KRISHNA INSTITUTE OF MEDICAL SCIENCES "DEEMED TO BE UNIVERSITY", KARAD

Accredited By NAAC With 'A' Grade

Revised Syllabus (CBCS) For

Master of Science Microbiology

To be implemented from 2019-20

(In a Phase Manner)

Prologue

The Faculty Allied Sciences (Then Krishna Institute of Biotechnology and Bioinformatics) was established in 2007 with Two Post graduate courses Microbiology, Biotechnology. Currently Five faculty members are engaged in Academic functions.

The seemingly overwhelming and ever expanding state of knowledge about microorganisms, their genetic material, Molecular Biology and Recombinant DNA Technology increases the scope of Biotechnology. This newly emerging branch of science offers something for everyone and it cultivates informed citizens who can make perceptive decisions on important events. Many discoveries made by Microbiologists and Biotechnologists have spawned new fields of science such as molecular Biology, Genetics, Enzyme Technology, Fermentation Technology, Bioengineering, Genetic Engineering, Immunology etc. Many studies have been made using Science and Biotechnology to understand the principles that govern life.

New developments are occurring constantly in these areas and thus Biotechnologies have become the mainstays of many technologies. This has necessitated the formation of the Biotechnology courses for the development of competent, smart and dynamic Biotechnologists that are required in Academic Institutes, Research organizations, Professional organizations and in various industries such as Pharmaceutical Industries, Enzyme Industries, Food and Dairy Industries, Wine and Alcohol Industries, Agro based Industries. **The Choice –Based Credits System (CBCS)** provides for a framework within which there is flexibility in the design of courses and their content ,simultaneously also providing the students a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to courses content and structure

The rapid pace of discovery and their application dictates a somewhat selective inclusion of theory paper / topics and practical and proper training of the students. The course is designed in such a way that students remain constantly busy with their studies through the Lecture and Practical periods, Seminar periods, Home assignments, Mid – term examinations (Periodic tests), Preliminary or term end examinations and also gets exposure to outside world through visits to Research Laboratories / Science Institutes / Industries of Biotechnological interest. The course also makes the provision for training in research through the research project (during one or two semesters) and / or Industrial training in organization of Microbiological interest. (During one semester / one summer vacation.)

Over all it is aimed to design **Two year post graduate (M.Sc.) course in Microbiology** with a balanced coverage of traditional and “cutting edge technology” along with the necessary courses (Communication skills, Biostatistics, Computer science, Scientific writing and Presentation, Research training / Industrial training) as per the UGC guidelines and produce competent Biotechnologists to meet the demand of Industries, Research organizations and Academic Institutes in the country and abroad.

Process of Curriculum Design

The Choice-Based Credit System (CBCS) provides a framework within which there is flexibility in the design of courses and their content. At the same time it also provides the student a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to course content and structure.

Curriculum Designing Process

Following procedure was adopted for curriculum designing: For curriculum development first need analysis was done and then based on need analysis draft syllabus was prepared in the Departmental Curriculum Committee meeting and it was subsequently discussed in College Curriculum Committee meeting were all faculty members participated in the discussion and debated over the draft syllabus. The draft syllabus approved in the College Curriculum Committee meeting was sent to BOS were given by external subject experts were considered and incorporated in the final draft. The draft syllabus finalized in BOS was sent to Academic Council for it's approval.

When revising the syllabi for the courses, the courses to be implemented as well as the content of each course was extensively discussed and debated on, feedback obtained from students, faculty, subject experts from academic institutes, industry experts, alumni were extensively discussed and debated in the meetings of curriculum committees and BOS and the inputs were considered. Thus for the development of syllabus contributions came from external subject experts, faculty members, feedback obtained from students, alumni, external experts and members of industry.

M.Sc. Microbiology program objectives

After completion, the students are expected to understand the:

(a) Basic and applied aspects of microbial diversity and systematic taxonomy, Physiology, biochemistry and applications of basic aspects of microbial diversity.

(b) Principles, working and application of bioinstruments used in isolation and identification of microbes and structural determination of biomolecules,

(d) characteristics and significance of archea, algae, fungi, viruses,

(e) Impact of various groups of microbes on earth atmosphere, human, plant and animal health and technology development,

(f) structure, properties, pathways, significance and applications of microbial biomolecules,

(g) basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses,

(h) causes, mechanisms and consequences of defect in gene/genome of microorganisms, and

(i) basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes, enzyme function in non-aqueous environment.

Structure of M.Sc. program in Microbiology

M.Sc. Microbiology program is of two years duration and is conducted in four semesters. As recommended by UGC university has adopted a outcome-based education approach. The various courses of the program are designed to include classroom teaching, laboratory work, project work, seminars, home assignments, industrial visit etc.

Program Educational Objectives:

The objectives of the **M. Sc. Programme in Microbiology** is:

(i) To equip the students with the basic and applied knowledge of molecular mechanisms of cellular processes in living systems including microbes, plants, animals and humans.

(ii) To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.
(iii) To provide the students with the current updates in the areas of Analytical Techniques, Industrial Fermentations, Environmental Biotechnology.
(iv) To train students with research work methodology through small project work.
(v) To generate competent skilled human resource for industries and research organization.

Eligibility

Candidates must have passed B.Sc. With minimum 50% marks with Biotechnology/ Microbiology/ Industrial Microbiology/ Zoology/Botany as principal subject or with Biochemistry/ Microbiology/ Botany/ Zoology as subsidiary subjects at B.Sc. II level

Course fees

As shown in Admission Broacher of respective year (Subject to change as and when required)

Duration

The duration of M.Sc. (Microbiology) degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory and practical course must be completed in 60 lectures/Practical periods, respectively of 60 min duration.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture. While credit weightage for self-learning based on e-content shall be 50% or less than that for lectures.

Attendance

The student enrolled for M.Sc. Microbiology must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per ordinance.

1. The entire M.Sc. course in Microbiology shall be covered in 16 [sixteen] theory papers, 7 [seven] practical course [semester I, II, III] and a project work / Industrial training [in lieu of one practical courses of semester IV] each semester there shall be four theory papers each carrying 100 marks and for first three semesters viz. semester I, II and III, there shall be two practical courses each practical course shall carry 100 marks. However, for semester IV there shall be a research project work / Industrial training of 100 [one hundred] marks in lieu of one practical course in addition to four-theory paper and one practical course.
   Semester I: Four theory papers and two practical courses.
   Semester II: Four theory papers and two practical courses.
   Semester III: Four theory papers and two practical courses.
   Semester IV: Four-theory papers. One practical course and a project work / Industrial training practical course for every student.

2] Each theory paper will be covered in four lectures of 60 minuteseach per week.

Practical course shall be covered in 04 practical turns of 04 clock hours practical periods per week.

3] A practical batch shall be of 12 [twelve] to 15 [fifteen] students.

4] For university practical examination the duration should be as shown below,
For every semester there shall be two / three days practical examination for not less than 5 ½ hours.

5] Each candidate must produce a certificate from the Head of the Department in his/her college / Institute / University stating that he/she has completed, in a satisfactory manner, a practical course on the lines laid down from time to time by Academic Council on the recommendations of Board of studies and that the laboratory journal has been properly maintained. Every candidate must have recorded his/her observation in the laboratory journal and a written report on each exercise performed. Every journal is to be checked and signed periodically by a member of teaching staff and certified by the Head Of the Department at the end of each semester. Candidates are to produce their journal at the time of practical examination.

6] There shall be one compulsory seminar of minimum 15 min. delivery per paper per semester for each student and there shall be two marks for each seminar in Internal evaluation.

During semester I & II students shall have to undertake an academic tour to visit a minimum one place of academic interests like Academic Institute/ Research Institution / R&D Department/Industry. The student should submit the report of their visit at the time of practical examination. The report should be duly certified by the Head of the Department of Microbiology, Biotechnology.

7] During semester Student is to undertake a research project [as part of the semester IV] which is to be started in the beginning of semester III so as to give enough time for duly completion of project. In the project student is to study research methodology Information collection (reference work) selection of topic, outline of the work, thinking and planning, project report writing in the form of dissertation or small Project Report and the submission of the project report [Introduction, Aims and objectives, Material and method, Results and Discussions, summary, Conclusions and Bibliography] For the research project work out of one hundred marks, fifty marks shall be given by university examiners though assessment of Project Report at the time of semester IV practical examination. The remaining fifty marks shall be given by the Committee for Internal Evaluation of Projects (CIEP) as an internal evaluation. CIEP is to be constituted by the Principal (and which shall be consisting of HOD, Guide / Teacher in - charge and at least one other faculty members). The method and process of Internal evaluation is to be worked out by the CIEP.

**1) The Institute or guide of student should locate the industry and depute the student in the industry for the period of one month

2) Student should complete its industrial training cum industrial project in the vacation period after semester II

3) Student should study microbiological and / or biotechnological aspects in industry and submit its report in the form of dissertation or small Project Report duly signed by industry authority, concerned guide and Head of the Department of Microbiology, Biotechnology.

Two year M.Sc. Microbiology Programme (Programme Code: 5201)

Course Structure

M. Sc. Part I Semester I

		M. Sc. Microbiology CBCS w. e. f. 2019-20(Revised)									
	Sr. No.	Course Code	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
				T	P	Total	Internal		External		
							T	P	T	P	
CGPA		Theory									
	1	5201-11 CC	Foundation of Biochemistry for Microbiologist	4	--	4	20	--	80	--	4
	2	5201-12 CC	Foundation of Cell Biology and Biostatistics for Microbiologist	4	--	4	20	--	80	--	4
	3	5201-13 DSE	Medical Microbiology and Immunology-I	4	--	4	20	--	80	--	4
	4	5201-14 CCS	Biochemical, Biophysical Immunochemical and Microbiological Techniques	4	--	4	20	--	80	--	4
		Practicals									
	5	5201-15 CC	Practical Course I	---	4+4	8	--	20	--	80	4
	6	5201-16 CC	Practical Course II	---	4+4	8	--	20	--	80	4
		Mandatory Non CGPA Course									
NON CGPA(No Weightage in CGPA calculations)	7	01 AECC	Yoga and Meditation	2	2	2	50		---	--	2
		Total Credit for Semester I: 26 (T = Theory 16) ; P = Practical : 8; AECC= Ability Enhancement Compulsory Course: 2), CC: Core Course, CCS : Core course specialization DSE: Discipline Specific Elective, Total Credits for Semester I CGPA course = 24 credits									

M. Sc. Part I Semester II

		M. Sc. Microbiology CBCS w. e. f. 2019-20(Revised)				
	Sr.	Course	Course Title	Teaching Hours/	Marks (Total 100)	

	No.	Code		Week							Credits
				T	P	Total	Internal		External		
							T	P	T	P	
		Theory									
CGPA	1	5201-21 CC	Microbial physiology and metabolism	4	--	4	20	--	80	--	4
	2	5201-22 CCS	Microbial Genetics and Molecular biology	4	--	4	20	--	80	--	4
	3	5201-23 DSE	Medical Microbiology and Immunology – II	4	--	4	20	--	80	--	4
	4	5201-24 CC	Fundamentals for use of computers and communication skills and scientific writing and presentation	4	--	4	20	--	80	--	4
		Practicals									
	5	5201-25 CC	Practical Course III	---	4+4	8	--	20	--	80	4
	6	5201-26 CC	Practical Course IV	---	4+4	8	--	20	--	80	4
		Mandatory Non CGPA Course									
NON CGPA (No Weightage in CGPA calculations)	7	02 SECC	A Soft Skills and Personality Development	2	2	2	50		---	--	2
		Total Credit for Semester II: 26 (T = Theory 16 ; P = Practical : 8; SECC= Skill Enhancement Compulsory Course : 2), CC: Core Course, CCS : Core course Specialization DSE: Discipline Specific Elective, Total Credits for Semester II CGPA course = 24 credits									

M. Sc. Part II Semester III

	Sr. No.	Course Code	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
				T	P	Total	Internal		External		
							T	P	T	P	
CGPA		Theory									
	1	5201-31 CCS	Food and Dairy Microbiology	4	--	4	20	--	80	--	4
	2	5201-32 CC	Microbial Technology – I	4	--	4	20	--	80	--	4
	3	5201-33 DSE	Environmental and Applied Microbiology	4	--	4	20	--	80	--	4
	4	5201-34 GE	Bioinformatics for Microbiologist	4	--	4	20	--	80	--	4
		Practicals									
	5	5201-35 CC	Practical Course V	---	4+4	8	--	20	--	80	4
	6	5201-36 CC	Practical Course VI	---	4+4	8	--	20	--	80	4
NON CGPA (No Weightage in CGPA calculations)		Mandatory Non CGPA Course									
	7	03 AECC	Leadership Development	2	2	2	50		--	--	2
	8	Elective Course (EC)									
		EC	SWAYAM / MOOC courses								4
		Total Credit for Semester III: 30 (T = Theory: 16, P = Practical : 8; AECC =Ability Enhancement Compulsory Course:(02 +04)=06 , CC: Core Course, CCS : Core course Specialization DSE: Discipline Specific Elective, GE: Generic Elective Total Credits for Semester III CGPA course = 24 credits									

	Sr. No	Course Code	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
				T	P	Total	Internal		External		
							T	P	T	P	
		Theory									
CGPA	**1**	**5201-41 CC**	Enzymology	4	--	4	20	--	80	--	4
	2	**5201-42 CCS**	Microbial Technology II	4	--	4	20	--	80	--	4
	3	**5201-43 GE**	Recombinant DNA Technology	4	--	4	20	--	80	--	4
	4	**5201-44 DSE**	Pharmaceutical Microbiology	4	--	4	20	--	80	--	4
		Practicals									
	5	**5201-45 CC**	Practical Course VII	---	4+4	8	--	20	--	80	4
	6	**5201-46 CC**	Project Work **OR** Vocational Training (Industrial Training)	---	4+4	8	--	50	--	50	4
	7	**5201-47 CC**		----	*	*	50		---	50	4
		***- Minimum one month Vocational Training/ Industrial Training**									
NON CGPA (No Weightage in CGPA calculations)		**Mandatory Non CGPA Course**									
	8	**04 SECC**	Biotechnology Data Care Management	2	2	2	--	50	--		2
		Total Credit for Semester IV: 26 (T = Theory :16; P = Practical : 8; SECC = Skill Enhancement Compulsory Course: 2), CC: Core Course, CCS : Core course Specialization DSE: Discipline Specific Elective, GE: Generic Elective Total Credits for Semester IV CGPA course = 24 credits									

I CGPA Courses :

There shall be in all 24 courses per programme out of these there shall be

1. There shall be 16 core courses per program.
2. There shall be 04 Core course Specialization per programme.
3. There shall be 02 Discipline Specific Elective courses
4. There shall be 02 Generic Elective Courses.
5. Total credits for CGPA courses shall be of 96 credits per program.

II Mandatory Non-CGPA Courses:

1. There shall be 02 mandatory non CGPA Ability Enhancement Course (AEC) of 02 credits each per program.
2. There shall be 02 mandatory non CGPA Skill Enhancement Course (SEC) of 02 credits per program.
3. There shall be 01 Elective Course (EC) SWAYAM/MOOC. The credits of the course shall be as specified on SWAYAM/MOOC portal.
4. The total credits for Non CGPA course shall be of 08 +04 credits.

M. Sc. Microbiology Syllabus (CBCS)

(To be introduced with effect from academic year 2019-2020 for M. Sc. Part I (Semester I & II))
and

(To be introduced with effect from academic year 2020-2021 for M. Sc. Part II (Semester III & IV))

M.Sc. Part I Semester I

Course Code: 5201-11Foundation of Biochemistry for Microbiologists (04 credits)

Course Objectives:

1) To give students the knowledge about the important biomolecules like Protein, Carbohydrates, Lipids, Nucleic acids, Porphyrins.
2) To make students familiar with the vitamins and their structures & functions.
3) To give students the knowledge of chemistry of cell walls of Bacteria, Actinomycetes & Yeasts.

