DEPARTMENT OF
ZOOLOGY

Curriculum and Syllabus for Postgraduate Programme in Zoology
Under Credit Semester System
(with effect from 2019 admissions)

St Berchmans College
Founded 1922
AUTONOMOUS | College with Potential for Excellence | Reaccredited by NAAC with A Grade
Affiliated to Mahatma Gandhi University, Kottayam, Kerala
Changanassery, Kottayam, Kerala, India-686101

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BOARD OF STUDIES IN ZOOLOGY

Members

1. **Dr. Joe Prasad Mathew (Chairman)**
   Assistant Professor and Head, Department of Zoology
   St. Berchmans College, Changanassery

2. **Dr. John T. Kocheril**
   Associate Professor, Department of Zoology
   St. Berchmans College, Changanassery

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   St. Berchmans College, Changanassery

4. **Dr. Monichan K. K.**
   Assistant Professor, Department of Zoology
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6. **Dr. Martin J. Babu**
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7. **Dr. Rubin Philip**
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   Scientist, National Institute of Oceanography
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9. **Dr. Boby Jose**
   Associate Professor, Department of Zoology
   St. Josephs College, Devagiri (Autonomous)
   Kozhikode

10. **Dr. Sanil George**
    Scientist E
    Rajiv Gandhi Center for Biotechnology
    Thiruvananthapuram

11. **Dr. Nagendra Prabhu**
    Associate Professor, Department of Zoology
    S. D. College, Alappuzha

12. **J. Patrick David**
    Ecologist, Periyar Tiger Conservation Foundation
    Thekkady, Kerala

Programme Objectives

1. To understand the molecular nature of life and life processes.
2. To attain broad knowledge about the relationship between various living forms.
3. To gain critical understanding on human influence on environment.
4. To learn current environmental issues based on ecological principles.
5. To endow practical skills in laboratory and field work.
6. To train the students to use tools and techniques for research in biology.
7. To help the students to improve analytical and critical thinking skills.
8. To equip the learner to carry out original research in biology.

Programme Outcome

1. Appreciate the commonality between various living forms.
2. Gain a deeper understanding of various physiological & biochemical processes.
3. Attain mastery of the subject at molecular levels.
4. Understand the delicate relationship between various living forms that sustain life on earth.
5. Ability to understand, think and evolve strategies for management and conservation of environment.
6. Develop critical thinking capability.
7. Develop the skill to design and carry out research.
8. Acquire the ability to design novel approaches to resolve problems.

REGULATIONS FOR POSTGRADUATE (PG) PROGRAMMES UNDER CREDIT SEMESTER SYSTEM (SB-CSS-PG) 2019

1. SHORT TITLE

1.1 These Regulations shall be called St. Berchmans College (Autonomous) Regulations (2019) governing postgraduate programmes under Credit Semester System (SB-CSS-PG).

1.2 These Regulations shall come into force with effect from the academic year 2019 - 20 onwards.

2. SCOPE

2.1 The regulation provided herein shall apply to all regular postgraduate programmes, MA/MSc/MCom, conducted by St. Berchmans College (Autonomous) with effect from the academic year 2019 - 20.

3. DEFINITIONS

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

3.2 'College' means St. Berchmans College (Autonomous).

3.3 There shall be an Academic Committee nominated by the Principal to look after the matters relating to the SB-CSS-PG system.

3.4 'Academic Council' means the Committee consisting of members as provided under section 107 of the University Act 2014, Government of Kerala.

3.5 'Parent Department' means the Department, which offers a particular postgraduate programme.

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

3.7 'Faculty Mentor' is a teacher nominated by a Department Council to coordinate the continuous evaluation and other academic activities of the Postgraduate programme undertaken in the Department.

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

3.9 'Duration of Programme' means the period of time required for the conduct of the programme. The duration of a postgraduate programme shall be four (4) semesters.

3.10 'Semester' means a term consisting of a minimum 90 working days, inclusive of tutorials, examination days and other academic activities within a period of six months.

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

3.12 'Course Teacher' means the teacher who is taking classes on the course.

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

3.14 'Elective Course' means a course, which can be substituted, by equivalent course from the same subject and the number of courses required to complete the programme shall be decided by the respective Board of Studies.

3.15 The elective course shall be either in the fourth semester or be distributed among third and fourth semesters.

3.16 'Audit Course' means a course opted by the students, in addition to the compulsory courses, in order to develop their skills and social responsibility.

3.17 'Extra Credit Course' means a course opted by the students, in addition to the compulsory courses, in order to gain additional credit that would boost the performance level and additional skills.

3.18 Extra credit and audit courses shall be completed by working outside the regular teaching hours.

3.19 There will be optional extra credit courses and mandatory audit courses. The details of the extra credit and audit courses are given below.

Semester	Course	Type
I	Course on Mendeley Reference Management Software	Optional, Extra credit Grades shall be given
	Course on Basic Life Support System and Disaster Management	Compulsory, Audit Grades shall be given
First summer vacation	Internship/Skill Training	Optional, Extra credit Grades shall be given
Any time during the programme	Oral Presentation in National/International seminar	Optional, Extra credit
	Publication in a recognized journal with ISSN number	

3.20 'Project' means a regular research work with stated credits on which the student conducts research under the supervision of a teacher in the parent department/any appropriate research centre in order to submit a report on the project work as specified.

3.21 'Dissertation' means a minor thesis to be submitted at the end of a research work carried out by each student on a specific area.

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

3.23 'Seminar' means a lecture expected to train the student in self-study, collection of relevant matter from books and Internet resources, editing, document writing, typing and presentation.

3.24 '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.

3.25 'Improvement Examination' is an examination conducted to improve the performance of students in the courses of a particular semester.

3.26 'Supplementary Examination' is an examination conducted for students who fail in the courses of a particular semester.

3.27 The minimum credits, required for completing a postgraduate programme is eighty (80).

3.28 'Credit' (C) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.29 'Course Credit': One credit of the course is defined as a minimum of one (1) hour lecture/minimum of two (2) hours lab/field work per week for eighteen (18) weeks in a semester. The course will be considered as completed only by conducting the final examination.

3.30 'Grade' means a letter symbol (A, B, C etc.) which indicates the broad level of performance of a student in a course/semester/programme.

3.31 'Grade Point' (GP) is the numerical indicator of the percentage of marks awarded to a student in a course.

3.32 'Credit Point' (CP) of a course is the value obtained by multiplying the grade point (GP) by the credit (C) of the course.

3.33 'Semester Grade Point Average' (SGPA) of a semester is calculated by dividing total credit points obtained by the student in a semester by total credits of that semester and shall be rounded off to two decimal places.

3.34 'Cumulative Grade Point Average' (CGPA) is the value obtained by dividing the sum of credit points in all the courses obtained by the student for the entire programme by the total credits of the whole programme and shall be rounded off to two decimal places.

3.35 'Institution average' is the value obtained by dividing the sum of the marks obtained by all students in a particular course by the number of students in respective course.

3.36 'Weighted Average Score' means the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

3.37 'Grace Marks' means marks awarded to course/courses, in recognition of meritorious achievements of a student in NCC/NSS/ Sports/Arts and cultural activities.

3.38 First, Second and Third position shall be awarded to students who come in the first three places based on the overall CGPA secured in the programme in the first chance itself.

4. PROGRAMME STRUCTURE

4.1 The programme shall include two types of courses; Core Courses and Elective Courses. There shall be a project/research work to be undertaken by all students. The programme will also include assignments, seminars, practical, viva-voce etc., if they are specified in the curriculum.

4.2 Total credits for a programme is eighty (80). No course shall have more than four (4) credits.

4.3 **Project/dissertation**

Project/research work shall be completed by working outside the regular teaching hours except for MSc Computer Science programme. Project/research work shall be carried out under the supervision of a teacher in the concerned department. A student may, however, in certain cases be permitted to work in an industrial/research organization on the recommendation of the supervisor. There shall be an internal assessment and external assessment for the project/dissertation. The external evaluation of the Project/Dissertation shall be based on the individual presentation in front of the expert panel.

4.4 **Evaluations**

The evaluation of each course shall contain two parts.

i Internal or In-Semester Assessment (ISA)

ii External or End-Semester Assessment (ESA)

Both ISA and ESA shall be carried out using indirect grading. The ISA:ESA ratio is 1:3. Marks for ISA is 25 and ESA is 75 for all courses.

4.5 **In-semester assessment of theory courses**

The components for ISA are given below.

Component	Marks
Attendance	2
Viva	3
Assignment	4
Seminar	4
Class test	4
Model Exam	8
Total	**25**

4.6 Attendance evaluation of students for each course shall be as follows:

% of Attendance	Marks
Above 90	2
75 - 90	1

4.7 **Assignments**

Every student shall submit one assignment as an internal component for every course.

4.8 **Seminar**

Every student shall deliver one seminar as an internal component for every course. The seminar is expected to train the student in self-study, collection of relevant matter from the books and internet resources, editing, document writing, typing and presentation.

4.9 **In-semester examination**

Every student shall undergo at least two in-semester examinations one as class test and second as model examination as internal component for every theory course.

4.10 To ensure transparency of the evaluation process, the ISA mark awarded to the students in each course in a semester shall be published on the notice board according to the schedule in the academic calendar published by the College. There shall not be any chance for improvement for ISA. The course teacher and the faculty mentor shall maintain the academic record of each student registered for the course which shall be forwarded to the office of the Controller of Examinations through the Head of the Department and a copy shall be kept in the office of the Head of the Department for at least two years for verification.

4.11 **In-semester assessment of practical courses**

The internal assessment of practical courses shall be conducted either annually or in each semester. There shall be one in-semester examination for practical courses. The components for internal assessment are given below.

Component	Marks
Attendance	2
Lab Test	15
Viva-Voce	5
Record	3
Total	**25**

Attendance evaluation of students for each course shall be as follows:

% of Attendance	Marks
Above 90	2
75 - 90	1

4.12 **End-semester assessment**

The end-semester examination in theory and practical courses shall be conducted by the College.

4.13 The end-semester examinations for theory courses shall be conducted at the end of each semester. There shall be one end-semester examination of three (3) hours duration in each lecture based course.

4.14 The question paper should be strictly on the basis of model question paper set by Board of Studies.

4.15 A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions. Marks for each type of question can vary from programme to programme, but a general pattern may be followed by the Board of Studies.

4.16 Question Pattern for external theory examination shall be,

Section	Total No. of Questions	Questions to be Answered	Marks	Total Marks for the Section
A	14	10	2	20
B	8	5	5	25
C	4	2	15	30
			Maximum	**75**

4.17 Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny as per the regulations in the examination manual.

4.18 Practical examination shall be conducted annually or in each semester. Practical examination shall be conducted by one external examiner and one internal examiner. The question paper setting and evaluation of answer scripts shall be done as per the directions in the examination manual of the College. The duration of practical examination shall be decided by the Board of Studies.

4.19 Project/Dissertation evaluation shall be conducted at the end of the programme. Project/Dissertation evaluation shall be conducted by one external examiner and one internal examiner. The components and mark division for internal and external assessment shall be decided by the respective Board of Studies.

Components of Project Evaluation	Marks
Internal Evaluation	25
Dissertation (External)	50
Viva-Voce (External)	25
Total	**100**

4.20 Comprehensive viva-voce shall be conducted at the end of the programme. Viva-voce shall be conducted by one external examiner and one internal examiner. The viva-voce shall cover questions from all courses in the programme. There shall be no internal assessment for comprehensive viva-voce. The maximum marks for viva-voce is one hundred (100).

4.21 For all courses (theory and practical) an indirect grading system based on a seven (7) point scale according to the percentage of marks (ISA + ESA) is used to evaluate the performance of the student in that course. The percentage shall be rounded mathematically to the nearest whole number.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
40 to below 45	D	Pass	4
Below 40	F	Failure	0

4.22 **Credit Point**

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the credit and GP is the grade point

4.23 **Semester Grade Point Average**

Semester Grade Point Average (SGPA) is calculated using the formula

SGPA = TCP/TCS

where TCP is the total credit point of all the courses in the semester and TCS is the total credits in the semester

GPA shall be rounded off to two decimal places.

4.24 **Cumulative Grade Point Average**

Cumulative Grade Point Average (CGPA) is calculated using the formula

CGPA = TCP/TC

where TCP is the total credit point of all the courses in the whole programme and TC is the total credit in the whole programme

GPA shall be rounded off to two decimal places.

Grades for the different courses, semesters, Semester Grade Point Average (SGPA) and grades for overall programme, Cumulative Grade Point Average (CGPA) are given based on the corresponding Grade Point Average (GPA) as shown below:

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
4 to below 4.5	D	Pass
Below 4	F	Failure

4.25 A separate minimum of 40% marks each in ISA and ESA (for theory and practical) and aggregate minimum of 40% are required for a pass in a course. For a pass in a programme, a separate minimum of grade 'D' is required for all the individual courses.

5. SUPPLEMENTARY/IMPROVEMENT EXAMINATION

5.1 There will be supplementary examinations and chance for improvement. Only one chance will be given for improving the marks of a course.

5.2 There shall not be any improvement examination for practical courses and examinations of the final year.

6. ATTENDANCE

6.1 The minimum requirement of aggregate attendance during a semester for appearing the end semester examination shall be 75%. Condonation of shortage of attendance to a maximum of ten (10) days in a semester subject to a maximum of two times during the whole period of postgraduate programme may be granted by the College. This condonation shall not be counted for internal assessment.

6.2 Benefit of attendance may be granted to students representing the College, University, State or Nation in Sports, NCC, NSS or Cultural or any other officially sponsored activities such as College union/University union activities etc., on production of participation/attendance certificates, within one week from competent authorities, for the actual number of days participated, subject to a maximum of ten (10) days in a semester, on the specific recommendations of the Faculty Mentor and Head of the Department.

6.3 A student who does not satisfy the requirements of attendance shall not be permitted to appear in the end-semester examinations.

6.4 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch after readmission.

7. BOARD OF STUDIES AND COURSES

7.1 The Board of Studies concerned shall design all the courses offered in the programme. The Board shall design and introduce new courses, modify or re-design existing courses and replace any existing courses with new/modified courses to facilitate better exposure and training for the students.

7.2 The syllabus of a programme shall contain programme objectives and programme outcome.

7.3 The syllabus of a course shall include the title of the course, course objectives, course outcome, contact hours, the number of credits and reference materials.

7.4 Each course shall have an alpha numeric code which includes abbreviation of the course in two letters, semester number, course code and serial number of the course.

7.5 Every programme conducted under Credit Semester System shall be monitored by the Academic Council.

8. REGISTRATION

8.1 A student who registers his/her name for the external exam for a semester will be eligible for promotion to the next semester.

8.2 A student who has completed the entire curriculum requirement, but could not register for the Semester examination can register notionally, for getting eligibility for promotion to the next semester.

8.3 A student may be permitted to complete the programme, on valid reasons, within a period of eight (8) continuous semesters from the date of commencement of the first semester of the programme

9. ADMISSION

9.1 The admission to all PG programmes shall be as per the rules and regulations of the College/University.

9.2 The eligibility criteria for admission shall be as announced by the College/University from time to time.

9.3 Separate rank lists shall be drawn up for seats under reservation quota as per the existing rules.

9.4 There shall be an academic and examination calendar prepared by the College for the conduct of the programmes.

10. ADMISSION REQUIREMENTS

10.1 Candidates for admission to the first semester of the PG programme through SB-CSS-PG shall be required to have passed an appropriate degree examination of Mahatma Gandhi University or any University or authority, duly recognized by the Academic council of Mahatma Gandhi University as equivalent thereto.

11. MARK CUM GRADE CARD

11.1 The College under its seal shall issue to the students, a Mark cum Grade Card on completion of each semester, which shall contain the following information.

i. Name of the Student
ii. Register Number
iii. Photo of the Student
iv. Degree

v. Programme
vi. Semester and Name of the Examination
vii. Month and Year of Examination
viii. Faculty
ix. Course Code, Title and Credits of each course opted in the semester
x. Marks for ISA, ESA, Total Marks (ISA + ESA), Maximum Marks, Letter Grade, Grade Point (GP), Credit Point (CP) and Institution Average in each course opted in the semester
xi. Total Credits, Marks Awarded, Credit Point, SGPA and Letter Grade in the semester
xii. Weighted Average Score
xiii. Result
xiv. Credits/Grade of Extra Credit and Audit Courses

11.2 The final Mark cum Grade Card issued at the end of the final semester shall contain the details of all courses taken during the entire programme including those taken over and above the prescribed minimum credits for obtaining the degree. The final Mark cum Grade Card shall show the CGPA and the overall letter grade of a student for the entire programme.

