UNIVERSITY OF CALCUTTA

Notification No. CSR/ 74 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus of Two-Year (Four-Semester) M.Sc. Course of Study in Microbiology under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018

17/08/18
(Debabrata Manna)
Deputy Registrar (Acting)

Syllabus for
M. Sc. Course in Microbiology
(from the academic session 2018-2019)

University of Calcutta

The regulations and academic syllabus for the Two-year M.Sc. course in Microbiology, University of Calcutta offering Choice Based Credit Courses (CBCC)

ADMISSION CRITERIA

1. A candidate who has passed the 3-year B.Sc. Examination **with a minimum of 55% aggregate marks in Honours in Microbiology** will be eligible for admission to this course. Reservation of seats will be governed by the rules of Govt. of West Bengal**.** At present, applicants from University of Calcutta will get admission to the 60% of seats (Part-A) in the order of their aggregate marks in B. Sc. Hons. Examination.
2. Seats available to the non-C.U. candidates will be guided by the directives of University applicable during the time of notification of admission process. These students, however, will have to satisfy the same eligibility criteria applicable to the students of University of Calcutta. Currently, forty percent of the seats (Part-B) will be filled up from a merit list prepared from the performance in a multiple choice question based admission test. This admission test is open to both C.U. and non-C.U. candidates.
3. The courses shall comprise a total of 1000 marks and 80 (eighty) credits evenly distributed over four semesters. The courses grouped as Core, Supportive and Choice based, will carry credits according to the number of theoretical classes required, study hours and laboratory hours. The duration of the semesters shall be as follows:

1st Semester	**July - December**
2nd Semester	**January - June**
3rd Semester	**July – December**
4th Semester	**January – June**

Examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as on the final Viva-Voce examination of the students on the experiments.

Semester-wise distribution of courses:

Courses	**No. of courses**	**Marks**	**Credits**
1st Semester			
Core courses	5	190	17
Supportive courses	1	60	3
2nd Semester			
Core Courses	5	220	18
Supportive Courses	1	30	2
3rd Semester			
Core Courses	3	125	10
Summer Project Seminar	1	25	2
Choice based Courses	2	100	8
4th Semester			
Core Courses	4	140	12
Supportive Courses	1	50	3
Dissertation		30	3
Grand Viva		30	2
Total		1000	80

Orientation of courses in different semesters for M.Sc. in Microbiology

1st Semester

CORE COURSES	**Theoretical**	**Practical**	**17 credits**
Micro C11: Biomolecular Structures & Their Interactions	30	-	3 + 0
Micro C12: Microbial Cell Biology	30	20	3 + 1
Micro C13: Molecular Biology	30	-	3 + 0
Micro C14: Biophysical Methods & Instrumentation	30	20	3 + 1
Micro C15: Microbial Metabolism	30	-	3 + 0
SUPPORTIVE COURSES			**3 credits**
Micro S11: Enzymes and Reaction Kinetics	30	30	2 + 1

2nd Semester

CORE COURSES			**18 credits**
Micro C21: Eukaryotic Microbiology	30	-	3 + 0
Micro C22: Recombinant DNA Technology	30	25	3 + 1
Micro C23: Diversity of life forms and environmental applications	30	25	3 + 1
Micro C24: Genetics (Prokaryotes & Eukaryotes)	50	-	4 + 0
Micro C25: Antibiotics	30	-	3 + 0
SUPPORTIVE COURSES			**2 credits**
Micro S21: Biostatistics	30	-	2 + 0

3rd Semester

CORE COURSES			**10 credits**
Micro C31: Fermentation and Bioprocess Engineering	25	-	2 + 0
Micro C32: Proteomics and Genomics	40	20	4 + 1
Micro C33: Regulation of Eukaryotic Gene Expression	40	-	3 + 0
CHOICE BASED COURSES			**8 credits**
CBCC- A: Choice Based Credit Course A	50	-	4 + 0
CBCC- B: Choice Based Credit Course B	50	-	4 + 0
Summer project and Seminar	25		0 + 2

4th Semester

CORE COURSES			**12 credits**
Micro C41: Virology	30	-	2+ 0
Micro C42: Immunology	30	20	3 + 1
Micro C43: Medical Biotechnology and Gene Therapy	30	-	3 + 0
Micro C44: Host-microbe interactions	30	-	3 + 0
SUPPORTIVE COURSES			**3 credits**
Micro S41: Computer Application and Bioinformatics	30	20	2 + 1
Dissertation	-	30	0 + 3
Grand Viva	-	30	0 + 2

Duration of theoretical examinations in different semesters for M.Sc. in Microbiology

All theoretical papers of 30 marks will be of 1hour 30 minutes duration. The examination for papers with 25 and 50 marks will be of 1 and 2 hours duration.

4. **FEES STRUCTURE:** Monthly and yearly fees to be collected from a student as per academic year July to June. Examination fees and other related fees are payable by the candidates as may be prescribed by university from time to time.

