

**ST. THOMAS' COLLEGE (AUTONOMOUS)
THRISSUR, KERALA – 680001**

**Affiliated to University of Calicut
Nationally recredited with 'A' Grade**



**CURRICULUM AND SYLLABUS
FOR
POSTGRADUATE PROGRAMME IN ZOOLOGY**

**UNDER CHOICE BASED CREDIT AND SEMESTER SYSTEM
(w.e.f. 2020 Admission onwards)**

<u>Members of Board of Studies in Zoology</u>				
Sl. No	Name	Designation with email	Address	Mob No.
1.	Dr. Francy K Kakkassery	Associate Professor and Head of the Department kakkassey@yahoo.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9387105360
2.	Dr. Britto Joesph K	Associate Professor and Dean of Science drbrittojoseph@gmail.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	8848162583
3.	Dr. Achuthan C Raghavamenon	Associate Professor, achuthanm@gmail.com	Department of Biochemistry, Amala Cancer Research Institute Amala Nagar Thrissur	9567988570
4.	Dr. K K Joshi	Head of Department joshyguru@gmail.com	Central Marine Fisheries Research Institute , Diversity division P.B no. 1603 Ernakulum North Kerala ,	9447209179
5.	Dr. Vincent Terrence Rebello	Associate Professor and Dean of Academics drterencerebello2012@gmail.com	PG Dept. of Zoology, St. Albert's College, Ernakulam. M.G University	9447410294 , 6238177699
6.	Dr. Joshi C.O.	Associate Professor,	Department of Zoology, Christ College, Irinjalakuda	9847908357
7.	Dr. K S Rishad	Research Coordinator rishad61@gmail.com	Unibiosys Biotech Research Labs, Cochin Kerala, India	9846832596

8.	Dr. C V David	Associate Professor cvdavid4@gmail.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9446417055
9.	Dr. C F Binoy	Assistant Professor drcfbinoy@gmail.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9567026534
10.	Dr. Vimala K John	Assistant Professor vimalmary@yahoo.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9446440296
11.	Dr. Joyce Jose	Assistant Professor joyceofthejungle@gmail.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9446812852
12.	Sri. Shaun Paul Adambukulam	Assistant Professor shaunpaultcr@gmail.com	Research and Postgraduate Department of Zoology St. Thomas' College (Autonomous), Thrissur	9496185360

ST. THOMAS COLLEGE (AUTONOMOUS), THRISSUR

OUTCOME BASED EDUCATION POST GRADUATE PROGRAM OUTCOMES

At the end of Post Graduate Program at St. Thomas College (Autonomous), a student would have:

PO1:	Attained profound Expertise in Discipline.
PO2:	Acquired Ability to function in multidisciplinary Domains.
PO3:	Attained ability to exercise Research Intelligence in investigations and Innovations.
PO4:	Learnt Ethical Principles and be committed to Professional Ethics.
PO5:	Incorporated Self-directed and Life-long Learning.
PO6:	Obtained Ability to maneuver in diverse contexts with Global Perspective.
PO7:	Attained Maturity to respond to one's calling.

M.Sc. Zoology programme

The needs and aspirations of societies keep evolving and to cater to these changes higher education needs to reinvent itself to stay relevant. Needs of the industry and society, changing employment opportunities and learning methodologies all dictate that the essential be retained and the non essential be discarded while the recent changes are incorporated. In this context the syllabus of M.Sc. Zoology programme has been redesigned.

Aims and Objectives of the Programme

The Board of Studies in Zoology considers curriculum, course content and assessment of scholastic achievement as essential part of education. The revised Curriculum for Postgraduate Programme of Zoology envisages Postgraduate Education as a combination of general and specialized education, This syllabus aims to prepare the students for lifelong learning by interesting them in the natural world, especially the faunistic components and to introduce the habit of academic pursuit.

Programme Specific Outcomes

PSO1	Apply the advanced principles and techniques of Biochemistry, Cytogenetics, Biophysics, Biostatistics, Physiology, Molecular Biology, Immunology, Developmental Biology, Endocrinology, Biotechnology, Microbiology
PSO2	Evaluate the mechanisms of ecology, ethology, systematics and evolution in the natural world
PSO3	Apply the principles of entomology for the betterment of natural and human world
PSO4	Analyze biological and non biological samples using experimental techniques
PSO5	Create new knowledge using ethical biological research for the betterment of natural and human world

ADMISSION:

Admission for the programme shall be as per the CBCSS PG Regulations of St. Thomas College (Autonomous) wef from 2020 admission.

ATTENDANCE:

The requirement of attendance shall be as per the CBCSS PG Regulations applicable at the time.

EVALUATION AND GRADING

The evaluation scheme for each course shall contain two parts; (a) Internal / Continuous Assessment (CA) and (b) External / End Semester Evaluation (ESE). Of the total, 20% weightage shall be given to internal evaluation / Continuous assessment and the remaining 80% to External/ESE and the ratio and weightage between Internal and External is 1:4. Primary evaluation for Internal and External shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values (Grade Points) of 5, 4, 3, 2, 1 & 0 respectively.

Grade Point Average: Internal and External components are separately graded and the combined grade point with weightage 1 for Internal and 4 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization based on ten point scale.

Evaluation of Audit Courses: The examination and evaluation shall be conducted by the college in a common pattern for all the PG programmes. The question paper shall be for minimum 20 weightage and a minimum of 2 hour duration for the examination. The result has to be intimated/ uploaded to the college site during the Third Semester as per the notification of the college.

Evaluation of Certificate Courses: The evaluation shall be conducted by the college in a common pattern for all the PG programmes. The question paper shall be for minimum 30 weightage and a minimum of 2 hour duration for the examination. The result has to be intimated/ uploaded to the college site during the Third Semester as per the notification of the college.

INTERNAL EVALUATION / CONTINUOUS ASSESSMENT (CA)

This assessment shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars and viva-voce in respect of theory courses and based on tests, lab skill and records/viva in respect of practical courses.

The criteria and percentage of weightage assigned to various components for internal evaluation are as follows:

(a) Theory:

Sl. no	Component	Percentage / Weightage
1	Examination /Test	40%
2	Seminars / Presentation	20%
3	Assignment	20%
4	Attendance	20%

(b) Practical :

S. No.	Component	Percentage
1	Lab Skill	40%
2	Records	30%
3	Practical Test	30%

(Grades shall be given for the internal evaluation based on the grades A+, A, B, C, D & E with grade points 5,4,3,2, 1 &0 respectively. The overall grades shall be as per the Ten point scale. There shall be no separate minimum Grade Point for internal evaluation. To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be published on the notice board at the commencement of external examination. There shall not be any chance for improvement of internal marks. The course teacher shall maintain the academic record of each student registered for the course, which shall be forwarded to the University, through the college Principal, after being endorsed by the Head of the Department. Each student shall be required to do at least one assignment for each course. Assignments after valuation must be returned to the students. The teacher shall define the expected quality of the above in terms of structure, content, presentation etc. and inform the same to the students. Punctuality in submission is to be considered. Every student shall deliver one seminar / presentation as an internal component for every course and must be evaluated by the respective course teacher in terms of structure, content, presentation and interaction. The soft and hard copies of the seminar report are to be submitted to the course teacher. All the records of St Thomas College (Autonomous), Thrissur-1

Continuous Assessment (CA) must be kept in the college and must be made available for verification by university, if asked for.)

EXTERNAL / END SEMESTER EVALUATION (ESE)

The semester-end examinations in theory courses shall be conducted by the College with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. After the external evaluation, only Grades are to be entered in the space provided in the answer script for individual questions and calculations need to be done only up to the Cumulative Grade Point (CGP) and all other calculations including grades are to be done by the College. Students shall have the right to apply for revaluation or scrutiny as per rules within the time permitted for it. Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny on request by them as per rules. The external evaluation shall be done immediately after the examination preferably in a Centralized Valuation Camp.

PATTERN OF QUESTIONS FOR EXTERNAL ESE

Questions shall be set to assess the knowledge acquired, standard, and application of knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightage shall be given to each module based on content/teaching hours allotted to each module. It has to be ensured that questions covering all skills are set. The setter shall also submit a detailed scheme of evaluation along with the question paper. A question paper shall be a judicious mix of short answer type, short essay type /problem solving type and long essay type questions. The question shall be prepared in such a way that the answers can be awarded A+, A, B, C, D & E Grades. End Semester Evaluation in Practical Courses shall be conducted and evaluated by two examiners of which one should be an External Examiner and the other examiner should be the teacher who offers the course/ the senior most teacher who offers the course. Different types of questions shall be given different weightages to quantify their range given in the following model:

Number of questions to be answered:**1. Theory**

Sl. No.	Type of Individual Questions	Total No. of Questions	Weightage
1.	Short answer	4 out of 7	2x4=8
2.	Short essay/problem solving	4 out of 7	3x4=12
3	Long Essay type	2 out of 4	5x2=10
Total		10 out of 18	30

(All questions should be in such a way that 6 grades could be awarded. Short answer questions should have a minimum of 4 value points, short essays a minimum of 6 value points and long essays a minimum of 10 value points).