11.3 A separate grade card shall be issued at the end of the final semester showing the extra credit and audit courses attended by the student, grade and credits acquired.

12. AWARD OF DEGREE

The successful completion of all the courses with 'D' grade shall be the minimum requirement for the award of the degree.

13. MONITORING COMMITTEE

There shall be a Monitoring Committee constituted by the Principal to monitor the internal evaluation conducted by the College. The Course Teacher, Faculty Mentor, and the College Coordinator should keep all the records of the continuous evaluation, for at least a period of two years, for verification.

14. GRIEVANCE REDRESS COMMITTEE

14.1 In order to address the grievance of students relating to ISA, a two-level grievance redress mechanism is envisaged.

14.2 A student can approach the upper level only if grievance is not addressed at the lower level.

14.3 Department level: The Principal shall form a Grievance Redress Committee in each Department comprising of course teacher and one senior teacher as members and the Head of the Department as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

14.4 College level: There shall be a College level Grievance Redress Committee comprising of Faculty Mentor, two senior teachers and two staff council members (one shall be an elected member) and the Principal as Chairman. The Committee shall address all grievances relating to the internal assessment of the students.

15. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Principal shall, for a period of three 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.

REGULATIONS FOR EXTRACURRICULAR COURSES, INTERNSHIP AND SKILL TRAINING

COURSE ON BASIC LIFE SUPPORT SYSTEM AND DISASTER MANAGEMENT (BLS & DM)

i. The course on BLS & DM shall be conducted by a nodal centre created in the college.
ii. The nodal centre shall include at least one teacher from each department. A teacher shall be nominated as the Director of BLS & DM.
iii. The team of teachers under BLS & DM shall function as the trainers for BLS & DM.
iv. The team of teachers under BLS & DM shall be given intensive training on Basic Life Support System and Disaster Management and the team shall be equipped with adequate numbers of mannequins and kits for imparting the training to students.
v. Each student shall under go five (5) hours of hands on training in BLS & DM organised by the Centre for BLS & DM.
vi. The training sessions shall be organised on weekends/holidays/vacation during the first semester of the programme.
vii. After the completion of the training, the skills acquired shall be evaluated using an online test and grades shall be awarded.
viii. Nodal centre for BLS & DM shall conduct online test and publish the results.
ix. Students who could not complete the requirements of the BLS & DM training shall appear for the same along with the next batch. There shall be two redo opportunity.
x. For redressing the complaints in connection with the conduct of BLS & DM students shall approach the Grievance Redress Committee functioning in the college.

COURSE ON MENDELY REFERENCE MANAGEMENT SOFTWARE

i. College shall arrange workshop with hands on training in Mendely reference management software during the first semester.
ii. Students completing the course can enrol for an evaluation and those who pass the evaluation shall be given one credit.

INTERNSHIP/SKILL TRAINING PROGRAMME

i. Postgraduate student can undergo an internship for a minimum period of five days (25 hours) at a centre identified by the concerned department. In the case of disciplines where internship opportunities are scanty (e.g. Mathematics) special skill training programmes with duration of five days (25 hours) shall be organised.
ii. Each department shall identify a teacher in charge for internship/skill training programme.
iii. The department shall select institutions for internship/organising skill training programme.
iv. Internship/skill training programme shall be carried out preferably during the summer vacation following the second semester or during the Christmas vacation falling in the second semester or holidays falling in the semester.
v. At the end of the stipulated period of internship each student shall produce an internship completion cum attendance certificate and an illustrated report of the training he/she has underwent, duly certified by the tutor and Head of the institution where the internship has been undertaken.
vi. Students undergoing skill training programme shall submit a training completion cum attendance certificate and a report of the training he/she has underwent, duly certified by the trainer, teacher co-ordinator of the programme from the concerned department and the head of the department concerned.
vii. Upon receipt of the internship completion cum attendance certificate and illustrated report of the training or a training completion cum attendance certificate and a report of the training, the teacher in charge of internship/skill training programme shall prepare a list of students who have completed the internship/skill training programme and a list of students who failed to complete the programme. Head of the department shall verify the lists and forward the lists to the Controller of Examinations.

PAPER PRESENTATION

i. During the period of the programme students shall be encouraged to write and publish research/review papers.
ii. One research/review paper published in a UGC approved journal or oral presentation in an international/national seminar which is later published in the proceedings shall fetch one credit.

VIRTUAL LAB EXPERIMENTS/MOOC COURSES

i. During the tenure of the programme, students shall be encouraged to take up Virtual Lab Experiments and/or MOOC Courses.
ii. College shall arrange dedicated infrastructure for taking up Virtual Lab experiments and/or MOOC courses.
iii. There shall be a Nodal Officer and a team of teachers to coordinate the logistics for conducting Virtual Lab experiments and MOOC courses and to authenticate the claims of the students regarding the successful completion of the Virtual Lab experiments and or MOOC courses.
iv. Students who are desirous to do Virtual Lab experiments and or MOOC courses shall register with the Nodal Officer at the beginning of the experiment session/MOOC course. Students also shall submit proof of successful completion of the same to the Nodal officer.
v. Upon receipt of valid proof, the Nodal Officer shall recommend, to the Controller of Examinations, the award of extra credits. In the case of Virtual Lab experiments, 36 hours of virtual experimentation shall equal one credit and in the case of MOOC courses 18 hours of course work shall equal one credit.

Model Mark cum Grade Card

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Changanassery, Kottayam, Kerala, India-686101

MARK CUM GRADE CARD

Date:

Name of the Candidate :

Permanent Register Number (PRN) :

Degree :

Programme :

Name of Examination :

Faculty :

Photo

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
	Total SGPA: SG: WAS: ***End of Statement***												

*WAS: Weighted Average Score

Entered by:

Verified by:

Controller of Examinations
Principal

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Changanassery, Kottayam, Kerala, India - 686101, Tel: 91-481-2420025, 9961231314
E-mail: sbc@sbcollege.org Web: www.sbcollege.ac.in

CONSOLIDATED MARK CUM GRADE CARD

Name of the Candidate :
Permanent Register Number (PRN) :
Degree :
Programme :
Faculty :
Date :

Photo

Course Code	Course Title	Credits (C)	Marks						Grade Awarded (G)	Grade Point (GP)	Credit Point (CP)	Institution Average	Result
			ISA		ESA		Total						
			Awarded	Maximum	Awarded	Maximum	Awarded	Maximum					
SEMESTER I													
SEMESTER II													
SEMESTER III													

SEMESTER IV													
	End of Statement												

PROGRAMME RESULT

Semester	Marks Awarded	Maximum Marks	Credit	Credit Point	SGPA	Grade	WAS	Month & Year of Passing	Result
I II III IV									
Total					**FINAL RESULT: CGPA =**		**; GRADE =**	**;WAS =**	

*** Separate grade card is issued for Audit and Extra Credit courses.**
**** Grace Mark awarded.**

Entered by:

Verified by:

Controller of Examinations **Principal**

Reverse side of the Mark cum Grade Card (COMMON FOR ALL SEMESTERS)

Description of the Evaluation Process

Grade and Grade Point

The evaluation of each course comprises of internal and external components in the ratio 1:3 for all Courses. Grades and Grade Points are given on a seven (7) point scale based on the percentage of Total Marks (ISA + ESA) as given in Table 1. Decimals are corrected to the nearest whole number.

Credit Point and Grade Point Average

Credit Point (CP) of a course is calculated using the formula

CP = C × GP

where C is the Credit and GP is the Grade Point

Grade Point Average of a Semester (SGPA) or Cumulative Grade Point Average (CGPA) for a Programme is calculated using the formula

SGPA or CGPA = TCP/TC

where TCP is the Total Credit Point for the semester/programme and TC is the Total Credit for the semester/programme

GPA shall be rounded off to two decimal places.

The percentage of marks is calculated using the formula;

$$\% \text{ Marks} = \left(\frac{\text{total marks obtained}}{\text{maximum marks}}\right) \times 100$$

Weighted Average Score (WAS) is the score obtained by dividing sum of the products of marks secured and credit of each course by the total credits of that semester/programme and shall be rounded off to two decimal places.

Percentage of Marks	Grade	Performance	Grade Point
95 and above	S	Outstanding	10
85 to below 95	A+	Excellent	9
75 to below 85	A	Very Good	8
65 to below 75	B+	Good	7
55 to below 65	B	Above Average	6
45 to below 55	C	Satisfactory	5
40 to below 45	D	Pass	4
Below 40	F	Failure	0

Table 1

Grades for the different Semesters and overall Programme are given based on the corresponding GPA, as shown in Table 2.

GPA	Grade	Performance
9.5 and above	S	Outstanding
8.5 to below 9.5	A+	Excellent
7.5 to below 8.5	A	Very Good
6.5 to below 7.5	B+	Good
5.5 to below 6.5	B	Above Average
4.5 to below 5.5	C	Satisfactory
4 to below 4.5	D	Pass
Below 4	F	Failure

Table 2

Note: Course title followed by (P) stands for practical course. A separate minimum of 40% marks each for internal and external assessments (for both theory and practical) and an aggregate minimum of 40% marks is required for a pass in each course. For a pass in a programme, a separate minimum of Grade D for all the individual courses and an overall Grade D or above are mandatory. If a candidate secures Grade F for any one of the courses offered in a Semester/Programme, only Grade F will be awarded for that Semester/Programme until the candidate improves this to Grade D or above within the permitted period.

PROGRAMME STRUCTURE

	Course Code	Course Title	Hours /Week	Total Hours	Credit	ISA	ESA	Total
Semester 1	BMZO101	Physiology and Endocrinology	5	90	4	25	75	100
	BMZO102	Genetics and Biotechnology	5	90	4	25	75	100
	BMZO103	Research Methodology and Biological Techniques	5	90	4	25	75	100
	BMZO104	Biochemistry	5	90	4	25	75	100
	BMZO1P01	Physiology, Research Methodology, Genetics and Biochemistry (P)	5	90	3	25	75	100
		Total	**25**	**450**	**19**	**125**	**375**	**500**
Semester II	BMZO205	Developmental Biology	5	90	4	25	75	100
	BMZO206	Evolutionary Biology and Biosystematics	5	90	4	25	75	100
	BMZO207	Cell Biology	5	90	4	25	75	100
	BMZO208	Neurobiology and Behavioural Biology	5	90	4	25	75	100
	BMZO2P02	Developmental Biology, Evolutionary Biology, Cell Biology and Neurobiology (P)	5	90	3	25	75	100
		Total	**25**	**450**	**19**	**125**	**375**	**500**
Semester III	BMZO309	Ecology and Conservation	5	90	4	25	75	100
	BMZO310	Molecular Biology, Genomics, Proteomics and Bioinformatics	5	90	4	25	75	100
	BMZO311	Disease Biology and Microbiology	4	72	4	25	75	100
	BMZO312	Principles of Immunology	3	54	3	25	75	100
	BMZO3P03	Ecology and Conservation (P)	4	72	2	25	75	100
	BMZO3P04	Microbiology, Immunology and Bioinformatics (P)	4	72	2	25	75	100
		Total	**25**	**450**	**19**	**150**	**450**	**600**
Semester IV	BMZO413	Insect Morphology and Taxonomy	5	90	4	25	75	100
	BMZO414	Insect Anatomy, Physiology and Ecology	5	90	4	25	75	100
	BMZO415	Applied Entomology	5	90	4	25	75	100
	BMZO4P05	Insect Morphology, Anatomy and Taxonomy (P)	5	90	3	25	75	100
	BMZO4P06	Insect Physiology and Applied Entomology (P)	5	90	3	25	75	100
	BMZO4PJ	Project	-	-	3	25	75	100
	BMZO4VV	Viva voce	-	-	2		100	100
		Total	**25**	**450**	**23**	**150**	**550**	**700**
		Grand Total	**-**	**-**	**80**	**550**	**1750**	**2300**

SEMESTER I

BMZO101: PHYSIOLOGY AND ENDOCRINOLOGY

Credit – 4 **90 Hrs**

Course Objectives:

- To study and compare the functioning of organ systems across the animal world
- To give an over view of the comparative functioning of different organ systems in animals
- To explain the molecular and cellular basis of physiological functions in animals.

Course Outcomes:

- Students will be able to understand the fundamental physiological functions of organ system and its regulatory mechanisms
- Students will be able to integrate the regulation of organ system functions in a whole animal

PHYSIOLOGY (40 Hrs)

Module 1: Nutrition, Digestion and Absorption **7 Hrs**

1.1. Physiology of digestion and absorption of carbohydrate, proteins and lipids

1.2. Gastro intestinal hormones and their roles

1.3. Structural and biochemical adaptations to special dietary pattern- symbiotic digestion

1.4. Neuronal and hormonal regulation of nutritional intake, hunger drive and thirst

1.5. Obesity- causes and consequences, outline of hormonal involvement

1.6. Role of leptin and secretin in adipogenesis

Module 2: Circulation **8 Hrs**

2.1. Circulatory mechanisms- movement of body fluids by somatic muscles, open system, closed system, lymph channels

2.2. Types of hearts- chambered heart, tubular heart, ampullar heart, and lymph heart, neurogenic and myogenic heart

2.3. Pace makers and conducting system

2.4. Cardiac cycle

2.5. Cardiac output and blood pressure

2.6. Effects of exercise on cardiovascular physiology

2.7. ECG - its principle and significance

2.8. Human congenital heart diseases

2.9. Circulatory shock and Circulatory arrest

Module 3: Respiration **6 Hrs**

3.1. Respiration in different animal groups

3.2. Pulmonary ventilation, gas exchange and transport of respiratory gases

3.3. Respiratory centers and regulation of respiration

3.4. Respiration in unusual environment – fetal and neonatal

3.5. Respiration, high altitude and in diving

3.6. Structure and functioning of respiratory pigments

Module 4: Osmoregulation and Excretion **7 Hrs**

4.1. Osmoregulation in fresh water, marine and terrestrial animals

4.2. Regulation of water balance, electrolyte balance and acid-base balance

4.3. Excretion in vertebrates. Physiology and regulation of urine formation, Hormonal regulation of urine formation

4.4. Dialysis, artificial kidney, kidney transplantation

Module 5: Muscle Physiology **7 Hrs**

5.1. Comparative physiology of skeletal, smooth and cardiac muscles.

5.2. Skeletal muscle

5.2.1. Ultra structure and molecular organization. Types of muscle proteins

5.2.2. Mechanism of muscle contraction and relaxation

5.2.3. Energetics of muscle contraction

5.2.4. Effect of exercise on muscles

5.2.5. Red and white muscles

5.2.6. Catch muscle and fibrillar muscle

Module 6: Thermoregulation **5 Hrs**

6.1. Body temperature – physical, chemical, neural regulation

6.2. Acclimation, Acclimatization; Comfort zone

6.3. Impact of temperature on the rate of biological functions, Arrhinius equilibrium, Q10

6.4. Temperature compensation and temperature regulation in poikilotherms and homoeotherms

6.5. Adaptations for extreme environments, aestivation and hibernation

REPRODUCTIVE PHYSIOLOGY (18 Hrs)

Module 7: Male Reproductive Physiology **5 Hrs**

7.1. Anatomy and histology of human testis

7.2. Physiological role of androgens

7.3. Endocrine control of testicular function

7.4. Pathophysiology- Abnormal spermatogenesis

7.5. Abnormalities of male sexual function-prostate gland abnormalities, hypogonadism and hypergonadisms, testicular tumors

Module 8: Female Reproductive Physiology **6 Hrs**

8.1. Anatomy and histology of female reproductive organs

8.2. Chemistry and metabolism of ovarian steroid hormones

8.3. Reproductive cycles of mammals – estrous cycle

8.4. Menstrual cycles

8.5. Regulation of reproductive cycles – hormonal, neural and environmental

8.6. Physiological roles of ovarian steroid hormones

8.7. Feedback oscillation of hypothalamic pituitary-ovarian system

Module 9: Pregnancy, Parturition and Lactation **7 Hrs**

9.1. Fertilization and transport of fertilized ovum in fallopian tube

9.2. Physiology of implantation

9.3. Decidualization

9.4. Placentation, structure and function of placenta

9.5. Placenta as an endocrine entity

9.6. Response of mother's body to pregnancy

9.7. Parturition and mechanism of labor

9.8. Development of mammary gland

9.9. Lactation- galactopoiesis, physiology of milk secretion and milk ejection, Composition of milk

ENDOCRINOLOGY (32 Hrs)