5. **ATTENDANCE:** A candidate shall be eligible for appearing at the examination provided he/she prosecutes a regular course of studies in the concerned Post Graduate (PG) Department for that semester in the subject and attends at least 65% of the total number of the Theoretical, Practical and Seminars separately held during the semester. A candidate failing to secure pass marks in a specific paper(s) shall not have to attend classes for appearing in the corresponding back paper(s) in a subsequent semester.
Condonable Limit: A student who has attended at least 55% of the classes but less than 65% of the classes shall, however, be eligible to appear in the examination upon payment of a fee as may be prescribed by the university from time to time and after obtaining the order order from the Vice Chancellor.
A candidate who becomes ineligible to appear in a semester examination due to shortage of attendance will have to attend the classes in the corresponding semester of the following academic session by paying prescribed fees.

6. **MAXIMUM PERMISSIBLE TIME FOR COMPLETING THE COURSE:** Students have to clear the entire course within 4 years from the year of first admission.

7. **EXAMINER:** Paper setters, moderators, examiners, and scrutineers for each paper will be appointed on the recommendations of the Board of Post Graduate studies in the concerned subject. Scripts will be examined by single/multiple examiner(s) for all theory papers and double/multiple (internal and external) for all practical papers, dissertation, viva voce etc.

8. **PASSING CRITERIA**: A candidate is required to appear at the examination in each and every paper/course/module/part/group of the respective syllabus. A candidate in order to be declared to have passed an examination, must obtain at least 40% marks in each paper/course/module/part/group. In case of a paper/course/module/part/group containing both theoretical and practical portions, a candidate is required to secure at least 35% marks separately in the theoretical and practical portions and at least 40% marks in aggregate in that paper. Candidates shall not be allowed to appear at any higher semester examination without appearing and clearing the minimum number of requisite paper(s) of all the previous semester examinations as mentioned hereinafter.

9. **CRITERIA FOR RE-APPEARING AT SUPPLEMENTARY EXAMINATION:** If a student gets 'F' in a particular paper, he/she shall be deemed to have failed in that paper only and shall be required to appear in a supplementary examination to be offered within one year of the original examination. Candidate who fails in one or two papers can clear the paper/s in two more consecutive chances **(excluding the first examination)** along with higher semester examination. If the candidate is unable to clear the same within two consecutive chances, he/she shall be dropped from the concerned course.

   A candidate who has **failed** in more than two papers will have to appear at the same semester without appearing at the higher semester. In that case, attendance in the theoretical classes will not be mandatory; however, the candidate has to attend practical classes, considering the evaluation of practical is through continuous assessment. A failed

candidate, intending to re-appear in a subsequent semester has to take permission from the concerned Faculty Secretary through the Head of the Department immediately after publication of result.

If all the chances of a candidate (first attempt + 2) has been exhausted, he/she has to drop or leave the course. He may apply for re-admission in the same course of study in the 1st Semester of the next academic session along with the fresh applicants. In any case, the candidate has to clear the entire course within 4 years from the year of first admission.

10. **ABSENT CRITERIA:** Failure to fill up the examination form shall be considered as missing a chance and such candidates who have not filled up the examination form shall have to appear at the same semester examination with required attendance. A candidate who has filled up the examination form but remains absent in the entire examination or more than two courses will be considered to have lost a chance and shall be required to re-appear at the same semester examination. A candidate remaining absent in one or two papers/courses but clearing the other papers/courses shall be considered to have failed in those papers/courses in which he remains absent and shall be eligible to clear those as stated above.

11. **READMISSION CRITERIA:** If a student is dropped from the respective course of study because of his failure to clear a particular course within 4 years, he/she may apply for readmission in the same course of study in the 1st semester of the next academic session along with the fresh applicants.

12. **CONSOLIDATED MARK SHEET:** After passing all the semesters a candidate may apply for a consolidated mark sheet to the Controller of Examinations upon payment of such fees as prescribed by the university.

13. **DATE OF PUBLICATION OF FINAL RESULT:** For a regular student who has cleared all the semesters in normal course, the date of publication of final result shall be the date of publication of result of the 4th semester. The final date of publication of result for students clearing previous semester(s) subsequent to their clearing 4th semester examination will be **date of publication of the last result clearing all papers.**

14. **CALCULATION OF GRADE POINTS, SGPA AND CGPA:** The schedule of papers, distribution of marks and credits, for the M.Sc course shall be determined by the concerned department duly approved by the respective Faculty Council/PG Board of studies. Credit-weighted grade point system will be followed and therefore only the grade points but not the overall percentage of marks either in individual paper or in aggregate marks will be provided. The grade points will be given according to the following computation.