Course Outcomes:

1) Students would be well versed on the fundamental principles of Biochemistry.
2) Students will have through knowledge of structures and functions of Bio-macromolecules like proteins, carbohydrates, lipids, Nucleic acids (DNA and RNA). Students will be well versed with structure and functions of vitamins, and chemistry of cell walls of bacteria, actinomycetes & yeasts.

Unit I (12)

- **Chemical Bonding:**

Introduction to chemical bonds, covalent bonds, ionic bonds, hydrogen bond, coordinate bond, metallic bond, Van der Waals forces.

- **Protein chemistry:**

Amino acids: Properties, structures, functions and classification of common amino acids. Uncommon amino acids.

Peptides and proteins: Peptides bond formation, types of peptides, and lengths of peptides chain, conjugated proteins and their classification.

Protein structure: Levels of organization of protein structures – primary, secondary, tertiary and quaternary structures. The three dimensional structure of proteins, determination of sequence of amino acids in peptides or protein.

- **Proteins purification and characterization:** Fractionation, Dialysis, Chromatographic techniques, Electrophoresis, Sequencing methods for polypeptide

Unit II (12)

- **Lipid chemistry:**

Storage lipids: fatty acids – nomenclature structure and properties of some naturally occurring fatty acids, Triacylglycerols and their functions as storage lipids.

Structural lipids in cell membranes: Glycerophospholipids, galactolipids, sulfolipids, sphingolipids, and sterols. Lipids as signals, cofactors and pigments.

Phosphatidyl inositols and sphingosine derivatives as intracellular signals Eicosanoids, Prostaglandins, Thromboxanes, Leukotrienes, Vitamins: A, D, E and K.

An outline of method of the extraction, separation and identification of cellular lipids.

Unit III **(12)**

- **Carbohydrate chemistry**:

Nomenclature of carbohydrates, Types of carbohydrates:

(a) Monosaccharides & disaccharides

(b) Polysaccharides

(c) Glycoconjugates

Carbohydrate as informational molecules – the sugar code, An outline of methods of carbohydrate analysis.

Unit IV **(12)**

- **Nucleic acid chemistry:**

Nucleotides (the building blocks of nucleic acids): components, structures and nomenclature.

Nucleic acid structures:

(a) DNA: Watson – Crick Model, Three-dimensional forms of DNA

(Comparison of A, B and Z form of DNA)

Unusual DNA structures – palindromes, mirror repeats, inverted repeats, hairpin (or cruciform), Hoagsteen pairing, triplex DNA's, G tetraplex DNA, H - DNA.

(b) RNA: monocistronic and polycistronic RNA, base – paired helical structure in RNA.

(c) Denaturation and renaturation of double stranded DNA and RNA, DNA hybridization, DNA sequencing by Sanger method. Chemical synthesis of DNA (Automated)-Principle and major steps involved.

- Ribozymes- **types and therapeutic applications.**

Unit V **(12)**

- Chemistry of porphyrins: Chlorophylls, Cytochromes, and Hemoglobin.
- Chemistry of Microbial Pigments.
- Chemistry of cell walls of Gram positive bacteria, Gram negative bacteria, Actinomycetes and Yeasts.
- **Vitamins:** (Water soluble and fat soluble vitamins): Structure and functions of:

(a) Water soluble Vitamins – Vitamins B1, B2, B6, B12, Folic acid, Pantothenic acid, Niacin and Biotin.

(b) Fat soluble Vitamins – Vitamins A, D, E and K.

Reference Books:

1. "Biological Chemistry", by Mehlar, H. R., and E. H. Cord, 1968, Harper & Row Publishers Inc, New York.
2. "Biochemistry", by Stryer, L., 1981, 2nd edition, W. H. Freeman and Company, San Francisco.
3. "Principles of Biochemistry", by Lehninger, A. L., 1984, 1st Indian Edition, LBS Publishers and Distributors Pvt. Ltd., New Delhi.

4. “Biochemistry”, by Stryer, L., 1988, 3rd edition, W. H. Freeman and Company, San Francisco.
5. “Principles of Biotechnology,edited by Wiseman, Alan, 1988, Chapman and Hall, New York, USA.
6. “Biochemistry”, by Menlo Park: Benjamin / Cummings.
7. “Biochemistry”, by Lehninger, A. L., 1993, Kalyani Publishers, New Delhi.
8. “Microbiology”, by Prescott, L.M. Harley, J.P.Klein, D.A.,“ International edition”, 5th edition, 2003, McGraw – Hill Publications, New York.
9. “Principles of Microbiology”, by Atlas R.M., 1st edition, 1995,Mosby–YearBook Inc. St.Louis, Missouri.
10. “Microbiology–Concepts and Applications”, by Pelczar, Chan and Krieg, 1993, McGraw – Hill Inc.
11. “Lehninger Principles of Biochemistry”, David L. Nelson & Michael M. Cox. 4 th edition, W.H. Freeman & Co.
12. “Text Book of biochemistry with clinical correlations”, Edited by Thomas M. delving 1997, Wiley – Liss A John Wiley & Sons Inc. Publication New York.
13. “ Biochemistry” by U Satyanarayana & U. Chakrapani 3rd revised edition (Multicolour) 2006 Books & Allied (P) Ltd. Kolkatta (India)

Course Code: **5201-12 Foundation of Cell Biology and Biostatistics for Microbiologist (04 credits)**

Course Objectives:

1) To make students familiar with the various anatomical parts of typical prokaryotic and eukaryotic cells.
2) To give students knowledge about the various methods of organization of statistical data and it’s presentation.
3) To give them concept of regression and probability.

4) To give them insight in biochemical cell membrane, membrane transport mechanisms, cell biosignalling and cell differentiation.

Course Outcomes:

1) Students will have through knowledge of structural organization of prokaryotic and eukaryotic cells
2) Students will gain knowledge of structure and function of biological membranes and solute transport through them.
3) Students will also be well versed with the fundamental principles and examples of cell biosignalling and cell differentiation processes
4) Students will be able to apply statistical methods to handle biological bulky data and will be able to interpret the results. .

Unit I **(12)**

1. **Cell Biology**: Early History, Modern History, Latest significant events in cell biology.

2. **The cell:** Definitions of the cell, cell theory, exception to the cell theory.

Unit II **(12)**

3. **Prokaryotic cells:**
   (i) Cell shape, cell size and examples of Prokaryotic cells.
   (ii) Structural organization of a Prokaryotic cell – Of a typical bacterial cell: capsule Or slime layer, cell wall, flagella, Pili, cell membrane, cytoplasm, reserved food Materials (inclusion bodies), Nucleoid and plasmids.

4. **Eukaryotic cell:**
   (i) Cell shape, cell size, cell volume, cell number and examples of Eukaryotic cells.
   (ii) Structural organization of Eukaryotic Cell – cell wall, plasma (cell) membrane, Cytoplasm, matrix or cytosol – cytoskeleton and Microtrabecular lattice Cytoplasmic structures – cytoplasmic inclusions, Cytoplasmic Organelles – Endoplasmic reticulum (ER): Protien sorting Golgy apparatus, Lysozomes, Cytoplasmic Vacuoles, Peroxisomes, Glyoxysomes, Mitochondria, Plastids, ribosomes microtubules and microtubular organelles, Nucleus – Chromatin, nuclear envelope and nucleoplasm.

Unit III **(12)**

5. **Biological Membrane**:
   Molecular constituents of membrane, supra molecular architecture of membrane.

6. **Membrane Transport:**
   Various mechanisms of transport of solutes across the membrane – Simple diffusion, Facilitated diffusion (passive transport) and active transport, carriers, Ion channels, Transport of ions – Uniport, symport, antiport, sodium and potassium ions in cells.

7. Cell Biosignalling:

Signal transduction, molecular mechanism of signal transduction, general features of signal transduction, receptor enzymes.

8. Cell differentiation:

Definition and type of differentiation, factors that operate in control of differentiation. Examples of differentiations [Endospore formation in Bacteria and plasma cell (Antibody forming cell) formation (from B – Lymphocyte)].

Unit IV (12)

- **Sampling:**

  Advantage of sampling over census, sampling methods – Random sampling, non- random Sampling, Limitations of sampling.

- **Handling of bulky data:**

  (i) Measures of central tendency – mean, mode and median.

  (ii) **Measures of dispersion – Concept of dispersion, range, measures of dispersions – Variance**

  (iii) Grouped data and ungrouped data, combined variance for two groups, merits and demerits.

  (iv) Preparation of tables of : frequency distribution, cumulative frequency distribution and relative frequency distribution.

  (v) Graphical and diagramatic representation of statistical data – Construction of histogram and frequency polygon, Diagrams-Bar diagrams and pie diagrams.

  (vi) Representing the normal curve as straight line.

Unit V (12)

- **Regression:**

  Concept of regression, types of regression – Simple, multiple, linear and non- linear, Regression lines, regression equation.

- **Probability:**

  Concept of Probability, basic laws and its applications to Mendelian segregation. Concept of Probability distribution, Binomial and Poisson distributions. Normal distribution and their application to biology

- **Vital statistics** – Death rate and death ratio, measures of morbidity and measures of mortality.

Reference Books:

1. "Cell Biology and Molecular Biology", by S. C. Rastogi, 2nd edition, 2003, new age International (p) Ltd., New Delhi.

2. "Principles of Biochemistry", by D. L. Nelson and M. M. Cox, First Indian edition, 1993, CBS Publishers and Distributors, Delhi.

3. "Biostatistics", by P. G. Dixit, V. R. Prayag and P. S. Karpe, 2002, Nirali Prakashan, Pune.

4. “Cell Biology, Genetics, Molecular Biology, Evolution and Ecology”, by P. S. Verma and V. K. Agarwal First multicolor edition, 2004, S. Chand and Company Ltd.

5. “Fundamentals of Biostatistics”, by Rastogi, V. B., 2007, Ane Books.

6. “Biostatistics: A foundation for Analysis in Health Sciences”, by Wayne, W. Daniel, John Wiley and Sons Inc.

7. “Statistics for Biologists”, by R. C. Campbell,

8. “Biostatistics in Theory and Practice”, by T. K. Saha, Emkay Publications, New Delhi.

9. “Lehninger Principles of Biochemistry”, by David L. Nelson and Michael M. Cox 2005, 4th edition W.H. Freeman and company. New York.

Course Code: 5201-13 Medical Microbiology and Immunology – I (04 credits)

Course Objectives:

1) To give the students detailed knowledge about virulence of pathogenic microorganisms.
2) To give them of knowledge infections caused by anaerobes and fungi and diseases of tooth.
3) To make them understand the role of cytokines, chemokines and their receptors.

Course Outcomes:

1)Students will acquire the knowledge of pathogenesis of infectious diseases, epidemiology, Dental and periodontal diseases and medical mycology.

2) Students will be able to describe components of immune system and how cells and organs of immune system play an important role in the immune responses of the host.

3) Students will have the knowledge of cytokines, chemokines and their receptors.

Unit I (12)

- **Pathogenesis of infectious diseases:**

Infection and disease:

Virulence of pathogenic microorganisms.

(a) Invasiveness – Enzymes as virulence factors, Antiphagocytic factors (Interference with phagocytosis), Adhesion factors – mechanism of adhesion, Iron up take – role of siderophores, Spread in the tissue

(b) Bacterial toxigenicity: Toxin producing Microorganisms, Toxins: Exotoxins and Endotoxins, Lipopolysaccharide Endotoxins of gram negative bacteria.
Protein toxins: (Exotoxins):
Clostridial toxins - Botulinum toxin, Tetanus toxin (Tetanospasmin) Cholera toxin (choleragen), Diptheria Toxin, Pertussis toxin, Staphylococcal toxins, Streptococcal toxins.

(c) Tissue damage

(d) Spread of pathogen in the body

(e) Viral pathogenesis – mechanisms of viral cellular pathogenesis.

(f) Quorum sensing & pathogenicity

Unit II (12)

- **Epidemiology:**

The study of disease in populations: Tracking disease in the population. Epidemiological Statistics: frequency of cases, Investigative strategies of the epidemiologist.

- **Medical Mycology:**

Pathogenic fungi – true and opportunistic, structural dimorphism in fungi, pathogenesis of fungi, Epidemiology of the mycoses, diagnosis of mycotic infections, control of mycotic infections.

- **Dental caries and periodontal disease:**

The structure of the teeth and associated tissues.
Dental caries: hard – tissue disease – etiology, pathogenesis, and prevention and control.
Periodontal disease: soft - tissue disease – etiology, pathogenesis, and prevention and control.

- **Anaerobic infections of human beings:**

Tetanus, Gas gangrene, Antibiotic associated – pseudomembranous colitis, Bacteroid abscess.

Unit III (12)

- **Host defense mechanisms:**

Non-specific defense mechanisms, phagocytosis – process and mechanisms of killing the organisms, Humoral immune response (Antibody production) and cellular immune response (sensitization of T cell), signal transduction.

- **Complement system:**

Components, activation of complement – classical and alternative Pathways, regulation of complement pathways, biological consequences of complement activation, Significance of complement activation.

- Effects of sex hormones, nutrition and aging on the immune responses.

Unit IV (12)

- **Immunological tolerance -** Mechanism of tolerance, T cell tolerance, B cell tolerance
- Antigen processing and presentation to T and B cells.
- **Antibodies:**

Basic structure, classes, physico chemical and biological properties and functions, assembly and control of antibody synthesis, Mechanisms of generation of antibody diversity.

Unit V (12)

- **Cytokines, Chemokines and their receptors**

Cytokines: General characteristics and their actions, Molecular characterization and their functions, Role in regulation of immune response.

Chemokines: Chemokines and their structures, function of chemokines and their receptors.

- Cell signaling and Trafficking

Reference Books:

1. "Immunology and serology", by Carpenter, P. L., 3rd edition.
2. "Basic and Clinical Immunology", edited by Stites et al., 5th edition, 1984.
3. "Essential Immunology", by Roitt I. M., 8th edition, 1994.
4. "Immunology", by Roitt et al., 2nd edition, 1989.
5. "Immunology", by Roitt et al., 3rd edition, 1993.
6. "Immunology", by Roitt et al., 4th edition, 1996.
7. "Medical Immunology", edited by Stites et al., 9th edition, 1997.

8. "Medical Microbiology", by Mims et al., 2nd edition, 1998.
9. "Handbook of Experimental Immunology",Vol. I, (Vol. II and Vol. III) edited by D. M. Weir, 1978.
10. "Principles of Microbiology", by Atlas, R.M., first edition, 1995. Mosby-year book, Inc.St. Louis, Mission.
11. "Foundation in Microbiology", by K.Talaro and A.Talaro, 2nd edition, 1996,Wm.C. Brown publishers, Dubuque, IA..
12. "Topley and Wilson's Principles of Bacteriology, Virology and Immunology", 8th edition, Vol. 4 (Virology).
13. "Mechanism of Microbial disease", by Schaechter et al. (editors), 1989.
14. "Fundamentals of Immunology", by Myrvik and Weiser, 2nd edition, 1984.
15. "Immunology – a short course", by Benjamini et al., 3rd edition.
16. "Ananthnarayan and Paniker's – Text book of Microbiology", 7th edition, 2005, edited by C.K.J. Paniker orient Longmar (P) Ltd.