Module 10: **Introduction** **2 Hrs**

10.1. Hormones and homeostasis; Neuroendocrine integration

10.2. Chemical nature of hormones

10.3. Local hormones and circulating hormones

Module 11: **Mechanism of Hormone Action** **5 Hrs**

11.1. Plasma Membrane hormone receptors; Regulation of receptor number

11.2. Signal transduction mechanisms: Role of G proteins, Second messengers of hormonal action

11.3. Intracellular hormone receptors and mode of action

Module 12: **Hypothalamus and Neurohypophysis** **4 Hrs**

12.1. Structure of endocrine hypothalamus

12.2. Releasing and inhibitory hormones of Hypothalamus

12.3. Neurohypophysis: general organization

12.4. Neurohypophysial octapeptide hormones

Module 13: Adenohypophysis **4 hrs**

13.1. Adenohypophysial cell types and functions

Chemistry and physiological roles of Adenohypophysial hormones:

13.2. Growth Hormone and Prolacin

13.3. Glycoprotein hormones- FSH, LH and TSH

13.4. Pro-opiomelanocortin- ACTH and MSH

Module 14: **Thyroid Hormones** **3 Hrs**

14.1. Structure of Thyroid gland

14.2. Biosynthesis of T3 and T4; Control of thyroid hormone secretion

14.3. Physiological roles of thyroid hormones

Module 15: **Hormones and Calcium Homeostasis** **2 Hrs**

15.1. Calcium homeostasis -Role of Parathormone, Calcitonin and Vitamin D

Module 16: **Adrenal Hormones** **4 Hrs**

16.1. Adrenal Cortex- Organization, Physiological roles of glucocorticoid, mineralocorticoid and sex steroids, Control of cortical hormone secretions

15.2. Adrenal Medulla- Organisation, Physiological role of Catecholamine and its release

Module 17: **Pancreatic Hormones** **3 Hrs**

17.1. Islets of Langerhans – organisation and its hormones

17.2. Physiological role of insulin, glucagon, somatostatin and pancreatic polypeptide and their release

Module 18: Hormones and Metabolism **2 Hrs**

18.1. Hormonal regulation of Carbohydrate, Protein and Lipid metabolism

Module 19: **Invertebrate Endocrinology** **3 Hrs**

19.1. Structure, functions and molecular actions of insect and crustacean hormones with special reference to reproduction

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Physiology

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2. Hill, W.R., Wyse, G.A and Anderson, M. 2007, Animal Physiology (2nd edn), Sinauer Associates Inc. Publishers, MA, USA
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Endocrinology

1. Bentley P. J., 1998, Comparative Vertebrate Endocrinology, 1998, Cambridge University Press, UK
2. Hadley, Mac E, 2012, Endocrinology, Prentice Hall, NJ, USA
3. Larsson, P. R. et al., 2002, William's Text Book of Endocrinology (10th ed), W.B. Saunders, Philadelphia, USA
4. Squires, E. J. 2003, Applied Animal Endocrinology, CABI Publications, UK

BMZO102: GENETICS AND BIOTECHNOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

- To give an in-depth understanding on the principles and mechanisms of inheritance
- To help study the fine structure and molecular aspects of genetic material
- To give students an intensive and in-depth learning in the field of biotechnology
- To familiarize the students with public policy, biosafety, and intellectual property rights issues related to biotechnology

Course Outcomes:

- Students will learn the principles of inheritance and mechanisms of inheritance
- Students will learn the fine structure and molecular aspects of genetic material
- Students will understand the modern biotechnology practices and approaches

GENETICS (54 Hrs)

Module 1: Molecular Organization of Chromosomes **8 Hrs**

1.1. Structural organization of eukaryotic chromosome- primary, secondary and tertiary level

1.2. Centromere- molecular structure and function, kinetochore, telomere- molecular structure and its maintenance, secondary constriction, satellite chromosomes , euchromatin and heterochromatin.

1.3. Repeated DNA sequences in eukaryotic genomes- Unique, moderately repetitive and highly repetitive sequences, Satellite DNA- mini and micro satellites, Kinetics of renaturation: Cot and Cot curve

1.4. Special kinds of chromosomes - Polytene chromosomes, Lampbrush chromosomes and B chromosomes

1.5. Chromosome banding techniques and different types of banding

Module 2: Gene Concept **8 Hrs**

2.1. Evolution of the concept of gene function and structure.

2.2. Interrupted genes in eukaryotes, exons and introns-R loops, significance of introns. Overlapping genes- Bacteriophage Ö X174, Pseudogenes

2.3. Transposable Genetic Elements– definition, characteristics, types. Transposable genetic elements in Bacteria –IS elements, composite transposons, Tn3 elements, medical significance.

2.4. Transposable genetic elements in Eukaryotes-P elements, Ac / Ds elements, mariner; Retrotransposons- Tyl elements. Reteroposons, Transposable elements in man – LINEs and SINEs. Significance of transposons.

Module 3: Gene Mutation and Repair **6 Hrs**

3.1. Mutation – definition, characteristics, types - germ-line and somatic mutation, lethal mutation, conditional mutation, spontaneous and induced mutation, classification by function.

3.2. Molecular Basis of Gene Mutation-nucleotide substitution, missense mutation, insertion, deletion, frame shift mutations, mutation of trinucleotide repeats, mutation by transposable elements.

3.3. Mutation induced by chemicals and radiation- depurination, deamination, base analog mutation, alkylating agents, intercalating agents, UV irradiation, Ionizing radiations.
Ames Test

3.4. Mechanism of DNA Repair – mismatch repair, AP repair, photoreactivation, excision repair, post replicative repair and SOS repair.

Module 4: Linkage, Recombination and Chromosome Mapping **8 Hrs**

4.1. Linkage and recombination of genes in a chromosome. Molecular basis of Genetic Recombination – Holliday Model. Gene Conversion.

4.2. Recombination mapping with two-point and three –point test cross in *Drosophila*, Coincidence and Interference, Genetic mapping by tetrad analysis in *Neurospora*. Mitotic recombination.

4.3. Linkage analysis in Human- Pedigree analysis, somatic cell hybridization, Lod score for linkage testing.

Module 5: Epigenetics **6 Hrs**

5.1. Introduction, Mechanisms -DNA methylation, chromatin remodelling, Histone-code hypothesis, histone modifications and its effects- methylation, acetylation, phosphorylation, ubiquitination and sumoylation. Genomic imprinting, RNA interference, Position effect, position effect variegation, gene silencing in *Drosophila.*

Module 6: Inheritance of Complex Traits **8 Hrs**

6.1. Complex traits, characteristics. Complex pattern of inheritance- Quantitative traits and threshold traits

6.2. Statistics of Quantitative inheritance- frequency distribution, mean and model class, variance and standard deviation, causes of variation- genotypic, environmental and genotype-environmental interaction.

6.3. Analysis of Quantitative Trait, multiple factor hypothesis, Portioning of phenotypic variance, heritability and measurement- broad sense heritability, narrow sense heritability, artificial selection.

6.4. Quantitative trait loci (QTL). QTL mapping

Module7: Human Genetics **7 Hrs**

7.1. Normal Human Karyotype, Chromosome identification and nomenclature (ISCN).

7.2. Human Pedigree and its interpretation. Genetic disorder and Inheritance Pattern: Autosomal inheritance - Dominant (Adult polycystic kidney), Autosomal inheritance - Recessive (Sickle cell anemia), X-linked Recessive: (Duchenne muscular dystrophy-DMD), X-linked Dominant: (Xg blood group), Y-linked inheritance (Testes determining factor –TDF) Multifactorial inheritance (Cleft lip and palate)

7.3. Eugenics and genetic counselling, Personalised medicine

Module 8: Extra Chromosomal Inheritance **3 Hrs**

8.1. Maternal inheritance. Inheritance of chloroplast gene- Inheritance of leaf colour in *Mirabilis*

Inheritance of mitochondrial genes- Respiratory defective mitochondrial mutants

Maternal inheritance verses maternal effect, Pigmentation in moth

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BIOTECHNOLOGY (36 Hrs)

Module 9: Basic Concepts **6 Hrs**

1.1. Restriction Enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase

1.2. Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric

tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes

1.3. Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization.

1.4. Chromatin Immunoprecipitation; DNA-Protein Interactions- Electromobility shift assay; DNase I footprinting; Methyl interference assay.

Module 10: Gene Cloning Vectors **8 Hrs**

2.1. Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors

2.2. Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vector: Human Artificial Chromosome

2.3. Animal Virus derived vector: SV-40; Expression vectors: pMal; pET-based vectors

2.4. Vectors for downstream Protein purification: His-tag, GST-tag, MBP-tag and Intein tag based vectors

2.5. Plant based vectors: Ti and Ri as vectors; Yeast vectors; Shuttle vectors

Module 11: Gene delivery and DNA libraries **8 Hrs**

3.1. Insertion of foreign DNA into host cells; Chemical and physical methods, Gene Gun. Transformation; Blue white screening, reporter genes

3.2. Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries

3.3. Phage display; Principles in maximizing gene expression

Module 12: PCR based Techniques **6 Hrs**

4.1. PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing

4.2. Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection

4.3. PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP,

4.4. Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Module 13: Applications of Genetic Engineering **8 Hrs**

5.1. Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing

5.2. Gene knockouts and Gene Therapy; Creation of knockout mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting

5.3. Gene disruption; FLP/FRT and Cre/Lox recombination. Stem cell therapy. DNA vaccines, Gene editing; CRISPR-Cas9

5.4. Creating transgenic animals and Transgenic plants: Plants resistant to pests, Plants with increased shelf life; Terminator Gene technology, Examples of Biotechnological applications in Bioremediation, Bioleaching.

References

Genetics

1. Brown, T. A., 2017, Genomes 4, CRC Press, FL, USA
2. Dale, Jeremy W and Schantz, Malcom V. 2002, From Gene to Genomes. John Wiley and Sons Ltd, NY, USA
3. Daniel L. Hartl and Bruce C, 2017, Genetics: Analysis of Genes and Genomes, Jones and Bartlett Publishers, MA, USA
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5. Kumar, H. D., 2003, Genomics and Cloning, EWP, New Delhi
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Biotechnology

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2. Bernard R. Glick, Jack J. Pasternak, 2002, Molecular Biotechnogy, Principle and Applications of Recombinant DNA, ASM Press, Washington, USA
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BMZO103: RESEARCH METHODOLOGY AND BIOLOGICAL TECHNIQUES

Credit – 4 **90 Hrs**

Course Objectives:

- To impart concepts, generate enthusiasm and make awareness about the tools/gadgets and accessories of biological research
- To equip the learner to carry out original research in biology
- To help the students to improve analytical and critical thinking skills through problem solving

Course Outcomes:

- Students learn to improve analytical and critical thinking skills through problem solving
- Students acquire an understanding of the principles of various tools and techniques
- Students acquire the ability to use the tools and techniques for project work/ research in biology

RESEARCH METHODOLOGY (18 Hrs)

Module 1: Concepts of Research **4 Hrs**

1.1. Research- Its Meaning, Objectives and Motivation

1.2. Scientific method and Research Process

1.3. Inductive and Deductive approach

1.4. Research methods versus Methodology

1.5. Types of Research (Descriptive/Analytical, Applied/ Fundamental, Quantitative/Qualitative, Conceptual/ Empirical)

Module 2: Research Formulation **2 Hrs**

2.1. Selecting the problem and defining the problem

2.2. Literature review- Critical literature review, Identifying gap areas from literature review

2.3. Formulation of hypothesis

Module 3: Research Design **3 Hrs**

3.1. Research Design - Meaning, Basic principles, Need and features of good design

3.2. Types of research design

3.3. Development of a research plan -Explorative, Descriptive, Diagnostic and Experimental; Experimental design

3.4. Dry and wet labs

Module 4: Scientific Information Resources **3 Hrs**

4.1. Sources of Information –Books, Periodicals, Journals, Reviews, Treatise, Monographs

4.2. Electronic Sources- abstracting and indexing sources
Digital libraries and repositories – Digital Library of India, INFLIBNET, Institutional Websites, Shodh Ganga, Shodh Gangotri

Module 5: Scientific Documentation and Communication **3 Hrs**

5.1. Research Paper, Oral presentation, Poster Presentations, Thesis and dissertations

5.2. Research Paper formats and Bibliography styles

5.3. Reference management software: Mendeley

5.4. Project proposal writing

5.5. Research metrics- journal level, article level and author level metrics

Module 6: Research Considerations **3 Hrs**

6.1. Copy right, Designs, Patents, Trademarks, Geographical indications

6.2. ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, Radiation hazards.

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

6.4. Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution

BIOSTATISTICS 32 Hrs

Module 7: Basics of Biostatistics **8 Hrs**

7.1. Steps in Statistical Investigation

7.2. Data and Variable (Collection, Types, Sources)

7.3. Population, Sample, Sampling Methods (Random, Cluster, Stratified and Geographical) and Sampling Errors;Bias in sampling

7.4. Organization of Data - Editing, Classification, Tabulation (forming a frequency distribution from raw data and types and characteristics of

a Frequency table)

7.5. Presentation of Data - Types and Characteristics of Tables and Visual aids – Graphs, Charts, Diagrams, Flow charts, Carto graphs

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

Module 8: Correlation and Regression Analysis **7 Hrs**

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

8.2. Regression and Line of Best Fit, Types and methods of regression analysis. Graphic Methods (Scatter method, Curve fitting). Regression equation.

8.3. Probit analysis (Brief account only), Mathematical Models in Biology. Length – Weight Relationship, Von- Bertalanffy's Growth Model.

Module 9: Theory of Probability **4 Hrs**

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

Module 10: Testing of Hypothesis **9 Hrs**

10.1. Hypothesis and types, Confidence Interval. Level of significance

10.2. Tests of significance (For large and small samples – Critical Ratio and P value)

Z Test (Problem for small samples)

Chi- Square Test (Problem for 2×2 table only)

Student 't' test (Problem for small samples comparing mean of two variable)

F-test and Analysis of Variance (ANOVA - One way) (Brief account only)

Module 11: Population Statistics **4 Hrs**

11.1. Introduction, uses, records and system of classification of vital statistics.

11.2. Sample registration system, Survey of causes of death and Age classification.

11.3. Measures of Vital Statistics and Measures of Population (Mortality rates, Fertility rates).

11.4. Life tables (Brief account only).

BIOLOGICAL TECHNIQUES (40 Hrs)

Module 12: Microscopy **8 Hrs**

12.1. Light microscope

12.2. Phase contrast microscope

12.3. Fluorescence microscope

12.4. Differential Interference Contrast (Nomarsky) microscopy

12.5. Confocal microscope

12.6. Electron microscope – TEM, SEM and Atomic Force Microscopes

Module 13: Chromatography **7 Hrs**

Principle, procedure and application of the following chromatographic techniques

13.1. Paper chromatography

13.2. Thin Layer Chromatography (TLC)

13.3. Ion exchange chromatography

13.4. Gel permeation chromatography

13.5. Affinity chromatography

13.6. Gas chromatography (GC)

13.7. High Performance liquid chromatography (HPLC)

Module 14: Electrophoresis **7 Hrs**

Principle, procedure and application of the following electrophoresis techniques

14.1. Paper electrophoresis

14.2. Gel electrophoresis

14.3. Polyacrylamide gel electrophoresis (PAGE) & SDS-PAGE

14.4. Agarose gel electrophoresis (AGE)

14.5. Disc electrophoresis

14.6. Immuno- electrophoresis

Module 15: Spectroscopy **4 Hrs**

15.1. Principle and applications of colorimetry and spectrophotometry

15.2. Flame emission spectroscopy

15.3. Atomic absorption spectroscopy

15.4. Nuclear Magnetic- resonance spectroscopy (NMR)

Module 16: Centrifugation **4 Hrs**

16.1. Basic principles of sedimentation

16.2. Types of centrifuges

16.2.1. Analytical and Preparative centrifugation

16.2.2. Differential and density gradient centrifugation

Module 17: Radioisotope Detection and Measurement **2 Hrs**

17.1. Dosimetry: Ionization chamber, GM counter

17.2. Solid and liquid scintillation counters

17.3. Tracer techniques, Autoradiography

Module 18: Histological Techniques **6 Hrs**

18.1. Cytochemical and histological methods- Tissue processing methods – Cryostat and Microtome techniques

18.2. Cytochemistry of nucleic acids, carbohydrates, proteins and lipids

18.3. Specimen preparation for Electron Microscopy, shadow casting, freeze fracturing, freeze etching, negative staining.

