MAR ATHANASIUS COLLEGE (AUTONOMOUS)

KOTHAMANGALAM, KERALA686 666 NAAC

Accredited 'A^{+}' Grade Institution

Email: mac@macollege.in

www.macollege.in

SCHEME AND SYLLABUS

FOR

POST GRADUATE PROGRAMME

UNDER CREDIT SEMESTER SYSTEM

MAC-PG-CSS 2020

IN

M.Sc. MICROBIOLOGY

EFFECTIVE FROM THE ACADEMIC YEAR 2020-2021

BOARD OF STUDIES IN MICROBIOLOGY (PG)

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ACADEMIC COUNCIL

COMPOSITION – With Effect From 01-06-2020

Chairperson : **Dr. Shanti.A.Avirah**
Principal
Mar Athanasius College (Autonomous), Kothamangalam

Experts/Academicians from outside the college representing such areas as Industry,Commerce, Law, Education, Medicine, Engineering, Sciences etc.

Members in Academic Council

Experts:

1. **Dr. Winny Varghese**
   Secretary
   Mar Athanasius College Association
   Kothamangalam

2. **Prof. Dr. V.N. Rajasekharan Pillai,** Former Vice-chairman
   University Grants Commission, New Delhi

3. **Dr. R.K. Chauhan**
   Former Vice-Chancellor, Lingaya's University, Faridabad, Haryana -121002

4. **Dr. Sheela Ramachandran**
   Pro-Chancellor,
   Atmiya
   University Rajkot**.**

5. **Prof. Kuruvilla Joseph**
   Senior Professor and Dean
   Indian Institute of Space Science and Technology
   (IIST) Department of Space, Govt. of India
   Valiyamala,
   Thiruvananthapuram Kerala

6. **Dr. M. C. Dileep**
   Kumar Vice-Chancellor
   SreeSankaracharya University of Sanskrit
   Kalady,
   Kerala

7. **Dr. Mathew. K.**
   Principal
   Mar Athanasius College of Engineering,
   Kothamangalam, Kerala - 686 666

8. **Adv. George Jacob**
   Senior Advocate
   High Court of Kerala
   Ernakulam

Nominees of the university not less than Professors:

9. **Dr. Biju Pushpan**
   SAS SNDP Yogam College
   Konni

10. **Dr. Suma Mary**
    Sacharia UC College
    Aluva

11. **Dr. V.B. Nishi**
    Associate Professor
    Sree Shankara College, Kalady.

Member Secretary:

12. **Dr. M.S.Vijayakumary**
    Dean - Academics
    Mar Athanasius College
    (Autonomous) Kothamangalam

Four teachers of the college representing different categories of teaching staff by rotation on the basis ofseniority of service in the college:

13. **Dr. Bino Sebastian. V** (Controller of Examinations)
14. **Dr. Manju Kurian,** Asst. Professor, Department of Chemistry
15. **Dr. Smitha Thankachan**, Asst. Professor, Department of Physics
16. **Dr. Asha Mathai**, Asst. Professor, Department of Malayalam

Heads of the Departments

17. Dr. Mini Varghese, Head, Department of Hindi
18. Dr. Jayamma Francis, Head, Department of Chemistry
19. Dr. Igy George, Head, Department of Economics
20. Ms. Shiny John, Head, Department of Computer Science
21. Dr. Rajesh.K. Thumbakara, Head, Department of Mathematics
22. Dr. Aji Abraham, Head, Department of Botany
23. Dr. Selven S., Head, Department of Zoology
24. Dr. Deepa. S, Head, Department of Physics
25. Dr. Aswathy Balachandran, Head, Department of English
26. Dr. Diana Ann Issac, Head, Department of Commerce
27. Dr. Seena John, Head, Department of Malayalam
27. Smt. Sudha. V, Head, Department of Statistics
28. Dr. Diana Mathews, Head, Department of Sociology
29. Dr. Jani Chungath, Head, Department of History
30. Mr. Haary Benny Chettiamkudiyil, Head, Department of Physical Education
31. Ms. Shari Sadasivan, Head, Department of International Business
33. Ms. Sheeba Stephen, Head, Department of B. Com Tax Procedure and Practice
34. Dr. Julie Jacob, Head, Department of Biochemistry
35. Ms. Nivya Mariyam Paul, Head, Department of Microbiology
36. Ms. Jaya Vinny Eappen, Head, Department of Biotechnology
37. Ms. Shalini Binu, Head, Department of Actuarial Science
38. Prof. Dilmol Varghese, Head, Department of M. Sc Zoology
39. Ms. Simi. C.V, Head, Department of M.A.History
40. Ms. Bibin Paul, Head, Department of M. A. Sociology
41. Ms. Shari Thomas, Head, Department of M.Sc Statistics

MEMBERS OF BOARD OF STUDIES

Subject: Microbiology (PG)

NAME	DETAILS
CHAIRMAN	
Dr. A.A.Mohamed Hatha	Professor, Department of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and Technology, Cochin-682016.
EXPERTS (2)	
1. Dr. P.N. Rangarajan	Professor, Department of Biochemistry, Indian Institute of Sciences, Bengaluru.
2. Dr. Tapas Manna	Associate Professor and Head, Department of Biology, Indian Institute of Science Education and Research, Thiruvannthapuram.
EXPERT NOMINATED BY VC (MGU)	
Dr. Ajay Kumar	Scientist, Bacterial and Parasite Disease Biology Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram
MEMBER FROM INDUSTRY	
Dr. Anu Yamuna Joseph	Managing Director, Primordia Life sciences, KRIBS BIONEST, Kochi.
MERITORIOUS ALUMNI	
Mr. Shaheer P	Junior Research Fellow, Central Institute of Fisheries Technology (CIFT), Kochi

MEMBER TEACHERS	
1. Mrs. Nivya Mariyam Paul	Assistant Professor and Head, Department of Microbiology Mar Athanasius College, Kothamangalam
2. Mrs. Elza John	Assistant Professor Department of Microbiology Mar Athanasius College, Kothamangalam
3. Dr. Nayomi John	Assistant Professor Department of Microbiology Mar Athanasius College, Kothamangalam
4. Dr. Julie Jacob	Assistant Professor and Head Department of Biochemistry Mar Athanasius College, Kothamangalam
5. Dr. Asha Gangadharan	Assistant Professor Department of Biochemistry Mar Athanasius College, Kothamangalam
6. Mrs. Elizabeth Jacob	Assistant Professor Department of Biochemistry Mar Athanasius College, Kothamangalam
7. Mrs. Jaya Vinny Eapen	Assistant Professor and Head Department of Biotechnology Mar Athanasius College, Kothamangalam.
8. Mr. Paul George	Assistant Professor Department of Biotechnology Mar Athanasius College, Kothamangalam
9. Dr. Jithin Thomas	Assistant Professor Department of Biotechnology Mar Athanasius College, Kothamangalam

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PREFACE

Education in India has always been valued more than mere considering it as a means towards earning a good living. Right from pre-historic days, Education, especially higher education, has been given a predominant position in the Indian society. Ancient India considered knowledge as the third eye that gives insight into all affairs of life. Indian Higher Education Structure is traced back to Nalanda and Takshashila Institutions. Nevertheless, Gurukulas, Agrahars, Viharas and Madarasas were the nerve centres of knowledge and wisdom. The great universities flourished in India even centuries back, when most of the western world was groping in the dark. Those were the halcyon days when India led the world in scientific knowledge and philosophical speculations. Great scholar Max Muller has narrated in his own words: "If I were asked under what sky the human mind has most fully developed some of its choicest gifts, has most deeply pondered on the greatest problems of life, and has found solutions to some of them which well deserve the attention of even those who have studied Plato and Kant, I should point to India".

Mar Athanasius College has been instrumental in providing knowledge to thousands and thousands of students in the realm of Higher Education. The educational framework of the institution creates an atmosphere to flourish arts, science and research. The institution has crossed another milestone on its path towards academic excellency when the autonomy was conferred on it in March 2016. In order to fulfill the dreams of academic autonomy, the institution had resolved to constitute Board of Studies for all PG Programmes for restructuring the Curriculum and Syllabi, subject to the Regulations and Guidelines of the Parent University, i.e, Mahatma Gandhi University, Kottayam and also in accordance with the UGC rules. This regulation is the accomplishment of the task of imparting knowledge and wisdom to the students at the higher education level, so as to prepare them to live with dignity and noble thoughts.

The task of restructuring was done by the proposals and recommendations of the members of Board of Studies constituted by the institution for each PG Programme. The duration of the programme, examination pattern, method of valuation and number of credits assigned to each course remain on par with that of the parent university.

LIST OF PG AND UG PROGRAMMES IN MAR ATHANASIUS COLLEGE (AUTONOMOUS), KOTHAMANGALAM

SL. NO.	PROGRAMME	DEGREE	FACULTY
1	ENGLISH	MA	LANGUAGE AND LITERATURE
2	ECONOMICS	MA	SOCIAL SCIENCES
3	SOCIOLOGY	MA	SOCIAL SCIENCES
4	HISTORY	MA	SOCIAL SCIENCES
5	MATHEMATICS	M.Sc	SCIENCE
6	CHEMISTRY	M.Sc	SCIENCE
7	PHYSICS	M.Sc	SCIENCE
8	BOTANY	M.Sc	SCIENCE
9	STATISTICS	M.Sc	SCIENCE
10	ZOOLOGY	M.Sc	SCIENCE
11	BIOCHEMISTRY	M.Sc	SCIENCE
12	BIOTECHNOLOGY	M.Sc	SCIENCE
13	MICROBIOLOGY	M.Sc	SCIENCE
14	ACTUARIAL SCIENCE	M.Sc	SCIENCE
15	FINANCE AND TAXATION	M.Com	COMMERCE
16	MARKETING AND INTERNATIONAL BUSINESS	M.Com	COMMERCE

REGULATIONS OF THE POSTGRADUATE PROGRAMMES
UNDER CREDIT SEMESTER SYSTEM
MAC-PG-CSS2020
(2020 Admission onwards)

1. SHORT TITLE

1.1 These Regulations shall be called "Mar Athanasius College (Autonomous) Regulations (2020) governing Postgraduate Programmes under the Credit Semester System (MAC-PG-CSS2020)".

1.2 These Regulations shall come into force from the Academic Year 2020-2021.

2. SCOPE

2.1 The regulations provided herein shall apply to all Regular Postgraduate (PG) Programmes, M.A. /M.Sc. /M.Com. conducted by Mar Athanasius College (Autonomous) with effect from the academic year 2020-2021 admission onwards.

3. DEFINITIONS

3.1 **'Academic Committee'** means the Committee constituted by the Principal under this regulation to monitor the running of the Post-Graduate programmes under the Credit Semester System (MAC-PG-CSS2020).

3.2 **'Academic Week'** is a unit of five working days in which distribution of work is organized from day one to day five, with five contact hours of one hour duration on each day. A sequence of 18 such academic weeks constitutes a semester.

3.3 '**Audit Course**' is a course for which no credits are awarded.

3.4 **'CE' means Continuous Evaluation (Internal Evaluation)**

3.5 **'College Co-ordinator'** means a teacher from the college nominated by the Principal to look into the matters relating to MAC-PG-CSS2020 for programmes conducted in the College.

3.6 **'Comprehensive Viva-Voce'** means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.7 **'Common Course'** is a core course which is included in more than one programme with the same course code.

3.8 '**Core Course**' means a course that the student admitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

3.9 '**Course**' means a segment of subject matter to be covered in a semester. Each Course is tobe designed variously under lectures / tutorials / laboratory or fieldwork / seminar / project /practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

3.10 **'Course Code'** means a unique alpha numeric code assigned to each course of a programme.

3.11 '**Course Credit**' One credit of the course is defined as a minimum of one hour lecture /minimum of 2 hours lab/field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the final examination.

3.12 **'Course Teacher'** means the teacher of the institution in charge of the course offered in the programme.

3.13 **'Credit (Cr)'** of a course is a numerical value which depicts the measure of the weekly unit of work assigned for that course in a semester.

3.14 '**Credit Point (CP)**' of a course is the value obtained by multiplying the grade point (GP) by the Credit (Cr) of the course **CP=GP x Cr**.

3.15 '**Cumulative Grade Point Average(CGPA)**' is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.CGPA determines the overall performance of a student at the end of a programme.

(CGPA = Total CP obtained/ Total credits of the programme)

3.16 '**Department**' means any teaching Department offering a programme of study in the institution.

3.17 '**Department Council**' means the body of all teachers of a Department in a College.

3.18 'Dissertation' means a long document on a particular subject in connection with the project /research/ field work etc.

3.19 '**Duration of Programme**' means the period of time required for the conduct of the programme. The duration of post-graduate programme shall be 4 semesters spread over two academic years.

3.20 '**Elective Course**' means a course, which can be substituted, by equivalent course from the same subject.

3.21 'Elective Group' means a group consisting of elective courses for the programme.

3.22 'ESE' means End Semester Evaluation (External Evaluation).

3.23 'Evaluation' is the process by which the knowledge acquired by the student is quantified as per the criteria detailed in these regulations.

3.24 External Examiner is the teacher appointed from other colleges for the valuation of courses of study undergone by the student in a college. The external examiner shall be appointed by the college.

3.25 '**Faculty Advisor**' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department.

3.26 '**Grace Grade Points**' means grade points awarded to course(s), recognition of the students' meritorious achievements in NSS/ Sports/ Arts and cultural activities etc.

3.27 '**Grade Point**' (GP) Each letter grade is assigned a Grade point (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

3.28 '**Grade Point Average (GPA)**' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade point obtained in the course by the sum of the weights of Course **(GPA= ∑WGP / ∑W)**

3.29 '**Improvement Course**' is a course registered by a student for improving his performance in that particular course.

3.30 **'Internal Examiner'** is a teacher nominated by the department concerned to conduct internal evaluation.

3.31 '**Letter Grade**' or '**Grade**' for a course is a letter symbol (A+, A, B+, B, C+, C, D) which indicates the broad level of performance of a student for a course.

3.32 MAC-PG-CSS2020 means Mar Athanasius College Regulations Governing Post Graduate programmes under Credit Semester System, 2020.

3.33 '**Parent Department**' means the Department which offers a particular postgraduate programme.

3.34 '**Plagiarism**' is the unreferenced use of other authors' material in dissertations and is a serious academic offence.

3.35 '**Programme**' means the entire course of study and Examinations.

3.36 **'Project'** is a core course in a programme. It means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department/ any appropriate research centre in order to submit a dissertation on the project work as specified. It allows students to

work more autonomously to construct their own learning and culminates in realistic, student-generated products or findings.

3.37 '**Repeat Course**' is a course to complete the programme in an earlier registration.

3.38 '**Semester**' means a term consisting of a minimum of 90 working days, inclusive of examination, distributed over a minimum of 18 weeks of 5 working days each.

3.39 '**Seminar**' means a lecture given by the student on a selected topic and expected to train the student in self-study, collection of relevant matter from various resources, editing, document writing and presentation.

3.40 '**Semester Grade Point Average(SGPA)**' is the value obtained by dividing the sum of credit points (CP) obtained by the student in the various courses taken in a semester by the total number of credits for the course in that semester. The SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of a semester (SGPA = Total CP obtained in the semester / Total Credits for the semester).

3.41 '**Tutorial**' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

3.42 '**Weight**' is a numeric measure assigned to the assessment units of various components of a course of study.

3.43 University means Mahatma Gandhi University Kottayam to which the college is affiliated.

3.44 '**Weighted Grade Point (WGP)**' is grade points multiplied by weight. **(WGP=GPxW)**

3.45 'Weighted Grade Point Average (WGPA)' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points by the sum of the weights. WGPA shall be obtained for CE

(Continuous Evaluation) and ESE (End Semester Evaluation) separately and then the combined WGPA shall be obtained for each course.

4. ACADEMIC COMMITTEE

4.1. There shall be an Academic Committee constituted by the Principal to Manage and monitor the working of MAC-PG-CSS2020.

4.2. The Committee consists of:

1. Principal
2. Dean, Administration
3. Dean, Academics
4. IQAC Coordinator
5. Controller of Examinations
6. One Faculty each representing Arts, Science, Commerce, Languages, and Self Financing Programmes

5. PROGRAMME STRUCTURE

5.1 Students shall be admitted to post graduate programme under the various Faculties. The programme shall include three types of courses, Core Courses, Elective Courses and Common core courses. There shall be a project with dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments / seminars/ practical's etc.

5.2 No regular student shall register for more than 25 credits and less than16 credits per semester unless otherwise specified. The total minimum credits, required for completing a PG programme is 80.

5.3. Elective Courses and Groups

5.3.1 There shall be various groups of Programme Elective courses for a Programme such as Group A, Group B etc. for the choice of students subject to

the availability of facility and infrastructure in the institution and the selected group shall be the subject of specialization of the programme.

5.3.2 The elective courses shall be either in fourth semester or distributed among third and fourth semesters. There may be various groups of Elective courses (three elective courses in each group) for a programme such as Group A, Group B etc. for the choice of students, subject to the availability of facility and infrastructure in the institution.

5.3.3 The selection of courses from different elective groups is not permitted.

5.3.4 The elective groups selected for the various Programmes shall be intimated to the Controller of Examinations within two weeks of commencement of the semester in which the elective courses are offered. The elective group selected for the students who are admitted in a particular academic year for various programmes shall not be changed.

5.4 P**roject Work**

5.4.1. Project work shall be completed in accordance with the guidelines given in the curriculum.

5.4.2 Project work shall be carried out under the supervision of a teacher of the department concerned.

5.4.3. A candidate may, however, in certain cases be permitted to work on the project in an Industrial/Research Organization on the recommendation of the supervising teacher.

5.4.4 There shall be an internal assessment and external assessment for the project work.

5.4.5. The Project work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the viva-voce on the project.

5.4.6 The external evaluation of project work shall be conducted by two external examiners from different colleges and an internal examiner from the college concerned.

5.4.7 The final Grade of the project (External) shall be calculated by taking the average of the Weighted Grade Points given by the two external examiners and the internal examiner.

5.5 Assignments: Every student shall submit at least one assignment as an internal component for each course.

5.6 Seminar Lecture: Every PG student shall deliver one seminar lecture as an Internal component for every course with a weightage of two. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the various resources, editing, document writing and presentation.

5.7 Test Papers (Internal): Every PG student shall undergo at least two class tests as an internal component for every course with a weight one each. The best two shall be taken for awarding the grade for class tests.

5.8. No courses shall have more than 5 credits unless otherwise specified.

5.9. Comprehensive Viva-Voce -Comprehensive Viva-Voce shall be conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the examiners of the project evaluation.

5.9.1. Comprehensive Viva-Voce shall cover questions from all courses in the Programme.

5.9.2. There shall be an internal assessment and an external assessment for the Comprehensive Viva-Voce.

6. ATTENDANCE

6.1. The minimum requirement of aggregate attendance during a semester for appearing at the end-semester examination shall be 75%. Condonation of shortage of attendance to a maximum of 15 days in a semester subject to a maximum of two times during the whole period of the programme may be granted by the University.

6.2 If a student represents his/her institution, University, State or Nation in Sports, NCC, or Cultural or any other officially sponsored activities such as college union/ university union etc., he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum 15 days in a Semester based on the specific recommendations of the Head of the Department or teacher concerned.

