamics, pharmaco kinetics ,pharmaco genomics etc

Syllabus:

Fundamental Principles of Pharmacology , Principles of Chemotherapy,
Principles of Toxicology ,Drug Discovery, Design and Development
Drug receptor interactions,IPR in Pharma/Biotech industry
FDA rules and regulations for the approval of new drugs
Major companies in the pharmaceutical industry,Molecular Diagnostics
Current trends in Pharma/Biotech industry

References:

1. Pharmaceutical Biotechnology by Daan J. A. Crommelin, et al
2. "Principles of Pharmacology by D. Golan, A. Tashjian, E. Armstrong, J.Galanter, A.W.Armstrong, R. Arnaout and H.Rose. 2005, Lippincott Williams and Wilkins.
3. Goodman and Gilman's The Pharmacological Basis of Therapeutics Book by J.Hardman, Lee Limbird and A.G. Gilman.

Course outcome:

1. Students get familiarized with pharmaceutical industry.
2. They learn the process of drug discovery, mechanism of action of different groups of drugs, Pharmacokinetics,etc.
3. They are also exposed to pharmacogenomics and toxicology.

MIC509 Environmental And Agricultural Microbiology Credits 3

Learning Objectives: The course should enable the students to 1. Familiarize with the microbial environment and ecosystems 2. Decipher the treatments for both - solid waste as well as waste water 3. To get requisite knowledge about the habits and habitats of microorganisms and their implications in ecology 4. To evaluate explicitly the various biogeochemical cycles 5. Get insight into the various applications of microorganisms, such as bioremediation, composting"

Introduction to Environmental microbiology-Cultivation of microbial communities: community culture and significance. **Methods for detection of community cultures**, Physiological, Phylogenetic and molecular profiling of microbes in the environment. **Water microbiology**: Waste water treatment: methods: aerobic and anaerobic processes. Solid waste management; Landfills, containment types, Composting and applications. **Bioremediation and phytoremediation:** biofilters, Microbial polymers, microbial plastics. Bioaccumulation, Biomagnification, Marine pollution: concepts and remediation strategies.

Agriculturalmicrobiology:

Introduction,**Biofertilizers**:Azolla,Azospirillum,Frankia,Azotobacter,Cyanobacteria,VAM: production and applications. **Microbial insecticides**.Biocontrol agents and applications. **Nitrogen fixation** and concepts. Concepts on plant growth promoting bacteria, Siderophores.**Bacterial diseases of agriculture and aquaculture.**

REFERENCE

1. Manual of environmental microbiology, Christon J. Hurst, Ronald L. Crawford Second edition,ASM Press.
2. Agricultural Microbiology: Subba rao
3. Microbial Ecology –Atlas and Bartha.

Course outcomes:

The students should be able to

1. Thoroughly know the microbial diversity in the various biomes

2. Identify terrestrial as well as marine habitats and know how humans have impacted the environment resulting in climate change

3. Postulate application of microorganisms for pollution abatement, bioremediation, biofertilization and various other industrial applications

4. Evaluate the meta-analysis data in the context of ecology and environment "

MIC506 Parasitology CREDITS :2

Learning objective:

To understand the common parasitic relation in nature, focusing more on parasite causes diseases

Syllabus:

Parasitology-Introduction, Parasitic association, host parasitic interaction, Effect of parasitism in the host, Sources of parasitic infections. Classification, Introduction of protozoa**,** Protozoa-Amoeba Flagellates-*Intestinal, Hemoflagellates,* Sporozoa and Microspora, Trematodes- *Schistosoma haematobium, S.mansoni, S.japonicum* , Cestodes-Intestinal Tapeworms and extra intestinal tape worm, Nematodes-Intestinal, Blood and tissues .Diagnostic methods of parasitic infections.

REFERENCE:

Human parasitology-Burton J Bogtish

Text Book:

General parasitology-Thomas C Cheng

Medical parasitology-Markell and Voges

Foundation of parasitology-Roberts, Janovy.

Course outcomes:

1. Understand protozoan parasites, their habitat, lifecycle and also diseases conditions in

humans,

2. Understand different classes of helminths includes cestodes, nematodes and trematodes.
3. Study their lifecycle and implications in human

MIC505 MYCOLOGY CREDITS 2

Learning objective:

Learn about the importance of fungi- in ecosystem, Pharmaceutical industry, agriculture, health sectors, food industry etc. Learning cell wall structure in detail of fungi in general. Also learn about their classification, toxins produced by fungi, mushrooms and the symptoms, pathogenesis and identification method for the diseases causes by fungi.

Syllabus:

Introduction & Historical overview of mycology, General characteristics**,** Fungal cell wall structure in detail and the signaling pathway for the cell wall integrity, melanin biosynthesis, Importance of fungi in Human life, Fungi –Taxonamy and Systematics , Fungal Metabolism,Fungal Growth-Apical growth Fungi- Reproduction and Life cycles of Chytridioomycota, Glomeromycota, Zygomycota, Macro fungi-Ascomycota and Basidiomycota, Saccharomyces cerevisiae-Model organism , Mushrooms and their medical relevance , Mycotoxins and Mushroom poisoning Fungi- Ecological importance Mycorrhiza, Lichens, Medical mycology- Culture methods for fungi, Diagnosis, Superficial mycosis, cutaneous mycosis, sub cutaneous mycosis, Opportunistic Systemic mycosis and infectious mycosis. Mechanism of dimorphism in fungi. Host responses to fungal infection-Immunity Antifungal agent.

REFERENCE:

1. Introductory mycology, Alexopoulos, et al

Text books

1. Topley & Wilson's Microbiology and Microbial Infections, Volume 4: Medical Mycology -- by Leslie Collier, et al;
2. Medical Mycology and Human Mycoses -- by Everett Smith, Ph.D. Beneke, Alvin Lee, Ph.D. Rogers

Course outcome:

1. Understand about the importance of fungi in ecosystem, agriculture, pharmaceutical industries,

food
industries and in health sectors.