Module 19: Nanotechnology **2 Hrs**

19.1. Introduction to Nano-biology

19.2. Nano sensors

19.3. Nanomedicines

References

Research Methodology

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Biostatistics

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Biological Techniques

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BMZO104: BIOCHEMISTRY

Credit - 4 **90 Hrs**

Course Objectives:

- To understand the chemical nature of life and life process
- To provide in-depth knowledge on structure, function and metabolism of biomolecules
- To generate an interest in the subject and help students explore the new developments in biochemistry

Course Outcomes:

- Students learn the basic principles of biochemistry useful for biological studies by illustrating different kinds of biomolecules, their structure, function and metabolism

BIOMOLECLES: STRUCTURE AND FUNCTION

Module 1: Water and Intermolecular interactions **4 Hrs**

1.1. Behaviour of polar, non polar and amphipathic molecules in water

1.2. Hydrogen bonding, ionic interactions, hydrophobic interactions and van der Waals interactions in macromolecular structures

1.3. Ionisation of water, Concept of pH and p*K*a

1.4. Buffers, Henderson-Hasselbalch equation

Module 2: Carbohydrates **10 Hrs**

2.1. Biological importance of carbohydrates

2.2. Stereoisomerism: Chiral centre, Enantiomers, Diastereomers, Epimers, Anomers, Mutarotation

2.3. Monosaccharides: Aldoses and Ketoses; Structure and functions of common monosaccharides and their derivatives
Pyranose and Furanose structures

2.4. Glycosidic bond; Structure and function of common disaccharides; Reducing and nonreducing ends of sugars

2.5. Polysaccharides: Homopolysaccharides- Starch, Glycogen, Cellulose, Chitin; Heteropolysaccharides: Glycosaminoglycans

2.6. Glycoconjugates: Proteoglycans, Glycoproteins, Glycolipids, ABO Blood group antigens

2.7. The Sugar code: Carbohydrate - Lectin recognition and binding

Module 3: Amino acids and Proteins **12 Hrs**

3.1. Structure, properties and classification of proteinogenic amino acids; Chirality and optical isomerism in amino acids; p*K*a and pI of amino acids

3.2. Structure of proteins: Primary structure- Peptide bond and its planar nature; *cis* and *trans* conformations; Phi and Psi angles; Ramachandran plot

3.3. Secondary structure- Helical structures: Pitch and handedness of helix, Alpha helix, 3_{10} helix, $\boldsymbol{\pi}$ helix; Parallel and anti-parallel beta sheets; Loops and turns; Random coil

3.4. Super secondary structures/Motifs: Helix-Turn-Helix, Coiled coil, β-hairpin, Greek key

3.5. Tertiary structure: Forces stabilizing tertiary structure; Protein Domains: structure and function

3.6. Fibrous proteins – Keratin and Collagen

3.7. Globular proteins –Molecular structure of Myoglobin; Quaternary structure of Haemoglobin

3.8. Molecular Chaperons, GroEL/GroES Chaperonin, Protein denaturation

Module 4: Lipids **10 Hrs**

4.1. Biological importance of lipids

4.2. Fatty acids: saturated and unsaturated; Naming convention of fatty acids; PUFA, Omega-3 fatty acids

4.3. Triglycerides - Structure and properties, Rancidity, Trans fatty acids

4.4. Structural lipids in membranes: Glycerophospholipids: Phosphatic acid, Phosphatidylserine, Phosphatidylethanolamine, Phosphatidyglycerol, Phosphatidylcholine, Phosphatidylinositol, Cardiolipin

4.5. Sphingolipids: Phosphosphingolipids-Sphingomyelin; Glycospingolipids-Cerebrosides, Globosides and Gangliosides

4.6. Saponification and Saponification number, Acid number, Iodine number, Polenske number and Reichert-Meissl number

4.7. Cholesterol; VLDL, LDL, and HDL

4.8. Prostaglandins

Module 5: Nucleic Acids **5 Hrs**

5.1. Structure of nucleic acids and nucleotides

5.2. Structural organization of DNA – Watson and Crick model, Triple helix model

5.3. Forms of DNA – A, B, C and Z

5.4. Factors that stabilize DNA

5.5. DNA supercoiling and Topoisomerases

5.6. Types of RNA; Structural organization of tRNA

Module 6: Enzymes **10 Hrs**

6.1. Nomenclature and IUBMB classification

6.2. Enzyme specificity; Features of active site

6.3. Mode of enzyme action: Enzyme substrate complex, Lowering of activation energy

6.4. Enzyme kinetics: Michaelis-Menten equation, K_m value and its significance

6.5. Enzyme inhibition: Competitive and non-competitive inhibition, Feedback inhibition

6.6. Enzyme regulation: Allosteric regulations, Covalent modification

6.7. Monomeric and oligomeric enzymes, Ribozymes , Abyzmes, Isozymes, Multienzymes

METABOLISM

Module 7: Carbohydrate Metabolism **10 Hrs**

7.1. Glycolysis

7.1.1. Fate of pyruvate- fermentation

7.1.2. Glycolysis of Fructose, Mannose and Galactose

7.2. Central role of citric acid cycle, Glyoxylate acid cycle

7.3. Gluconeogenesis, Cori cycle. Alanine shuttle, Malate – aspartate shuttle

7.4. Glycogen metabolism

7.4.1. Regulation of glycogen synthesis

7.4.2. Adenylate cascade system: Protein kinase, Ca^{2+}-Calmodulin sensitive phosphorylase kinase

7.5. Pentose Phosphate pathway

7.6. Glucuronic acid metabolism

7.7. Metabolic disorders of Carbohydrates-Glycogen storage diseases, Lactose

intolerance, Galactosuria

Module 8: Protein Metabolism **5 Hrs**

8.1. Amino acid metabolism-Deamination, Transamination, Transdeamination, Decarboxylation

8.2. Formation of Ammonia

8.3. Urea synthesis

8.4. Creatine synthesis

Module 9: Lipid Metabolism **8 Hrs**

9.1. Oxidation: Beta oxidation of different types of fatty acids, Energetics of Palmitate oxidation

9.1.2. Peroxysomal oxidation

9.1.3. Alpha oxidation

9.1.4. Omega oxidation

9.2. Fatty acid biosynthesis and modifications

9.3. Metabolism of Cholesterol, synthesis and its regulation

9.4. Metabolism of triglycerides

9.5. Metabolism of ketone bodies

Module 10: Nucleic Acid Metabolism **4 Hrs**

10.1. Biosynthesis and degradation of purine nucleotides and its regulation

10.2. Biosynthesis and degradation of pyrimidine nucleotides and its regulation

10.3. Biosynthesis of deoxyribonucleotides

Module 11: Porphyrin Metabolism **2 Hrs**

11.1. Biosynthesis and degradation of porphyrins

11.2. Production of bile pigments, Bilurubin metabolism and Jaundice

Module 12: Photosynthesis and Oxidative Phosphorylation **10 Hrs**

12.1. Light reaction, Light absorption, Light harvesting complexes: PS I, PSII

12.2. Photolysis

12.3. Dark reactions

12.4. Synthesis of Starch and Sucrose

12.5. C4 and C5 pathway

12.6. ATP synthesis

12.6.1. Chemiosmotic theory

12.6.2. Photophosphorylation and electron transport

12.6.3. Oxidative phosphorylation and electron transport

12.6.4. Substrate phosphorylation

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PRACTICAL

BMZO1P01: PHYSIOLOGY, RESEARCH METHODOLOGY, GENETICS AND BIOCHEMISTRY

Credit – 3 **90 Hours**

Course Objectives:

- To study the comparative functioning of organ systems in animals
- To help the students to improve analytical and critical thinking skills through problem solving
- To provide hands on training in the use of various tools and techniques
- To provide practical knowledge on quantitative analysis and metabolism of biomolecules and enzymes

Course Outcomes:

- Students will learn the comparative functioning of organ systems
- Students get hand on training in the use of various tools and techniques useful in research
- Students will be able to quantitatively analyze of biomolecules and carry out enzyme assay

PHYSIOLOGY

1. Influence of temperature on salivary amylase activity – Calculation of Q_{10}
2. Oxygen consumption in fish (normal and stressed) Graphical representation and interpretation.
3. Kymograph: working principle and applications.
4. Virtual Practicals in Physiology
    i. Muscle Twitch and the Latent Period
    ii. Effect of stimulus Voltage on Skeletal Muscle Contraction
    iii. Tetanus
    iv. Fatigue
5. Differential count of Human WBC
6. Haematocrit and ESR of Human blood
7. Feeding activity of paramecium

8. 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 blood from a plot of diameter of RBC against concentration of NaCl using micrometry.

RESEARCH METHODOLOGY

9. MS Excel: Graphical representation of data
10. PH Stat and SPSS:
    Basic statistics (mean, median, mode, standard deviation)
    Correlation and Regression analysis
    Chi square test, Students t test, ANOVA
11. Reference management using Mendley

GENETICS

12. Isolation of genomic DNA
13. Culture, sexing and etherization of *Drosophila.*
14. Study of mutants in *Drosophila.*

BIOCHEMISTRY

15. Quantitative estimation of blood glucose by O-Toluidine/Enzymatic method
16. Quantitative estimation of serum creatinine
17. Quantitative estimation of cholesterol in the blood
18. Estimation of proteins by Lowry *et al.* method
19. Estimation of alkaline phosphatases
20. TLC of amino acids
21. Study of Enzyme kinetics - Amylase activity on starch standards-influence of temperature and substrate concentration on enzyme activity (Lineweaver Burk Plot).

SEMESTER II

BMZO205: DEVELOPMENTAL BIOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

1. To provide advanced concepts of developmental biology
2. To help students understand and appreciate the genetic mechanisms and the unfolding of the same during development
3. To expose the learner to the new developments in embryology and its relevance to man

Course Outcomes:

- Students understands the embryonic and post embryonic development process and the genetic mechanism controlling such process
- Students become aware about modern implications of developmental biology regarding in-vitro fertilization, stem cells and amniocentesis techniques

Module1: Introduction: Basic Concepts of Development **4 Hrs**

1.1. Potency of embryonic cells

1.2. Commitment, Specification, Induction, Competence, Determination and Differentiation; Morphogenetic gradients

1.3. Cell fate and cell lineages.

1.4. Genomic equivalence and Cytoplasmic determinants.

Module 2: Gametogenesis and Fertilization **10 Hrs**

2.1. Spermatogenesis-cells in seminiferous tubule, meiosis, differentiation of spermatozoa.

2.2. Oogenesis- Growth of oocyte, nuclear activity during growth, accumulation of food resources, organization of the egg cytoplasm, maturation of egg, the egg envelopes.

2.3. Fertilization- Recognition of sperm and egg, acrosome reaction, contact of gametes-species recognition in sea urchin, gamete binding in mammals, gamete fusion and prevention of polyspermy, fusion of genetic material, activation of egg metabolism, biochemical and molecular aspects of fertilization.

Module 3: Cleavage and Blastulation **8 Hrs**

3.1. Patterns of cleavage

3.2. Peculiarities of cell division in cleavage

3.3. Distribution of cytoplasmic substance in the egg during cleavage, morphogenetic gradient in egg cytoplasm

3.4. Manifestation of maternal genes during development

Module 4: Gastrulation and Organogenesis **9 Hrs**

4.1. General metabolism during gastrulation, gene activity during gastrulation

4.2. Introduction to organogenesis, development of ectodermal organs in vertebrate (CNS, eye, neural crest and its derivatives, epidermis and cutaneous structures), Development of mesodermal organs (muscles, bones, heart and blood vessels), Development of endodermal organs (digestive tract, liver and pancreas), Tetrapod limb development.

Module 5: Growth and Differentiation **5 Hrs**

5.1. Mechanism of cell reproduction, growth of individual cells.

5.2. Types of growth-auxetic, multiplicative and acretionary.

5.3. Chemical basis of differentiation, Control of differentiation by the intra organismic environment

Module 6: Axis specification and Pattern formation **18 Hrs**

6.1. Cleavage and axis formation in *C. elegans*

6.1.1. Rotational cleavage of egg

6.1.2. Cell lineage

6.1.3. Anterior-posterior axis formation

6.1.4. Formation of dorsal-ventral and right-left axes

6.2. Early development and axis specification in *Drosophila*

6.2.1. Fertilization, Cleavage and Midblastula transition

6.2.2. Primary axis formation during oogenesis

6.2.2.1. Anterior-posterior polarity in the oocyte

6.2.2.2. Dorsal-ventral polarity in the oocyte

6.2.3. Dorsal-ventral polarity in the embryo: effect of Dorsal protein gradient

6.2.4. Anterior-posterior polarity in the embryo: role of Maternal effect genes- *bicoid, nanos, hunchback, caudal*

6.2.5. Body segmentation in Drosophila embryo: role of Segmentation genes

6.2.5.1. Gap genes

6.2.5.2. Pair rule genes

6.2.5.3. Segment polarity genes

6.2.5.4. Homeotic selector genes

6.2.5.5. Realisator genes

6.3. Anterior –posterior patterning in Vertebrates: The Hox code hypothesis

Module 7: Cellular interactions in Development **13 Hrs**

7.1. Nieuwkoop centre and mesodermal polarity. Molecular basis of mesoderm induction. Transcription factors induced in the organizer. Neural induction, Regional specificity of induction, Genetic specificity of induction.

7.2. 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.

Module 8: Postembryonic Development **10 Hrs**

8.1. Changes of organization during metamorphosis, causation of metamorphosis in amphibian tissue, reactivity in amphibian metamorphosis, process of induction during metamorphosis of amphibians

8.2. Metamorphosis in Insects, causation of moulting; role of imaginal disc. Hormonal control of metamorphosis in insects

8.3. Regeneration - different types of regeneration; Histological processes during Regeneration; Polarity and Metaplasia in regeneration; Lens regeneration in amphibian.

Module 9: Environmental Regulation of Animal Development **7 Hrs**

9.1. Environmental regulation of normal development – types of

polyphenism, phenotypic plasticity. Sex determination in *Bonellia*; primary and secondary sex determination, environmental sex determination

9.2. Environmental disruptions of normal development (Teratogenesis)
Teratogenic agents - Alcohol, retinoic acid, bisphenol, heavy metals, pathogen, Environmental oestrogens

Module 10: Human Welfare and Developmental Biology **3 Hrs**

10.1. Infertility-causes of infertility in man and woman, Test tube babies (IVF) process of IVF. Nuclear transplantation experiments in Amphibians and Mammals

Module 11: Stem cells **3 Hrs**

11.1. Different types - Adult Stem Cells, Cord Blood Stem Cells, Embryonic Stem Cells and Induced Pluripotent Stem Cells.
Properties of stem cells; Application of stem cells; Ethical issues in stem cell research.

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BMZO206: EVOLUTIONARY BIOLOGY AND BIOSYSTEMATICS

Credit - 4 **90 Hrs**

Course Objectives:

- To give a thorough understanding of the principles and practice of systematics
- To develop an holistic appreciation on the phylogeny and adaptations in animals
- To provide an understanding on the process and theories in evolutionary biology
- To help students develop an interest in the debates and discussion taking place in the field of evolutionary biology

Course Outcomes:

- Students learn the process of evolution in traditional and modern approaches Students can better appreciate the phylogeny and adaptations in animals
- Equips the learners to critically evaluate the debates and take a stand based on science and reason

EVOLUTIONARY BIOLOGY (65 Hrs)

Module 1: Modern Concepts in Evolution **12 Hrs**

1.1. Concepts of variation, adaptation natural selection Experimental evidence for selection through case studies (moths, sticklebacks, guppies, Ice fish, fruit flies)

1.2. Artificial selection. Neutral Evolution, Endosymbiosis of Eukaryotic organelles from bacteria

1.3. Punctuated equilibrium. Y-chromosome evolution, epidemics and antibiotic resistance

1.4. HIV evolution. Exaptations

Module 2: Origin and Evolution of Life **14 Hrs**

2.1. Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers. The RNA world.

2.2. The universal common ancestor and tree of life, three domain concept of living kingdom; molecular divergence and molecular clocks.

2.3. Evolution of gene families. Origin and diversification of bacteria and archea; genome evolution and diversification of genomes; Evolution of genome size.

2.4. The nature of bacterial and archeal genomes; origin of genomes by horizontal gene transfer; role of plasmid, Evolution by transposition.

integrons and genomic islands in DNA transfer . Evolution by gene duplication.

Module 3: Geological Timescale **5 Hrs**

3.1. Major events in evolutionary timescale. Anthropocene.

3.2. Tools and techniques in estimating evolutionary time scale.

3.3. Mass extinction and its consequences.

3.4. Fossils- fossilization and its significance.

Module 4: Origin and Evolution of Vertebrates **10 Hrs**

4.1. Origin and evolution of Pisces, Amphibia, Reptilia, Aves and Mammalia

Module 5: Primate Evolution and Human Evolution **8 Hrs**

5.1. Stages in Primate evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin, hominid fossils

5.2. Mitochondrial Eve, Tracing human evolution through migration
Cytogenetic and molecular basis of origin of man
African origin of modern man

5.3. Evolution of human brain communication, speech and language. Evolution of culture

Module 6: Evolutionary Developmental Biology **8 Hrs**

6.1. Gene co-option. The idea of Evo-Devo. Modularity: divergence through dissociation.

6.2. Mechanisms of macroevolutionary change: Heterotopy, heterocrony, heterometry, heterotypy.

6.3. Developmental constrains on evolution. Concept and definitions of homology; recent examples of studies on the molecular and developmental nature of homology and convergence.