2. Practical

<u>With submission</u>	<u>Weightage</u>	<u>Without submission</u>	<u>Weightage</u>
Major question (1 number)	14	Major question(1number)	14
Minor question (2 numbers)	2x5=10	Minorquestion(2numbers)	2x5=10
Spotters (2 numbers)	2x1=2	Spotters(4numbers)	4x1=4
Submission (slides)	2	Record	2
Record	2		
Total	30	Total	30

Project Work shall be done based on the following criteria and weightages as detailed below:

Sl. No	Criteria	% of weight age	Weightage External	Weightage Internal	Remarks
1	Relevance of the topic and Statement of problem	80%	8	3	For subject specific sub headings with the total weightage should be 24 and 6 for External and Internal, (details given under project work)
2	Methodology & Analysis		8	3	
3	Quality of Report & Presentation		8	2	
4	Viva-voce	20%	6	2	Mandatory criteria
Total Weightage		100%	30	10	

**CURRICULUM AND SYLLABUS FOR CHOICE BASED CREDIT SEMESTER
SYSTEM (CBCSS -2020) M. Sc. ZOOLOGY COURSE
w.e.f. 2020 ADMISSION**

FIRST SEMESTER- THEORY COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL1C01- Biochemistry and Cytogenetics	4	30	5
ZOL1C02- Biophysics and Biostatistics	4	30	5
ZOL1C03- Ecology and Ethology	4	30	5

AUDIT COURSE

Code No. & Title of the Course	Credits		
ZOL1A01- Academic Writing /Scientific Writing	4		

SECOND SEMESTER- THEORY COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL2C04- Physiology	4	30	5
ZOL2C05- Molecular Biology	4	30	5
ZOL2C06- Systematics and Evolution	4	30	5

AUDIT COURSE

Code No. & Title of the Course	Credits		
ZOL2A02- Introduction to Bioinformatic softwares/Introduction to Statistical Software	4		

FIRST & SECOND SEMESTER- PRACTICAL COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL2L01- Biochemistry, Biophysics and Biostatistics	4	30	10
ZOL2L02- Physiology, Molecular Biology and Cytogenetics	4	30	10
ZOL2L03- Ecology, Ethology, Systematics and Evolution	4	30	10

ZOL-Zoology, 1-I semester, C- Course Theory, L- Course Practical, 2- II semester

THIRD SEMESTER- THEORY COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL3C07-Immunology	4	30	5
ZOL3C08- Developmental Biology and Endocrinology	4	30	5
ZOL3E09- Entomology 1: Morphology and Taxonomy	4	30	5

ZOL- Zoology, C- Course Theory, E- Elective Theory, 3- III semester

FOURTH SEMESTER – THEORY COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL4C10- Biotechnology and Microbiology	4	30	5

ZOL4E11- Entomology II: Anatomy and Physiology	4	30	5
ZOL4E12- Entomology III: Agricultural, Medical & Forensic Entomology	4	30	5

THIRD AND FOURTH SEMESTER PRACTICAL COURSES

Code No. & Title of the Course	Credits	External Weightage	Internal Weightage
ZOL4L04-Immunology, Developmental Biology, Endocrinology, Biotechnology, Microbiology & Microtechnique	4	30	10
ZOL4L05- Entomology 1 & II	4	30	10
ZOL4L06- Entomology III	4	30	10
ZOL4P07- Project Work	4	30	10
ZOL4V08- Viva Voce (Project-2 + General-2)	4	30	10

ZOL- Zoology, C- Course Theory, E- Elective Theory, L – Practical, V – Viva voce, P – Project, 4- IV semester

Total number of theory courses	- 12	Total number of practical courses	- 6
Credit for each theory course	- 4	Credit for each practical course	- 4
Total credits for theory course	- 48	Total credits for practical courses	- 24
Credit for Project work	- 4	Total credit for the course	- 80
Credit for Viva- voce	- 4		

1. Practical examination shall be conducted at the end of second and fourth semesters.
 2. The teacher who gives guidance to project work can select any topic from the syllabi
- St Thomas College (Autonomous), Thrissur-1

including the elective course and the topic shall be assigned to each student. The research work on this topic shall be carried out by each student under the supervision of the teacher. The report of the research work shall be submitted by each student in the form of a Dissertation which shall be attested by the Head of the Department and shall be submitted for the evaluation. A declaration by the student to the effect that the dissertation submitted by him/ her has not previously been formed the basis for the award of any degree or diploma and a certificate by the supervising teacher to the effect that the dissertation is an authentic record of work carried out by the student under his/her supervision are to be furnished in the dissertation.

3. Weightage for each core and elective theory course shall be 30 for the external examination and 5 for the internal theory examination.
4. Weightage for each core and elective practical course shall be 30 for the external examination and 10 for the internal core and elective practical examination.
5. Theory examination question paper shall contain 7 short answer questions of weightage 2 each of which 4 should be answered; 7 short essay questions with weightage 3 each of which 4 should be answered; 4 essay questions of weightage 5 each of which 2 should be answered. .
6. Weightage for the external practical examination can be distributed as follows:

<u>With submission</u>	<u>Weightage</u>	<u>Without submission Weightage</u>
Major question (1 number)	14	Major question(1number) 14
Minor question (2 numbers)	2x5=10	Minorquestion(2numbers) 2x5=1 0
Spotters (2 numbers)	2x1=2	Spotters(4numbers) 4x1=4
Submission (slides)	2	Record 2
Record	2	
Total	30	Total 30

7. No submission is required for the practical in elective course, unless mentioned in syllabus.
8. A candidate has to submit the following at the time of practical examination -
 - ZOL4L04 Whole mount: 4 numbers
 - Slides: Histology: 4 numbers
 - Slides: Histochemistry: 2 numbers (To test the presence of carbohydrate and protein. (Control not required))
9. If a candidate fails to submit the field study / tour report/Institutional visit, no marks for the record be awarded. (Field Study and institutional visit is to be undertaken for paper Ecology and Ethology during the first year and for Entomology during the second year. The visits for each paper may not be less than 5 days and not more than 7 days each. It need not be undertaken at a stretch)
10. Project report shall be presented using power point option. Credit given for project is limited to maximum 4 and project and general viva-voce is limited to 4.
11. A minimum of two test papers for each course have to be conducted and the average shall be counted for internal evaluation in each semester.
12. One seminar for each course is compulsory.

AUDIT COURSES

Each student shall undergo an audit course viz. Ability enhancement course (AEC) and Professional Competency Course (PCC) in the I and II semesters respectively. The student should undergo any one course listed under each category (AEC and PCC) in the respective semesters. Each student will be under the supervision of a faculty who will be responsible for monitoring the course and evaluation. The allotment of the faculty will be decided by the Department Council. The examination and evaluation for Professional competency course should focus on evaluating the skill component involved.

1. Ability enhancement course (AEC) – (In the I semester)

- a) Scientific Writing/ Academic Writing
- b) Paper review on a topic of choice.
- c) Internship for a minimum of 40 hours.

- d) Industrial or Practical training for a minimum of 40 hours.
- e) Community linkage programme for a minimum of 40 hours.
- f) Seminar presentation on a frontier area of biological research. The topic should be from outside the syllabus.

2. Professional Competency Course (PCC) (In the II semester)

- a) Statistical (SPSS/R/any software relevant to the programme of study) softwares
- b) Museum curation skills (Taxidermy, etc.)
- c) Bioinformatics softwares.

MODEL QUESTION PAPER PATTERN

I/II/III/IV SEMESTER M.Sc. DEGREE EXAMINATION (CUCSS), Month & Year

Branch: Zoology

Course Code: Course Name

Time :3hrs

MaximumWeightage:30

I. Answer any 4 of the following (Short Answer type questions) (Weightage-2).

- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

4 x 2 = 8

II. Answer any 4 of the following (Short essay type questions) (Weightage-3)

- 8.
- 9.
- 10.
- 11.
- 12.
- 13.
- 14

4 x 3 = 12

III. Answer any 2 of the following (Long essay type questions) (Weightage-5)

- 15.
- 16.
- 17.
- 18.

2 x 5 = 10

FIRST SEMESTER				
Course code	ZOL1C01			
Name of the course	BIOCHEMISTRY AND CYTOGENETICS			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
01	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the chemical nature of life at molecular level.	26	U	C	PO1, PO2	PSO1
CO2	Comprehend the mechanism of enzyme action	10	U	C	PO1, PO2	PSO1 PSO4
CO3	Apply the bioenergetics principles in life process	3	Ap	C	PO1, PO2	PSO1 PSO4
CO4	Compare the metabolism of biomolecules in human life process.	15	E	C	PO1, PO2	PSO1 PSO4
CO5	Understand the membrane structure and signal transduction in cells.	18	U	C	PO1, PO2	PSO1
CO6	Understand the cellular organization and role of cell organelles	8	U	C	PO1, PO2	PSO1
CO7	Comprehend the structural and functional organization of Nucleus.	6	U	C	PO1, PO2	PSO1
CO8	Analyze the process of apoptosis, genes involved, and its importance	4	An	C	PO1, PO2	PSO1

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply, An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Part A. Biochemistry (54 HOURS)

PART-A. BIOCHEMISTRY (54 hrs)

Module - I - Chemistry and functions of Biomolecules

(26 hrs)

1.1. Introduction -Macromolecules and their subunits .Chemical bonds of bio-molecules

(Covalent and Non-covalent bonds),. Mention the bio-molecules and its biological roles. (2 hrs)

1.2.. Carbohydrates (9hrs)

1.2.1 Monosaccharides : Classification with examples- Structure of glucose, fructose, galactose, mannose,ribose and deoxy ribose,.,Methods of representation of sugars (Ball and stick, projection formula and perspective formula),Isomerism - Structural isomerism (functional group isomerism) and stereo isomerism (optical isomerism)- mention epimer, anomer and enantiomer with examples ,Mutarotation,Reactions - Oxidation (by acids, metal hydroxides and H₂O₂), dehydration (by acid) and reduction (by alkali), reactions with phenyl hydrazine.,. Derivatives - Acetal and hemiacetal, ketal and hemiketal, glycosides - glycosidic bond

1.2.2 Disaccharides : Structure and biological roles of Maltose, Sucrose, Lactose, Cellobiose and Trehalose, Biosynthesis of trehalose and lactose ,

1.2.3. Polysaccharides :Homopolysaccharides - Structure and biological roles of cellulose, starch, glycogen, inulin and chitin ,Mode of action of amylase on homopolysaccharides (starch and glycogen) ,Heteropolysaccharide - Structure and biological roles of hyaluronic acid, proteoglycans and glycoproteins, glycosamines, chondroitin sulphate, keratin sulphate, heparin and dermatan sulphate.

1.3 . Proteins (6hrs)

1.3.1. Amino acids -Classification: (a) on the basis of number of amino and carboxyl group (b) on the basis of the chemical composition of side chain (c) based on the polarity of side chain (R); Amphoteric properties of amino acids; Isoelectric point (pI) of amino acids;Peptide bond and peptides (di, tri, tetra, oligo and polypeptide);

1.3.2. Structure of protein -Primary structure, Secondary structure (α -helix -parallel & antiparallel and β pleated sheet), random coil conformation, Tertiary structure (Myoglobin),

Quaternary structure (Hemoglobin). Brief note on protein domains, motifs, folds and Ramachandran plot.

1.3.3. Isolation and Purification of Proteins

1.4. Lipids (6hrs)

1.4.1. Classification of lipids -Simple lipids (fats, oils and waxes), compound lipids (phospholipids, glycolipids, lipoproteins and sulpholipids) and derived lipids.

