ST. ALBERT'S COLLEGE (AUTONOMOUS),

ERNAKULAM

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

SYLLABUS FOR POST GRADUATE PROGRAMME

MASTER OF SCIENCE IN ZOOLOGY

UNDER CREDIT SEMESTER SYSTEM

(WITH EFFECT FROM 2019 ADMISSION)

Syllabus of M.Sc. Zoology

Proposed by the Board of Studies on 14th June 2019

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Chairman, Board of Studies

Approved by the Academic Council on 16th August 2019

Dr. M.L Joseph, Principal

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Adopted by the Governing Council on 19th August 2019

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Chairman and Members

Board of Studies in Zoology

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Preface

As envisaged in the recent regulations of Autonomous colleges in India by University Grants Commission, autonomous colleges enjoy the academic freedom to enrich the curriculum by incorporating recent trends and needs. Curriculum and syllabus of each academic program has to be revised periodically to impart major objectives like global competency, skill component, values and regional relevance. Academicians and scholars in the respective area of knowledge have to express a missionary zeal for this great purpose.

In 2016, when St. Albert's College was granted autonomy, we adopted the curriculum and syllabus followed by the Mahatma Gandhi University, Kottayam for the year 2016. In 2019, when the Mahatma Gandhi University made a comprehensive revision of their curriculum and syllabus, it was adopted by the college as it was a better curriculum that met the needs and current demands of the culture, the society, and the expectations of the population being served. However the Syllabus revision committee of the department studied the present curriculum in detail and proposed some reasonable changes for further enrichment which may expected to be implemented in the forthcoming years .

The present M.Sc. Degree programme in Zoology is a Credit Semester System with four semesters with an elective course in the fourthsemester. The present curriculum offers wide exposure to various conventional, advanced and applied fields in Zoology which will facilitate them for pursuing higher studies and research in Zoology and related fields. It is intended that students will acquire due knowledge and skill which will enable them to get employed in the biological research Institutes, and in related industries/departments. Attempts were also made to integrate the essential components to generate interest for self employment or start ups among the pupils. All possible attempts have been made to update the syllabus by incorporating current and most recent developments in various branches of Zoological Sciences.

Programme Outcomes

In depth Knowledge in the Discipline and allied Sciences: Develop a thorough knowledge about the subject and its allied realms by conscious and continuous process of learning and get informed about the cutting-edge research in the frontier areas of the subject.

Critical thinking, Effective Communication and leadership Qualities: Foster an analytical approach with logical reasoning; demonstrate proficiency in communicating effectively in groups and organizations, deliver formal and informal presentations to a variety of audiences in multiple contexts; to build essential features of a true leader

Environmental Consciousness and Ethical Standards: Discern the issues of environmental contexts and engage in promoting values and attitudes that claim coexistence and sustainable living with minimal, or no harm upon ecosystems. To recognize values such as justice, trust, equity, kindness and develop a commitment to meeting and upholding standards of ethical behavior in all walks of life.

Lifelong Learning: Develop a passion to be an independent lifelong learner by imbibing real-time changes in the socio-technological context, promoting continuous development and improvement of the knowledge and skills needed for employment and personal fulfillment.

Programme Specific Outcomes

- Integrate biological knowledge to allied disciplines and to inculcate interest in biodiversity, various ecosystems, its interactions and laws governing their conservation.
- Create awareness on the internal harmony of different body systems, at the molecular level and the need for maintaining good health through appropriate lifestyle.
- Imbibe basic skills in biological and analytical techniques, with scientific temper and ethics leading to research.
- Intellectual competency with innovative ideas and research aptitude enhanced with specialization in microbiology can avail career opportunities in higher education, scientific projects, health care, environmental and industrial organizations.

Regulations

1. SHORT TITLE

1.1. These regulations shall be called SACA Regulations (2020) governing Post Graduate Programmes under Credit Semester System (SACA-PG-CSS 2020).

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

2. Scope

2.1. The regulations provided herein shall apply to all Regular Post-graduate programmes (except M.B.A and M.Sc. Space Science and Technology) conducted in the Institution, with effect from the academic year 2020-2021.

2.2. The provisions herein supersede all the existing regulations for the regular post-graduate programmes conducted in the Institution (except M.B.A and M.Sc. Space Science and Technology).

3. DEFINITIONS

3.1. 'Academic Council' means the Committee constituted by the Governing body under this regulation to monitor the running of the post-graduate programmes under the Credit Semester System (SACA-PG-CSS 2020).

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 minimum 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. 'Comprehensive viva-voice' means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.6. 'Core Course' means a course which cannot be substituted by any other course.

3.7. 'Course' means a course segment of subject matter to be covered in a

semester. Each course is to be designed variously under lectures/ tutorials/ laboratory or fieldwork/ seminar/ project/ practical training/ assignments/ viva-voice etc., to meet effective teaching and learning needs.

3.8. 'Course Code' means a unique alphanumeric code assigned to each course of a programme.

3.9. 'Course Credit' on credit of a course is defined as a minimum of 1 hour lecture /minimum of two 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.

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

3.11. '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

3.12. '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.

3.13. 'Cumulative Grade point average (CGPA)' is the value obtained by dividing the sum of credit points of all the courses taken by the students 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 the programme. (CGPA = total CGPA obtained /Total credits of the programme)

3.14. 'Department' means any teaching Department in the Institution offering a programme of study approved as per the Act/ statutes of the University.

3.15. 'Department Council' means the body of all teachers of a Department in a college.

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

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

3.18. 'Elective course' means a course, which can be substituted, by an equivalent course from the same subject.

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

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

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

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

3.23. 'Exam Coordinator 'is a teacher nominated by the Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department of the college.

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

3.25. 'Grade point (GP) letter grade is assigned a 'Grade point' (GP) which is an integer indicating the numerical equivalent of the board level of performance of a student in a course.

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

3.27. 'Improvement course' is a course registered by a student for improving his/ her performance in that particular course.

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

3.29. '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.

3.30. 'SACA-PG-CSS 2020' means St. Albert's College Autonomous Regulations Governing Post Graduate Programmes under Credit

Semester System, 2020.

3.31. 'Parent Department' means the Department which offers a particular post graduate programme.

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

3.33. 'Programme' means the entire course of study and examinations.

3.34. 'Project' is a core course in a programme. It means a regular project work with stated credits on which the student undergoes a project under the supervision of a teacher in the parent department/ any appropriate research center 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 culminate in a realistic, student-generated product for findings.

3.35. 'Repeat course' is a course that is repeated by the student for having failed in that course in an earlier registration.

3.36. 'Semester' means a team consisting of a minimum of 90 working days, inclusive of examinations, distributed over a minimum of 18 weeks of 5 working days each.

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

3.38. 'Semester Grade Point Average'(SGPA) is the value of trained by dividing the sum of credit points CP obtained by a 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 the semester (SGPA= Total CP obtained in the semester /Total Credits for the semester).

3.39. '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.

3.40. 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.41. 'College' means St. Albert's College (Autonomous), Ernakulam, Kerala.

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

3.43. 'Weighted Grade Point'(WGP) is the grade point multiplied by weight. (WPG = GP x W).

3.44. '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.

3.45. Words and expressions used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes that you shall have the meaning assigned to them in the Act and Statute.

4. ACADEMIC COUNCIL: COMPOSITON OF ACADEMIC COUNCIL

4.1. The Principal (Chairman)

4.2. All Heads of the Departments

4.3. Four teachers of the college representing different categories of teaching staff by rotation on the basis of seniority of service in the college.

4.4. Not less than four experts/academicians from outside the college representing areas such as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc., to be nominated by the Governing Body.

4.5. Three nominees of the university not less than Professors.

4.6. A faculty member nominated by the Principal (Member Secretary).

5. PROGRAMME STRUCTURE

5.1. The medium of instruction shall be English except for programmes under Faculty of Language and Literature.

5.2. Student shall be admitted to post graduate programmes under various

faculties. The programme shall include three types of courses, Core courses, Elective courses and Common core courses. There shall be a project with the dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments/ seminars/practicals project field study etc.

5.3. Elective course and Groups

5.3.1. There shall be at least two and not more than four elective groups (Group A, Group B, Group C, etc.) comprising of three courses each for a programme and these elective courses shall be included either in the fourth semester or be distributed among third and fourth semesters. This clause is not applicable to MSW, MBA and M. Voc.

5.3.2. The number of elective courses assigned for study in a particular semester shall be the same across all elective groups for the programme concerned.

5.3.3. The colleges shall select any one of the elective groups for each programme as per the interest of the students, availability of faculty and academic infrastructure in the Institution.

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

5.3.5. The elective group selected by the college shall be intimated to the Controller of Examinations without within two weeks of commencement of the semester in which the elective courses are offered. The elective group selected by the college for the students who are admitted in a particular academic year shall not be changed.

5.4. Project work

5.5. Project work shall be completed in accordance with the guidelines given in the curriculum and shall be carried out under the supervision of a teacher of the department concerned. 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.

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

5.7. 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.

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

5.9. 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.

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

5.11. Seminar Lecture: Each 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 is self-study, collection of relevant matter from the various resources, editing, document writing, and presentation.

5.12. Test Papers (Internal): Student shall undergo at least two class tests as an internal component for each course with a weightage of one each. The best two shall be taken for awarding the grade for class tests.

5.13. No course shall have more than 5 credits unless otherwise specified.

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

5.14.1. Comprehensive Viva-Voce cover questions from all courses in the programme.

5.14.2. 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 operating at the end-semester examination shall be 75%.

Condonation of shortage of attendance for students having a minimum of 65% attendance, (up to a maximum of 10 days) in a semester subject to a maximum of two times during the whole Period of the programme may be granted by the College.

6.2. If a student represents his/her institution, University, State or Nation in Sports 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 of 10 days in a semester based on the specific recommendations of the teacher concerned, class tutor, Head of the Department forwarded through the Dean Students Affairs subjected to the approval of the Principal. For exceptional achievements/situations, the Principal may recommend for the award of additional attendance to the Governing Body.

6.3. Those who could not register for the examination of a particular semester due to shortage of attendance will not be able to repeat the semester and will be removed from the rolls.

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 has registered for the programme shall complete the programme within a period of four years from the date of commencement of the programme.

8. Admission

8.1 The admission to all regular PG programme shall be through the Centralised Allotment Process of the College.

8.2 If there is an entrance examination specified for the admission for a particular programme, it will be as per the directions of the office of the CoE of the college.

8.3 The eligibility criteria for admission to PG programmes shall be published by the College in the prospectus.

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 any recognized university/institutions. Other eligibility requirements for specific programmes will be published in the prospectus.

9.2 Students admitted under this programme are governed by the Regulations of the College.

10 Promotion

10.1 A student who registers for a particular semester examination shall be promoted to the next semester.

11 Examinations

11.1 There shall be an examination conducted by St. Albert's College, (Autonomous) at the end of each semester.

11.2 Practical Examination shall be conducted by the College at the end of semester or at the end of even semester as prescribed in the syllabus of the particular programme. The number of examiners for the Practical Examination shall be prescribed by the Board of Studies of the program.

11.3 End Semester Examinations: The examinations shall normally be conducted at the end of each semester.

11.4 There shall be one End-semester examination of 3 hours duration for each lecture based courses.

11.5 A question paper may contain short answer type/annotation, short essay type questions problem and long essay type questions. Different types of questions shall have different weightages.

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). The ratio of weightage between internal and external is 1:3 (unless for the courses, it is otherwise specified by the BoS). 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.

12.4 Internal evaluation for regular programme: The internal evaluation shall be based on a predetermined transparent system involving 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 based on the Direct Grading System.

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

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

12.8 The model of the components and its weightages of continuous evaluation (CE) and End Semester Evaluation (ESE) are Shown in below:

For theory (CE)(Internal)

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

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

For the theory (ESE) (External)

Evaluation is based on the pattern of questions specified 12.16.5

a) For Practical (CE) (Internal)

Components	Weightage
Written/Lab test	2
Lab involvement and Record	1
Viva	2
Total	5

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

a) For Practical (ESE) (External)

Components	Weightage
Written / Lab test	7
Lab involvement and Record	3
Viva	5
Total	15

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

b) 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.)

a) 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.)

a) 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.)

a) Comprehensive viva-voce (CE)(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 unless specified by the respective BoS for a particular course.)

12.9 All grade point averages shall be rounded to two decimal points.

12.10 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 the external examination.

12.11 There shall not be any chance for improvement for internal grade.

12.12 The course teacher and the Exam coordinator shall maintain the academic details of each student registered for the course and a copy should be kept in the department for verification for at least five years after the student completes the programme.

12.13 External evaluation: The external examination in theory courses is to be conducted by the College at the end of the semester. The answers should be in English expect 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.

12.14 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 College.

12.15 The question paper should be strictly on the basis of model question papers set and the directions prescribed by the BOS/Governing Body of the college for each programme.

13 Pattern of questions

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

13.2 The question setter shall ensure that questions covering all outcomes are met.

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

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

13.5 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

13.6 **Pattern of questions for practical**: the pattern of questions for external evaluation of practical shall be prescribed by the Board of Studies.

13.7 **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 Points
A+	5
A	4
B	3
C	2
D	1
E	0

a) Performance Grading

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

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(pass)
up to 1.99	D	Deficient (Fail)

No separate minimum is required for internal evaluation for a pass, but a minimum C grade is required for a pass in an external evaluation. However, a minimum C grade is required for pass in a course.

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.

Improvement of course: The candidates who wish to improve the grade/ grade point of the external examination 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 semesters of the program.

Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) calculations. The SGPA is the ratio of the sum of the credit points of all courses taken by a student in the 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 all semesters / 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 i^{th} course.

a) Cumulative Grade Point Average (CGPA) of a programme is calculated

using the formula:-

Cumulative Grade Point Average (CGPA) $=\sum(C_i x S_i) / \sum C_i$ (CGPA = Total credit Points awarded in a semester / Total credits of the programme)

Where 'C_i' is the credits 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.

3. Grade Card

A. The College 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 College

b. Name of the University

c. Title of the PG Program

d. Name of the Semesters

e. Name and Register Number of the student

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 Program.

k. Separate Grade card will be issued at the request of candidates and based on College Guidelines issued from time to time.

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.

4. 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.

5. Monitoring Committee

There shall be a Monitoring Committee constructed by the Principal to monitor the internal evaluation conducted by departments.

6. Position Certificate

The College shall publish the list of top 3 candidates for each programme after the publication of the programme results. Position certificate shall be issued to candidates on their request.

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 that rank/position. Position certificates shall be signed by the Controller of Examinations.

7. Grievance Redressal Committee

In order to address the grievance of students a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

a. Class Level: The cell is chaired by the class tutor and the course teacher or a teacher nominated by the Head of the Department.

b. 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 grade of the students.

c. College level: A committee with the Principal as Chairman, Dept. Coordinator, HOD of concerned Department and a senior teacher nominated by the Executive Committee as members.

8. Transitory Provision

Notwithstanding anything contained in these regulations, the Governing

Body shall, for a period of two years 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.

9. Credits allotted for program and Courses

a. Total credit for each program shall be 80 except MSW , M.Voc. and MBA programs.

b. Semester-wise total credit can vary from 16 to 25.

c. The minimum credit of a course is 2 and maximum credit is 5 except for M. Voc, MBA and MSW.

10. **Course code:** The course codes assigned for all courses (core courses, elective courses, common courses etc.) shall be unique.

11. **Models of distribution of courses, course codes, type of the course, credits, teaching hours for a program are given in the following table.**

Example **Programs with the practical-Total Credits 80-** scheme of the syllabus

Semester	Course Code	Course name	Type of the course	Teaching Hours Per Week	Credit	Total Credits
I	Course code1	Name1	Core	4	4	19
	Course code2	Name2	Core	4	4	
	Course code3	Name3	Core	4	4	
	Course code4	Name4	Core	3	3	
	Practical Course code5	Name5	Core	10	4	
II	Course code6	Name6	Core	4	4	20
	Course code7	Name7	Core	4	4	
	Course code8	Name8	Core	4	4	
	Course code9	Name9	Core	3	4	

	Practical- Course code10	Name10	Core	10	4	
III	Course code11	Name11	Core	4	4	20
	Course code12	Name12	Core	4	4	
	Course code13	Name13	Core	4	4	
	Course code14	Name14	Core	3	4	
	Practical Course code15	Name15	Core	10	4	
IV	Course code16	Name16	Elective	5	3	21
	Course code17	Name17	Elective	5	3	
	Course code18	Name18	Elective	5	3	
	Practical- Course code19	Name19	Core	10	5	
	Project- Course code20	Name20	Core		5	
	Comprehensive viva- voce – Course code 21	Name 21	Core		2	
	Total					80

Example Programmes without practical - Total credit 80 schemes of the syllabus

Semester	Course code	Course name	Type of the course	Teaching Hours per week	Credit	Total Credits
I	Course Code 1	Name 1	Core	5	4	20
	Course Code 2	Name 2	Core	5	4	
	Course Code 3	Name 3	Core	5	4	
	Course Code 4	Name 4	Core	5	4	
	Course Code 5	Name 5	Core	5	4	
II	Course Code 6	Name 6	Core	5	4	20
	Course Code 7	Name 7	Core	5	4	
	Course Code 8	Name 8	Core	5	4	
	Course Code 9	Name 9	Core	5	4	
	Course Code 10	Name 10	Core	5	4	
III	Course Code 11	Name 11	Core	5	4	19
	Course Code 12	Name 12	Core	5	4	
	Course Code 13	Name 13	Core	5	4	
	Course Code 14	Name 14	Core	5	4	
	Course Code 15	Name 15	Core	5	3	

IV	Course Code 16	Name 16	Core	5	3	21
	Course Code 17	Name 17	Core	5	3	
	Course Code 18	Name 18	Elective	5	3	
	Course Code 19	Name 19	Elective	5	4	
	Course Code 20	Name 20	Elective	5	4	
	Project- Course Code 21	Name 21	Core	5	2	
	Comprehensive viva-voce- Course Code 22	Name 22	Core		2	
	Total					80

Appendix

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

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

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
Up to 1.99	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	11	B	3	2	6

Essay	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	20	A+	5	5	25
	21	-	-	-	-
	22	-	-	-	-
	23	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 weight 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 5. Therefore Maximum Weighted Grade Point (WPG) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Written/Lab	7	A	4	28	
Test					WGP/Total
Lab					weight
Involvement & Record	3	A+	5	15	= 58 / 15 = 3.86
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	2	C	2	4	WGP/Total weight = 59/15= 3.93
Project content & presentation	8	A+	5	40	
Project viva-voce	5	B	3	15	
Total	15			59	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	1	A+	5	5	

viva- voce					
Total	5			21	A

Comprehensive viva-voce-External-ESE

Maximum weight for External evaluation is 15. Therefore, maximum Weighted Grade Point (WGP) 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-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+

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

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

The End Semester Evaluation valuation (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			

Evaluation- Third stage (to be done by the College)

Semester Grade Point Average (SGPA)

Course code	Title of 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				

Evaluation- Fourth 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) and semester 4 (SGPA of semester 4) and a B grade in semester 3 (SGPA of semester 3). Then the 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 program is A				

Programme Design

SEMESTER I

No	Course Code	Course Title	Course Category	Hours per week	Credits
1	PZO1CRT0120	Animal Diversity: Phylogenetic and Taxonomic Approaches	Core	4	4
2	PZO1CRT0220	Evolutionary Biology and Ethology	Core	4	4
3	PZO1CRT0320	Biochemistry	Core	4	4
4	PZO1CRT0420	Biostatistics and Research Methodology	Core	3	3
5	PZO1CRP0120	PRACTICAL 1 Animal Diversity: Evolutionary, Ethological and Biochemical methods &Approaches	Core Practical	10	4
		Total		25	19

SEMESTER II

No	Course Code	Course Title	Course Category	Hours per week	Credits
1	PZO2CRT0120	Field Ecology	Core	4	4
2	PZO2CRT0220	Developmental Biology	Core	4	4
3	PZO2CRT0320	Genetics and Bioinformatics	Core	4	4
4	PZO2CRT0420	Microbiology and Biotechnology	Core	3	3
5	PZO2CRP0120	Practical 2 Diversity of Life: Ecological, Embryological, Hereditary and Microbial Methods and Approaches	Core Practical	10	4
		Total		25	19

SEMESTER III

No	Course Code	Course Title	Course Category	Hours per week	Credits
1	PZO3CRT0120	Animal Physiology	Core	4	4
2	PZO3CRT0220	Cell and Molecular Biology	Core	4	4
3	PZO3CRT0320	Biophysics, Instrumentation and Biological Techniques	Core	4	4
4	PZO3CRT0420	Immunology	Core	3	3
5	PZO3CRP0120	Practical 3 Molecular, Physiological and Immunological Methods and Approaches in Biosciences	Core Practical	10	4
		Total		25	19

SEMESTER IV

No	Course Code	Course Title	Course Category	Hours per week	Credits
1	PZO4CRT0120	General Microbiology and Parasitology	Core	5	4
2	PZO4CRT0220	Bacteriology, Virology and Mycology	Core	5	4
3	PZO4CRT0320	Clinical microbiology	Core	5	4
4	PZO4CRP0120	Practical: Microbiology	Core Practical	10	4
5	PZO4CPR0120	Project			5
6	PZO4CRV0120	Viva			2
		Total		25	23
		Grand Total			80

ELECTIVES	COURSE CODE	COURSE TITLE
A–FISHERY SCIENCE	1	Nutrition, Growth and Physiology of fishes
	2	Fishery Resource Management
	3	Fishery Science and Technology
	4	Practical : Fishery Science – Methods and Approaches
B–ENVIRONMENTAL SCIENCE	1	Environmental Science: Concepts and Approaches
	2	Environmental Pollution and Toxicology
	3	Environmental Management and Development
	4	Practical : Environmental Science
C –ENTOMOLOGY	1	Morphology and Taxonomy
	2	Anatomy and Physiology
	3	Applied Entomology
	5	Practical : Morphology, Aanatomy and Ttaxonomy, Insect Physiology and Applied Entomology
D-MEDICAL MICROBIOLOGY	PZO4CRT0120	General Microbiology and Parasitology
	PZO4CRT0220	Bacteriology, Virology and Mycology
	PZO4CRT0320	Clinical Microbiology
	PZO4CRT0120	Practical : Microbiology

Detailed Syllabus: Semester I

Animal Diversity: Phylogenetic and Taxonomic Approaches (PZO1CRT0120)

72 Hours 4 Credits

Course Outcomes

- Acquire knowledge about the origin of animals and different hypothesis
- Interpret phylogenetic relationships and evolutionary advantages among the different groups of animals.
- Advance knowledge on vertebrate phylogeny (Herpatofauna, birds and mammals) and on their diversity, status, threats and causes of extinction.
- Develop thorough knowledge on the principles of systematics and taxonomy and familiarize in using taxonomic tools and techniques.
- Conceptualize newer trends in taxonomy such as chemotaxonomy, cytotaxonomy, molecular systematics and barcoding. Acquire knowledge on handling taxonomic Keys and Publications; and ethics to be followed in taxonomy

PHYLOGENETIC APPROACHES (45 Hours)

Module I (20 Hours)

Origin of Animals (05 Hours)

Progenote, Prokaryotes and Eukaryotes. Extant and ancient stromatolites. Unicellularity to metazoans – consequences and complexity.
Multicellular organisms – Ediacaran fauna, Burgess Shale Fauna. Cambrian explosion, Cropping and Red Queen Principle. Different hypothesis of metazoan origin – Gastraea hypothesis, Planula hypothesis.

Invertebrate Phylogeny (15 Hours)

Phylogenetic relationships among Porifera, Placozoa, Mesozoans; Cnidaria and Ctenophora; Platyhelminthes and other acoelomates.
Phylogenetic relationships among the protostome lineage – Mollusca, Annelida and Arthropoda. Evolutionary advantages of Symmetry, Metamerism and Coelom. Reasons for the success of Arthropod.
Adaptive radiation in Mollusca, Annelida, Arthropod and Echinoderms. Position and phylogeny of Hemichordates.