6.3 Those who could not register for the examination of a particular semester due to shortage of attendance may repeat the semester along with junior batches, without considering sanctioned strength, subject to the existing University Rules and Clause 7.2.

6.4. A Regular student who has undergone a programme of study under earlier regulation/ Scheme and could not complete the Programme due to shortage of attendance may repeat the semester along with the regular batch subject to the condition that he has to undergo all the examinations of the previous semesters as per the MAC-PG-CSS2020 regulations and conditions specified in 6.3.

6.5 A student who had sufficient attendance and could not register for fourth semester examination can appear for the end semester examination in the subsequent years with the attendance and progress report from the principal.

7. REGISTRATION/ DURATION

7.1 A student shall be permitted to register for the programme at the time of admission.

7.2 A student who registered for the Programme shall complete the Programme within a period of four years from the date of commencement of the programme.

7.3 Students are eligible to pursue studies for additional post graduate degree. They shall be eligible for award of degree only after successful completion of two years (four semesters of study) of college going.

8. ADMISSION

8.1 The admission to all PG programmes shall be done through the Centralised Allotment Process of Mar Athanasius College (Autonomous), Kothamangalam (MAC-PG CAP) as per the rules and regulations prescribed by the affiliating university and the Government of Kerala from time to time.

8.2 The eligibility criteria for admission shall be as announced by the Parent University from time to time.

9. ADMISSION REQUIREMENTS

9.1 Candidates for admission to the first semester of the PG programme through CSS shall be required to have passed an appropriate Degree Examination of Mahatma Gandhi University as specified or any other examination of any recognized University or authority accepted by the Academic council of Mahatma Gandhi University as eligible thereto.

9.2 Students admitted under this programme are governed by the Regulations in force.

10. PROMOTION:

10.1 A student who registers for the end semester examination shall be promoted to the next semester

10.2 A student having 75% attendance and who fails to register for examination of a particular semester will be allowed to register notionally and is promoted to the next semester, provided application for notional registration shall be submitted within 15 days from the commencement of the next semester.

10.3 The medium of Instruction shall be English except programmes under faculty of Language and Literature.

11. EXAMINATIONS

11.1 **End-Semester Examinations**: The examinations shall be at the end of each semester of three hour duration for each centralised and practical course.

11.2 Practical examinations shall be conducted at the end of each semester or at the end of even semesters as prescribed in the syllabus of the particular programme. The number of examiners for the practical examinations shall be prescribed by the Board of Studies of the programmes.

11.3 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Different types of questions shall have different weightage.

12. EVALUATION AND GRADING

12.1 **Evaluation:** The evaluation scheme for each course shall contain two parts; (a) End Semester Evaluation (ESE) (External Evaluation) and (b) Continuous Evaluation (CE)(Internal Evaluation). 25% weightage shall be given to internal evaluation and the remaining 75% to external evaluation and the ratio and weightage between internal and external is 1:3. Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using direct grading system.

12.2 **Direct Grading: The direct grading for CE (Internal) and ESE (External Evaluation) shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively.**

12.3 **Grade Point Average (GPA): Internal and External components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided in 12.16.**

12.4 **Internal evaluation:** The internal evaluation shall be based on predetermined transparent system periodic written tests, assignments, seminars, lab skills, records, viva-voce etc.

12.5 Components of internal (CE) and External Evaluation (ESE): Grades shall be given to the evaluation of theory / practical / project / comprehensive viva-voce and all internal evaluations are based on the Direct Grading System.

Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and comprehensive viva-voce within the framework of the regulation.

12.6 There shall be no separate minimum grade point for internal evaluation.

12.7 **The model of the components and its weightages for Continuous Evaluation (CE) and End Semester Evaluation (ESE) are shown in below:**

a) For Theory (CE) (Internal)

	Components	Weightage
i.	Assignment	1
ii.	Seminar	2
iii.	Best Two Test papers	2(1 each)
Total		**5**

(Average grade of the best two papers can be considered. For test paper all the Questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grades)

b) For Theory (ESE) (External)

Evaluation is based on the pattern of Question specified **in 12.15.5**

c) For Practical (CE) (Internal)

Components	Weightage
Written / Lab Test	2
Lab Involvement and Record	1
Viva	2
Total	**5**

(The components and weightage of the practical (Internal) can be modified by the concerned BOS without changing the total weightage 5)

d) For Practical (ESE) (External)

Components	Weightage
Written / Lab Test	7
Lab Involvement and Record	3
Viva	5
Total	**15**

(The components and weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15)

e) For Project (CE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Project content and presentation	2
Project viva	1
Total	**5**

(The components and the weightage of the components of the Project (Internal) can be modified by the concerned BOS without changing the total weightage 5)

f) For Project (ESE) (External)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	**15**

(The components and the weightage of the components of the Project (External) can be modified by the concerned BOS without changing the total weightage 15)

g) Comprehensive viva-voce (CE) (Internal)

Components	Weightage
Comprehensive viva-voce(all courses from first semester to fourth semester)	5
Total	**5**

(Weightage of the components of the Comprehensive viva-voce (Internal) shall not be modified.)

h) Comprehensive viva-voce (ESE) (External)

Components	Weightage
Comprehensive viva-voce(all courses from first semester to fourth semester)	15
Total	**15**

(Weightage of the components of the Comprehensive viva-voce (External) shall not be modified.)

12.8 **All grade point averages shall be rounded to two digits.**

12.9 To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination.

12.10 **There shall not be any chance for improvement for Internal Grade.**

12.11 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course and a copy should be kept in the college for verification for at least two years after the student completes the programme.

12.12 **External Evaluation.** The external examination in theory courses is to be conducted by the College at the end of the semester. The answers may be written in English or Malayalam except those for the Faculty of Languages. The evaluation of the answer scripts shall be done by examiners based on a

well-defined scheme of valuation. The external evaluation shall be done immediately after the examination.

12.13 Photocopies of the answer scripts of the external examination shall be made available to the students on request as per the rules prevailing in the University.

12.14 The question paper should be strictly on the basis of model question paper set and directions prescribed by the BOS.

12.15. **Pattern of Questions**

12.15.1 **Questions shall be set to assess knowledge acquired, standard, and application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightage shall be given to each module based on content/teaching hours allotted to each module.**

12.15.2 The question setter shall ensure that questions covering all skills are set.

12.15.3 A question paper shall be a judicious mix of short answer type, short essay type /problem solving type and long essay type questions.

12.15.4 The question shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, E grades.

12.15.5 Weight: Different types of questions shall be given different weights to quantify their range as follows:

Sl.No.	Type of Questions	Weight	Number of questions to be answered
1	Short Answer type questions	1	8 out of 10
2	Short essay / problem solving type questions	2	6 out of 8
3	Long Essay Type questions	5	2 out of 4

12.16 **Pattern of question for practical**. The pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

12.17 **Direct Grading System**

Direct Grading System based on a 6- point scale is used to evaluate the Internal and External examinations taken by the students for various courses of study.

Grade	Grade point(G)	Grade Range
A+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

12.18 **Performance Grading**

Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7-point scale as detailed below.

Range	Grade	Indicator
4.50 to 5.00	**A+**	**Outstanding**
4.00 to 4.49	**A**	**Excellent**
3.50 to 3.99	**B+**	**Very good**
3.00 to 3.49	**B**	**Good(Average)**
2.50 to 2.99	**C+**	**Fair**
2.00 to 2.49	**C**	**Marginal**
up to 1.99	**D**	**Deficient(Fail)**

12.19 No separate minimum is required for Internal Evaluation for a pass, but a minimum grade is required for a pass in an External Evaluation. However, a minimum C grade is required for pass in a Course

12.20 A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

12.21 **Improvement of Course**- The candidate who wish to improve the grade/grade point of the external examination of the of a course/ courses he/ she has passed

can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semester of the programme.

12.22 **One Time Betterment Programme**- A candidate will be permitted to improve the **CGPA** of the programme within a continuous period of four semesters immediately following the completion of the programme allowing only once for a particular semester. The **CGPA** for the betterment appearance will be computed based on the **SGPA** secured in the original or betterment appearance of each semester whichever is higher.

If a candidate opts for the betterment of **CGPA** of a programme, he/she has to appear for the external examination of the entire semester(s) excluding practical /project/comprehensive viva-voce. One time betterment programme is restricted to students who have passed in all courses of the programme at the regular (First appearance)

12.23 **Semester Grade Point Average (SGPA) and Cumulative Grade Point Average** (**CGPA) Calculations.** The SGPA is the ratio of sum of the credit point of all courses taken by a student in a semester to the total credit for that semester. After the successful completion of a semester, Semester Grade Point Average(SGPA) of a student in that semester is calculated using the formula given below.

Semester Grade Point Average -SGPA (S_j) = $\sum(C_i \times G_i) / \sum C_i$

(SGPA= Total credit Points awarded in a semester / Total credits of the semester)

Where 'S_j' is the j^{th} semester, 'G_i' is the grade point scored by the student in the i^{th} course 'C_i' is the credit of the i^{th} course.

12.24 Cumulative Grade Point Average (**CGPA)** of a programme is calculated using the formula:-

Cumulative Grade Point Average (CGPA) = $\sum(C_i \times S_i) / \sum C_i$

(CGPA= Total credit Points awarded in all semester / Total credits of the programme)

Where 'C_i' is the credit for the i^{th} semester, 'S_i' is the SGPA for the i^{th} semester. The **SGPA** and **CGPA** shall be rounded off to 2 decimal points. For the successful completion of semester, a student shall pass all courses and score a minimum **SGPA** of 2.0. However a student is permitted to move to the next semester irrespective of her/his **SGPA**

13. GRADE CARD

13.1 The Institution under its seal shall issue to the students, a consolidated grade card on completion of the programme, which shall contain the following information.

a) Name of the University.

b) Name of college

c) Title of the PG Programme.

d) Name of Semesters

e) Name and Register Number of students

f) Code, Title, Credits and Max GPA (Internal, External & Total) of each course (theory &practical), project, viva etc in each semester.

g) Internal, external and Total grade, Grade Point (G), Letter grade and Credit point (P) in each course opted in the semester.

h) The total credits and total credit points in each semester.

i) Semester Grade Point Average (SGPA) and corresponding Grade in each semester

j) Cumulative Grade Point Average (CGPA), Grade for the entire programme.

k) Separate Grade card will be issued.

l) Details of description of evaluation process- Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

14. AWARD OF DEGREE - The successful completion of all the courses with 'C' grade within the stipulated period shall be the minimum requirement for the award of the degree.

15. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluations conducted.

16. RANK CERTIFICATE

Rank certificate shall be issued to candidates who secure positions 1st and 2nd . Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing the rank. Rank certificate shall be signed by the Principal and the Controller of Examinations.

17. **GRIEVANCE REDRESSAL COMMITTEE**

17.1 Department level: The College shall form a Grievance Redressal Committee in each Department comprising of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The Committee shall address all grievances relating to the internal assessment grades of the students.

17.2. College level: There shall be a college level Grievance RedressalCommittee comprising of faculty advisor, college co-ordinator, one senior teacher and one staff council member and the Principal as Chairperson.

18. **FACTORY VISIT/ FIELD WORK/ VISIT** to a reputed research institute/ student interaction with renowned academicians may be conducted for all programmes before the commencement of semester iii.

19. Each student may undertake **INTERNSHIP/ON THE JOB TRAINING** for a period of not less than 15 days. The time, duration and structure of

internship/on the job training can be modified by the concerned Board of Studies.

20. **TRANSITORY PROVISION**

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three year from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

21. **REPEAL**

The Regulations now in force in so far as they are applicable to programmes offered by the college and to the extent they are inconsistent with these regulations are hereby repealed. In the case of any inconsistency between the existing regulations and these regulations relating to the Credit Semester System in their application to any course offered in a College, the latter shall prevail.

22. **Credits allotted for Programmes and Courses**

22.1 Total credit for each programme shall be **80**.

22.2 Semester-wise total credit can vary from 16to25

22.3 The minimum credit of a course is 2 and maximum credit is 5

23. **Common Course:** If a course is included as a common course in more than one programme, its credit shall be same for all programmes.

24. **Course Codes:** The course codes assigned for all courses (Core Courses, Elective Courses, Common Courses etc.) shall be unique.

25. **Models of distribution of courses, course codes, type of the course, credits, teaching hours for a programme are given in the following tables**

Programme with practical -Total Credits 80- M.Sc Microbiology

Semester	Course-Code	Course Name	Type of the Course	Teaching Hours Per Week	Credit	Total Credits
I	PG20BS101	Biochemistry	Core	4	4	19
	PG20BS102	Cell Biology and Genetics	Core	4	4	
	PG20BS103	Biophysics, Bioinstrumentation and Bioinformatics	Core	4	4	
	PG20BS104	Human Physiology and Biostatistics	Core	3	3	
	PG20BSP1-MB	Laboratory Course I	Core	10	4	
II	PG20BS205	General Microbiology	Core	4	4	19
	PG20BS206	Immunology	Core	4	4	
	PG20BS207	Molecular Biology and Genetic Engineering	Core	4	4	
	PG20BS208-MB	Metabolism and Enzymology	Core	3	3	
	PG20BSP2-MB	Laboratory Course II	Core	10	4	
III	PG20BS309-MB	Food and Industrial Microbiology	Core	4	4	19
	PG20BS310-MB	Environmental and Agricultural Microbiology	Core	3	3	
	PG20BS311-MB	Marine Microbiology	Elective	4	4	
	PG20BS312-MB	Environmental Science	Elective	4	4	
	PG20BSP3-MB	Laboratory Course III	Core	10	4	

IV	PG20BS413-MB	Systematic Bacteriology	Core	5	4	23
	PG20BS414-MB	Virology, Mycology and Protozoology	Core	4	4	
	PG20BS414-MB	Clinical Microbiology	Elective	4	4	
	PG20BSP4-MB	Laboratory course IV	Core	12	5	
	PG20BS4P-MB	Dissertation/Project	Core		4	
	PG20BS4V-MB	Viva - Voce	Core		2	
Total						**80**

Appendix

1. Evaluation first stage – Both internal and external to be done by the teacher)

Grade	Grade Points	Range
A+	5	4.50 to 5.00
A	4	4.00 to 4.49
B	3	3.00 to 3.99
C	2	2.00 to 2.99
D	1	0.01 to 1.99
E	0	0.00

The final Grade range for courses, SGPA and CGPA

Range	Grade	Indicator
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
Upto1.99	D	Deficient(Fail)

Theory-External-ESE

Maximum weight for external evaluation is 30. Therefore Maximum Weighted Grade Point (WGP) is 150

Type of Question	Qn. No.'s	Grade Awarded	Grade Point	Weights	Weighted Grade Point
Short Answer	1	A+	5	1	5
	2	-	-	-	-
	3	A	4	1	4
	4	C	2	1	2
	5	A	4	1	4
	6	A	4	1	4
	7	B	3	1	3
	8	A	4	1	4
	9	B	3	1	3
	10	-	-	-	
Short Essay	11	B	3	2	6
	12	A+	5	2	10
	13	A	4	2	8
	14	A+	5	2	10
	15	-	-	-	-

	16	-	-	-	-
	17	A	4	2	8
	18	B	3	2	6
Long Essay	19	A+	5	5	25
	20	-	-	-	-
	21	-	-	-	-
	22	B	3	5	15
			TOTAL	**30**	**117**

Calculation :
Overall Grade of the theory paper = Sum of Weighted Grade Points /Total Weight = 117/30 = 3.90 = Grade B

Theory-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Assignment	1	A	4	4	**WGP/Total Weight= 24/5 =4.8**
Seminar	2	A+	5	10	
Test Paper 1	1	A+	5	5	
Test Paper 2	1	A+	5	5	
Total	**5**			**24**	**A+**

Practical-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75

Components	Weight(W)	Grade Awarded	Grade Point(GP)	WGP=W*GP	Overall Grade of the Course
Written/Lab Test	7	A	4	28	**WGP/Total Weight= 58 / 15 = 3.86**
Lab involvement & record	3	A+	5	15	
Viva	5	B	3	15	
Total	**15**			**58**	**B+**

Practical-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Written/ Lab Test	2	A	4	8	**WGP/Total Weight=17/5 =3.40**
Lab involvement & record	1	A+	5	5	
Viva	2	C	2	4	
Total	**5**			**17**	**B**

Project-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP= W*GP	Overall Grade of the Course
Relevance of the topic & Analysis	3	C	2	6	**WGP/Total Weight = 59/15= 3.73**
Project Content &Presentation	7	A+	5	35	
Project Viva- Voce	5	B	3	15	
Total	**15**			**56**	**B**

Project-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Relevance of the topic & Analysis	2	B	3	6	**WGP/Total Weight= 21/5 = 4.2**
Project Content & Presentation	2	A+	5	10	
Project Viva-Voce	1	A+	5	5	
Total	**5**			**21**	**A**

Comprehensive viva-voce-External-ESE

Maximum weight for external evaluation is 15. Therefore Maximum Weighted Grade Point (WGP) is 75

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W*GP	Overall Grade of the Course
Comprehensive viva-voce	15	A	4	60	**WGP/Total Weight =60/15=4**
Total	**15**			**60**	**A**

Comprehensive viva-voce-Internal-CE

Maximum weight for internal evaluation is 5. Therefore Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point(GP)	WGP=W *GP	Overall Grade of the Course
Comprehensive viva-voce	5	A+	5	25	**WGP/Total Weight =25/5=5**
Total	**5**			**25**	**A+**

2. Evaluation Second stage-(to be done by the College)

Consolidation of the Grade (GPA) of a Course PC-1

The End Semester Evaluation (ESE) (External evaluation) grade awarded for the course PC-1 is A and its Continuous Evaluation (CE) (Internal Evaluation) grade is A. The consolidated grade for the course PC-1 is as follows

Evaluation	Weight	Grade awarded	Grade Points awarded	Weighted Grade Point
External	3	A	4.20	12.6
Internal	1	A	4.40	4.40
Total	**4**			**17**
Grade of a course.	GPA of the course =Total weighted Grade Points/Total weight= **17/4 =4.25 = Grade A**			

3. Evaluation Third stage-(to be done by the College) Semester Grade Point Average (SGPA)

Course code	Titleof the course	Credits (C)	Grade Awarded	Grade Points(G)	Credit Points (CP=C X G)
01	PC-1	5	A	4.25	21.25
02	-----	5	A	4.00	20.00
03	-----	5	B+	3.80	19.00
04	-----	2	A	4.40	8.80
05	-----	3	A	4.00	12.00
TOTAL		20			81.05
SGPA	Total credit points / Total credits = 81.05/20 = 4.05= Grade- A				

4. Evaluation Third stage-(to be done by the College) Cumulative Grade Point Average (CGPA)

If a candidate is awarded three **A+** grades in semester 1 (SGPA of semester 1), semester 2 (SGPA of semester 2), semester 4 (SGPA of semester 4) and **B** grades in semester 3 (SGPA of semester 3). Then CGPA is calculated as follows:

Semester	Credit of the Semesters	Grade Awarded	Grade point (SGPA)	Credit points
I	20	A+	4.50	90
II	20	A+	4.60	92
III	20	B	3.00	60
IV	20	A+	4.50	90
TOTAL	**80**			**332**
CGPA= Total credit points awarded / Total credit of all semesters = 332 / 80= 4.15 (Which is in between 4.00 and 4.49 in 7-point scale) Therefore the overall Grade awarded in the programme is A				

M. SC. MICROBIOLOGY PROGRAMME

ELIGIBILITY FOR M.Sc MICROBIOLOGY PROGRAMME

Academic eligibility should be satisfied as on the last date of submission of academic data. No candidate shall be admitted to the PG programme unless he/she possess the qualifications and minimum requirements thereof, as prescribed by Mahatma Gandhi University from time to time.