Course Code: 5201-14 Biochemical, Biophysical, Immunochemical and Microbiological Techniques
(04 credits)

Course Objectives:

1) To give students the knowledge about the principles various Microbiological, Physicochemical and Biochemical techniques used in research laboratories, industries and diagnostics.
2) To make students know the operative procedures and applications of the techniques in diagnostics, research laboratories and industries.

Course Outcomes:

1) Student would be able to understand the difference between UV visible and fluorescence spectroscopy & colorimetry.

2) Student will be able to describe the basic principle, technique and applications of different types of chromatographic techniques like paper, ion exchange and affinity chromatography.

3) Student will gain knowledge regarding fundamental principles of centrifugation and electrophoresis.

4) Student will be able to get the thorough knowledge of ESR, NMR and various principles and instrumentation behind them.

5) Student would be well versed with the knowledge of x- ray and radioisotopes, radiography and the dangers, safety precautions associated with them

6) Student will understand the principles and applications of SDS- PAGE, Southern blotting.

Unit I (12)

- **Chromatographic Techniques:**
  (1) Paper and thin layer Chromatography – Principle, material, methods and applications.
  (2) Column Chromatography:
    (i) **Adsorption Chromatography** :
      (a) Ion exchange Chromatography- Principle, material, ion exchange gels, media, kinetics, operative procedures and applications.
      (b) Affinity Chromatography - Principle, material, methods, and Applications – Industrial and Medical.
    (ii) **Molecular exclusion Chromatography(Gel filtration)** – Types of Gels, Technique, and Applications.
    (iii) **Gas Liquid Chromatography (GLC)** – Principle, Equipment, Evaluation of performance, comparison with traditional Chromatography and with HPLC –
    (iv) **High performance liquid Chromatography (HPLC)** – Principle, basic instrumentation and applications.

Unit II (12)

- **Electrophoretic Techniques:**
  (i) Principles of Electrophoresis, moving boundary and zonal electrophoresis,
  (ii) Paper Electrophoresis – Principle and procedures involved, and applications.
  (iii) Gel Electrophoresis:
    (a) Protein Electrophoresis – Polyacrylamide Gel Electrophoresis (PAGE), SDS – PAGE and 2-D PAGE, Isoelectrofocussing.
    (b) Nucleic acid Electrophoresis – DNA sequencing gels, pulse field gel Electrophoresis (PFGE), RNA Electrophoresis
- **Centrifugation Techniques:**
  Principles of Centrifugation, different types of centrifuges and types of rotors and their usages.

Density gradient centrifugation – rate zonal technique, Isopycnic centrifugation, performing density gradient centrifugation – Discontinuous and continuous techniques, applications of preparative centrifuges.

Unit III (12)

- **Microfilm Ultra filtration:**

  Principles, material and methods, and applications; reverse osmosis, nanofilters.

- **Manometric techniques:**

  Principles, apparatus, operative procedure and applications.

- **Spectroscopic technique:**

  General principles of electromagnetic radiation spectroscopy, principles, procedures and applications UV – visible spectrometry, turbidometry and nephelometry, fluorimetry, luminometry, atomic absorption and mass spectroscopy.

- **Radioisotopic Techniques:**

Radioisotopes and units of radioactivity, methods of detection and measurement of radioactivity - Geiger – Muller counters, scintillation counting, Autoradiography. Salient features of scintillation counting.

Applications of radioisotopes – diagnostic, therapeutic, systemic and other uses.

Unit IV (12)

- **Biophysical Techniques:**

(i) X ray diffraction analysis and crystallography.
(ii) Infra red and Raman spectroscopy.
(iii) Electron spin and nuclear magnetic resonance spectroscopy.

- Immunochemical Techniques:

(i) Radioimmunoassays.
(ii) Enzyme linked immunosorbent assays (ELISA).
(iii) Isolation of sub population of lymphocytes by fluorescent activated cell sorter (FACS).
(iv) Western blot analysis and its applications.

Unit V (12)

D. Microbiological Techniques:

(i) Isolation of pathogenic bacteria.
(ii) Preservation of bacteria – periodic transfer method, lyophilization method, preservation at ultra low temperature.
(iii) Enrichment culture techniques – Principles involved, selective factors employed and applications.

(iv) Isolation, Cultivation and preservation of molds.

(v) Isolation and Cultivation of anaerobic organisms – Anaerobic Jar method, Hungate's Serum bottle modification and anaerobic glove boxes.

(vi) Isolation and cultivation of viruses and Rickettsia.

(vii) Isolation of pathogenic fungi causing subcutaneous and deep – seated mycoses in man and animals.

(viii) Identification of microorganisms by fatty acid lipid profile

E. Analysis of Gene expression

Reference Books:

"Principles and Techniques of Biochemistry and Molecular Biology", edited by Keith Wilson and John Walker, 6th edition, 2005, Cambridge University Press, New York.

2. "Understanding enzymes", by T. Palmer, 2nd edition, 1985, Ellis Horwood Limited, West Sussex, England.
3. "Basic and Clinical Immunology", edited by Stites et al., 5th edition, 1984.
4. "Essential Immunology", by Roitt I. M., 6th edition, 1988.
5. "Essential Immunology", by Roitt I. M., 8th edition, 1994.
6. "Immunology", by Roitt et al., 4th edition, 1996.

7. "Medical Immunology", edited by Stites et al., 9th edition, 1997.

8."Handbook of Experimental Immunology", Vol. I, (Vol. II and Vol. III) edited by D. M. Weir, 1978.

9. "Elements of Biotechnology", by P. K. Gupta, 1st edition, 2004.

10. "Outline of plant Biotechnology", by E. John Jothi Prakash, 1st edition, 1997.

11. "Biotechnology – Foundation course",by Anant N. Rao, 2007, Jaypee Brothers Medical Publishers (p) Ltd, New Delhi.

12. "Isolation of anaerobes", by Shapton D. A., 1971

13. "Methods in Microbiology",, Vol. 3A and 3B, edited by J. R. Norris and D. W. Ribbons, 1969 Academic Press, London.

14. "Methods in Microbiology",, Vol. 4, edited by Booth, C., 1970, Academic Press, London

15. "Biophysical Chemistry – Principles and Techniques", by A. Upadhya K. Upadhya & N. Nath 4th revised edition 2007 Himalaya Publishing House.

16. "Anaerobic Bacteria", by K. T. Holland, J. S. Knapp & J. G. Shoesmith , 1987, Chapman & Hall, New York.

Course Code: 5201-15 Practical Course – I (04 credits)

Course Objectives:

1) To acquaint the students with the techniques of isolation of various types of bacteria, yeast, molds and bacteriophages.
2) To make the students able to carry out isolation of pathogens.
3) To train the students able to carry out enrichment and isolation of Acidophilic, Alkalophilic, Osmophilic, Thermophilic and Halophilic microorganisms.

Course Outcomes:

1) Students will be able to carry out isolation of various types of bacteria, yeast, molds and bacteriophages.
2) Students will also be able to carry out isolation of pathogens.

3) Students will be able to carry out enrichment and isolation of Acidophilic, Alkalophilic, Osmophilic, Thermophilic and Halophilic microorganisms.

1. Nuclear staining: (i) Staining of nuclear material (DNA) of bacteria
(ii) Staining of nuclear material (DNA) of yeast.
2. Induction of Ascospore formation in yeasts.
3. Induction of Endospore formation in bacteria.
4. Isolation of some common Saprophytic Microorganisms from their natural habitats and their cultural and Morphological Characterization and identification:
   (i) Bacteria – *Bacillus, Micrococcus, Proteus, Clostridium andNitrobacter species.*
   (ii) Fungi – *Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus, Saccharomycesspecies.*
   (iii) Algae – *Spirulina species*.
   (iv) Protozoa – *Euglena, Paramoeciumspecies.*
5. Preparation of bacterial protoplasts.
6. Preparation of Yeast protoplasts.
7. Isolation of psychrophilic bacteria.
8. Isolation of osmophilic yeast and bacteria.
9. Determination of titer of ***E. coli***. phages of the phage stock.
10. Isolation of yeast from natural sources (Fruits / Flowers / Honey).
11. Isolation of Halophilic and Halotolerant organisms from Saline soils / Sea water.
12. Enrichment and isolation of Acidophilic and Alkylophilic organisms from Industrial waste / Sewage.
13. Enrichment and isolation of Chemolithotrophic bacteria (*Nitrosomonas* and *Nitrobacter* species) from soils.
14. Isolation of etiological agent of dental caries
15. Isolation of *Candida albicans* from clinical specimens
16. Isolation of Thermophilic microorganisms.
17. Determination of susceptibility to dental carries by synder test.
18. Demonstration for the presence of actinophages.
19. Visit to Industry / Science Institute / Research Laboratories. Report of the visit to be submitted.

Course Code: 5201-16 Practical Course – II (04 credits)

Course Objectives:

1) To train the students properly to be able to perform the qualitative and quantitative estimation of proteins, lipids, carbohydrates, DNA, RNA.

2) To make the students able to statistically analyze biological data and interpret the results.

3) To give the students enough demonstration and practices so as to enable them to perform the electrophoresis and chromatographic techniques

Course Outcomes:

1) Students will know and able to perform the techniques of qualitative and quantitative estimation

of proteins, lipids, carbohydrates, DNA, RNA and shall be able to carry out the estimations independently.
2) Students will learn to apply the statistical methods on biological data and interpret the results.
3) Students will be able to perform the electrophoresis and chromatographic techniques

1. Determination of Carbohydrate content of bacteria.
2. Determination of Protein content of bacteria / yeast.
3. Determination of Lipid content of bacteria.
4. Estimation of DNA of the sample.
5. Estimation of RNA of the sample.
7. Separation of dyes, plant pigments by column chromatography.
8. Separation of amino acids by paper and thin layer chromatography.
9. Electrophoretic separation of serum proteins by Agarose and Polyacrylamide gel electrophoresis (PAGE).
10. Electrophoretic separation of nucleic acids by Agarose and Polyacrylamide gel electrophoresis.
12. Determination of acid value of fat
13. Determination of saponification value of fat
14. Determination of iodine number of fat
15. Measures of central tendency – Mean, mode and median.
16. Measurement of dispersion – Variance and standard deviation.
17. Construction of histogram and frequency polygon.
18. ANOVA – CRD and CBD.
19. Determination of carbohydrates by Anthrone method
20. Preparation of Buffers
21. Preparation of Normal and Molar solutions

Reference Books for Practical course I and Practical course II

1. "Laboratory manual in Biochemistry", by Jayraman, J., 1998, New age International Publishers, New Delhi.

2. "Experiments in Microbiology, Plant Pathology and Tissue Culture", by Aneja, K. R., 1993, Wishwa Prakashan.

3. "Practical Biotechnology", by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical Publishers(p) Ltd. New Delhi.

4. "Medical Microbiology", Vol. 2, 12th edition, 1975 by Cruickshank, R. Duguid, J. P. Marriman, B. P. and R. A. Swan, Churchill Livingstone, London.

5. "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.

6. "Manual of laboratory techniques", by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.

7. "Illustrated genera of imperfect fungi", by Barnett, H. L., and Hunter, B. B., 3rd edition, 1972, Burgess Publishing Company, Minneapolis, Minnesota.

8. "Compendium of soil fungi", by Domsch, K. H., Gams, W. and Anderson, T. H., 1980, Academic Press, London.

9. "Standard methods for the examination of water and waste water", 20th edition, edited by Greenberg, et al., 1998, APHA, AWWA, Washington, DC.

11. "Methods in Microbiology", Vol.3A and Vol.3B edited by Norris and Ribbons, Academic Press, London.

12. "Methods in Microbiology", Vol.4 edited by Booth, C., Academic Press, London.

13. "Methods in Microbiology", Vol.5 edited by Norris and Ribbons, Academic Press, London.

14. "Microbiological applications", by Benson, H. J., 6th edition, 1994, Wm. C. Brown Publishers, Dubuque, Iowa.

15. "Identification methods for Microbiologists", edited by Gibbs, G. M. and Shapton, D. A., 1968, Academic Press, London.

16. "Biostatistics", by P. G. Dixit, V. R. Prayag and P. S. Karpe, 2002, Nirali Prakashan, Pune.

17. "Biostatistics: A foundation for Analysis in Health Sciences", by Wayne, W. Daniel, John Wiley and Sons Inc.

18. "Biostatistics in Theory and Practice", by T. K. Saha, Emkay Publications, New Delhi.

Ability Enhancement Compulsory Course (AECC)

01 Yoga and Meditation (02 Credits)

PREAMBLE:

The ultimate aim of Yoga is to experience the truth, by realizing the true nature of our self and universe. Yoga education helps in self discipline and self control, leading to immense amount of awareness, concentration and higher level of consciousness. Experience based Yoga education can be integrated in higher education to enhance Academic social activities of students.

OBJECTIVES:

1) To enable the students to have good health

2) To learn to maintain the mental hygine by performing yoga posture and meditation.

Unit I

- **Ashtangyoga**
  Introduction, Meaning, definition, Objectives
  Performing Yogabhyasa
- **Pranayamas**

  Anulom Vilom, Bhramari, Kapalbhati and Bhasrika Omkar Sadhana, Prayer and Guruvandana

Unit II

- **Suryanamaskar**

  Introduction, Postures, Benefits and practice

Unit III

- **Asanas**

  Vajrasan, Padmasan, Vakrasan, Uttan Padmasan, Pawanmuktasan, Shavasan, Bhujangasan, Shalabhasan, Makrasan, Tadasan, Verasan, Ardhachakrasan- Introduction, Postures, Benefits and practice.

Unit IV

- **Meditation**:

  Types of meditation techniques commonly practiced, benefits of meditations.

Reference Books :

1. Yoga for Beginners by Emily Oddo
2. Yog Sadhana v Yog Chikitsa Rahasya by Swami Ramdeo
3. Yoga and Meditation by Ann Wilde
4. Yoga for Beginners by Denise Flow

M.Sc. Part I Semester II

Course Code: 5201-21 Microbial Physiology and Metabolism (04 Credits)

Course Objectives:

1) To give students the knowledge about the microbial heterotrophic metabolic pathways & their functions.
2) To give the students knowledge about the autotrophic mode of microbial metabolism.
3) To give students the knowledge of various metabolic reactions and their role.
4) To introduce the students with the phenomenon of chemotaxis, phototaxis and magnetotaxis.

Course Outcomes:

1) Students will be able to illustrate various anabolic and catabolic pathways of carbohydrates, lipids, proteins and amino acids.
2) Students would be able to illustrate the various catabolic pathways of carbohydrate proteins and amino acids.
3) Students would be able to understand, able to describe various mechanisms of ATP synthesis by metabolism and chemiosmotic hypothesis of ATP synthesis.
4) Students will have knowledge about phototactic, chemotactic and magnetotactic bacteria.

Unit I (12)

- **Chemotaxis, magnetotaxis and phototaxis**:

  i) Chemotaxis : Chemotactic behavior of bacteria, molecular mechanism of chemotaxis.

  ii) Magnetotaxis: Magnetotactic bacteria, mechanism of magnotaxis.

  iii) Phototaxis: Phototactic organisms, mechanism of phototaxis.

- **Autotrophic Metabolism:**

  i) **Chemoautotrophic metabolism:**

  Concept of chemoautotrophy Hydrogen oxidation, Autotrophic methanogenesis, sulfur and Iron oxidation Ammonium and nitrite Oxidation – Nitrification

  (ii)**Photoautotrophic metabolism :**

  Characteristic of photoautotrophic microorganisms, Photophosphorylation, comparison of oxygenic and anoxygonic photosynthesis.