Module II

Vertebrate Phylogeny (10 Hours)

Affinity with invertebrates and protochordata. Paedomorphosis in vertebrate phylogeny. Jawless vertebrates – Ostracoderms and Cyclostomes. Properties and advantages of bone in vertebrate evolution. Evolution of jawed vertebrates – Acanthodian, Placoderm, Chondricthyes, Osteichthyes. Actinoptegygians and Sarcopterygians.

Module III (15 Hours)

Phylogeny of Herpetofauna (08 Hours)

Amphibian phylogeny– Osteolepiforms, stem tetrapods and early amphibians. Lissamphibians – distribution, diversity, status and threats.
Reptilian phylogeny – amniotic egg, distinguishing features between amniotes from extant amphibians. Adaptive radiation in reptiles. Importance of skull in reptilian classification. Endothermy in Dinosours. Causes of extinction.

Phylogeny of Birds and Mammals (07 Hours)

Evidences for the origin of birds from reptiles. Mammalian phylogeny and therapsids – significance of teeth, jaws and hearing. Adaptive radiation in mammals. Phylogeny of mammalian orders. Rare, endangered and endemic birds and mammals of Indian subcontinent.
Prerequisite: Classification of mammals

TAXONOMIC APPROACHES (27 Hours)

Module IV (16 Hours)

Biological Classification (09 Hours)

Hierarchy of categories and higher taxa. Taxonomic Procedures-collection, preservation, curetting and process of identification (Brief and general account only). Taxonomic characters of different kinds and analysis of variation. Concept of species.
Zoological type – Principles of typification, different kinds of type.
International code of Zoological Nomenclature – features, principles and rules. Phylocode. Zoobank.

New trends in Taxonomy (07 Hours)

Modern methods – Morphological, embryological, ecological, behavioural, cytological, biochemical, numerical, molecular. Cytotaxonomy, Chemotaxonomy.

Bar coding of life – basics of barcoding, application of barcode. Molecular operational taxonomic units (MOTU), Integrated operational taxonomic unit (IOTU). Global taxonomic initiative (GTI). Constraints of DNA taxonomy. Integrative taxonomy.

Microtaxonomy and macrotaxonomy. e-taxonomy. Cybertaxonomy. Significance of Taxonomy and biosystematics.

Module V (11 Hours)

Taxonomic Keys and Publications (04 Hours)

Different types of keys – single access keys, diagnostic and synoptic keys, dichotomous and polytomous keys. Taxonomic keys presentation. Computer aided keys. Merits and demerits of keys.

Types of taxonomic publications – atlas, catalogue, checklist, filed guide, field book, hand book, manual, monographs. Zoological records. Ethics in taxonomy.

Molecular Phylogeny and Systematics (07 Hours)

Use of protein and nucleotide sequence in molecular phylogeny. Protein sequence – haemoglobin and cytochrome. Nucleic acid phylogeny Importance of molecular phylogeny.

Cladistic analysis – Apomorphy, Plesiomorphy, Symplesiomorphy and Synapomorphy. Characteristic features of cladistics. Methodology of cladistics analysis – construction of cladogram. Significance of phylogenetic systematics. Phylogenetic trees. Different kinds – cladogram, phenogram, phylogram, dendrogram, curvogram, eurogram, swoopogram, chronogram.

References

- Anderson,T.A.2001. Invertebrate Zoology (2nd edn). Oxford University Press, New Delhi. Ashok Verma 2017. Principles of Animal Taxonomy. NarosaPublicing home pvt. Ltd.
- Barnes, R. D.1987. Invertebrate Zoology. Saunders College Publishing/Harcourt Brace; 5th Revised edition
- Barrington, E. J. W. 2012. Invertebrate Structure and Functions. Affiliated

east-west press Pvt. Ltd. New Delhi, 2nd edition.

- David, M. H, Craig Moritz and K.M. Barbara.1996. Molecular Systematics. Sinauer Associates, Inc.
- Hickman Jr., Cleveland, Larry Roberts, Susan Keen, Allan Larson, and David Eisenhour.2011.
- Animal Diversity. McGraw-Hill Companies, Inc. NY
- Kapoor, V.C. 2017. Theory and Practice of Animal Taxonomy. 8th edition, Oxford and IBH Publishing Co., Pvt. Ltd. New Delhi.
- Margulis,Lynn and M.J.Chapman 2001. Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth(4th edn.). W.H.Freeman&Company,USA
- Mayer, E.2014. Principles of Systematic Zoology. 2nd edition, McGraw Hill Book Company, Inc., NY.
- Narendran, T.C. 2008. An introduction to Taxonomy. Zoological survey of India. Strickberger, M.W. 2013. Evolution. Jones and Bartett Publishers, London.
- Simson G. G. 2012. Principles of animal taxonomy. Scientific publishers, India.
- Winston, J.E.2000. Describing species: Practical Taxonomic Procedures for Biologists. Columbia University Press,Columbia, USA.

Evolutionary Biology and Ethology (PZO1CRT0220)

72 Hours 4 Credits

Course Outcomes

- Describe the concept of relatedness and its connection to biological evolution
- Effectively communicate the principles of evolution and its application to human biology
- Develop a deeper knowledge about the probable concepts of molecular evolution, biochemical and genomic evolution and origin of higher categories
- Explore the basics and advances in ethology, information on the complexities of animal behavior at every level of biological hierarchy
- Gain Knowledge about the influence of environment on organism and their behavioral differences.

EVOLUTIONARY BIOLOGY (44 Hours)

Module I (22 Hours)

Concepts in Evolution (06 Hours)

Concepts of variation, adaptation, struggle, fitness and natural selection- spontaneity of mutation and the evolutionary synthesis. Contributions of Margulis (Endosymbiotic theory), Eldredge and Gould (Punctuated equilibrium), Rose Mary and Peter Grant (Molecuar evolution in Darwinian finches).

Origin and Evolution of Life (05 Hours)

The RNA world, The First Cell. Evolution of Prokaryotes- origin of eukaryotic cells- evolution of unicellular eukaryotes. Anaerobic metabolism - origin of photosynthesis and aerobic metabolism.

Molecular Evolution (11 Hours)

Neutral theory of molecular evolution; molecular divergence; molecular drive. Molecular clocks- genetic equidistance. Phylogenetic relationships- Homology; Homologous sequences of proteins and DNA - orthologous and paralogous; parsimony analysis; nucleotide and protein sequence analysis.

Module II (13 Hours)

Population Genetics (08 Hours)

Gene pool, gene frequency, Hardy-Weinberg Law. Rate of change in gene frequency through natural selection, migration and random genetic drift, Founder effect and Bottle check phenomenon, Isolation and speciation, Co-evolution

Developmental and Evolutionary Genetics (05 Hours)

The idea of Evo-Devo, Heterochrony, Heterotopy, Heterometry and Heterotypy. Developmental genes and gene co-option. Evolution of plasticity and complexity.

Module III

Primate Evolution and Human Origins (09 Hours)

Geological time scale, Mass extinction and its consequences, Stages in Primate evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin – morphological, anatomical, hominid fossils. Cytogenetic and molecular basis of origin of man - African origin of modern man - Mitochondrial Eve, Y chromosomal Adam.

ETHOLOGY (28 Hours)

Module III (13 Hours)

Introduction (03 Hours)

Definition, historical out line,
Terminologies : Sign stimuli, key stimuli, social releasers, displacement activities, ritualization, Ethograms, super normal stimuli, stimulus filtering, open and closed IRM, mimetic releaser, code breakers. JP Scotts categories of behaviour.

Neurophysiological Aspects of Behaviour (04 Hours)

Reflex action, Sherrington‟s neuro-physiological concepts in behavior – Latency, summation, fatigue. Fixed action patterns. Goal oriented drive, Psycho-hydrologic model of motivation. Studies of motivation in guppies.

Learning and Genetics (03 Hours)

Short and long term memory, Habituation, Sensitization. Conditioning, Reasoning. Genetic basis of behaviour.

Communication (03 Hours)

Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory and Visual. Dance language of honey bees, Pheromonal communication (Ants and mammals).

Module IV (15 Hours)

Reproduction and Behaviour (03 Hours)

Reproductive strategies, Mating systems, Courtship, Sexual selection- intrasexual and intersexual, good gene hypothesis, parental care and investment – significance of prolactin

Complex behavior/Biological rhythm (04 Hours)

Orientation, Navigation, Migration, Navigation cues. Biological rhythms – Circadian, Circannual, Lunar periodicity, Tidal rhythms. Genetics of biological rhythms.

Social Behaviour (04 Hours)

Sociobiology (Brief account only), Aggregations – schooling in fishes, herding in mammals, Group selection, Kin selection, altruism, reciprocal altruism, inclusive fitness, Hamilton‟s rule, co-operation, alarm call, social organization in insects and primates.

Foraging behavior: Habitat selection and optimality in foraging; social foraging, territoriality.

Stress and Behaviour (04 Hours)

Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance. Adolescent behavior- emotions aggression. Hormones and behavior.

References

- Arthur,W. (2011). *Evolution – A Developmental Approach.* Wiley- Blackwell, Oxford,UK Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007).
- Evolution.Cold Spring, Harbour Laboratory Press.
- Camilo J.Cela - Conde and Francisco J. Ayala. (2007). *Human Evolution- Trails from the Past*. Oxford University Press.Oxford ,UK

- Campbell.B.G. (2009). *Human Evolution*. Transaction Publishers, NJ, USA
- Chattopadhyay Sajib. (2002). Life, Origin, Evolution and Adaptation.Books and Allied (P) Ltd. Kolkata, India.
- Dan, G. and Li,W.H. (2000). *Fundamentals of Molecualr Evolution*. (2nd edn.). Sinauer Associates Inc. MA, USA
- Gould, S,J. (2002). *The Structure of Evolutionary Theory*. Harvard University Press, MA, USA. Hall, B. K. and Hallgrimsson, B. (2008), Evolution. 4th Edition; Jones and Bartlett Publishers Hall, B.K and Hallgrimsson, B. (2008). *Strickberger's Evolution* (4th edn). Jones and Bartlett Pub.London,UK
- Hall, B.K. and Olsen, W. M., (Ed). (2007). Keywords and Concepts in Evolutionary Developmental Biology. Discovery Publishing House, New Delhi,
- Jha A.P (2000) Genes and Evolution - Macmillan Publishers India
- Kimura,M. (1983). *The neutral theory of molecular evolution*.Cambridge University Press Lindell Bromham (2016) An Introduction to Molecular Evolution and Phylogenetics, 3rd edition, Oxford press
- Ridley, M. (2004), Evolution 3rd Edition. Blackwell Publishing
- Roderick Page, D.M. and Edward Holmes, C.(2009). Molecular Evolution: A phylogenetic approach, Willey Blackwell publisher.
- Strickberger, M.W. (2000) Evolution. Jones and Bartlett, Boston.

Web Resources

- http://www.talkorigins.org
- http://www.ucmp.berkely.edu
- http://www.academicearth.org

Ethology

- Alcock John (2009). *Animal Behaviour : An Evolutionary Approach* (8th edn). Sinauer Associates Inc. Sunderland, Massachusetts.
- Aubrey Manning and Mariam Stamp Dawkins (2000). *An Introduction to Animal Behaviour* (5th Edn). Cambridge University Press, U.K.
- Dawkins, M.S. (1995).Unravelling Animal Behaviour. Harlow: Longman.

- Fatik Baran Mandal (2009). *A Textbook of Animal Behaviour*. PHI Learning Private Limited, New Delhi.
- Gundevia J.S. and Singh H.G. (1996), A Text Book of Animal Behaviour. S. Chand and Company Pvt. Ltd., New Delhi.
- Hauser, M.(1998). *The Evolution of Communication*. MIT Press, Cambridge, Mass. USA.
- Judith Goodenough, Betty McGuire .2010. *Perspectives of Animal Behaviour*. John Wiley & Sons Inc. USA
- Lee Alan Dugatkin (2009). *Principles of Animal behaviour* (2nd edn). W.W. Norton and Company.
- Macfarland, D (1998). *Animal Behaviour – Psychobiology, Ethology and Evolution*. Pitman publication Ltd. London.
- Michael D. Breed and Janice Moore (2015) Animal Behaviour, Academic press, USA.
- Scott Graham (2005). *Essential animal behavior*. Blackwell Publications Company, Oxford ,UK Wilson, E.O. (2000). *Sociobiology: The new synthesis*. Harvard Univ. Press, Cambridge, Mass. USA.
- *Web Resources:* www.animalbehavioronline.com/modestable.html

Biochemistry (PZO1CRT0320)

72 Hours 4 Credits

Course Outcomes

- Explore the chemical nature of life and life processes.
- Provide an idea on the structure and functions of biomolecules
- Explore the recent developments in biochemistry.
- Describe the metabolic pathways and inborn errors of metabolism.
- Explore the energy yielding pathways, key enzymes and its regulation and significance of free radicals and antioxidants.

Module I (18 Hours)

Carbohydrates (06 Hours)

Classification, Structure, nomenclature and Biological functions of carbohydrates. Glycoproteins and Mucoproteins. Isomerism – structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism. Mutarotation and inversion of sugars. Glycosidic bond.

Carbohydrate Metabolism (09 Hours)

Major metabolic pathways- Glycolysis, Citric acid cycle and its significance. Oxidative and substrate level phosphorylation. Gluconeogenesis, Cori cycle. Glycogen metabolism- Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism, Role of insulin and glucagon. Adenylate cascade system, Ca+2 Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis. Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism, Galactose metabolism.

Disorders of Carbohydrate Metabolism (03 Hours)

Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, Inborn errors associated with carbohydrate metabolism. Glycogen storage diseases, Lactose intolerance, Galactosuria, pentosuria, galactosemia.

Module II (18 Hours)

Proteins (09 Hours)

Structure, classification and properties of amino acids. Amphoteric properties of amino acids, pH, Buffer, pK value and iso-electric point of amino acids. Classification, properties and biological functions of proteins. Primary structure of protein (e.g. insulin). Conformation of proteins- chemical bonds that stabilise higher order structures. Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins- examples (brief account on any two: Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons. Tertiary structure- e.g. Myoglobin. Quaternary structure – e.g. Haemoglobin.

Metabolism of Proteins (07 Hours)

Amino acid metabolism-Deamination, Transamination and Trans-deamination. Formation and disposal of ammonia. Urea cycle. Fate of carbon skeletons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples. Synthesis of biologically significant compounds from different aminoacids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan.

Inborn Errors of Metabolism (02 Hours)

Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia.

Module III (18 Hours)

Lipids (18 Hours)

Classification of lipids: simple, compound and derived lipids. Biological importance of lipids. Fatty acids: classification, Genevan system of nomenclature. Simple fats: Triacylglycerol (Triglycerides) :-fats, oils and waxes. Physical properties. Reactions-Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert- Meissl number of lipids. Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmologens. Glycolipids, Sphingolipids. Derived Lipids, Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes, Lipoproteins. Prostaglandins- structure, types and functions.

Metabolism of Lipids (07 Hours)

Beta oxidation, alpha oxidation and omega oxidation of fatty acids. De novo

synthesis of fatty acids.

Lipid peroxidation. Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Free radical scavenger systems. Preventive antioxidants and chain breaking antioxidants.

Disorders of Lipid metabolism (02 Hours)

Plasma lipoproteins, cholesterol and its clinical significance,, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher‟s disease, Tay-Sach‟s and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia.

Module IV (08 Hours)

Nucleic Acids (06 Hours)

Structure of nucleic acids, Structural organization of DNA (Watson –Crick model) Characteristic features of A, B, C and Z DNA. DNA topology of circular forms. Structural organization of tRNA; Protein-nucleic acid interaction. DNA regulatory proteins, folding motifs and conformation flexibilities, denaturation, renaturation, Biological roles of nucleotides and nucleic acids.

Nucleic Acid and Mineral Metabolism (02 Hours)

Catabolism of purines and pyrimidines.

Module V (10 Hours)

Enzymes: Classification- (I.U.B.system), co-enzymes, ribozyme. Enzyme specificity. Mode of enzyme action: Concept of Active site, Formation of enzyme substrate complex, Lowering of activation energy. Lock and key theory, induced fit theory, transition state and strain theory. Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Kinetics of enzyme inhibition, suicide inhibition, feedback inhibition- sequential, concerted and cumulative feedback control. Control of enzyme activity:-control of activity by changes in covalent structures of enzymes, control of activity by ligand induced conformational changes in enzymes. Enzyme regulation: Allosteric regulations- Monod-Wyman-Changuex model, Koshland-Nemethy-Filmer model Key enzymes, Flux analysis. Iso-enzymes and clinical significance.

References

- Creighton, T.E. Protein Structure and Molecular Properties. 1993. W.H. Freeman & Co, NY. Deb, A.C.2004. Fundamentals of Biochemistry. New Central Book Agency (P) Ltd. New Delhi. Elliott, W.H and C. Elliott, 2003. Biochemistry and Molecular Biology. Oxford University Press, Oxford,UK.
- Eric E. Conn, Paul K. Stumpf, George Bruening, Roy H. Doi, 2007. Outlines of Biochemistry. (5th edn). John Wiley &Sons Inc., NY.
- Garret, R.H. and C.M. Grisham. 1995. Biochemistry. Saunders College Publishers,USA. Lenhninger, A.L. 2008. Principles of Biochemistry. (5th edn). CBS Publishers and Distributors, New Delhi. Hanes, B. D. and N.M. Hoopar. 1998. Instant notes: Biochemistry. University of Leeds, Leeds, UK.
- Horton, H.R., Morsan, L.A., Scrimgeour,K.G.,Perry, M.D and J.D.Rawn. 2006. Principles of Biochemistry. Pearson Education International, New Delhi.
- Keith Wilson and John Walker. 2008. Principles and Techniques of Biochemistry and Molecular biology(6th edn). Cambridge University Press, UK.
- Murray, K., Granner, D.K., Maynes, P.A and V.W.Rodwell, 2006. Harper‟s Biochemistry (25th edn). McGraw Hill, New York, USA.
- Oser, B.L.1965. Hawk‟s Physiological Biochemistry. McGraw Hill Book Co. New Delhi. Palmer Trevor. 2001. Enzymes: Biochemistry,Biotechnology & Clinical chemistry. Horwood Publ.Com., England.
- Rama Rao, A.V.S.S. 1986. Text Book of Biochemistry. L.K. & S Publishers, New Delhi. Stayer, L. 2011. Biochemistry. (7th edn). W.H. Freeman & Co. NY.
- Vasudevan, D.M. and S.Sreekumari. 2000. Text of Biochemistry for Medical Students. Jaypee Brothers, Medical Publishers (P) Ltd. New Delhi
- Voet, D and J.G Voet, 2004. Biochemistry. John Wiley & Sons.,NY. Zubay, G, 1989. Biochemistry. McMillan Publishing Co., New York.

Biostatistics and Research Methodology (PZO1CRT0420)

54 Hours 3 Credits

Course Outcomes

- To impart concepts of statistics and research methodology, and create awareness about the gadgets, tools and accessories of biological research
- To help students improve analytical and critical thinking skills through problem solving
- To enable learners to effectively apply suitable statistical tests in research
- To sensitize students about the ethics involved in research and enable them to come up with innovative research designs
- To equip learners to prepare research papers and project proposals

BIOSTATISTICS (30 Hours)

Module I (09 Hours)

Basics of Biostatistics (03 Hours)

Scope and Significance of Biostatistics. Steps in Statistical Investigation, Data and Variable (Collection, Types, Sources).

Statistical Analysis Tools - Parametric and Non-Parametric; Bivariate and Multivariate Analysis. Interpretation and Forecasting.

Measures of Central Tendency – mean, median and mode.

Measures of Dispersion (06 Hours)

Introduction, Characteristics. Quartiles and Percentiles. Merits and Demerits of Range, Quartile Deviation, Mean Deviation and Standard Deviation. Relative Measures of Dispersion.

Calculations/Problems for frequency table. Standard error. Skewness and Kurtosis (Brief account only).

Module II (11 Hours)

Correlation Analysis (03 Hours)

Correlation - types and methods of correlation analysis, Problems for Karl Pearson‟s correlation coefficient and Spearman‟s rank correlation.

Regression Analysis (04 Hours)

Regression and Line of Best Fit, Types and methods of regression analysis.

Graphic Methods (Scatter method, Curve fitting). Algebraic method (Fitting of strait line through regression equation). Comparing correlation and regression.

Probit Analysis (Brief account only).

Theory of Probability (04 Hours)

Measures of Probability and Theorems in Probability. Probability distributions – Binomial, Poisson and Normal (Brief Account only).

Module III (10 Hours)

Testing of Hypothesis (07 Hours)

Hypothesis and types, Confidence Interval, Sampling, Methods and Errors. Tests of significance (For large and small samples – Critical Ratio and P value).

Z Test (Problem for small samples), Chi- Square Test – test of independence and goodness of fit (Problem for 2×2 table only).

Student‟s „t‟ test (Problem for small samples comparing mean of two variable).

F-test, Analysis of Variance (ANOVA - One way), Kruskal Wallis test (Brief account only). Mc Nemar and Mann Whitney U test (Brief account only).

Mathematical modeling in Biology (03 Hours)

Introduction to mathematical modeling. Applications: Medicine - models to predict spread of infectious diseases, drug discovery, Systems Biology – Blue Brain project, Ecology – Lotka Volterra model. Length - Weight Relationship. Von- Bertalanffy‟s Growth (VBG) Model.

Statistical Software: MS Excel, SPSS; Introduction to „R‟ (Basics only).

Research Methodology (24 Hours)

Module IV (12 Hours)

Concepts of Research (04 Hours)

Scientific temper, Empiricism and Rationalism. Knowledge, Information and Data. Science and Pseudoscience. Basic concepts of research -Meaning, Objectives, Motivation and Approaches.

Types of Research - Descriptive/Analytical, Applied/ Fundamental,

Quantitative/Qualitative, Conceptual/Empirical. Research methods versus Methodology, Research Process.

Research Formulation (04 Hours)

Research formulation -Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating the research problem, Selecting the problem and necessity of defining the problem. Literature review - Importance of literature review in defining a problem, Critical literature review. Theory, Principle, Law and Canon.

Research Designs (04 Hours)

Research Design -Basic principles, Meaning, Need and features of good design. Types of research designs.

Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Case-control studies and cohort studies.

Module V (12 Hours)

Scientific Documentation and Communication (06 Hours)

Structure and components of Scientific Reports – types of Report – Technical Reports and Thesis/dissertations.

Preparing Research papers for journals, Seminars and Conference; Impact factor, Citation Index, h-index. DOI. ISBN & ISSN.

Conventions and strategies of authentication – citation styles, bibliography, referencing and foot notes. Software for managing bibliographies – End Note.

Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference, Oral presentation, Poster Presentation.

Preparation of Project Proposal. Project funding agencies – UGC, DST, BDT, MoEF. Women Scientists schemes.

Global Information System – BIOSIS, Medline and Medlars, AGRIS, Pubmed, Google Scholar.

Information Science, Extension and Ethics (06 Hours)

Sources of Information - Primary and secondary sources. Library - books, journals, periodicals, reference sources, abstracting and indexing sources,

Reviews, Treatise, Monographs.

Online resources – INFLIBNET, e-libraries, e-Books, e-Encyclopedia, e-Journals, e-Thesis, Shodhganga, PG-Pathshala, TED Talk, Institutional Websites. MOOC - SWAYAM, NPTEL. Networking platforms for researchers - Academia, Research Gate.

Ethics in research - Plagiarism, Plagiarism checking softwares - Turnitin, Viper, Urkund; Citation and Acknowledgement.

Extension: Lab to Field, Extension communication, Extension tools.