If an applicant for admission is found to have indulged in ragging in the past or if it is noticed later that he/she had indulged in ragging, admissions shall be denied or he/she will be expelled from Mar Athanasius College (Autonomous), Kothamangalam.

Candidates should have passed the corresponding Degree Examination under the 10 + 2 + 3 pattern with one core/main subject and two complementary/subsidiary subjects from any of the Universities in Kerala or of any other University recognized by Mahatma Gandhi University as equivalent thereto for admission, subject to the stipulation regarding marks.

OR

Candidates who have passed Degree examination with Double or Triple main subject and candidates who have passed the Degree Examination in Vocational or Specialized Programmes are also eligible for admission. However, they have to submit copy of the Equivalency/Eligibility Certificate from Mahatma Gandhi University, stating that, their Qualifying Examination is recognized for seeking admission to the relevant P.G. Degree Programme(s) as applicable, at the time of admission. This provision is not applicable in the case of those applicants who have passed their qualifying examination from MG University.

The minimum requirements for admission to M.Sc Microbiology Degree Programme are:

- **M.Sc MICROBIOLOGY (SF)**

Graduates who have passed qualifying examination in CBCS (2017)/CBCSS (2013) pattern	**Graduates who have passed qualifying examination in CBCSS (2009) pattern**	**Graduates who have passed qualifying examination in other patterns**
Graduation in Biological Sciences viz. Zoology, Botany, Biochemistry, Biophysics, Biotechnology, Biological Techniques & Specimen Preparation and Microbiology or Chemistry under Core Group (Core + Complementary + Open Courses) or Medical Microbiology /MLT with not less than CGPA/CCPA of 5.00 out of 10.0	Graduation in Biological Sciences viz. Zoology, Botany, Biochemistry, Biophysics, Biotechnology, Biological Techniques & Specimen Preparation and Microbiology or Chemistry under Core Group (Core + Complementary + Open Courses) or Medical Microbiology/MLT with not less than CGPA of 2.00 out of 4.	Graduation in Biological Sciences viz. Zoology, Botany, Biochemistry, Biophysics, Biotechnology, Biological Techniques & Specimen Preparation and Microbiology or Chemistry under Part III (Main/Core + subsidiaries/Complementaries) or Medical Microbiology /MLT with not less than 50% marks.
Weightage of 10% of marks, scored by the candidate in Part III (Core/Main), shall be added to the total of Part III subjects, for those candidates who have studied B Sc. Microbiology (Core/Main), after standardizing the marks secured for the same to 600.		

The Open course under core group is taken only for reckoning the eligibility for applying for the PG programmes concerned. But a candidate cannot apply for the respective PG programmes solely on the basis of the open course selected under core group.

Objective of the Programme

Microbiology deals with the study of microbes. The main objective of this M.Sc. Degree programme is providing an in-depth understanding of the biochemistry, cell biology, molecular biology, human physiology and almost all fields of microbiology and their experimental aspects. This programme also aims to study the emerging areas of Bioscience along with analytical techniques, bioinformatics and biostatistics.

Post Graduate Programme Outcome

PO No.	Upon completion of Postgraduate Programme, the students will be able to:
PO 1	Basic understanding about various precepts of the discipline, in synchronic and diachronic manner.
PO 2	Critical thinking about what they learn, that prompts them to research about its technical and philosophical nuances.
PO 3	Inter-personal skills enabling them to work in teams, facilitating effective interaction in their respective work places.
PO 4	Environmental and social consciousness, leading to a sustainable living.
PO 5	An urge for lifelong learning towards professional advancement and kindle the spirit of entrepreneurship.
PO 6	A holistic view regarding life and a self-disciplined learning ability for becoming a valuable person to the institution a well as the society.

Programme Specific Outcome for M.Sc Microbiology

PSO No.	Upon completion of M.Sc. MICROBIOLOGY Programme, the students will be able to:	PO No.
PSO 1	Able to characterize Microorganisms based on Taxonomical features, phenotypical and genotypical characteristics	PO 1,2
PSO 2	Able to analyze the Structure function relationships of biomolecules, interaction between macro molecules and cellular processes at the molecular level.	PO 1,2
PSO 3	Understand the concepts of microbiology and immunology and their application	PO 1,2
PSO 4	Utilize interdisciplinary knowledge in basic Biotechnology and Biochemistry.	PO 2,3
PSO 5	Understand the concepts of molecular biology and applications in genetic engineering	PO 1,2
PSO 6	Relate the Metabolic pathways, Clinical aspects, Bioenergetics and Catalysis.	PO 1,2
PSO 7	Role of microorganisms and their interactions in the ecosystem including Biogeochemical cycles, Biodegradation *etc.*	PO 1,4
PSO 8	Explain the reason for ubiquitous distribution of microorganism in wide range of ecological habitat including extreme environments in nature.	PO 1,2
PSO 9	Attain laboratory skills in microbiological practices including immunological and molecular microbiological methods.	PO 1,2,3
PSO 10	Application of microorganisms in the production of fermented food products and organic compounds, biofertilizers, bioactive compounds etc.	PO 1,4,5

PSO 11	Students will be able to conduct experiments, analyze and interpret for various problems in the field of medical, industrial, agricultural and environmental microbiology	PO 1,2,3,4
PSO 12	Awareness of Environmental policies, problems and ethical issues related to Bioscience research.	PO 2,3,4
PSO 13	Promoting scientific discoveries and familiarizing research methodology through implementation of projects.	PO 1,2,3,5
PSO 14	Students can go for Higher studies, can become technical assistants or production analyst in various Microbiology Industries.	PO 1,2,3,4,5,6

INTRODUCTION

The board of studies in Microbiology (PG) of Mar Athanasius College (Autonomous), Kothamangalam, proceeded with the task of restructuring the curriculum and syllabi of post graduate programme in Microbiology in the college (affliated to Mahatma Gandhi University, Kottayam) with a multifaceted task. The Master of Science in Microbiology is a two year full time programme, with each year comprising of two semesters. The present syllabus has been framed taking into account the suggestions and modifications emerged in the board of studies meeting. Special efforts were made to restructure the syllabus well suited to the changing scenario within the constraints set by the parent university.

BASIC FRAMEWORK OF THE PROGRAMME

The following is the schematic pattern in which a student will do the core (compulsory) and elective (optional) papers. The Board of studies identified 12 core and 3 elective papers and 4 laboratory courses. A short dissertation cum viva and general Viva-voce is introduced in the final semester of the programme.

NOTES

- Students must take 12 Compulsory papers, 3 Elective, 4 Practicals and a Dissertation comprising an Evaluation and a Viva-Voce.
- Total credit of the program shall be 80.
- Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in new situations and critical evaluation of knowledge.
- Evaluation pattern, components of evaluation, grading, weightage, consolidation of grades, SGPA, CGPA are as per the institutional and University regulations.

M.Sc. MICROBIOLOGY PROGRAMME STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits
FIRST SEMESTER				
PG20BS101	Biochemistry	Core course	04	04
PG20BS102	Cell Biology and Genetics	Core course	04	04
PG20BS103	Biophysics, Bioinstrumentation and Bioinformatics	Core course	04	04
PG20BS104	Human Physiology and Biostatistics	Core course	03	03
PG20BSP1-MB	Laboratory Course I	Core course	10	04
Total			**25**	**19**
SECOND SEMESTER				
PG20BS205	General Microbiology	Core course	04	04
PG20BS206	Immunology	Core course	04	04
PG20BS207	Molecular Biology and Genetic Engineering	Core course	04	04
PG20BS208-MB	Metabolism and Enzymology	Core course	03	03
PG20BSP2-MB	Laboratory Course II	Core course	10	04
Total			**25**	**19**

THIRD SEMESTER				
PG20BS309-MB	Food and Industrial Microbiology	Core course	04	04
PG20BS310-MB	Environmental and Agricultural Microbiology	Core course	03	03
PG20BS311-MB	Marine Microbiology	Elective- 1	04	04
PG20BS312-MB	Environmental Science	Elective- 2	04	04
PG20BSP3-MB	Laboratory Course III	Core course	10	04
Total			**25**	**19**
FOURTH SEMESTER				
PG20BS413-MB	Systematic Bacteriology	Core course	05	04
PG20BS414-MB	Virology, Mycology and Protozoology	Core course	04	04
PG20BS414-MB	Clinical Microbiology	Elective- 3	04	04
PG20BSP4-MB	Laboratory course IV	Core course	12	05
PG20BS4P-MB	Dissertation/Project			04
PG20BS4V-MB	Viva - Voce			02
Total			**25**	**23**
Total Credits				**80**

LIST OF ELECTIVES

LIST OF ELECTIVES IN 3RD SEMESTER

1. **PG20BS311-MB - Marine Microbiology**
2. **PG20BS312-MB - Environmental Science**
3. **PG20BS313-MB - Microbial Diversity & Extremophiles**
4. **PG20BS314-MB - Molecular Microbiology**
5. **PG20BS315-MB - Nanobiotechnology**
6. **PG20BS316-MB - Microbial Quality Assurance, Biosafety and Intellectual Property Rights**

LIST OF ELECTIVES IN 4TH SEMESTER

7. **PG20BS415-MB - Clinical Microbiology**
8. **PG20BS416-MB - Microbial Genetics**
9. **PG20BS417-MB - Biostatistics and Research Methodology**

GROUPS OF ELECTIVES

SEMESTER	GROUP A	GROUP B	GROUP C
Third Semester	PG20BS311-MB Marine Microbiology	PG20BS313-MB Microbial Diversity and Extremophiles	PG20BS315-MB Nanobiotechnology
	PG20BS312-MB Environmental Science	PG20BS314-MB Molecular Microbiology	PG20BS316-MB Microbial Quality Assurance, Biosafety and Intellectual Property Rights
Fourth Semester	PG20BS415-MB Clinical Microbiology	PG20BS416-MB Microbial Genetics	PG20BS417-MB Biostatistics and Research Methodology

SYLLABUS

First Semester M.Sc. Microbiology

PG20BS101	Biochemistry
PG20BS102	Cell Biology and Genetics
PG20BS103	Biophysics, Bioinstrumentation and Bioinformatics
PG20BS104	Human Physiology and Biostatistics
PG20BSP1-MB	Laboratory Course I

PG20BS101 - BIOCHEMISTRY

Hours / Week: 4 **Credits: 4**

Course Objective

- **To gain deep understanding of the structures of biological macromolecules and their structure function relationship**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the basic concepts of biomolecules	K2
2	Analyze the structure - function relationship of biomolecules	K4
3	Explain about the interactions between macromolecules	K2

UNIT I (9)

Brief Review of Basic Biochemistry

Role of Water in biological systems; physiological buffers; importance of Carbon, hydrogen, oxygen, nitrogen and phosphorus in biological systems.

Chemical bond and interactions: Covalent bonds; Ionic bonds; Disulfide linkages; Non-covalent interactions: Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction.

Introduction to Biomolecules: Composition; basic structure and function of biomolecules: carbohydrates, lipids,proteins, nucleic acids and vitamins, hormones. Charge properties of biological molecules; Isoelectric pH.

UNIT II (15)

Complex Carbohydrates

Oligosaccharides: Glycosidic bonds; Classification: glycoproteins (O-linked and N-linked), glycolipids; Nature of carbohydrate moiety attached; Functions: as cell recognition factors, in intracellular targeting; Purification and Characterization of oligosaccharides from cell membranes

Polysaccharides: Classification: Homopolysaccharides (Cellulose, Starch, Chitin and Glycogen), Heteropolysaccharides (bacterial peptidoglycans, glycosaminoglycans, hyaluronic acid, and heparin); Structural characteristics and functions of above mentioned polyasaccharides; Exopolysaccharides from bacterial systems and their uses; Purification and Characterization of Polysaccharides from biological systems.

UNIT III (14)

Complex Lipids: Glycerophospholipids: Structure and function of (Phosphatic acid, cardiolipin, Phosphatidylserine, Phosphatidyl ethanolamine, Phosphatidyl glycerol, Phosphatidyl choline, Phosphatidyl inositol), CDP-diacylglycerol, Lung surfactants.

Glycosphingolipids: Structure and function of Sphingosine, ceramides&sphingomyelins,cerebrosides, globosides, gangliosides, sulfatides .

Eicosanoids: Prostaglandins, Leukotrienes and Thromboxanes: Chemistry, formation andphysiological function.

Steroids: Steroids in animal system: Glucocorticoids, mineralocorticoids and Sex hormones (Site of biosynthesis, functions); Sterols in Plant system: Phytohormones: Brassinosterroids (functions); Sterols in microbial system.

UNIT IV (14)

Protein structure and function: Primary, Secondary, Tertiary and Quaternary structure of Proteins w.r.t: Globular protein (eg: Hemoglobin and Myoglobin), Fibrous protein (Collagen), Membrane Protein (ATP synthetase); Structural implication of the peptide bond: rigid planar

peptide unit; cis and trans configuration; conformations of a pair of linked peptide units; torsion angles: phi and psi; steric hindrance; allowed and disallowed conformation – Ramachandran diagram: conformational maps of glycine and other natural amino acids. Protein families, alpha domain, beta domain, Protein structure and molecular approach to medicine: introduction, Sickle cell anaemia. Protein –DNA interaction nhelix turn helix, helix loop helix, zinc fingers, homeo box.

Protein –RNA interaction RNA recognition motif. Protein-protein interaction-leucine zippers, bHLH, bZip motifs, PTB SH2, SH3 domains.Protein lipid interaction – PH domain.Protein drug interaction.

UNIT V (12)

Nucleic acid structure and function: Discoveryof nucleic acid structure, Contribution of Indian Scientists in the elucidation of structure, Types of DNA -A, B and Z. GC content, Denaturation kinetics, cot curve, Supercoiling of the DNA molecule; topoisomers and superhelixes; Higher orders of DNA Structure: Chromatin Structure: Histones and Nucleosomes; histone modifiacation and their importance, Conformation of Chromatin fibers.

Organization of the DNA Sequence: Genes, pseudogenes, extragenic regions (beta globin gene and gene family) duplicated genes; Repetitive DNA sequences:Tandem repeats (Satellites, minisatellites, and microsatellites), Interspersed repeats (LINE,SINEs) Single copy genes; RNA Structure: Types of RNA; structure of mRNA, tRNA, SiRNA, micro RNA with emphasis on importance of structure to its function, non –coding RNAs, Regulatory RNAs.

REFERENCES

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2. Introduction to Biophysics by Pranab Kumar Banerjee(2008) Publishers: S.Chand& Company Ltd ISBN:81-219-3016-2

3. Lehninger, Principles of Biochemistry, Fourth Edition by David L.Nelson Michael. M Cox Publisher: W.H.Freeman; Fourth Edition (April 23,2004) ISBN-10:0716743396 ISBN-13:978-0716743392
4. Biochemistry(2011) by Donald Voet, Judith G Voet Publisher: JohnWiley&SonsInc ISBN: 978-1-1180-25024
5. Principles of Biochemistry,4/e(2006)by Robert Horton H, Laurence A Moran, GrayScrimgeour K Publisher Pearsarson ISBN:0131977369,
6. Biochemistry 6^{th} Edition (2007)by Jeremy M.Berg John L.tymoczkoLubertStryerPublisher:B.I Publications Pvt.Ltd ISBN:071676766X ISBN-13:9780716767664, 978716767664
7. Biochemistry (2008) by Rastogi, Publisher: Mcgraw Hill ISBN: 0070527954 ISBN-13:9780070527959, 978-0070527959
8. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson ,JulianLewis, MartinRaff, KeithRoberts, Peter Walter Publisher: Garland Science; 5 edition ISBN-10: 0815341059 ISBN-13: 978-0815341055
9. Genes IX by Benjamin Lewin(2008)Publisher: J&b ISBN:07637
10. 52223ISBN-13: 9780763752224, 978-0763752224
11. Molecular Biology of the Gene 5/e(s)by James D Watson, Tania A Baker, Stephen P Bell (2008) Publisher: Dorling Kindersley (India) Pvt Ltd ISBN: 8177581813 ISBN-13: 9788177581812, 978-8177581812
12. Cell and Molecular Biology by S. SundaraRajan (2003) Publisher: Anmol Publications ISBN: 8126113553 ISBN-13: 9788126113552, 978-8126113552

PG20BS102 - CELL BIOLOGY AND GENETICS

Hours / week: 4 **Credit: 4**

Course Objective

- **To have an overview of various cellular organelles**
- **To understand the significance of cell signaling pathways**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain and Illustrate the various organelles of a cell and its functions	K2
2	Demonstrate the different cellular receptors and signal transduction pathways	K3
3	Illustrate the etiology of cancer	K2
4	Analyze the genetic aspects of inheritance	K4

Unit I (12)

Cell: An Introduction. Membrane proteins, lipids.Fluid mosaic model, membrane fluidity, membrane asymmetry, lipid raft.Functions of the membrane. Membrane transport: Passive transport- Diffusion, facilitated diffusion- glucose porter molecules. Channel proteins- aquaporins. Ionicchannels – voltage gated and ligand gated channels. Transmission of electrical impulses- resting and action potential. Active transport: Features, Na^+ K^+ pump. Cell junctions: Adherens junctions, desmosomes, tight junction, gap junction.

Unit II (17)

Extracellularmatrix: composition and functions. Cell signaling- Gprotein coupled receptors, Ion channel coupled receptors. Synaptic transmission. Enzyme coupled receptors-ras pathway.

Camp as second messengers- glycogen breakdown by epinephrine.Ca ions as second messenger. ER: structure and function, Golgicomplex: structure, types, protein sorting and trafficking, exo and endocytosis, coated pits and vesicles. Lysosomes and peroxisomes: enzymatic components and functions, Mechanism of autophagy. Cytoskeleton: Microtubule, assembly and organization, microfilaments:actin structure and assembly, filament based movement in muscle, sliding filament model. Intermediate filaments- types and functions.

Unit III (17)

Intracellular structures: Mitochondrion: structural features and functions, Chemiosmotic coupling, Chloroplast-structural features and functions, LHC, Rubisco. Nucleus, nuclear pore complex, structure of chromosomes, chromosome banding, mitosis and meiosis, Model organisms in cell biology.Cellcycle: G1, S, G2, M phases, MPF, cyclins, checkpoints, Role of Rb& p53. Cell cycle inhibitors, Aging-significance of glutathione.Apoptosis and necrosis, apoptotic pathways.Types of tumor, induction of cancer, properties of cancer cells, oncogenes and concogenes, tumor suppressors, Molecular pathways- PIP3Akt, JAKSTAT.

Unit IV (20)

Genetics: Mendel's laws, dominance, epistasis, pleiotropic interactions, multiple alleles-ABO blood groups, pseudoalleles, atavism, linkage, sex linkage, linkage groups, two point and three point test crosses, determination of gene order, chromosome mapping, sex influenced genes, sex limited genes, inherited disorders in metabolism- maple syrup urine disease, LeschNyhan syndrome, Down's syndrome, polyploidy, aneuploidy, Cytoplasmic inheritance, cytoplasmic male sterility.