Unit II (12)

- **Heterotrophic metabolism :**

  (i) **<u>Conversion of carbohydrates to pyruvate</u>** -Glycolytic pathways, Embden Meyerhof pathway, Entner – Doudoroff pathway, Pentose phosphate pathway, methyl glyoxal pathway, Archaebacterial Glycolytic pathways – modified Entner – Doudoroff pathway

  ii) **<u>The citric acid cycle: Tri carboxylic acid cycle (TCA)</u>**

  Production of acetyl CoA, reaction of citric acid cycle, energetics, Anaplerotic reactions, regulation of the citric acid cycle, The glyoxylate cycle, coordinated regulation of glyoxylate and citric acid cycle.

iii) **Fermentations :** Mixed acid fermentations, Propionic and butyric acid fermentations, Amino acid fermentation, Fermentation of acetate to methane : Methanogenesis

Unit III **(12)**

- Conversion of Lipids to acetyl-CoA Fatty acid oxidation - Beta,(β) and Omega (ω)
- Conversion of proteins to amino acids and oxidation of amino acids.
- **Protein Metabolism –** Biosynthesis of amino acids
- **Purine andpyrimidine–** de novo and salvage pathway

Unit IV **(12)**

- Oxidative Phosphorylation :

Electron transport chain – components (carriers), their organization into large functional complexes, the path of electron flow through them, Proton gradient, Proton motive force. ATP synthesis – Mechanisms : chemiosmotic model proposed by Peter Mitchell, ATP synthase complex of mitochondria, Binding change mechanism (rotational catalysis mechanism) proposed by Paul Boyer, Shuttle systems to convey cytosolic NADH into mitochondria for oxidation – malate aspartate shuttle, glycerol – 3 – phosphate shuttle

Regulation of oxidative phosphorylation

Mitochondrial genes: their origin and the effects of mutations. Role of mitochondria in Apoptosis and oxidative stress.

Unit V **(12)**

- **Photophosphorylation:**

General features of photophosphorylations, light absorption, primary Light absorbing pigment – Chlorophylls,

Secondary Light absorbing pigments or accessory pigment, organization of photo system (PS)

Photophosphorylation in bacteria:

Type II reaction center in purple bacteria

Type I reaction center in Green sulfur bacteria

Photosynthesis in cyanobacteria , algae and vascular plants –

Photosystem II (PS II) and photosystem I (PS I) integration in chloroplast

Dual roles of cytochrome b6f and cytochrome C6 in cyanobacteria.

Photophosphorylation in halophilic bacterium *Halobacterium salinarum*

ATP synthesis: Mechanisms: Chemiosmotic coupling electron flow and phosphorylation

ATP synthase complex of chloroplast.

Reference books:

1. "Physiology of the Bacterial cell a molecular approach" by Neidhardt FC, JL Ingraham, in scratchier: 1990, sinauer, Sunderland, MA.

2. "Microbial physiology", by moat AG and JW Foster, 1988, John Wiley and sons, New York.

3. "Principles of Microbiology", by R.M. Atlas, 1995, mosby year bwk, Inc. St. Louis, Missouri 631146 (USA).

4. "Lehninger Principles of Biochemistry", by David L Nelson and Michael M Cox, 4th edition, W.H. Freeman and Co.

5. "General Microbiology", by Stanier R. et al , Macmillan Co. 2005

6. "Bacterial Metabolism", by Doelle H.W. Academic Press 2005.

7. "General Microbiology", by Schlegel H.G. Cambridge University Press 2004.

Course Code: 5201-22 Microbial Genetics and Molecular biology (04 Credits)

Course Objectives:

1) To give students the knowledge about the genetic code, DNA replication, translation, and transcription in prokaryotes and eukaryotes.
2) To give students the knowledge about gene, gene regulation, gene expression.
3) To give students the knowledge of DNA damage and repair, mutagens, mutations and DNA transfer methods.

Course Outcomes:

1) Students will get thorough knowledge of mechanisms of DNA replication, transcription and translation in prokaryotes and eukaryotes.

2) Students will have a deep insight into the genetic code and regulation of gene expression giving emphasis on operon models, in prokaryotes and chromatic remolding, DNA binding transactivators and coactivators with intracellular signaling in eukaryotes.

3) Students will know about various types of DNA damage and DNA repair mechanisms that occur in prokaryotic and eukaryotic cells.

4) Students will also able to understand mutations, types of mutations and methods of detection of mutation, recombination and DNA transfer methods like transformation, conjugation, transduction, electroporation, transfection. Students will also know about protoplast and spheroplast fusions etc.

5) Students will also know about Archaebacteria and will be able to understand Archaebacterial genetics.

Unit I **(12)**

- **DNA replication:**

ii) Enzymes involved in DNA replication and their Topoisomerases (I&II) Helicases,

DNA polymerases in prokaryotic cells DNA Pol I, Pol II, and Pol III, DNA Polymerases of Eukaryotic cells – Alpha (α) Beta (β) gamma (γ) and delta (δ), DNA Ligases.

iii) Post –Replication Modification of DNA: DNA methylation by DNA methylases.

- **Inhibitors of DNA replications**: Transcription and translation of RNA and their mode of action.
- **Transcription in Prokaryotes and Eukaryotes: RNA processing**:
  Post transcriptional modification of RNA

Unit II **(12)**

- **The Genetic code:**
  Deciphering of genetic code, important features of genetic code.
- **The translation machinery in prokaryotes and Eukaryotes**
- **Translation:** Initiation of translation of mRNA, role of tRNA, Elongation of peptide, Termination of protein synthesis.

Unit III **(12)**

- **Regulation of Gene expressions:**
  Principles of gene regulation: RNA polymerase, promoters, regulation of transcription initiation and its common patterns, operons model of regulation, Regulation proteins. Regulation of gene expression in prokaryotes: Regulation, Lactose, Trytophan and Arabinose operons, regulation by genetic recombination. Regulation of gene expression in Eukaryotes: chromatic remodeling, promoters and regulatory proteins – DNA binding transactivators and coactivators, transcriptional activation. Signals Regulation of genes of galactose metabolism in yeasts, gene regulation by inter cellular and intracellular signal, translational regulation of Eucaryotic mRNA, Post – transcriptional gene silencing – RNA Interference.

Unit IV **(12)**

- **DNA damage and repair:**

  Types of damages, damaging agents, Repair mechanisms – mismatch repair, excision repair, photoreactivation, dark repair, recombinational repair, SOS system, Role of DNA repair system in conservation of genome integrity, relationships to life span and aging processes.

- **Mutations :**

  (i) **Detection of mutations**: Replical planting, complementantation

  (ii) **Mutation rates and mutagenic agents** : Mutation rate, physical mutagens, chemical mutagens, Detection of chemical mutagens and carcinogens (Ames test)

  (iii)Site directed mutagenesis.

Unit V **(12)**

- **Recombination:**

  Types of recombinational processes: Homologous – molecular basis of recombination, Non homologous – molecular Mechanism of recombination

- **DNA transfer in prokaryotesand Eukaryotes:**

  Transformation, transduction, conjugation, transfection, protoplast and spheroplast fusions, electroporation.

- Gene Transfer in Aechaebacteria: Archaebacterial genetics
- Catalytic RNA
- Genetics of population with reference to Hardy-Weimberg principle and it's applications.
- Metabolism of nucleotides – synthesis and degradation.

Reference Book:

1. "DNA Replication", by Adams R.L.P., 1992, IPL Oxford, England.
2. "Genes VII", by Lewin 2002, Oxford University Press.
3. "Recombinant DNA and Biotechnology", by Singh, 2007.
4. "Biotechnology", by B.D. Singh, 1998 kalyani publishers, New Delhi.
5. "Recombinant DNA", by Watson, J.D. et al., 2nd and 3rd editions scientific American Books, New York.
6. "Cell Biology, Genetics, Molecular Biology, evolution and ecology", by P.S. Verma. And V.K. Agarwal, First multicolour edition, 2004, S. Chand and company Ltd.

7. “Elements of Biotechnology”, by P.K. Gupta, first edition, 2004.
8. “Microbial Genetics”, by Freiffeldor David, 10th edition, 2004, Naroja publishing house, New Delhi.
9. “Molecular Genetics of Bacteria”, by Dale, J.W. 1994, John Wiley & sons.
10. “General Microbiology”, by Stainier et. al.
11. “Principle of Microbiology”, by Atlas R.M. 1995.
12. “Principle of gene manipulation”, by R.W. Old & S.B.Primrose 5th edition, 1994.

Course Code: 5201-23 Medical Microbiology and Immunology – II (04 Credits)

Course Objectives:

1) To give students the knowledge about the etiology, epidemiology, prevention and control and diagnostic techniques of various microbial diseases.
2) To give the students knowledge of immune responses mountained by host to various viral, bacterial and fungal infections and to tumors.
3) To give students the knowledge of autoimmune diseases and immunodeficiency diseases
4) To give students the knowledge about the recently emerged viruses and current developments in disease specific vaccines.

Course Outcomes:

1) Students will gain knowledge regarding various microbial diseases - etiology, epidemiology, prevention and control and diagnostic techniques.
2) Students will also have knowledge about how immune responses are given by host to viral, bacterial and fungal infections and to tumors.
3) Students would also have knowledge regarding role of HLA antigens in transplantation and graft rejection. Students will be able to understand abnormal manifestations of immune response in the form of autoimmune diseases.
4) Students will also gain knowledge regarding immune deficiency diseases.
5) Students will gain knowledge regarding recently emerged viral diseases like Ebola, Swine-flu.

Unit I (12)

- **Medical Microbiology:**
- **Microbial diseases:**

Etiology, Epidemiology, characteristic signs and symptoms, Laboratory diagnosis, Mode of transmission, Prevention and control of the diseases caused by:

Legionella pneumophila, *Helicobacter pylori*, *Leptospira icterohaerrhagiae,Wuchereria bancrofti,* Rubella and Rubiola virus, Japanese encephalitis virus, yellow fever virus, Dengue fever virus.

Unit II (12)

- **Diagnostic Medical Microbiology**:

(a) Collection and transport of clinical specimens, preliminary processing of specimens

(b) Serological test – Widal test, ASO test Cold heamagglutination test, Paul – Bunnel test, Weil – Felix test, Streptococcus – MG test, Tuberculin test, Immuno - PCR.

(c) Rapid methods of identification of infectious microorganisms: Commercial systems for rapid identification of bacteria (e.g. Enterotube, API, Minitech, Micro - ID), FAT, RIA, and western blot techniques.

- Advanced Techniques in Molecular Diagnostic microbiology**.**
- **Vaccine technology –** General methods, Disease specific vaccine**,** Design – Tuberculosis vaccine, Malaria vaccine, HIV/AIDS vaccine**.**

Unit III (12)

Immunology.

- **Immunity to viral infection:** Antigenic drift and shift. Interferon, Interleukins, Humoral and cell mediated Immunity.
- **Immunity to Bacterial infections:**

Phagocytosis, role of complement and antibody, Role of CMI and activated macrophages, bacterial strategies to avoid phagocytosis,

- **Major Histocompatibility Complex:**

Inheritance and arrangement of MHC genes, Cellular distribution, structures and function of MHC antigens, Human HLA complex, Class I and class II molecules, HLA typing.

Unit IV (12)

- **Tumor Immunology:**

Tumor associated antigens, Tumor specific antigens, immune response to tumor, immune escape mechanisms, Immunosurveillance, Natural immunity, to tumors, Immunodiagnosis of tumors – detection of tumor markers: alpha feto proteins, carcinoemryonic antigen, Immunotherapy.

Unit V (12)

- **Immunodeficiency disorders:**

(i) B cell immunodeficiency disorders.

(ii) T cell immunodeficiency disorders: congenital thymic aplasia (Digorge syndrome), chronic mucocutaneous candidiasis, AIDS.

(iii)Phagocytic dysfunction diseases (polymorphonuclear leucocytes and mononuclear leucocytes), CGD Chronic granulomatous disease, (CGD) Lazy leukocyte syndrome (LLS).

(iv) Complement disorder, - Hereditary angioneurotic edema, deficiencies of complement components

(v) Allergic diseases – allergic respiratory diseases, allergic skin disorder, food and drug allergy.

- **Autoimmune diseases:**

Autoantigens and autoimmunization, Types of autoimmune diseases, spectrum of autoimmune diseases, genetic factors in autoimmune diseases, pathogenesis, etiology (mechanisms) and approaches to the treatment of autoimmune diseases.

Reference Books:

1. "Immunology and serology", by Carpenter, P.L., 3rd edition.
2. "Basic and Clinical Immunology", edited by Stites et al., 5th edition, 1984.
3. "Essential Immunology", by Roitt I.M., 8th edition, 1994.
4. "Immunology", by Roitt et al., 3rd edition, 1993.
5. "Immunology", by Roitt et al., 4th edition, 1993.
6. "Medical Immunology", edited by Stites et al., 2nd edition, 1997.
7. "Medical Microbiology", by Mims et al., 2nd edition, 1998.
8. "Handbook of Experimental Immunology", Vol. I, (Vol. II and III) edited by D.M. Weir, 1978.
9. "Principles of Microbiology", by Atlas, R.M., first edition, 1995. Mosby-year book, Inc. St. Louis, Mission.

10. "Foundation in Microbiology", by K. Talaro and A. Talaro 2nd edition, 1996, Wm. C. Brown publishers, Dubuque, IA…
11. "Topley and Wilson's Principles of Bacteriology, Virology and Immunology", 8th edition, Vol. 4 (Virology).
12. "Mechanism of Microbial disease", by Schaechter et al. (editors), 1989.
13. "Fundamentals of Immunology", by Myrvik and Weiser, 2nd edition, 1984.
14. "Immunology – a short course", by Benjamini et al., 3rd edition.
15. "Anantnarayan and Paniker's – Text book of Microbiology", 7th edition, 2005 edited by C.K.J. Paniker orient Longmar (P) Ltd.
16. "Essentials of Immunology and Serology", by Stanley, J , 2002 Delmer Thomson Learning , New York.

Course Code: 5201-24 Fundamentals for use of computers and communication skill and Scientific writing and presentation. (04 Credits)

Course Objectives:

1) To give students the knowledge about the computer hardware & software.
2) To make students conversant to writing and publishing scientific paper.
3) To give students the knowledge of communication skills.

Course Outcomes:

1) Students would know the fundamentals of computer hardware & software.
2) Students will become well versed with how to write and publish the scientific paper/ document.
3) Students shall gain information about communication cycle, types of communication, verbal &nonverbal communication, writing skills.

Unit I (12)

Computers:

- **General Introduction to Computers**: Definition, computer tasks, classification of computers.
- **Hardware** - Different components of a computer – Input unit, Arithmetic Logic unit (ALU), Control unit, Memory, Secondary storage devices, output unit.
- **Software** – Application programs, The Binary number systems, system programs, utility programs programming,

Unit II (12)

- **Introduction to Computer programming Languages**

Operating systems: Batch operating system , Personal operating systems , MS Word MS Access, MS Excel, MS Power Point.

- **Introduction to Bioinformatics:**
  Concept of Bioinformatics, Data base, Types of data base, major biological data bases with website addresses, Applications of Bioinformatics

Unit III (12)

Communication Skills:

- **Language** – A means of communication, principles of Communication, Types of Communication, Principles of effective Communication – Definitions, communication barriers and overcoming the barriers, developing effective messages.
- **Formal written skills :**
  Office drafting job applications, report writing, academic correspondence, Leave applications,
- **Communication skills –** Interview skills

Unit IV (12)

Scientific writing and presentation:

- **Good English and grammar in scientific writing**: Use and misuse of words, Jargon and Avoiding Jargon, Abbreviations –Guidelines for use of abbreviations, accepted abbreviations and symbols. Common errors in style and in spelling.

- **Programme of writing:** Selection of topic and outline, Thinking and planning, Information collection, Paragraph writing: Paragraph, Order of paragraph, writing and revising of paragraph.