References

- Chap T. Le.2003.*Introductory Biostatistics*. John Wiley &Sons, NJ, USA.
- Clough, P. and C.Nutbrown.2002. *A Student's Guide to Methodology: Justifying Enquiry*. Sage, London.
- Daniel W.W. 2006. *Biostatistics: A Foundation for Analysis in the Health Sciences* (7th edn). John Wiley & Sons, New York.
- Freedman D. F., Pisani R. and Purves R. 2011. Statistics. Viva Books, New Delhi.
- Dharmapalan Biju. 2012. *Scientific Research Methodology*. Narosa Publishing House, New Delhi.
- Gupta S. P. 2014. Statistical methods for CA foundation course. Sultan Chand & Sons, New Delhi.
- Kothari C. R. 2009. *Research Methodology: Methods and Techniques* (2ndedn.). NewAge International Publishers, New Delhi.
- Paul Oliver. 2005. *Writing Your Thesis*. Vistaar Publications.New Delhi.
- Rajathi A. and P. Chandran, 2010. *SPSS for You*. MJP Publishers, Chennai
- Samuels M. L., Witmer J. A. and Schaffner A. 2016. Statistics for Life Sciences (5th edn). Pearson Education Inc., New delhi.
- Sundar Rao P.S.S. and Richard J. 2006. .*Introduction to Biostatistics and Research Methods* (4th edn). Prentice Hall, New Delhi.
- Zar J. H. 2008. *Biostatistical Analysis* (3rd edn.). Pearson Education Inc., New Delhi

Practical I: Animal Diversity: Evolutionary, Ethological and Biochemical Methods & Approaches (PZO1CRP0120)

180 Hours 4 Credits

Course Outcomes

- Become familiar with museum specimens and the tools and techniques to study their evolutionary relationships
- Be able to identify larval forms
- Explore the behavioral pattern of different organisms
- Become familiar with online tools to analyze the structure of biomolecules
- Estimate and analyze biomolecules and their significance and Gain knowledge in descriptive statistics and apply in academic and research fields

Biosystematics, Evolutionary Biology and Ethology (60 Hours)

- Study of museum specimens - 50 invertebrates and 20 vertebrates (List the studied items with brief descriptions enlisting at least five taxa or taxonomic rank (Diagrams not necessary)
- Larval forms - any 10 larvae from different taxa (emphasizing phylogenetic, morphological, ecological and pathological significance)
- Mounting and Submission of any three larval forms.

  (Diversity should be maintained depending on the number of students and one specimen each should be submitted for the practical examination, Repetition should be avoided for examination)
- Preparation of dichotomous key up to the family of four specimens each from any of the three, from the following five groups (ie., from insects, spiders, fishes, amphibians and snakes) with necessary diagrams.
- Dichotomous key using appropriate software or online tools (students should be familiarized with the computer aided keys)
- Hardy Weinberg Law for calculation of gene frequency
- Preparation of Cladogram based on the specimens provided (at least five museum specimen) (OR software programmes can be used for construction with more number of specimens).

- Study on the skull pattern of reptiles/mammals.
- Behavioural study or activity pattern of any two organism (insects, fish, reptile, birds, mammals) based on field observation with respect to diurnal and seasonal. Viva based on behavioral observation reported. (Repetition of reports, organism and observations should be avoided on records)

Biochemistry (80 Hours)

- Study of structure of biomolecules (carbohydrate , amino acids , cholesterol), using ball and stick models and Protein and Nucleic acid using software tools
- Preparation of Buffers of specific pH using pH meter.
- Calculation of Molality, Normality, percentage W/V, serial dilution and preparation of standard solutions.
- Preparation of standard curve for protein (by Lowry or Biuret methods) ,glucose, cholesterol and/or creatinine and estimation of unknown concentration.
- Estimation of protein or cholesterol from fresh tissue
- Estimation of Enzyme activity from fresh tissue (alkaline phosphatase or acid phosphatase)

Biostatistics (40 Hours)

- Calculation of corrected mean, and standard deviation (Problems can be solvedusing scientific calculator).
- Derive regression equation for protein, cholesterol and creatine using Optical density and Concentration.
- Drawing best line of fit for protein, cholesterol and creatine (Problems can be solved using scientific calculator).
- Calculation of Pearson correlation coefficient.
- Calculation of regression coefficient and regression equation („x" on „y"only).
- Calculation of Chi -square value (2x2 tableonly).

- Calculation of „t" value (for small sample comparing two samples)
- MS Excel: Preparation of graphs (bar, histogram, frequency polygon, frequency curve, pie diagram and ogives).
- MS Excel/PH Stat/SPSS: Basic statistics (mean, median, mode, standard deviation), Correlation Analysis, Regression analysis , Test of significance (T test between two sample or sample and population), Chi-square test, Problems using one way ANOVA

Detailed Syllabus: Semester II

Field Ecology (PZO2CRT0120)

72 Hours 4 Credits

Course Outcomes

- Acquire deep knowledge on the structure and basic components of the ecosystem and their interactions and inter-relationships to sustain life on earth
- Provide knowledge on various animal adaptations to a variety of environments
- Conceptualize theory and practice of remote sensing for resource management
- Be aware of both renewable and non-renewable resources and their conservation
- Make in-depth studies in the field of applied ecology such as sewage treatment, solid waste disposal and be well versed with the concepts and dimensions of sustainable development

Module I

Animal and Physical Environment (18 hours)

Effect of cold and hot temperature on organisms. Global warming and change of species phenologies. Effect of soil development on nutrient level. Herbivore population and plant nutrient level. Availability of O2and Co2 on growth and distribution of organisms. Water availability and abundance of organism. Significance of salt concentration in soil and water. Effect of soil and water pH on distribution oforganisms.

Cybernetic nature of ecosystem, homeostasis and feedback systems.

Animals and nutrient acquisition – herbivory, carnivory, omnivory, detritus feeding.

Animal adaptations to thermal environment – thermal balance, poikilotherms, homeotherms, heterotherms. Animal adaptations to moisture environment – maintenance to water balance, response to drought and flooding. Animal adaptations to light environment.

Prerequisite: Ecosystem concept – structure and function, Productivity, Food chain and food web, Energy flow

Module II

Population Ecology (15 hours)

Properties – patterns of dispersion, dispersal movements, age structure, sex ratio, life table, survivorship curve, density, population growth-exponential and logistic growth, time lags, carrying capacity. Population growth and global warming.

Density dependent and density independent influences. Population fluctuations and cycle. Extinction – deterministic extinction and stochastic extinction.

Life history strategies – Reproductive strategies, *r* and *k* selection. Human population growth. Concept of ecological foot print.

Population regulation – dispersal, social dominance, territoriality: types of territory, territorial defence, floaters, home range.

Aggregation, Allee‟s principle, Isolation

Metapopulation – Concept, Structure

Module III (17 hours)

Population Interactions: Competition and Predation (10 hours)

Interspecific competition – Competitive Exclusion Principle, Resource partitioning and utilization. Niche, Niche overlap, Niche width, Niche responses-niche compression and niche shift. Character replacement. Ecological and evolutionary effects of competition.

Predation – Antipredator adaptations.

Foraging theory – optimal diet, foraging efficiency, risk-sensitive foraging.

Animal prey defence – chemical defence, warning coloration and mimicry, cryptic colouration, armor and defence, behavioural defence, predatory sanitation.

Predator offence – hunting tactics, cryptic coloration and mimicry in predators, adaptations of hunting. Cannibalism, Intraguild predation (IGP).

Population Interactions: Parasitism and mutualism (7 hours)

Characteristics and life-cycle of parasite, host response to parasitism – biochemical, abnormal growth, sterility, behavioural change, mate selection. Social parasitism – Brood parasitism and kleptoparasitism.

Types of defence against parasites by host. Invasive parasite. Parasitism and climate change. Non-native parasite and biological control.

Mutualism – Origin and types. Dispersive mutualism, defensive mutualism, resource based mutualism. Mutualistic relationship of human with crops.

Module IV

Applied Ecology (10 hours)

Air, water, soil and radioactive pollution – Sources, causes and consequences.

Disposal of radioactive waste. Ecological indicators.

Concept of waste – types and sources of solid waste. Health and environmental implications. E- waste-types and management aspect. Environmental biotechnology and solid waste management – aerobic and anaerobic systems. Concept of bioreactors in waste management. Liquid wastes and Sewages.

Scope of bioremediation. Phytoremediation, bio-augmentation, biofilms, bio filters, bio scrubbers and trickling filters.

Module V

Resource Ecology (12 hours)

Currents status of forest resources and deforestation in India. Significance of Western Ghats. Fresh water sources, water scarcity and water conservation measures. Wet lands, its importance, reclamation and conservation measures. Sand mining and its impacts.

Energy resources – solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear. Recent issues in energy production and utilization. Green technology and sustainable development. Depletion of natural resources and its impacts on life.

Ecosystem monitoring – GIS and its application, Role of remote sensing in

ecology. Environmental Impact Assessment (EIA)-Tools and technique. Ecosystem modelling (Brief account only).

References

- Abbasi, S.A. and Ramasami, E.V 1998. Biotechnological Methods of Pollution Control. Oxford University Press, Hyderabad.
- Benton, A.H. and Werner, W.E 1976. Field Biology and Ecology. Tata McGraw Hill, New Delhi. Boitani, L and T.K.Fuller2000.Research Techniques in Animal Ecology. Columbia University Press, USA
- Daniel, C.D 2010.Environmental Science.(8thedn.).Jones and Bartlett Publishers. Misra, S P and Pandey S. N.2009. Essential Environmental Studies. AneBooksPvt. Ltd. Odum, E P. 2017.Fundamentals of Ecology, India edition.
- Peter Stilling, 2012. Ecology: Global Insights and Investigations. The McGraw-Hill companies, New york
- Peter, H.R., Berg, L.R., and Hassenzahl, D.M. 2008. Environment. (5thedn.).John Wiley Publishers. Pianka, E. R. 1981. Competition and Niche Theory in "Theoretical Ecology". (2ndedn.).In: May, R.M. (Ed.). Blackwell, London.
- Rana,S.V.S. 2009.Essentials of Ecology and Environmental Science.(4thedn.). PHI learning Pvt. Ltd., New Delhi
- Simons, I.G. 1981. Ecology of Natural Resources. Edwin-Arnold Ltd., London.
- Robert Leo Smith and Thomas M Smith 2001. Ecology and Field biology (6th Edition), New York

Developmental Biology (PZO2CRT0220)

72 Hours 4 Credits

Course Outcomes

- Get introduced to the concepts and process in developmental biology like fertilization, gene action in development, potency, induction, competence, determination (specification & commitment) and differentiation
- Could unfold the genetic mechanisms during development
- Awareness on the developments in embryology with study of model organisms and their cellular interactions
- Acquire knowledge on processes like metamorphosis of amphibians & Insects and regeneration
- Get exposed to the new developments in embryology and its relevance to human welfare

Module I (24 hours)

Introduction: Basic Concepts of Development (14 hours)

Potency of embryonic cells, Commitment, Specification (Autonomous and Conditional), Induction, eye lens induction, Regional specificity of induction, Genetic specificity of induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages. Genomic equivalence and Cytoplasmic determinants, DNA methylation, Genomic imprinting.

Fertilization and Early development (10 hours)

Fertilization-(biochemical and molecular aspects, cell surface molecules in sperm-egg recognition), Polyspermy. Early development and axis specification in *Caenorhabditis elegans,* Vulval induction in *C.elegans*

Module II

Development of Model organisms—Drosophila (14 hours)

Early development and axis specification in Drosophila (cleavage, midblastula transition, gastrulation).Anterior-posterior patterning in Drosophila (Maternal effect genes, zygotic genes, gap genes, pair rule genes, segment polarity genes; homeotic selector genes, realisator genes), Dorsal- ventral patterning

and left right patterning, Dorsal protein gradient.

Module III

Axis and Pattern Formation in Amphibians (16 hours)

Axis formation in amphibia -- Anterior-posterior patterning in Amphibia. Hox code hypothesis. Nieuwkoop centre and mesodermal polarity. Molecular basis of mesoderm induction. Transcription factors induced in the organizer. Neural induction. Vertebrate limb development.

Module IV (14 hours)

Cellular Interactions in Development (6 hours)

Paracrine factors - Hedgehog family, Wnt family, TGF, BMP. Surface receptors and signal transduction pathway - RTK pathway, Smad pathway, Wnt pathway, Hedgehog pathway and cell death pathway.

Metamorphosis and Regeneration (8 hours)

Metamorphosis of Amphibians and Insects; Hormonal control of metamorphosis. Heterochrony- neoteny, progenesis (Brief accounts); regeneration - different types of regeneration; Histological processes during regeneration; Polarity and Metaplasia in regeneration; Lens regeneration in amphibia.

Module V

Human Welfare and Developmental Biology (4 hours)

Stem cells and their applications, ethical issues. Malformations and disruptions, Gene – phene relationship, Autophene, Allophene and Pleiotrophy; Environmental oestrogens.

References

- Balinsky, B.I.2004. An Introduction to Embryology.W.B.SaundersCo.,Philadelphia. Berril, N.J. 1979. Developmental Biology.Tata McGraw-Hill Pub.Co.Ltd.,New Delhi.
- Gilbert, S.F. 2016. Developmental Biology (11thedn).Sinauer Associates Inc., Publishers, Masachusettes, USA
- Hopper, A.F. and Hart ,N.H.1985. Foundations of Animal Development.Oxford University Press, Oxford.

- Lewis Wolpert. 2007. Principles of Development. Oxford University Press.Oxford Saunders,
- J.W.1982. Developmental Biology-Patterns,Principles and Problems. Macmillan Publishing Co.,New York.
- Subramanian, T. 2002. Developmental Biology.Alpha Science International Ltd.,New Delhi
- Sunstard,D.P., Simmons, M. J. and J.B Jenkins.1997. Principles of Genetics.John Wiley and sons, New York.
- Wolpert L. and C. Tickle. 2011. Principles of Development.(4thedn). Oxford University Press, Oxford.

Genetics and Bioinformatics (PZO2CRT0320)

72 Hours 4 Credits

Course Outcomes

- Apply the principles of Mendelian genetics and mechanism of inheritance
- Gain knowledge on the fine structure of genetic material and molecular basis of heredity
- Informed about the concepts of linkage, recombination, crossing over etc
- Gain knowledge on various types and effects of mutation, DNA replication , damage and repair and significance of inheritance of traits and gene mapping techniques in humans
- Explore the emerging field of bioinformatics and analyze biological data.

GENETICS (54 hours)

Module 1 (14 hours)

Principles of Genetic Transmission (04 hours)

(Prerequisites: The basic principles of inheritance: Alleles, Pseudo alleles, Dominance, Segregation, Independent assortment, Test cross and ratios)

Extensions of Mendelian Principles:

Codominance, Incomplete Dominance, Gene interactions with Epistasis,Pleiotropy, Penetrance and Expressivity, Phenocopy,

Linkage, Recombination and Crossing over, Cytogenetic Mapping (10 hours)

Linkage, Recombination, Sterns experiment, Crossing over as the physical basis of recombination, Molecular mechanism of crossing over and recombination, Holiday Model

Recombination mapping with a three point test cross in Drosophila, Interference and the Coefficient of Coincidence. Mitotic recombination, Evolutionary significance of recombination

Mapping genes using conjugation data, Fine structure

Mapping of Phage genes: Complementation Mapping, Deletion Mapping, Organization and mapping of mitochondrial genome

(Prerequisites: Mechanisms of genetic exchange in Bacteria)

Module II (16 hours)

Molecular Organization of Chromosomes (06 hours)

Genome size and C – value paradox, Chromatin Structure and levels of DNA packaging in Prokaryotic and Eukaryotic chromosomes, Molecular structure of Centromere and Telomere, Telomere shortening and Aging (Werner's syndrome), Repeated DNA sequences in Eukaryotic Genome: Highly repetitive, Moderately repetitive, Single copy, Kinetics of renaturation, Cot Curve.

(Prerequisites: DNA, Histone, Chromatin, Euchromatin and heterochromatin)

Gene Fine Structure (10 hours)

Classical versus Molecular concept of the gene, Cis-Trans test for functional allelism, Fine structure of the phage T4 rII locus, Modern findings on the nature of gene: Interrupted genes in eukaryotes, Exons and introns, Genes with in genes in phage ϕx174, Gene synthesis : in vitro synthesis - Works of Watson and Crick, Khorana, Kornberg and Nirenberg.

Transposible genetic elements

Transposible elements in Bacteria, Cut and Paste transposons in Eukaryotes, Retrotransposons Transposable elements in Humans. Genetic and evolutionary significance of transposable elements.

Module III

Replication and Mutation (10 hours)

Unidirectional replication, Bidirectional replication, Theta replication, Rolling circle replication, eukaryotic replication and Replication Machineries – prokaryotes and eukaryotes.

Mutagenesis and Molecular Mechanism of Mutation, Tautomeric shift, DNA Repair Mechanisms, Inherited Human Diseases with defects in DNA repair, Gene conversion, The Ames test.

(Prerequisites: Messelson and Stahl Experiment, Semiconservative replication, Somatic or germinal mutation, Spontaneous or induced Mutation, Conditional lethal mutation, Variation in chromosome Number and Structure: Aneuploidy, Deletions and Duplications, Inversions, Translocations)

Module IV (14 hours)

Human Genetics, Quantitative Genetics and Population Genetics (10 hours)

Karyotype, Chromosome banding techniques, Pedigree analysis, anticipation, Lod Score, Complex traits, Quantitative traits, Threshold traits. Analysis of quantitative traits: The Multiple Factor Hypothesis, Broad sense heritability, Narrow sense heritability. Artificial selection, Correlations between Relatives.

The theory of allele frequencies and allelic natural selection.

Applications of Molecular Genetics

Identification of human genes and diagnosis of human diseases. Uni parental Disomy, Huntington's disease, Fragile X syndrome, Cystic fibrosis. Gene therapy- SCID- Autosomal disease of immune system, DNA profiling, Micro RNA, Si RNA and their control in Genetic disorders. Mitochondrial gene in Aging and Human Disease

(Prerequisite: Sex chromosome and sex determination, Sex-linked genes in humans, Dosage compensation of X-linked genes, Sex limited and sex influenced characters in man.)

Epigenetics (04 hours)

Epigenetics, Histone code hypothesis. Chromatin modifications and their mechanisms of action: Modification of histone proteins - Acetylation, phosphorylation, methylation, ubiquitylation, sumoylation. Chromatin remodeling, Genomic imprinting, X chromosome inactivation, Gene Silencing. Epigenetics in Drosophila: Position effect variegation(PEV), Gene silencing - Polycomb Group Genes(PcG) - Yeast and Drosophila models

BIOINFORMATICS (18 hours)

Module V

Biological Databases (06 hours)

Primary databases - Nucleotide sequence databases: GenBank, EMBL, DDBJ;

Protein sequence databases: SWISSPROT, PIR; steps involved in use and interpretation of results

Structure databases: PDB, NDB; Secondary databases: PROSITE, Pfam, CATH; Composite databases: OWL; Literature database: PubMed; Database searching – Entrez; Database sequence submission – BankIt.

Sequence Analysis (06 hours)

Types of sequence alignment, methods of sequence alignment, scoring schemes, gaps and gap penalties, Phylogenetic trees – CLUSTAL W and CLUSTAL ω, PHYLIP

Genomics and Proteomics and Systems Biology (06 hours)

Structural genomics, functional genomics, comparative genomics, data mining, proteomics – Microarrays. Protein modeling and drug designing.

System Biology - metabolomics, gene network, synthetic biology.

References

- Concepts of Genetics, Pearson (Global Edition), 11 edition , William S Klug, Micheal R Cummings, Charlotte A Spenser, Machael A Palladino
- Principles of Genetics, Wiley, 8th Edition, Eldon John Gardner, Michael J Simmons, D Peter Snustard
- Genetics: Principles and Analysis, Daniel Hartel and Elizabeth W Jones
- Lewins Genes X , Jones and Bartlett, 10 Edition Jocelyn E Kreb, Elliott S Goldstein Stepen T Kilpatrik
- Epigenetics CSH Press, Second Edition, C David Allis, Marie-Laure Capparros, Thomas Jenuwein, Danny Reinberg (E
- Main references: Principles of Genetics, Gardner, Simmons, Snustad.
- Principles of Genetics, Snustad, Simmons. Genetics, A Conceptual Approach, Benjamin A. Pierce

Bioinformatics

- Alberghina, L and H.V. Westerhoff (Eds).2008. Systems Biology- Definitions & Perspectives. Springer-Verlag, Berlin.

- Attwood T.K. and Parry Smith, D. 2006. Introduction to Bioinformatics. Pearson Education. Bourne P. E and Weissig H, 2003. Structural Bioinformatics. Wiley -Liss. USA
- David W. M. 2004. Bioinformatics, Sequence and Genome Analysis (2ndedn). CSHP, New York Krane, D. E and M.L. Raymer. 2006.Fundamental concepts of Bioinformatics. Pearson Education, New Delhi
- Lesk A. M, 2005. Introduction to Bioinformatics. Oxford Press, New Delhi
- Pengcheng Fu and Sven Panke, (Eds.) 2009. Systems Biology and Synthetic Biology. John Wiley & Sons, Inc. NJ,USA
- Tisdall J. D, 2001. Beginning Perl for Bioinformatics. O"Reilly Media Inc. CA,USA
- Masaru Tomita and Takaai Nishioka, 2005. Metabolomics. The Frontier of Systems Biology. Springer Japan

Microbiology and Biotechnology (PZO2CRT0420)

54 Hours 3 Credits

Course Outcomes

- To provide an over view of the microbial world, its structure and function
- To understand the fundamental aspects of the basic biology of bacteria and viruses
- To give students an intensive and in-depth learning in the field of biotechnology
- To familiarize the student with emerging field of biotechnology
- To understand the modern biotechnology practices and approaches with an emphasizing technology application, medical, industrial, environmental and agricultural areas and nanomedicine
- To familiarize the students with public policy, biosafety, and intellectual property rights issues related to biotechnology

MICROBIOLOGY (18 hours)

Module I (10 hours)

General Characters and Classification of microbes (04 hours)

General characters of microorganisms- bacteria, virus, fungi, Outline classification of microrganisms

Functional Anatomy of Prokaryotic Cells - Cell structure, plasma membrane, cytoskeleton, cytoplasm, nucleoid, cytoplasmic inclusions. The prokaryotic cell envelope, peptidoglycan structure, gram positive and negative cell walls. Components outside the cell wall: capsules, slime layers, pili and fimbriae, flagella and motility.

Methods in Microbiology (06 hours)

Culture medium, methods of isolation, pure culture techniques, microbial strain identification – cultural and biochemical, Control of microorganism- physical, chemical and antimicrobial agents.

Module II

Microbial Growth and Interactions (08 hours)

Nutrient requirements, growth factors, uptake of nutrients by the cell. Growth

curve. Physical requirements for bacterial growth and influence of environmental factors on growth. Mirobes in nutrient cycling.

Symbiosis, commensalism. Mutualism between microbes, microbes and plants, microbes and animals. Cooperation, competition, predation, antagonism. Parasitism, plant parasites, animal parasites. Microbial communication system- Quorum sensing, Biofilms.

BIOTECHNOLOGY (36 hours)

Module III

Recombinant DNA Technology - Tools and Techniques (12 hours)

Introduction – rDNA and cloning, Restriction enzymes and DNA modifying enzymes.

Vectors: cloning and expression vectors - Plasmids, Ti and Ri plasmids, cosmids, phagemids, bacteriophage, SV40, vectors with combination features; PUC19 and Bluescript vectors, shuttle vectors, viral vectors, BAC and YAC vectors. Adaptors, Linkers

Methods of gene transfer: chemical transfection methods: calcium chloride, PEG, polyplex, DEAE dextran. Physical methods: electroporation, microinjection, particle bombardment, ultrasonication, liposome mediated transfer. Biological methods: use of vectors, Selection and screening of recombinants, insertional activation- blue white screening, Generation of cDNA and genomic library.

Basic techniques in Biotechnology

Polymerase chain Reaction- different types and applications, Gene cloning, Chromosome walking, chromosome jumping, DNA foot printing.

DNA sequencing methods- Maxam and Gilberts chemical degradation method, Sanger and Coulson method, Automated DNA sequencers.

Protein sequencing methods

Module IV

Animal Biotechnology and health care (12 hours)

Cell and Tissue culture: Basic techniques of mammalian cell culture Growth media- types, biology and characterization of cultured cells.Measurement of

viability and cytotoxicity, organ culture.

Cryopreservation and maintenance of cell line

Transgenic animals – production and its applications. Gene knockout and gene knock, Site directed mutagenesis, molecular chimeras

Gene therapy: Exvivo, Invivo, Insitu- Cell and tissue engineering, Gene products in medicine – Humulin, Erythropoietin, Growth Hormone/Somatostatin, tPA, Interferon. DNA vaccine Biosensors and Biochip.