2. Learn in detail about the cell wall structure of fungi in general.
3. Understand the general characteristic featueres of fungi.
4. Understand the fungal classification and its morphological characteristics.
5. Students understand how to identify a disease caused by fungi.

MIC503 FOOD MICROBIOLOGY CREDITS: 2

Learning objective:

To understand the importance of microbes in food

Syllabus:

History and development of Food microbiology: History of Microorganisms in Food-developments: Common Food borne Bacteria,Molds Role, and Significance of Microorganisms in Foods.Parameters Affecting Microbial Growth: Intrinsic, Extrinsic.Combined Intrinsic and Extrinsic Parameters-

Microorganisms in Foods and methods for detection: Culture, Microscopic, and Sampling Method for detecting microbes, Physical, Chemical methods,Whole animal assays, Immunological methods.

Food Preservation & Principles of Quality Control: Chemicals antibiotics, Radiation,Low and high temperature, High-Pressure Processing, , Pulsed Electric Fields .Aseptic Packaging, Modified atmospheric packaging, Novel processing technologies, Combination methods
Microbiological quality standards of food, FDA, HACCP, ISI.
Microbial Food Spoilage and Food borne diseases: Staphylococcal, Ecoli, Salmonellosis, shigellosis, Listerial infections. Botulism, Vibrio spp Mycotoxins, Aflatoxins Alternaria Toxins, Toxigenic Phytoplanktons and viruses.

Applications of Food Microbiology: Beneficial Uses of Microorganisms in Food Intestinal Beneficial Bacteria-Concept of Prebiotics and Probiotics, Genetically modified foods. Biosensors in food, Starter cultures

REFERENCES

1. Food Microbiology. 2nd Edition By Adams
2. Modern Microbiology, James M.Jay
3. Fundamental Food Microbiology, Bibek Ray.

Course outcome:

1. Understand the microbial growth pattern in food
2. Beneficial use of microbes in food
3. Different food preservation techniques
4. Food borne diseases
5. HACCP and other food regulatory agencies etc.

BIO 584 **Immunology Lab** **CREDITS: 2**

Learning outcome:

To study cells of the immune system.To be able to perform experiments to understand antigen-antibody interactions enabling them to use that knowledge to detect and quantitate different biomolecules in biological experiments. To be able to perform experiments to understand quantitate methods of immunological reactions and immune cells. To have lab discussions to inculcate basic principles and problem solving skills in biological research. To have lab record keeping and writing exercises to inculcate, proper recording of observations and to improve the scientific writing abilities

Syllabus:

Blood smear for identification of different types of blood cells, Principle of basic cell culture and cell counting, Principles of Antigen-antibody interactions**,** Applications of antigen-antibody interactions in research**,** Blood typing by agglutination, Latex agglutination, Ouchterlony diffusion on gels for antibody titration **, ELISA-Dot and Sandwich ,Western Blot.**

REFERENCE :

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition
Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition

Wiley- Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman
and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland
Science Publishers, New York.
5. Practical Immunology, 4th Edition (2008). Frank C. Hay, Olwyn M. R. Westwood
ISBN: 978-1-4051-4673-9 408 pages, Wiley-Blackwell

Course outcome:

1. Students will be able to successfully perform immunological experiments such as agglutination reactions, immuno diffusion, ELISA and western blotting.
2. Students will be able to identify and understand the cells of immune system
3. Students will understand the principles of the use immunological experiments such as agglutination reactions, immuno diffusion, ELISA and western bloting.
4. Students will understand the standard lab practice for the safe handling of immunological reagents.
5. Students will understand documenting the results in laboratory reports.
6. Students will improve on their problem solving and creative thinking

MIC 581 FOOD MICROBIOLOGY LAB CREDITS: 2

Learning objective:

To understand the microbial growth in food,isolation of microbes from food,methods for the quality assessment of food

Syllabus:

Water quality analysis-MPN, Milk quality-dye reduction test, Direct Microscopic Count of Organisms in Milk:The Breed Count, Bacterial count of food products-standard Plate counts, Food production-yoghurt., Microflora comparison in fermented and non fermented foods, Isolation of spoilage pathogens from contaminated foods. Production and estimation of lactic acid by Lactobacillus Sp.

Detection of microbial spoilage of canned foods. Detection of thermal death point and thermal death time of bacteria. Optimisation of yeast fermentation. Isolation of fermenting microbes from fermented food.

REFERENCES

Microbiology: A Laboratory Manual, James G. Cappuccino, Natalie Sherman: Benjamin-Cummings Publishing Company, 2002

Prescott, L.M J.P. Harley and C.A. Klein 1995. Lab manual: Microbiology 5th edition Wm, C. Brown publishers.

Course outcome:

1. Students expected to know the assessment of quality of food and potability of drinking water,
2. Isolation of fermenting microbes which may lead to the development of starter cultures,
3. Understand the pattern of microbial growth in food which may help for the proper preservation etc.
4. Lab activity (mini projects) open up arears of food microbiology related research

SSD501 Soft Skills III Credits:1

Course Objective: This course is designed to help the student discover their skills in problem solving and reasoning. These skills can effectively help them in clearing the aptitude tests conducted by companies and help them in clearing various competitive exams like CAT, MAT, RRB, SSC NET etc., This course will teach student how to be confident and prepared with the knowledge of problem solving and reasoning skills. The key learning topics focus on making students to develop more math skills that can help them get better jobs. Applicants will also learn how to develop skills for critical thinking and analytical reasoning. This Course is a complete tool to help you launch your formal preparation for Quantitative section in various aptitude tests like the CAT, GRE and GMAT.