6.4. Developmental gene toolkit and body plans: homoplasy

6.4. Human adaptations: lactose tolerance, lactase persistence, sickle cell disease, and bitter taste perception.

Module 7: Population Genetics **8 Hrs**

7.1. Gene pool, gene frequency, Hardy-Weinberg Law. Rate of change in gene frequency through natural selection, migration and random genetic drift.

7.2. Founder effect. Isolating mechanisms and speciation.

7.3. Micro, Macro and Mega evolution. Co-evolution. Genetic variability in natural population Chromosomal polymorphism. Enzyme polymorphism. DNA polymorphism.

7.4. Concept of species and modes of speciation: sympatry, allopatry, stasipatry & parapatry.

BIOSYSTEMATICS 25 Hrs

Module 8: Biological Classification **5 Hrs**

8.1. Taxonomic Procedures-collection, preservation, curetting and process of identification

8.2. Taxonomic characters of different kinds- quantitative and qualitative analysis of variation

8.3. Process of Typification, different zoological types and their significance

8.4. Hierarchy of categories and higher taxa

Module 9: Methods in Biosystematics **10 Hrs**

9.1. Importance and application of biosystematics in biology

9.2. Trends in biosystematics- Classical and modern methods: Typological, Phenetics, Evolutionary, Phylogenetic, Cladistics and Molecular Taxonomy

9.3. Phylocode

9.4. Tree of Life

9.5. Bar-coding of Life

Module 10: Principles of Nomenclature **5 Hrs**

10.1. International Code of Zoological Nomenclature (ICZN)

10.2. Rules and formation of scientific names of different taxa.

10.3. Homonymy and Synonymy.

10.4. Types of Keys, use of keys, merits and demerits.

10.5. Ethics in taxonomy- authorship, suppression of data, undesirable practices in taxonomy.

Module 11: Concepts and Techniques in Biosystematics **5 Hrs**

11.1. Three Domain concept in Systematics; Two, five and six kingdom classification

11.2. Concept of species, Taxonomic diversity within species- different species concept, sub species and other infra–specific categories.

11.3. Molecular Phylogeny-use of Proteins, DNA and RNA for determining phylogeny.

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Evolutionary Biology

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BMZO207: CELL BIOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

- To help study the structural and functional details of the basic unit of life at the cellular level
- To motivate the learner to refresh and delve into the depths of cell biology and cancer biology
- To introduce the new developments in cell biology and its implications in human welfare

Course Outcomes:

- Students acquire the knowledge of evolution of cells, its diversity, cell organelles and the mechanism of cell divisions
- Students understand the cellular and molecular regulatory mechanism of cancer
- Students learn the new developments in cell and cancer biology

Module 1: Cellular Membranes **4 Hrs**

1.1. Membrane functions

1.2. Membrane structure and chemistry

1.2.1. Lipids: Phospholipids, Sphingolipids and Cholesterol

1.2.2. Proteins: Integral, Peripheral and Lipid anchored

1.2.3. Lipid rafts

1.3. Membrane fluidity and asymmetry

1.4. Glycocalyx and Cell recognition

Module 2: Membrane Transport **10 Hrs**

2.1. Relative permeability of various molecules

2.2. Mechanism of transport: Simple diffusion, Facilitated diffusion, Active transport, Secondary active transport

2.3. Membrane transport proteins: Mode of function of Carriers & Channels

2.4. Carrier Proteins: Uniporter (GLUT), Symporter (Na^+-Glucose transporter), Antiporter (Anion Exchanger Protein)

2.5. ATP powered pumps: P type (Na^+-K^+ ATPase), V type (Osteoclast H^+ pump), F type (ATP Synthase), ABC transporters (MDR protein)

2.6. Channel Proteins: Facilitated transport of water –Aquaporin

2.7. Ion channels: General characteristics, Gated ion channels (KcsA channel)

2.8. Membrane potential

Module 3: Endomembranes and Protein Trafficking **12 Hrs**

3.1. Protein synthesis on ER- Signal hypothesis

3.2. Post translational modifications of proteins in ER

3.3. Mechanism of *N*-Glycosylation in ER; Unfolded Protein Response

3.4. Glycosylation in Golgi

3.5. Cargo movement through Golgi: Cisternal maturation model and Vesicular transport model

3.6. Protein targeting: ER retention and retrieval tags

3.7. Protein import pathways into Mitochondria

3.8. Packaging and targeting of lysosomal proteins, Mannose-6-Phosphate Receptors

3.9. Receptor mediated endocytosis; Endosomes to Lysosomes

3.10. Vesicular traffic: COP I, COP II & Clathrin coated vesicles

3.11. Vesicle docking: v-SNARE & t-SNARE

3.12. Constitutive and regulated secretory pathways

Module 4: Cell Adhesion and Cell Junctions **6 Hrs**

4.1. ECM proteins: Collagens, Proteoglycans, Fibronectin, Laminin

4.2. Cell-ECM interactions: Integrins

4.3. Cell-Cell interactions: Selectins, Cadherins

4.4. Anchoring junctions:

4.4.1. Focal adhesions & Hemi desmosomes

4.4.2. Adherence junctions & Desmosomes

4.5. Occluding junctions: Tight junctions and transcellular transport

4.6. Channel forming junctions:

4.6.1. Gap junctions, Structure of Connexon

4.6.2. Plasmodesmata

Module 5: Cytoskeleton **8 Hrs**

5.1. Microtubules: Structure and organization

5.2. Microtubule Organizing Centres (MTOC)- Centrosome

5.3. Ultra structure of Cilia and Flagella

5.4. Microtubular motor proteins: Kinesin and Dynein

5.5. Intermediate Filaments: Structure and assembly

5.6. Major classes of Intermediate Filaments: Keratin, Desmin, Vimentin, Neurofilament, Lamins

5.7. Microfilaments: Assembly and disassembly of Actin filaments, Treadmilling

5.8. Microfilament based structures: Microvilli, Stress fiber

Module 6: Cell cycle and its control **6 Hrs**

6.1. Phases of eukaryotic cell cycle

6.2. Control of cell cycle: Role of Cyclins and Cdks, Synthesis and degradation of Cyclins, Activation and inactivation of Cdks

6.3. Checkpoints during cell cycle:

6.3.1. G1 to S check point

6.3.2. G2 to M check point

6.3.3. Spindle (Anaphase) Checkpoint

6.3.4. Regulators of check points

Module 7: Senescence **6 Hrs**

7.1. Cellular senescence and Organismal senescence

7.2. Theories of ageing

7.3. Exceptions of aging

7.4. Genes and ageing

7.5. Environmental and epigenetic causes of aging

7.6. Aging studies in *Saccharomyces, Caenorhabditis* and *Drosophila*

Module 8: Cell Death **6 Hrs**

8.1. Apoptosis, Necrosis, and Autophagy

8.2. Proapoptotic and Antiapoptotic proteins

8.3. Extrinsic and intrinsic pathways of Apoptosis

8.4. Mechanism of action of Autophagy

8.5. Significance of PCD in ageing, embryo development and cancer cells

Module 9: Cancer **12 Hrs**

9.1. Basic properties of cancer cells; Types of cancer

9.2. Causes of cancer

9.2.1. Carcinogens and its types

9.2.2. Free radicals –Generation, ROS and RNS, Free radical scavenger system, Lipid per oxidation, Antioxidants

9.2.3. Tumor viruses (RNA and DNA)

9.3. Development of cancer

9.3.1. X chromosomal inactivation model and Multi hit model of cancer induction

9.3.2. Tumor initiation, promotion, progression, clonality

9.4. Metastasis and Invasion

9.4.1. Cellular changes during Metastasis

9.4.2. Tumor angiogenesis

9.5. Genetics of cancer

9.5.1. Oncogenes, Viral oncogenes, Proto-oncogenes and mechanism of activation of proto-oncogene

9.5.2. Oncoproteins

9.5.3. Tumor suppressor gene and its types with examples, Cellular roles of TSG

9.5.4. Familial cancers

9.5.5. Genetic path way of cancer – Colorectal and Prostate cancer

9.6. Cancer screening – Pap smear, Mammography, Blood tests, Proteomic analysis

9.7. Prevention of cancer

Module 10: Cell Signalling **16 Hrs**

10.1. Extracellular messengers (signalling molecules)

10.2. Role of Calcium and Nitric oxide (NO) as intercellular messengers

10.3. Receptors:

10.3.1. G- Protein coupled receptors (GPCR)

10.3.2. Receptor tyrosine kinases (RTK)

10.3.3. Ion channel receptors

10.3.4. Cytokine receptors (Tyrosine kinase linked receptors)

10.4. Second messengers: Cyclic-AMP, Cyclic-GMP, Inositol 1, 4, 5-trisphosphate (IP3), Di-acyl glycerol (DAG)

10.5. Signalling pathways:

10.5.1. GPCR and cyclic AMP pathway – role of protein kinase A (PKA), GPCR pathway in rod cells

10.5.2. Receptor protein tyrosine kinase and Ras-MAP Kinase pathway

10.5.3. JAK-STAT pathway

10.5.4. Calcium Phosphatidylinositol pathway

10.5.5. Phospho Inositide 3-kinase (PI3K) pathway

10.5.6. Transforming growth factor (TGF) signalling pathway

10.5.7. Regulation of signalling pathways

Module 11: Cell Culture **4 Hrs**

11.1. Cell culture requirements: Culture hood, Growth media, CO_2 incubator

11.2. Basic techniques: Disaggregation, Passaging

11.3. Primary culture, Cell lines

11.4. Cryopreservation of cells

11.5. Uses of cell culture

References

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BMZO208: NEUROBIOLOGY AND BEHAVIOURAL BIOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

- To expose students to the basics and advances in neurobiology and behavioural biology
- To impart basic knowledge of motor systems and neuropathology

Course Outcomes:

- Students acquire in depth knowledge in the nervous organization and function
- Students understand how animal behaviour is regulated by neural mechanisms
- Familiarize with animal behavioral patterns and their significance

NEUROBIOLOGY 50 Hrs

Module 1: An overview of the Nervous System **5 Hrs**

1.1. Neurons: Introduction to neurons, The Neuron Doctrine, The Nissl and Golgi stains, Components of neurons

1.2. Cytology of neurons, Classification and types of neurons

1.3. Dendrites: structure and function, Axons: structure and function, Myelination, Synapses

1.4. Glial cells: structure and function, Glial –Neuronal interplay in the CNS.

Module 2: Neurochemistry **10 Hrs**

2.1. Synaptic transmission and cellular signaling- Brief account on Acetylcholine: Nicotinic and muscarinic receptors

2.2. Catecholamines: Dopamine receptors and adrenergic receptors
Serotonin: 5HT receptors, Role of serotonin receptors in behavior
Excitatory amino acid transmitters: Histamine, GABA, Glycine.
Peptide neurotransmitters.

2.3. Opioid peptide and opioid receptors

2.4. Mechanism of action of drugs. Drug addiction, drug abuse and adverse drug reaction.

Module 3: Cellular Neurophysiology **6 Hrs**

3.1. Neural Signals: Overview of Neurons, Synapses and Networks. Stimulus-Sensory perception - Motor Action- Higher Brain Function

3.2. Methods to record electrical activity of a neuron.

3.3. Action potential, non-gated ion channels and generation of action

potential.

3.4. Voltage gated channels; Biophysical, biochemical and molecular properties of voltage gated channels

Module 4: Sensory and Motor Systems **18 Hrs**

4.1. Sensation and perception, Organizational principles and coding mechanisms of sensory systems, Sensory Receptors, Parallel processing, Central processing.

4.2. **Somatosensory System**: Peripheral mechanisms of somatic sensation, Spinal and Brainstem components of somatosensory system, somatosensory areas of cerebral cortex.

4.3. **Touch**: Active and passive touch, Properties and functional features of mechanoreceptors, Primary somatosensory cortex and information processing on touch, Representation of body surfaces in the brain.

4.4. **Pain**: Nociceptors, Taste: Taste receptors and taste buds, Innervations by cranial nerves.

4.5. **Olfaction**: Odor stimuli, Olfactory receptor cells, Convergence of olfactory projections, Information processing in the olfactory bulb, Olfactory cortex. Vomeronasal system and pheromones detection in Accessory Olfactory Bulb.

4.6. **Vision**: Fundamental concepts in visual physiology, eye and retina, retinal ganglion cells, basic retinal circuit, Visual cortex.

4.7. **Audition**: External & middle ear, The Cochlea, The auditory nerve, Fundamentals of Motor Systems: Spinal cord as central pattern generator; Brain projections to spinal cord, Posture and voluntary movement

4.8. A brief account of cognitive neuroscience. Organization of central nervous system in relation to cognition

Module 5: Neuropathology **8 Hrs**

5.1. Ischemia and hypoxia induced seizures, Epileptic seizures.

5.2. Alzheimer's disease: Molecular, genetic, immunological aspects and diagnostics

5.3. Neurobiology of aging: cellular and molecular aspects of neuronal aging. Parkinson's disease. Motor Neuron Diseases.

5.4. Prion Disease.

5.5. Biochemical basis of mental illness: Anxiety disorders, Mood disorders, Attention disorders; Schizophrenia

Module 6: Brain Imaging **3 Hrs**

6.1. Imaging techniques: PET, SPECT, MRI/FMRI

BEHAVIOURAL BIOLOGY 40 Hrs

Module 7: Introduction **2 Hrs**

7.1. Historical background and scope of Ethology

7.2. Branches of Ethology

7.3. Ethograms

Module 8: Behavioural Genetics **3 Hrs**

8.1. Genetic basis of behaviour-role of genes

8.2. Experimental behavioural genetics

8.2.1. Hygienic behavior of honey bee

8.2.2. Nest building material transport in love birds

Module 9: Motivation **3 Hrs**

9.1. Goal oriented drive, Internal causal factor

9.2. Homeostatic and Non-homeostatic drives

9.3. Psycho-hydrologic model of motivation

Module 10: Learning and Memory **7 Hrs**

10.1. Types of Learning: Instinct, Imprinting, Habituation

10.2. Classical conditioning (Pavlov's experiments)

10.3. Instrumental conditioning

10.4. Latent learning, Trial and error learning

10.5. Specialized type of learning-Honey bees and food storing birds

10.6. Memory: nature of memory, Types of memory- Short and long term memory

Module 11: Communication **4 Hrs**

11.1. Types of Communications: Electrical, Chemical, Olfactory, Auditory (Songs and Calls), Visual

11.2. Dance language of honeybees

11.3. Pheromones and its role in communication (Ants and mammals)

Module 12: Social Behaviour **8 Hrs**

12.1. Socio-biology (Brief account only)

12.2. Costs and benefits of group living, Evolutionary advantages and disadvantages of group living, Dominance hierarchy

12.3. Territoriality- territory marking in animals, Aggressive behaviour

12.4. Altruism and reciprocal altruism, Evolution of altruism, Alarm calls-in birds and ground squirrel

12.5. Aggregations – Schooling in fishes, Herding in mammals

12.6. Foraging behaviour social organization in insects and primates

12.7. Group selection, Kin election

Module 13: Reproduction and Behaviour **9 Hrs**

13.1. Reproductive strategies

13.2. Sexual selection

13.3. Mating systems

13.4. Courtship and ritual behaviour

13.4.1. Courtship behaviour in invertebrates

13.4.2. Courtship behaviour in vertebrates-Stickle back behaviour and Peacock dance

13.5. Hormones of gonads, pituitary, adrenal gland and their role in sexual behaviour

13.6. Parental care and investment, Nesting behaviour

Module 14: Complex Behaviour **4 Hrs**

14.1. Orientation, Navigation, Navigation cues

14.2. Migration (Fishes and birds)

14.3. Biological rhythms – Circadian, Circannual, Lunar periodicity, Tidal Rhythms, Genetics of biological rhythms

References

Neurobiology

1. Alan Longstaff, 2011, Bios Instant Note: Neuroscience, Garland Science, NY, USA
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3. Carlton K. Ericsson, 2007, The Science of Addiction from Neurobiology to Treatment, WW Norton Co, NY, USA
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12. Peggy Mason, 2011, Medical Neurology, Oxford University Press, UK
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Behavioural Biology

1. Alcock, 2013, Exploring Animal Behaviour- An Evolutionary Approach, Edn. Sinauer Associates Inc. MA, USA.
2. David McFarland, 1999, Animal Behaviour: Psychobiology, Ethology and Evolution, 3rd Edition. Pearson Education, London, UK
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PRACTICAL

BMZO2P02: DEVELOPMENTAL BIOLOGY, EVOLUTIONARY BIOLOGY, CELL BIOLOGY AND NEUROBIOLOGY

Credit – 3 **90 Hrs**

Course Objectives:

- To understand the processes of early embryonic stages of development
- To make aware of different cell organelles, their structure and role in living organisms
- To understand the stages of cell divisions in Mitosis and Meoisis
- To better understand the nervous system organization and function

Course Outcomes:

- Students learn early embryonic stages of development in chick embryo
- Students acquire the knowledge of cell organelles and the mechanism of cell divisions
- Students acquire in depth knowledge in the nervous organization and function

DEVELOPMENTAL BIOLOGY

1. Identification of different developmental stages of frog (egg, blastula, gastrula, neurula, tadpole, with external gill and internal gill).
2. Vital staining of early gastrula of chick to study morphogenetic movement – window method.
3. Blastoderm mounting and determination of developmental stage in chick embryo using vital stains.
4. Whole mount preparation of imaginal disc in Dorsophila.
5. Regeneration studies in Earthworm.