Unit V (10)

Population Genetics: Behavioral genetics, Hardy Weinberg principle-natural selection, genetic drift, Genetic variation, Allele frequencies and its changes, mutation, gene flow, random mating, inbreeding, outbreeding, assertive mating, hybrid vigour. Mutational analysis using principles of probability- Chis-quare test.

REFERENCES

1. Principles of Genetics, Snustad DP, Simmons and Jenkins, John Wiley and Sons Inc*ISBN*-13:978-1118129210.
2. Genetics, Robert Weaver and Philip Hendricks, WH.C.Brown Publishers, Iowa.
3. Fundamentals of Genetics, BD Singh, Kalyani Publishers.
4. Introduction to Genetic Analysis, Griffiths, Wessler, Lewontin, Gelbart, Suzuki and Miller, Freeman's and Co, NewYork.
5. Principles of Genetics: MJ Gardner, John Wiley and sons.
6. Cell Bilogy, Smith and Wood.
7. Cell and Molecular Biology by Gerald Karp, Academic Press.
8. Cell and Molecular Biology Cooper, Hausman, ASM Press. ISBN: 9781605351551.
9. World of the Cell, Becker, Reece, Poenie. The Benjamin/ Cumming's Pub. *ISBN:* 10:0134145798.
10. Cell Biology, Lodish*et al*, W H Freeman and Co., NewYork. ISBN-13:978-1429234139.
11. Cell Biology, Thomas D Pollard and W.C. Earnshaw, Saunder's Publishers ISBN: 9780323341264.
12. Cell Biology Organelle, structure and function: David E Sadava. Jones and Barlette series in Biology. *ISBN:* 10:9780867202281.
13. Cell and Molecular biology: CSR astogi NEW Age International Pub. *ISBN*:13:978-8122416886.

PG20BS103 - BIOPHYSICS, BIOINSTRUMENTATION AND BIOINFORMATICS

Hours / Week: 4 **Credits: 4**

Course Objective

- **To gain an understanding of the principle and working of various instruments and tools for biological anlaysis**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the biochemical techniques used in research and industry	K2
2	Practice experiment with various instruments used in laboratories	K3
3	Demonstrate the Insilico tools for biological data analysis	K3
4	Analyze the significance and precautions to be taken during radioactivity experiments	K4

UNIT I (6)

Thermodynamics: Laws of thermodynamics, the concept of enthalpy, entropy and free energy, thermodynamic equilibrium, high energy molecules, redox potential, examples of redox potential `in biological system, Nernst equation.

UNIT II (15)

Mass Spectrometry: Principle, Applications; Peptide mass finger printing using MALDI-TOF, MASCOT database.ORD, CD, Flow cytometry, X-ray diffraction by crystals, Electron diffraction, Application of radioactive and non radioactive methods: GM counter, Liquid scintillation counting, phosphoimager.

UNIT III (20)

Microscopy: Light, Scanning and Transmission electron, phase contrast, polarization, confocal, Fluorescence and interference microscopy, Application of immunofluorescence in microscopy, Microscopy for detecting chromosomal aberrations.

Spectroscopy: Beer-Lamberts law, Principle, Instrument Design, methods and Applications of UV-Visible spectra, IR spectra, Raman Spectra, Fluorescence spectra, NMR and ESR spectra.

UNIT IV (16)

Chromatography: Principle, methods and Applications of Chromatography, ion exchange, molecular sieve, affinity chromatography, TLC, GC-MS, HPLC, Centrifugation and Ultra centrifugation, PAGE, SDS PAGE, 2D Gel Electrophoresis, Capillary Electrophoresis, isoelectric focusing.

UNIT V (15)

Bioinformatics: Introduction to Bioinformatics, data mining Online databases and search tools, data organization, Biological data bases, structural data bases, derived and specialized data bases, DNA and RNA sequence data bases, genomic sequences, protein sequence data bases, Distance matrix methods and parsimony. Multiple sequence alignments-tree alignments, star alignments, pattern in pair wise alignment, genetic algorithm. Sequence analysis softwares, SS search, BLAST, FASTA, CLUSTAL, Phylogenetic analysis, construction of phylogenetic tree, evolutionary changes in nucleotide and protein sequences, structure prediction, structural alignment tools, homology modeling, drug design, Energy

minimization in molecular docking. Applications of Bioinformatics: pharmaceutical industry, immunology, agriculture, forestry, basic research, chemiinformatics in biology, geoinformatics, legal ethical and commercial considerations.

REFERENCES

1. Introduction to Protein structure: Branden and Tooze1.
2. Biophysics-Hoope W *et al*
3. Molecular Biophysics- Volkenstain M.V
4. Introduction to Thermodynamics Of Irreversible Process-Joh Wiley
5. Statistical Methods In Biology- Briley N.J.T
6. Introduction to Biophysics-Sokal R.R &Rohl F.J
7. Bioinformatics: Sequence and Genome Analysis- David Mount, Cold Spring HarbourLabPress, New York.
8. Bionformatics and Molecular Evolution: Paul G Higgs, Teresa K Attwood. Blackwell pub.
9. Introduction to Bioinformatics; Attwood T K and Parry-Smith D J Pearson Education Ltd.
10. Bioinformatics Seuqence, structure and database; Des Higins, Willie Taylor.

PG20BS104 - HUMAN PHYSIOLOGY AND BIOSTATISTICS

Hours/week: 3 **Credits: 3**

Course Objective

- **To have a basic knowledge of the structure and functions of various organs and tissues and organs of human body**
- **A brief overview of different statistical tools in biology**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the tissues and organs of the human body	K2
2	Demonstrate the ability to differentiate physiology from the cellular and molecular level to the organ system	K3
3	Apply physiological and anatomical knowledge to enhance their well-being	K3

UNIT-1

Tissues: Epithelial tissue, connective tissue, muscle and nervous tissue

Nervous system: Organization and function of Central and peripheral nervous system, Parts of Brain- Forebain, Midbrain, Hindbrain. Neurons –Structure, Properties, Types of neurons. Neuroglial cells. Synapse - Chemical and electrical synapse.

UNIT –II

Muscle: Muscle classification- skeletal muscle, smooth muscle, cardiac muscle. Muscle contraction, neuromuscular junction.

Blood: Formed elements of blood- RBC, WBC, platelets. Haematopoiesis. Blood groups – ABO blood group, Rh blood group. Blood grouping. Blood transfusion. Blood coagulation.

Heart: Cardiac muscle, cardiac cycle, heart sounds, conducting mechanism of heart. Cardiac output, ECG, blood pressure.

UNIT-III

Excretory system: Kidney- structure of nephron, urine formation, GFR, renal circulation. Micturition. Composition of urine. Renal regulation of water and electrolyte balance.

UNIT –IV

Respiratory system: Structural organization of respiratory system, respiratory membrane, mechanism of breathing, pulmonary ventilation, pulmonary volumes and capacities, alveolar ventilation, pulmonary surfactants, exchange and transport of gases, regulation of respiration. Acclimatization. Acid-base balance. Periodic breathing. Artificial respiration.

Abnormal respiratory patterns: Apnea, dyspnea, Hypoxia, cyanosis, hyper capnia, asphyxia. Carbon monoxide poisoning.

UNIT –V

Biostatistics: Introduction, scope, probability and probability distribution analysis, variables in biology, collection, classification and tabulation of data, graphical and diagrammatic representations-scatter diagrams, histograms, frequency polygon, frequency curve, logarithmic curves, Descriptive statistics, measures of central tendency, Arithmetic mean, median, mode, geometric mean, harmonic means, Measures of dispersion, Standard deviation, standard error, Variance, coefficient of variation, correlation and regression, Principal component analysis test of significance, Basic idea of Significance test, hypothesis testing, students′t test, Chi-square test, statistical packages, use of statistical softwares, Excel, SPSS, Prism, graphed software.

REFERENCES

1. Text book of Medical physiology. InduKhurana. Elsevier. ISBN:978-81-8147-850-4.
2. Vander's Human Physiology-The mechanism of Body function, Widmaier, Raff, strang.
3. Text book of Medical Physiology. Arthur.C.Guyton&John.E.Hall
4. Review of Medical Physiology-William F.Ganong
5. Essentials of Medical Physiology K.Sembulingam&PremaSembulingam
6. Statistical methods in Biology-Briely N.J.T.
7. Introductory Practical Biochemistry, S.K.Sawhney&Randhir Singh (eds), Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, P195-303.
8. Standard Methods of Biochemical Analysis, S.K.Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, P12-18.
9. Expeimental Biochemistry, A Student companion, BeeduSasidharRao and Vijay Deshpande(ed), I.K.InternationalPvt.Ltd, NewDelhi, ISBN 81-88237-41-8, PB13-17, P 49-72.
10. Practical Biochemistry, R.C.GuptaS.Bhargava(eds) CBS Publishers and Distribuors, New Delhi ISBN 81-239-0124-0 P9-27

PG20BSP1-MB - LABORATORY COURSE I

Hours/week: 10 **Credits: 4**

Course objective

- **To make student understand the basic principles of assays and instruments in biochemistry, cell biology and physiology.**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Prepare molar, normal and percentage solutions	K5
2	Analyze unknown samples by systematic analysis-	K4
3	Assess samples, present in solutions by selecting appropriate methods-	K6
4	Analyze and evaluate samples present in a mixture, by various separation techniques-	K4 & K6
5	Demonstrate laboratory experiments in physiology-	K3
6	Analyze data and/or information present in databanks-	K4

Biochemistry

1. **Preparation of Solutions:**
   - Percentage solutions,
   - Molar solutions,
   - Normal solutions
   - Dilution of Stock solutions

2. **Preparation of buffers using the Henderson Hasselbach equation**
3. **Spectrophotometric Experiments:**
    - Determination of UV-Visible spectrum of compounds
    - Determination of Concentration of molecules from Molar Extinction coefficient values.

Quantitative Analysis-Any five from plant or animal source

- Extraction and Quantitative estimation of reducing sugars by Dinitrosalicylic acid method/ Nelsons Somogyi method
- Extraction and Quantitative Estimation of fructose by Roe and Papadopaulose method
- Estimation xylose by orcinol method
- Extraction of polysaccharide Anthrone method (starch,glycogen) and quantification.
- Quantitative estimation of tyrosine by Folinsciocalteumethod
- Quantitative estimation of Methionine by Nitroprusside method
- Extraction and Quantitative Estimation of protein by biuret method./ Lowry's method/ BCG method
- Estimation of Cholesterol by Zak's method
- Estimation of DNA by Diphenylamine and estimation of RNA by Orcinol method
- Determination of Saponification value, acid value,iodine number of oils or fats.

4. **Separation Techniques**
    - Separation of amino acids by Paper chromatography(Descending or Ascending)
    - Separation of Plant pigments/lipids/sugars by Thin layer chromatography
    - Separation of any biomolecule by column chromatography (gel filtration/ ion exchange chromatography)
    - SDS PAGE

Cell Biology and Genetics

1. Study of various stages of mitosis using cytological preparations of onion root tips.
2. Karyotype study using cytological preparation of dividing root tip cells of onion /photographs /permanent slides
3. Study in the ultra structure of cell organelles using electron microphotographs pics.
4. Solving genetic problems related to monohybrid, dihybrid ratio and interaction of genes

Physiology

1. Determination of haemoglobin concentration
2. Determination of haematocrit value
3. Enumeration of blood cells: Erythrocytes by haemocytometry, Total leukocyte by haemocytometry
4. Preparation of Blood smears for differential count and cell morphology
5. Determination of Erythrocyte sedimentation rate

Bioinformatics

1. Familiarizing with the different data bank mentioned in the syllabus.
2. Retrieve a document reporting recent work on a genomic analysis of human disease.
3. Retrieve one sequence both DNA and protein from database retrieval systems.
4. Retrieve nucleotide sequences and construct a distance tree.
5. Online sequence analysis, BLAST.
6. Phylogenetic analysis.

Biostatistics

1. Problems on Arithmetic mean, Standard deviation, Correlation, regression, Chi - square test
2. Visit a research Institute to familiarize with the Instrumentatin . Submit a report

REFERENCES

1. Introductory Practical Biochemistry, S .K. Sawhney&Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, P195-303
2. Standard Methods of Biochemical Analysis, S.K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 12-18
3. Hawk's Physiological Chemistry, Bernard L.Oser (ed) TATA McGraw Hill Publishing Company LTD, New Delhi, p 60-127, 1317-1334
4. Practical Clinical Chemistry, Harold Varley, CBS Publishers and Distributors, New Delhi,
5. Medical Laboratory Technology – A procedure manual for routine diagnostic tests Volume 1, K.L. Mukherjee, Tata McGraw-Hill Publishing company LTD, New Delhi

SYLLABUS

Second Semester M.Sc. Microbiology

PG20BS205	General Microbiology
PG20BS206	Immunology
PG20BS207	Molecular Biology and Genetic Engineering
PG20BS208-MB	Metabolism and Enzymology
PG20BSP2-MB	Laboratory Course II

PG20BS205 - GENERAL MICROBIOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective

- **To gain an understanding of the general characteristics and cultivation of bacteria, virus, fungus**
- **Understanding of importance of sterilization and disinfection in microbiology**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	llustrate the diversity of microbial world and their interactions with the environment	K2
2	Explain thegeneticmaterialsand mechanisms in bacteria and their role in the transmission of genetic characters	K2
3	Illustrate the importance of sterilization and disinfection and the methods used in a microbiology laboratory and premises	K2
4	Demonstrate microorganisms based on their characteristics	K3

UNIT I

Introduction: The historical foundations and development of microbiology. Outline classification of microorganisms- Haeckel three Kingdom classification, Whittaker five Kingdom classification and Woese three domain classification.

Principles of bacterial taxonomy: Numerical taxonomy, Identification characters-morphological, staining, physiological, biochemical and molecular (mol % G+C, nucleic acid hybridization, 16SrRNA sequencing) characters.Bacterialclassification as per latest edition ofBergey's Manual of systematic Bacteriology.Archaebacteria and Bacteria.

UNIT II

General properties of bacteria: Morphology and structure of bacteria-size, shape and arrangement. Surface structures and inclusions of bacteria-Capsule, pili, fimbriae, flagella, cell wall, cell membrane, cell organelles, genetic material, plasmid, spore, inclusion bodies. Microbial locomotion - flagellar motility, gliding motility and amoeboid motion.Chemotaxis.

General properties of viruses: Morphology and structure of viruses, Bacteriophages, viroids, prions. Genetic modification of viruses.Virus multiplication.Cultivation of viruses.
General properties of fungi: Classification of fungi, Reproduction in fungi. Methods for the study of fungi. Cultivation of fungi.

UNIT III

Bacterial growth and nutrition: Factors influencing bacterial growth – nutritional and environmental factors. Bacterial growth at different temperature, pH and oxygen level. Nutritional types of bacteria. Binary fission. Bacterial growth curve. Batch, fed-batch and continuous culture. Measurement of bacterial growth.

Cultivation of bacteria: Culture media - Composition and preparation of culture media. Types of culture media – Solid, semi-solid, liquid and bi-phasic media, simple media, differential media, special media, enriched media, enrichment media, auxanographic and anaerobic media.Culture methods- Aerobic and anaerobic.

Identification of bacteria: Staining reactions- Principles of staining. Types of staining-Simple staining, Differential staining, Special staining- capsule, spore, flagella and volutin granule. Cultural, morphological and biochemical properties. Molecular methods for

identification - Isolation of bacterial DNA, electrophoresis, amplification of DNA -PCR technique, 16SrRNA sequencing. Phylogenetic tree.

UNIT IV

Sterilization: Principles and methods, physical and chemical methods. Disinfectants - modes of action. Testing of disinfectants.

Antibiotics: Antibacterial, antifungal, antiviral, mechanism of action. Classification of antibiotics based on mechanism of action. Drug resistance in bacteria. Antibiotic sensitivity tests.

UNIT V

Bacterial genetics: Genetic materials in bacteria. Bacterial chromosome.Extrachromosomal genetic elements.Plasmid- copy number and incompatibility, Replication of plasmid.Episomes. Transposable element-IS element and transposon, Integrons and Antibiotic resistance cassettes, Multiple antibiotic resistant bacteria, Mutation- types of mutations, DNA repair-Photolysis, Excision repair, NER, SOS repair, Mutant selection. Mechanism of gene transfer - transformation, transduction and conjugation.Recombination-types, mechanism and enzyme involved. Gene mapping.Metagenomics.

REFERENCES

1. Prescott LM, Harley JP, & Klein DA (2005) Microbiology (McGraw-Hill, Boston;London) 6th ed.
2. Russell AD, Hugo WB, &Ayliffe GAJ (1999) Principles and practice of disinfection,
3. preservation, and sterilisation (Blackwell Science, Oxford) 3rd ed
4. Bryan LE (1984) Antimicrobial Drug Resistance (Academic Press, Orlando
5. Topley WWC, Wilson GS, Parker T, & Collier LH (1990) Topley and Wilson'sPrinciples of Bacteriology, Virology and Immunology .Edward Arnold, London. 8thed.
6. Davis BD (1990) Microbiology (Lippincott, Philadelphia) 4th ed
6. Zinsser H &Joklik WK (1992) Zinsser Microbiology (Appleton & Lange, Norwalk,CT) 20th Ed
7. Gerhardt P (1994) Methods for General and Molecular Bacteriology. American Society for Microbiology, Washington, D.C.
8. Pelczar MJ, Chan ECS, & Krieg NR (1993) Microbiology: concepts and applications McGraw-Hill.5thed.

PG20BS206 - IMMUNOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective

- **To have an understanding of the immune system and their functions**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the cellular and molecular basis of the immune system	K2
2	Demonstrate the adaptive immune responses coordinate to fight against invading pathogens	K3
3	Describe the structure and functions of MHC molecules and Immunoglobulins	K2
4	Explain the complement system, its activation and biological consequences of complement activation	K1 & K2
5	Illustrate the use of vaccines and analyze the strategies for future vaccines	K2 & K4
6	Explain the genetic defects that lead to immunodeficiency diseases and their treatment as well as the current status of gene therapy	K2

UNIT I

Introduction to the immune system: Organs and cells with immune function. Infection, Source of infection, Methods of transmission. Immunity- Types of immunity. Mechanisms of innate immunity- barriers, inflammation, phagocytosis-mechanisms, Pattern recognition receptors - Scavenger receptors and the Toll-like receptors.

UNIT II

Antigen, antibody and immunological techniques: Antigens, Antigenicity, Epitopes, Antibodies, Immunoglobulin – structure, classes and functions Fc receptors. Monoclonal antibodies – production and application, Antibody engineering.Antigenic determinants on Ig-Isotype, Allotype, Idiotype. Genetic basis of antibody diversity. Organization and Expression of Immunoglobulin Genes, V(D)J rearrangements; somatic hypermutation and affinity maturation,Class-switching, Antigen-antibody reactions - Agglutination, Precipitation, Complement fixation, Immunodiagnosis: Radioimmuno assay, Immunoflourescence, ELISA, lateral flow assay, Western blotting, Flow cytometry etc.