Syllabus:

Geometry: 1 D & 2 D:Lines, Angles, Pythagoras Theorem, Triangle & its types, Similar, Congruent, Quadrilateral, Other polygons & Circles. **Mensuration**: 3D:Cuboid, Cube, Cylinder, Cone,

Sphere, Frustum etc. **Cubes**: N cuts, N+1 pieces, Painting a cube, Dice, Different views of the same dice. **Alpha Numeric Puzzles**: No: series, letter series, coding & decoding, odd man out, symbols & notation.

Logical Connectivities & Binary Logic; Conditions: If, Whenever, Wherever, Unless, Only if, If and only if. **Basic of Non Verbal Reasoning** : Clock wise, Anticlock wise, 1 step, Angles. **Clocks**: Angle, Minute hand & Hour hand speed,Time, Relative speed, Gain/ Loose. **Calendars**: Leap year, Non leap year, Odd days. **Data Interpretation** : Bar chart, Pie chart, Line graph, Table method, Data reasoning. **Syllogism**: All, Some, Some not, No, statements, conclusion. **Net papers solving**: Aptitude questions

Course Outcome:

1. To discover the patterns, find lengths, angles, areas, Study the polygons & its properties.
2. Process of finding out Volume, LSA, CSA & TSA and many real life applications
3. To find the number of cubes after division, Questions related to SA painting etc
4. To find the missing letter/number , Analogy, Odd man out, Symbols based questions
5. To find the exact conclusion from given statements
6. To find the next pattern or odd man out
7. To find the angle between the hands, to find the time when the angle is given
8. To find the exact day of the week when the date is given
9. Understanding the given data and to answer the questions based on that data, Percentage change
10. Deductive reasoning
11. Solving Aptitude question

ELECTIVE 2 **CREDITS: 3**

BIO 559 **Molecular and Cellular Neuroscience**

Learning objective:

This course deals with the study of structure and function of nervous system in detail.

Syllabus:

The Central Nervous System: Organization and cells of the nervous system, Protection and nourishment of the brain. Overview of the CNS: Cerebral cortex, Basal nuclei, Thalamus and Hypothalamus. Emotion, behavior and Motivation, Learning and memory, Cerebellum, Brain stem Spinal Cord, Cranial nerves, Meninges, Vascular supply, Ventricular system.

Cellular Neuroscience: Neurons: morphology, staining and imaging, Neuronal subcellular components, Neuronal classification and connections, Cytoskeletal elements of neurons and glia Axonal transport, supporting cells of the nervous system.

Intercellular communication and signal transduction: Membrane potential, Graded and action potential, Electrical signals of nerve cells, Voltage dependent membrane permeability, Channels and transporters.

Synaptic transmission: pre synaptic mechanisms: Molecular mechanisms of neurotransmitter release, Post-synaptic responses and neuronal communication, Synaptic modulation, Molecular signaling within neurons, Synaptic plasticity.

Neurotransmitters and their receptors: Overview of different neurotransmitter systems in the CNS, The life cycle of neurotransmitter systems: biosynthesis, storage, release, inactivation, reuptake and actions at receptors. Neurochemical transmission: Acetylcholine, Neurochemical transmission (amino acids): Glutamate, GABA, Glycine, Two faces of GABA, Neurochemical transmission (biogenic amines): Dopamine, Norepinephrine, epinephrine, serotonin, histamine, Neurochemical transmission: Neuropeptides & atypical neurotransmitters. The Peripheral Nervous System: Afferent Division

Receptor Physiology,Somatosensory system, Pain, Eye:Vision, Ear: Auditory and vestibular physiology, Chemical Senses: Gustatory and Olfactory.

The Peripheral Nervous System: Efferent Division: Autonomic Nervous System, Somatic Nervous System, Visceral motor system, Neuromuscular Junction, Motor neuron circuits and motor control, Modulation of movement by brain stem, cerebellum and basal ganglia, Complex brain functions, Learning and memory, Emotions.

Developmental neurobiology: Growth factors ,Stem cells, Axonal growth guidance and growth cones, Construction of neural circuits, Cellular and molecular basis of Neurological disorders Neurodegenerative diseases.

REFERENCE:

Neuroscience, Dale Purves 5th ed

Human Physiology, From cells to systems; 7th Ed. Lauralee Sherwood

Course outcome:

1. Students who complete this course will have a deeper understanding on the nervous system

BIO553 NANOBIOTECHNOLOGY

Learning objective:

To help the students to appreciate the overarching structural and functional principles of biological systems viz. molecular interactions, energetics, transport, self-assembly, self-organisation and informaion processing. To educated them how these principles can be employed as a strategy construct bionanomachines that is destined work in non biological contexts.

Syllabus:

History, Definition, Structural Principles: Historical perspective- Seminal paper of Dr.Feynman. What is Bionanotechnology? Key features of nanomachines and the environment in which it functions. About Bionanomachines- Raw materials employed, information for its design. Structural principles of Bionanomachines- Environment centered design, Hierarchical construction strategy, raw material and it's stabilization forces, protein folding, Self-assembly, Self-Organization, Molecular recognition, Flexibility.

Functional principles of Bionanotechnology. Information driven nanoassembly, Energetic, Bimolecular motor, Traffic across membranes, Biomolecular sensing taste, Machine phase Bionanotechnology.

Applications OF Bionanotechnology: Applications- Using Molecular Motors, DNA Computers, Hybrid Materials, Biosensors Ethical Considerations, Potential Dangers.

REFERENCE:

1. Bionanotechnology: Lessons from Nature David S. Goodsell, .JOHN WILEY & SONS, INC., PUBLICATION

Course outcome:

1.To enable comprehensive understanding of the structural and functional principles of bionanomachines.