1.4.2. Brief account of the chemistry of sterols, terpenes and carotenoids.

1.4.3. Acid number, saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids, Rancidity

1.4.4. Fatty acids - definition; essential fatty acids; Classification with examples- Saturated, unsaturated, hydroxyl and cyclic fatty acids; Nomenclature of fatty acids - Geneva system

1.4.5. Prostaglandins - Chemical nature and functions.

1.4.6. Extraction and analysis of lipids.

1.5. Nucleic acids (3hrs)

1.5.1. Structure of nitrogen bases and nucleotides

1.5.2. Structural organization of DNA (Watson -Crick model) -Characteristic features of A-, B- C- and Z-DNA

1.5.3. Structural organization of t-RNA; brief note on micro-RNA

Module - II - Enzymes

(10 hrs)

2. 1. Classification- (I.U.B. system)

2.2. Specificity of enzyme action

2.3. Mechanism of enzyme action: Formation of enzyme substrate complex- Gibbs free energy of activation; Michaelis-Menten theory, Fischer's template theory and Koshland's induced fit theory. Electrostatic, hydrogen and Van der Waal's bonds in Enzyme-substrate complex.

2.4. Enzyme kinetics - Michaelis-Menten equation - derivation; significance of K_m and V_{max} Values.

2.5. Lineweaver-Burk equation and double reciprocal plot of enzyme reaction.

2.6. Enzyme inhibition - Competitive, non-competitive and uncompetitive inhibition (distinguish kinetically), suicide inhibition and feedback inhibition

2.7. Allosteric enzymes - positive and negative modulators

2.8. Factors influencing enzyme action

2.9. Iso-enzyme, ribozyme, co-enzymes and zymogens

2.10. Vitamins as co-enzymes

Module - III - Bioenergetics

(3 hrs)

- 3.1 Laws of thermodynamics and biological system, Enthalpy, Entropy, Free energy concept
- 3.2 Energy of activation, Standard free energy change
- 3.3 Role of ATP as a free energy carrier in the biological system

Module - IV - Metabolism and biosynthesis of biomolecules

(15 hrs)

4.1 Carbohydrate metabolism

(6hrs)

4.1.1. Glycolysis - (PFK as pacemaker - Hexokinase conformation and change by glucose), Fate of pyruvic acid

4.1.2. Metabolism of 2, 3 DPG as regulator of oxygen transport

4. 1.3. Citric acid cycle; Pyruvate dehydrogenase complex and ketoglutarate dehydrogenase complex

4. 1.4. Electron transport system and oxidative phosphorylation; Redox potential, Chemiosmotic hypothesis; inhibitors of electron transport chain

4. 1.5. Gluconeogenesis, Glycogenesis, Glycogenolysis; regulation of glycogen synthesis and breakdown

4.1.6. Pentose phosphate pathway (HMP pathway) and its significance.

4. 1.7. Uronic acid pathway

4.1.8. Metabolism of Fructose and Galactose

4.2. Amino acid metabolism

(4hrs)

4. 2.1. Biosynthesis and degradation of - glutamic acid, phenyl alanine, methionine, tryptophan, isoleucine, histidine, valine,

4.2.2. Fate of amino acids in the body, Transamination, Decarboxylation and deamination reactions in the biological system.

4.3. Lipid metabolism (3hrs)

4.3.1. Oxidation of fatty acids

4.3.2. Biosynthesis of fatty acids

4.3.3. Biosynthesis of cholesterol

4.4. Nucleic acid metabolism (2hrs)

4.4.1. Biosynthesis and degradation of purines and pyrimidines

Part B. Cytogenetics (36 hrs)**Module - V - Structural and functional organization of cell-membrane (18 hrs)**

5.1. Membrane structure and function.(4hrs)

5.1.1. Molecular organization of cell membrane - Lipid bilayer and membrane protein. Molecular models of cell membrane.

5.1.2. Cell permeability-osmosis, diffusion, ion channels, active transport, membrane pumps.

5.1.3. Mechanism of sorting and regulation of intracellular transport.

5.1.4. Electrical properties of membranes.

5.1.5. Microvilli and cell coat.

5.2. Cellular communication(6hrs)

5.2.1. General principles of cell communication

5.2.2. Cell-cell interactions – cell adhesion and roles of different adhesion molecules

5.2.3. Intercellular attachments- gap junctions, desmosomes, intermediary and tight junctions.

5.2.4. Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes.

5.2.5. Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherens.

5.3. Cell signaling (8hrs)

5.3.1. Signal transduction

5.3.2. Concept of cell-signaling

5.3.3. Signaling through cell surface receptors: G protein linked receptors; signaling via cAMP, PKA, IP3, Ca²⁺/calmodulin, PKC, Ca-MK, Enzyme linked receptors, Receptor tyrosine kinase (RTK), signaling of growth factors, Tyrosine kinase associated receptors, JAK- STAT signaling pathway, Receptor protein tyrosine phosphatase (PTP), Receptor serine/threonine kinase, Receptor guanylylase, cGMP, PKG, Histidine kinase associated receptors

Module VI. Structural and functional organization of Cell organelles. (8 hrs)

6.1. Structure of cell organelles.

6.2. Functions of cell organelles.

6.3. Organization of Mitochondria, Golgi complex, Lysosomes, Endoplasmic reticulum, Ribosomes, Peroxisomes and Cytoskeleton.

6.4 Extra chromosomal inheritance- inheritance of mitochondrial and chloroplast genes, maternal inheritance.

Module VII. Structural and functional organization of Nucleus. (6 hours)

7.1. Structure of Nucleus

7.2. Structure of chromatin and chromosomes, heterochromatin, euchromatin –unique and repetitive DNA

7.3. Chromosomal changes- euploidy, aneuploidy, chromosomal aberrations- Structural alterations- gene mutations- molecular changes- deletion, duplication, translocation, inversion and sister chromatid exchange.

7.4. Interrupted genes and gene families.

7.5. Concept of gene- Allele, multiple alleles, pseudo-allele, complementation tests.

Module VIII Apoptosis and its significance (4hrs)

8.1. Process of apoptosis: Initiation, Execution: cytochrome C, Caspases, Phagocytosis

8.2. Regulation of apoptosis - Extracellular and Intracellular

8.3. Apoptosis in *Caenorhabditis elegans*, *Drosophila*, mammals and bacterial population

8.4. Mechanism of cell death.

8.5. Necrosis; Programmed and induced cell death

8.6. Genes involved in apoptosis.

8.7. Significance of apoptosis

References

Biochemistry

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2. Benjamin Lewin (2008). Genes IX. Jones & Bartlett Learning Publishers, New York.
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FIRST SEMESTER				
Course code	ZOL1C02			
Name of the course	BIOPHYSICS AND BIOSTATISTICS			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
02	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the applications of Colloidal System, Diffusion and Osmosis and Hydrogen ion Concentration (pH) in Biological Studies	9	U	C	PO1, PO2	PSO1, PSO4
CO2	Understand bioinstrumentation techniques and their applications	17	U	C	PO1, PO2	PSO1, PSO4
CO3	Recognize Separation Techniques and applications	10	U	C	PO1, PO2	PSO1, PSO4
CO4	Understand the applications of Radiation Biology and Nanotechnology	8	U	C	PO1, PO2	PSO1
CO5	Comprehend the biological aspects of acoustics and gravity	10	U	C	PO1, PO2	PSO1
CO6	Understand data handling, descriptive statistics and probability distribution	15	An	P	PO2, PO3	PSO1, PSO5
CO7	Use statistical inference tests on biological data	14	An,E	P	PO2, PO3	PSO1, PSO5
CO8	Identify basic ecological data analysis (alpha and beta diversity)	7	An,E	P	PO2, PO3	PSO1, PSO5

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Part A. Biophysics (54 HOURS)

MODULE I: BIO-PHYSICAL ASPECTS AND ITS SIGNIFICANCE (9 hrs)

1.1. Colloidal System (3 hrs)

- 1.1.1. Crystalloids and Colloids,
- 1.1.2. Properties of colloids- Kinetic, optical and electrical properties- Electro-osmosis, Cataphoresis.
- 1.1.3. Forms of colloids, Suspensions and Emulsions, preparation and properties of emulsions.
- 1.1.4. Biological importance of colloids.

1.2. Diffusion and Osmosis (4 hrs)

- 1.2.1. Fick's laws and diffusion coefficient.
- 1.2.2. Gibb's Donnan equilibrium.
- 1.2.3. Application of diffusion processes in biology: haemolysis.
- 1.2.4. Osmosis, Osmotic concentration, Osmotic pressure and osmotic gradient.
- 1.2.4. Vant Hoff's laws, Electrolytic and ionic balance in biological fluid.

1.3. Hydrogen ion Concentration (pH) (2 hrs)

- 1.3.1. Dissociation of water.
- 1.3.2. Henderson Hasselbalch equation.
- 1.3.3. Electrometric determination of pH, pH meter
- 1.3.4. Buffer –Importance of buffers in biology.

MODULE II: BIO-INSTRUMENTATION and APPLICATIONS (17 hrs)

2. 1.Principles and applications of Microscopy (6 hrs)

- 2.1.1. Resolving powers of different microscopes
- 2.1.2. Fluorescent, Interference, Scanning and Transmission electron microscopes (SEM & TEM).
- 2.1.3. Different fixation and staining techniques for EM
- 2.1.4. Freeze-etch and freeze fracture methods for EM-image processing methods in microscopy.

2.2. Biophysical methods (Brief account of the following) (5 hrs).

- 2.2.1. Properties of electro magnetic radiations.
- 2.2.2. Molecular analysis using UV / visible spectroscopy, Mass spectroscopy.
- 2.2.3. NMR and Electron Spin Resonance (ESR) spectroscopy-Applications
- 2.2.4. Structure determination using X-ray diffraction crystallography.
- 2.2.5. Circular dichroism, Surface Plasma Resonance(SPR)

2.3. Electrophysiological methods (Brief) (3 hrs)

- 2.3.1. Single neuron recording and Patch clamp recording.
- 2.3.2. EEG, Brain activity recording.
- 2.3.3. Lesion and stimulation of brain.
- 2.3.4. PET (Positron Emission Tomography), MRI, fMRI, CAT.
- 2.3.5. Laser and its applications in Biology

2.4. Radiation Technology in Biology-(3 hrs)

- 2.4.1. Radiation dosimetry- dose units and dose measurement.
- 2.4.2. Radiation Detectors - GM Counter, Solid and Liquid Scintillation Counter, Proportional counter,
- 2.4.3. Autoradiography

MODULE III: Separation Techniques (10 hrs)

3.1. Chromatography

- 3.1.1. Different types - Adsorption, Partition and Ion exchange chromatography.
- 3.1.2. Column chromatography
- 3.1.3. Paper chromatography
- 3.1.4. Thin- layer chromatography
- 3.1.5. Gel-filtration
- 3.1.6. Gas chromatography,
- 3.1.7. Affinity chromatography,
- 3.1.8. HPLC

3.2. Electrophoresis

- 3.2.1. Paper electrophoresis
- 3.2.2. Disc electrophoresis
- 3.2.3. PAGE, Two dimensional PAGE, High voltage Electrophoresis
- 3.2.4. Isoelectric focusing.