Module VI. Biotechnology in Industry, Agriculture and Environment (05 hours)

Fermentation technology – Stages of fermentation - Fermentation products (antibiotics, alcohol, amino acids, organic acids, vinegar, vitamins, and fuels). Enzyme engineering and applications. Transgenic plants, Biological nitrogen fixation; Nif genes, Nitrogen fixers – Bio fertilizers (Rhizobium, Azotobacter, Azospirillum, VAM) - Bio pesticides (Bacterial, Fungal, Viral). Terminator gene technology

Module V

Nanobiotechnology (03 hours)

Introduction, Nano biotechnological devices, Types and applications of Nano biosensors, Drug delivery technologies, personalized nanomedicine.

Intellectual Property Rights, Biosafety and Bioethics (04 hours)

Introduction to Intellectual Property Rights, Types of IP: Patents, Trademarks, Copyrights.

Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments, Protection of New GMOs. IPs of relevance to Biotechnology and few Case Studies (Rice, Neem, Curcumin). Introduction to History of GATT, WTO, WIPO and TRIPS.

Biosafety concepts and issues. Biosafety protocol 2000.

Bioethics: Principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity

References

- Ananthanarayanan, R. and Jayaram Panikar, C.K. (2013). Text Book of Microbiology. University Press, Hyderabad.
- Arora,D.R. and Arora,B. (2008). Text Book of Microbiology. CBS Publishers and Distributers, New Delhi
- Atlas RM. (2005). Principles of Microbiology. 4th edition. WMT. Brown Publishers. Chakraborty, P. A. (2009). Text Book of Microbiology. New Central Book Agency. New Delhi Harma and Kanika (2009). Manual of Microbiology Tools and Techniques. Ane Books Pvt. Ltd. New Delhi
- Ingraham, J. L. and Ingraham, C. A. (2000). Microbiology (2ndedn). Brooks/Cole-Thomson Learning, MA,USA
- Pelczar MJ, Chan ECS and Krieg NR. (2010). Microbiology. 8th edition. McGraw Hill Book Company.
- Talaro, Park.,Kathelee, N and Talaro, Arthur. (2002). Foundations of Microbiology. McGraw Hill Higher Education, NY
- Wheelis Mark (2010). Principles of Modern Microbiology. Jones and Bartlett Publishers, NY,USA.
- Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 8th edition. McGraw Hill Higher Education.

Biotechnology

- Sathyanarayana, U. (2009), Biotechnology, Books and allied (p) Ltd Singh, B.D. (2009). Biotechnology, Kalyani publishers.
- Click, B. R. and Pasternak (2002). Molecular Biotechnology: Principle and applications of recombinant DNA. ASM Press.
- Dale, Jeremy W and Schantz, Malcom V. (2002). From Gene to Genomes. John Wiley and Sons Ltd, NY,USA
- Das, H.K. (2007). Text book of Biotechnology. Wiley India Pvt. Ltd. New Delhi
- Doyle, Alan and Griffith Bryan J. (1999). Cell and Tissue Culture- Laboratory Procedures in Biotechnology.Wiley International, NY.
- Freshney, Ian, R. (2006). Culture of Animal Cell (5th edn).Wiley- Liss publications.

- Jenkins, N (Ed) (1999). Animal cell biotechnology: Methods and Protocols. Humana press, New Jersey.
- Pandian, T.T. and Kandavel, D. (2008). Text Book of Biotechnology. I.K International Publishing House, New Delhi.

Practical II: Diversity of Life: Ecological, Embryological, Hereditary and Microbial Methods & Approaches (PZO2CRP0120)

180 Hours 4 Credits

Course Outcomes

- Imbibe the characteristics of various ecosystems, procedures to estimate different parameters in ecosystem and their effects.
- Identify marine and fresh water plankton
- Use online tools for sequence alignment, database search and retrieval, phylogenetic studies and structure analysis.
- Demonstrate the development of chick embryo and the morphological and histological details of placenta.
- Acquire skills in microbial techniques.

Ecology (70 hours)

- Study of Pond/ Wetland/ River ecosystem (any one) – Separate work book should be maintained by each student specifying objectives and methods adopted based on field study.
- Ecological analysis - Estimation of following parameters Water:- Salinity, Phosphates, Nitrate , pH & Conductivity Soil:- Organic carbon and Chlorides.
- Separation and identification of soil arthropods using Berlesse funnel

  (A minimum of five specimens should be reported with the comments in practical record)
- Qualitative and Quantitative study of marine/freshwater planktons.
- Collection and temporary mounting of minimum 3 fresh water planktons (Group/Generic level identification is necessary).
- Viva based on field study

Genetics (20 hours)

- Culture, sexing and etherization of Drosophila.
- Study of Mutants in Drosophila.

- Genetics problems (Di hybrid cross, test cross and sex linked inheritance)
- Gene order mapping in three point cross (Data to be provided)

Bioinformatics (30 hours)

- Data base search and data retrieval-using NCBI, SWISS-PROT, PDB, Expasy.
- Methods of sequence alignment-BLAST and ClustalW.
- Phylogenetic tree using MESQUITE/MEGA/ PHYLIP.
- Gene Prediction using GENSCAN/GRAI.
- Protein structure visualization using RASMOL.

Developmental Biology (30 hours)

- Study of the developmental stages of Drosophila
- Study of the developmental stages of frog (egg, blastula, gastrula, neurula, tadpole, with external gill and internal gill) using permanent slides/Diagrams.
- Study of serial sections of embryo (tadpole/chick).
- Vital staining of early gastrula of chick - Window method.
- Blastoderm mounting and age determination of chick embryo using vital stains.
- Morphological and histological details of different types of mammalian placenta.

Microbiology (30 hours)

- Sterilization, disinfection and safety in microbiological laboratory.
- Preparation of culture media

  liquid media – nutrient broth , peptone water

  Solid media – Nutrient Agar, Mac Conkey" Agar.

  Semi solid agar

  Firm agar.

- Culturing of microorganism –

broth culture

pure culture techniques- streak plate, pour plate culture, lawn culture, stab culture

- Serial dilution and standard plate count, calculation of Cfu/ml in water samples.
- Isolation and preservation of bacterial culture.
- Identification of microorganisms-

  Staining techniques- gram staining of mixed cultures, negative staining and spore staining, oxidase test, catalase test
- Oxidation/fermentation (O/F) test
- Antibiotic sensitivity (different natural fluids)
- Staining and enumeration of microorganisms:

  (a)using haemocytometer

  nephelometry/ Turbidimetry
- Environmental sample analysis.

  a. Coliform count in water

  b. Isolation and enumeration of soil bacteria

  c. Identification of symbiotic bacterioids from root nodules of leguminous plants Bacteriological analysis of milk- methylene blue reductase test

Detailed Syllabus: Semester III

Animal Physiology (PZO3CRT0120)

72 Hours 4 Credits

Course Outcomes

- Gets an overview on the structure and working of different organ systems in humans.
- Acquire knowledge on the comparative anatomy of heart in different animals
- Familiarize the anatomy of respiratory organs and mechanism of respiration in invertebrates and vertebrates.
- Acquire detailed knowledge on the hormonal control of urine formation; the role of kidney in maintaining homeostasis and the concepts of thermoregulation in homeotherms and poikilotherms
- Familiarize with the endocrine functions; the concepts of reproduction and reproductive organs in human

Module I

Digestion and Absorption (08 Hours)

Physiology of digestion and absorption (A brief account on vertebrates and invertebrates), Neural regulation of thirst and hunger, Events of absorptive and postabsorptive states and their neural and endocrine regulation, , Physiology of starvation and obesity, Leptin: synthesis, secretion and its role in adipogenesis

Module II (16 Hours)

Circulation (08 Hours)

Circulatory mechanisms in different animal groups , Haemodynamics, Blood volume and its regulation, Comparative anatomy of heart structure in different animals, Myogenic heart- Conducting system, Cardiac cycle, Cardiac output, stroke volume, Neural and chemical regulation of cardiac activity ECG - its principle and significance.

Respiration (08 Hours)

Anatomy of respiratory organs and mechanism of respiration in invertebrates and vertebrates, Pulmonary ventilation, Neural and Chemical Regulation of respiration. Respiration in unusual environment– foetal and neonatal respiration, high altitude, diving.

Module III (22 Hours)

Nerve Physiology (06 Hours)

Neuroanatomy of the central and peripheral nervous system, Modifications of synaptic transmission, Mechanism of excitatory and inhibitory pathway. Neuromuscular Junction- organization and properties, neuromodulators. Neural control of muscle tone and posture.

Sensory and Effector Physiology (10 Hours)

Classification of somatic senses and somatic receptors, modality of sensation, exteroceptors, interoceptors, Chemo receptors: Mechanism of reception.

Mechanoreceptors: Mechanism of hearing and Equilibrium

Photo receptors: Structure of invertebrate and vertebrate eye. Physiology of vision. Pain receptors: Headache, pain suppression (analgesia).

Tactile receptors: Mechanism of transmission of signals

Muscle Physiology (06 Hours)

Skeletal muscle- ultra structure and molecular organization. Red and white muscles, Mechanism of muscle contraction and relaxation. Energetics of muscle contraction. Catch muscle and fibrillar muscle.

Module IV (10 Hours)

Osmoregulation and Excretion (06 Hours)

Osmoregulation in fresh water, marine and terrestrial animals.

Comparative physiology of excretion in different animals, Hormonal regulation of urine concentration, Role of kidney in maintaining homeostasis. Micturition, Dialysis, kidney transplantation.

Thermoregulaion (04 Hours)

Temperature compensation and temperature regulation in poikilotherms and homeotherms, Comfort zone, body temperature– physical, chemical, neural regulation,

Adaptations for extreme environments, aestivation and hibernation.

Module V (16 Hours)

Endocrinology (10 Hours)

Invertebrate and vertebrate endocrine glands, Synthesis(Peptide- Insulin, Steroid hormones, Amines- Thyroid) physiological role and mechanism of hormone action. Bioamines, Ecosanoids, Chalones, Lumones, Phytohormones, Synthetic hormones, Pheromones

Reproductive physiology (06 Hours)

Anatomy and histology of Testis and Ovary, Hormonal regulation of gametogenesis, Physiology of implantation, pregnancy, parturition, and lactation.

References

- Bentley,P.J. 1998. *Comparative Vertebrate Endocrinology* (3rd edn). Cambridge University Press Bray, J.J., Cragg, P. A, Macknight, A.D, Mills, R.S and Taylor, D.W 1986. *Lecture Notes on human Physiology*. ELBS, New Delhi.
- William. S.Hoar, General and comparative physiology
- C.L. Prosser, Comparative animal Physiology
- Kenneth .S. Saladin 2011, Anatomy and Physiology Sixth edition
- Brijlal Gupta and J.A. Ramsay, 1977. *Transport of Ions and Waterin Animals*. Academic Press, New York.
- Chatterjee, C.C. 1997. *Human Physiology*. Medical allied agency, Calcutta. Ganong, W.F1987. *Review of Medical physiology*. Appleton and lang, Norwalk.
- Guyton, A.C. 1996. *Text Book of Medical physiology*. Prism Books Pvt.Ltd. Bangalore

Cell and Molecular Biology (PZO3CRT0220)

72 Hours 4 Credits

Course Outcomes

- Gain knowledge on the structural and functional details of cells at the molecular level
- Be aware of the new developments in molecular biology and its implications in human welfare.
- Develop thorough knowledge on cell cycle and its regulation and cell signalling.
- Acquire detailed knowledge on transcription and RNA processing, translation-gene expression and gene regulation mechanisms.
- Gain knowledge about the growth and development of cell, cellular interactions leading to abnormal proliferation and new advancements in treatment.

Module I (24 hours)

Cell Membrane & Cell Interactions (08 Hours)

Membrane structure, chemistry and functions, dynamic nature of the plasma membrane, membrane potentials, ion channels.

Extracellular matrix: Basement membrane, Collagen, Proteoglycans, Fibronectin and laminin. Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes. Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherens.

Cell Junctions: Tight junctions, Gap junctions, Desmosomes and Plasmodesmata

Prerequisite: membrane models, membrane transport: Simple diffusion, Facilitated, Active & Bulk transport

Cell Organelles (08 Hours)

Endoplasmic reticulum – protein insertion, protein folding, signal sequences and signal hypothesis, Golgi complex-protein glycosylation and protein sorting , mechanism of vesicular transport, Lysosomes.

Prerequisite: Mitochondria, Peroxisomes, Glyoxysomes, Nucleus and Nuclear membrane.

Cell organization and Cell movement (08 Hours)

Structure and organization of Microtubules, Intermediate filaments & Microfilaments, Molecular motors, Non muscle motility and muscle contractility.

Module II

Cell Signaling (12 Hours)

Extracellular messengers (signaling molecules), role of Calcium and Nitric oxide (NO) as intracellular and intercellular messengers.

Receptors: G- Protein coupled receptors, Receptor tyrosine kinases (RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors).

Second messengers: Cyclic-AMP, Cyclic-GMP, Inositol1, 4,5-trisphosphate (IP3), Di-acyl glycerol (DAG). Signaling pathways: G-protein coupled receptor (GPCR) and cyclic AMP pathway – role of protein kinase A (PKA), GPCR pathway in rod cells, Receptor protein tyrosine kinase and Ras-MAP kinase pathway, JAK-STAT pathway, Calcium phosphatidyl- inositol pathway, Phospho Inositide 3-kinase (PI-3 kinase),Transforming growth factor (TGF) signaling pathway. Regulation of signaling pathways. Convergence, divergence and crosstalk among different pathways.

Prerequisite: Basic principles of cell communication

Module III

Gene Expression (12 Hours)

Transcription in prokaryotes and eukaryotes, Promoter, enhancer and silencer RNA processing in prokaryotes and eukaryotes, post transcriptional modifications, Translation in prokaryotes and eukaryotes, Genome engineering by the CRISPR/ Cas system

Pre- requisite: Gene and Genetic code

Module IV

Gene Regulation (12 Hours)

Regulation of gene expression in *E. coli* :Catabolite repression, *Trp* operon in *E.coli*-repression and attenuation, *Ara* operon in *E.coli*-positive and negative controls. Riboswitches.

General introduction to gene regulation in eukaryotes at the level of chromatin structure, transcriptional - Transcription activators, coactivators and

repressors, Activation and repression of transcription, post transcriptional, translational and post translational levels, methods to identify post translational modification: RNA editing, RNA interference (RNAi).

Pre-requisite: Fundamentals of gene regulation, Lac operon, Monocistronic and Polycistronic mRNA

Module V (12 Hours)

Cell Growth (05 Hours)

Cell cycle: Stages in cell cycle, Control of cell cycle, Checkpoints in cell cycle. Control of cell division and cell growth. Apoptosis- extrinsic and intrinsic pathways, significance.

Prerequisite: Mitosis, meiosis

Cancer (07 Hours)

Basic properties of a cancer cell: Metastasis, interaction of cancer cells with normal cells, Types of cancer, Causes of cancer, Genetics of cancer, Tumor suppressor gene, Oncogene.

New strategies for combating cancer: Immunotherapy, Gene therapy, inhibiting cancer promoting proteins, inhibiting formation of new blood vessels.

Prerequisite: benign and malignant tumour

References

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. And Walter, P. 2017. *Molecular Biology of the Cell.* (6thedn). Garland Science.- Taylor and Francis group, USA.
- Clark, D.P. 2010. *Molecular Biology.* Elsevier Publishers, London.
- Cooper, G.M. and Hausman, R.E. 2018. *The cell: A Molecular Approach* (8thedn). Sinauer Associates, Inc, ASM Press, Washington DC.
- Griffiths, A.J.F., Wesler, S.R., Carroll, S.B. and Doebley, J. 2008. *Introduction to Genetic Analysis.* W H Freeman and Company, USA
- Hardin, J., Bertoni, G. 2018. *Becker's World of the Cell.* (9thedn). Pearson, England.

- Hyde, D.R. 2010.*Genetics and Molecular Biology*. Tata McGraw Hill Education Private Ltd., NewDelhi.
- Karp, G. 2013. *Cell and Molecular Biology* (7thedn). John Wiley and Sons, Inc. NJ, USA.
- Klug, W.S. and Cummings, M.R. 2004. *Concepts of Genetics*. Pearson International, New Delhi. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. 2017. *Lewin's Genes XII*. Jones and Bartlett publishers, NY.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H.,Amon, A.and Martin,K.C. 2016. *Molecular Cell Biology* (8th edn). W H Freeman & Company, U.S.A. Pierce, B.A. 2008. *Genetics: A conceptual approach*. W H Freeman and Company.
- Pollard, T.D. and Earnshaw, W.C. 2008. *Cell Biology*. Saunders Elsevier.
- Snustad, D.P. and Simmons, M.J. 2010. *Principles of Genetics*. John Wiley and Sons. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. 2013. *Molecular Biology of the Gene*(7th edn). Pearson.

Biophysics, Instrumentation and Biological Techniques (PZO3CRT0320)

72 Hours 4 Credits

Course Outcomes

- Gain knowledge with the physical principles governing life processes.
- Provide an insight on the tools and techniques of various instruments available for biochemical and biophysical studies
- Illustrate the principles and applications of biochemical and histological techniques
- Explain the recent trends in nanobiotechnology
- Demonstrate the application of instrumentation and biological techniques in scientific research.

BIOPHYSICS (18 Hours)

Module I

Diffusion and Osmosis (06 Hours)

Diffusion – Kinetics of diffusion. Fick's law and diffusion coefficient. Gibb's Donnan equilibrium. Application of diffusion processes in biology: haemolysis. Vant Hoff‟s laws. Osmotic concentration, Osmotic pressure and osmotic gradient.

Biological significance of osmosis in animals and plants.

Bioenergetics (06 Hours)

Reversible thermodynamics and irreversible thermodynamics; Systems – open, closed and isolated. Photo bioenergetics. Photosynthesis – light and dark reactions, Redox couple and redox potential. Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemiosmotic theory and binding change mechanism of ATP synthesis.

Radiation Biophysics (06 Hours)

Interaction of radiation with matter – Photoelectric effect, ion pair production, absorption and scattering of electrons. Biological effects of radiation: effect on nucleic acids, proteins, enzymes and carbohydrates. Cellular effects of radiation: somatic and genetic. Nuclear medicine: Internally administered radioisotopes. Radioiodine in thyroid function analysis.

INSTRUMENTATION & BIOLOGICAL TECHNIQUES (54 Hours)

Module II

Microscopy and Histological Techniques (18 Hours)

Microscopy (10 Hours)

Differential Interference contrast (Nomarsky) microscopy, Fluorescence microscopy, Confocal microscope, Scanning Tunnelling, Electron microscope - TEM, SEM, Specimen preparation- Shadow casting, Freeze fracturing, Freeze etching, Negative staining. Microphotography, Atomic force microscope

Histological Techniques (08 Hours)

Types of microtomes and microtomy. Fixation, preparation of temporary and permanent slides, whole mounts, smears, squashes and sections. Cytochemical and histological method, Histochemistry of nucleic acids, detection of carbohydrates, proteins and lipids.

Module III

Separation Techniques (20 Hours)

Centrifugation (02 Hours)

Basic principle and application. Differential, density and ultracentrifugation.

Chromatography (10 Hours)

Basic principles, working and applications of Thin-layer chromatography, Ion – exchange and Affinity chromatography; High performance liquid chromatography (HPLC), Fast protein liquid chromatography (FPLC),Gel permeation chromatography.

Electrophoresis (08 Hours)

Gel electrophoresis– PAGE, SDS and non SDS,2D Gel electrophoresis, Isoelectric focusing,Density gradient gel electrophoresis, Disc electrophoresis, High voltage electrophoresis, Capillary gel electrophoresis, Electrophoretic mobility shift assay (EMSA).

Module IV

Advanced Techniques and Applications (12 Hours)

Colorimetry (02 Hours)

Principle and applications of colorimetry and spectrophotometry- Beer

Lambert law

Spectroscopy (10 Hours)

Fourier-Transform infrared spectroscopy (FTIR), Raman spectroscopy, Circular dichroism spectroscopy, Flame emission spectroscopy, Atomic absorption spectroscopy, Nuclear Magnetic- resonance spectroscopy (NMR)and Electron Spin Resonance (ESR) spectroscopy, Mass spectroscopy- Different types and applications: MALDI-TOF, LCMS, Tandem Mass Spectrometry.

Module V (04 Hours)

Radioisotope Detection and Measurement (02 Hours)

Dosimetry: Ionizationchamber, GM counter, Solid and liquid scintillation counters, Autoradiography.

Biomimetics technology (02 Hours)

Principles and applications-Bio-Nanorobotics, Artificial muscles using Electroactive polymers, Multifunctional materials

References

- Alonso, A., and Arrondo, J.L.R.2006. *Advanced Techniques in Biophysics*. Springer, UK Arora, M. P. 2007. *Biophysics*. Himalaya Publishing House, New Delhi
- Bar-Cohen, Yoseph. *Biomimetics: Biologically-Inspired Technologies*. 2006. CRC Press. Das, D. 1991. *Biophysics and Biophysical Chemistry*. Academic Publishers, Calcutta Edward, A.L. 1997. *Radiation Biophysics*. Academic Press, NewYork, USA
- Ernster, L. (Ed.). 1985. *Bioenergetics*. Elsevier, NewYork, USA
- Ghatak K.L. 2011.*Techniques and Methods in Biology*. PHI Learning Pvt. Ltd. New Delhi Gupta A. 2009. *Instrumentation and Bio-Analytical Techniques*. Pragati Prakashan, Meerut Hoope, W. et.al. 1983. *Biophysics*. Springer Verlag, Berlin
- Keith Wilson and John Walker. 2010. *Principles and techniques of Biochemistry and Molecular Biology*.7th Edition.
- Lehninger, A.L.1971. *Bioenergetics*. W.A. Benjamin, London, UK
- Narayanan, P. 2000. *Essentials of Biophysics*. New Age International (P)

Ltd. Publishers, New Delhi

- Nelson D.L. & Cox, M.M., 2006. *Lehninger's Biochemistry*, W.H. Freeman and company, USA Pradeep T. 2007. *NANO: The Essentials. Understanding Nanoscience and Nanotechnology*. Tata McGraw Hill Education Pvt. Ltd., New Delhi
- Roy, R.N. 1996. *A Textbook of Biophysics*. New Central Book Agency (P) Ltd. Calcutta
- Sandhu, G.S. 1990. *Research Techniques in Biological Sciences*. Anmol Publications, New Delhi
- Srivastava, P.K. 2006. *Elementary Biophysics. An Introduction*. Narosa Publishing House, New Delhi
- Trunk Dung Ngo. 2015. *Biomimetic Technologies: Principles and Applications.* Woodhead Publishing
- Varghese, T. and Balakrishna, K.M.2012. *Nanotechnology-An Introduction to Synthesis, Properties and Applications of Nanomaterials*. Atlantic Publishers and Distributors. (P) Ltd. New Delhi

Immunology (PZO3CRT0420)

54 Hours 3 Credits

Course Outcomes

- Get an intensive and in-depth knowledge in immunology
- Provide an overview of immune system, compare and contrast innate and acquired immunity
- Describe the mechanism of immune response and its adverse effects
- Illustrate antigen antibody interactions and its biological significance
- Comprehend the role of immunology in human health and well-being, Illustrate immunological response in transplantation and justify the role of vaccines in immunoprophylaxis

Module I (12 Hours)

Overview of the Immune System (04 Hours)

Cells, tissues and organs involved in immune system, Haematopoiesis- B-cell and T-cell maturation and differentiation, Haematopoietic growth factors, B-Cell receptors, T-Cell receptors, Toll-like receptors.

Immunogenicity and Antigenicity (08 Hours)

Factors that influence immunogenicity, Haptens, Adjuvants, Epitopes., Properties of B-cell and T-cell epitopes, Immunoglobulins-structure, classes and functions. Antigenic determinants of immunoglobulin - (a) Isotype (b) Allotype (c) Idiotype. Immunoglobulin genes- Multigene organization, Generation of antibody diversity. Monoclonal antibodies and clinical uses. Antibody engineering.