2. To introduce the characteristics of different bionanomachines such as kinein, dynien, ATP synthase, chaperons, ABC transpoters, porins, bacteriorhodopsins, sarcomeres etc.

3. To help students appreciate the application of bionanotecnology for eg. from tinckering existing proteins to solving salesman problems to building proteins from the scratch.

BIO527 MASS SPECTROMETRY & PROTEOMICS

Learning Objectives:

The main aim of this course is to provide in-depth knowledge of concepts and techniques within the field of mass spectrometry and proteomics.

Learning Objectives:

The main aim of this course is to provide in-depth knowledge of concepts and techniques within the field of mass spectrometry and proteomics.

SYLLABUS:

History of mass spectrometry, Basics of MS instrumentation, Ionization Sources: Electrospray (ESI), Matrix assisted laser desorption and ionization (MALDI), Mass analyzers: Quadrupole, Ion traps (Linear trap, 3D trap, Orbitrap, Ion Cyclotron Resonance), Time-of Flight, Hybrid analyzers, Ion mobility mass spectrometers, Detectors: Electron multiplier, Microchannel plate, Photomultiplier tube. Fundamental parameters of mass spectrometers: Mass accuracy, Resolution, Sensitivity.

Understanding mass spectra: Peptide and protein data interpretation, Tandem mass spectrometry, Fragmentation techniques: Collision induced dissociation (CID), Electron transfer dissociation (ETD), Electron capture dissociation (ECD), Sequential Window Acquisition of all Theoretical Mass Spectra (SWATH), In-source decay (ISD), Post-source decay (PSD),

History of proteomics, Protein and peptide separation techniques: Electrophoresis, Liquid chromatography, MudPIT, Peptide mass finger printing, Data dependent and data independent MS/MS, Database search algorithms, Proteomic work-flows, Protein identification, analysis and validation.

Posttranslational modification analysis: Phosphorylation, Glycosylation,. Quantitative proteomics: Absolute and relative quantitation through stable isotope labeling (AQUA, SILAC, iTRAQ, ICAT), DIGE, Label-free quantitation: Spectral count, Peak area.

REFERENCE:

Mass Spectrometry for Biotechnology by Gary Siuzdak, Academic Press.

Introduction to Mass Spectrometry by Throck Watson and David Sparkman, Wiley.

Proteomics for Biological Discovery byTimothy Veenstra and John Yates, Wiley.

Proteomics of Biological Systems by Bryan M. Ham, Wiley.

Data Mining in Proteomics, Ed. Michael Hamacher, Humana Press.

Web/Journal Resources.

Course Outcome:

1: Familiarization of basic concept of mass spectrometers used for biomolecular characterization and understand the major physical components and performance parameters of mass spectrometers

2: Able to apply the advanced knowledge acquired to interpret mass spectrometric data

3: Perceive multiple work-flows for large scale protein identification and protein structural characterization

4: Learn to apply multiple proteomic strategies to quantitate biomolecules

BIO550 Developmental Biology

Learning objectives:

To provide an understanding about the basic principles of development of multicellular organisms . To provide an understanding of the role of genes in development. To compare the development of different organisms and to understand the similarities in development. To highlight the application of the field in stem cell therapy, regenerative medicine, drug development etc.

Syllabus:

History & Basic concepts of development : Overview of how the modern era of developmental biology emerged through multidisciplinary approaches stages of development- zygote, blastula, gastrula ,neurula cell fate & commitment – potency- concept of embryonic stem cells, differential gene expression, terminal differentiation ,lineages of three germ layers, fate map Mechanisms of differentiation- cytoplasmic determinants, embryonic induction, concept of morphogen, mosaic and regulative development Pattern formation-- axis specification, positional identification (regional specification) Morphogenetic movements Model organisms

Early Development in invertebrate /vertebrate models: Drosophila, C.elegans, Xenopus, Mouse/ human: Cleavage, gastrulation, Axis specification (Dorsoventral, anterior posterior), & body plan patterning, left right asymmetry in vertebrates

Late Development in invertebrate /vertebrate models : Organogenesis- development of ectodermal organs, mesodermal organs, endodermal organs. vulval formation in C.elegans. **Germ cell specification& migration, Overview of plant development. Medical implications of developmental biology - genetic errors/ teratogenesis/ stem cell therapy etc**

References:

Developmental Biology, Eighth Edition" by Scott F Gilbert.
Essential Developmental Biology by Jonathan Slack

Developmental Biology, Werner A Muller
Principles of Development - Lewis Wolpert
Website: virtual embryo- http://people.ucalgary.ca/~browder/virtualembryo/dev_biol.html

Course outcome:

Students learn about the role of genes in the development of different organisms.

BIO561 Glycobiology

Learning objective:

To provide the student with an overview of one of the important biomolecules ie carbohydrate(sugar) which has immense role in biology as well as indutry. The course will highlight on the carbohydrate classification, structure and function with special reference to plant, animal and microbial systems. Detailed explanation on synthesis and degradation of carbohydrates and the enzymes . Special mention to Carbohydrate binding modules (CBMs), Glycoproteins Vs Proteoglycans, Glycolipids and lectins. Application of carbohydrates in pharmaceutical and textile industry, biofuel production and food production and nutrition will be one of the key topics of discussion. Glycobiology of host-pathogen interaction, inherited diseases and protein trafficking will be studies based on specific examples and cases.