Grading of students' performance:

Grade scores will be calculated in a scale of 6 (six) as per the following table:

Marks (%)	Grade Score Brackets	Grade Score added per each additional mark to minimum grade score in the bracket
80-100	5.00 - 6.00	0.05
70-79	4.50 – 4.99	0.05
60-69	4.00 – 4.49	0.05
55-59	3.75 – 3.99	0.05
50-54	3.50 – 3.74	0.05
40-49	3.00 – 3.49	0.05

00-39	Below 3.00	0.075

Award of Grade Points:

For example, if a student scores 53% in theory and 68% in practical in a 3-credit course (2+1), his/her grade point for the course will be as follows:

$$\text{Grade point} = \frac{2x(3.5+0.05x3)+1x(4.0+0.05x8)}{2+1} = 3.90$$

For a credit course with no practical component, for example a 2-credit course, if a student scores say, 56%, then the grade point will be:

$$\text{Grade point} = \frac{2x(3.75+0.05x1)}{2} = 3.80$$

Semester Grade Point Average (SGPA):

The computation of average grade point of a student in a semester will be worked out as follows:

N^{th} Semester

Course	Credits	Grade Scored
1	3+1	5.65
2	3+1	5.33
3	2+0	3.99
4	2+0	5.05
5	3+1	4.22
6	3+1	4.46

Semester Grade Point Average (SGPA) = 4.836

$$\text{SGPA} = \frac{(5.65x4)+(5.33x4)+(3.99x2)+(5.05x2)+(4.22x4)+(4.46x4)}{20} = 4.836$$

Cumulative Grade Point Average (CGPA) over four semesters:

Working out simple average of SGPA obtained over four semesters, cumulative grade point average will be given after four semesters.

Significance of grades:

On the basis of the cumulative results of the student's performance, the following grades will be given in each semester as well as over four semesters.

Grade points	Grades	Class
5.00 - 6.00	Outstanding (O)	First (I)
4.50 – 4.99	Excellent (A+)	First (I)
4.00 – 4.49	Very good (A)	First (I)
3.75 – 3.99	Good (B+)	Second (II)
3.50 – 3.74	Fair (B)	Second (II)
3.00 – 3.49	Satisfactory(C)	Second (II)
Below 3.00	Fail (F)	Fail

If a candidate gets "F" grade in one or more courses/modules/groups in a semester examination, his SGPA in that semester shall be temporarily withheld and GPW (Grade Point Withheld) shall be marked against SGPA on the mark sheet. A fresh mark sheet with duly calculated SGPA shall be issued only when a candidate clears the course subsequently but within the stipulated period.

15. **GRACE MARKS:** A candidate failing to obtain the pass marks in a semester examination shall be given benefit of one additional mark in the paper in which he/she secured lowest marks and the same shall be shown in the Tabulation Rolls. A candidate failing to obtain 50% or 55% or 60% marks in the aggregate of all the semesters by one mark only shall be given the benefit of one additional mark in the result of final semester and the same shall be reflected both in the Tabulation Roll as well as in the mark sheet.

16. **RANKING**: Candidate unable to clear each part of all the semester examinations in one chance shall not be entitled to any position in order of merit. To be eligible for award of rank in order of merit, a candidate must pass all the semesters at first chance as regular candidate.

17. **CANCELLATION OF EXAMINATION:** Candidates may apply to the Controller of Examinations for cancellation of enrolment of the said examination within fifteen days from the date of completion of theory papers. The said cancelled examination will also be counted as a chance.

18. **DIPLOMA**: A candidate shall be declared to have obtained the degree of M.Sc (2 year course) and shall get a degree certificate in the format specified hereunder (a candidate who has passed his/her undergraduation with honours in B.Sc will get the M.Sc degree)

"This is to certify that _____ obtained the degree of Master of Science in this university in ____ , under semester examination system, the special branch in which he/she was examined having been_____ and that he/she was placed in the class attaining grade_____ ."

Senate house

Dated *Vice Chancellor*

19. **CHOICE BASED CREDIT COURSE**: A student will have to take two courses from Choice Based Credit Courses (CBCCs) in addition to courses offered by the department. The students will have to choose one course each from two different groups. Each course is of 50 marks and carries 4 credits.

20. **Detailed academic syllabus for the two year M. Sc. Course in Microbiology**

1st Semester

CORE COURSES

Micro C11: Biomolecular Structures & Their Interactions, Theoretical : 30

(3 + 0 credits)

General structure of proteins in relation to biological function; chemistry of amino acids, polypeptides; four levels of protein structure, shape of protein molecules; there-dimensional protein structure determination; concept of protein structure motif, idea of prosthetic groups, chemical modification of proteins, protein splicing, unfolding of protein structure, effect of heat, pH and chemicals, denaturation and refolding of proteins, in vivo protein folding: concept of chaperones. Structure of DNA, (A, B, Z), supercoiling, nucleosomes, RNA, lipids, fatty acids and carbohydrates

Micro C12: Microbial Cell Biology Theoretical: 30, Practical: 20

(3 + 1 credits)

Cell as a basic unit of living systems; precellular evolution of cell; the evolution of cell from prokaryotes to eukaryotes and from single cells to multicellular organisms; Structure of the cell;