Module II (10 Hours)

Antigen –Antibody Interactions (06 Hours)

Strength of antigen-antibody interaction- antibody affinity and avidity. Types of antigen-antibody reactions - Cross-reaction, Precipitation, Agglutination. Immunological Techniques - Immunoprecipitation. Immunofluorescence. Flow cytometry and fluorescence. Immunoelectron microscopy. Radio-allergo sorbent Test (RAST). ELISA and RIA .

The Complement System (04 Hours)

Complement Activation-Classical, Alternate and Lectin Pathways. Terminal sequence of complement activation (MAC).), Regulation of complement system, Biological consequences of complement activation. Complement deficiencies.

Module III (09 Hours)

Immune Effector Mechanisms

Types of Inflammation- acute and chronic. Chemokines. Properties and functions of Cytokines. Cytokine antagonists. Therapeutic uses of cytokines.

Hypersensitivity (04 Hours)

Types of Hypersensitivity- IgE- mediated (type- I) hypersensitivity. Antibody-mediated cytotoxic (type- II) hypersensitivity. Immune complex- mediated (type- III) hypersensitivity. Delayed type (type- IV) hypersensitivity. Stimulatory (type V) hypersensitivity

Module IV (18 Hours)

Major Histocompatibility Complex (08 Hours)

General organization and inheritance of MHC. MHC genes. Genomic map of H-2 Complex in the mouse. HLA Complex in humans. MHC-peptide interaction. Expression of MHC molecules on different cell types. Biological significance of MHC. HLA typing, Antigen processing and presentation

Immunity in Health and Disease (10 Hours)

Congenital immunodeficiency diseases (SCID, WAS, CVI, Ataxia, CGD,LAD).Acquired Immunodeficiency Disease (AIDS). Autoimmunity. Organ-specific autoimmune diseases. Systemic auto-immune diseases. Immune response during bacterial (Tuberculosis), parasitic (Malaria) and viral (HIV) infections (include).

Vaccines –Whole organism vaccines, Purified macromolecules as Vaccines, Recombinant vector vaccines, DNA vaccines. Synthetic peptide vaccines, Multivalent subunit vaccines.

Module V

Transplantation immunology (05 Hours)

Immunologic basis of graft rejection. Clinical manifestation of graft rejection. General and specific immunosuppressive therapy. Clinical transplantation.

References

- Abbas, A.K., Lichtman,A.K and Pober , J.S. 1997. Cellular and Molecular Immunology. W.B. Saunders Co. New York
- Ashim K. Chakravarthy. 1998. Immunology. Tata McGraw-Hill, New Delhi.
- Chakraborty, A.K. 2006.Immunology and Immunotechnology. Oxford University Press, New Delhi
- Darla,J, Wise & Gordeon, R.Carter. 2004. Immunology- A Comprehensive Review. Iowa State University Press. A Blackwell Science Co,USA
- David Male, Jonathan Brostoff, David Roth and Ivan Roitt. 2006. Immunology. Mosby, Edinburg
- Goldsby, R.A.,Kindt, T.J. and Osborne, B.A.2000. Immunology (4thedn.). W.H. Freeman and Co. NY,USA
- Hannigan, B. M., Moore, C. B. T. and Quinn, D. G. 2010.Immunology. Viva Books, New Delhi.
- Helen Chappel and Maused Harney, 2006.Essentials of Clinical Immunology (5thedn.) Blackwell Scientific Publications
- Ivan M. Roitt, 2002. Essential of Immunology. ELBS, New Delhi.
- Khan.F.H. 2009.The Elements of Immunolgy. Pearson Education. New Delhi. Kuby J, 2000. Immunology (7thedn.). WH Freeman & Co. New York. Richard Coico and Geoffrey Sunshine. 2009. Immunology: A short course. Wiley- Blackwell, CA,USA

Practical III: Molecular, Physiological and Immunological Methods & Approaches in Biosciences (PZO3CRP0120)

180 Hours 4 Credits

Course Outcomes

- Become familiar with museum specimens and the tools and techniques to study their evolutionary relationships
- Be able to identify larval forms
- Explore the behavioural pattern of different organisms
- Become familiar with online tools to analyze the structure of biomolecules
- Estimate and analyse biomolecules and their significance and Gain knowledge in descriptive statistics and apply in academic and research fields

Cell & Molecular biology and Biotechnology (72 Hours)

- Squash preparation of grasshopper testis to study meiotic stages.
- Squash preparation and identification of salivary gland chromosomes in *Drosophila / Chironomus* larva.
- Determination of mitotic index in the squash preparation of onion root tip.
- Effect of drugs on cell division (Colchicine or any other inhibitor)
- Live staining of cells using vital stains and viability study
- Cell fractionation and Differential Centrifugation to isolate mitochondria and nuclei
- Preparation of Microtome section & spreading
- Histochemical staining of carbohydrates (PAS), Protein (Bromophenol blue), lipids (Sudan Black), DNA (Fuelgen stain
- Gel electrophoresis of protein and nucleic acid (Demonstration)
- Isolation of genomic and Plasmid DNA.

Biophysics/Instrumentation/Biological Techniques (36 Hours)

- Micrometry- principle and measurement of microscopic objects: Low power and high power
- Camera Lucida – Diagrammatic representation of specimen using camera

lucida

- Principle and working of phase contrast microscope, Micro-photographic equipment,
- Identification of absorption maxima of the given sample by colorimetry
- TLC using amino acids from purified samples and calculation of RF values
- Analysis of biological materials (Arthropodan perilymph) using TLC

Animal Physiology (72 Hours)

- Rate of salivary amylase activity on starch (colorimetry)
- Effect of different pH on salivary amylase activity (colorimetry)
- Influence of temperature on salivary amylase activity – Calculation of Q10
- Effect of drugs on the heartbeat of cockroach (Result with graphical representation corresponding to different concentration and time intervals expected)
- Oxygen consumption in fish (normal and stressed).
- Kymograph: working principle and applications.
- Virtual Practicals in Physiology

  (Use of PhysioEX 9.0 : *Laboratory Simulations in Physiology* by P.Zao., T.Stabler., L.A.Smith and E .Griff. 2011.is suggested) for muscle and nerve physiology practical for class room training and for practical examination in order to replace Frog as per UGC guidelines). Any four of the following:

  Muscle Twitch and the Latent Period, The effect of stimulus Voltage on Skeletal Muscle Contraction, Tetanus, Fatigue, Receptor Potential, The Action Potential Threshold, Importance of Voltage –Gated Na+ Channels
- Differential count of Human WBC
- Haematocrit and ESR of Human blood
- Feeding activity of paramecium
- Effect of different concentration of NaCl solution (0.1%-2%) on the diameter of RBCs (preferably human) and determination of the concentration , which is isotonic to the blood from a plot of diameter of RBC against concentration of NaCl

Immunology

- Separation of lymphocytes from whole blood.
- Separation of T and B lymphocytes
- Blood Typing in Man.
- WIDAL Test and Western Blotting –Demonstration
- ELISA -Demonstration
- Rocket Immuno electrophoresis- Demonstration

Note: Good laboratory practices and green protocol should be practiced in the lab. Virtual Practical developed by the Ministry of Human Resources, Govt. of India and available in the web site: www.vlab.ac.in can be availed for demonstration.

Detailed Syllabus: Semester IV

ELECTIVE A: FISHERY SCIENCE

Sl.no	Name of the Course
1	Nutrition, Growth and Physiology of fishes
2	Fishery Resource Management
3	Fishery Science and Technology
4	Practical : Fishery Science – Methods and Approaches

Nutrition, Growth and Physiology of Fishes Approaches

90 Hours 4 Credits

Course Outcomes

- To impart knowledge on various aspects of fish biology
- To understand the basic principles of fish nutrition and the function of individual nutrients.
- To learn functional physiology of fishes.

Module I (20 Hours)

Food and feeding biology (04 Hours)

Components of balanced food, classification of fish food organisms, ingestion of food and feeding mechanism. Feeding adaptations.

Digestive system and physiology of digestion (10 Hours)

Digestive system in fin fish and shell fish. Anatomy, histology and functions of different parts of gastro-intestinal tract in herbivores and carnivores. Modification of digestive system in relation to age and growth.

Physiology of digestion, absorption and assimilation. Role of hormone in the regulation of digestion. Factors affecting digestion and transport of nutrients.

Module II (27 Hours)

Fish Nutrition (20 Hours)

Energy nutrition – Definition, energetics, expression of energy value of feed – gross energy, digestible energy, metabolizable energy, net energy. Partitioning of energy, protein energy ratio. Protein nutrition of fish– source, function and deficiency symptom. Lipid nutrition – source, function and deficiency symptom. Carbohydrate nutrition – source and function.

Vitamin and mineral nutrition –source, functions, deficiency symptoms.

Larval nutrition – Importance of live feed and artificial feed, different types of feed available for larvae, larval gut morphology and mode of nutrition.

Brood stock nutrition – Nutrients required for reproduction, egg and sperm quality.

Feed additives – classification, function, specific use for economic and quality fish and shellfish production.

Growth (07 Hours)

Concept of growth, determination of age and growth, growth curve, length weight relationship. Metabolism (anabolism and catabolism) and growth. Biotic and abiotic factors affecting growth. Role of nutrients and hormones in the regulation of growth.

Module III (20 Hours)

Reproductive physiology and endocrinology

Sexual dimorphism, primary and secondary sexual characters, bisexual reproduction, inter-sexes, hermaphroditism, sex differentiation and factors affecting sex differentiation. Sex reversal in fish and factors affecting sex reversal.

Development of gonad, oogenesis, Mechanism of oocyte maturation and ovulation, spermatogenesis, metabolic changes during oogenesis and spermatogenesis, vitellogenesis and gonadal steroidogenesis.

Modes of reproduction – oviparity, aplacental viviparity and placental viviparity.

Annual reproductive cycle and breeding patterns in male and female, pheromones and reproductive behaviour, nest building and parental care. Hormonal and environmental regulations of reproduction.

Regulation of seasonal reproduction – Role of environment: temperature, photoperiod, rainfall. Role of hypothalamo-hypophyseal system and pineal gland, role of peripheral endocrine system.

Module IV (19 hours)

Sensory Organs (07 hours)

Structure and function of sense organs. Visual, chemoreception, statoacoustic, mechanoreceptors, thermoreceptors, electroreceptors.

Specialised Characters (12 hours)

Gill structure and physiology of respiration. Accessory respiratory organs, mechanism of air breathing. Swim bladder, structure and function.

Weberianossicle. Electric organs, Luminescent organs. Sound production and detection. Acoustic communication. Venomous fishes.

Adaptations to special conditions of life – hill stream, cave, deep sea. Chromatophore pigments and colouration. Physiology of colour change.

Module V

Physiology of behaviour (10 hours)

Concepts on fish behaviour and regulatory mechanism. Alarm reaction transduction mechanisms.

Domestication processes in communicative behaviour. Locomotive behaviour. Behaviour due to environmental partition.

Chemical signals to evoke feeding behaviour. Aestivation and hibernation.Migrations and orientation. Predatory avoidance. Adaptation mechanism in altered environment.

References

- Brown C, Laland KN & Krause J. 2006. Fish Cognition and Behaviour. Blackwell. Pitcher TJ. 1993. Behaviour of Teleost Fishes. Springer.
- Chandrasekhar, Y.S. 2013. Fish Nutrition in Aquaculture. Swastick Publications, Delhi.
- Cyrino EP & Bureau D & Kapoor BG. 2008. Feeding and Digestive Functions in Fishes.Science Publ.
- Evans, D.H and Claiborne, J.D 2006. The physiology of fishes. Taylor and Francis group, CRC Press, UK
- Guillame J, Kaushik S, Berqot P &Metallier R. 2001. Nutrition and Feeding of Fish and Crustaceans. Springer Praxis.
- Holt, G.J. 2011. Larval Fish Nutrition. Springer-Verlag, New York Halver JE & Hardy RW. 2002. Fish Nutrition. Academic Press.
- Hoar WS & Randall DJ.1988. Fish Physiology. Academic Press.
- Lovell, T. 2009. Nutrition and Feeding of Fish. Springer-Verlag, New York
- Lynwood S Smith, 1999. Introduction to fish Physiology. Narendra Publishing house, Delhi Rankin JC & Pitcher TJ.1983. Control Processes in

Fish Physiology. Springer.

- Raghunath, M.R. 2013. Nutrition and Feeding of Fishes. Swastik Publishing House, Delhi. Smyth & Lynwood. 2003. Introduction to Fish Physiology. Narendra Publishing House, Delhi, 352pp.
- SurendraNath. 2002. Food, Feeding habits and Alimentary canal of fishes. Vinod Publishers and Distributors, India.

Fishery Resources and Management

90 Hours 4 Credits

Course Outcomes

- To impart knowledge in inland and marine fishery resources of India
- To educate the students on the oceanographic concepts related to fisheries
- To impart theoretical knowledge on application of remote sensing and GIS in fisheries
- To impart theoretical knowledge of benthic ecology.
- To impart knowledge on interactions between aquaculture and the environment.

Module I (30 Hours)

Inland Fishery Resources (10 Hours)

Categorization of different fresh water and brackish water resources – Ponds, lakes, tanks, rivers, reservoirs, estuaries, brackish water lagoons, wetlands, mangroves and derelict water bodies. Important economically important fin and shell fish resources of Kerala. Scope of inland fishery in Kerala.

Riverine fishery resources – major riverine fisheries in India. Penninsul arrivers and its fishery diversity with special reference to endemic species in Kerala. Present status of riverine fishery in Kerala.

Reservoir fisheries – Classification of reservoirs. Reservoir fishery of Kerala. Methods for enhancement of productivity.

Estuarine fisheries – Classification of estuaries. Status and potential of estuarine fisheries in Kerala. Status of mangrove fishery in India.

Inland Fishery – Problems, conservation and management (20 Hours)

Direct and indirect effects of human intervention and management challenges in riverine fishery. Present trend of dwindling riverine fishery resources. Habitat modification and improvement – restoration, rehabilitation of channels and flood plain. Stock enhancement strategies.

Methods for conservation, management and enhancement of productivity in reservoirs.

Effect of dam on riverine fishery. Protection and restoration of fish movements – different types of fish passes and enhancement of fish migration.

Strategies for the conservation and management of estuarine system. Mangrove ecosystem – degradation and its problems on fisheries.

Derelict water bodies – problem and fishery management aspects. Riverine sand mining and its effect on benthic biodiversity and fisheries. Invasive species and its effect of indigenous species and fishery.

Activities of FIRMA. Matsyafed – objectives and different activities for the development of fishery of Kerala.

Module II (15 hours)

Marine fishery resources (07 hours)

Major fishing regions of the sea. Important finfish and shellfish resources in demersal and pelagic system. Sea weeds.

Issues and challenges of managing multi-gear fisheries.

Mud bank formation and significance. Mud bank fishery in Kerala.

Marine Biodiversity and conservation (08 hours)

Marine biodiversity – threats, planning and management aspects.

IUCN criteria – Red list, Wild life Protection Act, International treaties and conventions, Marine protected areas, Sanctuaries and Biosphere reserves. Establishment of National marine parks, in situ and ex situ conservation. Coastal tourism.

Module III

Fisheries Oceanography (20 hours)

Oceanographic factors in fisheries – effects of physicochemical (Salinity, temperature, pH, light, pressure, dissolved gasses and nutrients) and biological oceanographic factors on adaptation, behaviour, abundance and production of organisms.

Synoptic oceanographic analysis – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns.

Fisheries forecasts – Remote sensing, Global positioning system (GPS). Application of remote sensing in fisheries. Eco-sounders and Sonar – applications in fishery. Interpretation and use of thermal structure in fisheries.

Factors affecting coastal marine fishery – environmental factors influencing the seasonal variations in fish catches in the Arabian Sea. Potential fish zones (PFZ). Fishery trawling ban in Kerala.

Module IV

Aquaculture and Management Aspects (20 hours)

Fresh water fish farm – survey of site, layout, soil and water quality requirements. Pond fertilization. Different kinds of fertilizers and manures. Bio-fertilizers, use of treated sewage for pond fertilization.

Methods of culture fishes of Indian major Carps, exotic Carps, Catfishes, Murrels, Tilapiaand Prawns.

Methods of culture of grey mullet, milk fish, crabs, shrimps. Traditional (Bheries, Pokkali) and modern methods of prawn culture. Culture of pearl oyster, edible oyster and sea mussels.

Integrated fish culture. Composite fish culture. Integrated farming and aquaponics. Benefits of aquaponics.

Ornamental fishery and its export from India. Aquarium fishes. Setting up and maintenance of an aquarium.

Management of hatcheries and farms. Methods for control and management of aquatic weeds in the system. Role of microorganisms in fish production, microbial load and algal bloom. Algal bloom control.

Module V

Fisheries Education (05 hours)

Objectives and functions of Fisheries Institutes – Central Institutes of Fisheries Education (CIFE), Central Inland Capture Fisheries Research Institute (CICFRI), Central Marine Fisheries Research Institute (CMFRI), Central Institute of Fisheries, Nautical and Engineering Training (CIFNET), Central Institute of fisheries technology (CIFT), National Institute of Oceanography (NIO), National Institute of Fisheries Post Harvest Technology and Training (NIFPHATT).Central Institute of Brackish water Aquaculture (CIBA), Fishery

survey of India (Brief account only).

References

- Aravind Kumar, 2004. Fishery Management. APH Publ. Corpn., New Delhi, 371 pp Badapanda, K.C. 2012. AquacultureVol.1 .Narendra Publishing House, Delhi, 496pp.
- Balakrishnan Nair N and Thampi D M 1980. A text book of marine ecology. Publisher Macmillan
- Carter RWG. 1998. Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines. Academic Press.
- Dholakia A D 2001. Fisheries and Aquatic Resources of India. Daya Publishing House, New Delhi.
- De Silva SS & Anderson TA. 1995. Fish Nutrition in Aquaculture. Chapman & Hall. Jhingran VG. 1991. Fish and Fisheries of India. Hindustan Publ. Corp.
- Laevastu T & Hayes ML. 1981. Fisheries Oceanography and Ecology. Fishing News Books. Lalli CM & Parsons TR. 1993. Biological Oceanography: An Introduction. Elsevier.
- Long, A.C. 2012. Fish feeding and integrated fish farming. Cybertech Publications, Delhi. Miller CB. 2004. Biological Oceanography. Blackwell.
- Patro&Lingaraj. 2012. Fisheries & Aquaculture. Sonali Publication, Delhi, 473pp
- Pillay TVR &Kutty MN. 2005. Aquaculture: Principles and Practices. 2ndEd. Blackwell. Pillai N.G.K 2011. Marine fisheries in India, ICAR, New Delhi
- Pandey N &Davendra SM. 2008. Integrated Fish Farming. Daya Publ. House. Reddy MPM. 2007. Ocean Environment and Fisheries. Science Publ.
- Sakhare, V.B. 2012. Inland fisheries. Daya publishing house, Delhi, 326pp.
- Sharma A.P. 2012. Management issues in Inland Fisheries and Aquaculture.Narendra Publishing House, Delhi, 243pp.
- Sugunan, V.V. 1995. Riverine Fisheries of India. FAO Publication, 423 pp. Sugunan V.V. 1997. Reservoir Fisheries of India. Daya Publ. House.
- Welcomme RL. 2001. Inland Fisheries: Ecology and Management. Fishing News Books. Society of Fisheries Technology (India), 2000.

- Riverine and Reservoir fisheries of India. Proceedings of the National Seminar on Riverine and Reservoir Fisheries – Challenges and Strategies, 2001, Cochin.

Fishery Science and Technology

90 Hours 4 Credits

Course Outcomes

- To understand the advances in aquaculture
- To outline an overview on the potential marine resources for bioactive compounds and pharmaceuticals
- To give detailed insight into various aspects of freezing of fish and thermal/heat processing.
- To understand various aspects of quality assurance system, quality management and national/international certification system.
- To learn factory sanitation and hygiene, water quality and standard
- To provide information on various fish by-products and fishing methods

Module I (27 Hours)

Aquaculture Biotechnology (20 Hours)

Fish breeding – Induced breeding and hypophysation: synthetic and natural hormones, cryopreservation of gametes and artificial fertilization. Application of biotechnology for accelerating gonadal growth and manipulation of the duration of spawning.

Transgenesis – methods of gene transfer in fishes, screening for transgenics, applications, regulation of GMOs, IPR, evaluation of GFP transgenics.

Gene bank and conservation – conservation of gametes and embryos.

Algal technology – microalgae: indoor and mass culture methods, biotechnological approaches for production of important microalgae, single cell protein from Spirulina, raceway system of micro algae culture, vitamins, minerals and omega3 fatty acids from micro algae, enrichment of micro algae with micronutrients.

Post harvest biotechnology – delaying spoilage, detection of toxic substances and pathogenic microbes, biosensors for toxins.

Marine Biotechnology (07 Hours)

Marine resources – biodiversity, marine natural products, valuable

chemicals, biomedical and bioactive compounds from marine organisms, commercial bio-products from marine organisms, green fluorescent protein form jelly fish and its application, marine organisms as a sources of polysaccharides, antiviral, anticancer and anti-inflamatory compounds. Commercially important enzymes-xylanase, agarase, proteaess, chitinases, lipases, cellulae and phytase.

Module II

Advances in Feed Technology (15 Hours)

Feed formulation – least cost formulation, linear programming. Quality of feed ingredients and their biochemical composition. Protein and energy supplements. Premixes of vitamins and minerals. Antioxidants in diets. Toxins in feeds. Exogenous enzymes. Feed probiotics and their role. Feed additives. Water stability of diets.

Feed technology – micro encapsulated feeds, micro coated feeds, micro particulate feeds and bio capsulated feeds, mycotoxins and their effects on feeds.

Feed manufacture – processing of feed mixtures, steam pelleting. Stability of nutrients. Factors affecting feed manufacture. Effects of processing on the nutritional value of feeds. Process of reducing anti-nutritional factors. Feed mills. Quality control of feed. Storage of feed and feed deterioration.

Module III

Technology of fish freezing (12 Hours)

Crystallization, homogeneous and heterogeneous nucleation, super cooling, crystal growth eutectic point, location of ice crystals in tissue, physical changes during freezing.

Technological aspects of freezing: slow and rapid freezing, methods of freezing, comparison of various freezing methods, selection of a freezing method, product processing, packaging and different types of freezers.

Chemical treatments prior to freezing: antioxidants, cryoprotectants and other addictives, theories of cryopreservation, glazing

Frozen storage: physical and chemical changes, freezer burn and recrystallization, different types of recrystallization.

Different methods of thawing frozen fish, advantages and disadvantages. Recent advances in fish thawing.

Module IV (21 Hours)

Thermal processing of fishery products (08 Hours)

Principles of thermal processing. Mechanism of heat transfer: conduction, convention, radiation and dielectric and microwave heating, heat resistant of bacteria and spores. Thermal death time. Significance of thermal death curve. Heating equipment.

Canning process, steps involved, process flow, addictives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment.

Spoilage of canned food, physical, chemical and microbial. Thermo bacteriology, death of bacteria, auto sterilisation bacteriology of canned/heat processed fishery product, examination of canned and seams.

Fishery By-products (05 Hours)

Traditional fishery by-products: fish meal and fish oil – preparation and uses. Processing of wastes – prawn heads, chitin, chitosan, fish protein concentrate (FPC) preparation. Uses of shell, isinglass, glue, guano, fins and leathers. Packaging, storage and transport of fish products.

Quality control in processing industry (08 Hours)

Plant sanitation and hygiene. Water quality and standard. Inspection system.

Quality assessment of fish and fishery products – physical, organoleptic and microbiological quality standards. National and International standards. Integrated food law.

Sensory evaluation of fish and fish products, basic aspect, different methods of evaluation.

Module V

Fishing Methods (15 Hours)

Crafts and gears used for fishing in inland and marine waters. Gears – types and designs, operation and efficiency. Destructive and prohibited fishing practices. Recent advances in fishing method. Fishing using electricity, light. Bycatch reduction devices: definition, types of bycatch reduction

devices and the principles of operation. Fish finders – ecosounders and sonar and their use. Different type of turtle excluder devices (TEDs). Advanced communication systems – VHF, SSB, Inmarsat system. Vessel monitoring systems (VMS): Important uses, role in fisheries management.