UNIT III

Cell and humoral Immune response: Receptors on T and B cells for antigens, MHC, Antigen processing and presentation, Complement system, Complement activation, regulation, Biological effects of complements, B cell- generation, activation, differentiation, Humoral Immune response- Antibody formation, Primary and secondary immune response, Clonal selection theory. T-cell maturation, activation and differentiation, Cell mediated Immune response, Cytokines, Immune modulation

UNIT IV

Transplantation and immunotherapy: Immunology of organ and tissue transplantation-Allograft reaction and GVH reaction, Factors influencing allograft survival, Immunology of malignancy- Tumor antigens, Immune response in malignancy, Immunotherapy of cancer, Immunohematology- ABO and Rh blood group system, Immunology of blood transfusion, Hemolytic disease of new born.

UNIT V

Hypersensitivity, Autoimmunity and vaccines: Immunological Tolerance, Autoimmunity-Mechanisms of autoimmunity, Autoimmune diseases. Inflammation, Hypersensitivity–immediate and delayed reactions, Clinical types of hypersensitivity, Immunodeficiency diseases, Immunoprophylaxis- Vaccines –types of vaccines: 1) Conventional vaccines-

Attenuated, live; 2) recombinant vaccines- carbohydrate, protein and DNA based vaccines, Combination vaccines, Edible vaccinees. Recent trends in vaccine development. Role of Adjuvants. Immunoregulation

REFERENCES

1. Roitt IM & Delves PJ (2001) *Roitt's essential Immunology*.Blackwell Science, Oxford. 10th ed.
2. Kindt TJ, Goldsby RA, Osborne BA, &Kuby J (2006) *KubyImmunology*.W.H. Freeman, New York. 6th ed
3. Murphy K, Travers P, Walport M, &Janeway C (2008) *Janeway's Immunobiology*. Garland Science, New York. 7th ed
4. Chapel H (2006) *Essentials of clinical Immunology* .Blackwell, Malden, Mass. ; Oxford. 5th ed
5. Kimball JW (1986) *Introduction to Immunology*. Macmillan, London 2nded
6. Paniker CKJ (2006) *Ananthanarayan & Paniker's Textbook of microbiology*. Orient Longaman.

PG20BS207 - MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Hours / Week: 4 **Credits: 4**

Course objective

- **To gain an understanding of molecular biology of the cell**
- **Application of recombinant DNA technology**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain the various molecular mechanism underlying the transmission of genetic information	K2
2	Illustrate the theoretical aspects of rDNA technology and genetic engineering	K2
3	Apply the different molecular tools and strategies explored in rDNA technology	K3
4	Formulate the outcome of various molecular biology experiments	K5

Unit I

Structural organization of genome: chromatin, nucleosome, chromosomes. Functional organization: genes, controlling sequence, split gene concept, exons, introns, intergenic DNA-repetitive sequences- interspersed repeats-SINE, LINE transposons-types (ISelements, replicative transposons, retroposons) & significance, tandemrepeats- micro, mini satellites. DNA Replication. Models of DNA Replication, Conservative, Semi conservative and discontinuous, Messelson and Stahl experiment, Steps ininitiation of replication, Enzymatic factors involved, Orisite, Okazaki fragments, Termination of replication, DNA polymerases in eukaryotes and prokaryotes, Klenow fragment, Primosome, SSB, Ligase, modes of

replication, theta, rolling circle, d-loop replication, end problem of replication, telomerase-structure and functions, Inhibition of replication. Role of enzymes in proof reading, Repair mechanisms: Photolyase, Excision Repair-BER, NER. Mismatch repair, SOS repair, Recombination repair systems.

Unit II

Transcription:

Process of transcription, stages in transcription, RNA polymerases in prokaryotes and enkaryotes, sigma factor in prokaryotes, Rho dependant and Rho independent termination. Enhancers, Transcription factors in Eukaryotes, Differences in transcription between prokaryotes and Eukaryotes, posttranscriptional modifications- Polyadenylation, capping, r-RNA processing, Splicing- Spliceosome, lariat structure, Group1, IIand III Introns. Ribozyme, Importance of ribozyme, properties, application, RNaseP, RNAseIII, RNAseH. Monocistronic and polycistronic m-RNA, Joint transcript fr-RNA and t-RNA in prokaryotes and their processing, Transplicing, alternate splicing, inhibitors of Transcription.

Molecular mechanism of gene regulation in prokaryotes-Transcriptional regulation in prokaryotes; Inducible & repressible system, positive and negative regulation; Operon concept, structure of operon, Lac, Trp, Ara operon, Catabolic repression, Attenuation. Role of Hormones in gene regulation.

RNA World, RNA based technology- Molecular mechanism of Ribozyme, Antisense RNA,SiRNA, MicroRNA, Riboswitches & their applications; Telomerase structure and function Nucleic acid as therapeutic agent

UNIT III

Translation: Process of translation. Stages in translation, genetic code, properties, wobble hypothesis, eukaryotes and prokaryotes ribosomes, m-RNAs, t-RNAs, aminoacyl t-RNA synthetases, protein factors initiation complex, peptidyl transferase , releasing factors, differences between prokaryotic and eukaryotic systems, inhibition of translation. Post translation modification by cleavage, self assembly, assisted self assembly, chaperones,

acylation, phosphorylation, acetylation and glycosylation, Histone acetylation and deacetylases, chromosome remodeling complex. Intein splicing.

UNIT IV

Tools and techniques for Genetic Engineering: History of rDNA Technology, Cohen And Boyer Patents. Enzymes used in genetic engineering with special reference to restriction enzymes, ligases, and other DNA modifying enzymes. Modification of restriction fragments, vaccinia topoisomerases, Cloning strategies - Use of linkers, adaptors, TA cloning, and homopolymer tails . Nucleic acid hybridization - Colony hybridization, plaque hybridization; Blotting techniques – Southern, Northern.

Vectors – Plasmid- pSC101, pBR322, pUC their development, features and selection procedures; Bacteriophages- λ and M13, Cosmids- features advantages and cosmid cloning schemes; Phagemids- pEMBL, pBluescript, pGEM3Z, pSP64. Shuttle vectors- YAC. Ti-plasmids. Expression vectors. Construction of genomic libraries and cDNA libraries, procedure for recombinant selection and library screening, Chemical synthesis of DNA, DNA Sequencing- plus and minus sequencing, Sanger's dideoxy sequencing, Maxim and Gilberts method. Advanced sequencing procedures – pyrosequencing, Illumina, ABI/SOLiD and their applications. Principles, techniques and applications- PCR, RFLP, RAPD, AFLP, Foot and Finger printing.

UNITV

Applications of Genetic Engineering: DNA chips and microarray, gene screen technology; site directed mutagenesis, gene knockout techniques, Genetic markers, Gene transfer in plants and animals. Applications of transgenic technology. Animal cloning- stem cell technology, somatic cell nuclear transfer, Plant cell culture based techniques. Applications of Molecular Biology in forensic sciences, medical science etc.

REFERENCES

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PG20BS208-MB - METABOLISM AND ENZYMOLOGY

Hours/ Week: 3 **Credits: 3**

Course Objective

- **To gain an understanding of the various metabolic pathways in the body and their regulation**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain the metabolism of carbohydrates, proteins, lipids and nucleic acids	K2
2	Illustrate the structure, functions and mechanism of action of enzymes	K2 & K3
3	`Describe the classification of enzymes based on the reactions catalysed	K1 & K2
4	Explain the kinetics of enzyme catalysed reactions and enzyme inhibitory and regulatory processes	K2

UNIT 1

Metabolism of carbohydrates: Glycolytic pathway, substrate level phosphorylation, significance of the mitochondrial respiratory chain and oxidative phosphorylation, Electron transport chain: structural components of the chain, complexes, free elements; Generation of the electrochemical proton gradient: Chemiosmosis ATP synthesis: structural and functional properties of ATP synthesis; Inhibitor agents and decoupling agents of the respiratory chain and ATP synthesis; Regulation of glycolytic pathway, Etner Dudoruff pathway, Gluconeogenesis and Glycogenesis. Synthesis of bacterial peptidoglycan, Bacterial photosynthesis- photosynthetic and accessory pigments.

UNIT II

Metabolism of Proteins, lipids and nucleic acids: Synthesis and degradation of aromatic and aliphatic amino acids with two examples each, deamination, transamination, urea cycle, β oxidation, synthesis of fatty acids, FAS, synthesis of cholesterol, degradation of cholesterol. Synthesis of bacterial LPS, Synthesis of purines and pyrimidines, salvage pathway, degradation regulation of pathways.

UNIT III

Enzymes and Enzyme kinetics : Holoenzyme, apoenzyme, and prosthetic group; Interactionbetween enzyme and substrate- Features of active site, activation energy, Rate Enhancement Through Transition State Stabilization, Enzyme specificity and types; Enzyme Commission system of classification and nomenclature of enzymes,ribozymes,abzymes measurement and expression of enzyme activity, enzyme assays. Definition of IU, katals, enzyme turnover number and specific activity, Isolation of enzymes and the criteria of purity; Characterization of enzymes, Order of reaction, study of the factors affecting the velocity of enzyme catalyzed reaction-Derivation of Michaelis -Menten equation and Km value determination and its significance, Definition of V_{max} value of enzyme and its significance, Line weaver- Burk plot; Bi-substrate reactions: Classification.

UNIT IV

Enzyme inhibition and regulation: Reversible and irreversible – examples. Reversible-competitive, noncompetitive and uncompetitive inhibition;; Dose—Response Curves of Enzyme Inhibition; Structure—Activity Relationships and Inhibitor Design; Application of inhibitors as therapeutic agents for HIV, Cancer. Covalently modulated enzymes with examples of adenylation and phosphorylation; Zymogen form of enzyme and zymogen activation; Multienzyme complexes and their role in regulation of metabolic pathways; Allosteric enzymes: Examples, Effects of Co-operativity on Velocity Curves, Sigmoidal Kinetics for Nonallosteric Enzymes Allosteric regulation: example Aspartate trascarbamoylase, Isoenzymes-Lactate dehydrogenase and creatine phosphokinase.

UNIT V

Application of enzymes: Immobilisation of enzymes, Industrial uses of enzymes: production of glucose from starch, cellulose and dextrans, use of lactase in diary industry, production of glucose fructose syrup from sucrose, use of proteases in food, leather and detergent industry. Diagnostic and therapeutic enzymes.

REFERENCES

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2. Enzyme Kinetics: A Modern Approach Book: Enzyme Kinetics: A Modern Approach by Alejandro G. Marangoni (2003) Publisher: Wiley-Interscience ISBN: 0471159859 ISBN-13: 9780471159858, 978-0471159858
3. Enzyme Kinetics and Mechanisms by Taylor Publisher: Spring ISBN: 8184890478 ISBN-13: 9788184890471, 978-8184890471
4. Enzyme Mechanism by P.K. Shivraj Kumar (2007) Publisher: RBSA Publishers ISBN: 8176114235 ISBN-13: 9788176114233, 978-8176114233
5. Enzymes in Industry: Production And Applications by Aehle W (2007) Publisher**:**JohnWiley& Sons Inc ISBN: 3527316892 ISBN-13: 9783527316892, 978-3527316892
6. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (second Edition) by Trevor Palmer, Philip Bonner (2007) Publisher: Horwood Publishing Limited ISBN: 1904275273 ISBN-13: 9781904275275, 978-1904275275
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8. 9.E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974

PG20BSP2-MB - LABORATORY COURSE-II

Hours / Week: 10 **Credits: 4**

Course Objective

- **To make the student efficient in handling various microbiological, immunological and enzymological assays.**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe good microbiological practices in the laboratory	K1 & K2
2	Illustrate various Culture media and their applications and also understand various physical and chemical means of sterilization	K1 & K2
3	Experiment to perform staining, biochemical and cultural tests to characterize and identify microorganisms	K4
4	Illustrate the procedures for sterilization, cultivation procedures and enumeration methods of microorganism	K2 & K3
5	Describe the principle and practices of immunological tests	K1, K2 & K3
6	Discuss and practice basic technique in molecular biology	K2 & K3

(Microbiology, Immunology, Molecular Biology, Genetic Engineering and Enzymology)

MICROBIOLOGY AND IMMUNOLOGY

- Microscopic examination of bacteria in living conditions- Testing of motilityby hanging drop method.
- Staining procedures- Gram, Volutin, Spore, Capsule, Negative, Acid Fast, Fungal staining.
- Cultivation of bacteria and fungi
- Sterilization methods
- Study of cultural characteristics and biochemical reaction of bacteria
- Testing of disinfectants
- Bacterial growth curve
- Antibiotic sensitivity tests- disc diffusion, MIC
- Serological tests for the diagnosis of microbial infections
- Agglutination and precipitation tests
- Immunodiffusion in gel
- ELISA
- Bacterial identification using software based on morphological and biochemical characters

MOLECULAR BIOLOGY AND GENETIC ENGINEERING

- PAGE- Protein separation
- Genomic DNA, Plasmid DNA and RNA isolation from different microbial sources
- Agarose gel electrophoresis of nucleic acids
- Estimation of DNA and RNA
- Polymerase Chain Reaction
- Restriction enzyme digestion
- Ligation, Bacterial transformation and blue white screening
- Expression and purification of recombinant proteins
- Metagenomics

ENZYMOLOGY

- Estimation of enzyme activity (ALP,SGPT,SGOT)
- Determination of Km and Vmax
- Effect of temperature and pH on enzyme activity
- Purification of enzyme using Ammonium sulphate precipitation, dialysis, gel filtration and ion exchange chromatography.

REFERENCES

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SYLLABUS

Third Semester M.Sc. Microbiology

PG20BS309-MB	Food and Industrial Microbiology	Core course
PG20BS310-MB	Environmental and Agricultural Microbiology	Core course
PG20BS311-MB	Marine Microbiology	Elective
PG20BS312-MB	Environmental Science	Elective
PG20BS313-MB	Microbial Diversity and Extremophiles	Elective
PG20BS314-MB	Molecular Microbiology	Elective
PG20BS315-MB	Nano biotechnology	Elective
PG20BS316-MB	Microbial Quality Assurance, Biosafety and Intellectual Property Rights	Elective
PG20BSP3-MB	Laboratory course III	Core course

PG20BS309-MB - FOOD AND INDUSTRIAL MICROBIOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To have an overview of bioprocess technology in industrial applications.**
- **Understand control and designing of bioreactor.**
- **To have an in-depth knowledge of the role of microorganisms in food industry**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the beneficial role of microorganisms in fermented foods, dairy and food products. Principles involving various methods of food preservation	K1 & K2
2	Analyze the spoilage mechanisms in food and the role of microorganisms in spoilage of foods	K4
3	Illustrate the design of bioreactors, factors affecting growth and production	K2
4	Analyze the techniques applicable for improvement of microorganisms based on known biochemical pathways and regulatory mechanisms	K4
5	Apply microbiology in manufacture of industrial products	K3

UNIT I

Food Spoilage and Preservation: Incidence and type of microorganisms in food and milk. Contamination and Spoilage of food and milk, Principles of food preservations. Analysis of microbial quality of food and milk. Ames test. Preservation and preparation of milk products. Fermented food products, alcoholic beverages - wine, beer, liquor, brandy, whiskey, distilled spirit.

UNIT II

Role of Microorganisms in Food Industry: Lactic Acid Bacteria – homo and heterolactic fermentations. Probiotics, Prebiotics, Synbiotics, Nutraceuticals. Single cell protein, Production of edible mushroom, GMOs, IPR. Microbiological quality standards of food. Indicators of food microbial quality - Coliforms, Enterococci, Bifidobacteria, Coliphages and Enteroviruses, Food safety management- HACCP.

Food poisoning: Food borne diseases, newer pathogens and emerging food borne diseases.

UNIT III

Industrial microbiology: Introduction to microbes in industrial processes. Isolation and screening of industrially useful microorganisms, Primary and secondary screening, Strain improvement in industrial microbiology; improvement of characters other than product yield.Preservation of strains.

UNIT IV

Fermentation process: Design of a fermentor, instrumentation and process control, Types of fermentors. Types of fermentations - aerobic and anaerobic; Submerged and Solid State; Dual. Fermentation media formulation and modification.Kinetics of growth in batch, continuous, fed-batch fermentation. Fermentation process - Inoculum preparation, scaling up of fermentation. Assay of fermentation products (physical, chemical and biological assay). Downstream processing.

UNIT V

Industrial applications of Microorganisms: Microbes in the production (microbial strains, substrate, flow diagrams, product optimization, and applications) of the following: Industrial alcohol; organic acids, amino acids, alkaloids, vitamins, enzymes and antibiotics. Microbial transformations of steroids. Immobilisation of microbial cells. Recombinant DNA products-insulin, Recombinant vaccine production.

REFERENCES

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PG20BS310-MB - ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

Hours / Week: 3 **Credits: 3**

Course Objective:

- **To have an in-depth knowledge in environmental and agricultural applications of microorganisms**
- **To have an overview in types of microbial interactions**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the beneficial and harmful role of microorganisms in agriculture and environment	K2
2	Explain various biogeochemical cycles occurring in soil	K2
3	Analyze plant – microbe interactions and microbe - microbe interactions in soil and there by improve the fertility of soil and yield	K4
4	List various plant diseases caused by bacteria, fungi and viruses and their control measures	K1
5	Illustrate genetically modified crops and their importance in various aspects such as pest resistance, high nutrient value, easy to grow under unfavorable weather conditions, etc	K2 & K3
6	Demonstrate the use of microorganisms in the process of extraction of metals in an economic and ecofriendly manner	K3
7	Analyze the pollutants in the environment using microorganisms	K4

UNIT I

Aerobiology: Microbial contamination of air – Sources of contamination. Microbial indicators of air pollution. Enumeration of bacteria in air. Air sampling devices. Air sanitation. Significance of air pollution on plants and humans.

UNIT II

Aquatic microbiology: Microbiology of water – water borne pathogens. Bacteriological examination of water. Indicator organisms. Purification and disinfection of water. Microbiology of sewage - Waste water treatment. BOD, COD. Role of microbes in marine fouling.

UNIT III

Soil microbiology: Microbial flora of soil and factors affecting them. Bio geochemical cycling - Nitrogen, Carbon, Phosphorus, Sulphur cycles and its importance. Biodegradation of organic compounds.

UNIT IV

Agricultural microbiology: Microbial interaction – Plant-microbe, microbe-microbe interactions. Mycorhizzae. Biological Nitrogen fixers-Symbiotic and free living nitrogen fixers, physiology and genetics of nitrogen fixers. Phosphate solubilizers.

Plant diseases:Viral diseases **–** Tobacco mosaic disease, citrus tristeza disease, bunchy top of banana. Bacterial diseases **–** Angular leaf spot disease, leaf blight of rice, fire blight of apple, soft rot of potato, wilt of potato, crown gall disease, citrus canker**.** Fungal diseases – Late blight of potato, Fusarium wilt, corn smut. Integrated pest management. Biofertilizers, Biopesticides. GM crops and its importance.

UNIT V

Applied microbiology: Recycling of liquid and soild wastes – Composting, Biogas. Bioremediation - Xenobiotic degradation, Degradation of petroleum products. Microbes in mineral leaching and metal concentration, Microbial enhanced oil recovery.