Syllabus:

Carbohydrate structure- Simple, complex and conjugate. CAZyme structure/ function relationships **Common sugars in plant, microbial and animals-** Cell wall, structural glycans. **Glycosides**- Glycosyl transferases (GTs), Glycoside hydrolases and transglycosidases (GHs), Carbohydrate binding modules

(CBMs), Polysaccharide lyases (PLs), Carbohydrate esterases (CEs)

Glycoproteins Vs Proteoglycans, N- and O-linked glycans- cellular membrane trafficking and trafficking of N-glycoproteins, O-Linked glycosylation, Mucins and Mucin type glycoproteins

Glycolipids- Glycosphingolipids and associated diseases , Lignin- Carbohydrate complex. Lipid rafts

Applications in Industry and Medicine: Cellulases, Xylanases, Amylases, Xyloglucanases, Xyloglucan endo-transglycosylases. Sucrose bioethanol, starch bioethanol, lignocellulosic bioethanol

Roles in protein trafficking, innate immunity, therapeutic glycoprotein clearance

Lectins- Toxicity and applications of plant lectins, Lectins as microbial toxins and bacterial adhesion molecules Influenza - hemagglutinins and neuraminidases, Fabry and Schindler diseases, Blood groups and blood group interconversion

REFERENCE:

1. Essentials of Glycobiology. *Ajith Varki, Richard Cummings* et.al Cold Spring Harbor Laboratory Press. Second Edition
2. Carbohydrate Based Drug Discovery. Volume 1. *Chi Huey Wong*. John Wiley and Sons. 2003
3. Internet resources/journals.

Course outcome:

1.Students should be able to understand the role of glycans in biology

2.Students should be knowing carbohydrate classification, structure and function with special reference to plant, animal and microbial systems.

3. Students will understand the application of carbohydrates in pharmaceutical and textile industry, biofuel production and food production and nutrition will be one of the key topics of discussion.

4. They will be knowing the Glycobiology of host-pathogen interaction of inherited diseases and protein trafficking , detailed mechanisms etc.

BIF514 BIOINFORMATICS

Learning objective:

To introduce to the field of bioinformatics via an array of publicly available tools and resources.

Syllabus:

Introduction to Bioinformatics: Definition - Importance and uses of Bioinformatics- Information

Technology - Systems Biology. Bioinformatics Software**:** Clustal V - Clustal W 1.7 - RasMol – Oligo – Molscript – Treeview – Alscript - Genetic Analysis Software- Phylip. Biocomputing**:** Introduction to String Matching Algorithms. Database Search Techniques - Sequence Comparison and Alignment Techniques - Use of Biochemical Scoring Matrices-BLAST and FASTA- Pairwise and Multiple sequence alignment. Profiles, motifs and features identification –Phylogenetics analysis

Introduction to Graph Matching Algorithms - Automated Genome Comparison and its Implication - Automated Gene Prediction - Automated Identification of Bacterial Operons and Pathways

Introduction to Signaling Pathways and Pathway Regulation. Gene Arrays - Analysis of Gene Arrays - Machine Learning Methods in Bioinformatics - Hidden Markov models - Applications of HMM in gene identification and Profiles HMMs - Neural Networks and Support Vector machines.

Matlab- Introduction to MATLAB commands, Introduction to arrays- indexing. R package- Statistical Analysis. Use R to analyze biological data. Introduction to internet and its application.

References:

1. "Fundamental Concepts of Bioinformatics" by Dan E Kramer and Michael L Raymer
2. "R Programming for Bioinformatics" by Robert Gentleman
3. "Fundamentals of Bioinformatics and Computational Biology: Methods and Exercises in MATLAB" by Gautam B. Singh
4. Bioinformatics for dummies: by Cedric Notredame and Jean Michel Claverie.
5. Bioinformatics Concepts, Skills and Applications by Rastogi
6. Bioinformatics: Sequence and Genome Analysis by David W Mount.

Course outcome:

Students should be able to apply basic bioinformatic tools for the studies and research in other areas of their biotechnology and microbiology programs, such as finding gene/protein homologs, designing primers, identifying mutations, etc.

BIO568 ECOLOGY AND EVOLUTION

Learning objective: To offer insights on the basic ecological and evolutionary theories and their interrelationships in the environment.

Syllabus:

Evolution- Definition, scope and history, Darwinian view of life, Population-The basic unit of evolution, Origin of species, Phylogeny and systematics, Ecology and Biosphere-Introduction, biotic and abiotic factors, Biomes, Population ecology -Dynamics of population, Population growth-Exponential model Logistic growth model, Community ecology- Interactions- Biogeography, Speciation, Ecological succession, Disturbances Structure- Contrasting view, Ecosystems- Energy flow and trophic levels, Biological and geochemical processes (BC cycles, B Pyramids etc) Human impacts on ecosystems.

REFERENCE:

1. Reece, Jane B., Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, and Robert B. Jackson. Campbell biology. Boston: Pearson, 2011.
2. Odum, E. P. (2006). *Ecology, the link between the natural and the social sciences*. Oxford and IBH Publishing.

Books:

1. Ecology, Third Edition, 2013, by Michael L. Cain and William D. Bowman
2. Molecular Ecology, 2011, by Joanna R. Freeland and Stephen D. Petersen
3. Evolution, 2011, by Carl T. Bergstrom and Lee Alan Dugatkin

Course outcome

Students should be able to apply basic bioinformatic tools for the studies and research in other areas of their biotechnology and microbiology programs, such as finding gene/protein homologs, designing primers, identifying mutations, etc.

BIO552 Recent Trends in RNA Biology

Learning objectives:

This course is aimed at Masters students pursuing LIfe Sciences to have a general introduction to RNA biology and the recent advances in molecular biology w.r.t. RNAi, CRISPR-Cas, and other tools and techniques of targeted gene editing.

SYLLABUS:

Small RNAs as regulatory molecules with the potential to transmit information between cells, organisms and species. small RNA mobility in plants and nematodes, nature of the mobile RNA species, their distribution in the organism and inside cells, as well as the cellular machinery required for mobility, including channel proteins and cellular trafficking factors. Mobile RNAs function in antiviral defence, cell signalling and gene expression regulation, and transgenerational epigenetic inheritance.