Fishing harbours – classification, facilities, layout of a typical fishing harbour. Fishing harbours of Kerala coast.

References

- Balachandran KK. 2001. *Post-harvest Technology of Fish and Fish Products*. DayaPubl.House. Fingerman M, Nagabushana M & Thompson R. 1998. *Recent Advances in Marine Biotechnology*. Vol.II. Science Publ.
- Fingermann, Milton, Nagabhushanam&Rachakonda. 2000. *Recent Advances in Marine Biotechnology*. Oxford & IBH publishing Co. Pvt. Ltd., Delhi, 382pp
- Fusetani N. 2000. *Drugs from Sea*. Karger Publ.
- Gopakumar K. (Ed.) 2002. *Text Book of Fish Processing Technology*. ICAR
- Huss HH, Jakobsen M & Liston J. 1991. *Quality Assurance in the Fish Industry*. Elsevier.
- Lakra WS, Abidi SAH, Mukherjee SC &Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
- Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*. Dominant Publ. Nagabhushanam R, Diwan AD, Zahurnec BJ &Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.
- Nambudiri DD. 2006. *Technology of Fishery Products*. Fishing Chimes.
- Ninawe A. S &Khedkar G D, 2009. *Nutrition in Aquaculture*. Narendra Publishing house, Delhi Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.
- Reddy PVGK, Ayyappan S, Thampy DM &Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.
- Sen DP. 2005. *Advances in Fish Processing Technology*. Allied Publ. Venugopal V. 2006. *Seafood Processing*. Taylor & Francis.
- Vincent K &Omachonu JER. 2004. *Principles of Total Quality*. CRC Press.

Zeathen P. 1984. *Thermal Processing and Quality of Foods*. Elsevier.

- *Training Programme on Seafood quality Assurance*. Central Institute of Fisheries Technology (ICAR).
- *Quality Assurance in seafood processing*, 2000. Published by CIFT and Society of Fisheries Technology.

Fishery Science: Methods & Approaches

180 Hours 4 Credits

Taxonomy

Study of distinguishing features (morphometric and meristic)

- Identification of bony and cartilaginous fishes using manuals (marine and freshwater – any 10 fishes)
- Identification and classification of distinguishing features of commercially important shell fishes (crustaceans and molluscs – any 5 shell fishes)

Anatomy (54 Hours)

Study of anatomy of a teleost fish

- Studies on gills, scales, pharyngeal teeth and brain of fishes (Mounting and/or spotters).
- Dissection and display of

  Digestive system, (Minor) Urinogenital system (Minor)

  Swim bladder (Minor)

  Weberian ossicles, (Minor)

  Branchial Blood vessels and Blood supply to air breathing organs Cranial nerves – V, VII, X
- Study of skeletal system – skull and vertebrae

Physiology (36 Hours)

- Determination of haemoglobin content in fish blood
- Identification of blood cells in teleost fish
- Determination of the rate of ammonia excretion in fish
- Estimation of total protein in fish muscles
- Identification of amino acids in fish muscles by TLC

Fishery Biology (36 Hours)

- Study of feeding habits of fish through qualitative and quantitative analysis of gut contents of herbivore, carnivore and omnivore species.

- Determination of gonadosomatic index
- Estimation of fecundity
- Measurement of ova diameter
- Length – weight relationship

Fishery technology (18 Hours)

Fishing crafts and gears –

- Identification of various components of a mechanized fishing craft from actual specimen/model/drawing (Inland and Marine)
- Study of principal types of fishing gears from actual specimen/model/drawing
- Identification of fishing gear materials: twine, ropes, floats, sinkers, buoys and anchors.
- Identification of fishery by-products
- Formulation and preparation of artificial fish food

Fishery Resources (18 Hours)

- Identification of exotic and indigenous aquarium fishes (any 10 fishes)
- Setting up an aquarium tank – fresh water
- Identification of aquarium plants (any 5)
- Breeding trials on selected aquarium fishes: Breeding and rearing of any three ornamental fishes (one each from live bearer, egg scatterer and bubble nest builder)
- Collection and identification of aquatic weeds and aquatic insects.
- Identification of pathogenic organism or parasites
- Treatment of fish diseases

Group activity (18 Hours)

- Setting up a freshwater aquarium by 4 or 5 students (Individual evaluation during practical).

Field work and study tour

- Two to three days tour to study various fishery activities at selected centres/sites. Visit to a fish seed production farm. Fresh water and brackish water aquaculture. Fishing operations, fish landing centres, packing, and transport. Fish preservation and processing chain. Boat building yard and net making plant. CMFRI, CIFT, CIFNET, NIFPHATT, NIO, KUFOS.
- Report the study conducted and submit a 10 page write up/printout giving dates, methodology, results and references including photographs of the field study.
- Viva

ELECTIVE B: ENVIRONMENTAL SCIENCE

Sl.no	Name of the Course
1	Environmental Science: Concepts and Approaches
2	Environmental Pollution and Toxicology
3	Environmental Management and Development
4	Practical : Environmental Science

Environmental Science: Concepts and Approaches

90 Hours 4 Credits

Course Outcomes

- To provide a broad and deep understanding on environment and influence of man on environment
- To equip the students to use various tools and techniques for the study of environment
- To enable the learner to understand, think and evolve strategies for management and conservation of
- environment for sustaining life on earth
- To take up further studies and research in the field

Module I (26 hours)

Earth System and Biosphere (4 hours)

Concept of life and life supporting systems. The origin and structure of earth, primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere.

The Physical Environment (22 hours)

Lithosphere - Weathering and soil formation, - soil colloids, adsorption and exchange of anions and cations, role of microbes in soil, types of soil, soil profile, classification of rocks, folds, faults and dykes and other geological formations and their environmental significance. Geomorphological processes- plate tectonics, sea floor spreading, mountain building, evolution of continents and structural deformation.

Atmosphere -Physico-chemical characteristics, divisions, composition and significance of atmospheric components.

Hydrosphere -Visible and invisible hydrosphere, Range of aquatic habitats, water cycles between earth and the atmosphere, Global water balance, ice sheets, origin and composition of sea water, sea level changes, River basins and watershed. Physico-chemical characteristics of water- diffusion of oxygen from the atmosphere to surface waters. Influence of pH, turbidity and light on aquatic life.

Module II (18 hours)

Weather, Climate and Microclimate (12 hours)

Definitions and scope of climatology, weather, climate and microclimate, components of climate system, earth's thermal environment, earth intercepts solar radiation, seasonal variation in intercepted solar radiation, air temperature in relation to altitude, global circulation of air masses, wind and earth's rotation onocean currents, influence of temperature on moisture content of air, global pattern of precipitation, influence of topography on regional pattern of precipitation. Classification of climate-Koeppen's classification and Thornthwaite's scheme. Climatic types and zones.

Climate Change (3 hours)

Global climatic phenomena-El Nino and La Nina. Causes and factors of climate change. Effect of Climate change on ecosystems and human welfare. Global climate models.

Climate of India (3 hours)

Climatic regions of India, tropical monsoon climate-onset, rain bearing systems, break in the monsoon, retreat of monsoon. Monsoon in Kerala : Western Ghats, oceanic and continental influence.

Module III

Landscape Ecology (10 hours)

Ecological principles at work with Landscapes ; Land Use in agro-ecosystems, urban ecosystems, rangelands, riparian and wetland systems, coastal and estuarine systems.

Concept of ecological land degradation, desertification, water logging, salinisation and soil erosion.

Integrated analytical techniques- land suitability analysis and carrying capacity studies; Use of soil survey, aerial photos, topographic maps and other resource data in landscape management; corridor selection problems.

Module IV

Biodiversity and Conservation (20 hours)

Biodiversity-concepts and patterns. Types of biodiversity-wild biodiversity, agro-biodiversity, domesticated biodiversity. Values of biodiversity, ecosystem

functions and biodiversity, mobile links and valuating ecosystem services. Drivers of biodiversity loss.

Tools and techniques for biodiversity estimation- biodiversity indices.

Strategies for biodiversity conservation- In-situ conservation: sanctuaries, biospheres reserves, national parks, nature reserves, preservation plots.

Ex-situ conservation: botanical gardens, zoos, aquaria, homestead garden; herbarium; In-vitro Conservation: germplasm and gene bank; tissue culture: pollen and spore bank, DNA bank. GEF-World Bank initiatives. Biodiversity hotspots and their characteristics, global distribution. CBD, National and international programmes for biodiversity conservation. CITES and TRAFFIC.

Indian Biodiversity Act 2002 and laws, National Board of Biodiversity, State Board of Biodiversity. Ecosystem people and traditional conservation strategies; People's participation in conservation-PFM, community reserve and People's Biodiversity Register (PBR). Biodiversity Management Committee (BMC). Wildlife values and eco-tourism, wildlife distribution in India, problems in wildlife protection-Policies and programmes. Threatened animals of India, Project Tiger

Module V (16 hours)

Biological Invasions (12 hours)

Introduction Elton‟s hypothesis – Invasion patterns and process biological attributes for invasion: Reproductive potential, Allelopathy, Phenotypic plasticity, fitness to the new environment. Hypotheses for invasion success: Natural enemy hypothesis, evolution of invasiveness hypothesis, empty niche hypothesis, novel weapon hypothesis, disturbance hypothesis and Propagule pressure hypothesis. Invasive alien species of India (plants and animals). Databases of biological invasions. Impacts and management of invasions:

impacts of exotics on biodiversity, productivity, nutrient cycling. Management: Bio-control programmes, mechanical and chemical control Positive utilization Quarantine and EIA of biological invasion.

Environmental Economics (4 hours)

Origin and scope of environmental economics, Green Economy: sustainable utilization of natural resources.

Environmental Pollution and Toxicology

90 Hours 4 Credits

Module I (15 hours)

Introduction (3 hours)

Definition of pollution, Different types of pollution- Air, Water and soil and their local, regional and global aspects.

Air Pollution (12 hours)

Sources and classification of air pollution; particulates and gaseous pollutants in the atmosphere(GHG). Primary and secondary pollutants. Effects of air pollutants on human health, animals, vegetation, materials and structures. Air pollution monitoring - methods, air quality standards; ISI, EPA.Sampling and measurement of particulate matters (SPM) - gaseous pollutants, C02, CO, NOx, S02, H2S, oxidants, ozone and hydrogen fluoride.Control of gaseous emission: adsorption by liquids,adsorption by solids, combustion and condensation.

Control of S02, NOx, CO, CO2and hydrocarbons. Carbon sequestration,Carbon Credit,Carbon foot print and carbontrade,Case study:Air pollution in Delhi.

Module II

Water Pollution (15 hours)

Sources of water Pollution-Domestic (municipal sewage), industrial and agricultural. Ground water pollution. Water quality standards for potability:BIS,WHO,Pollution parameters:BOD, COD, Coliform bacteria. Effects of water pollution on human health and aquatic systems. Traditional water purification techniques. Treatment of water for potable purpose (mixing, sedimentation, coagulation, filtration and disinfection).

Waste water treatment: Primary and Secondary treatment, Biological treatment: Kinetics of Biological growth - activated sludge treatment - trickling filters - anaerobic digestion, combined aerobic and anaerobic treatment process, aerobic process.Sludge disposal

Advanced waste water treatment - removal of dissolved organics and inorganic - precipitation, iron exchange, reverse osmosis, electro dialysis, adsorption and oxidation. Removal of nutrients. Removal of heavy metals.

overall waste water treatment for sewage water. Sewage treatment and Sewage treatment plants. Water pollution treatment using constructed wetlands. Ganga action plan.

Soil Pollution (10 hours)

Sources of soil pollution; - agricultural, industrial and domestic. Hazardous waste compounds, formulations and classes of substances, chemical classification of hazardous waste. Soil factors affected by pollution – physico-chemical and biological impacts. Case study on soil pollution in wetland and Highland soils in Kerala. Control of soil pollution. Soil quality parameters.

Module III

Solid Waste Management (15 hours)

Municipal solid wastes (MSW) - quantities and characteristics, waste collection and transport, waste processing and resources recovery and recycling. Aerobic and anaerobic systems- composting, vermicomposting; Bio digesters (Biogas plants); incineration, pyrolysis, plasma pyrolysis; sanitary y landfills and open dumping yards. Management of plastic and e-waste.

Treatment process for unsegregated waste, fixation of hazardous solid waste prior to disposal, hazardous waste in land fill. Hazardous waste (Management and Handling) Rules 1989 - the Manufacture Storage and Import ofHazardous Chemicals Rules 1989 - Biomedical Waste (Management and Handling) Rules 1998 -Plastic Act 1999.

Module IV (15 hours)

Noise, Thermal and Oil Pollution (7 hours)

Definition: sound and noise. Assessment and measurement of sound, National and International Standards, Effects of noise on People and ecosystem. Basic principles of noise control.

Thermal Pollution-causes and consequences.

Oil pollution – causes and consequences (any two case studies).

Radiation Pollution (8 hours)

Radiation pollution- Definition, Sources and effects

Radioactive pollution: Radioactivity, Radioactive decay and build up,

Radionuclide, Radiation emissions, safety standards. Radioactive waste management. Nuclear reactor disasters (Any one case studies), Impacts radiation pollution on ecosystem.

Module V

Toxicology (20 hours)

Acute and chronic toxicity, Selective toxicity, dose, synergism and antagonism.

Dose – Response relationships – Graded response, quantal response, Time action curves, Threshold Limit value (TLV); LC50; Margin of safety; Toxicity curves; Cumulative toxicity and LD50and CTF.

Toxic chemicals in the Environment – Biochemical aspects of As, Cd, Pb, Hg, Cu, O3, PAN, pesticides, MIC and other carcinogens.

Bio accumulation and bio magnification.

Occupational toxicology- hazardous chemicals, disorders from chemical exposure at work, assessment of occupational hazards.

Toxicity testing and Bioassay – Definition, purpose, criteria for selection of test organism, methodology, estimation of LC50, acute toxicity (single); sub-acute toxicity; chronic toxicity; teratogenicity, carcinogenicity and mutagenicity.Limitation and importance of bioassay.

Bio-monitoring of toxic chemicals, concepts of bio indicators.Bio-transformation of Xenobiotics, Bioremediation

Environmental Management and Development

90 Hours 4 Credits

Module I

Environmental Management (20 hours)

Basic principles: Management of physical, social, and economic environment. Concepts and scope of environmental planning, regional planning and management. Cost-benefit analysis and Resource economics. Environmental modelling- simulation modelling, input-output modelling, Linear programming

SEA, Ecological Economics, Eco funds.

Environmental auditing and standards, Eco labelling and certification, accreditation – need, objectives and benefits; Corporate social responsibility and Corporate environmental responsibility, ISO standards for environmental management systems (EMS) ISO 14000, 14001 and 26001; OHSAS 18001.

Module II

Ecosystem Management (20 hours)

An overview Population, Resources and ecosystem management Exponential growth in human numbers and the implications.

Major management concepts and methodologies The five basic laws of Ecology and their relevance for ecosystems management;

Management practices for various ecosystems: grasslands, forests, mountains, wetlands and coastal areas. Environmental planning and management of – waste lands, reclaimed lands, mining areas, human settlements, industrial lands and agricultural lands.

Eco restoration/remediation; the common property resources and their management; local knowledge and management systems; environment management through Biotechnology; Green revolution-environmental impacts

Module III

Environmental Impact Assessment (EIA) (20 hours)

Introduction- Definition, history, Aim, principles, concept and scope. Baseline data collection, Methods and steps - Adhoc method, checklist method,

matrices, Map overlays method, network method, index method.

Impact assessment and impact evaluation-E1A Processes, Stages, E1A Statement Environment management plan- Risk assessment. National Policy on EIA and Regulatory Framework:

Environmental Impact Assessment Notification 2006 and Coastal Zone Notification 1991; and its amendments. Environmental Clearance Process in India; Legislative requirements (discharge requirements and area restrictions); Environmental Appraisal procedure. Central and state pollution control boards for environmental protection. EIA case studies. Life Cycle Assessment (LCA) and its significance.

Module IV (22 hours)

Remote Sensing and GIS* (17 hours)

Principles and concepts of Remote Sensing, Electromagnetic spectrum; spectral characteristics of surface features (rocks, soils, vegetation, water).

Space Imaging Landsat, SPOT, IRS, NOAA, Seasat, ERS, RADARSAT, INSAT. Geometry and radiometry,

Digital Image Processing: Principles, Image Rectification and restoration, Image enhancement and Mosaicing. Image classification. Supervised, Unsupervised, Ground truth data and training set manipulation

Geographical Information System (GIS): Basic principles, Raster and vector data, Map projection, Topology creation, overlay analysis, Data structure and Digital cartography; Software used in GIS, Geodetic survey;

Global Positioning System (GPS) Basic principles, Applications to environmental studies.

Module V. Disaster management (5 hours)

Disaster management-definition and classification: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Nuclear hazards. Mitigation Measures.

Module V

Sustainable Development (10 hours)

Environment Vs Development. The idea of Sustainable Development - concepts and dimensions. Basic needs-Imperatives relating to sustainable

development. Johannesberg Conference 2002 and follow up Conference on sustainable development. Securing Sustainable futures, Millennium Development Goals and Strategies (MDG & S); the earth charter; need and scope for evolving participatory, community based environmental management strategies. . Ecological Foot Print analysis and its significance. Environmental concerns in traditional societies, Gandhian environmentalism.

* Note:

Students and faculty can avail of the facility RS & GIS Division of School of Environmental Sciences of the MG University for technical support and guidance for Module IV.

References

- Agarwal, N.K. 2004. Essentials of GPS. Spatial Networks Pvt. Ltd., Hyderabad. Agarwal, S.K. 2002. Eco informatics. APH Publishing Corporation, Hyderabad.
- Asit K. Biswas et.al., 1987. EIA for Developing Countries. United Nations University, Tokyo. Carter,L.1996. Environmental Impact Assessment. McGraw Hill,New Delhi
- Coronel, C., Morris, S. and Rob, P. 2009. Database Systems: Design, Implementation and Management.9th edn., Course Technology.
- Eagles, P.F.J.1987. The planning and Management of Environmentally Sensitive areas. Longman Group Ltd., USA.
- Elachi, C. 1978. Introduction to Physics and Techniques of Remote sensing. John Wiley Pub., N.Y.
- Ewing B., D. Moore, S. Goldfnger, A. Oursler, A. Reed, and M. Wackernagel. 2010.
- Floyd F., and SabinsJr.,W.H. 1987.Remote Sensing, Principles and Interpretation. Freeman & Company, New York, 2nd Ed., 1987.
- Gadgil, M. and Guha, R. 1995. Ecology and Equity- The Use and Abuse of Nature in ContemporaryIndia,.Penguin India.
- Gadgil, M. and Guha, R.1998. The Fissured Land; An Ecological History of India; Oxford University Press, New Delhi.

- Goldsmith, B. 1992. (Ed.) Monitoring for Conservation and Ecology. Chapman and Hall, London.
- Jorgensen, S.E. 1996. Applications of ecological modeling in environmental management. Elsevier Sci. Co., London.
- Jorgensen, S. E., Chon, T S. and Recknage, F. A., 2009. Handbook of Ecological Model inand Informatics. WIT Press
- Kang-tsung, C. 2000. Introduction to GIS. Tata Mc Graw Hill, New Delhi.
- Knight, R L and White, L. 2009. Conservation for a New Generation Redefinig Natural ResourcesManagement. Island Press, USA
- Kurian Joseph and Nagenddran, R. 2004. Essentials of Environmental Studies. Pearson Education (Singapore) Pvt.Ltd. New Delhi.
- Lawrence, D.P. 2003. Environmental Impact Assessment: Practical Solutions to Recurrent Problems.John Wiley and Sons, New Delhi.
- Lillesand, T.M.and Kiefer, R.F. 1994. Remote Sensing and Image interpretation. John Wiley & Sons, New York.
- Maguire, D., Batty, M., Goodchild, M., (Eds.) 2005. GIS, Spatial Analysis,and Modeling, Esri Press, USA
- Meadows, D., Randers, J. and Meadows, D. 2004.Limits to Growth: The 30 Year Update London, Earthscan.
- Meffe, G. K., L. ,Nielsen, R. ,KnightandSchenborn. 2002. Ecosystem Management: Adaptive, CommunityBased Conservation.Plenum Press.
- Miller. G.T., Jr. 2004. Environmental Science. Thomson, California.
- Milner Gulland,E.J. and J Marcus Rowcliffe, 2007. Conservation and Sustainable Usea handbook of Techniques. Oxford University Press
- Muralikrishna, I.V. 2001. Spatial Information Technology- RS and GIS. Vol.I and II BS
- Peter Calow. 1998. (Ed.) Handbook of Environmental Impact Assessment. Mc Graw Hills Inc., New Delhi
- Pullin, A.S. 2002. Conservation Biology. Cambridge University Press, UK.
- Rao,D.P (Ed).1998. Remote Sensing for Earth Resources. Association of

Exploration Geophysicist,Hyderabad

- Simon Dresner 2008. The Principles of Sustainability Solutions. Earthscan paperbacks, The Ecological Footprint Atlas 2010. Oakland: Global Footprint Network.
- Tyler Miller, G Jr, 2005. Advantage Series: Sustaining the EarthAn Integrated Approach (with CD ROM and Info Trac). 7th Edition., Thomson/Brooks Cole, USA
- UN General Assembly.2010. Keeping the promise: a forward-looking review to promote an agreedaction agenda to achieve the Millennium Development Goals by 2015. Report of the SecretaryGeneral.
- Westman W.E 1995. Ecology, Impact Assessment and Environmental Planning. John Wiley and sons.NY,USA.
- World Commission on Environment and Development.1987. „Our Common Future', New York: Oxford University Press

Web Resources

www,moef.gov.in (of Ministry of Environment and Forests, Govt. of India) www.millenniumassesment.org. (for Millennium Ecosystem Assessment Synthesis Reports) www.unep.org

Environmental Science

180 Hours 4 Credits

Soil texture using micrometry from two different sites. Determination of moisture content.

Determination of soil pH from at least three different locations and correlate it with the soil type.

Determination of Chloride, Calcium, Magnesium, Potassium and Phosphorous. Determination of Calcium Carbonate in Egg shell- (Three different types of egg. Identification of trophic levels from gut analysis (Fish or insect)

Analysis of soil enzymes : Cellulase, Phosphatase and Urease

Air Quality Analysis:

Air samplers - Simple, Handy and High volume air samplers. Monitoring of the following pollutants in ambient and polluted air:

1. Dust fall
2. Suspended particulate matter
3. Sulphation rate using lead peroxide candle.
4. Sulphur dioxide
5. Nitrogen dioxide
6. Ammonia

Water Quality Analysis:

a. Determination pH, Electrical conductivity, Alkalinity, Hardness, Phosphate and Silica

b. Determination of total dissolved salts (TDS)

Toxicity Analysis of Water: For Chlorine, H2 S, Ammonia, Copper and Chromium Estimation of BOD and COD of polluted water

Study of histo-pathological changes in any two of the tissues (Liver/Kidney/ Gonad) using CCl4 or NH3 (five stained permanent slides [normal and affected] to be submitted for the examination).

Field Study Report:

An internship/training/field study of not less than 10 days related to environment/ environmental pollution/environmental management. Submit a detailed report with a minimum of 10 pages giving the dates, day wise itinerary, methodology, results/activity and references. Include photographs of the activity. Group and individual assignments shall be preferred.

ELECTIVE C: ENTOMOLOGY

Sl.no	Name of the Course
1	Morphology and Taxonomy
2	Anatomy and Physiology
3	Applied Entomology
4	Practical : Morphology, Anatomy and Taxonomy Insect Physiology and Applied Entomology

Morphology and Taxonomy

90 Hours 4 Credits

Course Outcomes

- To introduce the insect diversity and its significance
- Students will be able to understand the morphology of the insects, and taxonomic characters of important insects.
- To study the economical and medical importance of insects
- To learn about the insect pest , vectors and their control measures
- To provide skills for scientific study of insects
- To develop aptitude for research in entomology

Module I

Introduction (02 Hours)

- Origin and evolution of insects (including theories-Atelocerata hypothesis, Pancrustacea theory), phylogenomics studies.
- Fossil insects (mention importance of Amber).