REFERENCES

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6. Alexander M (1977) Introduction to soil microbiology (Wiley, New York ; London) 2nd ed.
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PG20BS311-MB - MARINE MICROBIOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To understand the complexity of marine environment and various adaptive mechanisms found in marine microorganisms**
- **To have an overview of the applications of marine microorganisms**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the marine ecosystem and discuss the structure and various habitat of marine environment	K1 & K2
2	Categorize water borne diseases and water borne pathogen	K4
3	Demonstrate the biotechnological applications of marine microbiology such as biosensor, transgenic, biosurfactant etc	K3
4	Assess marine pollution and control measure, bio-corrosion and bioremediation	K6

UNIT I

Marine Microbial flora: Marine environment –Benthic & littoral zone, zones of marine environment. Mangroves and estuarine microbes, microbial loop. Marine microbial community – planktons, bacteria, fungi, protozoa. Methods of collection and study of marine microbes. Influence of physical, chemical and biological factors on marine microbes.

UNIT II

Marine Adaptability: Survival at extreme environments – adaptive mechanisms inthermophilic, alkalophilic, osmophilic, barophilic and psychrophilic microorganisms. Hyperthermophiles and halophiles.

UNIT III

Marine Microbial Disease: Marine food borne pathogens & Water borne pathogens – A*eromonas, Vibrio, Salmonella, Pseudomonas.* Sea food poisoning.

UNIT IV

Marine Pollution: Microbial indicators of marine pollution and control. Biofouling, biocorrosion, biofilms and bioremediation. Quorum sensing, Bioluminiscence, Eutrophication, harmful algal blooms.

UNIT V

Marine Microbial Biotechnology: Marine natural products and bioactive compounds from marine microorganisms. Transgenic fish. Biosurfactants, biopolymers and novel enzymes from marine organisms.

REFERENCES

1. Prescott LM, Harley JP, & Klein DA (2005) Microbiology (McGraw-Hill, Boston ; London) 6th ed
2. Maier RM, Pepper IL, & Gerba CP (2009) Environmental Microbiology (Elsevier Academic Press)
3. Nybakken JW &Bertness MD (2005) Marine biology: an ecological approach (Pearson/Benjamin Cummings)
4. Belkin S & Colwell RR (2006) Oceans And Health: Pathogens In The MarineEnvironment (Springer Science+Business Media)
5. Gal YL, Ulber R, &Antranikian G (2005) Advances in BiochemicalEngineering/Biotechnology Series Vol 96. Marine Biotechnology Vol 1 Series Editor: Scheper, T
6. Bhakuni DS &Rawat DS (2005) Bioactive Marine Natural Products (Springer)

PG20BS312-MB - ENVIRONMENTAL SCIENCE

Hours/Week: 4 **Credits: 4**

Course Objective:

- **To have an in-depth knowledge of structural features of different ecosystem and its biodiversity status**
- **To have an idea on different environmental problems and its control measures**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the ecosystem and discuss the structure and various features of ecosystem	K2
2	Explain different types of ecology and endangered and threatened Species	K2
3	Demonstrate the status of biological diversity and its conservation	K3
4	Compare different types of environmental pollutions and Illustrate control measures, bioremediation and bio-weapons	K2 & K6
5	Analyze various environmental problems and efforts for environmental protection	K4

UNIT I

Ecosystem: Ecosystem, pathways in ecosystem. Structure and functions of ecosystem-Abiotic and biotic components (Physico - Chemical and Biological factors in the environment). Geographical classification and Zones. Energy flows, Food chains, Food web, Ecological pyramids - types and diversity. Terrestrial (Forest, grass land) and Aquatic (Fresh

water, marine, eustarine) ecosystems. Mineral cycling. Habitat and niche. Major terrestrial biomes. Impact of microorganisms on global ecology, Microorganisms in extreme environment.

UNIT II

Ecology: Definition, Principles and scope of ecology. Human ecology and Human settlement. Population ecology - characteristics and regulation. Community ecology - structure and attributes. Levels of species diversity and its management. Edges and Ecotones. Ecological succession. Endangered and Threatened Species.

UNIT III

Biodiversity: Biodiversity status - monitoring and documentation. Biodiversity management approaches. Conservation of biological diversity, methods and strategies for conservation. Natural resources, conservation and sustainable development. Hotspots of biodiversity.

UNIT IV

Environmental pollution: Air pollution - Natural and anthropogenic source of pollution, Primary and Secondary pollutants, Methods of monitoring and control of air pollution. Acid rain, Air Quality standards. Water pollution - Types, Sources and consequences of water pollution, Physio-chemical and bacteriological analysis of water quality, Soil pollution - causes, control of soil pollution. Physio - chemical analysis of soil quality, Effect of Industrial waste effluents and heavy metals on soil components, Noise pollution – Sources of noise pollution. Impact of noise on human health and noise control. Radioactive and thermal Pollution. Bioremediation - Strategies for bioremediation, Biosensors, mycotoxins. Biological weapons.

UNIT V

Environmental impacts: Introduction to environmental impact analysis, Impact Assessment Methodologies, Generalized approach to impact analysis, Guidelines for Environmental Audit, Environmental priorities in India and Sustainable development, Environment

protection - issues and problems, International and national efforts for environment protection. Global environmental problems. Ozone depletion, global warming, climatic change, desertification, green movement, ecofeminism.

REFERENCES

2.2 Chapman JL & Reiss MJ (1999) Ecology: principles and applications (Cambridge University Press, Cambridge) 2nd ed.

2.3 Jones A (1997) Environmental biology (Routledge, London)

2.4 Odum EP & Barrett GW (2005) Fundamentals of ecology (Thomson Brooks/Cole, Belmont, CA) 5th Ed

2.5 Odum EP (1983) Basic ecology (Saunders College, Philadelphia, [Pa.] ; London

2.6 Kumar A (2004) A Textbook of Environmental Science (APH Publishing Corporation)

2.7 Allaby M (2000) Basics of Environmental Science (Routledge)

2.8 Cunningham WP, Cunningham MA, & Saigo BW (2003) Environmental science : a global concern (McGraw-Hill, Boston ; London) 7thed

2.9 Pickering KT & Owen LA (1997) An introduction to global environmental issues (Routledge, London) 2nd ed.

PG20BS313-MB - MICROBIAL DIVERSITY AND EXTREMOPHILES

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To have an overview in the extend of microbial diversity and its characterization**
- **To have an idea on exceptional nature of microorganisms and their interactions to extreme environments**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Recognize the extend of microbial diversity in the universe comprising archae, eubacteria and eukarya	K2
2	Describe the molecular techniques used to study the microbial diversity	K1 & K2
3	Explain the characteristics and uniqueness of extremophilic organisms	K2
4	Infer knowledge on intricate relationship between microbes and their extreme environments and to apply this knowledge to study the potential applications of extremophiles	K3 & K4
5	Analyze the exceptional nature of microorganisms and their interactions to extreme environments	K4

UNIT I

Biodiversity: Introduction to Microbial biodiversity – distribution, abundance, ecological niche. Types - Bacterial, Archael and Eucaryal. Molecular techniques for studying microbial biodiversity- use of DNA probes, markers, Expressed sequence tagging (EST), Denatured Gradient Gel electrophoresis, RFLP, RAPD, MALDI-TOFF, Fluorescent in situ hybridization (FISH) Conservation of marine Bio resources, Metagenomics etc.

UNIT II

Characteristics and classification of Archaebacteria: Psychrophiles; Thermophiles: Classification, habitats and ecological aspects. Extremely Thermophilic Archaebacteria, Applications of thermozymes and psychrophilic archaeal extremozymes; Methanogens: Classification, Habitats and applications.

UNIT III

Alkalophiles and Acidophiles: Classification , alkaline environment , soda lakes and deserts ,calcium alkalophily Applications .Acidophiles: Classification, life at low pH, acidotolerence, applications.

UNIT IV

Halophiles and Barophiles: Classification, Dead Sea, discovery basin, cell walls and membranes – Purple membrane, compatible solutes. Osmoadaptation/ halotolerence. Applications of halophiles and their extremozymes. Barophiles: Classification, high-pressure habitats, life under pressure, barophily, death under pressure.

UNIT V

Space Microbiology: Aims and objectives of Space research. Life detection methods a]Evidence of metabolism (Gulliver) b] Evidence of photosynthesis (autotrophic and heterotrophic) c] ATP production d] Phosphate uptake e] Sulphur uptake .Monitoring of astronauts microbial flora.

REFERENCES

1. Extremophiles by Johri B.N. 2000. Springer V erlag. , New York
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4. Microbiology of Extreme Environments. Edited by Clive Edward. Open University Press.Milton Keynes.
5. Microbiology of Extreme Environments and its potential for Biotechnology. Edited byM.S. Da Costa, J.C. Duarate, R.A. D. Williams. Elsiever Applied Science, London.
6. Extreme Environment. Mechanism of Microbial Adaptation. Edited by Milton R.Heinrich. Academic Press.
7. Thermophiles. General, Molecular and Applied Microbiology. Edited by Thomas D.Brock. Wiley Interscience Publication.
8. Microbiology: Dynamics and Diversity by Perry.
9. Microbial Ecology. Fundamentals and Applications by. Ronald M. Atlas and RichardBartha. 2nd and 4th Edition. The Benjamin Cummins Publication Co. Inc.
10. Microbial Ecology. 2nd Edition. by R. Campbell. Blackwell Scientifc Publication.
11. Brocks Biology of Microorganisms. 8th Edition. (International Edition - 1997) byMichael T. Madigan, John M. Martinko. Jack Parker. Prentice Hall Internation Inc.
12. Advances in Applied Microbiology. Vol. 10. Edited by Wayne W. Umbreit and D.Pearlman. Academic Press.

PG20BS314-MB - MOLECULAR MICROBIOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To have an in-depth knowledge in the applications of different molecular methods in microbiology**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Illustrate the phylogenetic status of bacteria and principles of molecular typing methods	K2
2	Recognize the genetic principles behind the adaptive nature of bacteria in adverse environments	K2
3	Describe the molecular basis of bacterial virulence and detection methods of pathogens	K1 & K2
4	Discuss the concepts of gene and chromosome and basics of genetic engineering	K2

UNIT 1

Phylogenetic overview of bacteria and archaea, Molecular biology of microbial evolution, rRNA sequence and cellular evolution, Signature sequences and phylogenetic probe.Identification and characterization of microorganisms. Molecular typing methods: Bacterial strain typing, Pulsed Field Gel Electrophoresis, PCR-based microbial typing, Genotyping by Variable Number Tandem Repeats, Multilocus Sequence Typing, Automated Ribotyping, Molecular subtyping for epidemiology.

UNIT II

Genome wide approach to study prokaryotic biology, Microbial genome – comparison of genome size, Insight from genome of *E.coli, Streptomyces coelicolor* and *Neurosporacrassa*.Unculturable bacteria and Metagenomics. Bacterial differentiation and molecular basis of endospore formation, Microbial stress response, Microbes in special habitat: Bacterial biofilm, molecular basis of biofilm development, biofilm dispersal strategies, biofilm in infection, quorum sensing. Extremophiles, molecular adaptation to extreme environment. Endophytes – metabolite diversity.

UNIT III

Molecular basis of microbial virulence. Bacterial adherence: basic principles, effects of adhesion on bacteria and host cells. Bacterial invasion of host cells; mechanism. Bacterial toxins: classification based on molecular features, Identification of novel toxins by genome mining, Application of bacterial toxin in cell biology and pharmacology.

UNIT IV

Microbial induction of apoptosis.Molecular and visual clinical diagnosis methods. Molecular detection and characterization of bacterial pathogens, detection of bioterrorism. Laboratory controls and standards in molecular diagnostics.

UNIT IV

Microbial production of recombinant proteins : expression, purification and applications, Microbes in plant transformation, *Agrobacterium tumefaciens* T-DNA transfer process, Manipulation of *Agrobacterium* for genetic engineering, vectors for *Agrobacterium* mediated transformation, Microbial production of plant metabolites; engineering *E.coli* for the production of curcumin. Combinatorial and engineered biosynthesis, Microbial polketides and their applications.

REFERENCES

1. Persing DH (2011) *Molecular microbiology : diagnostic principles and practice* (ASM Press, Washington, DC) 2nd ed
2. Madigan MT, Martinko JM (2006) *Brock biology of microorganisms* (Pearson Prentice Hall, Upper Saddle River, NJ ; London) 11th ed.
3. Moat AG, Foster JW, & Spector MP (2002) *Microbial physiology* (Wiley-Liss, New York ; [Chichester]) 4th ed.

PG20BS315-MB - NANOBIOTECHNOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To have an in-depth knowledge in advanced experimental and computational techniques for studying nanomaterials**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe the basic science behind the properties of materials at the nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials	K1 & K2
2	Illustrate clearly, precisely and effectively using conventional scientific language and mathematical notation	K2 & K3

UNIT I

History -bionanotechnology – concept and future prospects – application in Life Sciences. Terminologies – nanotechnology, bionanotechnology, biogenic nanoparticles, nanomedicine, nanowires, quantum Dots, nanocomposite, nanoparticles.

UNIT II

Molecular nanotechnology- nanomachines – collagen.Uses of nanoparticles – cancer therapy

- manipulation of cell and biomolecules. Cytoskeleton and cell organelles. Types of nanoparticles production – physical, chemical and biological. Biosynthesis of nanoparticles by various groups of microorganisms, Microorganisms synthesizing silver nanoparticles,

Mechanism involved in silver nanoparticles biosynthesis, Process design for industrial scale synthesis of nanoparticles.

UNIT III

Nanoparticles - types, functions – Silver, Gold and Titanium. Physical and chemical properties of nanoparticles. Interaction of nanoparticles with biomolecules, Characterization of nanoparticles – UV-Vis spectroscopy, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD, F-IR and DLS.

UNIT IV

Uses of nanopartcles in biology - Drug delivery – protein mediated and nanoparticle mediated. Uses of nanoparticles in MRI, DNA and Protein Microarrays. Nanotechnology and nanoparticles in health sectors. Toxicology in nanoparticles – Dosimetry.

UNIT V

Advantages of nanoparticles- drug targeting, protein detection, MRI, development of green chemistry – commercial viability of nanoparticles. Disadvantages – health risk associated with nanoparticles, inadequate knowledge on nanoparticles research.

REFERENCES

1. Parthasarathy, B.K. (2007). Introduction to Nanotechnology, Isha Books.
2. Elisabeth Papazoglou and AravindParthasarathy (2007). Bionanotechnology. Volume 7of Synthesis Lectures on Biomedical Engineering. Morgan & Claypool Publishers.
3. Bernd Rehm (Ed) (2006). Microbial Bionanotechnology: Biological Self-assemblySystems and Biopolymer-based Nanostructures. Horizon Bioscience.
4. David E. Reisner, Joseph D. Bronzino (2009). Bionanotechnology: Global prospects. CRC Press.
5. Ehud Gazit (2007). Plenty of Room for Biology at the Bottom: An Introduction toBionanotechnology. Imperial College Press, London

PG20BS316-MB - MICROBIAL QUALITY ASSURANCE, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To understand various safety concerns and ethical issues on application of biotechnology**
- **To have an overview of importance of Intellectual Property Rights**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain the basic issues of Bioethics, Biosafety, Food safety and IPR	K2
2	Illustrate the ethical underpinnings of bioethics and to develop ethical intuitions on bioethical issues	K2 & K3
3	Recognize safety concerns and ethical issues on application of biotechnology	K2
4	Describe current *food safety* programs that are used in the *food* industry inorder to assure a *safe food* supply	K1 & K2
5	Illustrate different types of Intellectual Property Rights like patents, copy right, trademarks, designs, information Technology etc	K2 & K3

UNIT I

Bioethics: Principles of Bioethics; Belmont Report on protection of human beings on biomedical and behavioral research: respect for persons, beneficence, justice, etc.; Bioethic committees; professional ethics- medical, euthanasia; Public perception of process of biotechnology involved in generation new forms of life; example: ethical issues related to creations of Dolly and on reproductive cloning- Human Fertilization and Embryology Act & Cloning Prohibition Bill 1997; ethical concerns of biotechnological research and innovations.

UNIT II

Biosafety and Genetically Modified Organisms: Guidelines on biosafety in conducting research in biology / biotechnology; ethics in use of animals for scientific
research; ethical clearance norms for conducting studies on human subjects; Biosafety regulatory framework for GMOs at international level: Cartagena protocol on Biosafety; Advanced Information Agreement (AIA) procedure - procedures for GMOs intended for direct use, risk assessment, handling, transport, packaging and identification of GMOs; Different levels of regulatory framework in India governing research in GMOs; National Environment Policy. Biosafety guidelines, Requirements and procedures for recombinant DNA: Registration, review and approval of rDNA research. IBSC, RCGM and GEAC for GMO applications in food and agriculture.

UNIT III

Food safety and Quality assurance: Food safety- issues and factors affecting. Shelf life of Food Products- factors affecting shelf life and methods to check the shelf life. Food laws and regulations- National food legislation/ authorities and their role, product certifications (ISI mark of BIS), international organization and agreements-food and agricultural organization (FAO), world health organization(WHO), codex alimentarius, codex India, world international organization for standardization(ISO) Food safety and quality management systems: general principle of food safety, risk management, hazard analysis critical control point system (HACCP), quality management system, Food Packaging: Need, material used and labeling.

UNIT IV

IPR: Types of IP: Patents, Trademarks, Copyright & Related Rights GATT and IPR, IPR inIndia, WTO Act, Convention on Biodiversity (CBD), patent Co-operation Treaty (PCT), Procedure for filing a PCT application, forms of patents and patentability, The patentability of microorganisms, process of patenting, process and product patenting, Indian and international agencies involved in IPR & patenting, Global scenario of patents and India's position, patenting of biological material, GLP, GMP. Patent databases, patent infringement. Patent law for protection of traditional knowledge, Geographical Indicators.

REFERENCES

1. Frederic H. Erbisch, Karim M. Maredia (2004). Intellectual Property Rights in AgriculturalBiotechnology, CABI Publisher.
2. Mittal D.P. (1999). Indian Patents Law. Taxmann Allied Services (p) Ltd.
3. Christian Lenk, Nils Hoppe, Roberto Andorno (2007). Ethics and Law of Intellectual Property:Current Problems in Politics, Science and Technology, Ashgate Publisher (p) Ltd.
4. Felix Thiele, Richard E. Ashcroft (2005). Bioethics in a Small World. Springer.
5. John Bryant (2002) Bioethics for Scientists. John Wiley and Sons Publisher
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9. Sasson A. (1988) Biotechnologies and Development, UNESCO Publications
10. Singh K (1993) Intellectual Property rights on Biotechnology- A status report. BCIL, New Delhi
11. Regulatory Framework for GMOs in India (2006) Ministry of Environment and Forest,Government of India, New Delhi

12. Cartagena Protocol on Biosafety (2006) Ministry of Environment and forest, Government ofIndia, New Delhi
13. Birch, G. and Campbell-Platt, G. (Eds.). (1993) .Food Safety - the Challenge Ahead. Intercept Ltd., Andover, England
14. Finley, J., Robinson, S. and Armstrong, D. (Eds.). 1992. Food Safety Assessment. Vol. 484 of ACS symposium series. American Chemical Society, Washington D.C
15. Jones, J. (1992). Food Safety. 2nd ed. Eagen Press, St. Paul Minnesota
16. Sohrab.(2001) A Practical Guide For Implementation Of Integrated ISO 9001 HACCP SystemFor Food Processing Industries. Allied Publishers.
17. Bhatnagar, D. and Cleveland, T. (Eds.). (1992). Molecular Approaches to Improving FoodQuality and Safety. Van Nostrand Reinhold, New York
18. Hubbert. W and Hagstad, H. (1996). Food Safety & Quality Assurance. 2nd ed. Iowa State University Press, Ames, Iowa
19. Roberts, H. (Ed.). (1981). Food Safety. John Wiley & Sons, New York
20. Krammer, A. and Twigg, B.A. (1970). Quality control for the food industry. 3rd Ed., Avi Pub Co.,Westport.