Bacterial Cell wall: structures, diversities and biosynthesis, different cell wall hydrolyzing enzymes; bacterial endospores: structure, formation and germination; Uncommon bacterial genera: Rickettsia, Chlamydia, Mycoplasma, sheathed bacteria, stalked and budding bacteria, gliding bacteria including Myxobacteria. Cellular structure and function; flagella, pili, capsules; specialized features of higher bacteria like budding, gliding bacteria etc.; fruiting body formation in myxobacteria.
Internal organization of the cell; Cell membrane structure; membrane constituents; phospholopids, glycolipids, cholesterol, membrane proteins, receptors and phospholipases; bilayer structure, asymmetry, fluid mosaic model of random diffusion of membrane components, domains in membrane- natural and artificial membranes;
General strategies of cell division: bacteria and yeast, molecular genetics of cell cycle regulation; Cell signaling; Chemotaxis, Quorum sensing; Regulation of biofilm formation,

Practical: Subcellular fractionation of nucleus, cell membrane and cytoplasm by differential centrifugation , nuclear staining by DAPI, subcellular localization of proteins: immunostaining methods and GFP-tagging.

Micro C13: Molecular Biology Theoretical: 30 (3 + 0 Credits)

DNA replication in prokaryotes and eukaryotes: General features and enzymology; detailed mechanisms of initiation, elongation and termination; experiments underlying each step and role of individual factors; telomerases: mechanism of replication, maintenance of integrity and role in cancer; Transcription: RNA polymerase subunits, different sigma factors- related to stress, viral infections etc., initiation, elongation and termination (rho- dependent and independent) of RNA synthesis; antitermination, attenuation and other influences of translational apparatus on the process of transcription; various protein motifs involved in DNA-protein interactions during transcription; translation: in prokaryotes and eukaryotes, processing of mRNA for translation and involvement of different translational factors at different stages of the process.

Micro C14: Biophysical Methods & Instrumentation Theoretical: 30, Practical: 20
(3 + 1 Credits)

Thermodynamics: extensive and intensive variables; mathematical description of a system with two or more variables, exact and partial differential; first law of thermodynamics, isothermal process, entropy and second law of thermodynamics, reversible and irreversible process, free energy and chemical potential; Gibb's free energy; potentiometric determination of pK's of amino acids. Free energy of charged macro-ions; Debye-Huckel theory; Hydration, solvation number.

Instrumentation: Principles of light absorption, extinction coefficient, ultraviolet, visible and infrared absorption spectrophotometer and their working principles; molecular vibrations, normal modes and group vibrations- hydrogen bonding effect on vibrational spectra; resonance Raman spectroscopy and its biological applications; Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD) and their application in the study of macromolecules; fluorescence and phosphorescence. Introduction to Mass Spectrometry, MALDI-TOF, ESI.

Practical: General laboratory practices and handling of instruments; training on centrifugation, microscopy and spectroscopy.

Micro C15: Microbial Metabolism Theoretical: 30 (3 + 0 Credits)

Bacterial photosynthesis (different types of photosynthetic bacteria, photopigments, paths of carbon and electron in bacterial photosynthesis); metabolism of energy reserve compounds (polyglycans, poly- and β-hydroxybutyrate); metabolic energetics: basic differences in anaerobic and respiratory kinds of energy metabolism; electron transport system; basic mechanisms of ATP synthesis; energy conservation in chemolithotrophic bacteria (*Nitrobacter, Nitrosomonas, Thiobacilli* including *Thiobacillus ferrooxidans*, methanogens, hydrogen oxidizing bacteria); respiratory metabolism- Embden-Meyerhoff pathway, Entner-Doudroff pathway, phosphoketolase pathway, glyoxalate pathway, Krebs' cycle, oxidative and substrate level phosphorylation, reverse TCA cycle, gluconeogenesis- Pasteur effect; energy metabolism and microbial growth; growth yield coefficients, theoretical growth yield; fermentation of carbohydrates-homo and heterolactic ferementations- mixed acid, propionic acid, butyric acid, acetone-butanol etc. fermentations, substrate level phosphorylation in anaerobic energy metabolism; transport processes

SUPPORTIVE COURSES

Micro S11: Enzymes and Reaction Kinetics Theoretical: 30, Practical: 30 (2 + 1 credits)

Definition of enzymes; active site, substrate, coenzyme, cofactor and different kinds of enzyme inhibitors; enzyme kinetics, two substrate kinetics, three substrate kinetics, deviation from linear kinetics; ligand binding studies; rapid kinetics; association and dissociation constants; use of isotopes in enzyme kinetics mechanism analysis; effect of pH, temperature and isotopically labeled substrates on enzyme activity; allosteric model of enzyme regulation; substrate induced conformational change in enzyme; techniques for purifying and characterizing proteins and enzymes; idea of all analytical techniques like electrophoresis, liquid chromatography, crystallography, column chromatography for enzyme protein analysis.

Practical: Estimation of proteins, enzyme kinetics, effects of pH and temperature on enzyme, use of inhibitors for active site determination, chromatographic techniques, purification of enzymes, chemical estimation of vitamins, minerals like calcium, iron etc, separation of biomolecules by electrophoresis, determination of molecular weight by gel filtration.