Module II

Insect Morphology (26 Hours)

- **Segmentation and tagmosis of the body**: Primary and secondary segmentation; external and internal features of the body wall.
- **General morphology of head:** Head segmentation; Head skeleton; Tentorium; Modifications of head capsule (opisthognathus, prognathus, hypognathus).
- **Cephalic appendages**: Antennae – Structure, types and functions
- **Mouth parts:** – Structural modifications, Mechanics and control of feeding.
- **General morphology of thorax:** Thoracic segmentation, thoracic skeleton and thoracic appendages).
- **Wings**– Structure; Venation (generalized neopteran wing); Modifications, Wing articulation and coupling mechanisms.
- **Legs** - Structure and adaptive radiation of legs, Locomotion.

- General morphology of abdomen: Structure; abdominal appendages.
- External genitalia: Basic structural features; complexity and diversity of male and female genitalia. eg. Odonata, Orthoptera, Diptera, Dictyoptera. Mention sexual dimorphism.
- Sense organs (morphology): Structure and classification of sense organs (Mechanoreceptors- sensory hairs, chordotonal organs, proprioceptors- trichoid and campaniform sensilla; photoreceptors - compound eyes, simple eye, stemmata, Chemoreceptors- sensilla, Soundreceptors: Johnston‟s organ, tympanal organs, subgenual organs).
- Light producing organs: –Structure.
- Sound producing organs: -. Stridulatory organs in various insects.

Module III

Insect Classification (38 Hours)

Introduction to classification of insects. Mention Apterygota, Exopterygota,Endopterygota

- General characters, Biology, Habits and Classification up to family of the following orders of insects with special emphasis on economically important insects

  Earliest Insects: Archaeognatha, Dicondylia, Zygentoma.

  Pterygota:

  Palaeoptera:

  Ephemeroptera,

  Metapterygota:

  Odonata

  Neoptera:

  - Polyneoptera (Orthopteroid–Plecopteroid assemblage): Plecoptera, Mantodea, Blattodia, Isoptera, Grylloblattodea, Mantophasmatodea, Orthoptera, Phasmatodea, Embiidina, Dermaptera, and Zoraptera.
  - Paraneoptera (Acercaria or Hemipteroid assemblage): Psocoptera, Phthiraptera, Thysanoptera, and Hemiptera

- Endopterygota (=Holometabola): Coleoptera, Raphidioptera, Megaloptera, Neuroptera, Mecoptera, Siphonaptera, Strepsiptera, Diptera, Hymenoptera, Trichoptera, Lepidoptera.

Module IV

Social Organization and Behaviour (16 Hours)

- Social organization and behaviour in termites, ants and honeybees.
- Study of Gall forming insects: Gall formation - cecidogenesis, Types of galls – open and closed, common gall pests, adaptations for gall making habit, economic impact of galls.Leaf mining insects – Types of leaf mines, feeding habits, frass disposal.
- Communication – Acoustic, visual, tactile and chemical methods.
- Adaptations of parasitic and predatory insects
- Study of aquatic insects: Aquatic insect habits, factors influencing the aquatic life, food capture – modifications, anchorage, locomotion, respiration, oviposition and adaptations of swimming forms.
- Insect plant interactions: Host plant resistance. Insect pollinator – plant interaction.

Module V

Insect Development (08 Hours)

- General pattern of embryonic development, Polyembryony, Parthenogenesis, Paedogenesis.
- Egg - Types, structure, egg cases and adaptations of eggs, diapause.
- Types of metamorphosis, different types of larvae and pupae.

References

- Ananthakrishnan T.N. 1998. *Dimensions of Insect Plant Interactions*. Oxford and IBH Pub.Co.
- Pvt. Ltd. N. Delhi.
- Awasthy V.B. 1998. *Introduction to General and Applied Entomology*. ELBS, London
- Carde R.T. and W.J. Bell. 1995.*Chemical Ecology of Insects* (2nd edn).

Chapman and Hall, NY.

- Chapman R.F. 2012. *The Insects Structure and Functions*. Edited by Stephen J. Simpson, Cambridge University Press, 929 pages, ISBN 9781139035460
- Essig E.O. 1982. *College Entomology*. (Indian Reprint) Satish Book Enterprises Agra.
- Fenmore P.G. and A. Alkaprakash. 1992. *Applied Entomology*. Wiley Eastern Ltd. New Delhi.
- Gillott, C. Entomology 2005. 3rd edition, Published by Springer, 834 pages ISBN-10 1-4020- 3182-3
- Grimaldi, D. and M.S. Engel. 2005. *Evolution of the Insects*. Cambridge University Press, Cambridge,. U.K. xv + 755 pp. Hardback, ISBN 0-521-82149-5
- Gullan, P. J. and P. S. Cranston. 2005. *The Insects: An Outline of Entomology*, 3rd Edition.
- ISBN: 978-1-405-11113-3. Wiley-Blackwell. 528 pages.
- Johnson, Norman F. and Charles A. Triplehorn. 2005. *Borror and DeLong's Introduction to the Study of Insects*, Publisher: Cengage Learning, 7th Edition, 888 pages. ISBN: 9780030968358
- Mani M.S. 1974. *Modern Classification of Insects*. Satheesh Book Enterprise, Agra.
- Mani M.S. 1982.*A General Text Book of Entomology*. Oxford and IBH, New Delhi.
- Metcalf C.L. and Flint W.P. (revised by Metcalf R.L.) 1962. *Destructive and Useful Insects*.
- McGraw-Hill Book Co. NY,USA
- Nayar K.K., Ananthakrishnan T.N. and David B.V. 1976.*General and Applied Entomology*.
- TATA Mc Grew Hill New Delhi.
- Oster G.F. and Wilson E.O. 1978. *Caste and Ecology in the Social Insects*. Princeton University Press Princeton.

- Pathak S.C. Ed. 1986. *Recent Advances in Insect Physiology, Morphology and Ecology.* Today and Tomorrow Printers and Publishers, New Delhi.
- Richards O.W. and Devis R.G. 1993.*Imm's General Text Book of Entomology,* 10th Edn. Vol I and II. (Indian reprint). B.I. Publications Pvt. Ltd. New Delhi.
- Ross H. H. *et.al*. 1982. *A General Text Book of Entomology*. John Wiley Son‟s, N. York. Snodgrass R.E. 1935. *Principles of Insect Morphology*. McGraw Hill Book Co. N. York. Tembhare D.B. 1997. *Modern Entomology*. Himalaya Publishing House, New Delhi

Anatomy and Physiology

90 Hours 4 Credits

Module I (14 Hours)

Integumentary System (04 Hours)

- Anatomy and histology, Physical and chemical properties
- Chemistry of the Cuticle
- Moulting and sclerotization - role of hormones.

Digestive System (10 Hours)

- Anatomy and histology of gut, modifications of gut (filter chamber).
- Physiology of digestion and absorption (wood, keratin, wax and silk).
- Extra intestinal digestion.
- Role of the microbes in digestion.

Module II (18 Hours)

Circulatory System (08 Hours)

- Structure of the insect circulatory system: dorsal vessel, dorsal and ventral diaphragms, accessory pulsatile organs.
- Hemolymph: Plasma and Hemocytes - Composition and functions.
- Course of circulation, heartbeat and its regulation - Cardioacceleratory peptides .
- Immune mechanisms in insects: cell-mediated immunity & humoral immunity; short notes on transferrins, Dscam.

Respiratory System (10 Hours)

- Organization and Structure of the Tracheal System: trachea, trachioles, spiracles and air-sacs.
- Movement of Gases within the Tracheal System: Diffusion, discontinuous gas exchange, active ventilation.
- Respiratory pigments.
- Gas Exchange in Aquatic Insects: Closed and open tracheal systems; Gas Exchange in Endoparasitic Insects; Gas exchange in insect eggs.

Module III (16 Hours)

Muscular System (08 Hours)

- Histo-morphology of muscles, skeletal muscles and visceral muscles.
- Physiology of Neuromuscular junctions.
- Excitations of muscle fibres, role of fast and slow axons.
- Flight Metabolism

Fat Body and Intermediary Metabolism (08 Hours)

- Fat body structure and development.
- Storage and utilization of energy and nutrients.
- Intermediary metabolism- glycolysis, glycerol phosphate shuttle, trehalose biosynthesis
- Metabolism of insecticides, diapause as a metabolic process

Module IV (22 Hours)

Excretory System (10 Hours)

- Anatomy and histology of Malpighian tubules (Hemiptera, Coleoptera, Lepidoptera)
- Nephro-rectal complex and labial glands.
- Physiology of excretion.
- Salt and water balance – terrestrial, freshwater, brackish-water and saltwater
- Hormonal control

Nervous System (12 Hours)

- Basic components and anatomy of the nervous system.
- Physiology-reception and transmission of stimuli, production and conduction of nerve impulses.
- Physiology of Chemoreception
- Photoreception: Form and Movement Perception, Distance Perception, Spectral Sensitivity and Color Vision, Sensitivity to Polarized Light

- Mechanism of sound and light production in insects

Module V (20 Hours)

Endocrine System (12 Hours)

- Endocrine organs: Corpora cardiaca, corpora allata, molt glands and prothoracic glands.
- Hormones and their functions, regulation of hormone titer.
- Insect semiochemicals and communication: Pheromones (types), kairomones, synomones
- Environmental, Neural, and Endocrine Interaction

Reproductive System (08 Hours)

- Anatomy of the internal reproductive organs in male and female insects.
- Spermatozoa, transfer of sperm to the female, oogenesis, ovulation, fertilization and oviposition.
- Formation of blastoderm and differentiation of germ layers.
- Viviparity, oviparity, eclosion.

References

- Beament, J.W.L., Treherne, J. E. & Wigglesworth. Advances in Insect Physiology, Academic press, London
- Bursell, E 1970. An Introduction to Insect physiology, Academic Press
- Chapman R.F. 2012. The Insects Structure and Functions. Edited by Stephen J. Simpson, Cambridge University Press, 929 pages, ISBN 9781139035460
- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- Gilbert, L.I. & Kerkut. G.A. 1985. Comprehensive Insect Physiology, Biochemistry and Physiology, Vol. 1-12
- Gillott, C. Entomology 2005. 3rd edition, Published by Springer, 834 pages ISBN-10 1-4020- 3182-3
- Pathak, S.C. (Ed) 1986. Recent advances in Insect Physiology, Morphology and Ecology. Today and Tomorrow Publishers, New Delhi.

- Patnaik BD. 2002. Physiology of Insects. Dominant, New Delhi.
- Patton, R. 1963. Introductory Insect Physiology, Saunders, USA.
- Richards, O.W. and Davis, R.G. 1977. Imms General Text Book of Entomology.Vol.I. Chapman & Hall, London
- Rockestein, M. (Ed) 1974. Physiology of Insecta Vol 1.VI. Academic press, New York
- Roeder, K. D. 1953. Insect Physiology, Wiley, New York.
- Simpson Stephen 2005. Advances in Insect Physiology. Elsevier
- Wigglesworth, V.B. 1972. Principles of Insect Physiology, Methuen, London

Applied Entomology

90 Hours 4 Credits

Module I (20 Hours)

Insect Pests (08 Hours)

- Classification of Insect pests

  Key pests, Potential pests, Occasional pests, Sporadic pests, Seasonal pests, Regular pests, Persistent pests (Based on occurrence)

  Endemic, Epidemic and Pandemic pests (Based on level of infestation) Migrant pests and Exotic pests

- Causes of insect assuming pest status
- Causes of pest outbreak
- Pest surveillance and Forecasting pest outbreaks (Short term and long term forecasting) Forecasting based on observations – climatic and empirical factors.
- Pest resurgence and replacement (secondary pest outbreak). Causes and management of resurgence and replacement.
- Types of damage caused by insect pest to crops

  (Injury by chewing, piercing, sucking insects, internal feeders, subterranean insects, to stored products and indirect effect of feeding)

- Concepts of Economic levels

  Economic injury level, Economic threshold level, Damage boundary Pest categories according to EIL, GEP AND DB

- Estimation of damage caused by insect to crops(Brief account only)

Module II (20 Hours)

Insect Pests of Crops (24 Hours)

Identification, Life history, nature of damage and control measures of major pests of

PADDY: Major pests including stem borers, army worm, rice thrips, gall midge, mealy bug, BPH, green & white leaf hoppers, rice caseworm, rice leaf roller, rice hispa, rice earhead bug, root weevil, rice grass hoppers (Any ten

pests).

SUGARCANE: Major pests including shoot, internode & top borers, white grub, leaf hopper, sugarcane scale, mealy bug, whiteflies, Termites, Black winged bug (Any three pests).

COTTON: Major pests - Aphid, leaf hopper, thrips, whitefly, Pink, spotted and American boll worms, stem weevil, Red and Dusky cotton bugs, leaf roller (Any three pests).

COCONUT: Rhinoceros beetle, red palm weevil, black-headed caterpillar, white grub, Scale insect, Lace wing bug, coconut skipper (Any five pests)

PULSES: Gram pod borer, plume moth, red gram pod fly, pod borer, spotted pod borer, Blue butterflies, bean aphid, white fly(Any three pests)

FRUIT TREES:

Mango- hopper, flower webber, Leaf webber, gall midges, Nut weevil, stem borer, red tree ant (Any three pests)

Cashew-hopper, flower webber, Leaf webber, gall midges, Nut weevil,

stem borer, red tree ant(Any three pests) Citrus - Fruit sucking moth, citrus butterfly Banana -rhizome weevil, banana aphid

SPICES:

Pepper- pollu beetle, shoot borer, Marginal gall thrips (Any two pests) Cardamom-cardamom thrips, rhizome borer, cardamom whitefly, hairy caterpillars, *Eupteroteand pericallia* (Any two pests)

Turmeric and Ginger(Leaf roller, shoot borer)

OTHER CROPS: Coffee, Tea, Tapioca and Rubber (Any two pests for each crop)

VEGETABLES: Brinjal, Gourd, Tomato and Bhendi(Any three pests for each)

STORED PRODUCTS: Identification, nature of damage & control of insect pests of Rice weevil, sweet potato weevil, Lesser grain borer, tobacco beetle, Drug store beetle, Pulse beetle, Angoumois grain moth, Potato tuber moth, Red flour beetle, Rice moth.

(Any five pests)

LOCUSTS: Life history and migration, damage and methods of control

TERMITES: Life history, damage and control measures.

Module III (20 Hours)

Principles of Insect pest management (15 Hours)

Ecology based pest management

Prophylactic methods

Curative methods

Cultural methods

Mechanical methods

Physical methods

Legal methods

Biological control: History of biological control, ecological basis of biological control, natural enemies (Parasites, Parasitoids, Predators), feasibility of biocontrol; Applied biological control (Conservation and enhancement, Importation and colonization, Mass culture and release); Importance of systematics in biocontrol, Important biocontrol projects undertaken in India by employing parasites and predators.

Autocidal control - Sterile male technique and other methods, Chemosterilants, Methods of sterilization, Application, Dynamics, Advantages and disadvantages Examples of autocidal control

Insect growth regulators (IGRs) – Brief note on Insect growth hormones and mimics (JH mimic & ecdysone agonists and chitin synthesis inhibitors as insect control agents)

Behavioural (pheromonal) control: Mode of application, Pest management with pheromones, Advantages and disadvantages, Examples

Insect attractants: definition, types of attractants, applications in insect pest management, examples, advantages and disadvantages

Insect repellents: definition, desirable features of good repellent, types of repellents, applications in insect pest management, examples, advantages and disadvantages

Insect antifeedants: definition, examples, applications in insect pest management, advantages and disadvantages

Microbial control of crop pests by employing Bacteria, Virus and Fungi -

Classification of entomophagus Bacteria, Virus, Fungi, Mode of action, formulation, Application, Examples

Integrated Pest Management- Definition, IPM in Agroecosystem, Establishing the need to take action, Guidelines for developing IPM, Tactics in IPM, IPM of Rice.

Module IV

Chemical Control (20 Hours)

Insecticide formulation

(Brief note on Emulsifiable concentrates, Water-miscible liquids, Wettable powders, Water soluble powders, Oil solutions, Flowable powders, Aerosoles, Granulars, Fumigants, Ultra-low volume concentrates, Fogging concentrates, Dusts, Poison baits and Slow release insecticides) Classification of insecticides

1. Based on mode of entry
2. Based on mode of action
3. Based on chemical nature

Chemical nature, toxicology & mode of action of following class of insecticides (mention examples for each class)

Synthetic Organic compounds

- Organochlorine insecticides (DDT, BHC, Cyclodiene group (special reference to endosulfan; examples: heptachlor, aldrin)
- Organophosphorous insecticides (examples: TEPP,Dichloros, monocrotophos, parathion) Carbamates (special mention of carbofuran and carbaryl)
- Inorganic compounds as insecticides - arsenic compounds, fluorides, sulphur compounds
- Fumigants – definition, examples, methods of fumigation, hazards of fumigation, advantages and precautions
- Botanical insecticides- chemical properties, mode of action and toxicity of the following: Nicotine, Rotenone, Pyrethrum and Neem
- Synthetic pyrethroids – definition, uses as insecticides, mode of action

(examples: Pyrethrin, allethrin)

- Insecticide synergists – definition, types of synergism, mode of action & examples

Module V (23 Hours)

Insecticide Application Technology (06 Hours)

- Dusting and dusters
- Spraying and sprayers – syringes, knapsack sprayers, foot pump-sprayers, rocker sprayer, pneumatic hand sprayers, pneumatic knapsack sprayers, hand atomizer, hydraulic sprayers
- Aerosols
- Other equipments (mist blower, fog generators, smoke generators, aerosol bombs)

Insecticides and Environment (05 Hours)

- Insecticide resistance -Genetic, Physiological and biochemical mechanism
- Pesticides and the environment- its impact on wildlife and human health
- Microbial and environmental degradation of pesticides

Medical and Veterinary Entomology (10 Hours)

- Identification, nature of attack & control of Insect pests of domestic animals Cattle (any five pests)

  Fowl (any three pests)

  Dog & Goat (any two pests)
- Ticks and Mites of Medical and veterinary importance – Morphology, biology and control measures
- Major arthropod vectors of human diseases (Malaria, Lymphatic Filariasis, Yellow Fever, Dengu Fever, West Nile Disease , Chickungunia,Japanese Encephalitis, Zika Kala-azar,African sleeping disease Plague, Typhus, Kyasanur Forest Disease, Scabies)

Forensic Entomology (02 Hours)

- Introduction to Forensic entomologyInsects used in forensic entomology

(Dipterans and coleopterans)

- Succession of insect fauna on a cadaver.

References

- Ananthakrishnan, T.N. 1977 Insect and Host Specificity, Mc Millan Co, India LTD
- Apple, J.L. and R.R. Smith .1976. *Integrated Pest Management*. Plenum Press, New York.
- Atwal, A.S., Agricultural Pests of India and South East Asia. Kalyanai Publishing, New Delhi.
- Awasthi, V.B. 2002. *Introduction to General and Applied Entomology* (2nd edn). Scientific Publishers (India), Jodhpur.
- Brown, A.W.A. (1978): Ecology of Pesticides, John Wiley Sons, N.Y.
- Byrd, J.H and J.L Castner (Eds).2000. *Forensic Entomology: The utility of arthropods in legal investigations,* CRC Press,London
- D'Brien, R.D. 1967 Insectcide- action and metabolism, Academic Press, N.Y.
- Dent, D.1991. *Insect Pest Management.* CAB International, UK
- Edwards, C.A. 1973 Persistent pesticides in the environment, C.R.C. Press
- Ghosh M.R. 1989. *Concepts of Insect Control.* Wiley Eastern Ltd. Bangalore and New Delhi
- Harward, R.F. and James, M.T. 1979 Entomology in Human and Animal Health. 7th Edn. Cther Mc Millan Publishing London
- Hill, D.S. and Waller, Insect Pests of Agriculture and their Control
- Hill, D.S., Agricultural Entomology
- Kettle, D.S.1995. *Medical and Veterinary Entomology.* CAB International.Matsumura, F. (1975): Toxicology of Insecticides – Plenum
- Metcalf and Flint. Revised by Metcalf, R.L., Destructive and Useful Insects, their Habits and Control, Mc Graw Hill, N.Y.
- Metcalf, R.L. and Luckman, W.H., Introduction to Insect Pest management, 3rd Edn. John Wiley & Sons

- Moriarty, F., 1975 Organochlorine insecticides persistant organic pollutants, Academic Press, INC, London
- Mullen, G. and Durden, L. (Eds).2002. *Medical and Veterinary Entomology*. Academic Press.
- Nair, M.R.G.K.1975 Insect and Mites of Crops in India, ICAR, New Delhi
- Nayar, K.K., Ananthakrishnan, T.N. and B.V. David. 1976. *General and Applied Entomology*. Tata McGraw Hill Publ. Co. Ltd New Delhi
- O'Brian, R.D. and Yamanots, I. 1970 Biochemical Toxicology of Insecticides, Academic Press INC, London
- Patton, W.S. and Crag, F.N. 1973. *A Textbook of Medical Entomology*. International Books and Periodicals, New Delhi
- Pedigo, L.P.2002 Entomology and Pest Management. EEE. Prentice Hall India
- Perry, A.S., Yamamoto, I., Ishaaya, I. and Perry, R. 1998 Insecticides in Agriculture and Environment – Retrospects and Prospects, Narosa Publishing House, New Delhi
- Pradhan, S. 1969 Insect pests of Crops, National Book Trust, New Delhi
- Ramakrishna Ayyer, R.V. 1963. *A Handbook of Economic Entomology of South India*. Govt of Madras Publications Service, M.W.1996.*Medical Entomology for Students.* Chapman and Hall, UK.
- Rao, V.P. Ghani, M.A., Sankaran T and Mathur, K.C. 1971. *A Review of Biological Control of Insects and Other Pest in South East Asia and Pacific region.* CAB, England.
- Romoser, W.S. and Stoffalano, J.G. Jr., The science of Entomology 3rd Edn. Wm. C. Brown Publishing
- Smith, K.V.G.1986. *A Manual of Forensic Entomology*. British Museum Natural History.
- Srivastava, K.P.1996 A Text Book of applied Entomology Vol.1, Kalyani publishers. Vasantharaj David and Kumaraswami, Hand Book of Economoc Zoology Wilkinson, C.F. 1976 Insecticide Biochemistry and Physiology – Plenum Press N.Y.

Morphology, Anatomy and Taxonomy, Insect Physiology and Applied Entomology

180 Hours 4 Credits

Morphology, Anatomy and Taxonomy

- Study of various types of insect head (prognathous, hypognathous,opisthognathous
- Mouthparts in insects (Grasshopper,plantbug,mosquito,honeybee, house fly)
- Study of different types of antennae. (cockroach,grasshopper,termite,house fly,mosquito)
- Adaptive radiation of pterygote legs (ambulatorial,cursorial,saltatorial,natatorial,clapsorial, fossorial etc.)
- Sting apparatus –honeybee
- Wings and wing venation in insects of 5 pterygote orders.
- Study of sexual dimorphism in insects
- Preparation of dichotomous keys with reference to various insect orders
- Morphological studies of different castes of social insects. eg: Honey bee
- Dissection of alimentary canal and associated glands of different insects (oryctes, grasshopper.)
- Dissection of nervous system in different insects (plantbug, ,oryctes,grasshopper)
- Dissection of reproductive system in insects (cockroach, ,grasshopper,)
- Dissection of stomatogastric nervous system –cockroach
- Training for students in the various methods of collection and preservation of insects for scientific studies.
- Visit to entomology research institute and museum .

Field study shall be conducted to collect the insects in their natural habitat like forest, agro- ecosystem, grass lands, water bodies, sandy areas, litter, and so on with the procedures adopted . students are required to submit an insect collection belonging to 30 families of different orders- dry collection,wet

collection, whole mounts and slides at the time of practical examination.