PG20BSP3-MB -LABORATORY COURSE -III

Hours / Week: 10 **Credits: 4**

Course Objectives:

- **To train students in demonstrating the theories and principles of food microbiology in practical.**
- **To understand the procedures for the microbiological analysis of food**

Course outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also outline different methods for their detection and characterization	K1 & K2
2	Explain and demonstrate the theories and principles of food microbiology in practical	K2 & K3
3	Illustrate various methods for their isolation, detection and identification of microorganisms in food	K2 & K3
4	Investigate ways to control microorganisms in foods and thus know the procedures for the microbiological analysis of food	K4

Agricultural and Environmental Microbiology

- Isolation and Study of common soil bacteria, fungi and actinomycetes
- Enumeration of soil microbes by plate culture methods
- Study of antagonistic activities among soil microbes

- Estimation of rhizosphere microbial population and calculation of R:S ratio
- Isolation of non-symbiotic nitrogen fixing bacteria
- Isolation of Rhizobium from nodules of leguminous plants
- Study of common plant pathogens
- Isolation of Agrobacterium
- Isolation of phosphate solubilizing microorganisms
- Azolla cultivation
- Bacteriological examination of air
- Bacteriological examination of water- SPC, Presumptive, Confirmed and Complete test etc.
- Determination of BOD, DO & COD

Food and Industrial Microbiology

- Bacteriological examination of food- vegetables, meat products, traditional foods etc
- Bacteriological analysis of milk - standard plate count, presumptive test for coliforms, methylene blue reduction test and phosphatase test.
- Cultivation of edible mushrooms.
- Crowded plate technique for screening of industrially important microorganisms- microbes producing enzymes, antibiotics etc.
- Production of ethyl alcohol, Alcoholimetry
- Production of wine
- Production of citric acid
- Solid state and submerged fermentation

REFERENCES

1. Practical Microbiology (2002) DubeyR.C.andMahaswari D.K. S.Chand& Company Limited, New Delhi.
2. Experiments in Microbiology, Plant pathology and Biotechnology. (1996) K.R.Aneja, New Age International (P) Limited, New Delhi. 2nd ed

SYLLABUS

Fourth Semester M.Sc. Microbiology

PG20BS413-MB	Systematic Bacteriology	Core course
PG20BS414-MB	Virology, Mycology and Protozoology	Core course
PG20BS415-MB	Clinical Microbiology	Elective
PG20BS416-MB	Microbial Genetics	Elective
PG20BS417-MB	Biostatistics and Research Methodology	Elective
PG20BSP4-MB	Laboratory course IV	Core course

PG20BS413-MB - SYSTEMATIC BACTERIOLOGY

Hours / Week: 5 **Credits: 4**

Course Objectives:

- **To understand the morphological and physiological features of medically important bacteria**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain the morphology, culture, antigenic structure and virulence factors of microorganisms of medical importance and the diseases they produce	K2
2	Demonstrate the identifying characteristics of major classes of bacteria	K3
3	Examine the epidemiology and pathogenesis, lab diagnosis and treatment of different classes of bacteria	K4
4	Summarize and apply the information on lab diagnosis and treatment of different classes of bacteria	K2 & K3

Unit I

Study of identifying characters - Morphological and cultural; pathogenicity, epidemiology and laboratory identification, prophylaxis, treatment of - Aerobic cocci such as Staphylococci, Streptococci, Pneumococci and Neisseriae.Anaerobic cocci.

Unit II

Gram positive bacilli.Corynebacterium, Bacillus, Anaerobic rods - Clostridia, Nonsporing anaerobes.

Unit III

Gram negative bacilli. Enterobacteriaceae- *E.coli*, Proteus, Klebsiella, Shigella Salmonella etc. Pseudomonas.Haemophilus. Pasteurella, Yersinia, Francisella, Bordetella. Brucella.Vibrios.

Unit IV

Spirochetes.Mycoplasma.Rickettsiae.Chlamydiae.Miscellaneous Bacteria - Listeria, Campylobacter, Helicobacter, Legionella, Acinetobactor.

Unit V

Acid fast bacilli - Mycobacteria - *M.tuberculosis, M.leprae,* Non tuberculous mycobacteria. Actinomycetes - Nocardia, Actinomyces,

REFERENCES

1. J.G.Holt, (Ed) Bergey's Manual of Systematic Bacteriology, Vol.1-4 (1984-1989) Williams and Wilkins, Baltimore.
2. Greenwood, D., Slack, R.C.B., Peutherer, J.F., and Barer, M.R. (2007). Medical
3. Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control. Elsevier Health Sciences UK. 17thed
4. Topley, W.W.C., Wilson, G.S., Parker, T., and Collier, L.H. (1990). Topley and Wilson's Principles of Bacteriology, Virology and Immunology (Edward Arnold)
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6. Mackie, T.J., McCartney, J.E., and Collee, J.G. (1989). Mackie & McCartney practical medical microbiology. Churchill Livingstone, 13th ed
7. Jawetz, E., Melnick, J.L., and Adelberg, E.A. (1987). Review of medical microbiology (Appleton & Lange)
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9. Page, R.D.M., and Holmes, E.C. (1998). Molecular Evolution: A Phylogenetic Approach (Blackwell Science)
10. Adolph, K.W. (1996). Microbial Genome Methods (CRC Press)
11. Dunham, I. (2003). Genome Mapping and Sequencing (Horizon Scientific)
12. Brendan Wren (Ed), Nick Dorrell (2002) Functional Microbial Genomics. Volume 33, Methods in Microbiology, Academic Press, UK.
13. Primrose, S.B., and Twyman, R. (2009). Principles of Genome Analysis and Genomics (John Wiley & Sons) 3rd ed.

PG20BS414-MB - VIROLOGY, MYCOLOGY AND PROTOZOOLOGY

Hours / Week: 4 **Credits: 4**

Course Objectives:

- **To understand the general characteristics and pathobiology of different viral, fungal and protozoal diseases**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe & Explain the general characteristics and pathobiology of different classes of viruses	K1 & K2
2	Identify lab diagnosis, prophylaxis and treatment of viral diseases	K2
3	Illustrate different fungal infections and protozoal diseases	K2

Unit I

Systematic study of medically important DNA viruses - Pox, Herpes, Adeno, Papova, Parvo, Hepadna viruses.

Unit II

Systematic study of medically important RNA viruses- Entero, Myxo, Arbo, Rhabdo, Hepatitis, Oncogenic and HIV. Emerging viral infections – Nipah, Hendra, zika .

Unit III

General methods for the laboratory diagnosis of viral diseases. Prophylaxis of virus diseases - immuno prophylaxis. Antiviral agents.

Unit IV

Fungal infections in man.Superficial- Pityriasisversicolor, Piedra, dermatophytosis. Subcutaneous mycosis - Mycetoma, rhinodpirodiosis, sporotrichosis, chromoblastomycosisand systemic mycoses - Histoplasmosis, blastomycosis, cryptococcosis, paracocidioidomycosis and coccidioidomycosis. Opportunistic fungal infections- aspergillosis, candidiasis, penicillosis, zygomycosis.Common laboratory contaminants.

Unit V

Protozoa- General features and classification. Medically important protozoans. Entamoeba histolytica, Giardia lamblia, Trichomonas, Trypanosomes, Leishmania, Plasmodium, Toxoplasma and Pneumocystis.

REFERENCES

1. Molyneux, D.H., and Ashford, R.W. (1983). The biology of Trypanosoma and Leishmania, parasites of man and domestic animals (New York, International Publications Service)
2. Garraway, M.O., and Evans, R.C. (1991). Fungal nutrition and physiology (Malabar, FL, Krieger Pub. Co.).
3. Topley, W.W.C., Wilson, G.S., Parker, T., and Collier, L.H. (1990). Topley and Wilson's Principles of Bacteriology, Virology and Immunology (Edward Arnold)
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7. Beaver, P.C., Jung, R.C., Cupp, E.W., and Craig, C.F. (1984). Clinical parasitology (Lea &Febiger, Philadelphia) 9th ed
8. Desselberger, U. (1995). Medical virology: a practical approach (IRL Press)

PG20BS415-MB - CLINICAL MICROBIOLOGY

Hours / Week: 4 **Credits: 4**

Course Objectives:

- **To understand the concept of safe microbiology**
- **To have an in-depth knowledge in the infections of various organs and systems of the human body, its diagnostic methods and its prophylaxis**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe the concept of safe microbiology	K1 & K2
2	Explain the infections of various organs and systems of the human body	K2
3	Discuss the etiology, pathogenesis and laboratory diagnosis of local infections	K2
4	Describe and analyse various infections of skin, soft tissue and wound	K2 & K4
5	To compare and elaborate serological and molecular diagnostic methods	K5 & K6
6	Elaborate antibacterial therapy and prophylaxis	K5

Unit I

Microbiology laboratory safety - Biological Safety Cabinets; Biosafety Levels Biocontainment; Good microbiological practices. Classification of biological agents based on hazards. Mailing of biohazardous materials.

Unit II

Diagnostic cycle; General concepts for specimen collection, transport and processing. Emerging infections; Quality assurance & quality control in microbiology. Accreditation of laboratories. Microbiome of the human body.

Unit III

Etiology, pathogenesis and laboratory diagnosis of- Blood Stream infections, Respiratory Tract infections, Central Nervous System infections, Gastrointestinal Tract infections, Urinary Tract infections, Genital Tract infections. Sexually transmitted diseases. Nosocomial infections.

Unit IV

Skin and wound infections. Burn infections. Infections of bone and bone marrow. Infections of eye and ear. Infections in immunocompromised and immune-deficient patients. Infections in foetus and neonates.

Unit V

Serodiagnosis of infectious diseases; Molecular techniques in diagnostic microbiology.Automation in Microbiology; Laboratory control of antimicrobial therapy; Immunoprophylaxis.

REFERENCES

1. Blair, J.E.e., Lennette, E.H.e., and Truant, J.P.e. (1970). Manual of clinical microbiology. American Society for Microbiology, Bethesda, Md.
2. Gradwohl, R.B.H., Sonnenwirth, A.C., and Jarett, L. (1980). Gradwohl's clinical laboratory methods and diagnosis. Mosby, London.8th ed
3. Lennette, E.H., Balows, A., Hausler, W.J., and Shadomy, H.J. (1985). Manual of clinical microbiology. American Society for Microbiology, Washington, D.C. 4thed.
4. Topley, W.W.C., Wilson, G.S.S., Parker, T., and Collier, L.H. (1990b). Topley and Wilson's principles of bacteriology, virology and immunology.Edward Arnold,8thed
5. Mukherjee, K.L. (2010)Medical Laboratory Technology. Tata McGraw-Hill Education.2nd ed.
6. Sood, R. 1999. Medical Laboratory Technology- Methods and Interpretations. Jaypee Brothers Medical Publishers(P) Ltd. New Delhi. 5thed.
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8. Mackie, T.J., McCartney, J.E., and Collee, J.G. (1989). Mackie & McCartney practical medical microbiology. Churchill Livingstone, 13th ed
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PG20BS416-MB - MICROBIAL GENETICS

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To understand the gene expression, mutation and repair mechanisms in bacteria**
- **To have an overview of the applications of rDNA technology**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Explain the central dogma of molecular biology	K2
2	Illustrate the basic principle of gene expression and regulation	K2 & K3
3	Describe the concepts of genetic mutation and repair	K1 & K2
4	Illustrate the basic principles of gene transfer techniques	K2 & K3
5	Illustrate the concept, methods and application of r DNA technology	K2 & K3

UNIT 1

Introduction to microbial genetics, early concepts of bacterial variations, adaptations, mutation and genetic components of bacteria and fungi and segregation of genetic characters.

UNIT II

DNA as genetic material, Structure of Nucleic acid, DNA replication, DNA damage, repair and genetic code.Mutation types and induction by various agents. Genetics of bacteriophage, phage induced mutation.

UNIT III

Gene expression and regulation, Transcription, Post transcriptional modifications, translation, post translational modification, Reverse transcription, Regulation of mRNA synthesis-operon concept, Attenuation, Catabolic repression and autoregulation.

UNIT IV

Introduction to DNA technology, Conjugation, Transduction, and Transformation, Cloning vectors, Restriction enzymes, Plasmid, Transposon, and Insertion sequences.

UNIT V

Techniques used in molecular biology, Restriction Fragment Length Polymorphism, Randomly Amplified Polymorphic DNA, PCR, DNA finger printing, DNA sequencing and Gene therapy.

REFERENCES

1. Snustad, D.P. (2010). Principles of Genetics, 5th ed., International student edn (Hoboken, N.J., Wiley)
2. Prescott, L.M., Harley, J.P., and Klein, D.A. (2005). Microbiology, 6th ed. edn (Boston ; London, McGraw-Hill
3. Madigan, M.T., Martinko, J.M., Stahl, D.A., and Clark, D.P. (2011). Brock Biology ofMicroorganisms(Pearson Education) 13thed.

PG20BS417-MB - BIOSTATISTICS AND RESEARCH METHODOLOGY

Hours / Week: 4 **Credits: 4**

Course Objective:

- **To understand the applications of data analysis in biological research**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Discuss about biostatistics and apply it for data analysis in the field of biological research	K2 & K3
2	Describe the underlyingprinciplesof quantitative and qualitative research methods	K1 & K2
3	Develop learning opportunities to critically evaluate research methodology and findings	K5

UNIT I

Definition– Scope of Biostatistics, Probability analysis, Variables in Biology- Collection, Classification and Tabulation of data.Frequency distribution. Diagrammatical and graphical representations– Bar diagram, Histogram, Pie diagram.

UNIT II

Measures of Central tendency- Arithmetic Mean, Median, Mode. Calculation of Mean, Median, Mode in series of discrete and continuous observations. Open end classification. Measures of dispersion- standard deviation, standard error etc.ANOVA- one way and two way classification.

UNIT III

Correlation and regression- Karl Pearson's coefficient of correlation, Positive and Negative Correlation.Regression- linear and non-linear, regression coefficient.

UNIT IV

Basic ideas of significant tests- Testing of hypothesis, Level of significance, tests based on - z-test, Student's t-test, Chi square test. Testing of goodness of fit.

UNIT V

Problem, selection and project designing. Review of literature, Collection, processing and presentation of data. Interpretation of results.Editing the final draft.Presentation of research project.

REFERENCES

1. Gupta SP (2010) Statistical Methods.Sultan Chand & Sons. 28th ed.
2. Palanisamy.S and Manoharan M.(1994).Statistical methods for Biologists. Palaniparamount.
3. Khan I.A, Khanum.A, (2008) Fundamentals of Biostatistics. Ukaas Publications,Hyderabad. 3rd ed.
4. George W. Snedecor, William G. (1989) Cochran StatisticalMethods. Iowa State University Press. 8th ed.
5. Kothari CR (2008) Research Methodology: Methods and Techniques.New Age International Limited. 2nd ed.

PG20BSP4-MB - LABORATORY COURSE - IV

Hours / Week: 12 **Credits: 5**

Course Objectives:

- **Practice students to handle and identify medically important bacterial strains**
- **To train students in the procedures of fungal and viral cultivation**

Course Outcome

CO No.	Upon completion of this course, the students will be able to:	Knowledge Level
1	Describe standard laboratory procedures in clinical microbiology	K1 & K2
2	Recognise how to handle and identify medically important bacteria	K2
3	Describe how to learn culture, isolate and identify fungi	K1 & K2
4	Describe and demonstrate the procedures of viral cultivation	K2 & K3
5	Practice the antimicrobial sensitivity tests	K3

- Study of the morphology, staining characters, cultural characters and identification of medically important bacteria *Staphylococci, Streptococci, Neisseria, Pneumococcus, E.coli, Klebsiella, Salmonella, Shigella, Proteus, Pseudomonas, Vibrio, Bacillus and Mycobacterium sp.*
- Isolation and identification of bacteria from mixed culture.
- Study of common laboratory contaminants.

- Culture methods for isolation and identification of fungi - KOH mount preparation, Lactophenol cotton blue staining, Slide culture technique etc.
- Gram staining and Germ tube test of *Candida albicans*
- Cultivation of viruses in embryonated eggs different routes - harvesting
- Study of normal microbial flora of human beings
- Techniques for collection of clinical specimens for microbiological analysis Macroscopic and microscopic examination of clinical samples. Culture methods identification and antibiotic sensitivity test of isolates

REFERENCES

1. Cheesbrough, M. (2006). District Laboratory Practice in Tropical Countries.Cambridge University Press.2nded.
2. Mackie, T.J., McCartney, J.E., and Collee, J.G. (1989). Mackie & McCartney practical medical microbiology. Churchill Livingstone, 13th ed
3. Gradwohl, R.B.H., Sonnenwirth, A.C., and Jarett, L. (1980). Gradwohl's clinical laboratory methods and diagnosis. Mosby, London.8th ed
4. Cappuccino, J.G., and Sherman, N. (2008). Microbiology: A Laboratory Manual (Pearson/Benjamin Cummings. 9th ed

MODEL QUESTION PAPERS

FIRST SEMESTER

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FIRST SEMESTER - MODEL QUESTION PAPER

PG20BS101 - BIOCHEMISTRY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Give examples and functions of any 2 homopolysaccharides?
2. What are epimers? Give Examples
3. Explain histone acetylation. What is its importance in DNA activation and inactivation?
4. Briefly explain siRNA
5. What are physiological buffers?Give an example
6. Explain glycosidic bond.
7. What are the functions of topoisomerases?
8. Describe the sterols in microbes
9. What are modified aminoacids? Give an example
10. How is peptide bond formed? **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Describe the structure of t-RNA.what are its functions?
12. Explain lung surfactant and its role in prevention of pulmonary infection.
13. Differentiate between glucocorticoids and mineralocorticoids
14. What are the structural characteristics of glycosaminoglycans?
15. Describe Ramachandran diagram
16. Explain the different forms of DNA
17. What are fat soluble vitamins? Write a note on the structure and functions of any two of them.
18. Explain cot curve **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Describe the various bonds stabilizing biomolecules.
20. Briefly explain the methods you will adopt for the purification and subsequent characterization of a polysaccharide.
21. Describe the chemistry and physiological functions of eicosanoids.
22. Describe the various protein DNA interaction motifs (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FIRST SEMESTER - MODEL QUESTION PAPER

PG20BS102 - CELL BIOLOGY AND GENETICS

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Lipid raft
2. ERAD
3. Desmosomes
4. MPF
5. Cyclins
6. Tubulins
7. Tumor suppressor genes
8. MSUD
9. Genetic drift
10. Down's Syndrome **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Ionic Channels.
12. Facilitated diffusion.
13. Lysosomal Trafficking.
14. Sex linked Inheritance.
15. Cytoplasmic Inheritance.
16. Endo/Exo cytosis.
17. Role of Rb and p53
18. Chromosome Mapping. **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain in detail on cell cycle and check points involved in cell cycle.
20. Give a detail amount on protein trafficking.
21. Illustrate with diagrams on various transport mechanisms in a cell.
22. Explain Hardy Weinberg equilibrium principle.