- **Main requirements of a scientific document**:

Accuracy, Appropriateness, Clarity, Simplicity, Brevity, Precision, Balance, consistency, Impartiality, Sincerity, Objectivity, Control of interest and in Scientific Writing

- **Scientific paper –** Definitions and Organization of a scientific paper, History, IMRAD system.

Unit V (12)

- **Writing a scientific paper**: Title, Listing the authors and addresses, Abstract, Introduction, Materials and Methods, Results and Discussion, Summary and Conclusions, stating the acknowledgements and citing the references. Keyboarding the manuscript, submission of the manuscript, The Review process, The publishing process.
- **Designing of effective table, graphs, diagrams and illustrations**
- **Legal aspects of scientific authorship**: Copyright considerations, Plagiarism
- **Presentation of scientific paper**: Oral presentation, Preparation and presentation of a poster.
- Writing review papers, Conference reports, Book reviews, Project and Project reports, and a Thesis.

Reference Books:

1. "Communication skill", by B.V. Pathak First edition, Nirali Prakashan, Pune (India) 2006

2. "A Handbook of Communication skills in English" by R.A.Kulkarni, First edition, Phadke Prakashan, Kolhapur (India) 2001.

3. "Written communication in English", by sarah freeman.

4. "English for Communication (Science) Book I",, First edition, 1996 Shivaji University.

5. "Communication skill" by Anjali Ghanekar, 1996, Everest publishing house.

6. "How to write and publish a scientific paper", by Day R. A. 4th edition 1994, phoenix, Oryx press.

7. "The New York public Library Writer's guide to style and usage – published", by Mac Millan India Ltd. 1999.

8. "Writing a thesis" by George Watson, Longman Inc. New York.

9. "Bioinformatics – Modern approach" by Srinivas, 2007.

10. "Introduction to Computers", by Leon A. and Leon M. Leon Techworld, Vikas Publishing House Pvt. Ltd., New Delhi.

11. "Fundamentals of Computers", by Rajaraman V. Prentice Hall of India, New Delhi.

12. "Bioinformatics", by Baldi P. Affiliated East West Press 2003.

13. "Bioinformatics", by Lacroix Z., Elsevier Applied Science Pub. 2004.

14. "Basic Bioinformatics", by lgncimuthu S.J. Narosa 2005.

15. "Bioinformatics Computing", by Bergeron B. Prentice Hall of India 2003.

Course Code:5201-25 Practical course III (04 Credits)

Course Objectives:

1) To make the students able to perform various serological diagnostic tests.

2) To make students able to perform immobilization technique.

3) To make students able to determine growth patterns of microbial cells.

Course Outcomes:

1) Students will be able to perform and know the applications of various serological diagnostic tests viz. RA, ASO, CRP, SLE etc.

2) Students will be able to carry out immobilization of enzymes, microbial cells.

3) Students will be able to study the various growth patterns of microbial cells

1. Synchronous growth of yeast (*Saccharomyces cerevisiae*)

2. Continuous growth of bacteria.

3. Immobilization of microbial cells (Yeast cells)

4. Synthesis of inducible enzyme Beta galactosidase in ***E.coli***
5. Detection of β – Lactamase activity in bacterial isolates.
6. Demonstration of chemotaxis in bacteria
7. Immobilization of Yeast enzyme – Invertase.
8. Immubilization of bacterial enzymes – Amylase
9. Techniques of egg inoculations.
10. Separation of Lymphocytes from periperal blood
11. C- reactive protein test (CRP) test.
12. Rheumatoid arthritis (RA) test
13. Systemic Lupus erythematosus (SLE) test.
14. Anti Strptomycin – O (zASO) test.
15. Australia Antigen test.
16. Complement Fixation (CF) test.
17. Preparing 'Abstract' for a given scientific paper
18. Writing a 'Summary and Conclusion' for a given Scientific Paper
19. Writing 'Result & Discussion' part of the paper using given data

Course Code:5201-26 Practical course IV (04 Credits)

Course Objectives:

1) To give students knowledge of isolating the DNA and plasmids from bacteria/ yeast.
2) To train students in mutants isolation technique.
3) To equip students with the knowledge the mutagenecity testing.

Course Outcomes:

1) Upon competition of this course students will be able to carry out independently isolation of DNA as well as plasmids from bacteria and yeasts.
2) Students will be able to perform the isolation of drug resistant and nutritionally deficient mutants.

1. Isolation of DNA from Bacteria.
2. Isolation of DNA from Yeast.
3. Isolation of Bacterial palsmids

4. Isolation of yeast palsmids.
5. Isolation of RNA from yeasts.
6. Determination of base composition of nucleic acids.
7. Bacterial conjugation
8. Isolation of drug resistant mutant
9. Estimation of mutation rate in Bacteria
10. Fluctuation test
11. Isolation of plaque morphology mutants of coliphages.
12. Obtaining mutant of *Aspergillus terreus* by using chemical and physical mutagens.
13. Isolation of antibiotic resistant mutant of bacteria.
14. Nitrous acid mutagenesis in *Aspergillus nidulans*

Reference Books for Practical course III and Practical course IV

1. "Laboratory manual in Biochemistry", by Jayraman, J., 1998, New age International Publishers, New Delhi.

2. "Experiments in Microbiology, Plant Pathology and Tissue Culture" by Aneja, K. R., 1993, Wishwa Prakashan.

3. "Practical Biotechnology" by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical Publishers (p) Ltd. New Delhi.

4. "Medical Microbiology" Vol. 2, 12th edition, 1975 by Cruickshank, R. Duguid, J. P. Marriman, B. P. and R. A. Swan, Churchill Livingstone, London.

5. "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.

6. "Manual of laboratory techniques", by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.

7. "Official methods of analysis of association of official analytical chemists", 15th edition, Association of Official Analytical Chemists, Inc., Virginia, USA.

8. "Illustrated genera of imperfect fungi", by Barnett, H. L., and Hunter, B. B., 3rd edition, 1972, Burgess Publishing Company, Minneapolis, Minnesota.

9. "Compendium of soil fungi", by Domsch, K. H., Gams, W. and Anderson, T. H., 1980, Academic Press, London.

10. "Standard methods for the examination of water and waste water", 20th edition, edited by Greenberg, et al., 1998, APHA, AWWA, WEF, Washington, DC.

11. "An Introduction to practical Biochemistry", by D. T. Plummer, 2005, Tata McGraw – Hill Publication.

12. "Microbiological applications", by Benson, H. J., 6th edition, 1994, Wm. C. Brown Publishers, Dubuque, Iowa.

13. "Identification methods for Microbiologists", edited by Gibbs, G. M. and Shapton, D. A., 1968, Academic Press, London.

14. "Microbiological applications", by H. J. Benson, 6th edition, 1994.

15. "Methods in Microbiology", Vol. 5 edited by Norris and Ribbons, Academic Press, London.

16. "Text book of Practical Microbiology", by Subhashchandra Parija first edition 2007, Ahuja publishing House, Delhi.

Skill Enhancement Compulsory Course (SECC)

02 A Soft Skills and Personality Development (02 Credits)

PREAMBLE:

Soft skills comprise pleasant and appealing personality traits as self confidence, positive attitude, emotional intelligence, social grace flexibility, friendliness and effective communication skills. Personality development is the relatively enduring pattern of the thoughts, feelings and behaviors that distinguish individuals from each other.

OBJECTIVES:

1) To motivate and guide students towards goal setting and planning of career.
2) To make students able to cope up with the stress rescuing from conflicts.
3) To enhance student's communicative abilities.
4) To enhance student's presentation skills.

Unit I

- **Planning and Goal setting:**

  Five skills needed to achieve carrier goals: Human perceptions, Understanding people types of soft skills.

  Types of soft skills

  Need for achievement and Spiritual Intelligence, Developing potential and self actualization

Unit II

- **Conflicts and stress:** Types of conflicts, conflict resolution skills, Types of stress, causes of stress, effects of stress and regulating the stress Habits – Good and Bad habits, Forming Habits of success, Breaking bad habits.

Unit III

- **Communication skills**- Communication cycle advanced and essentials,

  Basic telephonic skills.

  Communication barriers- Interpersonal transactions, mis communication

  Technology and Communication- E-mail- Principle, Netiquettes, E-mail etiquettes

Unit IV

- **Presentation skills**: Overcomimg fear, Becoming a professional, the role of body language, effective reading and using visuals.

Reference Books

1. Personality development and Soft skills by Barun K Mitra, second edition, Oxford Higher Education.2.
2. “Communication skill”, by B.V. Pathak First edition, Nirali Prakashan, Pune (India) 2006
3. “A Handbook of Communication skills in English” by R.A.Kulkarni, First edition, Phadke Prakashan, Kolhapur (India) 2001.
4. “Communication skill” by Anjali Ghanekar, 1996, Everest publishing house.

M.Sc. Part II Semester III

Course Code: 5201-31 Food and Dairy Microbiology (04 Credits)

Course Objectives:

1) To make the students gain the knowledge regarding microbial flora of milk, microbial spoilage of foods, microbial spoilage of milk and other foods and food borne diseases, food preservation techniques.
2) To make the students know how to investigate the food borne disease outbreaks.
5) To make the students understand the importance of fermented food and milk products and Indian fermented and other fermented foods.

Course Outcomes:

1) Students will gain the knowledge regarding microbial flora of milk. .
2) Student would able understand the microbial spoilage of foods, microbial spoilage of milk and other foods and food borne diseases
3) Students will gain knowledge about food preservation techniques.
4) Students will able to know how to investigate the food borne disease outbreaks
5) Students will have knowledge of the fermented food and milk products and Indian fermented and other fermented foods.

Unit I (12)

- Food as the substrate for Microorganisms.
- **Microbial flora of fresh foods**: meat, fish, shellfish, egg, fruits, and vegetables.
- **Spoilage of food**: Microbiology and spoilage of fresh foods – meat, fish poultry products (egg) vegetables and fruits, sugar and sugary products, spoilage of canned foods.
- Microbiological and chemical examinations of food.

Unit II (12)

- **Milk and Milk Products**: Definition, Chemical composition, food and nutritive value properties, sources of microorganisms and microbial flora of raw milk.
- **Spoilage of milk and milk products**: raw milk, pasteurized milk, creams, ice cream, khoa.
- Microbiological and chemical examinations of milk**.**

Unit III (12)

- **Food poisoning and food Infections and milk borne disease**: Types of food poisoning and food infections, Investigations of food borne out breaks, prevention and control of food borne disease. Milk borne diseases: Pathogens involved, their sources, control of milk borne disease.

Unit IV (12)

- **Preservation of food**: General principles preservation of food. Preservation of food by: high temperature, low temperature, Dehydration, Osmotic pressure, chemicals, Radiations.
- **Preservation of milk and milk products**: Pasteurization methods, Determination of efficiency of pasteurization.

Unit V (12)

- **Fermented foods and fermented milk products:** Indian fermented milk & food products, starter cultures for fermented milk products and fermented food products.
- **Nutraceuticals**
- **Food safety and standards:**

  Introduction, Types of adulterants, Methods of detection of intentional adulteration, Foods laws and standards: International food safety Laws and standards. Hazard analysis and critical control point (HACCP) – A state of the art approach to food safety. International organization for standardization (ISO) – ISO 9000 and other series. Indian food Laws and standards.

Reference Books:

1. "A text book of Microbiology"' by Satish Gupte, 1st edition, 2003, Jaypee Brothers Medical publishers (P) Ltd., New Delhi.
2. "Food science", 5th edition, Norman N. Potter 1996. CBS publishers and Distributors.
3. "Food processing Biotechnological application (2000)", by S.S. Marwaha and K.Arora Asiatech Publishers INC., New Delhi.
4. "Food Microbiology", edited by Rose A.H. 1983 Academic press London.
5. "Modern food Microbiology", by Jay, JM 1991 4th edition Van Nostrand Reinhold Co., New York.
6. "Manual of Industrial Microbiology and Biotechnology", by Demain, AL and NA Solomon, 1986, American Soc. for Microbiology, Washigton, D.C.
7. "Microbiology of fermented foods", edited by wood, B.J.B., 1998, Vol.1 and Vol. 2, Blackie Academic and Professional, London.
8. "Biotechnology: Food fermentations", edited by Joshi, V.K. and Pandey, A., 1999, Educational Publishers and Distributors New Delhi.

9 "Milk and milk products", by Sukumar Day.

Course Code: 5201-32 Microbial Technology – I (04 Credits)

Course Objectives:

1) To make the students well versed with the screening techniques, Microbial assays, Primary & secondary metabolites.

2) To give the students knowledge of design of fermentors, types of fermentors , equipments & instruments used in fermentation and sterilization processers.

3) To acquaint the students with fermentation media, innoculum preparation, Scale up processes &. various downstream processes used in fermentation industries.

Course Outcomes:

1) Students will be well versed with the screening techniques, Microbial assays, Primary & secondary metabolites.

2) Students will gain the knowledge of design of fermentors, types of fermentors , equipments, instruments used, sterilization processers.

3) Students will be well versed with fermentation media, inoculum preparation, Scale up Processes and with the various downstream processes of fermentation industries.

Unit I (12)

- **Industrially important metabolites of microorganisms**: Primary metabolites and Secondary metabolites.

- **Screening, strain improvement Programmes and maintenance of stock cultures of microbial strains in industry** – An overview.
- **Maximizing the efficiency of fermentation process:** Monitoring and controlling of parameters such as pH, temp, dissolved O_2 concentration etc.
- **Microbial process kinetics:** Introduction, kinetic modeling of cell growth,mass balances for ideal bioreactors.

Unit II (12)

- **Fermentor Design:**

(i) Bioreactors configurations-Stirred tanks, Bubble column, Airlift, fluidized bed, packed bed, hollow fiber, Novel seesaw bioreactor.

(ii) Bioreactor design features: Principal features of a typical (conventional) bioreactor.

(iii) Bioreactor design for sterile operation – sterilization in place, Clean in place considerations.

(iv) Photo bioreactors: Configurations –continuous run tubular loop, multiple parallel tube, helical wound tubular loop, flat panel

(v) Heat Transfer.

(vi)Shear effects in culture.

Unit III (12)

- **Designing of Fermentation Media**: Sources of Carbon, Nitrogen, Minerals ,Trace elements, growth factors (Vitamins, amino acids), Use of buffering agents, antifoam agents, inducers, repressors and precursors.
- **Sterilization of Fermentation media and fermentation vessel.**
- **Inoculum development and fermentation process** – Steps in inoculum development, Critical factors- quantity and reproducibility, mutation problems, Operation of fermentor, Detection of contamination.

Unit IV (12)

- **Mass Transfer** – Mass transfer steps, Mass transfer equations, Determining the volumetric mass transfer coefficient, effect of scale on mass transfer .
- **Contamination problems in fermentation industry and their control.**
- **Computer application in fermentation technology -** Introduction, History, General specific applications, System configuration

Unit V (12)

- **Downstream processing**

Introduction, Stages in the isolation and purification of products –
Solid Liquid separation – Filtration, centrifugation, Pretreatment release of intracellular components – Disruption of microbial cells, homogenization of animal /plant tissues, Concentration of biological products-Evaporation, liquid-liquid extraction, membrane filtration ,precipitation, adsorption to chromatographic particles, purification by chromatography, product formulation , monitoring of downstream processing , process integration.