EVOLUTIONARY BIOLOGY

6. Study of museum specimens - 30 invertebrates and 20 vertebrates (List the studied items with systematic description)
7. Study of evolutionary significance of Larval forms – any 10 larvae from different taxa.
8. Study of the skull of vertebrates - Chelone, Crocodile, Bird, Dog, Rabbit/ Rat
9. Preparation of Cladogram based on the specimens provided (at least five museum specimen).
10. Calculating gene frequencies and genotype frequencies in the light of Hardy-Weinberg Law in human/other populations.

CELL BIOLOGY

11. Squash preparation of grasshopper testis to study meiotic stages.
12. Squash preparation and identification of Polytene chromosomes in Drosophila / Chironomus larva.
13. Determination of mitotic index in the squash preparation of onion root tip.
14. Effect of drugs on cell division (Colchicine)
15. General staining using Hematoxylin and Eosin
16. Histochemical staining of carbohydrates (PAS), Protein (Bromophenol blue), lipids (Sudan Black), DNA (Fuelgen stain)

Submission of two slides from each category at the end semester practical examination is compulsory.

NEUROBIOLOGY

17. Virtual Practicals in Nerve Physiology using Physio Ex 9.0.

SEMESTER III

BMZO309: ECOLOGY AND CONSERVATION

Credit - 4 **90 Hrs**

Course Objectives:

- To provide an understanding on the basic theories and principles of ecology
- To learn current environmental issues based on ecological principles
- To gain critical understanding on human influence on environment
- To understand resource conservation efforts and relevant regulations

Course Outcomes:

- Students understand the importance of ecosystem components and its maintenance and management measures
- Learn to mitigate anthropogenic activity that degrades ecosystem functions and promote conservation

Module 1: Ecology and Environment **8 Hrs**

1.1. Physical Environment- biotic and abiotic interactions. Concept of Homeostasis

1.2. Concepts of habitats; host as habitat, niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement.

1.3. Gaia hypothesis. Concept of limiting factors- Liebig's law, Shelford's law. Ecological indicators.

Module 2: Ecosystem - Structure and Function **15 Hrs**

2.1. Ecosystem and Landscapes.

2.2. Energy in the environment-Laws of thermodynamics, energy flow in the ecosystem.

2.3. Primary productivity, Biomass and productivity measurement.

2.4. Ecological efficiencies, Ecological pyramids.

2.5. Biogeochemical cycles- patterns and types (CNP).

2.6 Tropical versus Temperate Ecosystems

Module 3: Population Ecology **15 Hrs**

3.1. Population group properties, density and indices of relative abundance,

Concept of rate. Natality and mortality. Population age structure.

3.2. Growth forms and concept of carrying capacity. Population fluctuations, density dependent and density independent controls.

3.3. Life history strategies, r & k selection. Population structure, aggregation, Allee's principle.

3.4. Population interactions- types, positive and negative, interspecific and intraspecific interactions. Ecological and evolutionary effects of competition.

3.5. Concept of metapopulation. Comparison of Metapopulation and Logistic population. Metapopulation structure.

Module 4: Community Ecology **10 Hrs**

4.1. Concept of community - community structure and attributes, ecotone and edge effect.

4.2. Development and evolution of the ecosystem, concept of climax.

4.3. Species diversity in community and it's measurement- Alpha diversity, Simpson's diversity index, Shannon index, Fisher's alpha, rarefaction. Beta diversity- Sorensen's similarity index, Whittaker's index, Evenness, Gamma diversity

4.4. Guild and its functioning in the community.

4.5. Drivers of species diversity loss and conservation.

Module 5: Resource Ecology **15 Hrs**

5.1. Natural Resources: Soil-soil formation, physical and chemical properties of soil. Significance of soil fertility.

5.2. Mineral resources with reference to India. Impact of mining on environment; Forest resources - deforestation, forest scenario of India, Sand mining and its impacts.

5.3. Aquatic resources - Freshwater and water scarcity, water conservation measures - case studies from India; Wetlands and its importance, international initiatives for wetland conservation - Ramsar sites. Wetland reclamation- causes and consequences.

5.4. Energy Resources- solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear. Energy use pattern in different parts of the world, recent issues in

energy production and utilization; Energy audit, Green technology and sustainable development.

5.5. Ecosystem monitoring- Application of GIS, remote sensing and GPS in ecology, Environmental Impact Assessment

Module 6: Applied Ecology **12 Hrs**

6.1. Environmental Pollution-types, causes and consequences.

6.2. Concept of waste, types and sources of solid wastes, e-waste.

6.3. Environmental biotechnology and solid waste management- aerobic and anaerobic systems. Concept of bioreactors in waste management. Liquid wastes and sewage.

6.4. Bioremediation- need and scope of bioremediation in cleaning up of environment. Phytoremediation, bio-augmentation, biofilms, biofilters, bioscrubbers and trickling filters.

6.5. Radiation Biology - natural and man-made sources of radioactive pollution; radioisotopes of ecological importance; effects of radioactive pollution; Biological effects of radiation -somatic and genetic. Nuclear disasters; Disposal of radioactive wastes.

6.6. Toxicology- Principles, toxicants- types, dose and effects, toxicity of heavy metals.

Module 7: Biogeography and Conservation **15 Hrs**

7.1. Major terrestrial biomes, island biogeography, bio-geographical zones of India

7.2. Western Ghats and its significance.

7.3. Climate change and the emerging discussions – mitigation and adaptation; Role of UNFCC and IPCC, Constitutional Provisions, Indian Penal Code (IPC)

7.4. Wildlife Protection Act 1972 amended 1991, Forest Conservation Act, 1980, Water (Prevention and Control of Pollution) Act 1974, amended 1988, The Biological Diversity Act 2002, Rules 2004.

7.5. Global environmental problems and debates - past and present; Participatory resource management, sacred groves, Role of Intergovernmental and Non-governmental organizations in conservation- IUCN, WWF, CI and Green Peace.

References

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17. Richard T. Wright, 2015, Environmental Science, Pearson Education, London, UK
18. Stanley E. Manahan, Environmental Chemistry, Lewis Publishers, Washington, USA
19. Subrahmanyam N. S. and Sambamurty AVSS, 2013, Ecology, Narosa Publishing House, New Delhi
20. Tietenberg, T., 2004, Environmental and Natural Resource Economics, (6thed.), Pearson Education, New Delhi.

21. Tyler, M. G., 2007, Living in the Environment. (15thed), Thomson Brooks/cole, New York, USA
22. WGEEP (Western Ghats Ecology Expert Panel, Gadgil Committee) Report, 31 August 2011, Ministry of Environment and Forests, Govt. of India

BMZO310: MOLECULAR BIOLOGY, GENOMICS, PROTEOMICS AND BIOINFORMATICS

Credit - 4 **90 Hrs**

Course Objectives:

- To help study the structural and functional details of the basic unit of life at the molecular level
- To motivate the learner to delve into the basics of genomics and proteomics
- To introduce the new developments in molecular biology and its implications in human welfare
- To expose the learners to the emerging field of bioinformatics and equip them to take up bioinformatics studies

Course Outcomes:

- Students understand the nature of molecular organization of cell, genetic material, gene regulation and its expression
- Students learn the genomics, proteomics and bioinformatics application in biological science
- Students develop bioinformatics skills to utilize the digital knowledge resources in learning

MOLECULAR BIOLOGY (36 Hrs)

Module 1: Introduction **2 Hrs**

1.1. DNA, RNA and Protein as Information molecules

1.2. Sequence-Structure-Function relationship in Nucleic acids and Proteins

1.3. Anatomy of eukaryotic gene

Module 2: DNA Replication **8 Hrs**

2.1. The Michelson-Stahl experiment

2.2. Semi conservative replication of DNA in chromosomes

2.3. Theta replication, rolling-circle replication

2.4. Molecular mechanisms of Prokaryotic replication

2.5. Molecular mechanisms of Eukaryotic replication

2.6. Telomere replication

Module 3: Transcription **12 Hrs**

3.1. Relationship between genes and proteins

3.2. Genetic code-Degeneracy and wobble hypothesis

3.3. Prokaryotic gene transcription

- 3.3.1. RNA polymerase and promoters
- 3.3.2. Stages of transcription
- 3.3.3. RNA processing in prokaryotes
- 3.3.4. Antibiotics & Prokaryotic transcription

3.4. Eukaryotic gene transcription

- 3.4.1. RNA polymerase and promoters
- 3.4.2. Regulatory elements: Promoter, Silencers, Mediators, Repressors and Activators
- 3.4.3. Role of transcriptional factors
- 3.4.4. Stages of transcription

3.5. RNA processing in eukaryotes –mRNA, rRNA and tRNA

3.6. Post transcriptional modification mechanisms

- 3.6.1. Capping, Splicing, Editing and Tailing
- 3.6.2. Alternative splicing - Sxl protein in Drosophila sex determination
- 3.6.3. Splicing and catalytic RNA
- 3.6.4. Clevage/ Polyadenylation and transcription termination
- 3.6.5. Editing by guide RNA and by enzymes (in Apolipoproteins)
- 3.6.6. mRNA transport and degradation

Module 4: Translation **6 Hrs**

4.1. Concept of second genetic code

4.2. Initiation- role of Aminoacyl tRNA synthetase, Initiation factors

4.3. Elongation- factors

4.4. Termination-factors

4.5. Recycling stages

Module 5: Gene Regulation **8 Hrs**

5.1. Prokaryotic Gene Regulation

- 5.1.1. Antitermination in E.coli
- 5.1.2. Catabolite repression
- 5.1.3. Trp operon in E.coli-repression and attenuation
- 5.1.4. Ara operon –positive and negative control

5.1.5. Gal operon

5.1.6. Riboswitches

5.2. Eukaryotic Gene regulation

5.2.1. General introduction

5.2.2. Chromatin remodeling

5.2.3. Gene silencing- X chromosomal inactivation and methylation

5.2.4. Noncoding RNA-Riboswitch

5.2.5. Regulatory RNA(small RNA)- in bacteria and eukaryotes

5.2.6. Role of micro RNA and RNAi

GENOMICS, PROTEOMICS & BIOINFORMATICS (54 Hrs)

Module 6: Introduction **2 Hrs**

6.1. Introduction to the concepts of genome and proteome

6.2. Human Genome Project and its implications

6.3. Metagenomics: Concept and applications

Module 7: Genome Sequencing Technologies **8 Hrs**

7.1. Sanger sequencing

7.2. Maxam-Gilbert sequencing

7.3. Dye termination technology

7.4. Whole genome sequence assembly

7.5. Next Generation Sequencing (NGS): Pyrosequencing, Illumina, Ion Torrent 7.6. Pros and cons of sequencing techniques

Module 8: Functional Genomics **3 Hrs**

8.1. Genome wide expression analysis – Microarrays, ESTs

8.2. Transcriptomics

Module 9: Proteomics **7 Hrs**

9.1. Isoelectric focusing, 2-D electrophoresis

9.2. N-terminal & C terminal sequencing

9.3. Peptide fingerprinting

9.4. Mass Spectrometry, MALDI-TOF, SAGE

Module 10: Biological Databases **6 Hrs**

10.1. Retrieval methods for DNA sequence, protein sequence and protein structure information; Database search tool: Entrez

10.2. Primary databases

10.2.1. Nucleotide sequence databases: GenBank, EMBL Bank

10.2.2. Protein sequence databases: SWISSPROT, TrEMBL

10.2.3. Structure database: PDB

10.3. Secondary databases: PROSITE, CATH

10.4. Organism specific database: FlyBase, WormBase

Module 11: Sequence Analysis **8 Hrs**

11.1. Methods of sequence alignment: Local and Global alignments

11.2. Gaps and gap penalties

11.3. Scoring schemes: PAM and BLOSUM

11.4. Pair wise alignment: Dot plot, Dynamic Programming, Word method

11.5. Multiple Sequence Alignment: Exhaustive and heuristic algorithms

Module 12: Comparative Genomics **6 Hrs**

12.1. Concepts of Similarity, Identitiy, Homology, Paralogy and Orthology

12.2. Inferring phylogenetic relationship from sequence comparison

12.3. Gene tree versus Species tree

12.4. Phylogenetic tree building methods

12.5. Applications of Molecular Phylogenetics

Module 13: *In silico* Predictions **5 Hrs**

13.1. Gene prediction: ORF, Codon bias, Intron-Exon junctions, CpG islands, Upstream regulatory elements

13.2. Prediction of regulatory motifs and TFBS

13.3. Computational prediction of miRNA and their target genes

Module 14: Structural Bioinformatics **6 Hrs**

14.1. Protein structure visualization tools

14.2. Protein structure prediction

14.3. Structure based drug design

14.4. Molecular docking

Module 15: New Approaches in Bioinformatics **3 Hrs**

15.1. Metabolomics, Lipidomics and Glycomics

15.2. Systems biology

15.3. Synthetic biology

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21. Volkhard Helms, 2008, Principles of Computational Cell Biology: From Protein Complexes to Cellular Networks, Wiley-VCH, Weinheim, Germany

BMZO311: DISEASE BIOLOGY AND MICROBIOLOGY

Credit - 4 **72 Hrs**

Course Objectives:

- To provide an over view of the microbial world, its structure and function
- To familiarize the learner with the applied aspects of microbiology
- To give students an intensive and in-depth learning in the field of disease biology and microbiology

Course Outcomes:

- List and explain the biological principles required to understand the distribution of infectious and non-infectious diseases
- Illustrate the application of biological principles in treating diseases of public health significance
- Highlight areas of public health where recent biological research is likely to be of particular importance

DISEASE BIOLOGY (36 Hrs)

Module 1: Introduction to Infectious Diseases **4 Hrs**

1.1. Concept of disease, Epidemiological triad, 'Iceberg of disease'

1.2. Dynamics of disease transmission- Sources and reservoir

1.3. Modes of transmission- Direct and indirect transmission

1.4. Emerging and re-emerging infectious diseases

1.5. Nosocomial Infections

Epidemiology, Pathology and control of Infectious Diseases

Module 2: Viral Infections **10 Hrs**

2.1. Chickenpox

2.2. Japanese Encephalitis

2.3. Dengue

2.4. Chikungunya

2.5. Hepatitis A, B, C

2.6. Rabies

2.7. Nipah

2.8. Kyasanur Forest Disease

2.9. H1N1, H5N1

Module 3: Bacterial Infections **6 Hrs**

3.1. Tuberculosis

3.2. Leptospirosis

3.3. Tetanus

3.4. Typhus

3.5. Shigellosis

3.6. Salmonellosis

Module 4: Fungal Infections **3 Hrs**

4.1. Candidiasis

4.2. Tinea versicolor

4.3. Ringworm (Dermatophytosis)

4.4. Onychomycosis

Module 5: Protistan Infections **7 Hrs**

5.1. Amoebiasis

5.2. Giardiasis

5.3. Malaria

5.4. Leishmaniasis

5.5. Balantidiasis

Module 6: Helminth Infections **6 Hrs**

6.1. Taeniasis

6.2. Schistosomiasis

6.3. Fascioliasis

6.4. Wuchereriasis (Filariasis)

6.5. Enterobiasis

6.6. Ascariasis

MICROBIOLOGY (36 Hrs)