This course explores different tools and techniques used to manipulate genome and give an overview of recent advances in research. This course is related to applications in Molecular Biology. Each lecture involves group discussions on research articles. The course objectives and outcomes include an understanding of the importance of RNAi tools for research, to understand the purpose and use of these tools.

Course Outcomes:

Upon completion of the course, students are expected to be able to:

The students would be able to understand the intricacies of RNA-RNA, RNA-Protein, RNA-DNA and other interactions in the RNA world and how it affects various molecular/metabolic pathways.

They would be aware of tools and techniques to assay and experiment these interactions in real-time

Text Books

1. MicroRNAs -From Basic Science to Disease - Krishnarao Appasani- Cambridge University Press
2. RNAi: A Guide to Gene Silencing - Gregory J. Hannon - Cold Spring Harbor Laboratory Press

BIO555 Matrix Biology and Biomaterials

Learning Objective:

Advanced course of biology to understand extracellular matrix of any living cells with specific objective of their application to develop biomaterials or explore biological materials for economic applications

Syllabus:

Extracellular matrix diversity in different cell types, Extracellular matrix in animals: Collagen,

fibronectin, laminin, cadherins, hyalouronan, heparins, proteases (MMPs, serine proteases); Plant cell wall: structure of AGP, cellulose, hemicelluloses, pectins, lignin and their degradation/synthesis enzymes. Fungal Cell wall, Bacterial Cell wall. Interactions of different ECM components. Applications of Matrix Biology: Cell and tissue engineering, wound healing. Vaccine development from pathogen cell wall antigens. Utilization of lignocellulosic materials: bioethanol production, paper and pulp industry, wood/plywood industry. Biomaterials vs biologically derived materials, biopolymers, biomineralization, biocompatibility, applications.

REFERENCE:

1. Mecham, R. P. (2011). The extracellular matrix: An overview (No. s 439). Springer..
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell. New York: Garland Science; 2008.
3. Park, J., & Lakes, R. S. (2007). Biomaterials: an introduction. Springer..
4. Wong, J. Y., Bronzino, J. D., & Peterson, D. R. (Eds.). (2012). Biomaterials: Principles and Practices. CRC Press.

Course outcomes:

Design of new biomaterials for medical and other applications; exploitation of biological materials for fuel, fodder or fertilizer, bio-waste processing.

Semester 4

BIO599 Dissertation/Thesis Credits 10

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Evaluation Scheme and Grading System

CREDIT SYSTEM OF EVALUATION*

Introduction

Amrita School of Biotechnology follows a credit-based system for evaluation under a semester pattern. This allows flexibility on courses, time frame, teaching and learning, evaluation procedures and mobility.

Academic year and Semesters

An academic year (July to June) consists of two semesters and possibly a summer term. Each semester has a minimum of 80-85 teaching days and about 8-10 days for the end semester examinations.

Credit based Academic System

A credit-based system is a systematic way of describing an educational programme by attaching credits to its components. Credit is a way of quantifying the knowledge content. When enough credits are accrued or earned, the programme is completed successfully.

Credit system makes educational programmes easy to understand and compare both nationally and internationally. It facilitates mobility, academic flexibility and universality and helps universities to organize as well as reorganize their study programmes quickly. It can be used across a variety of programmes and modes of delivery.

Programme

An educational programme specializing in a specific area covers many knowledge segments. An example is the B.Sc. programme in Biotechnology.

Allotment of Credits

Credits are allocated to the knowledge segments giving due importance to their weightings. The sum of the credits allotted to the knowledge segments decides the programme credits. The programme is successfully completed from the academic angle, once the specified programme credits have been earned.

Example: (For a B.Sc. Biotechnology Programme)

Knowledge Segment	Category	Credits
Language, Cultural Education & Soft Skills	S	17

Mathematics, Physics & Chemistry	M	20
Core Lifesciences	C	67
Laboratory Courses	L	16
Project/Dissertation Thesis	P	7
Total Credits for programme completion		127

Under each knowledge component, the credits are again distributed among the identified courses. The number of courses and the credits allocated to each, could vary. However, the student need to get only the minimum credits in each of the components as mentioned in the example and a prescribed minimum total number of credits for successfully completing the academic programme. Additional credits taken will be an added advantage from the professional angle, but not from the academic requirements.

Course Credits

Each course, except for a few special courses, has a certain number of credits assigned to it depending on the lectures, tutorials, laboratory works and contact hours in a week. Lectures (L) and Tutorials (T) will have one credit per each contact hour in a week. Laboratory and Practical (P) classes carry one credit for two / three contact hours in a week. Projects, fieldwork etc are given a specific number of credits without any direct reference to the hours spent.

Example:

a) A Course on Plant Biology

Number of Lecture hours per week – 3 Credits: 3

Number of Tutorial hours per week – 1 Credits: 1

Total credits for the course 3 + 1 = 4

b) A Laboratory Course on Microbiology:

Number of Laboratory hours per week -3 Credits: 2

These are normally indicated in the curriculum, as follows:

Category	Course Code	Course Title	Hours per week			Credits
			L	T	P	
C	BIO223	Plant Biology	3	1	0	4
L	MIC281	Microbiology Lab	0	3	0	2
P	BIO399	Project	5	5	20	7

Curriculum

Curriculum is the framework of an academic programme. In the credit based system, curriculum will specify the category, course code, course title, course delivery (Lectures / Tutorials / Lab / Project) and the credits. Curriculum is presented semester-wise for convenience and will take into account all the knowledge segments and their assigned credits. The total credits to be earned for programme completion will be specified clearly.Our curriculum has the following credit allocations among the knowledge segments:

B.Sc. Biotechnology

Knowledge Segments	Category Admissions	2016 Admissions onwards
Language, Cultural Education & Soft Skills	S	17
Mathematics, Physics & Chemistry	M	20
Core Lifesciences	C	67

Laboratory Courses	L	16
Project/Dissertation Thesis	P	7
Total credits needed for programme completion		127

B.Sc. Microbiology

Knowledge Segments	Category Admissions	2016 Admissions onwards
Language, Cultural Education & Soft Skills	S	17
Mathematics, Physics & Chemistry	M	20
Core Lifesciences	C	66
Laboratory Courses	L	18
Project/Dissertation Thesis	P	7
Total credits needed for programme completion		128

For the **M.Sc. programmes,** a total of 76 credits (Biotechnology), 76 Credits (Microbiology), 79 credits (Bioinformatics) have to be earned. 10 credits of project work have to be earned additionally for the successful completion of the programme.

Credit System Flexibility

Credit system allows flexibility on the selection of courses and time frame for completion of the programme. It also provides a good blend of teaching and learning, ensuring credible evaluation procedures and student mobility. The credit system is evolved around the teacher and the taught.

The prominent features of the credit system cover continuous evaluation of students' performance through well-planned assessment procedures and the flexibility to allow a student to progress at a pace suited to his / her individual ability and convenience, subject to certain conditions. While a prescribed minimum number of credits are to be earned for the award of degree, a minimum level of performance is necessary for progressing with the studies.

Class Advisors and Counsellors

Each class will have one/two class counsellor(s) to help and guide the students in the academic process, solve their problems, if there is any, as also to provide counselling and guidance for the needy. They will also monitor the progress of the students in their studies and report the same to their parents periodically.

Checks and Controls in the Credit System

To achieve purposeful flexibility, a good system control is needed. Hence there are specific rules and procedures to be adhered to in the credit system. Certain courses in each knowledge segment are identified as core courses and others as electives. There is mandatory registration and credit earnings requirements for core courses. Electives are free to be chosen from those offered, for registration. While it is mandatory to register for the elective courses, failure to earn credits in them does not necessarily mean repeating the courses. Another elective course may be permitted as a replacement course.

Certain courses are pre-requisites for advanced courses. For example, Molecular Biology could be a pre-requisite for Genetic Engineering. This means that the student cannot take Genetic Engineering unless he/she has completed Molecular Biology. Here the term completion means that the student has registered for the course, done all assignments and tests, attended the class with 75% or more attendance and has written the end semester examination. The student need not have to earn credits (i.e., pass the course) for fulfilling the pre-requisite needs.

How to go about with the credit system?

The first step, in the credit based system, is the registration for the various courses. For first semester, registration is done at the beginning of the semester. In the subsequent semesters (2^{nd} semester onwards), registration will be done at the end of the previous semester. The students have to enroll for the courses, earlier registered, at the start of the semester.

During enrolment, one can drop the earlier registered courses or add new courses, with the approval of the faculty advisor / Counsellor and the concurrence of the Dean of the School.

All students will have to register before a specified date. However for valid reasons, late registration with a fine will be permitted up to a specified date. These dates will be announced well in advance.

Registration

Students will be made aware of all information on the courses being offered in that semester. There will be an on-line registration procedure. The students have to enter the details of the courses they want to register for. In the first few semesters there may not be much of a choice to decide on. As one progresses, the flexibility will become more evident. Students have to consult the faculty members who have been identified as their advisors, for advice and assistance in registration.

Minimum and Maximum credits for which one can register in a semester is specified in the relevant curricula. Any deviations will need the approval from the Dean , School of Biotechnology.

A student is permitted to register / enroll for courses only if he / she has:

a) Paid all fees and has no dues to the university
b) Has maintained a progress, as required by the university c) Has completed any pre-requisite courses prescribed
d) Has no disciplinary action pending against him / her

Conduct of Courses

Credit system encourages learning. Apart from regular class lectures, students will be given major assignments which will form a part of the course and will also be considered for evaluation. Seminars, design and other assignments, technical paper writing, quizzes etc. could also be a part of the course being conducted.

The teacher offering the course will evaluate the performance of the students at regular intervals and in the end semester examination. A class committee comprising all teachers handling all the courses for the class, the class advisor and students' representatives will monitor the conduct of all the courses of a class.

A course committee comprising all teachers / mentors offering a course in all the campuses will decide on the course plan, evaluation procedure and any midway correction to be taken. Decisions taken by this committee will be informed to all students who have registered for the course. The class / course committees without students' representative will finalise the grades and results for the class / course.

It is mandatory for the students to appear for the end semester examination / supplementary examination for the completion of the course.

If the Project work is not satisfactory, the student will be asked to continue the project till he / she completes it satisfactorily.

Attendance

- Additionaly, a 5% weightage is given to attendance above the total weightage
- All students are required to attend 100% of the classes.
- Leave of absence could be applied for in the form provided in the School website/Store and will be granted by Counsellor only in genuine cases.
- Two types of leave are permitted, namely, Duty Leave and Other leaves
- All leaves except Duty leave put together, as sanctioned by the Counsellor should not exceed 25% of the total classes, for eligibility to appear for the end semester examination.

- **Marks for attendance**

i) 5 marks for 96-100% attendance ii) 4 marks

for 91-95% attendance iii) 3 marks for 86-90%

attendance iv) 2 marks for 80-85% attendance v)

0 mark for 75-79% attendance

vi) 'FA' for < 75% attendance

Students representing the University events either within the campus or outside the campus will be marked as present (OD). However, students should submit an OD form approved by Chairperson/Dean prior to attending the event. OD form submitted after the event will not be entertained and the student will be marked absent.