Reference books:

1. "Prescott and Dunn's Industrial microbiology", edited by Reed, G., 4th edition, 1982.
2. "Industrial microbiology", by Miller B. M., and W. Litsky, 1976 Mc Graw-hill, New York.
3. "Pharmaceutical microbiology", edited by Hugo, W.B. and A.D. Russell 1977, Blackwell scientific, oxford.
4. "Biotechnology: A textbook of industrial microbiology", by Crueger, W. and A. Crueger, 1982, Sinauer Associates, Inc., Sunderland, Mass
5. "Biotechnology and its applications in pharmacy", by Giriraj Kulkarni T, Frist edition, 2002, Jaypee Brothers medical Publishers (P) Ltd,New Delhi.
6. "Methods in Industrial Microbiology", by B. Sikya ,1983 Ellis Horwood ltd
7. "Industrial Microbiology", by L.E. Casida,John Witey and Sons Inc.
8. "Industrial Microbiology", by A.H Patel, Mac millan India ltd,
9. "Microbial Technology vol I & II", by M.J Peppler and D.Perlman, Academic Press, London.
10. "Basic Biotechnology", edited by Colin Ratledge and Bjorn Kristiasen 2nd edition ,2001(Reprint 2004) Cambridge University press, New york.
11. "Pharmaceutical Biotechnology", by Purohit S.S.,Karkarni H.N. and Saluja A.K., Agrobios (India).
12. "Molecular Biotechnology", by Glick B.R. and Pasternak J.J., 3rd edition, 2003 (Third Indian Reprint 2007), ASM Press, Washington, D.C.

Course Code: 5201-33 Environmental and Applied Microbiology(04 Credits)

Course Objectives:

1) To make the students understand the various methods of Biomagnification and Eutrophication, microbial bioleaching of ores, bioremediation processes by microorganisms and their applications in degradation of xenobiotics.

2) To make the students familiar with basic concepts and basic design of biosensors.

3) To give the students detail knowledge about the solid waste treatment methods and liquid waste treatment methods & various aspects of waste disposal & control.

Course Outcomes:

1) Student will be able to understand the various methods of microbial bioleaching of ores, bioremediation processes by microorganisms and their applications in degradation of xenobiotics.

2) Students will be well versed with basic concepts and basic design of biosensors.

3) Students will also acquire the knowledge of Biomagnification and Eutrophication

4) Students will have detail knowledge about the solid waste treatment methods and liquid waste treatment methods & various aspects of waste disposal & control.

Unit I (12)

- **Microbial Ecology :**

  i) **Communities and ecosystems Population interactions**: Types of interactions,

  Commensalism, Synergism, mutualism, competition, Ammensalism, Parasitism.

  ii) **Invertebrate microbes interaction:**

  a*) Vibriofischeri* &*squideuprymna* mutualistic interactions.

  b) Hydrothermal vents – metabolic interactions – *Rifetia*& its bacterial endosymbionts.

  c) Bacterium – Aphid symbiosis – *Buchnera aphidicola* – Aphid symbiosis

- **Phototrophic microbes** – Food source for planet earth

Unit II (12)

- **Bioaugmentation :** Concept, Bioaugmentation with – chemical and other agents , with specific or group of microorganisms
- **Microbial degradation of Xenobiotics**
- **Microbial bioremediation –**

Microbial leaching of ores - Copper, Uranium and Gold Mercury and heavy metal transformation.

- Use of bacteria for detecting pollutants and pathogens pollutants and pathogens.

Unit III (12)

- **Special Environmental Phenomenon:**Acid mine drainage, Eutrophication, Biomagnification
- **Nanotechnology and Microbiology:** Nanotechnology- Introduction, Fundamental concepts, Importance, Nanotechnology and Microbiology

Unit IV (12)

- **Microbiology of Waste Treatment:**

(i) Biological treatment of Industrial wastes:

Solid Waste disposal - microbiology of land fills, backyard & commercial composting

Treatment of Liquid waste- Primary and secondary treatment of waste- Aerobic, Oxidation ponds, anaerobic lagoons, anaerobic digesters, trickling filter system, rotating biological contactor (Biodisc systems) Activated sludge process.
Tertiary treatment of waste – Use of chemicals, activated carbon filters, reverse osmosis.
Final treatment of Waste – Disinfection

(ii) Microorganisms in Waste Treatment Technology: Natural sources of microorganisms, Enrichment, Isolation and acclimatization of microorganisms to waste, treatibility studies, single culture and mixed culture, mass scale production of seed culture, application of microbial seed cultures in the treatment of industrial wastes.

Unit V (12)

- **Aquatic Microbiology**: The hydrologic cycle, The structure of aquatic ecosystems, Marine environments, fresh water environments, aquatic communities, oligotrophy, water pollution and its consequences. Water management to prevent diseases. Water quality Assays – Methods.

- **Waste Disposal control and regulations.**

i) Regulatory bodies- state level, national level and international level.

ii**)** Water Pollution control, board regulation- Limits for disposal of waste into lakes, rivers, Oceans and Land.

iii) Environmental Impact Assessment (EIA) and Environmental Audit (EA).

Reference Books:

1. "Microbial degradation of Xenobiotic and Recalcitrant compounds", edited by Leisinger T.et al. 1982, Academic press, New York.

2. "Microbial Ecology: Priciples, methods and applications", by Levin MA, RJ Seidler, M Rogne: 1991, Mc Graw-Hill, New York.

3. "Microbial Ecology", by Lynch JM and J.E Hobbie, 1988, Blackwell scientific, Boston.

4. "Biotechnology for Biological Control of Pests and Vectors", 1991 CRC press, Boca Raton, FL.

5. "Environmental microbiology", edited by Mitchell, R., 1992, John Wiley, New York

6. "Methods in Microbiology vol. 22, - Techniques in microbial Ecology", edited by Norris JR and Grigorova, 1990.

7. "Aquatic Microbiology", by Rheinheimer, G. 4th edition, 1991, John Wiley and Sons, New York

8. "Environmental Biotechnology for Waste treatment", by Sayler G.S., R.Fox, J.W. Blackburn, 1991, Plenum Press, New York.

9. "Principles of Microbiology" by Atlas, R.M.,1995, mosby-year book, inc. St. Louis, Missouri. Petroleum Microbiology" by Atlas, R.M. 1983, Macmillan, New York.

10. " Microbial Mineral Recovery" edited by Ehrlich H.L. and C.L. Brierley 1990, McGraw- Hill, New York.

11. "Prescott, Harley and Klein's Microbiology", by Wlley J.M, Sherwood L.M, and Woolverton C.J, 2008, Mc Graw- Hill companies Inc. New York

12."Bacterial Biogeochemistry: The ecophysiology of mineral cycling" by Fenchel, T. King ,G .M and Blackburn, T .H 1998, academic press, new york

13."Environmental Biotechnology: principles and application", by Rittmann, B E and Mc Carty , P L 2001, Mc Graw- Hill, New York

14. " Manual of Environmental Microbiology", by Hurst, C J; Crawford, R.L.,R L , Knudsen, G. R., Mc Inerney, M. J. ; and Stetzenbach , L.D. 2002, ASM press, Washington, D. C.

Course Code: 5201-34Bioinformatics for Microbiologist (04 Credits)

Course Objectives:

1) To give the students the basic knowledge about computers, operating system, internet resources.
2) To acquaint the students with the various important tools and techniques of information technology, Metabolimics and Phylogenetic analysis .
3) To make the students understand the basics of biological databases, Methods of sequence alignment, Genomics & Proteomics, Protein structure prediction & drug designing.

Course Outcomes:

1) Students will acquire the knowledge of computers, operating system, internet resources.
2) Students will get introduced with tools and techniques of information technology, Metabolimics and Phylogenetic analysis .
3) Students will acquire the knowledge of biological databases, Methods of sequence alignment, Genomics and Proteomics
4) Students will get introduced with basic of 'C' language and structured query language.
5) Students will get introduced with protein structure prediction and drug designing.

Unit I **(12)**

- **Fundamentals of Computers:**
  i. Internet: Resources, World Wide Web, Tools associated and terminologies.
  ii. Computer Viruses: Overview, Transmission and Precautions.
- **Programming Language: Basics of "C"**

1.Fundamentals of programming

a. Designing Flow charts / Algorithms
b. Pseudocodes

2.Fundamentals of C

b. Data types,
c. Operators and Expressions,
d. Hierarchy of operations, C instructions

3.Control statements

a. Decision (if, if-else)
b. Loops control (while, do-while, For)

4. Functions

5. Arrays and strings

Unit II **(12)**

- **Introduction to databases:**
  1. **Databases:** Primary, Secondary; Relational and Non relational; Redundant and Non Redundant.
  2. **E-R Model**
     a. Entity and Entity sets
     b. E-R Diagrams
     c. Reducing E-R diagram to tables
  3. **Introduction to SQL**
     a. Select statement
     b. Data definition Statements
     c. Data manipulation statements

Unit III **(12)**

Biological Databases:

1. Bioinformatics Resources: NCBI, EBI, ExPASY
2. Biological search Engines: SRS and ENTREZ
3. Biological Databanks: PDB, MMDB.
4. Derived, Databases: PROSITE, Pfam, PRINTS, CATH, SCOP, DSSP, FSSP, DALI.
5. Nucleic Acid databases and Protein databases:

Unit IV **(12)**

- **Biological Data Analysis:**
  1. Overview, Concepts and tools.
  2. Sequence comparison by Dot Matrix and Dynamic Programming.
  3. Pair wise Sequence Analysis by Needle man and Wunch algorithm
  4. Scoring Matrices: PAM, BLOSSUM
  5. Database Search: BLAST and FASTA
  6. Multiple Sequence Alignment: Basic concepts, Progressive and Hierarchical approaches CLUSTAL-W, Applications.
  7. Immunoinformatics databases

Unit V **(12)**

- **Protein structure prediction:**

i) Necessity of Protein structure Prediction
ii) Secondary structure prediction
iii) Fold Recognition
iv)Homology Modeling
v) Ab-initio Methods

- **Microbial Genomics and Proteomics** :

  a) Genomics:

i) Functional genomics and comparative genomics.

ii) Insight from microbial Genomes- Identification of genes with unknown function, Genomic analysis of pathogenic microbes and extremophiles, Environmental genomics (metagenomics)

b) Proteomics: Functional proteomics, structural proteomics, protein modeling

- **Metabolimics:**

1. Metabolic Pathway databases

a.KEGG

b. EcoCyc and MetaCyc

2. Enzyme compounds and Reaction Databases

a. LIGAND-Biochemical and Reaction Databases

b. ENZYME- Enzymes

c. BRENDA

d. Metabolic Pathway Prediction.

- **Structure based Drug Design :** Introduction

Reference books:

1. "Fundamental concepts of Bioinformatics", by Krane, D.E. and Raymer,M.L.2003,Benjamin cunning, San Francisco, Calif.
2. "Discovering genomics, proteomics and Bioinformatics", by Campbell, A.M, and Heyer, L.J., 2003, Benjamin cunnings, San Francisco, CA.
3. "Introduction to SQL and PLSQL", by Ivan Dayross".
4. "Bioinformatics", by C.S.V. Murthy, 2003, Himalaya Publishing House, Mumbai.
5. "Introduction to computers", by Leon A. and Leon M. Vikas Publishing House Pvt., New Delhi.
6. "Fundamentals of computers", by Rajaraman, V. Printice Hall of India, New Delhi.
7. "Prescott, Harley and Klein's microbiology", by Willey, Sherwood and Woolverton, 2008, Mc Graw- Hil companies, Inc, New york.

Course Code: **5201-35 Practical Course V (04 Credits)**

Course Objectives:

1) To give the students training and practice of carrying out physicochemical analysis of milk and food, microbiological examination of food, milk and milk products.
3) To enable the students to carry out examination of canned foods
4) To make the students independently search, store, retrieve and analyze the biological data
5) To give the students all the basic background needed for working in Food and Dairy industry.

Course Outcomes:

1) Students will be able to carry out physicochemical analysis of milk and food
2) Students will know how to carry out the microbiological examination of food, milk and milk products.
3) Students shall be able to independently search, store, retrieve and analyze the biological data
4) Student will get acquainted with all the basic background needed for working in Food and Dairy industry.

1. Microbiological examination of milk and milk products.

1. MBRT test for ice cream.
2. Phosphate test on pasteurized milk / pasteurized cream.
3. Turbidity test on sterilized milk.
4. Colony count test (SPC) on raw, pasteurized milk.
5. Detection of mastitis through milk test

2. Microbiological examination of food for Food poisoning / Food infection bacteria – Examination of:

(i) Fish - for ***Vibrio parahaemolyticus.***
(ii) Cream / hams for ***Staphylococcus aureus***
(iii) Rice dish - ***Bacillus cereus***
(iv) Processed meat /chicken for ***Campylobacter***
(v) Raw/ Under pasteurized milk or milk products - for ***Yersina enterocolitica.***

3. Examination of canned food.

4. **Physico chemical analysis of food:** Determination of colour, texture, taste, pH, Benzoate, sorbate.

5. Physico – Chemical examination of milk:

(i) Specific gravity
(ii) Solid content
(iii) Fat
(iv) Protein
(v) Sugar

6. Computer and Bioinformatics:

(i) Introduction to Computer system – components and function.
(ii) Introduction to word processing and spreed sheet application – M.S. Word, M.S. Excel,

Power Point.

(iii) Getting started with Internet and search Engines - creating personal E. Mail,using Google.

(iv) Creating and Populating data base- M.S. Access.

(v) Data base searching – Using Blast.

(vi) Bioinformatics recourses - NCBI, EMBL, ExPassy

(vii) Using nucleic acid databases - DDBJ, GenBank

(viii) Using protein databases- Swiss prot, TrEMBL, Uniprot

(ix)Construction phylogenetic trees

Course Code: 5201-36Practical Course VI (04 Credits)

Course Objectives:

1) To make the students demonstrate various microbial interactions such as commensalism, ammensalism , mutualism etc.
2) To make the students perform screening out industrially important microbial strains like organic acid producers, antibiotic producers, protease producers, enzyme producers.
3) To acquaint the students with the determination of BOD and COD removal efficiency of waste water treatment plant
4) To make the students know about producing biofertilizer(Azo, Rhizo) on the laboratory scale.
5) To make the students gain the knowledge of working in fermentation industry particularly in production units, micro-labs and Quality Control departments.

Course Outcomes:

1) Students will be able to demonstrate various microbial interactions such as commensalism, ammensalism , mutualism etc.
2) Students will be able to screen out industrially important microbial strains like organic acid producers, antibiotic producers, protease producers, enzyme producers.
3) Students will be able to determine BOD and COD removal efficiency of waste water treatment plant
4) Students will be able to produce biofertilizer(Azo, Rhizo) on the laboratory scale.
5) Students will be able to work in fermentation industry particularly in production units, micro-labs and Quality Control departments.

i. Screening of amino acid producers
ii. Screening of protease producers.
iii. Screening of organic acid producers.
iv. Biomass production – Production of Azotobacter and Rhizobium fertilizers
v. Development of Inoculum for activated Sludge process.
vi. Determination of BOD and COD removal efficiency of a waste treatment plant.
vii. Treatability tests for Industrial effluents
viii. Production of ethanol from sweet sorghum
ix. Production of Yoghurt.
x. Demonstration of Microbial interactions
   (i) Mutualism
   (ii) Commensalism
   (iii) Syntrophism
   (iv) Amensalism (Antagonism)
   (v) Parasitism
   (vi)Synergism (Protocooperation)

xi. Demonstration of indole acetic acid(IAA) production by soil fungi
xii. Isolation of *Azospirillum* from soil / roots.