Module 7: Introduction to Microbiology **6 Hrs**

7.1. Discovery of microorganisms: Contributions of scientists to the field of Microbiology: Anton Von Leewenhoek, Edward Jenner, Lazzaro Spallanzani, Louis Pasteur, Joseph Lister, Robert Koch, Alexander Fleming and lwanovsky

7.2. Main group of microorganisms and their general characters. Approaches to microbial classification, Outline classification based on Bergey's manual

Module 8: Microbiological Techniques **5 Hrs**

8.1. Aseptic techniques: Method of sterilisation and disinfection-physical and chemical agents

8.2. Culture techniques: Preparation of different culture media.

8.3. Plating techniques and isolation of pure colonies: Inoculating agar plates, Inoculating broths, Growth on selective media, isolating an organism from the environment

8.4. Enumerating Bacteria- Serial dilution, Plate counts, Most Probable Number (MPN)

8.5. Identification of Pathogen- Using a microscope, Gram's staining, Motility, Biochemical tests, Serotype

Module 9: Functional Anatomy of Microorganisms **5 Hrs**

9.1. Gram positive and negative cell walls composition and structure, mechanism of gram staining.

9.2. Capsules and slime layers

9.3. Flagella, fimbriae, and pili

9.4. Cytoplasmic structures

9.5. Nucleoid

9.6. Plasmids: types and functions

9.7. Cell wall and pellicle in Protists

Module 10: Nutrition and Growth **4 Hrs**

10.1. Growth factors; Physical requirements for bacterial growth; Influence of environmental factors on growth

10.2. Reproduction and exponential growth, the growth curve

Module 11: Microbial Interactions **5 Hrs**

11.1. Positive interactions- Mutualism - mutualism between microbes; microbes and plants, microbes and animals; Cooperation, Commensalism, Synergism, Neutralism

11.2. Negative interactions- Competition, Amensalism, Antagonism, Predation, Parasitism - plant and animal parasites

Module 12: Virology **5 Hrs**

12.1. Properties of viruses, genetic composition, host interaction and specificity

12.2. Classification: RNA virus, DNA virus, plant virus, animal virus, bacteriophage

12.3. Viral replication: Lytic and lysogenic cycles

12.4. Pathogenic virus

12.5. Oncovirus

Module 13: Applied Microbiology **6 Hrs**

13.1. Microbes associated with food production and spoilage, microbiology of milk and dairy products

13.2. Medical microbiology: normal microbial population on human body, mechanism of microbial pathogenicity.

13.3. Medical mycology

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Disease Biology

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BMZO312: PRINCIPLES OF IMMUNOLOGY

Credit - 3 **54 Hrs**

Course Objectives:

- To provide an intensive and in-depth knowledge to the students in immunology
- To help the learner to understand the role of immunology in human health and well-being
- To familiarize the students the new developments in immunology

Course Outcomes:

- Students will be able to identify the cellular and molecular basis of immune responsiveness.
- Students will be able to compare and contrast the innate versus adaptive immune systems.
- The students will be able to describe immunological response and how it is triggered and regulated.

Module 1: Types of Immunity **6 Hrs**

1.1. Introduction to Immunity. Types of Immunity- Innate and acquired, Passive and active.

Pattern recognition receptors- scavenger receptors and Toll – like receptors.

Humoral and cell-mediated immune responses. Primary and secondary immune responses. Clonal selection

1.2. Haematopoiesis. Lymphocyte subset population. B cell and T-cell maturation, Activation and differentiation. B and T cell receptors, recognition of antigen by T and B cell. Collaboration between innate and adaptive immunity.

Module 2: Antigens and Antibodies **6 Hrs**

2.1. Characteristics of Antigen. Types of antigens, Immunogenicity, antigenecity, adjuvants, epitopes. Haptens.

2.2. Antibody structure, classes of antibody and biological activities.

Hybridoma technology.

Monoclonal antibodies and abzymes.

2.3. Antigen- Antibody reactions, Avidity, affinity, specificity, cross reactivity.

Precipitation and agglutination.

Module 3: Organization and Expression of Immunoglobulin Genes **6 Hrs**

3.1. Genetic model compatible with Ig structure. Multi- gene organization of Ig genes.

Variable region gene arrangements.

3.2. Generation of antibody diversity. Expression of Ig genes and regulation of Ig genes transcription. Antibody genes and antibody engineering.

Module 4: Major Histocompatibility Complex **6 Hrs**

4.1. General organization and inheritance of MHC. MHC molecules and genes. Genomic map of HLA Complex in humans.

4.2. Antigen processing and presentation. MHC-peptide interaction. Expression of MHC molecules on different cell types. Regulation of MHC expression. MHC and disease susceptibility. Biological significance of MHC.

Module 5: Immune Effector Responses **12 Hrs**

5.1. **The Complement System** -Complement activation- Classical, Alternate and Lectin Pathways. Terminal sequence of complement activation (MAC). Regulation of complement system. Biological consequences of complement activation.

5.2. **Cell mediated effector mechanism**- various mechanisms. Role of cytokines in immune system.

5.3. **Inflammation**- Inflammatory Cells. Inflammatory process. Types of Inflammation- acute and chronic. Mediators of inflammation.

5.4. **Hypersensitivity** -Introduction to hypersensitivity. Types- Type I, type II, III, and delayed type hypersensitivity.

Module 6: Autoimmunity **4 Hrs**

6.1. Introduction to Autoimmunity. Organ- specific autoimmune diseases. Systemic auto-immune diseases. Hashimoto's Thyroiditis, Autoimmune Anemias, Goodpasture's Syndrome, Insulin Dependent Diabetes Mellitus, Graves ' disease, Myasthenia Gravis, SLE, Multiple Sclerosis and Rheumatoid Arthritis.

6.2. Mechanism of Induction of autoimmunity. Treatment of autoimmune diseases.

Module 7: Transplantation and Tumor Immunology **7 Hrs**

7.1. Introduction, type of transplants, Immunologic basis of graft rejection. Mechanism involved in graft rejection

7.2. Clinical manifestation of graft rejection-Hyperacute rejection, Acute rejection and chronic rejection. General and specific immunosuppressive therapy.

7.3. Tumor Immunology – tumors of the immune system, tumor antigens, immune response to tumor, tumor evasion and cancer immunology

Module 8: Immunity in Health and Disease **7 Hrs**

8.1. Vaccines, active and passive immunization, Whole organism vaccines, Purified macromolecules as Vaccines, Recombinant vector vaccines, DNA vaccines, Synthetic- peptide vaccines, multivalent subunit vaccines.

8.2. Immune response during bacterial (tuberculosis), Parasitic (Malaria) and viral (HIV) infections.

8.3. Primary immunodeficiency diseases (SCID, WAS, CVI, Ataxia, CGD, LAD). Secondary Immunodeficiency Disease- AIDS, clinical and immunological consequence of HIV-1 infection, control measures

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PRACTICAL

BMZO3P03: ECOLOGY AND CONSERVATION

Credit - 2 **72 Hours**

Course Objectives:

- To provide an understanding on the basic theories and principles of ecology
- To gain critical understanding on human influence on environment
- Identify factors that affect biological diversity and the functioning of ecological systems
- To study toxicants, their impacts on organisms and environment; and the remedial measures

Course Outcomes:

- Students understand the importance of ecosystem components and its maintenance and management measures
- Able to evaluate the toxicants and its impact on organisms and environment
- Learn to mitigate pollutants and anthropogenic activity that degrades ecosystem functions and promote conservation
- Use advanced tools of GIS for managing bioresources

1. Estimation of primary productivity in a pond ecosystem- dark and light bottle method
2. Preparation of food web and food chain from field collections from a pond ecosystem.
3. Determination of water transparency using Secchi disc.
4. Determination of soil organic carbon and chlorides.
5. Qualitative and Quantitative study of marine/freshwater planktons.
6. Quantitative estimation of salinity and phosphates in water samples.
7. Estimation of COD of polluted water.
8. Determination of LC50 for fish (pesticide) using Probit analysis (use of appropriate software is suggested to find out the value).
9. Habitat modelling using GIS
10. Construction of species distribution maps using GIS/GPS
11. Mapping of Ecological Land Units(ELU) using GIS
12. **Field Study**: Visit River/Wetland/ Marine/Forest/Grassland ecosystem. Record the ecosystem components, their interactions and conservation efforts, if any.

A field study report should be submitted at the end-semester examination during which, a viva shall be conducted based on field study.

BMZO3P04: MICROBIOLOGY, IMMUNOLOGY AND BIOINFORMATICS

Credit - 2 **72 Hours**

Course Objectives:

- To inspire the students to learn about microbial organisms, their culture and preservation techniques
- To make students aware of the pathogens, health related problems, their origin and treatment
- To impart basic knowledge of the organization and function of the immune system
- To expose the learners to the emerging field of genomics, proteomics and bioinformatics and equip them to take up such studies in research

Course Outcomes:

- Students learn to make culture mediums, maintain microbial cultures and identify microbes using staining protocols
- Students learn to distinguish microbial disease using immunologic protocols
- Students learn the genomics, proteomics and bioinformatics application in biological science
- Students develop bioinformatics skills to utilize the digital knowledge resources in learning

MICROBIOLOGY

1. Sterilization, disinfection and safety in microbiological laboratory
2. Preparation of culture media
   i. Liquid media – nutrient broth, peptone water
   ii. Solid media – Nutrient Agar, Mac Conkey' Agar
   iii. Semi solid agar
3. Culturing of microorganism – Broth culture
   Pure culture techniques- streak plate, pour plate culture, lawn culture, stab culture
4. Serial dilution and standard plate count, calculation of Cfu/ml in water samples.
5. Identification of microorganisms-
   i. Staining techniques- gram staining of mixed cultures, negative staining
   ii. Oxidase test
   iii. Catalase test
6. Antibiotic sensitivity test
7. Staining and enumeration of microorganisms using haemocytometer

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

IMMUNOLOGY

10. Separation of lymphocytes from whole blood.
11. WIDAL Test.

GENOMICS, PROTEOMICS AND BIOINFORMATICS

12. Biological Database search and data retrieval using NCBI, SWISS-PROT, PDB
13. Sequence alignment: BLASTX
14. Multiple Sequence Alignment: Clustal Omega
15. Gene prediction using GENSCAN
16. Promoter prediction using Promoter 2.0 Prediction Server
17. Phylogenetic tree building using MEGA
18. Identify Conserved Domains within Proteins using CD-Search
19. Gene/Protein function analysis using PANTHER
20. Protein-Protein interaction studies using STRING
21. Protein structure analysis using RASMOL

SEMESTER IV

BMZO413: INSECT MORPHOLOGY AND TAXONOMY

Credit - 4 **90 Hrs**

Course Objectives:

- To introduce the insect diversity and its significance
- To study the morphology and taxonomy of all insect orders
- To develop research interest among students in systematics

Course Outcomes:

- Students understands the insect diversity and its significance
- Learn and distinguish morphological characters in insect orders
- Able to classify insects scientifically

INSECT MORPHOLOGY (54 Hrs)

Module 1: Introduction **4 Hrs**

1.1. Origin and evolution of insects (including theories)

1.2. Fossil insects

1.3. Segmentation- Primary and secondary segmentation

1.4. Tagmosis and division of the body

Module 2: The Head **10 Hrs**

2.1 Head segmentation- Protocepahalon and Gnathocephalon, Mention Supralingua

2.1.1. Origin and evolution insect head

2.1.2. Head suture and areas

2.1.3. Preoral cavity- salivarium and cibarium

2.1.4. Head skeleton- Tentorium- Structure and functions

2.3.4. Types of head -Opisthognathus, Prognathus, Hypognathus

2.3.5. Head glands

2.2. Antennae – Structure, functions and types

2.3. Mouth parts- entognathus and ectognathus

2.3.1. Types of mouth parts

Module 3: The Thorax **15 Hrs**

3.1. Thoracic segmentation- Prothorax, mesothorax and metathorax

3.2. Structure of thorax and pterothorax

3.3. Endothorax- Structure and functions

3.4. Wings- origin and evolution

3.4.1. Venation and types of venations

3.4.2. Wing regions

3.4.3. Wing articulation

3.4.4. Wing coupling apparatus

3.4.5. Wing modifications

3.5. Legs- Structure

3.5.1. Adaptive radiation of legs

Module 4: The Abdomen **10 Hrs**

4.1. Structure and its appendages

4.2. Structure of preabdomen and postabdomen

4.3. Diversity of male and female genitalia (Grasshopper, *Drosophila*, Cockroach, Dragonfly)

Module 5: Sense Organs **15 hrs**

5.1. Structure and classification of sense organs

5.1.1. Hair organs

5.1.2. Plate organs

5.1.3. Campaniform sensilla

5.1.4. Chordotonal organs

5.1.5. Johnston's organ

5.1.6. Tympanal organ

5.1.7. Subgenual organs

5.2. Sound Producing Organs: Stridulatory organ, Tymbal organ

5.3. Structure of light producing organs, production of light in various insects 5.4 Compound eyes and vision

5.4.1. Simple Eyes

5.4.2. Ocelli

5.4.3. Stemmata

5.5. Chemoperception: Phagostimulant and Phagodeterrents

5.6. Communication: Acoustic, Visual, Tactile and Chemical methods

INSECT TAXONOMY (36 Hrs)

Module 6: Introduction **4 Hrs**

6.1. Methods of Insect collection and preservation

6.2. Use of keys, kinds of keys, their merits and demerits. E-keys and insect Database

Module 7: Insect Classification **32 Hrs**

7.1. Classification of insects up to families; General characters, Biology and habits of different orders of insects (special emphasis on economically important insects)

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BMZO414: INSECT ANATOMY, PHYSIOLOGY AND ECOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

- To study the anatomy and physiology of insects
- To understand insects ecology
- To develop research interest among students in advanced entomological studies

Course Outcomes:

- Students understands the insect diversity and its significance
- Learn and distinguish anatomical characters and physiological characteristics among insect orders
- Able to understand insect adaptations and its ecological preferences

INSECT ANATOMY AND PHYSIOLOGY (64 Hrs)

Module 1: Integumentary System **8 Hrs**

1.1. Histomorphology of Epidermis

1.1.1. Types

1.1.2. The basement membrane

1.1.3. Oenocytes and its function

1.2. Cuticle

1.2.1. Functions

1.2.2. Chemistry

1.2.3. Types

1.2.4. Plasticization

1.2.5. Sclerotisation

1.2.6. Modification of cuticle

1.2.7. Formation of cuticle

1.2.8. Moulting-Apolysis and Ecdysis

Module 2: Digestive System **5 Hrs**

2.1. Anatomy and histology of gut

2.1.1. Peritrophic membrane and its functions

2.1.2. Modifications of gut (filter chamber)

2.2. Physiology of digestion of wood, keratin, wax and silk

2.3. Extra intestinal digestion and role of microbes

2.4. Assimilation

Module 3: Circulatory System **5 Hrs**

3.1. Anatomy and histology of dorsal vessel

3.1.1. Dorsal and ventral diaphragms

3.1.2. Accessory pulsatile organs

3.2. Composition and cellular elements in haemolymph and its functions

3.3. Course of circulation and control of heart beat

Module 4: Respiratory System **6 Hrs**

4.1. Anatomy and histology of trachea, tracheoles, spiracles and air sacs.

4.2. Modifications of respiratory system

4.2.1. Abdominal gills

4.2.2. Caudal gills

4.2.3. Rectal gills

4.2.4. Spiracular gills

4.2.5. Blood gills

4.2.6. Physical gills

4.2.7. Plastron

4.3. Cutaneous respiration

4.4. Gas exchange: diffusion, ventilation, control of ventilation, cyclic release of CO_2

4.5. Respiratory pigments

Module 5: Excretory System **7 Hrs**

5.1. Anatomy and histology of Malpighian tubules (Hemiptera, Coleoptera, Lepidoptera)

5.2. Nephro-rectal complex

5.3. Acessory excretory organs

5.3.1. Nephrocyte

5.3.2. Oenocyte

5.3.3. Labial glands

5.3.4. Urate cells

5.3.5. Chloride cells

5.3.6. Anal sac and organs

5.4. Physiology of excretion, Absorption of water and ions, Reabsorption of

essential materials

5.5. Synthesis of uric acid, formation of excreta

Module 6: Nervous System **6 Hrs**

6.1. Anatomy and histology of brain, ganglia and nerves

6.2. Physiology-reception and transmission of stimuli, production and conduction of nerve impulses

Module 7: Endocrine System **6 Hrs**

7.1. Neurosecretory cells

7.1.1. Neurotransmitters

7.1.2. Neuromodulators

7.1.3. Neurohormones

7.2. Endocrine glands and their hormones

7.2.1. Corpora cardiaca

7.2.2. Corpora allata

7.2.3. Prothoracic glands

Module 8: Muscle Physiology **5 Hrs**

8.1. Histo-morphology of muscles

8.1.1. Skeletal muscles

8.1.2. Visceral muscles

8.2. Muscle innervations, Neuro-muscular junction

8.3. Excitation of muscle fibres, effect of fast and slow axons

Module 9: Fat Body and Intermediary Metabolism **6 Hrs**

12.1. Structure of fat body

12.2. Cell types in fat bodies: Trophocytes, Urate cells, Hemoglobin cells, other cell types

12.3. Role of fat body in storage of reserves

12.4. Functions of fat body

12.5. Intermediary metabolism

12.5.1. Glycolysis

12.5.2. Glycerol phosphate shuttle

12.5.3. Trehalose biosynthesis

Module 10: Reproduction and Development **10 Hrs**

10.1. Reproductive organs in male and female insects

10.2. Spermatogenesis and Oogenesis

10.3. Egg, structure and adaptations

10.4. Fertilization, General pattern of embryonic development

10.5. Polyembryony; Parthenogenesis; Paedogenesis

10.6. Metamorphosis; Diapause

INSECT ECOLOGY (26 Hrs)

Module 11: Chemical Ecology **8 Hrs**

11.1. Introductions to chemical ecology; chemically mediated flight behaviour in insects.

11.2. Chemical character, synthesis and release of pheromones; Pheromone communications-allelochemicals; allomones, kairomones and synomones.