2nd Semester

CORE COURSES

Micro C21: Eukaryotic Microbiology Theoretical: 30 (3 + 0 Credits)

Important human and veterinary parasites, life cycle and biology of *Plasmodium, Entamoeba, Leishmania, Wuchereria, Fasciola, Schistosoma*, host parasite interaction. Protozoa: Classification of Protozoa, general biology of protozoal cell, process of reproduction in common protozoal classes, importance of protozoa in soil and water eco-system.

Elements of mycology: General classification of fungi, fungal cell structure, structure and biology of fungal spores of different kinds, reproduction in fungi, mycotoxins.

Micro C22: Recombinant DNA Technology Theoretical: 30, Practical: 25 (3 + 1 Credits)

Principles and methods of recombinant DNA technology- hybridization, cloning, sequencing, polymerase chain reaction, genome projects; gene manipulations; cloning in *E.coli*, plasmids,

bacteriophages and cosmid vectors, cloning strategies, genomic and cDNA library; expression of cloned genes in *E. coli*, products made in *E. coli* by genetic engineering; cloning in yeast: transformation in yeast, yeast vector development: Yep, YRp, YCp and YIp, 2μ plasmid, yeast artificial chromosome (YAC), expression of proteins in yeast; yeast 2-hybrid system. Genetic engineering of plants: transformation of plants, manipulating gene expression in plants, selectable markers and reporter genes, *Agrobacterium tumefaciens*; Genetic elements present on the Ti plasmid, genetic engineering of the Ti plasmid, vectors used to introduce foreign DNA into plant cells- binary cloning vector, disarmed Ti plasmid, cointegrate cloning vector; comparison of methods for transfer of DNA to plants, manipulation of gene expression in plants; production of transgenic plants without reporter or marker genes.

Practical: Isolation of bacterial genome and plasmid DNA, restriction enzyme digestion, restriction mapping and cloning, Southern blotting, RT-PCR.

Micro C23: Diversity of life forms and environmental applications Theoretical: 30, Practical: 25 (3+ 1 Credits)

Evolution of environment and Origin of life, Diversification of life and speciation; Classifying organisms: Concepts of phenetics and cladistics; Principles of ecological organization; Basics of structural & functional ecology; Concept of Population genetics; Basic approach to evolutionary biology and behavioral ecology; Evolutionary principles and stable strategies; types of selections.

Biodiversity- levels of biodiversity, alpha, beta and gamma diversity, Values and ethics of biodiversity; Global patterns of biodiversity, hotspots of biodiversity and megadiversity country; Biogeographic zones in India; factors influencing local and regional biodiversity, Biodiversity documentation.

Threat to species diversity, Extinction vortex, Causes of extinction; Population viability analysis; Red Data Book, Biodiversity conservation approaches: Local, National and International, In situ and ex situ conservation, Concept of protected area network, Selecting protected areas, criteria for measuring conservation value of areas, Sanctuary, National Park and Biosphere reserves; Design and management of protected areas; Threats to wildlife conservation and wildlife trade; Tools for wildlife research, Wildlife threat, Use of Radiotelemetry and Remote sensing in wildlife research

Perception on Bioresource; Legal binding of biological materials- concept of Biopatents

Environmental biotechnology: Understanding biotechnology, Concept and outlines of various applications- GM crops and GMO: Environmental implications;; Biodegradation, Phytoremediation: types and applications Bio-fuel production, Bio fertilizer, Bio pesticides; Integrated Pest Management,

Microorganisms and environmental pollutants: Overall process of biodegradation, Environmental biomonitoring and indicator microorganisms, biodegradation of organic pollutants, anaerobic biodegradation, in-situ and ex-situ bioremediation, case studies of microbial remediation, lagoon and Vadose zone bioremediation, surface bioremediation of soils and sludge, Applied bioremediation and industrial applications, developing bioremediation technologies, Concept of Fermentation technology and Bioreactor, microorganisms and metal pollutants, metal – microbial interaction and metal remediation; Microbial transformation of pesticides.

Waste treatment – modern wastewater treatment, traditional methods, wetlands and aqua-culture systems, Surface Bioremediation of soil and sludge

Practical: Isolation of heavy metal resistant bacteria, Metabolic fingerprinting of microbes by BIOLOG, isolation of cellulolytic bacteria from soil sample, preparation of total DNA from soil and water, amplification of 16S rDNA and DGGE electrophoresis.

Micro C24: Genetics (Prokaryotes & Eukaryotes) Theoretical: 50 (3 + 0 Credits)

Prokaryotic

DNA damage and repair: factors affecting DNA bases, identification and molecular characterization of repair enzymes in photoreactivation, excision, recombination, and SOS pathways; recombination and transposition: models for homologous recombination- the Holliday, Meselson-Radding and RecBCD pathways and their experimental supports; meiotic recombination- mechanism, the double-stranded DNA breaks; site-specific recombination and transposition: lambda phage integration and excision, bacterial use of site-specific recombination, eukaryotic (yeast, maize, fruitfly) and prokaryotic transposons.