Reference Books for Practical Course

1. “Experiments in Microbiology, Plant Pathology and Tissue Culture”, by Aneja, K. R., 1993, Wishwa Prakashan.
2. “Practical Biotechnology”, by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical Publishers (p) Ltd. New Delhi.
3. “Medical Microbiology Vol. 2”, 12th edition, 1975 by Cruickshank, R. Duguid, J. P. Marriman, B. P. and R. A. Swan, Churchill Livingstone, London.
4. “Hand book of microbiological media”, by Atlas, R. M., 1993, CRC Press, Inc. Florida.
5. “Manual of laboratory techniques”, by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.
6. Official methods of analysis of association of official analytical chemists, 15th edition, Association of Official Analytical Chemists, Inc., Virginia, USA.
7. “ Bioinformatics”, by C.S.V. Murthy 1st edition publishers Himalaya Publishing House, Mumbai.
8. “Standard methods for the examination of water and waste water”, 20th edition, edited by Greenberg, et al., 1998, APHA, AWWA, WEF, Washington, DC.
9. “Laboratory Manual in Industrial Biotechnology”, by P. Chellapandi 2007, Pointer Publishers, Jaipur.
10. “Mackie and Mc Cartney Practical Medical Microbiology”, 14th edition 2007, by J.G. Collee, A.G. Fraser, B.P. Marmion, A. Simmons, Publisher Churchill living stone elsevier – New Delhi.
11. ‘Pharmaceutical Biotechnology”, by Purohit, Kakrani, Saluja 1st edition Publishers, Agrobios (India) Jodhpur.

Ability Enhancement Compulsory Course (AECC)

03 Leadership Development (02 Credits)

PREAMBLE:

Leadership is critical to the success of organizations and socities. Leaders are made, not born, for the situation at hand. Leadership is the ability to get people together to solve the problems.

OBJECTIVES:

1) To give students knowledge about how to do team work & lead the team.
2) To train the students for wise and prompt decision making ability.
3) To develop the student's to handle the workload effectively.

Unit I

- Introduction to leadership, functions of leadership, theories.

Unit II

- Leadership types- Effective leadership, successful management, leadership behaviors-Emergence, leadership and trust, Transformation leadership.

Unit III

- Leadership Skills- leadership and management, competencies and skills of leaders, leaders in action.

Unit IV

- Institution Building in framework and issues Institution building.

References:

- 1. Leaders Eat Last (Hardcover) by Simon Sinek (Goodreads Author) published 2013
- 2. The 7 Habits of Highly Effective People: Powerful Lessons in Personal Change (Paperback) by
- Stephen R. Covey published 1988
- 3. Leading Change (Audiobook) by John P. Kotter (Goodreads Author) published 1988

M.Sc. Part II Semester IV

Course Code: 5201-41 Enzymology (04 Credits)

Course Objectives:

1) To make the students conversant about enzymes, enzyme catalysis, rate of reactions, order of reactions, kinetics of enzyme catalysed reactions and enzyme inhibitions and their regulatory processes.
2) To give the students knowledge about the extraction, purification, immobilization and biotechnological applications of enzymes.
3) To make the students gain the knowledge of isoenzymes, multi enzymes and multi enzyme complexes.

Course Outcomes:

1) Student would able to describe structure, functions and the mechanism of action of enzymes, kinetics of enzyme catalysed reactions and enzyme inhibitions and their regulatory process.
2) Students would have the knowledge of immobilization of enzyme and exposure of wide applications of enzymes and future potential uses of enzymes.
3) Students would be well versed with kinetics of soluble and immobilized enzymes.
4) Students would gain the knowledge of enzyme catalysis, isoenzymes, multi enzymes and multi enzyme complexes.

Unit I (12)

- **Naming and classification of enzymes according to International Union of Biochemistry & Molecular Biology (IUBMB)**
- **Extraction and Purification of Enzymes :**

  Extraction of Enzymes– Introduction, The Extraction of Soluble Enzymes, The Extraction of Membrane-Bound Enzymes, The Nature of the Extraction Medium.

  Purification of Enzymes : Preliminary Purification Procedures, Further Purification Procedures, Criteria of Purity. Determination of Molecular Weights of Enzymes.

- **Monomeric and Oligomeric Enzymes :**

  (i) Monomeric Enzymes –Introduction, The Serine Proteases, Some other monomeric Enzymes.

  (ii) Oligomeric Enzymes – Introduction, Lactate Dehydrogenase, Lactose Synthase, Tryptophan Synthase, Pyruvate Dehydrogenase.

UNIT II (12)

- **An Introduction to Catalysis and Kinetics :**

(i) Factors Affecting The Rates of Chemicals Reactions– The Collision Theory, Energy of Activation and The Transition – State Theory, Catalysis.

(ii) Kinetics of Uncatalysed Chemical Reaction– The Law of Mass Action and the order of Reaction, The use of Initial Velocity.

Kinetics of Enzyme–Catalysed Reactions : An Historical Introduction.

(iii) Methods used for Investigating the Kinetics of Enzyme – Catalysed Reactions – Initial Velocity studies, Rapid– reaction Techniques.

- **The Chemical Nature of Enzyme Catalysis :**

(i) Mechanism of Catalysis – Acid – Base Catalysis, Electrostatic Catalysis, Covalent Catalysis, Enzyme Catalysis.

(ii) Mechanisms of Reactions Catalysed by Enzymes without Cofactors – Introduction, Chymotrypsin, Ribonuclease, Lysozyme, Triose Phosphate Isomerase.

(iii) Metal – Activated Enzymes and Metalloenzymes – Introduction, Activation by Alkali Metal Cations (Na^+ and K^+), Activation by Alkaline Earth Metal Cations (Ca^{2+} and Mg^{2+}) Activation by Transition Metal Cations (Cu, Zn, Mo, Fe, and Co Cations)

(iv)The Involvement of Coenzymes in Enzyme-Catalysed Reactions – Introduction, Nicotinamide Nucleotides (NAD^+ and $NADP^+$), Flavin Nucleotides (FMN and FAD), Adenosine Phosphates (ATP, ADP and AMP), Coenzyme A (CoA.SH), Thiamine Pyrophosphate (TPP), Pyridoxal phosphate, biotin, Tetrahydrofolate, Coenzyme B_{12}.

UNIT III (12)

- **Kinetics of Single – Substrate Enzyme – Catalysed Reactions :**

The Relationship Between Initial Velocity and Substrate Concentration – The Henri and Michaelis – Menten Equations, The Briggs – Haldane Modification of the Michaelis – Menten Equation, The Significance of the Michaelis – Menten Equation, The Lineweaver – Burk Plot, The Eadie – Hofstee and Hanes Plots, The Eisenthal and Cornish – Bowden Plot, The Haldane Relationship for Reversible Reactions. Rapid – Reaction Kinetics – Pre – Steady-state Kinetics, Relaxation Kinetics.
The King and Altman Procedure.

- **Kinetics of Multi – SubstrateEnzyme – Catalysed Reactions :**

(i) Examples of possible Mechanisms – Introduction, Ping-Pong Bi-Bi Mechanism,

Random – Order Mechanism, Compulsory – Order Mechanism

(ii) Steady – State Kinetics – The General Rate Equation of Alberty, Primary Plots for Mechanisms Following The General Rate Equation, The General Rate Equation of Dalziel, Rate Constants and the Constants of Alberty and Dalziel.

(iii) Investigation of Reaction Mechanism using steady – State Methods – The Use of Primary Plots, The use of Inhibitors which Compete with substrates for Binding sites,

(iv) Investigation of Reaction Mechanism using Non-Steady-State Methods – Isotope exchange at equilibrium, Rapid – reaction Studies

UNIT IV (12)

- **Enzyme Inhibition:**

Introduction, Reversible Inhibition – Competitive Inhibition, Uncompetitive Inhibition, Non – Competitive Inhibition, Mixed Inhibition, Partial Inhibition, Substrate Inhibition, Allosteric Inhibition, Irreversible Inhibition.

- **The Significance of Sigmoidal Behaviour :**

(i) The Physiological Importance of Cooperative Oxygen – Binding by Haemoglobin

(ii) Allosteric Enzyme Metabolic Regulation – Introduction, Characteristics of Steady – State Metabolic Pathways , Regulation of Steady – State Metabolic Pathways by control of enzyme activity, Allosteric enzymes and the Amplification of Metabolic regulation.

(iii) Other Mechanisms of Metabolic regulation, Some examples of Allosteric enzymes involved in metabolic regulation.

UNIT V (12)

- **Enhancement of enzyme activity & thermostability using nanotechnology**

- **Enzymes – Production, immobilization and Applications:**

Large-Scale production of Enzymes, Immobilised Enzymes – Preparation of Immobilised Enzymes, Properties of Immobilised Enzymes, Applications of Immobilised Enzymes : General Principles.

Applications of enzymes in Industries .

Application of Enzymes in Medicine and Diagnostics.

Reference Books :

1. “Understanding Enzymes”, by T. Palmer, Ellis Horwood limited.

2. “Lehninger Principles of Biochemistry”, by David L. Nelson and Michel M. Cox, 4th edition, 2005 W. H. Freeman and Co. New York.
3. “Pharmaceutical Biotechnology”, by S.S. Purohit, H.N. Kakarni and A.K. Saluja, 2007, Agrobios (India).
4. “Basic Biotechnology”, edited by colin Ratledge and Bjorn Kristiansen, 2001, Cambrige University, Press, New York.
5. “Enzyme Biotechnology”, by G. Tripathi.
6. “Fundamentals of Enzymology”, 2nd edition, by Nicholas C. Price and Lewis Stevens, 1989, Oxford University press, New York.

Course Code:5201-42 Microbial Technology II (04 Credits)

Course Objectives:

1) To give the students deep theoretical knowledge about the industrial production of yeast, yeast products, mushrooms , polysaccharides, pigments, bioinsecticides etc.
2) To make the studentswell versed with the instrumentation used in fermentation industry.
Students should also know applications of computers in fermentation industry.
3) To introduce the students with economics of fermentation processes, IPR, Patent office, Patent filling process etc.

Course Outcomes:

1) Students will gain deep theoretical knowledge about the industrial production of yeast, yeast products, mushrooms , polysaccharides, pigments, bioinsecticides etc.
2) Students will be well versed with the instrumentation used in fermentation industry.
3) Students will learn about the applications of computer in fermentation industry which will be increasing his skills for working in industry.

UNIT I (12)

- **Methods for laboratory fermentations – an overview :**
  Introduction, Experimental Design, Screening Techniques, Media Selection, Equipment, Intermediate scale-up.

- **Instrumentation of fermentation system :**
  Concepts of biological process Analysis and Control, Types of Instrumentation used in biological process analysis, Measurement and control environmental variables, Electronic Analysis of process data, Evaluation of control concepts in biological process, Auxillary instrumentation.

Unit II (12)

- **Production of Carotenoids :** Introduction, Production of β – carotene, Production of Lycopene, Production of Xanthophylls and Other pigments, Marketing Prospects for Carotenoids.

- **Microbial production of Nucleosides and Nucleotides :**
Introduction , Classification of methods for Production of 5′ IMP and 5′ GMP, Production 5′- IMP and 5′- GMP by hydrolysis of RNA, Production of 5′IMP and 5′GMP by fermentation, Production of Nucleic acid- related substances by fermentation.

- **Microbial production of Polysaccharides :**
  Introduction, Nature of Microbial Polysaccharides, Mechanism of synthesis, Bacterial Polysaccharides, Fungal Polysaccharides, Yeast Polysaccharides, commerically produced Polysaccharides.

UNIT III (12)

- **Mushroom Fermentation :**
  Introduction, Mushroom fermentation, Spawn production, Mushroom formation, Processing problems.

- **Production of yeasts and yeast Products:**
  Introduction, Yeast Production, Yeast- Derived product.

- **Production of Bioinsecticides :**
  Introduction, Historical background, Candidate microbial insecticides, Developmental phases of microbial insecticide, Technical Parameters: Microbial Insecticides.

UNIT IV (12)

- **Production of alcohol as a fuel source**

- **Vinegar Production :**
  History and development, Mechanism of Acetic Acid Fermentation, Acetic Acid Organisms, Commercial Vinegar Production, Finished Vinegars, Processing of Vinegar, Annual Production and Uses.
- **Production of acetone butanol by fermentation.**

- **Microbial synthesis of rubber, adhesive proteins & melanine**

UNIT V (12)

- **Fermentation Processes and products: problems in patenting**
  Introduction, Background, Patent Practice and Problems

- **Economics of fermentation processes** :
  Introduction, Plant Design, Process Design, Case study – project evaluation

- **Use of Immobilized cell systems to prepare Fine chemicals** :
  Introduction, Immobilization of microbial cells, Characteristic of Immobilized cells, Production of chemical by Immobilized microbial cells.

Reference Books :

1) "Microbial Technology", 2nd edition, volume I, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York.

2) “Microbial Technology”, 2nd edition, volume II, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York.

3) “Basic Biotechnology”, 2nd edition, by Colin Ratledge and Bjorn Kristiansen, 2001,Cambridge University Press, New York.

4) “Prescott and Dunn’s Industrial Microbiology”, edited by Reed, G., 4th edition, 1982.

Course Code: 5201-43 Recombinant DNA Technology (04 Credits)

Course Objectives:

1) To give the studentsthe knowledge of basic principles and methods of recombinant DNA technology, construction and screening of genome libraries and c DNA libraries.
2) To give the studentsthorough knowledge about advanced techniques used in rDNA technology like PFGE, RFLP, RAPD etc.
3) To make the students acquire knowledge about applications of recombinant DNA technology in the field of medicine and industry
4) To impart the basic understanding of gene therapy systems, protein engineering and ethical issues involved in genetic engineering to the students.

Course Outcomes:

1) Students would have the knowledge of basic principles and methods of recombinant DNA technology.
2) Students will get thorough knowledge about construction and screening of genome libraries and c DNA libraries.
3) Students will get a thorough knowledge about advanced techniques used in rDNA technology like PFGE, RFLP, RAPD etc.
4) Students will acquire knowledge about applications of recombinant DNA technology in the field of medicine and industry
5) Students will have the basic understanding of gene therapy systems, protein engineering and metabolic engineering
6) Students will also have a insight into the ethical issues involved in genetic engineering

UNIT I (12)

- **Selection of recombinant DNA clones :** Detecting target DNA phosphatases, labeling nucleic acids, reverse transcriptase, exonucleases, ribonucleases, proteases, linkers and adaptors, radioactive and non-radioactive labeling, nick translation, primer extension.

- **Construction of genome and c DNA Libraries:**
  (i) Aspect of gene Libraries.
  (ii) Genome DNA Library.
  (ii) c DNA Library.

- **Screening of gene Libraries:**
  Colony and plaque hybridization, PCR screening of gene Libraries Hybrid select / arrest translation, screening expression c DNA Libraries.

UNIT II (12)

- **Advanced Techniques used in r DNA Technology:**
  (i) Pulsed field gel electrophoresis (PFGE)

(ii) Contour clamped homogenous electric, field electrophoresis (CHEFE),
(iii) Polymerase chain reaction (PCR)
(iv) Microarrays,
(v) DNA Finger printing.

UNIT III (12)

- **Application of gene cloning :**
  Sequencing cloned DNA, In vitro mutagenesis and rational design, oligonucleotide – directed mutagenesis.

- **Recombinant DNA Technology in Medicine and Industry:**
  (i) New approaches to drug design
  (ii) Production of human Growth Hormone in bacteria.
  (iii) Macromolecular modification in proteins.
  (iv) Gene therapy
  (v) Construction of Industrially important bacteria.

UNIT IV (12)

- **Recombinant DNA technology in generation of agriculturally important plants:**
  (i) Production of human proteins in plants.
  (ii) Expressing viral coat proteins and bacterial toxins in plants.
  (iii) Developing new colours and patterns in flowers of plants.
  (iv) Herbicide tolerant transgenic plants
  (v) Use of anti sense RNA in transgenic plant Technology.

- **Recombinant DNA technology in generation of transgenic animals:**
  (i) Generation of transgenic farm animals.
  (ii) Production of Pharmaceutical proteins in transgenic animals – animal farming.