(**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FIRST SEMESTER - MODEL QUESTION PAPER PG20BS103 - BIOPHYSICS, BIOINSTRUMENTATION AND BIOINFORMATICS

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Homology modelling
2. ESR
3. Internal energy
4. LSC
5. Beer Lamberts Law
6. Interference Microscopy.
7. CD
8. FASTA
9. Phosphoimager
10. Ultracentrifugation **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. SDS PAGE
12. Isoelectric focussing
13. Immunofluoresence in microscopy
14. Flow cytometry
15. UV-Visible spectra
16. MALDI-TOF
17. Online databases and searchtools
18. Redox potential **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain the applications of bioinformatics
20. Elaborate on NMR
21. Write an essay on the principle, methods and applications of Chromatography
22. Write an essay on hydrolysis of high energy compounds (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FIRST SEMESTER - MODEL QUESTION PAPER

PG20BS104 - PHYSIOLOGY AND BIOSTATISTICS

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. ABO blood group
2. Neuroglial cells
3. Platelets
4. JG apparatus
5. Renal circulation
6. Chloride shift
7. Hypoxia
8. Standard error
9. Scatter diagrams
10. WBC **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. GFR
12. Respiratory membrane
13. Acclimatization
14. Alveolar ventilation
15. Structure & function of neuron
16. Measures of dispersion
17. Cardiac cycle
18. Chi-square test & goodness of fit **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain transport and exchange of gases
20. Explain the structure and function of nephron
21. Discuss the types of tissues of the body
22. Explain muscle contraction (**2x5=10)**

SECOND SEMESTER

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

SECOND SEMESTER - MODEL QUESTION PAPER

PG20BS205 - GENERAL MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Write notes on Archaea.
2. Differentiate positive & negative staining
3. What are Integrons?
4. Explain Bacterial Plasmids
5. Bacterial peptidoglycan
6. Chemotaxis
7. Write about Gene mapping
8. Bacterial endospore?
9. Describe about Whittaker five Kingdom classifications.
10. What is Transposon? **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Testing of disinfectants
12. Explain the Mechanism of multiplication of virus and its morphology.
13. Write a note on drug resistance in bacteria.
14. Classify fungi, and its economic importance and reproduction.
15. Give details about culture media used for aerobic bacterial cultivation.
16. Write a note on Site Directed Mutagenesis.
17. Give details on Gram negative Bacterial Flagella.
18. Explain bacterial growth curve **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Elaborate the sterilization techniques.
20. Explain DNA repair systems.
21. Write Elaborate essay on Generalized & Specialized transduction
22. Describe in detail the types of antibiotics, mechanism of action & antibiotic sensitivity tests**.**

(**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

SECOND SEMESTER - MODEL QUESTION PAPER

PG20BS206 - IMMUNOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. What are Haptens?
2. Write about Thymus.
3. What are the properties of cytokines?
4. Describe tumour antigen.
5. What are Inflammatory Barriers?
6. What is SLE?
7. Explain indirect ELISA.
8. What does a positive Coombs Test mean?
9. Local immunity
10. What is MALT? **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Give an account of the mechanism of autoimmune diseases.
12. Briefly explain the structure of Class II MHC.
13. Describe in detail the Cell-mediated immunity.
14. Describe the structure, properties, and functions of IgG.
15. Write short notes on GVH reaction.
16. Explain the role of Toll-Like Receptors in the pathogen associated pattern recognition.
17. Describe the endogenous and exogenous pathways of antigen processing.
18. Explain different types of vaccines

(6x2=12)

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Describe different pathways of complement activation.
20. Explain monoclonal antibody production and its applications.
21. Discuss the genetic basis of antibody diversity.
22. Give an account of the immediate and delayed hypersensitivity (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

SECOND SEMESTER - MODEL QUESTION PAPER

PG20BS207 - MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Rolling circle replication
2. Okazaki fragments
3. Ori site
4. Split gene concept
5. LINE
6. Peptidyl transeferase
7. Sigma factor
8. Cosmids
9. Vaccinia topoisomerase
10. Enhancers **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Write note on hybridization techniques
12. Blue white screening
13. Blotting techniques
14. Explain DNA modification during transcription
15. Attenuation control of TRP operon
16. Write note on Antisense technique
17. Messelson and Stahl experiment
18. Explain the process of Ligation with examples (**6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Discuss the hormonal regulation of gene expression taking any two hormones as examples.
20. Explain in detail on the various steps in Replication of prokaryotes.
21. Elaborate on the various enzymes used in recombinant DNA technology. Also add a note on various cloning modifications.
22. Briefly explain in detail on the translational events. (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

SECOND SEMESTER - MODEL QUESTION PAPER

PG20BS208-MB - METABOLISM AND ENZYMOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Cori cycle
2. Significance of Km
3. Beta oxidation of Palmitate
4. Glycogen synthase
5. Catalytic antibodies
6. What is trans deaminase
7. Zymogens
8. Functional properties of coenzyme Q
9. Transcriptional regulation of Cholesterol metabolism
10. Application of immobilization (**8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Uncouplers and inhibitors of ETC
12. Bisubstrate Reactions
13. Gluconeogenesis and its significance
14. Isoenzymes
15. Theraputic enzymes
16. Formation of uricacid
17. Urea cycle
18. Allosteric regulation of Aspartate Trans Cabomoylase (**6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Ellaborate different types of enzyme inhibition detail?
20. Illustrate eukaryotic electon transport chain and oxidative phosphorylation
21. Biosynthesis of aromatic aminoacids.
22. Write an essay on isolation and purification of enzyme and add note on characterization of enzymes? (**2x5=10)**

THIRD SEMESTER

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS309-MB - FOOD AND INDUSTRIAL MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Write a short note on LAB.
2. Write a note on beer production
3. probiotics.
4. Pasteurization
5. Cheese
6. Explain Secondary screening.
7. Define Auxanography
8. Note on anaerobic fermentation.
9. Describe liquid liquid extraction
10. Explain the importance of sparger. **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Explain food preservation methods.
12. GMOs
13. Explain HACCP in detail.
14. Describe detection and assay of fermentation products.
15. Neutraceuticals.
16. Elucidate the various methods in strain improvement
17. Describe media formulation.
18. Explain citric acid production. **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain in detail the microbiological examination of food & milk
20. Elucidate the design and automation of a fermenter. Explain any 1 fermenter in detail.
21. Elaborate the role of microorganisms in production of antibiotics with an example.
22. Give a detailed description of SCP production. Explain the advantage and disadvantage of SCP. **(2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER PG20BS310-MB -

ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Write a brief note on the effect of air pollution on plants. What are the sources of air pollution?
2. What are coliforms? Differentiate model and index indicators of water pollution
3. What are the chemical methods of disinfection of water
4. What are diazotrophs? Give examples
5. What are phosphate solubilizes? Explain with suitable examples
6. Write a note on VAM
7. What are GM crops? How these crops are beneficial to the common man.
8. xplain with two suitable examples
9. What are the organisms involved in the process of corrosion?
10. Explain the process of windrow composting **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. What are indicator organisms? Explain the types of microbial indicators of air pollution?
12. Briefly describe the process of fouling and its preventive measures
13. Explain the role of microorganisms in the transformation of carbon
14. Explain various types of microbial interactions in soil with examples
15. Write in detail about various types of biofertilizers and its advantages
16. Briefly explain bacterial diseases of plants
17. Write in detail about the biodegradation of petroleum compounds
18. What is bioremediation? Explain the methods involved? **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain the methods of enumeration of bacteria in air by air sampling devices
20. Explain the steps involved in sewage treatment process
21. What are the advantages of biopesticides over chemical pesticides? Give a note on the significance of integrated pest management
22. Explain the types of leaching and the organisms involved in metal concentration? Also write a note on MEOR (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS311-MB - MARINE MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Write a brief note on Alkalophiles?
2. Explain Biofilm?
3. Briefly explain algal blooms?
4. Explain littoral zone and sub littoral zone?
5. Biopolymers? Explain with suitable examples?
6. Write a brief note on Aeromonas?
7. Write a note on microbial indicators?
8. Explain salt pan?
9. What are the organisms involved in the process of corrosion?
10. Explain transgenic marine microbes? **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. What are methods used in collection and estimation of marine microbes?
12. Briefly describe the process of bio fouling and its preventive measures?
13. Explain biosurfactants
14. Explain various types of estuarine ecosystem?
15. Write in detail about environmental factors which can influence the marine microbes?
16. Briefly explain water born diseases and control measures?
17. Explain biopolymers
18. What is bioremediation? Explain the methods involved in the process of bioremediation? **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Briefly explain the bioactive compounds from marine microbes
20. Explain marine microbial adaptation?
21. Marine microbial habitat and marine micro flora?
22. Write a note on novel enzymes from marine microbes? **(2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS312-MB - ENVIRONMENTAL SCIENCE

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Thermal stratification of lake
2. Marine ecosystem
3. Greenhouse effect
4. Sources of air pollution
5. What is ecofeminism?
6. Anthropogenic pollution
7. Ecological succession
8. Hotspots of biodiversity
9. Ectone
10. Food chain **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Types of ecological pyramids
12. Sources of water pollution
13. Microbial indicators of water pollution
14. Organisms used as bioweapons
15. Current Major environmental issues in India.
16. Unidirectional flow of energy
17. Abiotic factors in the environment
18. Microorganisms in extreme environment **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Methods for conservation of biological diversity
20. Give a brief account of bacteriological analysis of water quality.
21. Write an essay on soil pollution
22. Discuss global environmental problems & solutions (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS313-MB - MICROBIAL DIVERSITY AND EXTREMOPHILES

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Archaea
2. Halophile
3. Barophile
4. Acidophile
5. Alkaliphile
6. Methanogen
7. Viking Mission
8. Ecological Niche Ectone
9. Extremophile
10. FISH **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. RAPD
12. Differentiae archaea and eukarya
13. Methods used for detection of life in space.
14. How are archaebacteria classified?
15. Adaptatios of halophiles to life in high salt conditions
16. Search for life on Mars
17. How are Methanogens classified?
18. Soda lakes and deserts **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. What are Extremophiles? What are the applications of extremozymes?
20. Elaborate on molecular techniques for studying microbial biodiversity.
21. Write an essay on microbial diversitiy. What are barophiles? How are they adapted to life under pressure?
22. What are aims and objectives of space research? Describe the Martian environment and the search for life on Mars. (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS314-MB - MOLECULAR MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. VNTR
2. PFGE
3. Quorum sensing
4. Molecular basis of endospore formation
5. Apoptosis
6. Bacterial toxins
7. T-DNA transfer
8. Plant metabolite
9. Unculturables
10. Extremophiles **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. RAPD
12. Probes used in molecular biology
13. Molecular biology of microbial evolution
14. Microbial genome analysis
15. Genome mining
16. Molecular basis of microbial virulence
17. Expression vector
18. Microbial polketides **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Elaborate on laboratory controls and standards in molecular diagnostics?
20. Elaborate on molecular techniques for studying microbial biodiversity.
21. Explain the different tools used for the comparison of microbial genomes
22. Elaborate on the different steps involved in the microbial production of recombinant proteins citing an example. (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS315-MB - NANOBIOTECHNOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Biogenic nanoparticles
2. Nanobiotechnology
3. Quantum dots
4. SEM
5. Role of fungi in nanoparticle synthesis
6. Nanoalloy
7. Extracellular synthesis of nanoparticles
8. AFM
9. TEM
10. Nanowires **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Use of nanoparticles in cancer therapy
12. Nanocomposite
13. Applications of silver nanoparticles
14. Uses of nanoparticles in MRI
15. Applications of Dynamic lightscattering technology in nanoscience
16. Green nanotechnology
17. Mechanism of silver nanoparticle biosynthesis
18. Electron microscopy **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain synthesis of nanoparticles by various groups of microorganisms
20. Explain toxicology of nanoparticles
21. Explain methods used for the characterization of nanoparticles
22. Explain methods used for the synthesis of nanoparticles (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

THIRD SEMESTER - MODEL QUESTION PAPER

PG20BS316-MB - MICROBIAL QUALITY ASSURANCE, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. GMP
2. WTO
3. Benefits of IPR
4. GHPs are critical for Food Safety
5. Hazardous materials in biotechnology
6. Distinguish between trade secret and trade mark
7. Copyright Infringment
8. Differentiate between genetically modified food and organic food
9. GMO
10. HACCP **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Give an account of ethical and safety aspects of animal cloning.
12. State 5 examples of geographical indications in India.
13. Elaborate on procedures for risk assessment of GM seeds and plants.
14. Comment on the ethical issues involved in xenotransplanation.
15. Significance of national biosafety boards in ensuring biosafety regulations and guidelines
16. Explain Food Safety Management Systems
17. Explain the procedure for filing a patent
18. Ethical concerns of biotechnological research and innovations **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain the ethical issues associated with the use of animal models.
20. Illustrate procedure involved in patenting living organisms.
21. Discuss the ethical and safety issues involved in testing of drugs on human volunteers.
22. Explain the ethical issues related to the Human genome project. (**2x5=10)**

FOURTH SEMESTER

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FOURTH SEMESTER - MODEL QUESTION PAPER

PG20BS413-MB - SYSTEMATIC BACTERIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Write a short note on satellitism.
2. Explain coagulase test.
3. Write notes on Anaerobic cocci
4. Write notes on listeria.
5. Explain Craigies tube technique.
6. What is Syphilis?
7. Botulism
8. Explain pyogenic Infection
9. Explain lepromin test
10. Explain lancefield grouping of streptococci

(8x1=8)

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Explain antigenic structure of salmonella.
12. Describe diarrheagenic *E.coli*
13. Explain laboratory diagnosis of diphtheria
14. Neisseriae
15. Identifying characteristics of any one anaerobic spore forming organism
16. Write a note on cultural characteresics and pigment production of Pseudomonas
17. Explain rickettsial infections
18. Explain non tuberculous mycobacteria

(6x2=12)

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Describe the pathogensis and laboratory diagnosis of pulmonary tuberculosis
20. Write an essay on systematic study of Staphylococci.
21. Describe pathogensis and laboratory diagnosis of *Vibrio cholerae*
22. Elaborate anaerobic sporogenous bacilli

(**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FOURTH SEMESTER - MODEL QUESTION PAPER

PG20BS414-MB - VIROLOGY, MYCOLOGY & PROTOZOOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Explain *Cryptococcus neoformans.*
2. What is Kyasanur Forest Disease?
3. What is Negri bodies?
4. What is Molluscum contagiousm?
5. What is the significance of Adeno Associated Viruses?
6. What is the importance of *Trichomonas vaginalis*?
7. What are Confirmatory tests for HIV infections
8. Describe MMR
9. Describe Hepatitis E.
10. What is the significance of *Rhinosporidium seeberi*? **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Explain Toxoplasmosis
12. Differentiate bacillary dysentery from amoebic dysentery
13. Describe the mechanism of viral oncogenesis
14. Explain Rubella
15. Differentiate between paramyxoviriuses and orthomyxoviruses
16. What are Antiviral agents?
17. Describe Herpes Zoster
18. Explain Dermatophytoses **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. What is Kala azar? Describe the methods used for laboratory diagnosis of kala azar.
20. What is rabies? Describe the laboratory methods for diagnosis and prophylactic measures used.
21. Write an essay on immunoprophylaxis of viral infection
22. Describe the different arboviruses you have studied and the diseases caused by them.

(2x5=10)

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FOURTH SEMESTER - MODEL QUESTION PAPER

PG20BS415-MB - CLINICAL MICROBIOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Biosafety cabinets
2. Write an account on general concept of specimen collection and transport?
3. Give an account on laboratory diagnosis of CNS infection?
4. Comment on immunoprophylaxis?
5. Write briefly on laboratory diagnosis of burn infection?
6. Give an account on Infections of sinuses?
7. Explain the methods for the laboratory diagnosis of urinary tract infections.
8. Write the procedure of ELISA
9. Explain the procedure for mailing of biohazardous materials.
10. Comment on doderline bacilli

(8x1=8)

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Explain the labortary control of antimicrobial therapy.
12. Explain molecular techniques in diagnostic microbiology.
13. Give an account on infections in immunocompromised persons.
14. Explain the infections of bone and bone marrow.
15. Explain the methods for the diagnosis of STD.
16. Comment on Nosocomial infections.
17. Normal flora of Human body.
18. Give an account on microbiology laboratory safety and design.

(6x2=12)

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Explain the etiology, lab diagnosis and pathogenesis of blood stream infections.
20. Give a detailed account on skin infections.
21. Describe the methods and role of QA and QC in microbiology laboratory
22. Write a detailed account on Biosafety levels and Biosafety guidelines

(**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FOURTH SEMESTER - MODEL QUESTION PAPER

PG20BS416-MB - MICROBIAL GENETICS

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Transcription
2. Phage induced mutation
3. Reverse transcription
4. Restriction enzymes
5. Plasmid
6. RAPD
7. Thymine dimer
8. Sexduction
9. Transformation
10. Conjugation **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Gene therapy
12. Differentiate between temperate and lytic phage
13. DNA repair
14. DNA sequencing
15. Attenuation
16. Post transcriptional modifications
17. PCR
18. Transduction **(6x2=12)**

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. Give a detailed account of the structure of DNA with the help of suitable diagrams.
20. What is meant by cloning? Describe the different types of vectors used for cloning?
21. Define Mutation. Explain the different types of mutations you have studied.
22. Explain tryptophan operon and its regulation (**2x5=10)**

M. Sc. MICROBIOLOGY DEGREE C.S.S EXAMINATION

MAR ATHANASIUS COLLEGE, KOTHAMANGALAM (AUTONOMOUS)

FOURTH SEMESTER - MODEL QUESTION PAPER PG20BS417-MB -

BIOSTATISTICS AND RESEARCH METHODOLOGY

Time: 3 Hours Maximum Weight: 30

SECTION A

Answer any **eight** of the following. Each question carries a weight of 1

1. Importance of statistics with reference to biology
2. What is frequency distribution? Illustrate with an example.
3. Diagrammatic representation- illustrate with examples from biological experiments.
4. Distinguish between diagrammatic and graphical distribution- with special reference to biostatistics.
5. Explain goodness of fit of data with special reference to $\chi 2$- test.
6. Distinguish between regression and correlation. Explain its importance in experimental data analysis.
7. Explain different methods of collection of data.
8. What are measures of central tendency? Explain the best measure of central tendency
9. ANOVA
10. Correlation **(8x1=8)**

SECTION B

Answer any **six** of the following. Each question carries a weight of 2

11. Arithmetic mean.
12. Correlation coefficient 'γ'.
13. Regression Coefficient 'b'.
14. Geometric mean.
15. Measures of dispersion and its significance in data analysis.
16. Explain analysis of variance in experiments.
17. Explain test of significance in statistical analysis of data.
18. Explain small sample test- give an illustrative example

(6x2=12)

SECTION C

Answer any **two** of the following. Each question carries a weight of 5

19. What is ANOVA? What are the assumptions under ANOVA illustrate?
20. Give the formula for 'z' test and't' test. Under what situation each one is applied.
21. What is rank correlation? How this type of correlation is calculated? Give its formula
22. Explain the levels of significance. Explain 5% and 1% level of significance. Give illustration of each level. (**2x5=10)**