MODULE IV: Radiation Biology and Nanotechnology (8 hrs)

4.1. Radiation Biology

- 4.1.1. Radioactivity, different types ionizing radiations and their sources
- 4.1.2. Radioactive disintegration. Decay curve, half-life.
- 4.1.3. Biological effects of ionizing radiations – effects at macromolecular, cellular and organ system level, effects of whole body irradiation-Radiation therapy.
- 4.1.4. Biological applications of radioisotopes.

4.2. Nanotechnology

- 4.2.1. Definition
- 4.2.2. Nanotechnology and its applications in the field of healthcare.
- 4.2.3. Role of nanotechnology in environmental management.

MODULE V Bioacoustics and Influence of gravity (10 hrs)

5.1. Bioacoustics (5 hrs)

- 5.1.1. Characteristics of sound.
- 5.1.2. Physical basis of hearing.
- 5.1.3. Physical organization of ear.
- 5.1.4. Physical aspects of sound transmission in the ear.
- 5.1.5. Audible sound frequency.
- 5.1.6. Pitch perception and theories.
- 5.1.7. Infrasonic and ultrasonic sounds.
- 5.1.8. Echolocation; receiving and analyzing echoes

5.2. Influence of gravity (5 hrs)

- 5.2.1. Human body posture in the gravitational field
- 5.2.2. Influence of G force.
- 5.2.3. Force of centrifugal acceleration - importance of aviation and space travel
- 5.2.4. Effect of positive G. Force & negative G .Forces.
- 5.2.5. Protection against G. Force
- 5.2.6. Influence of linear acceleration on the body

Part B –Biostatistics (36 HOURS)

MODULE VI: Introduction to Biostatistics, Data Handling Probability distributions and Descriptive Statistics (15 hrs)

6.1. Introduction (2 hrs)

- 6.1.1. Biostatistics: Definition,
- 6.1.2. Characteristics of Statistics
- 6.1.3. Importance and usefulness of statistics
- 6.1.4. Limitations of Statistics

6.2.Data (5 hrs)

- 6.2.1. Types of data: classification based on Source of data, Compilation, Variable, Nature.
- 6.2.2. Methods of data collection and classification.
- 6.2.3. Types of sampling methods.
- 6.2.4. Advantages and disadvantages of census and sampling method.
- 6.2.5. Class intervals- exclusive and inclusive method
- 6.2.6. Frequency curve (types. skewness, kurtosis, ogive)

6.3. Probability distributions (4 hrs)

- 6.3.1. Basic concepts and definition:
- 6.3.2. Laws of probability
- 6.3.3. Probability distribution: - Binomial, Poisson and Normal

6.4. Measures of central tendency and dispersal (4 hrs)

- 6.4.1. Mean, (raw data, discrete series and continuous series)
- 6.4.2. Standard deviation, Standard error, degree of freedom (raw data, discrete series and continuous series)
- 6.4.3. Quartile deviation- Box- whiskerplot

MODULE VII: Statistical inference, Correlation and Regression (problems to be discussed) (14 hrs)

7.1. Statistical inference (7 hrs)

- 7.1.1. Difference between parametric and non-parametric statistics;
- 7.1.2. Testing of hypothesis
- 7.1.3. Errors
- 7.1.4. Confidence interval; levels of significance, Critical region;
- 7.1.5. Normality test
- 7.1.6. t-test, chi-square test, F-test, ANOVA
- 7.1.7. Kruskal-Wallis, Mann-Whitney

7.2. Correlation and Regression (7 hrs)

7.2.1. Types of correlation.

7.2.2. Methods to measure correlation- Scatter diagram.

7.2.3. Karl Pearson's coefficient of correlation, Spearman's correlation

7.2.4. Types of regression analysis; Regression equations; Difference between regression and correlation analysis

Module VIII Ecological data analysis (problems to be discussed) (7 hrs)

8.1. Alpha diversity

8.2. Shannon diversity index, Simpsons Dominance index, Pielou's Evenness index, Margalef species Richness, Fisher's alpha,

8.3. Beta diversity

8.4. Morisita Horn index, Sorenson index, Bray-Curtis similarity

References

Biophysics

1. Alonso, A and Arrondo, J.L.R (2006) - Advanced techniques in Biophysics, Springer
2. Alok Srivastava and Ipsita Roy-(2009)-Bio-Nano- Geo Sciences- The future challenge- Ane Books Ltd.
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4. Daniel, M (2002), Basic Biophysics for Biologists. Agro Botanics, Bikaner
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7. Stephen W, Looney (2008) Methods in Molecular Biology-Biostatistical Methods Springer International Edition
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FIRST SEMESTER				
Course code	ZOL1C03			
Name of the course	ECOLOGY AND ETHOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
03	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the basic concepts of ecology and ecosystem	12	U	C	PO1, PO2, PO5	PSO2
CO2	Describe the characteristics of population; growth and regulation of human population	7	Ap	C	PO1, PO2, PO5	PSO2
CO3	Explain the characteristics of community (species diversity, ecological succession and species interactions)	13	Ap	C	PO1, PO2, PO5	PSO2 PSO4
CO4	Compare the major terrestrial biomes and biogeographical zones of India	10	E	C	PO1, PO2, PO5	PSO2 PSO4
CO5	Discuss important ecological initiatives and major conservation practices	12	U	C	PO1, PO2, PO5	PSO2
CO6	Understand the concepts of ethology	14	U	C	PO1, PO2, PO5	PSO2
CO7	Elucidate the evolutionary aspects and adaptiveness of behaviour	17	U	C	PO1, PO2, PO5	PSO2 PSO4
CO8	Illustrate the hormonal regulation of behaviour	5	Ap	C	PO1, PO2, PO5	PSO2

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Part-A-Ecology (54 HOURS)

Module I. Introduction to Ecology & Ecosystem

(12 hrs)

- 1.1. Habitat and Niche, Concept of habitat and Niche
- 1.2. Niche width and Niche overlap
- 1.3. Fundamental and Realized Niche
- 1.4. Resource partitioning
- 1.5. Character displacement

1.2. Ecosystem :

- 1.2.1. Structure and function
- 1.2.2. Ecosystem energetics
- 1.2.3. Primary production
- 1.2.4. Energy flow models
- 1.2.5. Mineral cycling(CNP)
- 1.2.6. Trophic levels, Food chain, food web and secondary production
- 1.2.7. Decomposers and detritivores

Module II. Population Ecology

(7 hrs)

- 2.1. Characteristics of a population
- 2.2. Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations
- 2.3. Sampling methods in the study of behaviour, habitat characterization
- 2.4. Ground and remote sensing methods
- 2.5. Population growth curves, Life tables, survivorship curves, population regulation, Life history strategies, r and k selection, Demes and dispersal, interdemec extinctions, age structure of populations
- 2.6. Growth and regulation of human population

Module III. Community Ecology and Species interactions

(13 hrs)

3.1. Community Ecology

- 3.1.1. Nature of communities
- 3.1.2. Characteristics of a biotic community
- 3.1.3. Species diversity and latitudinal gradients in diversity
- 3.1.4. Edges and ecotones

3.2. Ecological succession:

3.2.1. Types, mechanisms, changes involved in succession

3.2.2. Concept of climax

3.3. Species interactions

3.3.1. Types of interactions, intra specific and inter specific

3.3.2. Herbivory, Carnivory, Pollination, Competition, Amensalism, Symbiosis; mutualism, commensalism and proto co- operation

Module IV. Biogeography (10 hrs)

4.1. Major terrestrial biomes: (a) Tropical rain Forest (b) Grassland (c) Desert (d) Chaparral (e) Temperate deciduous Forest (f) Temperate boreal forest (g) Tundra (h) Savanna

4.2. Biogeographical zones of India: (a) Trans Himalayan zone; (b) Himalayan zone; (c) Desert zone; (d) Semiarid zone; (e) Western Ghats zone; (f) Deccan plateau zone; (g) Gangetic plain zone; (h) North east zone. (i) Coastal zone; (j) Islands present near the shoreline

Module V. Applied Ecology (12 hrs)

5.1. Carbon credit, Carbon trading, Blue Carbon

5.2. Green building technology and its ecological importance

5.3. Discuss the benefits and disadvantages of the idea of (brief)

5.3.1. Inter linking of major rivers of India

5.3.2. Sethusamudram ship canal project

5.3.3. Biodiversity with special reference to India-status, monitoring and documentation, major drivers of biodiversity change

5.4. Conservation Biology

5.4.1. Principles of conservation

5.4.2. Major approaches to management

5.4.3. Indian case studies on conservation & management strategy (concepts of project tiger, Biosphere reserves)

Part B. Ethology (36 HOURS)

Module VI. Concepts of Ethology (14 hrs)

6.1. Concepts of Ethology (14 hrs)

6.1.1. Ethology as different from the other schools studying animal behavior like behaviourism

6.1.2. Behaviour as a reaction to stimuli - sign stimuli, social releasers, Ethograms, super normal stimuli, stimulus filtering

6.1.3. Concepts of Fixed Action Patterns (FAP), Innate Releasing Mechanism (IRM), Action Specific Energy (ASE), Concepts of Learning and Imprinting

6.2. Motivating factors

6.2.1. Proximate and Ultimate factors

6.2.2. General factors in motivation; Studies of motivation in guppies

6.2.3. Mating systems - parental investment and reproductive success

6.3. Learning - Neural basis of learning, memory, cognition, sleep and arousal

6.4. Biological clocks and circadian rhythms

6.5. Types of orientation - reference theory of Von Holst & Mittel Steadt

6.6. Navigation & migration

Module VII. Evolution and adaptiveness of behavior (17 hrs)

7.1. Altruism, Kin selection, inclusive fitness, selfish gene theory, cultural transmission of behaviour

7.2. Conflict behaviour - stress-displacement activities - Ritualization

7.3. Instinctive behaviour & reflex action

7.4. JP Scott's categories of behaviour

7.5. Parental care

7.6. Mating systems, Parental investment and Reproductive Success

7.7. Development of behavior

7.8. Social communication; Social dominance; Use of space and territoriality; domestication and behavioural changes; Social behaviour of termites & Primates

Module VIII. Hormones and Behaviour- (5 hrs)

8.1. Hormones of gonads, adrenal gland, Pituitary gland

8.2. Hormonal effects on different behavioural patterns,

8.3. Maternal behaviour - mechanism of hormonal action

References

Ecology

1. Ahluwalia and Sunitha Malhorta - Environmental Science - Ane Books Pvt. Ltd

2. Allan Beebi and Anne Maria Brennan(2006)- First Ecology-Ecological principles and environmental issues-Oxford university press.
3. Archbold,O.W.(1995).Ecology of WorldVegetation.NewYork,NY:ChapmanandHall.
4. Begon,Harper, Townsend- Ecology- Individuals, Populations, and communities- Blackwell Science,Secondedition
5. Brewer Richard (1994).The Science of Ecology-Saunders collegepublishing.
6. Chapman J.L and Reiss.M.J- Ecology principles and applications-Cambridge low price editions
7. Charles J .Krebs- Ecology.The experimental analysis of distribution and abundance.
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Ethology

1. Chris Barnard (2003): Animal Behaviour: Mechanism, Development, Function and Evolution, Publisher: PearsonEducation.
2. David McFarland (1999): Animal Behaviour: Psychobiology, Ethology and Evolution, 3rd Edition. Publisher: PearsonEducation.
3. David Mcfarland (2006) A Dictionary of Animal Behaviour. Publisher: Oxford University Press.