11.3. Molecular basis of pheromone detection in insects: Bombykol, Bark beetle, Disparlure

11.4. Chemical Defense: Bombardier beetle, Blister beetle, Firefly

11.5. Semiochemicals and their role in insect ecology and behaviour; Cuticular hydrocarbons

Module 12: Insect Adaptations **8 Hrs**

12.1. Social organisation and behaviour with reference to Termites, Ants and Honey Bees

12.2. Brief account on Insect mimicry and camouflage

12.3. Gall forming insects: features, Gall formation, Types of Galls – open and closed, Common Gall pests, adaptations for Gall making habits, Economic importance

12.4. Aquatic insects: factors influencing the aquatic life, modifications for food capture, anchorage, locomotion, respiration and oviposition

Module 13: Insect-Host Interactions **10 Hrs**

13.1. Selection of hosts plants and animals; Phytophagy and haematophagy

13.2. Host plant resistance: Antixenosis, Antibiosis, Tolerence

13.3. Plant chemical defenses: constitutive and induced; Plant volatiles and their role in insect –plant interactions

13.4. Plant protection through strategies based on pheromones

13.5. Insect pollinator – plant interaction; Colours and fragrances and their value in pollination: signals for insects

13.6. Leaf mining insects: features, forms of leaf mines, feeding habits, Ecological aspects of leaf mining

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BMZO415: APPLIED ENTOMOLOGY

Credit - 4 **90 Hrs**

Course Objectives:

- To study the economic and medical importance of insects
- To learn about the pests of crops and vectors of diseases and their control measures
- To develop research interest among students in applied and agricultural entomology

Course Outcomes:

- Students understands the insect diversity and its significance
- Learn and distinguish economically and medically important insect groups
- Able to understand insect pest, insect vectors and their management

Module 1: Insect Pests **8 Hrs**

1.1. Kinds of pests: major and minor, key pests, sporadic pests, endemic pests, exotic pests, epidemic and pandemic pests, seasonal pests, occasional pests, regular pests, persistent pests.

1.2. Causes of pest outbreak.

1.3. Pest resurgence and replacement (secondary pest outbreak). Causes and management of resurgence and replacement; Forecasting pest outbreaks and surveillance (short term and long term forecasting); forecasting based on observations – climatic and empirical factors.

1.3. Types of damage caused by insect pest to crops: Injury by chewing, piercing, sucking, internal feeders, subterranean insects, Injury to stored products, indirect effects of feeding.

Identification, nature of damage and control measures of major pests of crops with special emphasis to Kerala

Module 2: Pests of Rice **5 Hrs**

2.1. Stem borers: *Scirpophaga incertulas, Chilo polychrysus*

2.2. Leaf feeders: *Orseolia oryzae*(Gall midge), *Spodoptera mauritia* (Rice swarming caterpillar), *Dicladipsa armigera* (Rice hispa), *Cnaphalocrosis medinalis* (Leaf folder)

2.3. Sap suckers: *Leptocorisa acuta* (Rice bug), *Nilaparvata lugens* (Brown plant hopper)

2.4. Root feeder: *Echinocnemus oryzae* (Root weevil)

Module 3: Pests of Plantation Crops **5 Hrs**

3.1. Pests of Coconut

Oryctes rhinoceros, *Rhynchophorus ferrugineus*, *Nephantis serinopa*, *Opisina arenosella* (Black headed caterpillar), *Aceria guerreronis* (Coconut eriophyid mite)

3.2. Pests of Arecanut

Carvalhoia arecae (Spindle bug), *Rhynchophorus ferrugineus*

3.3. Pests of Rubber

Aestherastis circulate (Bark caterpillar), *Acanthopsyche snelleni* (Basket worm), *Batocera rufomaculata* (Stem borer)

3.4. Pests of Cashew

Helopeltis antonii (Cashew mirid), *Plocaederus ferrugineus* (Stem borer)

Module 4: Pests of Fruit crops **4 Hrs**

4.1. Pests of Mango

Bactrocera (Dacus) dorsalis (Oriental fruit fly), *Batocera rufomaculata* (Stem borer), *Sternochaetus mangiferae* (Mango nut weevil)

4.2. Pests of Guava

Chloropulvinaria psidii (Guava mealy scale), *Deudorix isocrates*

4.3. Pests of Banana

Cosmopolites sordidus (Rhizome weevil), *Odoiporus longicollis* (Pseudo-stem borer), *Spodoptera litura* (Cut worm), *Pentalonia nigronervosa* (Banana aphid-Bunchy top disease)

Module 5: Pests of Spices **3 Hrs**

5.1. Pests of Pepper

Longitarsus nigripennis (Pollu beetle), *Cecidomyia malabarensis* (Pepper gall midge)

5.2. Pests of Cardamom

Sciothrips cardamomi (Cardamom thrips), *Lenodera vittata* (Hairy Caterpillar

5.3. Pests of Ginger

Aspidiotus hartti (Rhizome scale), *Udaspes folus* (Leaf roller)

Module 6: Pests of Pulses and Vegetables **6 Hrs**

6.1. Pests of Pulses

Aphis craccivora (Pea aphid), *Ophiomyia phaseoli* (Stem fly), *Melanagromyza obtuse* (Pod fly)

6.2. Pests of Vegetables

6.2.1. Pests of Okra

Earias vitella (shoot and fruit borer), *Sylepta derogate* (Leaf roller), *Amrasca biguttula* (Leaf hopper)

6.2.2. Pests of Brinjal

Leucinodes orbonalis (Shoot and fruit borer), *Henosepilachna(Epilachna) vigintioctopunctata*

6.2.3. Pests of Bitter gourd

Dacus cucurbitae (Melon fly), *Heniscpilachna(Epilachna) vigintioctopunctata*

6.2.4. Pests of Snake gourd

Anadevidia peponis (Snake gourd caterpillar), *Dacus cucurbitae* (Melon fly)

Module 7: Pests of Stored products **3 Hrs**

7.2. *Sitophilus oryzae, Trilobium castaneum, Tenebrio molitor, Trogoderma granarium, Sitotroga cerealella*

Module 8: Polyphagous Pests **4 Hrs**

8.1. Locusts –life history and migration, damage and methods of control

8.2. Grasshoppers- damage caused and control measures

8.3. Termites – life history, damage and control measures

Module 9: Pests of Domestic Animals **7 Hrs**

Identification, nature of attack, and control measures of insect pest of domestic animals:

9.1. Pests of Cattle

Tabanus striatus (Horse fly), *Stomoxys calcitrans* (Stable fly), *Hippobosca maculate* (Cattle fly), *Hypoderma lineatum* (Ox warble fly)

9.2. Pests of Goat

Oestrus ovis (Sheep bot fly), *Haematopinus eurysternus* (Sucking louse), *Bevicola caprae* (Biting louse), *Melophagus ovinus* (Sheep ked)

9.3. Pests of Fowl

Menacanthus stramineus (Chicken body louse), *Menopon gallinae* (Shaft louse), *Echidnophaga gallinacea* (Chicken flea)

9.4. Pests of Dog

Trichodectes canis (Dog lice), Acarid pests (Fleas, ticks and mites)

Module 10: Insect Vectors **4 Hrs**

10.1. Insect vectors belonging to Diptera, Anoplura, Siphonoptera

10.2. Vector control measures

Module 11: Basic Principles of Insect Control **16 Hrs**

11.1. Prophylactic methods

11.2. Curative methods- Cultural methods; Mechanical methods; Physical methods; Legal methods

11.3. Biological control- History, ecological basis and economic dimensions of biological control. Agents of biological control- Parasites, Parasitoids, Predators and pathogens. Practice of biological control - Conservation, enhancement, importation, colonization, mass culture and release of natural enemies

Important biological control projects undertaken in India against insect pests and weeds

11.4. Autocidal control- Sterile male technique and other methods, Chemo sterilants, methods of sterilisation, application advantages and disadvantages

11.5. Pheromonal control – Mode of application, advantages and disadvantages

Insect growth regulators (IGRS), Insect growth hormones and mimics. Insect attractants, Insect anti feedants and insect repellents in pest-management

11.6. Microbial control of pests- Mode of action, applications and examples.

11.7. Integrated pest management – definition, characteristics, strategies and techniques. Economic Injury Level, Economic Threshold Level, Agro ecosystem

Module 12: Chemical Control **15 Hrs**

12.1. Insecticide formulations, Insecticide appliances and applications; Classification of insecticides – based on mode of entry, mode of action, chemical nature, toxicity

Chemistry and mode of action of different classes of insecticides:

12.2. Inorganic compounds as insecticides - Arsenic, Fluoride and Sulphur compounds

12.3. Synthetic organic insecticides

12.3.1. Organochlorine compounds- (DDT, BHC, Endosulfan, Heptachlor, Dieldrin)

12.3.2. Organo phosphorous compounds – Monocrotophos, Tetra ethyl pyrophosphate, Parathion, Carbamates – Carbaryl, Carbofuran

12.4. Botanical insecticides

12.4.1. Chemical properties, mode of action and toxicity of nicotine, rotenone, pyrethrum and neem; Ethnobotanical traditions

12.4.2. Synthetic pyrethroids – definition, uses as insecticides, mode of action (Pyrethrin, Allethrin)

12.5. Fumigants – definition, examples, methods of fumigation, hazards, precautions, advantages

12.6. Insecticide synergists – definition, types of synergism, mode of action and examples

12.7. New generation insecticides- Bio pesticides: bacterial and viral

12.8. Pesticide impact on human and wildlife health. Microbial and environmental degradation of pesticides

Module 13: Beneficial Insects **10 Hrs**

13.1. Biology and rearing of Honey bees, Silk worm, Lac insect

13.2. Insects of forensic importance – crime detection using entomological science. Examples of forensically important insects; DNA techniques in forensic entomology

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28. Yazdani, S.S. and Agarwal, M. L., 1997, Elements of Insect Ecology, Narosa Publishing House, New Delhi

PRACTICAL

BMZO4P05: INSECT MORPHOLOGY, ANATOMY AND TAXONOMY

Credit - 3 **90 Hrs**

Course Objectives:

- To introduce the insect diversity and its significance
- To study the morphology, taxonomy and anatomy of insect orders
- To provide practical skills for scientific study of insects
- To develop research aptitude among students by introducing frontier areas of entomology

Course Outcomes:

- Students understands the insect diversity and its significance
- Learn and distinguish morphological characters in insect orders
- Learn and distinguish anatomical characters among in insects
- Able to classify insects scientifically

INSECT MORPHOLOGY

1. Study of mouthparts in insects (Grasshopper, Plant bug, Mosquito, Honeybee, House fly)
2. Study of different types of antennae, genitalia and legs.
3. Sting apparatus –Honeybee
4. Wings and wing venation in insects of 5 orders.
5. Study of sexual dimorphism in insects

INSECT ANATOMY

6. Dissection of alimentary canal and associated glands of different insects (Plant bug, Honeybee, Oryctes, Grasshopper)
7. Dissection of nervous system in different insects (Plant bug, Honeybee, Oryctes, Grasshopper)
8. Dissection of reproductive system in insects (Cockroach, Oryctes, Grasshopper, Plant bug)
9. Dissection of stomatogastric nervous system in Cockroach

INSECT TAXONOMY

10. Preparation of dichotomous keys with reference to various insect orders

11. ***Collection and preservation of insects:*** Students are required to submit an insect collection belonging to 50 families as dry collection/ wet collection/ whole mounts/ slides at the end-semester practical examination.
12. ***Report of Field study and Visit to research institutes:*** Visit institutes engaged in entomology research and different ecological locations other than local area for study of insects. The field study shall be for minimum 4 days. Submit a report of the study conducted.

BMZO4P06: INSECT PHYSIOLOGY AND APPLIED ENTOMOLOGY

Credit - 3 **90 Hrs**

Course Objectives:

- To study the economic and medical importance of insects
- To learn about the pests of crops and vectors of diseases and their control measures
- To provide practical skills for scientific study of insects
- To develop research interest among students in applied and agricultural entomology

Course Outcomes:

- Students understands the insect diversity and its significance
- Learn and distinguish physiological characteristics among insects
- Learn and distinguish economically and medically important insect groups
- Able to understand insect pest, insect vectors and their management

INSECT PHYSIOLOGY

1. Survey of digestive enzymes –amylase, invertase, protease and lipase in different parts of the gut in Cockroach, Grasshopper and Dragonfly
2. Dye transport by Malpighian tubule using dyes
3. Identification of free amino acids (at least 3) in haemolymph by paper chromatography.
4. Haemocytes –staining and identification.

APPLIED ENTOMOLOGY

5. Study of Insecticide appliances.
6. Collection and identification of insect pests of different crop plants:
    i. Rice
    ii. Coconut
    iii. Commercial crops: Cashew, Rubber
    iv. Fruit crops: Banana, Mango, Guava
    v. Spices: Cardamom, Pepper, Ginger
    vi. Pulses
    vii. Vegetables
    viii. Stored products
7. Collection and identification of insect vectors of man and domestic animals.
8. Collection and preservation of economically important insects and their life stages.
9. Collection and identification of damaged parts of crop plants and identification of causative insect pests - Coconut, Plantain, Mango, Rice, Vegetables

10. Collection and identification of damaged stored products and identification of causative insects.

Students are expected to submit a collection representing insect pests and pest affected parts of different crops, stored products, domestic animals and man, useful insects, their life stages and products, parasites and predators at the end-semester examination.

Model Question Paper

ST. BERCHMANS COLLEGE (AUTONOMOUS), CHANGANACHERRY

MSc Zoology

Semester 3

BMZO309: Ecology and Conservation

Time: 3 Hours **Maximum: 75 Marks**

Part A

Answer **any ten** *questions. Each question carries* **2 *marks***.

1. What is Liebig's law?
2. Comment on the Laws of Thermodynamics.
3. What are ecological corridors?
4. Comment on Allee's principle.
5. What are commensals?
6. Comment on the impact of sand mining on the environment.
7. What are non-conventional energy sources
8. Comment on laterite soil.
9. What is ecosystem modelling?
10. Comment on bio filters.
11. What are heavy metals and their threats to human life?
12. What is IPCC? Comment on its major activities.
13. Briefly describe Environment protection Act and its implications in India.
14. What is global warming? **(10×2=20)**

Part B

Answer **any five** *questions. Each question carries* ***5 marks***.

15. Give an account on different types of biogeochemical cycles.
16. Differentiate between tropical and temperate ecology.
17. What are ecological indicators? Explain with examples
18. Explain the concept of carrying capacity of a population.
19. Comment on ecological succession. What is its ultimate objective?
20. Which are the major Ramsar sites in Kerala? Identify the major conservation issues prevailing there.
21. Give an account on fossil fuels.
22. What is EIA? How do we use this technique in an effective manner?

(5×5=25)

Part C

Answer **any two** *questions. Each question carries* ***15 marks*****.**

23. Differentiate between a habitat and a niche. Explain the different concepts with examples.
24. Explain the concept of meta population. Comment on the different models.
25. Write an essay on Western Ghats with special reference to its conservation significance and latest controversies.
26. Write an essay on various global environmental problems and suggest measures to mitigate them.

(2×15=30)

St Berchmans College

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