Genetic recombination in Bacteria: Identification and selection of mutants; transformation: natural transformation systems, mechanism, gene mapping by transformation; chemical and electrotransformation. Conjugation: discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F12 heteroduplex analysis, chromosome transfer in other bacteria, Transduction: Generalized and specialized transduction; gene mapping by specialized transduction, mechanism of generalized transduction, abortive transduction.

Techniques of studying Bacteriophages-virulent phage(T4) and Temperate phage(phage lambda). Important aspects of life cycles; phage genome and gene mapping; host parasite relationship, immunity and repression; site specific recombination (lambda and PI), Transposable phage (Phage Mu), genetic organization and transposition , Phase variation in Salmonella and others.

Eukaryotic

Physical basis of Heredity: Cells, chromosomes, cell division, Mendel's laws, gametogenesis, life cycle (yeast, *C.elegans*); Single gene inheritance, terminology, allelic releationship, single gene crosses, Pedigree analysis; Two or more genes: Independent assortment, dihybrid cross, Genetic interactions: Two factor interaction, epistatic interaction, non-epistatic interaction, interactions with three or more factors. Linkage and Chromosome mapping: Linkage, cross over, chi square test for linkage, recombination frequency and map construction, tetrad analysis in yeast and recombination mapping with tetrad, mapping with molecular markers.

Yeast genetics: isolation and characterization of auxotrophic and temperature sensitive mutants, synthetic lethality, meiotic mapping, multicopy suppression.

Micro C25: Antibiotics Theoretical: 30 (3 + 0 Credits)

Definition, phenomenon of antibiotics, concept of secondary metabolites. Role of antibiotics in the producer organism. Assay of antibiotics: chemical versus microbiological assay system, different methods of antibiotic assays (serial dilution, photometric and agar-diffusion methods) - theory and practice; Chemical and biochemical modification of antibiotic structures: development of antibiotics (different generations of antibiotics) taking penicillins and chloramphenicols as parent compounds. Phenomenon of antibiotic resistance. Different biochemical mechanisms of resistance development, multiple-drug resistance, its genetics and chemical significance. Biochemical modes of action of antibiotics acting as inhibitors of ribosomal function (as for example aminoglycosides, tetracyclines, puromycin, choloramphenicol, microlides etc.), inhibitors of nucleic acid metabolism (actinomycin D, mitomycin C etc.), inhibitors of cell wall biosynthesis (penicilline, bacitracins etc.) and inhibitors of membrane function (polyenes, tunicamycin, ionophores etc.).

SUPPORTIVE COURSES

Micro S21: Biostatistics Theoretical: 30 (2 + 0 Credits)

Probability and statistics; population, variables, collection, tabulation and graphical representation of data, frequency distribution, central tendency and skewness, binomial, Poisson and Gaussian distributions, additive and multiplicative laws of probability, concept and correlation; regression; methods of least squares; chi-square tests, random number generation- testing and use; probability density and cumulative distribution function; systematic and random sampling.

3rd Semester

CORE COURSES

Micro C31: Fermentation and Bioprocess Engineering Theoretical: 25

(2 + 0 Credits)

Introduction to Bioprocess Engineering, Bioreactors, and Membrane Bio reactors, Isolation, preservation, and Maintenance of Industrialn Microorganisms, Kinetics of microbial growth and death, Media and medial sterilization for industrial Fermentation. Air quality Management and air sterilization. Types of Fermentation processes: Analysis of batch, Fed-batch and continuous bioreactors, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed, fluidized, photobioreactors etc.); Fermentation kinetic and monitoring; Measurements and control of bioprocess parameters.

Downstream processing: Introduction, removal of microbial cells and solid matter, foam preparation, precipitation, filtration, centrifugation, cell disruptions, liquid liquid extraction, chromatography, Membrane process, Drying and Crystaliztion, Effluent treatment: D.O.C. and C.O.D. treatment and disposal of effluents. Whole cell immobilization and their industrial applications: Immobilized enzymes, enzymes in aqueous and nonaqueous media, Bioconversion and biotransformation. Industrial production of chemicals: alcohol (ethanol), Acids (citric, acetic, and gluconic), solvents (glycerol, acetone, and butanol) antibiotics (ampicillin, streptomycin and tetracyclin), microlodes, anticancer antibiotics, aminoacids (lysine, glutamic acids), single cell protein, single cell lipids. Use of microbes in mineral beneficiation and oil recovery. Introduction to food technology: Elementary idea of canning and packing– fat based edible products, sterilization and pasteurization of food products, fat-based nutraceuticals technology of typical food/food products (bread, cheese, idli, agro-products (oilseeds), food preservation, food colors, flavors, and antioxidants. Introduction to Bioprocesses technology: Hydrogenation, oxidation, esterification.