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5. Graham Scott (2004) Essential Animal Behaviour. Publisher:Wiley-Blackwell
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8. Manning, A. and Dwakins, M.S. (1995) An Introduction to Animal Behaviour. Cambridge Univ. Press,Lond.
9. Martin P. and Bateson .P.(2001). Measuring Behaviour – an introductory guide. Cambridge University Press,UK.
10. Scott, J.P. (1972) Animal Behaviour. Publisher: Univ ofChicago.

FIRST SEMESTER PRACTICALS

ZOL2L01 - BIOCHEMISTRY

1. Actual acidity and titrable acidity of a strong and a weak acid.
2. Comparison of the buffering capacities of two buffers of same pH
3. Qualitative tests for carbohydrates
 - a) Qualitative tests for monosaccharides (Glucose and fructose)
 - b) Qualitative tests for disaccharides (Lactose, Maltose & Sucrose)
 - c) Qualitative tests for polysaccharides (Dextrin & Starch)
 - d) Identification of unknown carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose, Dextrin & Starch) by suitable tests.
4. Quantitative estimation of carbohydrates
 - Estimation of blood glucose by colorimetric method (Somogy-Nelson method/ O-Toluidine method)
 - Estimation of total carbohydrate by phenol-sulphuric acid method
5. Qualitative tests for proteins
 - a) Colour reactions with proteins (Albumin, Casein, Peptones & gelatin)
 - b) Precipitation reactions with proteins (Albumin, Casein, Peptones & gelatin)
 - c) Identification of unknown protein (Albumin, Casein, Peptones & gelatin)
6. Qualitative tests for non-protein nitrogenous substances (urea, uric acid and creatinine)
7. Identification of unknown carbohydrates, protein and non-protein nitrogenous substances from a given solution.
8. Quantitative estimation of proteins
 - a) Estimation of proteins by Biuret method
 - b) Isolation of casein from cow's milk
9. Quantitative estimation of non-protein nitrogenous substances
 - a) Quantitation of blood urea by diacetyl monoxime method
 - b) Determination of urine creatine by alkaline picrate method
10. Quantitative estimation of lipids
 - a) Estimation of total serum cholesterol by Zak's method
 - b) Saponification number of oils - coconut oil & ground nut oil.
 - c) Iodine number of fats

ZOL2L02 - CYTOGENETICS

1. Homogenization, cell fractionation and isolation of nuclear fraction.
2. Preparation and maintenance of *Drosophila* larva.
3. Preparation of salivary gland polytene chromosome from *Drosophila* larva.
4. Grasshopper testes- squash preparation to study various meiotic stages.
5. Study of normal human karyotype (male and female).
6. Study of genetics syndromes-Down's, Klinefelter's, Turner's and Edward's.

References

1. Plummer David, T.(2007). An introduction to practical biochemistry -Tata Mc Graw-Hill, New Delhi.
2. Oser, B.L., (1965) Hawk's Physiological Biochemistry, McGraw Hill BookCo.
3. Sadasivan,S.andManickam,A.,(2005),Biochemical methods,New Age International,New Delhi.
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9. Neidharth,F.C. and Beyd, R.F.(1965) Cell Biology- A laboratory text . Burgees PublishingCo.

ZOL2L01 - Biophysics and Biostatistics

Biophysics

1. pH meter and measurement of pH
2. Paper chromatography of amino acids
3. Separation and identification of amino acids in mixtures

4. Thin layer chromatography.
5. Gel electrophoresis.
6. Determination of unknown concentration of coloured solutions by calibration curve using colorimeter.
7. Absorption spectrum and max of a coloured solution (KMnO₄).
8. Drawings using Camera lucida.

Biostatistics

1. Preparation of frequency table with given data
2. Diagrammatic presentation of census data in Kerala in the form of bar diagrams and pie diagrams. (prepare same graph in Excel and keep print out)
3. Graphic presentation of population distribution in the form of histogram, frequency polygon and frequency curve. (prepare same graph in Excel and keep print).
4. Computation of measures of central dispersion anthropometric data of School children. (prepare same in Excel and keep print outs and add steps for excel)
5. Estimation of mean number of children per family (data from at least 10 families nearby campus) (prepare same in Excel and keep print outs and add steps for excel).
6. Designing of an experiment for the comparison of efficacy of a few diets on different types of animals by the method of ANOVA. (Prepare same in Excel and keep prints out and add steps for excel).
7. Regression analysis and correlation analysis of a data of height and weight of a group of students. (prepare same in Excel and keep print outs and add steps for excel)

References

1. Daniel, M. (1998). Basic Biophysics for Biologists.. Agri. Botanica, Bikaner.
2. Das, D.(1987). Biophysics and Biophysical Chemistry. Academic Publishers, Calcutta.
3. Gassey, E.J.(1962). Biophysical concepts and mechanics. Van Nostrand Reinhold Co.
4. Hoppe, W (1988). Biophysics, Springer Verlag.
5. White, D.C.S.(1974). Biological Physics, Chapman and Hall. London.
6. John T (2002) Practical statistics for environmental and biological scientists .John Wiley and Sons.

ZOL2L03 - Ecology and Ethology

Part A. Ecology

1. Identification of marine plankton.
2. Quantitative estimation of marine plankton.
3. Estimation of BOD in polluted water sample.
4. Estimation of salinity in water samples.
5. Estimation of nitrates-nitrogen in water samples.
6. Separation and identification of soil arthropods using Berlese funnel.
7. Determination of moisture content of soil sample.
8. Determination of water holding capacity of soil sample.
9. Testing the transparency of water using Secchi disc
10. Determination of primary productivity in pond water using light and dark bottle.
11. Study of termitorium / ant colony
12. Principle and application of the following instruments-GPS, Thermo hygrometer, Altimeter, Air samplers, soil samplers, Berlese funnel, Lux meter, anemometer, Rain gauge, Plankton net, Plankton counting chamber, Weather balloon, Secchi disc etc (at least six items)
13. FIELD STUDY-A study tour of at least five days duration (need not be at a stretch) to observe the ecology and behaviour of animals should be undertaken. The places of visit include inter tidal region, fresh water bodies, lakes, rivers, hill streams, wetlands, mangroves, forests grasslands, drinking water treatment plants, and sewage treatment plants. A report of the field study is to be included in the practical record to be submitted at the time of examination.

Part B Ethology

1. Studying and reporting the behaviour and ecology of animals in selected fields (Social spider/ Jungle babbler/white headed babbler or Bonnet Macaques)
2. Foraging behaviour of ants.
3. Study of circadian rhythm
4. Behavioural reaction to moisture and light

References:

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2. Goodenough, J; McGuire B. and Robert, W. (1993) Perspectives on Animal Behaviour.

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4. Manning, A. and Dawkins,M.S.(1995).An introduction to Animal Behaviour, CambridgePress.
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6. Michael, P.(1984). Ecological methods for field and laboratory investigations. Tata McGraw Hill publishing co.
7. Webber, W.J (1972).Physicochemical Processes for water quality control. Wileyinterscience.
8. George,T, Franklin, L. Burton and David, S.H.(2002). Waste water Engineering-Metcalf and Eddy.4th ed. Inc. Tata McGraw Hill publishingco.

SECOND SEMESTER				
Course code	ZOL2C04			
Name of the course	PHYSIOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
04	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Recognize the process of nutrition	8	U	C	PO1, PO2, PO5	PSO1
CO2	Explain the excretory and osmoregulatory mechanisms	10	U	C	PO1, PO2, PO5	PSO1
CO3	Identify the mechanisms of respiration	12	U	C	PO1, PO2, PO5	PSO1
CO4	Illustrate the structure and functioning of human brain	20	U	C	PO1, PO2, PO5	PSO1
CO5	Understand the neurophysiology of sense organs	20	U	C	PO1, PO2, PO5	PSO1
CO6	Understand the neurophysiology of sense organs	12	U	C	PO1, PO2, PO5	PSO1
CO7	Comprehend the structure and function of human heart	4	U	C	PO1, PO2, PO5	PSO1
CO8	Understand the physiology of muscle action	4	U	C	PO1, PO2, PO5	PSO1

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Module-I: Nutrition, Digestion and absorption

(8 hrs)

1. Nutrition

1.1. Constituents of normal diet and their daily requirements

1.1.1. Physiological calorie value of foodstuffs.

1.1.2. Antioxidant nutrients.

1.2. Physiology of digestion and absorption,

1.2.1. Movements of GI tract: deglutition, gastric motility and emptying, intestinal motility and defecation.

1.2.2. The role of hormones and neurotransmitters in the control of gastrointestinal motility.

1.3. Energy balance and obesity-causes and consequences

1.4. Physiology of starvation.

1.5. BMR and its significance.

Module-II. Excretion and Osmoregulation

(10 hrs)

2.1. Excretory system

2.1.1. Introduction: Brief description of different types of excretory organs in different animal groups (flame cells, green glands, Malpighi an tubules).

2.1.2. Functional anatomy of mammalian kidney, nephron and juxtaglomerular apparatus structure, parts and function.

2.2. Urine formation (glomerular filtration, tubular reabsorption and tubular secretion)

2.2.1. Regulation of water balance -Mechanism of concentration of urine –

2.2.2. Counter Current system (counter current multiplier and counter current exchanger).

2.3. Renal regulation of acid- base balance & electrolyte balance.

2.3.1..Structure of urinary bladder, micturition reflex and micturition.

2.3.2. .Renal clearance – definition, concept and significance; clearance value of urea, creatinine, phosphate, potassium, chloride and sodium.