UNIT V (12)

- **Recombinant DNA and enzyme Technology :**
  Enzyme over production, Superior enzyme production.

- **Advances in animal & human cloning :**Advantages and disadvantages of human & animal cloning.

- **Patents and Property Rights, WTO regulations and Biosafety regulations:** Social, Moral and Ethical issues.

Reference Books:

1. "Recombinant DNA: Genes and genomes – a short course", by Watson J.D. Myers, R.M., Caudy A.A. and Witkowski, J.A., 3rd edition 2007, W.H. Freeman and Company, New York.
2. "Recombinant DNA", by J.D. Watson, 2nd edition.
3. "Principles and Techniques of Biochemistry and Molecular Biology", edited by Keith Wilson and John Walker, Sixth edition, 2005, Cambridge University press, New York.
4. "Plant Biotechnology", edited by R. Keshwachandran and K. V. Peter Universities press Pvt. Ltd. Hydrabad.
5. "Principles of Gene manipulation", by R.W. Old and S.B. Primrose.
6. "Biotechnology-Principles and applications", by Rastogi, S.C., 2007, Narosa Publishing House, Pvt. Ltd. New Delhi.

Course Code: 5201-44 Pharmaceutical Microbiology (04 Credits)

Course Objectives:

1) To make the students to understand the Drug discovery and drug development

2) To impart the knowledge to the students about the production of various types of enzymes, amino acids, vitamins, and organic acids and probiotics to the students.

3) To give the students deep insight into the antibiotics, antimicrobial agents and their mode of action.

4) To give the students knowledge about good manufacturing practices.

Course Outcomes:

1) Students will gain the knowledge regarding Drug discovery and drug development

2) Students will get knowledge about production of various types of enzymes, amino acids, vitamins, and organic acids.

3) Students will have a deep insight into the antimicrobial agents and their mode of action.

Unit I **(12)**

- **Antibiotics and Drugs**: Antibiotics and synthetic antimicrobial agents: antibacterial, antifungal, antiviral, antiprotozoal and anti cancer antibiotics and drugs and their mode of action.
- **Microbial Production of Antibiotics :** Bacitracin, Cephalosporins, Tetracyclines, Anthracyclines**,** Amphotericin**,** Griseofulvin, Novobiocin, Rifamycin

Unit II **(12)**

- **Drug discovery and development:**

  (i) Drug discovery: Historical aspect, current approaches to drug discovery.
  Conventional process Bioprospecting; principles of extraction, purification and characterization of bioactive molecules from natural sources. Rational drug design- Principles and tools.

  (ii)Drug development:
  Preclinical development: Toxicological evaluation of drug mutagenicity, carcinogenicity and teratogenicity.

- **Clinical development :**
  Clinical trials- (Aims, Objectives and conduct)- (Phase I, II, III, IV)

Unit III **(12)**

- **Microbial production of amino acids in pharmaceutical industry.**

(i) Microbial production of amino acids : Introduction, Microbial stains employed in Amino acid production – Direct production of Amino acids from carbon sources, Precursor addition methods, Enzymatic methods, Process control in Amino acid fermentation – Maintenance of pure culture conditions, Automatic control of amino acid fermentation, Agitation – Aeration effectiveness.

(ii) Production of specific amino acids: L – Lysine, L - Glutamic acid, L – Leucine, L – Isoleucine

Unit IV (12)

- **Production of vitamins**: Riboflavin, Ascorbic acid
- **Production of Probiotics –** *Lactobacillus acidophilus, Lactobacillus casei*
- **Production of microbial enzyme by fermentation :**

  Oxidoreductases, Oxidases, Hydrolases, Transferases, Kinases, Isomerases.
- **Microbiological assays-**Antibiotics, Vitamins and amino acids
- **Sterility testing of pharmaceutical products.**

Unit V (12)

Regulatory aspects in pharmaceutical industries

Introduction to pharmacopoeia: Food and Drug Administration (FDA) regulation and India Pharmacopoeia (IP), British Pharmacopoeia (BP), United States Pharmacopoeia(USP) Good Laboratory Practices (GLP) Good Manufacturing Practices (GMP) and Current Good Manufacturing Practices (cGMP), Reimbursement of drugs and biological.

Reference Books :

1. "Pharmaceutical Biotechnology", by S.S. Purohit, H.N. Kakarni and A.K. Saluja, Agrobios (India).
2. "Basic Biotechnology", edited by colin Ratledge and Bjorn Kristiansen, 2001, Cambridge University, Press, New York.

3. "Biotechnology : A Text Book of Industrial Microbiology", 2nd edition by Wulf Crueger and Anneliese Crueger (Third Indian reprint 2005), Panima Publishing Corporation New Delhi / Banglore.

4. "Microbial Technology", 2nd edition, volume I, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York.

5. "Microbial Technology", 2nd edition, volume II, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York.

Course Code: 5201-45 Practical course VII (04 Credits)

Course Objectives:

1) The students should be able to isolate purify and assay the industrially important enzymes from microorganisms like protease, amylase etc.
2) Student should be able to carry out enzyme kinetic studies.

3) To make the students conversant with the use of PCR techniques through the demonstration.

Course Outcomes:

1) Students will acquire knowledge and skills of enzymatic assays – protease, lipase, cellulase, pectinase , chitinase, glucose oxidase and would able to carry out enzymatic assays independently in the laboratory.
2) Students will be able to perform independently DNA restriction digestion and DNA ligation techniques and PCR techniques.
3) Students will get conversant with the use of PCR techniques through the demonstration.
4) Students will be able to perform enzyme kinetics.

1. Production of protease from *Bacillus*SPPs.
2. Precipitation of protease.
3. Purification of protease.
4. Quantitative estimation of protease.
5. Assay of Enzymes :
   i)Lipase,
   ii) Cellulase,
   iii) Pectinase,
   iv) Chitinase,
   v) Glucose Oxidase.
6. Studies on the effect of various factors on enzyme activity :
   a. Effect of Substrate concentration
   b. Effect of Enzyme concentration
   c. Effect of P^H
   d. Effect of Temperature
   e. Effect of Metal ions.
7. Purification, storage and concentration of DNA.
8. Restriction enzyme digestion of DNA.
9. DNA Ligation.
10. Elusion of DNA fragments from agarose.
11. Generation of electricity by microorganisms – Biofuel cell.
12. Production of SCP – Mushroom
13. Isolation of probiotic bacteria – *Lactobacillus casei, Lactobacillus acidophilus* from curd.
14. Production of yeast & yeast derived products
15. Fermentative production of Amylase by *Aspergillus niger*

Reference Books:

1. "Practical Biotechnology", by S. Janarthanan and S. Vincent 2007, Universities Press (India) Pvt. Ltd. Hyderabad.

2. “Practical Biotechnology”,, by P. Ramadass and A. Wilson Aruni, 2007 Jaypee brothers Medical Publishers (P) Ltd., New Delhi.
3. “Laboratory manual in Biochemistry”, by J. Jayaraman, first edition, (Reprint 2007) New Age International (P) Ltd., Publishers, New Delhi.
4. “An Introduction to practical Biochemistry”, by David T. Plummer, 3rd edition (30th reprint 2007), Tata Mc Graw – Hill Publishing company Ltd., New Delhi.
5. “Experiment in Microbiology”, Plant pathology and Tissue culture”, by Aneja, K. R., 1993, Wishwa Prakashan.

Course Code: 5201 – 46 Project Work * (In lieu of Practical course VIII) (04 Credits)

Course Objectives:

1) To make the students prepare for selection of the project topic, carry out literature survey.

2) To make the students enable to set up experimental design, to investigate the problem and record the results and interpret.

3) To make the students able to write the project report in the IMRAD format – Title, Introduction, Aims & Objectives, Materials & Methods, Results & Discussion, Summary and Conclusion, citing references and preparation of bibliography.
4) To impart the students with the skills of presentation and defending the project report orally.

Course Outcomes:

After completion of project work, writing project report and presentation of project work student will be well versed with:
1) How to select the project topic.
2) How to make literature survey.
3) How to set up experimental design to investigate the problem and able to record and interpret the results.
4) How to write the project report in the proper format – Title, Introduction, Aims & Objectives, Materials & Methods, Results & Discussion, Summary and Conclusion.
5) How to cite references and to prepare bibliography.
6) How to write acknowledgements.
7) How to present and defend the project report orally.
8) Students will have all the basic knowledge of writing a scientific paper in proper format.

Project Work

*Student is to undertake a project work (as part of the semester IV in lieu of practical course VIII) In the project students is to study research methodology and project report writing (Introduction, Aims and Objectives, Materials and Methods, Results and Discussion, Conclusions and Bibliography). Student should submit Project Report in the form of a small dissertation duly signed by Guide / Teacher In - Charge, Head of the Department and or Dean/Principal/ Head of the Institute. For the project work, out of one hundred marks, fifty marks shall be given by university examiners through assessment of the project report at the time of semester IV practical examination. The remaining fifty marks shall be given by the Committee for Internal Evaluation of Projects (CIEP) as an internal evaluation. CIEP is to be constituted by the Principal (and which shall be consisting of HOD, Guide / Teacher in - charge and at least one other faculty members). The method and process of Internal evaluation is to be worked out by the CIEP.

Course Code: 5201-47 Vocational Training (Industrial Training) (04 Credits) (Minimum 01 month training)

Course Objectives:

1) To provide students opportunity to get exposure to industrial work culture.

2) To make the students enable to understand hands-on experience to industrial set up with experimental design and practical training.
3) To make the students aware about the various sections in the industries viz. quality control, quality assurance, research work etc.
4) To impart the students with the skills of working in different industries.

Course Outcomes:

1) Students will get hands-on training to work in the reputed industries before getting placed.
2) The students will be exposed to all the industrial work culture so as to adopt all the skills required for working in the industry.
3) The students will be imparted with the knowledge of soft skills, communication skills, professional attitude while working in the industries.

Vocational Training (Industrial Training) :

*Student is to work in the industry for a minimum of one month in lieu of project work. Student should submit the industrial report in the form of a dissertation duly signed by the competent authority of the concerned industry. He/She shall also produce a certificate issued by the competent authority for the completion of his/her work. Out of one hundred marks, fifty marks shall be given by university examiners through assessment of dissertation at the time of semester IV practical examination. The remaining fifty marks shall be given by the Committee for Internal Evaluation of as an internal evaluation. This committee is to be constituted by the Principal/Dean (and which shall be consisting of HOD, Guide / Teacher in - charge and at least one other faculty members). The method and process of Internal evaluation is to be worked out by the committee.

Skill Enhancement Compulsory Course (SECC)

04 Biotechnology Data Care Management (02 Credits)

PREAMBLE:
To nurture high quality biotechnologist/ microbiologist with the potential to innovate /invent and desseminate knowledge for the benefit of society and environment.

Objectives:
To understand the types of databases and their data formats.

To study the importance of various omics, data generation techniques, data management strategies.

Unit I

1) Databases: Format and Annotations Conventions for database indexing and specification of search terms, common sequence file formats, sequence databases.

2) Types of Biological databases: Nucleic and protein databases, organism specific databases, data Access, retrieval and submission. Standard search engines, data retrieval tools.

Unit II

3) Biological data acquisition: The form of biological information, retrieval methods for DNA sequence Protein sequence and protein structure information.

Unit III

4) Data structures: Introduction, the concept of Abstract Data Type (ADT), Tables, records, strings staeks, lists, trees Binary trees, Balanced trees graphs Introduction to object oriented programming.

Unit IV

5)Importance of omic technologies: Data collection and bioinformatics principles. Data standards for omic data, the basics of data sharing and reuse. Omic data management and annotation, Data and knowledge management in cross omics research projects. Bioinformatics for RNomics, the ENCODE project consortium, mining for specific applications.

Reference Books:

1)“Bioinformatics: genes, proteins and computers” by Christine Orengo, David Jones and Janet Thornton (editors), 2003, Published by Taylor and francis, New York.

2) “Elementary Bioinformatics” by Imtiyaz Alam Khan, Published by Pharma Book Syndicate, Hyderabad.

3) “Biological Data mining and it’s applications in health care” Volume 8 : by Xiaoli Li See- Kiong Ng & Jason T.L.Wang, editors: Jason T. L. Wang , Science, Engineering and Biology Informatics.

4) “Bioinformatics: Managing Scientific data” by Zoe Lacroix and Ternce Critchlow, 2003, © Elsevier Science.

5) “Biological Data storage, Access and sharing policy” National health portal https://www.nhp.gov.in

CBCS FOR M. Sc Microbiology

Program: M.Sc. Department: KIAS Subject: Microbiology Scheme: CBCS

Subject		Sem-I			Sem-II			Sem-III			Sem-IV			Total		
		T	**P**	**Total**	**T**	**P**	**Total**	**T**	**P**	**Total**	**T**	**P**	**Total**	**T**	**P**	**Total**
Core-I	Hr	60	120	180	60	120	180	60	120	180	60	120	180	**240**	**480**	**720**
	Cr	4	4	8	4	4	8	4	4	8	4	4	8	**16**	**16**	**32**
Core-II	Hr	60	120	180	60	120	180	60	120	180	60	120	180	**240**	**480**	**600**
	Cr	4	4	8	4	4	8	4	4	4	4	4	4	**16**	**16**	**24**
Core-III	Hr	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**
	Cr	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**
Core-IV	Hr	60	---	60	60	---	60	**---**	**---**	**---**	**---**	**---**	**---**	**120**	**---**	**120**
	Cr	4	---	4	4	---	4	**---**	**---**	**---**	**---**	**---**	**---**	**8**	**---**	**8**
Total	**Hr**	**180**	**240**	**360**	**180**	**240**	**420**	**120**	**240**	**360**	**120**	**240**	**360**	**600**	**960**	**1560**
	Cr	**12**	**8**	**16**	**12**	**8**	**20**	**8**	**8**	**16**	**8**	**8**	**16**	**40**	**32**	**72**

CBCS FOR M. Sc. Microbiology

Program: M.Sc. Department: KIAS Subject: Microbiology Scheme: CBCS

Subject		Sem-I			Sem-II			Sem-III			Sem-IV			Total		
		T	P	Total	T	P	Total	T	P	Total	T	P	Total	T	P	Total
DSE	Hr	60	---	60	60	---	60	60	---	60	60	---	60	**240**	---	**240**
	Cr	4	---	4	4	---	4	4	---	4	4	---	4	**16**	---	**16**
Generic	Hr	---	---	---	---	---	---	60	---	60	60	---	60	**120**	---	**120**
	Cr	---	---	---	---	---	---	4	---	4	4	---	4	**8**	---	**8**
Grand Total CGPA	**Hr**	**240**	**240**	**480**	**240**	**240**	**480**	**240**	**240**	**480**	**240**	**240**	**480**	**1230**	**960**	**2190**
	Cr	**16**	**8**	**24**	**16**	**8**	**24**	**16**	**8**	**24**	**16**	**8**	**24**	**64**	**32**	**96**
AECC/SECC	Hr	30	---	30	30	---	30	30+60	-	90	30	---	30	**180**	---	**180**
Non CGPA	Cr	2	---	2	2	---	2	2+4	-	6	2	---	2	**12**	---	**12**

DSE Sem I : Medical Microbiology and Immunology I
DSE Sem II : Medical Microbiology and Immunology II
DSE Sem III : Environmental and Applied Microbiology
DSE Sem IV : Pharmaceutical Microbiology
GE Sem III : Bioinformatics for Microbiologist
GE Sem IV : Recombinant DNA Technology

AECC Sem I : Yoga and Meditation
SECC Sem II : A Soft Skills and Personality Development
AECC Sem III : Leadership Development
SECC Sem IV : Biotechnology Data Care Management