Micro C32: Proteomics and Genomics Theoretical: 40 Practical: 20

(4 + 1 Credits)

Proteomics

Mass spectroscopy, basic principle, MALDI-TOF, ESI; 2-D Gel electrophoresis, Nuclear magnetic resonance spectroscopy (NMR), basic principles, chemical shift, spin-spin interaction, NOE, 2D-NMR**,** NOESY, COSEY.

X-ray Crystallography: Principle of X-ray diffraction, scattering vector, structure factor, phase problem, reciprocal lattice and Ewald sphere, Miller indices, Zone axes, crystal lattice, Lane Equations, Bragg's law, special properties of protein crystals, model building, refinement and R-factor.

Genomics

Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, chromosome microdisection, molecular markers in genome analysis; RAPD and AFLP analysis, molecular markers linked to disease resistant genes, application of RFLP in forensic, disease prognosis, genetic counseling, pedigree, varietal etc. Genome sequencing: genome sizes, organelle genomes, genoimc libraries, strategies for genome sequencing, packaging, transfection and recovery of clones, application of sequence information for identification of defective genes. Pharmacogenetics, genetics of globin triplet repeat disorders, cancer genetics; immunogenetics; mapping of human genome; somatic cell genetics; DNA polymorphism in mapping; structure and function; biochemical genetics; polygenic inheritance, Microarray

Practical: DNA sequencing, PCR based site directed mutagenesis, Protein electrophoresis-1D + 2D.

Micro C33: Regulation of Eukaryotic Gene Expression Theoretical: 40 (3+0 Credits)

Chromatin organization, cis- acting sequences in transcriptional regulation, mechanisms of action at a distance, trans- control of transcription, different modes of mRNA, tRNA splicing, general discussion on various snRNPs, capping, polyadenylation and other processing events in eukaryotes, RNA editing; discussion on ribozyme; RNA interference: mechanisms and enzymology; regulation of gene expression by miRNP pathway; regulation of translation, tissue specific regulation of transcription, dissecting eukaryotic regulatory elements. Intracellular protein trafficking

Summer Project and Seminar: Marks 25 (0+ 2 Credits)

A project performance report based on the summer research training in a reputed laboratory of excellence will have to be submitted. A presentation of the accomplishments will be required before a panel of experts. Evaluation will be based on both the project report and presentation.

4th Semester

CORE COURSES

Micro C41: Virology Theoretical: 30 (2+ 0 Credits)

Classification and modes of propagation, bacterial, plant and animal viruses: morphology and ultra structure; assay of viral particle, cell culture, viral enzymes, nuclic acids, bacterio phages; lambda, T4, T7, M13, lytic cycle, lysogeny; viral replication, nucleic acid and protein synthesis, viral diseases. Virus host interaction: virus infection, viral diseases and pathogenesis: Herpes, adeno, hepatitis, rhabdo, oncogenic viruses etc. DNA viruses: Herpes, hepatitis B, adenovirus; RNA viruses: polio, VSV, influenza, retroviruses: structure and life cycle, transformation; baculovirues.; molecular biology of genetic shift and drift in influenza virus, cellular trophism of HIV; Plant viruses: TMV.

Micro C42: Immunology Theoretical: 30, Practical: 20 (3 + 1 Credits)

Immunoglobins, organization and expressions of Ig genes; B cell maturation, activation and differentiation; MHC/ HLA; antigen processing and presentation; T-cells, T-cell receptors, T-cell maturation, activation and differentiation; cytokines; cell mediated and humoral effector responses, auto immunity, immunodeficiency diseases, transplantation immunology, cancer and immune system. Monoclonal and polyclonal antibodies, monoclonal antibody technique.

Practical: Immunization with a specific antigen and raising of the antibody, Determination of blood group (ABORL), Bacterial agglutination (raising antibody in rabbit using bacteria as antigen), ODD (Ouchterlony double diffusion), SRID (Mancini's method), Immunoelectrophoresis. Lymphocyte

preparation from peripheral blood and separation of macrophages. Antibody producing CFU form mouse spleen.

Micro C43: Medical Biotechnology and Gene Therapy Theoretical: 30 (2 + 0 Credits)

Disease diagnosis-probe, PCR, LCR immunological assay. Detection of genetic, Neurogenetic disorders involving Metabolic and Movement disorders. Treatment-products from recombinant and non-recombinant organisms, Interferons, Antisense therapy, cell penetrating peptides.

Gene therapy, Types of gene therapy, somatic virus germline gene therapy, mechanism of gene therapy, Immunotherapy, Detection of mutations in neoplastic diseases MCC, SSCP, DGGE, PTTC. Focusing on emerging infections, viral classifications, transmissions and preventions, viral pathogenesis, mechanisms of viral induced cancer and viral evolution, developmental biology of virally induced birth defects, factors in pathogenesis and transmission of prions. Cell mediated and Gene therapy as a novel form of drug delivery, vectors, cell types. Responses to viral infections; slow and persistent infections, anti viral agents, interferons, equipments and materials for animal cell culture technology. Primary and established cell line cultures. Introduction to the balanced salt solution and the simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Serum and protein free defined media and their applications. Measurements of viability and cytotoxicity. Biology and characterization of the culture cells, measuring parameters of growth. Basic techniques of mammalian cell culture in vitro; desegregation of tissue and primary culture, maintenance of cell culture, cell separation. Scaling up of animal cell culture. Cell synchronization. Cell cloning and micromanipulation. Cell transformation. Application of animal cell culture. Stem cell culture, embryonic stem cells and their applications. Cell culture based vaccines, somatic cell genetics, organ and histotypic cultures.