2.4. Kidney disorders, Dialysis and Kidney transplantation

Module-III. Respiratory system

(12 hrs)

3.1. Introduction: Brief description of major respiratory organs (tracheal system, book lungs, Gills and ctenidia).

3.2. Physiological anatomy and histology of respiratory passage and lungs in man

3.3. Mechanism of pulmonary ventilation (inspiration & expiration).

3.4. Alveolar ventilation, dead space and its effect on alveolar ventilation.

3.4.1. Role of surfactant in alveolar expansion-Pulmonary volumes and capacities – definition & normal values (tidal volume, inspiratory reserve volume, expiratory reserve volume, residual volume, functional residual capacity, inspiratory capacity, vital capacity, total lung capacity).

3.5. Exchange of gases- partial pressures involved-lung and tissues.- Oxygen dissociation curve – factors affecting binding of oxygen to hemoglobin (PO₂, PCO₂, CO, pH, body temperature, diphosphoglyceric acid level, foetal hemoglobin and also myoglobin).

3.6. Neural and chemical regulation of respiration: Respiratory centers & factors regulating respiration.

3.7. Respiratory disorders-Respiratory problems in high altitude and deep sea

Module-IV. Nervous system

(20 hrs)

4.1. Organization of human brain.

4.1.1. Cerebrum and cerebral lobe.

4.1.2. Cerebral cortex and its functional areas- Motor cortex, Broca's area, somatosensory cortex and its association area, gustatory cortex, visual cortex and its association area, auditory cortex and its association area, olfactory cortex, Wernicke's area, Brodmann map, cerebral dominance.

4.1.3. Cortical white matter- commissures, association fibers, projection fibers, corpus callosum and fornix, basal nuclei-organization and function.

4.1.4. Brain stem- organization and function.

4.1.5. Cerebellum- structure and function.

4.1.6. Diencephalon – organization and function.

4.2. Functional brain systems - Limbic system and reticular formation.

4.3. Protection of brain – Meninges, cerebrospinal fluid- formation and function, blood brain barrier and its function.

4.4. Diseased states of brain - schizophrenia, Alzheimer's disease, Senile dementia & Parkinson's disease.

4.5. Memory- definition, types of memory- short term, intermediate long term and long term memory, consolidation of memory.

4.6. PNS and Autonomic nervous system.

4.7. Spinal cord – structure.

4.8. Reflex action, reflex arc, monosynaptic and polysynaptic reflexes, inverse stretch reflex and Golgi tendon organ.

Module-V. Special senses

(20 hrs)

5.1. Vision:

5.1.1. Structure of eyeball

5.1.2. Fluid systems of the eye

5.1.3. Layers of Retina and photoreceptors (rods & cones)

5.1.4. Brief notes on the neuronal cell types and neural circuitry of the retina and visual pathways from retina to visual cortex

5.1.5. Image formation-Formation of image on the retina; A brief general account of electrophysiology of vision; Photochemistry of vision & color vision

5.2. Taste:

5.2.1. Primary sensations of taste (agents and site of sensation)

5.2.2. Taste buds (location, structure, receptors and nerve supply)

5.2.3. Physiology of taste (receptor stimulation, generation of nerve impulse by taste buds and its transmission to CNS)

5.3. Smell:

5.3.1. Olfactory membrane and receptor cells

5.3.2. Physiology of olfaction (stimulation of olfactory cells and transmission of smell signals to CNS)

5.4. Tactile response: (brief note)

5.4.1. Mechanoreceptors and their stimulation

5.4.2. Pain receptors and their stimulation, Pain suppression (Analgesia)

5.4.3. Thermal receptors and their stimulation

Module-VI. Physiology of Circulation

(12 hrs)

6.1 Cardiovascular system.

6.1.2. Introduction: Brief description of vertebrate hearts

6.1.3. Structural organization of myogenic heart (in human beings).

6.1.4. Physiological anatomy of cardiac muscle – specialized tissue.

6.1.5. Heart as pump.

6.1.6. Cardiac cycle.

6.1.7. Neural and chemical regulation of heart function.

6.1.8 Blood volume and blood pressure.

6.1.9. Physiological anatomy of coronary blood flow, coronary blood flow and its control.

6.1.10. Ischemic heart disease – mention causes.

6.2. .Lymphatic System

6.2.1. Lymph channels of the body.

6.2.2. Composition and formation of lymph.

6.2.3. Functions of lymph and lymphatic system including role of it in controlling Interstitial fluid protein concentration, interstitial fluid volume and interstitial fluid pressure.

Module-VII. Muscle Physiology

(4 hrs)

7.1. Ultra structure and molecular organization of muscles

7.2. Mechanism of muscle contraction and relaxation.

7.3. Energetics of muscle contraction

7.4. Exercise and Muscular strength, Endurance, Muscle spasm, Muscle cramps. (Brief account)

Module-VIII. Environmental Physiology (4 hrs)

8.1 Thermoregulation.

8.2. Comfort zone, normal body temperatures (oral, skin & core).

8.3. Temperature regulating mechanism (hot & cold), mention the role of hypothalamus, thyroid and adrenal glands.

8.4. Adaptations for extreme environments, Aestivation and hibernation. Acclimatization.

References

1. Arthur C.Guyton & John E. Hall (2003): Textbook of Medical Physiology, Saunders (An imprint of Elsevier).
2. William F.Ganong (1999): Review of Medical Physiology, Lange Medical Publications(Appleton & Lange).
3. JainA.K.(2009):TextBookofPhysiology(Vol.I&II),AvichalPublishingCompany,NewDelhi.
4. Deb, A.C. (2002): Fundamentals of Biochemistry (2002): New Central Book Agency(P) LTD, India.
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10. Oser,B.L.-(1965).Haw"s Physiological chemistry. Tata McGraw Hill Pub. Co. NewDelhi.
11. 11.Shepherd, G.M: Neurobiology-Principles of Neural Science, E. Kandel & P.Schwartz.
12. Campbell *et al.* (1984): Clinical Physiology, 5th Edn. BlackwallScientific Publications, Oxford.
13. Pragnelli,C.V& Farhi, L.E. (1989): Physiological function of special Environment-Springerverlag, N.Y.
14. Davie IV & Lewid S.M.- Practical Haematology, 6th Edn. Churchill,Livingstone, Edinburgh.

SECOND SEMESTER				
Course code	ZOL2C05			
Name of the course	MOLECULAR BIOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
05	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the universal principles of genetic code and its variations,	20	U	C	PO1, PO2, PO3	PSO1
CO2	Recognize the processes of DNA replication and the safeguard systems related to DNA	16	U	C	PO1, PO2, PO5	PSO1
CO3	Comprehend the processes of transcription and translation in prokaryotes and eukaryotes,	20	U	C	PO1, PO2, PO5	PSO1
CO4	Identify the control of gene expression at transcription and translation level	9	U	C	PO1, PO2, PO5	PSO1
CO5	Recognize the phenomenon and effects of Interrupted genes and Transposable genetic elements	10	U	C	PO1, PO2, PO5	PSO1
CO6	Understand the molecular mechanisms involved in recombination of DNA	5	U	C	PO1, PO2, PO5	PSO1
CO7	Evaluate the basic principles of microbial genetics	5	E	C	PO1, PO2, PO5	PSO1
CO8	Understand the molecular basis of Cancer	5	U	C	PO1, PO2, PO5	PSO1

Abbreviations used:

CL - Cognitive level

*R: Remember, U: Understand
Ap :Apply, An: Analyze
E:Evaluate, C : Create*

KC- Knowledge category

*C - Conceptual
F - Factual
P - Procedural
M - Metacognitive*

MODULE I- INTRODUCTION (20 hrs)**1.1.Genetic code (5 hrs)**

1.1.1. Characteristics of genetic code

1.1.2.Start codons and stop codons

1.1.3.Degeneracy of the code: Wobble hypothesis and iso acceptor RNAs

1.1.4.Special features of the genetic code in mitochondria, mitochondrial tRNA

1.1.5.Variations in the genetic code in *Mycoplasma* and *Tetrahymena*

1.1.6.Point mutations that alter genetic code (missense, nonsense & frame shift)

1.2.Eukaryotic genome: (5 hrs)

1.2. 1. Special features of eukaryotic genome

1.2.2. Features, components and reassociation kinetics of Unique, Moderately repetitive and Highly repetitive DNA, Junk DNA, Satellite DNA and Selfish DNA

1.2.3. Cot value and complexity of genome

1.2.4.Organisation of human genome (brief account)

1.3.Gene families: (6 hrs)

1.3.1.Definition and concept

1.3.2. Classification with example

Simple multigene family - organisation of rRNA gene in *Xenopus*Complex multigene family - organisation of histone genes in sea urchin and tRNA genes in *Drosophila*

Developmentally controlled complex multigene family e.g., globin gene

1.3.3.Globin genes and its products

1.3.4.Organisation of globin genes and its expression in Man

1.3.5.Evolution of globin genes

1.3.6.Concept of an evolutionary clock

1.3.7. Pseudogenes

1.4.Organelle genome (4 hrs)

1.4.1. Chloroplast genome: special features

1.4.2.Mitochondrial genome

1.4.3.Special features of yeast mitochondrial genome, petite mutants

1.4.4.Special features of human mitochondrial genome.

MODULE II- DNA REPLICATION AND REPAIR (16 hrs)**2.1. DNA replication (11 hrs)**

- 2.1.1.Semi discontinuous synthesis-Okazaki fragments
- 2.1.2. Replication origin and replication fork
- 2.1.3.Unit of replication, extra chromosomal replicon of bacterial Ti plasmid
- 2.1.4.Enzymes/proteins of replication- Primase, Replisomes, Helicase, DNA polymerases, Single strand binding proteins, Topoisomerases and Ligase;
- 2.1.5.Fidelity of replication
- 2.1.6.Replication of the ends of eukaryotic chromosome – role of telomerase
- 2.1.7. Models of DNA replication –Rolling circle model and looped rolling circle model, D-loop model, θ -model.
- 2.1.8. Inhibitors of DNA replication – Methotrexate and Fluorodeoxyuridylate

2.2. Safeguard systems of DNA (5 hrs)

- 2.2.1.Restriction: significance, role and features of Type I, II & III restriction enzymes
- 2.2.2.Modification: enzymes and significance
- 2.2.3.Repair: Major kinds of damage to DNA and causes
- 2.2.4. Repair mechanisms: Direct reversal, Mismatch repair, Excision repair, Recombination repair, SOS response

MODULE III- TRANSCRIPTION AND TRANSLATION (20 hrs)**3.1.Ribosome: The site of protein synthesis: (2 hrs)**

- 3.1.1.Structure
- 3.1.2.Composition; Reconstitution experiments
- 3.1.3.Active centres
- 3.1.4.Biogenesis of ribosome in eukaryotes

3.2.Transcription of mRNA in prokaryotes and eukaryotes (10Hrs)