INSECT PHYSIOLOGY

- Survey of digestive enzymes –amylase,invertase,protease and lipase in different parts of the gut in cockroach,grasshopper, dragonfly
- Dye transport by Malpighian tubule using dyes
- Identification of free aminoacids (at least 3) in haemolymph by paper chromatography.
- Haemocytes –staining and identification.
- Estimation of total haemolymph proteins

APPLIED ENTOMOLOGY

COLLECTION AND IDENTIFICATION (Preserve and submit)

1. Insect pests of different crop plants,fruit trees,vegetables and stored products (3 Pests each)
2. Insect vectors of man and domestic animals (3 pests)
3. Insect damages to crops (Any 5)
4. Economically important insects, their life stages, products (any one)
5. Natural enemies of crop pests (parasitoids- Trichocard, predatory insects)

- Study of life histories of insect pests (Any 5)
- Insecticide appliances and insecticide formulations.
- Forensically important insects.
- Determination of LC50 using probit analysis. Visit to laboratories (Any 2)

1. Parasitoids and predator breeding stations
2. Beekeeping stations
3. Sericulture institutes
4. Toxicology laboratories
5. Insect pathogen culture labs

(Report on the visit to any 2 laboratories with the dated signature of the teacher concerned and duly certified shall be submitted at the time of practical examination along with practical record. No marks shall be awarded for the record without the report)

ELECTIVE D: MEDICAL MICROBIOLOGY

Course Outcome

- To introduce the diversity of microbial world
- To learn various pathogens, parasites and related diseases of man
- To familiarise with various tools and techniques in the study of microbes and to manage a microbial laboratory
- To provide skills and competency in the field of clinical microbiology

Sl.no	Name of the Course
1	General Microbiology and Parasitology
2	Bacteriology, Virology and Mycology
3	Clinical Microbiology
4	Practical : Microbiology

General Microbiology and Parasitology (PZO4CRT0120)

90 Hours 4 Credits

Course Outcome

- Explain microbial diversity in different ecosystems; Classify and identify bacteria based on biochemical, serological and molecular techniques
- Acquire knowledge in sterilization techniques and antimicrobial agents
- Comment on microbial growth and reproduction
- Describe the life cycle, pathogenesis, lab diagnosis and treatment of protozoan and helminthic infections
- Detect microbial contamination of environmental samples. Identify the insect vectors transmitting infectious diseases

Module I (25 Hours)

History and introduction to Microbiology

History(Antony Von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Alexander Flemming), scope, relevance and future of microbiology.

General groups of microbes and their structural characteristic features - bacteria, (archae, cyanobacteria, actinomycetes), fungi (molds and yeast), virus and protozoa.

Morphological studies using different staining methods- Staining: Principle and Methods. Simple Staining and Differential staining - Gram staining, Acid fast staining (Ziehl-Neilson Method), Staining of Specific Structures - Spore staining (Schaeffer-Fulton Method), Capsule staining, staining of volutin granules, Negative staining.

Module II

Microbial Growth and Reproduction (15 Hours)

Nutritionalrequirements and types of bacteria - autotrophs, heterotrophs, chemotrophs - Measurement of growth: growth curve, Kinetics of Growth - Mathematical expression of exponential growth phase; Batch Culture

Continuous culture(Chemostat, turbidostat). Fungal growth requirements. Reproduction of bacteria and fungi - sexual and asexual.

Module III

Control of Microbial Growth (10 Hours)

Control of bacteria: Antibiotics- types, mechanism of action. Evaluation of antimicrobial agent effectiveness- Phenol coefficient method, Determination of MIC and MBC. Antibiotic sensitivity tests(Kirby- Bauer Method), antibiogram.

Module IV

Microbiology of air, water and food (20 Hours)

Air: Droplets, droplet nuclei, aerosol. Types of microbes in air and different methods of microbial enumeration from air. Air-borne diseases. Water: sources of contamination, methods of detection of microbial contamination in water, Microbial standards of drinking water, water- borne diseases.

Food: Types and sources of milk contamination, milk spoilage, milk quality testing methods (methylene blue reductase test, resazurin reductase test), Food poisoning and intoxication, major food- borne diseases.

Module V

Parasites and Vectors (20 Hours)

Structure, life cycle, pathogenesis, diseases, laboratory diagnosis, treatment and prevention of the following parasites: Protozoan parasites-*Entamoeba histolytica, Plasmodium vivax, Lieshmania donovani, Trypanosoma brucei, Trypanosoma cruzi, Trichomonas vaginalis, Giardia lambli.*

Helminthes :Nematodes- *Ascaris lumbricoides* (Giant round worm), *Ancylostoma duodenale* (Hook Worm), *Enterobius vermicularis* (Pin worm), *Wuchereria bancrofti*.

Helminthes :Cestodes –*Taenia solium*

A brief study of the following insects, the major diseases they transmit, epidemiology of such diseases, control and preventive measures: Mosquito, Sand fly, House fly, Tse-Tse fly, Fleas, Louse, Bed bug, Ticks, Mites.

References

- Ananthanarayanan R. and C.K. JayaramPanicker, 2006. *Text book of Microbiology*. Orient Long Man,New Delhi
- Case T.F, *et al.,* 2011. *Microbiology an Introduction* (9thedn.). The

Benjamin/Cummings Publishing Company.Inc. NY, USA.

- Davis, D. and E. Ginsberg, 1990.*Microbiology* (4 edn.).Harper and Row Publishers, Singapore.
- England P.T. and A.Sher. (eds). 1988. *The Biology of Parasitism- A Molecular and Immunological Approach*. Alar. R. Liss.New York
- Ketchum P.A. 1988. *Microbiology -Concepts and Applications*.Oakland University Press.NZ.
- Markell, E.K., Voge, M and D.T. John. 2002. *Medical Parasitology*. W.B. Saunders, Philadelphia.
- Prescott M.C, J.P.Hardley and D.A. Clean.2001.*Microbiology.* ASM, USA
- Ross,N.E. and J.D.Mclaren (eds). 1986. *Pathophysiological Responses to Parasites*. British Society for parasitology, London.

Bacteriology, Virology and Mycology (PZO4CRT0220)

90 Hours 4 Credits

Course Outcome

- Familiarizing the mechanism of pathogenesis; sources of infections, mode of transmission of infections and prophylaxis of communicable diseases;
- Inculcate knowledge on immunological and non-immunological response of viral infections.
- Gain knowledge on the structure and general principles of phage bacterium interaction
- Discuss emerging and re-emerging infectious diseases.
- Explain mycoses, lab diagnosis of fungal pathogens, antifungal agents etc.

Module I (15 Hours)

Pathogenesis and Epidemiology

Mechanism of pathogenesis- bacterial and viral. Epidemiology -Factors predisposing to microbial pathogenicity, Sources of infections, Mode of transmission of infections. Prophylaxis of communicable diseases.

Module II (25 Hours)

Pathogenic Bacteria (15 Hours)

Study of important properties, pathogenicity and laboratory identification of: Staphylococci, Streptococci, Pneumococcus, Corynebacterium diphtheriae, Bacillus anthracis, Clostridium tetani Neisseria, E.coli, Proteus, Klebsiella, Shigella and Salmonella, Vibrio, Pseudomonas, Brucella.

Study of important properties, pathogenicity and laboratory identification of: Mycobacterium, Treponema, Leptospira, Mycoplasma, Rickettsiae and Chlamydiae. A brief study of bacteria viz. Borrelia, Listeria, Campylobacter and Legionella.

Bacterial Infections of Human Body (10 Hours)

Bacterial infections of respiratory tract, Bacterial infections of gastro intestinal tract, Bacterial urinary tract infections, Bacterial infections of genital tract and reproductive organs, Bacterial infections of central nervous system, Skin and soft tissue infections, Bone and joint infections, Eye ear and sinus infections,

Cardiovascular infections, Zoonotic infections, Pyrexia of unknown origin.

Module III (30 Hours)

Virology (15 Hours)

Study of properties, replication and pathogenesis of Alpha virus, Pox, Herpes Virus, Orthomyxo virus and Papova virus.

Study of properties, pathogenesis and symptoms ofPolio, Influenza, Rabies, and Hepatitis viruses.

Oncogenic viruses, Slow viruses and Prion diseases

Emerging Viruses and Control of viral infections(15hrs) Emerging viruses: Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus. H1N1 viruses.

Control of viral infections through vaccines (Recent trends), interferons and chemotherapeutic agents. Immunological and non immunological response of viral infections.

Module IV

Bacteriophages (10 hours)

Structure and life cycle patterns of T-even phages; one step growth curve and burst size; Bacteriophage typing; Structure of Cyanophages, Mycophages. Growth cycle studies of RNA and DNA phages.

Module V

Mycology (10 hours)

Classification of fungi, General techniques used in mycology: Cultivation- slide culture technique, Staining of fungi - Lactophenol cotton blue staining.

Mycosis in man-Classification, pathogenesis and clinical findings in superficial, cutaneous and systemic fungal infections. Oppurtunistic mycoses. Antifungal agents and their mode of action.

References

- Ananthanarayan and Jayaram Panicker. 2002. Text Book of Microbiology. Orient Longman. Belsche, R.B., 1991. Text Book of Human Virology (2nd edn.). Mosby, St.Louis.
- Dimock, N and L.Primrose.1987.Introduction to Modern Virology

(3rdedn.).Oxford Blackwell.

- Duerdon, D.L.and Dresser, B.S. (eds).1991.Anaerobes in Human Disease. London Arnold. Emmons et al., 1997.Medical Mycology. Lea and Febiger ,Philadelphia.
- Goodfellow, M and R.G. Board (ed).1989. Microbiological Classification and Identification.
- Grady F.O, H.P. Lambert, R.G. Finch, G. Greenwood.1997. Antibiotic and Chemotherapy; Antiinfective Agents and their Use in Therapy (7thedn).Churchil Livingstone, NY.
- Kwon-Chung, K.J and J.E. Bennet.1992.Medical Mycology. Lea & Febiger, Philadelphia, Larone,D.H.1980. Laboratory Handbook of Medical Mycology. Academic press New York.
- Mims C.A. and D.O. White,1994. Viral Pathogenesis and Immunology. Oxford Blackwell. Monica Cheesbrough 1991. Medical Laboratory Manual for Tropical Countries.Vol.2.ELBS
- Szaniszlo, P.J. (edn) 1985.Fungal Dimorphism; with Emphasis on Fungi Pathogenic for Humans.
- Plenum, NY.
- Topley W.W.C. and G. Wilson. 2002. Principles of Bacteriology, Virology and Immunity.
- Systematic Bacteriology: (8th edn.). BWW Publishers.
- White, D.C. and F.J. Fenner.2004.Medical Virology. (4rdedn.) Academic Press, New York.

Clinical Microbiology (PZO4CRT0320)

90 Hours 4 Credits

Course Outcome

- Gain knowledge about safety in clinical microbiology laboratory and good lab practices
- Awareness on the aseptic techniques for sample collection, transport and processing
- Discuss the pathogenesis, laboratory diagnosis& treatment of microbial infections.
- Have an awareness on care, management and legal requirements of handling laboratory animals
- Describe the various conventional and molecular techniques in clinical diagnosis

Module I

Safety and Basic Laboratory Techniques in Microbiology (12 hours)

Safety in Clinical Microbiology laboratory. Good laboratory practices. Microbiological safety cabinets-Types. WHO safe code of practice for a clinical microbiology laboratory.

Cleaning of glassware. Sterilization of glassware and media. Isolation techniques- serial dilution, standard plate count, pure culture and enrichment culture methods. Preservation of microbes.

Module II

Sample processing for Microbiology (20 hours)

Collection, transport, processing and microscopical examination of Blood, Sputum, stool, urine, Cerebrospinal fluid, genital specimens, throat and mouth specimens, nasopharyngeal swabs and aspirates, ear discharges, eye specimens, pus from wounds, abscesses, burns.

Module III

Diagnosis of bacterial Diseases (18 hours)

Different methods of cultural, biochemical, serological and molecular analysis

of microbial pathogens.

Module IV (20 hours)

Diagnosis of Viral Diseases (10 hours)

Viral isolation and growth- Cell culture for viral detection Detection of viral proteins and viral genetic material, viral serology. Antiviral agents and their mode of action

Diagnosis of Fungal Diseases (10 hours)

Diagnostic procedures: Microscopical examination of spore structures, Superficial, Cutaneous and Systemic mycosis.

Module V (20 hours)

Diagnostic methods in Parasitology (10 hours)

Diagnostic procedures: Examination of faeces and blood, culture methods, animal inoculation, immunological diagnosis and molecular diagnosis.

Handling of Laboratory Animals (10 hours)

Legal requirements for animal experiments. General aspects of organization of animal experiments- Preparation of animals, common experimental procedures, Human methods of killing animals. Care and handling of common laboratory animals: Rabbit, guinea-pig, mouse and rat.

References

- Baron E.J, L.R. Peterson and S.M. Finegold.1994.*Bailey and Scott's Diagnostic Microbiology.*ASM, Washington, DC
- Cowan, S.T. and K.J.Steel.1985. *Manual for the Identification of Medical Bacteria.* Cambridge University Press, London.
- Chandrashekhar J Hiware, Babasaheb V Jadhav, Ashok D Mohekar, 2002. Applied Parasitology, A Practical Manual
- D.C. Kloss, W.E., and T.L. Bannermann.1995. ..*Manual of Clinical Microbiology* (6th edn.), American Society for Microbiology, Washington, USA
- Goodman and Guilman's Pharmacological Basis of Therapeutics, 2000.Tenth Edition. Gradwohl's clinical laboratory methods voll.1981.Academic Books, London.

- Howard B.J, J.F. Keiser. T.F. Smith, A.S. Weissfeld, R.C. Tolton, .2002.*Clinical and Pathogenic Microbiology.*
- Koneman E.W. D.Stephen, William A, Janda 2008. *Color Atlas and Textbook of Diagnostic Microbiology*. Tata McGraw Hill, NY.
- Mackie and Mccartney, 2008.*Practical Medical Microbiology* (14thedn). Churchill Livingstone, UK.
- Monica Cheesbrough, .*Medical Laboratory Manual For Tropical Countries.* Vol.II. Microbiology. ELBS.
- P.R.Murray, E.J.Baron, M,Patrick R. M,K.S.Rosenthal, G.S. Koayashi and M.A.Ptaller,1997.
- *Medical Microbiology.*
- Panicker, CKJ.1998.*Text book of Medical Parasitology*, Jaypee, New Delhi.
- Sherris Jc.,1990.*Medical Microbiology, An Introduction to Infectious Diseases*. Ed.2. New York.
- *Tille, Patricia M. 2014. Bailey & Scott's diagnostic microbiology. St. Louis, Missouri :Elsevier*

Microbiology (PZO4CRP0120)

180 Hours 4 Credits

Course Outcome

- Demonstrate various sterilization and aseptic techniques in handling microbes; bacterial staining and culturing.
- Perform antibiotic sensitivity test and interpret the result
- Quantitatively analyze the potability of drinking water
- Identify parasitic eggs & cysts by concentration & microscopic techniques
- Perform slide culture and identify pathogenic fungi; identify pathogenic bacteria based on biochemical and cultural characteristics.
- Acquire skills and competency in the field of clinical microbiology

General Microbiology and Bacteriology

- Isolation of bacteria in pure culture – streak, spread, pour plate technique
- Staining procedures- Gram's stain, AFB staining
- Microscopic examination of bacteria in living conditions - Testing of motility- Hanging drop method/ wet mount method
- Identification of medically important bacteria- Gram negative bacteria- E.coli, Klebsiella, Pseudomonas, Proteus, Salmonella/Shigella, Gram positive cocci-Staphylococcus sps. (Any 4)
- Cultural characteristics and biochemical reaction of bacteria- Colony morphology, staining, motility test, catalase, oxidase test, IMVIC test, TSI, Urease, Nitrate reduction, OF test.
- Antibiotic sensitivity test- Kirby Bauer method
- Slide Identification- *Neisseria, Mycobacterium, Clostridium sps.*
- Determine the portability of drinking water- MPN technique
- Enumeration of food microbes by plate count method

Mycology & Parasitology

- Culture methods for isolation and identification of fungi- Lactophenol

cotton blue staining,

- Slide culture technique
- Germ tube test of *Candida albicans*
- Aspergillus, Penicillium, Candida
- Slide identification of helminthic eggs- *Ascaris* (Fertilised and unfertilized), Eggs of *Ancylostoma, Trichuris, Enterobius*
- Stool concentration methods

Clinical Microbiology

- Serological Diagnosis – RA, ASO, CRP, RPR, Widal test (Interpretation)
- Rapid molecular diagnostic tests- Antigen Test/PCR/RT PCR/ELISA/Automated test (Any 2)
- 2 week internship/institution visit.

MODEL QUESTION PAPERS

M Sc.Zoology Degree (C.S.S) Examination

First Semester Faculty of Sciences

PZO1CRT0120 - ANIMAL DIVERSITY: PHYLOGENETIC AND TAXONOMIC APPROACHES

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Stromatolites
2. Cambrian explosion
3. Advantages of bone in vertebrate phylogeny
4. Significance of paedomorphosis in chordate phylogeny
5. Endothermy in dinosaurs
6. Evolutionary significance of Sarcopterygians.
7. What are the threats to the modern amphibian?
8. List out the endangered mammals of India
9. Phylocode
10. E-taxonomy

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Comment on the different hypothesis of metazoan origin.
12. What are the evolutionary advantages of symmetry and metamerism?
13. Comment on adaptive radiation in annelids
14. Discuss the affinity of invertebrates and protochordate in vertebrate evolution
15. Explain the importance of skull in reptilian classification

16. Comment on the significance of jaws and hearing in mammalian phylogeny
17. Briefly explain the taxonomic procedure
18. Give an account on the cladistics analysis in systematics

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Comment on the phylogenic relationship amongmollusca, annelida and arthropoda.
20. Write an essay on reptilian phylogeny and adaptive radiation
21. Explain about the different types of taxonomic publications
22. Write an essay on the use of biomolecules in molecular phylogeny

(2 x 5 =10)

M Sc Zoology Degree (C.S.S) Examination

First Semester Faculty of Science

PZO1CRT0220: EVOLUTIONARY BIOLOGY AND ETHOLOGY

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. What is meant by punctuated equilibrium?
2. Comment on RNA World.
3. Define heterochrony.
4. What is co-evolution?
5. Define key stimuli.
6. What is goal oriented drive?
7. Explain lunar periodicity.
8. Comment on pheromones.
9. Define sociobiology.
10. Differentiate avoidance from tolerance behaviour

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Write down the contributions of Margulis.
12. Explain evolution of prokaryotes
13. Comment on gene pool, gene frequency and Hardy Weinberg law.
14. Give an account on molecular evolution
15. Describe Lorenz‟s Psycho-hydraulic model of motivation
16. Explain conditioning with example

17. Give an account of navigation cues employed by animals during migration.

18. Discuss about hormones and behaviour.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Write an essay on isolating mechanisms and speciation.

20. Give an account on various stages in primate evolution.

21. Explain the social organisation in primates.

22. Explain different modes of communication in ants and mammals.

(2 x 5 = 10)

M Sc. Zoology Degree (C.S.S) Examination

Second Semester Faculty of Sciences

PZO2CRT0120: FIELD ECOLOGY

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Effect of global warming in species phonologies
2. Circadian rhythm and biological clock
3. Comment on mutualistic relationship of human with crops
4. Distinguish between deterministic extinction and stochastic extinction
5. Territoriality
6. Competitive exclusion principle
7. Different types of niches
8. Intraguild predation
9. Risk-sensitive foraging
10. Green technology

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. What are the effect of cold and hot temperature on organisms?
12. Comment on the response of animals to drought and flood
13. Comment on social parasitism
14. Discuss about the hunting tactics and adaptations
15. Write an account on different types of mutualism
16. Explain about antipredator adaptations
17. Comment on water scarcity and water conservation measures

18. What are the sources and effect of soil pollution?

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Discuss the characteristic properties of population

20. Write an essay on animal prey defense in natural ecosystem

21. Give an account on the responses of host to parasitism

22. Explain the biotechnological approaches to waste management

(2 x 5 = 10)

M Sc Zoology Degree (C.S.S) Examination

Third Semester Faculty of Science

PZO2CRT0420: MICROBIOLOGY AND BIOTECHNOLOGY

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. What is Slime layer?
2. Comment on culture medium.
3. Define quorum sensing.
4. What is YAC?
5. Define microinjection.
6. What is chromosome walking?
7. Explain cell culture.
8. Comment on Nif genes
9. Define nanobiosensors.
10. What is TRIPS?

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Give the general characters and outline classification of bacteria.
12. Describe the bacterial cell wall.
13. Give an account on pure culture techniques.
14. Explain the role of microbes in nutrient cycling.
15. Describe the different methods of gene transfer.
16. Explain the types of PCR. Add a note on its applications.
17. Give a brief account on gene therapy.

18. Discuss about terminator gene technology.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Write an essay on the various methods of sterilization.

20. Give an account on microbial interactions.

21. Explain the various sequencing methods.

22. Describe any four fermentation products.

(2 x 5 = 10)

M Sc. Zoology Degree (C.S.S) Examination

Fourth Semester Faculty of Sciences

PZO4CRT0120 : General Microbiology and Parasitology

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. List contributions of Edward Jenner
2. What is the role of sand fly in parasitic infection?
3. What is called as ray fungi? Explain its salient features.
4. Mycolic acid
5. What are chemotrophic bacteria? Give two examples
6. Mode of action of Penicillin
7. Droplet nuclei
8. Exponential phase
9. Antibiogram
10. Blue milk

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Phenol coefficient method
12. Chemostat
13. Air borne diseases
14. Difference between gram positive and gram negative bacteria
15. Pathogenesis and disease caused by Ascaris lumbricoides
16. Explain different milk quality testing methods.
17. What are the contributions of Louis Pasteur?

18. Explain differential staining technique with respect to acid fast staining.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Different methods of enumeration of microbes from air

20. Explain the structure, life cycle and pathogenesis of Entamoeba histolytica

21. Explain in detail the structure of Cyanobacteria

22. Explain both the sexual and asexual reproduction of fungi.

(2 x 5 = 10)

M Sc. Zoology Degree (C.S.S) Examination

Fourth Semester Faculty of Sciences

PZO4CRT0220: Bacteriology, Virology and Mycology

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Prophylaxis of communicable diseases
2. General properties of Neisseria
3. Pyrexia
4. Chikungunya virus
5. Prion diseases
6. Zoonotic infections
7. Interferons
8. Burst size
9. Cyanophages
10. Lactophenol staining blue technique

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Bacteriophage typing
12. Genomic organization of HIV virus
13. Antifungal agents and their mode of action
14. Pathogenesis and disease caused by Streptococcus
15. Immunological and non immunological response of virus infection
16. Bacterial infections of respiratory and gastrointestinal tract
17. Pathogenesis and laboratory infections of Treponema

18. Sources and mode of transmission of bacterial infections

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Control of virus infections
20. Pathogenesis of bacterial infections
21. Pathogenesis and diseases caused by oncogenic viruses
22. Systemic mycosis

(2 x 5 = 10)

M Sc. Zoology Degree (C.S.S) Examination

Fourth Semester Faculty of Sciences

PZO4CRT0320 : Clinical Microbiology

(2019 admissions onwards)

Time: 03 hours Max. Weight: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Good Laboratory Practice's
2. Enrichment culture
3. Lyophilization
4. Nasopharyngeal swab
5. Standard plate count method
6. Different colony morphology of bacteria
7. Imvic test
8. CPE
9. Superficial mycosis
10. Collection and transport of sputum sample

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

1. Explain the detection of viral proteins and viral genetic material
2. Describe the different microbiological safety cabinets
3. Explain the cleaning and sterilization of glassware
4. Explain the processing and microscopical examination of blood, stool and CSF samples
5. Explain the serological diagnosis of viral infections
6. Explain molecular diagnostic methods of microbes

7. Explain the biochemical tests for bacterial infections
8. Explain the legal requirements and humane method of killing animals

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

9. Explain any 2 diagnostic methods of parasitic infection in detail
10. Explain the culturing of viruses
11. Explain the diagnosis of fungal infection
12. Explain the different techniques in the preservation of microbes

(2 x 5 = 10)