Micro C44: Host-microbe interactions Theoretical: 30 (3 + 0 Credits)

Pathogenic bacteria, bacterial diseases, mechanism of pathogenesis, prophylaxis, therapy etc. (*Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Corynebacterium, B acillus, Closridium*,) enterobactriacae (*Shigella, Salmonella, E.coli*), *Vibrio* etc., *Mycobacterium* etc. Accute diarrhoeal diseases, food poisoning , Meningitis, tuberculosis, diptheria, leprosy, urinary tract infection, cystic fibrosis, typhoid, enteritis (in *Helicobacter pylorae*), gastritis, cholera, pneumonia; Bioweapons- infectious agents and their epidemiology. Common mycotic infections in human: superficial, subcutaneous, cutaneous, and systemic mycoses.

Plant-microbe interactions: Rhizosphere and phyllosphere microorganisms and their interactions with plants; Symbiotic vs nonsymbiotic nitrogen fixation, symbionts and their cognate hosts, regulation of nitrogen fixation in a symbiotic vs a non-symbiotic N fixer; mechanism of inception of symbiosis, symbiosis vs pathogenesis. Plant pathogens (bacterial, fungal, algal and mycoplasmal); mechanisms of plant pathogenicity, beneficial association between plant and microorganisms (association of plants with cyanobacteria, actinomycetes and fungi).

Human-microbe mutualism and disease, manipulation of host cell pathways by bacterial and parasitic pathogens. Different types of secretory bacterial pathways

Supportive Courses

Micro S41: Computer Application and Bioinformatics Theoretical 30, Practical: 20

(2 + 1 Credits)

Computer Application

Basic idea to work on Linux platform – basic concept of OS. Simple shell commands.

Bioinformatics

Concept of homology, paralogy, orthology, analogy and xenology

Comparison of sequences of biological macromolecules – Pairwise alignment: local and global alignment; Concept of indel, affine gap penalty; Database search algorithm, significance of hits, Karlin Altschul equation; Multiple sequence alignment, concept of consensus, interpretation with regular expression, concept of protein profile and PSSM, algorithm of PSI-BLAST. PHI-BLAST and other forms of BLAST.

Concept of tree, reading and interpreting phylogenetic trees, distance-based and character-based methods for the construction of phylogenetic trees, judging strength of clades (with BS or PP values) in a tree.

Kyte-Doolittle plot and Hopp-Woods plot- prediction of localization of a protein, prediction of TMD. Secondary, tertiary and quaternary structure prediction –concept of propensity in Chou-Fasman method; Homology modeling, threading and ab initio method; Docking – rigid and flexible, protein-protein and protein-ligand.

Practical: Pairwise alignment- local and global alignment using Smith-Waterman and Needleman-Wunsch algorithm respectively. Comparison of the results with reference to percentage identity, percentage gaps etc.
Comparison of the different BLOSUM matrices
Cross dot plot to identify regions of similarity/identity and self dot plot to identify repeats
Two BLAST searches - one using a house keeping protein and another using a rare protein. Comparison of the results with reference to elements of the search list
Study of the CATH and SCOP database to write a report followed by classification of a given protein
Hydropathy plot of a globular and a membrane protein followed by a comparison of the two plots
Identification of consensus sequence through multiple sequence alignment
Using the multiple sequence alignment for the construction of phylogenetic tree
Tertiary structure prediction using homology modelling and threading

Dissertation: 30 (0+ 2 credits)

A grant proposal on any relevant topic in biology will have to be prepared by students following the format of National Institute of Health, USA. The students will also be required to defend the proposal before a panel of experts. Both the written proposal and its defense will be taken into consideration for evaluation.

Grand viva: 30 (0+ 2 credits)

Students will be evaluated on all the topics discussed in the two years programme by a panel of experts.

CBCC to be offered to the students of other departments: Fundamentals of Bacteriology

1) The discovery of microorganisms, the conflict over spontaneous generation, Koch's postulates, an overview of prokaryotic cell structure, cell wall, cell membrane, nucleoid, plasmids, endospore, comparison of prokaryotic and eukaryotic cells.
2) Microbial nutrition, growth and control: Common nutrient requirements, nutritional types of organisms, culture media, isolation of pure culture, continuous cultures of microorganism; control of microorganism by physical and chemical agents, basics of water bacteriology, influence of environmental factors on microbial growth in natural environments.
3) Identification of microbe and microbial community, comparison of ribosomal RNA sequences – Pairwise alignment: local and global alignment, Multiple sequence alignment, construction of phylogenetic tree.