- 3.2. Structural organisation and life span of mRNA; mono cistronic and poly cistronic m RNA
- 3.2.1.Transcription in prokaryotes and eukaryotes
Promoter (mention Pribnow, TATA, CAAT and GC box), enhancer and silencer sites
Transcription factors; Transcription activators and repressors
- 3.2.2.Characteristic features of RNA polymerases of phages, prokaryotes and eukaryotes and

their functions

3.2.3. Post transcriptional modification of RNA

Capping, Polyadenylation, Splicing

3.1.4. RNA editing: site specific deamination and role of gRNAs, mRNA transport

3.3. Translation in prokaryotes and eukaryotes: (8Hrs)

3.3.1. Amino acylation of tRNA & initiation, elongation and termination of protein synthesis

3.3.2. Aminoacyl tRNA synthetases & initiation, elongation and termination factors

3.3.3. Translational proof-reading

3.3.4. Differences in protein synthesis between prokaryotes and eukaryotes

3.3.5. Translational inhibitors in prokaryotes and eukaryotes – role of tetracycline, streptomycin, neomycin, chloramphenicol, erythromycin, puromycin and diphtheriatoxin

3.3.5. Post- translational modification of proteins: protein folding (role of chaperones) and biochemical modifications

MODULE IV: GENE REGULATION

(9 hrs)

Control of gene expression at transcription and translation level:

(9Hrs)

4.1. Regulation of gene expression in Phages – alternate patterns of gene expression for control of lytic and lysogenic cycle in phage

4.2. Regulation of gene expression in bacteria – basic features of tryptophan, arabinose and galactose operons

4.3. Regulation of gene expression in eukaryotes–

4.3.1. Role of chromatin in regulating gene expression

4.3.2. Activation and repression of transcription

4.3.3. Regulation of translation by gene arrangement

4.3.4. Regulation of translation by alternate pathways of transcript splicing, Antisense RNA strategies for regulating gene expression, si RNA and mi RNA in regulation

MODULE V: Interrupted genes and Transposable genetic elements

(10 hrs)

5.1. Interrupted genes

(4hrs)

5.1.1. Definition and explanation

5.1.2. Organisation and special features of interrupted genes

5.1.3. Evolution of interrupted genes

5.2. Transposable genetic elements – Transposons

(6 hrs)

5.2.1. Definition, features and types

5.2.2. Transposition and mechanism

5.2.3. Transposons in bacteria

IS elements

Tn family

Mu phage as a transposable element

5.2.4. Transposons in eukaryotes

SINE, Alu family; LINE, L1

P elements in *Drosophila*

Transposons in Maize

5.2.5. Retroviruses and transposition

MODULE VI: Molecular mechanisms involved in recombination of DNA (5Hrs)

6.1. Genetic recombination – types with example

6.1.1. Site specific recombination

6.1.2. Non-homologous recombination

6.1.3. Homologous recombination

6.2. Molecular mechanism involved in homologous recombination of DNA in eukaryotes-

Holliday model: Holliday intermediate, hetero duplex DNA, gene conversion

6.3. Role of Rec A protein in genetic recombination

MODULE VII: Microbial genetics**(5 hrs)**7.1. Prokaryotic genome- *Escherichia coli* genome – basic features7.2. Methods of genetic transfers in bacteria– transformation (in *Streptococcus pneumoniae*), conjugation and sexduction, transduction

7.3. Brief note on mapping genes by interrupted mating (in bacteria)

MODULE VIII: Cancer**(5 hrs)**

8.1. Genetic rearrangements in progenitor cells, oncogenes, proto-oncogenes and tumour suppressor genes

8.2. Virus-induced cancer

8.3. Alteration of cell cycle regulation in cancer

8.4. Interaction of cancer cells with normal cells

8.5. New therapeutic interventions of uncontrolled cell growth (immunotherapy and gene

therapy).

References

1. Attwood T.K, Parry-Smith D.J. (2003): Introduction to Bioinformatics. Pearson Education
2. Benjamin Lewin (2006). Essential Genes, Pearson, London.
3. Benjamin Lewin (2008): Genes, Vol. IX, Boston, Jones, Bartlet.
4. Brown, T.A. (2006): Genomes 3. Garland Science, New York.
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SECOND SEMESTER				
Course code	ZOL2C06			
Name of the course	- SYSTEMATICS AND EVOLUTION			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
06	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the concepts of systematics and modern trends in taxonomy	16	U	C	PO1, PO2, PO5	PSO2
CO2	Identify the types of species and species concepts	10	U	F	PO1, PO2, PO5	PSO2
CO3	Understand collection and identification methods (taxonomic keys)	14	U	F	PO1, PO2, PO5	PSO2
CO4	Understand the different aspects of Zoological Nomenclature	6	U	C	PO1, PO2, PO5	PSO2
CO5	Identify the types of taxonomic publications and the impediments in taxonomic research.	8	U	F	PO1, PO2, PO5	PSO2
CO6	Recognize evolutionary mechanisms and natural selection	14	U	C	PO1, PO2, PO5	PSO2
CO7	Illustrate evolutionary trends	14	U	p	PO1, PO2, PO5	PSO2
CO8	Comprehend molecular basis of evolution	8	U	M	PO1, PO2, PO5	PSO2

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand
Ap :Apply , An: Analyze
E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual
F - Factual
P - Procedural
M - Metacognitive

SECOND SEMESTER

Part –A: Systematics (54 HOURS)

Module I. Definition and basic concepts in Systematics and Taxonomy (16hrs)

1.1. Levels of Taxonomy

(a) Alpha, Beta and Gamma taxonomy

1.1.1.Importance and applications of taxonomy

1.1.2.Goals of taxonomy

1.1.3. Definition of systematics

1.2. Newer trends in systematics

1.2.1.DNA Bar coding

1.2.2. Molecular systematics

1.2.3. Chemo taxonomy and serotaxonomy

1.2.4 .Cytotaxonomy

1.2.5. Numerical taxonomy

1.2.6. Cladistics

1.3 Definition of classification

1.3.1. Uses of Classification

1.3.2. Purpose of Classification

1.3.3. Theories of Classification

(b) Essentialism (b) Nominalism (c) Empiricism (d) Cladism (e)

Evolutionary Classification

1.3.4. Hierarchy of Categories

1.3.5. The objectives of classification

Module II: Species & Species Concepts

(10 hrs)

2.1.Species & Species Concepts

2.1.1..Monotypic species

2.1.2.Polytypic species

2.1.3. Ecospecies and Ceno species

2.1.4. Morpho species

2.1.5. Super species

2.1.6. Species as a Population Complex

2.2.Species Concepts

- 2.2.1. Typological Species Concept
- 2.2.2. Nominalistic Species Concept
- 2.2.3. Biological Species Concept
- 2.2.4. Evolutionary Species Concept
- 2.2.5. Difficulties in the application of the biological species concept

Module III. Taxonomic Collections and Taxonomic Characters (14 hrs)

3.1.Taxonomic collections: Types of collections, Value of Collection

- 3.1.1. Purpose of scientific collection
- 3.1.2. Preservation of Specimens
- 3.1.3. Labeling
- 3.1.4. Curating of collections
- 3.1.5. Curating of types
- 3.1.6. Identification- Methods of identification
- 3.1.7. Use of keys, types of keys.
- 3.1.8. Merits and demerits of different keys
- 3.1.9. Description and publication

3.2.Taxonomic Characters

- 3.2.1.Nature of taxonomic characters
- 3.2.2.Taxonomic characters and adaptation
- 3.2.3. Kinds of taxonomic characters
 - (a) Morphological (b) Physiological (c) Ecological (d) Ethological and (e) Geographical characters
- 3.2.4. Taxonomic characters and classification
- 3.2.5. Taxonomic characters and evolution
- 3.2.6. Functions of taxonomic characters

Module IV. Zoological Nomenclature (6 hrs)

- 4.1. Brief History of nomenclature
- 4.2. International Code of Zoological Nomenclature
- 4.3. The nature of scientific names
- 4.4. Species and infraspecies names
- 4.5. Gender of generic names

- 4.6. Synonyms and Homonyms
- 4.7. The Law of Priority
- 4.8. Rejection of names
- 4.9. Type method and different kinds of types

Module V. Taxonomic publications and Impediments (8 hrs)

5.1. Taxonomic publications and ethics

- 5.1.1. Authorship of taxonomic papers
- 5.1.2. Correspondence
- 5.1.3. Suppression of data
- 5.1.4. Undesirable features of taxonomic papers
- 5.1.5. Taxonomist and user communities

5.2. Taxonomic impediments

- 5.2.1. Impediments in taxonomic collections and maintenance
- 5.2.2. Shortage of manpower
- 5.2.3. Lack of funding for taxonomic research
- 5.2.4. Lack of training and library facilities
- 5.2.5. Impediments in publishing taxonomic work
- 5.2.6. Solutions to overcome the impediments
 - (a) Improve international co-operation
 - (b) Development of taxonomic centers
 - (c) Need for efficient international networking
 - (d) the desired end product

Part- B Evolution (36 Hrs)

Module VI. Natural Selection and Evolutionary Mechanism (14 hrs)

6.1. Natural Selection

- 6.1.1. Mechanism of natural selection- directional, disruptive and stabilizing selection
- 6.1.2. Natural selection in islands
- 6.1.3. Sexual selection; intra sexual and intersexual selection- secondary sexual characteristics-sexy son hypothesis, good gene hypothesis

6.2. Mechanisms

- 6.2.1. Population genetics- populations, gene pool, gene frequency, Hardy-Weinberg law, founder principle, bottleneck effect and genetic drift as factors in evolution

6.2.2. Evidence for evolution: DNA evidence, fossil evidence, embryological evidence, geological evidence, evolution in action, imperfection of evolution

6.2.3. Co-evolution: microevolution, macroevolution, convergent evolution (homoplasy), divergent (parallel) evolution

Module VII. Evolutionary trends & Tempo of evolution (14 hrs)

7.1. Biochemical evolution- Collapse of orthogenesis

7.2. Stages in primate evolution including Homo: dry and wet nosed primates, prosimians and simians, human and the African apes, African origin for modern humans, Y chromosome Adam and mitochondrial Eve

7.3. Can evolution explain language? Communication, speech, language and self awareness in primates.

7.4. Tempo of evolution

7.5. Gradualism Vs punctuated equilibrium

7.6. Anagenesis Vs Cladogenesis

Module VIII. Molecular evolution (8 hrs)

8.1. Neutral theory of molecular evolution

8.2. Molecular divergence

8.3. Molecular drive

8.4. Molecular clocks, genetic equidistance, human mitochondrial molecular clock

8.5. Phylogenetic relationships- Homology, homologous sequence of proteins and DNA, orthologous and paralogous evolution, nucleotide sequence analysis