Grading System

2015 Admissions onwards		
Grade Point	**Grade**	**Rating**
O	10	Outstanding
A+	9.5	Excellent
A	9	Very Good
B+	8	Good
B	7	Above Average
C	6	Average
P	5	Pass
F	0	Failed
FA	0	Failed due to lack of Attendance
I	-	Incomplete (Awarded only for Laboratory project courses)
W	-	Withheld

If the student secures 'F' grade in any of the courses, he/she can reappear for the supplementary exam.

If the student secures 'FA' grade in any of the courses, he/she has to re- register(redo) for the course when it is being offered next.

A student who has been awarded 'I' grade in the laboratory courses shall take up additional laboratory sessions during the first two months of the next semester and earn a pass grade, which will be reflected in the next semester's grade sheet.

If a student is absent for the end semester examination, he/she will be allowed to reappear on proper evidence for his/her absence.

Grade Point Average (SGPA)

Based on the credits for which the student has registered and the grades awarded, Semester Grade Point Average [SGPA] and Cumulative Grade Point Average [CGPA] are calculated.

$$SGPA = \Sigma (Ci \times GPi)/\Sigma Ci$$

where Ci is the number of credits for *it*h course in that semester and GPi is the grade points earned by the student for that course.

Cumulative Grade Point Average (CGPA)

The overall performance of a student at any stage of the M.Tech. program is evaluated by the Cumulative Grade Point Average (CGPA) upto that point of time.

$$CGPA = \Sigma (Ci \times GPi)/\Sigma Ci$$

where Ci is the number of credits for ith course in any semester and GPi is the grade points earned by the student for that course. The summation is over all the courses registered by the student and evaluated during all the semesters up to that point of time, including the failed courses. The CGPA is rounded off to two decimals. The ranking of the students in a batch at any intermediate or final stage is based on CGPA.

Grade Sheet

Grade sheet issued to the student at the end of the semester will contain the following information.

1. Name, Roll No., Grade Sheet No., Semester, Branch, Month and year of Examination.
2. Course Code, Course Title, Credits and Grade Obtained, Grade Points Earned for the courses registered.
3. Credits registered and earned during the semester.
4. Cumulative Credits earned and Grade Points.
5. SGPA.
6. CGPA.

Revaluation of Answer Papers

An aggrieved student can request for revaluation of answer script of the end semester examination, through a well laid out procedure. There will be revaluation fee for each paper. If the revaluation leads to a better grade, the revised grade will be awarded to the

student and in such cases the revaluation fee will be refunded in full. Revaluation is allowed only for lecture-based courses.

Course Completion

A student is said to have successfully completed a course and earned the corresponding credits, if he / she has;

- Registered for the course.
- Put in 75% or more attendance in the course.
- Written the periodical tests and end semester examination.
- Obtained a pass grade D or above in the course.
- No disciplinary proceedings against him / her.

REMEDIAL MEASURES

Supplementary Examination

- Students with 'F' Grade may take the supplementary examination in a course up to a maximum of three additional attempts (excluding main end semester examination) carrying the previous internal assessment marks earned by them.
- Students failing to pass the course after two additional attempt shall henceforth appear for the supplementary examination for the entire 100 marks and the internal assessment marks earned by them in their regular registration shall not be considered.
- Grade Rule for supplementary examination: Supplementary exams will be evaluated against the most recent grade rule(whenever the course was offered recently during a regular semester)
- Fee for the supplementary examination will be Rs.300/ - per paper during the regular duration of the program, after which the student shall pay Rs.1000 per attempt.

Re-registration/Redo

A student who has not secured a pass grade in a course in the initial registration can register for the same course when offered next along with the junior batch. Students with FA grade are also permitted to register. Two chances of re-registration is allowed per course apart from the regular registration.

Contact Courses

Students in the final semester with one or two arrears with F grade(s) can register for the contact course, if offered. The contact course will run for 45 / 60 hours of contact classes depending on the credit load of the course. Students with FA grade in a given course cannot register for the course under this option.

Runtime Re-do Course

Students with F / FA grade in course can register for a runtime re-do course, if available, on the condition that the total number of credits registered in the semester shall not exceed 28 credits. Runtime re-do courses are run concurrently with a regular semester and would last a full semester.

Discipline

Every student is required to observe strict discipline and decorous behaviour both inside and outside the campus and should not indulge in any activity which may bring down the prestige of Amrita Vishwa Vidyapeetham.

A disciplinary action committee will deal with any act of indiscipline of misbehaviour, unfair practice in the class / university examination etc., and its decision on the action to be taken shall be final. Serious acts of indiscipline may even attract penalty leading to expulsion from the University.

Award of the Degree

A student will be declared eligible for the award of the Degree, if he / she has:

- Registered and earned the credits for all the core courses and project work.
- Earned the minimum required number of credits for the branch of study as specified in the curriculum.
- Earned the specified number of credits in all categories.
- No disciplinary action pending against him / her.
- There are no outstanding dues against him / her.

Classification of successful candidates

A student shall be considered to have successfully completed the programme, if he/she has -

a) registered and successfully completed all the core courses and projects.

b) earned the required minimum number of credits as specified in the curriculum corresponding to the branch of his/her study, within the stipulated time.

c) Earned the specified number of credits in all the categories of courses.

Candidates, who have successfully completed the programme, shall be classified as follows:

a)Candidates securing a CGPA of 8.00 and above – DISTINCTION. b)Candidates securing a CGPA between 6.50 and 7.99 – FIRST CLASS and the same be mentioned in the Degree Certificate'.

c)If the programme is completed after six(B.Sc.)/four(M.Sc.) semesters of study, the candidates securing a CGPA of 6.50 and above shall be classified to have completed the programme, only with FIRST CLASS.