References

Part -A Systematics

1. David.M.H,CraigMortizandBarbaraK.M(1996)MolecularSystematics.SinauerAssociates,Inc
2. David, M.S (2009) DNA bar-coding will frequently fail in complicated groups: an example in wild potatoes. American journal of Botany 96(6) : 1177-1189. Downloadable from [www.vcru.wisc.edu/spoonerlab/.../Bar Codes %20 and % 20 wild% 20Potatoes.pdf](http://www.vcru.wisc.edu/spoonerlab/.../BarCodes%20and%20wild%20Potatoes.pdf)
3. Dalela, R.C. and Sharma, R.S.(1992). Animal Taxonomy and Museology, Jai Prakash Nath & Co Meerut City U.P(India)
4. KapoorV.C(1998)Theoryandpracticeofanimaltaxonomy.Oxford&IBH,Publi.CoNewDelhi

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6. Mayr. E (1969) Principles of Systematic Zoology.McGraw Hill Book Company, Inc, New York
7. Narendran, T.C (2008) An introduction to Taxonomy. Zoological Survey of India
8. Sneath P.H.A.(1973) Numerical Taxonomy: The Principles and Practice of Numerical Classification.W.H. Freeman&Co

Part- B Evolution

1. Coyne, J.A and Allen O.H (2004) Speciation. Sinauer Associates Inc. Massachusetts,USA
2. David,M.H,CraigMoritzandBarbaraK.M(1996)MolecularSystematics.SinauerAssociates,Inc.
3. David, M.S (2009) DNA bar-coding will frequently fail in complicated groups: an example in wild potatoes. American journal of Botany 96(6) : 1177-1189. Downloadable from [www.vcru.wisc.edu/spoonerlab/.../ Bar Codes %20 and % 20 wild % 20Potatoes.pdf](http://www.vcru.wisc.edu/spoonerlab/.../BarCodes%20and%20wild%20Potatoes.pdf)
4. Gould, S.J (1997) Ontogeny & Phylogeny, Belkrap Press. Harvard UniversityCambridge
5. Kipling, W.W; Brent, D.M and Quentin, D.W.(2005) The perils of DNA bar-coding and the need for Integrative Taxonomy. Syst. Biol. 54(5): 844-851, Downloadable from sysbio.oxfordjournals.org/cgi/reprint/54/5/844.pdf
6. McHenry, H.M (2009) Evolution. In Michael Ruse & Joseph Travis. Evolution: The first four Billion Years. Cambridge, Massachusetts: The Belknap Press of Harvard University Press.p265.
7. Motoo Kimura (1983) The neutral theory of molecular evolution. Cambridge UniversityPress.
8. Roderick D.M. Page and Edward. C.H. (2000) Molecular Evolution: A Phylogenetic Approach: BlackwellScience.
9. Strikberger, M.W. (2000) Evolution, Jones and Bartett Publishers, London.38
10. Brain,K.Hall and Benedikt, Hallgrinmson (2008). Strickberger"s Evolution, 4th ed. Jones and Barlett Publishers International,London.
11. Futuyama, D.J.(2005). Evolution. Sinauer Associates Inc. Sunderland,Massachusetts.

SECOND SEMESTER PRACTICALS

ZOL2L02 – PHYSIOLOGY

1. Kymograph: working principle and applications
2. Effect of different substrate concentration, pH and temperature on human salivary amylase activity. colorimetric method, plotgraphs.
3. Qualitative demonstration of digestive enzymes in cockroach – amylases, lipases, proteases, invertases and controls.
4. Digestion in a vertebrate and calculation of peptic value.
5. Influence of temperature and pH on the ciliary activity in fresh water mussel/mytilus using silver foil. Plot graph
6. Determination of respiratory quotient – estimation of O₂ consumption by an aquatic animal.
7. Determination of the rate of salt loss and gain in an aquatic animal (fish or crab).
8. Estimation of urea and ammonia in human urine. Titrimetric method.
9. Rate of glucose – absorption – calculation of Cori coefficient.
10. Estimation of haemoglobin of Fish/Man – Sahli's method.
11. Blood volume determination by dye dilution method (Vertebrate).
12. Blood: clotting time, bleeding time, rouleaux formation, preparation of haemincrystals.
13. Enumeration of RBCs in human blood.
14. Determination of lactic acid in muscle tissue.
15. Differential count of human WBCs
16. Haematocrit and ESR of human blood.
17. WBC total count

References:

1. Oser B. L. (1965). Hawk's Physiological chemistry, McGraw Hill Book Company
2. Hill R. W., Wyse G. A. (1989), Animal Physiology 2nd edition. Harper Collins Publishers
3. Schmidt-Nielsen, K. (1997), Animal Physiology, adaptation and environment, Cambridge University Press.
4. Dounersberger, Anne. B. Lesak, Anne, C and Timmons, Maichael, J. (1992). A laboratory Text Book Of Anatomy and Physiology. 5th ed. D. C. Heath & Co.

ZOL2L02- MOLECULAR BIOLOGY

1. Estimation of DNA by Diphenyl Aminemethod
2. Estimation of RNA by Orcinolmethod
3. Estimation of Protein by Lowry* method.
4. Isolation of genomicDNA.
5. Isolation of DNA fromLiver/Spleen/Thymus.
6. Study of principle and application of DNA fingerprinting.

References

1. Brown, T.A. (1998): Molecular biology Lab Fax. Vol. 1 and 2, Academicpress
2. Brown, T.A. (2007): Essential Molecular Biology – A practical approach Vol. 2, Oxford University Press
3. Wilson & Walker (2006): Principles and techniques of Biochemistry and Molecular biology, Cambridge UniversityPress.

ZOL2L03- SYSTEMATICS AND EVOLUTION

Systematics

1. Collection, Preservation and Curation ofspecimens
2. Identification of animals (Fishes/insects/any other) up to family/ genus / species level- minimum 15 specimens.
3. Preparation of dichotomous (simple bracket) keys to selected families with reference
4. to insect orders Orthoptera, Hemiptera, Coleoptera, Diptera and Hymenoptera (minimum five specimens from each order)

Evolution

1. Exercises in convergent evolution.
2. Exercises in divergent evolution.
3. Sympatric and Allopatric speciation.
4. Exercises in co-evolution.
5. Calculation of genotype / gene frequency based on Hardy –Weinberg equilibrium.

THIRD SEMESTER				
Course code	ZOL3C07			
Name of the course	IMMUNOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
07	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Know the definition, scope, brief history and common terms of immunology and hematopoiesis	9	U	C	PO1, PO2,	PSO1
CO2	Understand the different aspects of antigens, antigenicity and immunogenicity	8	U	F	PO1, PO2,	PSO1
CO3	Recognize the structure, functions and types of antibodies, the immunoglobulin gene and applications of the same in monoclonal hybridoma technology	10	U	F	PO1, PO2,	PSO1
CO4	Comprehend antigen- antibody interactions and different immunotechniques	10	U	C	PO1, PO2,	PSO1 PSO4
CO5	Enumerate the different steps and processes in the generation of B-cell and T-cell responses	9	U	F	PO1, PO2,	PSO1
CO6	Appreciate the structure and functioning of the cytokine and complement system	13	U	C	PO1, PO2,	PSO1
CO7	Discern the role of Major Histocompatibility Complex (MHC) in immunological processes	8	E	C	PO1, PO2,	PSO1
CO8	Understand the clinical applications of immunology such as hypersensitivities; transplantations, immunodeficiency diseases and vaccinations and use this knowledge for betterment of health	23	Ap	C	PO1, PO2,	PSO1

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

(90 Hours)

Module I: Introduction

(9 hrs)

- 1.1. Definition, Scope and Brief history of immunology; common terms associated with immunology; humoral immunity and cellular immunity; innate and acquired immunity; B- Lymphocytes, T- lymphocytes and Antigen presenting cells.

1.2. Hematopoiesis

Hematopoiesis – Lymphoid and myeloid lineages.

Hematopoietic growth factors.

Genes that regulate hematopoiesis.

Regulation of hematopoiesis.

Module II: Antigens

(8 hrs)

- 2.1. Immunogenicity, Antigenicity.
2.2. Factors that influence immunogenicity.
2.3. Adjuvants; Haptens; Epitopes.
2.4. Properties of B-cell and T- cell epitopes.

Module III: Immunoglobulins (Antibodies)

(10 hrs)

- 3.1. Structure and function of Antibody molecules.
3.2. Generation of Antibody diversity.
3.3. Immunoglobulin gene.
3.4. Antigenic determinants of immunoglobulin - (a) Isotype (b) Allotype (c) Idiotype.
3.5. B-cell receptor (BCR).
3.6. Monoclonal Antibodies.
3.7. Production of Monoclonal Antibodies (Hybridoma technology).
3.8. Clinical uses of Monoclonal Antibodies.
3.9. Antibody Engineering.

Module IV: Antigen Antibody interactions

(10 hrs)

- 4.1. Strength of antigen – antibody interactions. (a) Antibody affinity (b) Antibody avidity.
4.2. Cross-reactivity.
4.3. Precipitation reactions.

4.4. Immunotechnics – ELISA, RIA, Western Blot, Immunoelectrophoresis, Flow cytometry and fluorescence.

Module V: Generation of B-cell and T-cell responses. (9 hrs)

5.1. T- Cell receptor, TCR-CD3 complex.

5.2. Activation, maturation and differentiation of B-Cells.

5.3. Activation, maturation and differentiation of T-Cells.

Module VI: Cytokines and Complements system. (13 hrs)

6.1. Cytokines; Properties of cytokines; Structure and receptors; Cytokine antagonists
Cytokine secretion by TH1 and TH2-cells.; Cytokine related diseases. (a) Bacterial septic-shock (b) chaga's disease) (c) lymphoid and myeloid cancers ; Therapeutic uses of cytokines ; Toll- like receptors.

6.2. The Complement components: The functions of complement components.

Complement activation (a) Classical pathway (b) Alternate pathway (c) Lectin pathway

Regulation of complement system; Biological consequences of complement activation.

Complement deficiencies.

Module VII: Major Histocompatibility Complex (MHC) (8 hrs).

7.1. General organization and inheritance of MHC.

7.2. MHC molecules and genes.

7.3. Cellular distribution of MHC.

7.4. Antigen- processing and presentation- Exogenous and Endogenous pathways.

7.5. Presentation of non- peptide antigens.

Module VIII: Clinical Immunology (23 hrs)

8.1. Transplantation immunology

Auto graft, Allograft, Isograft and xenograft; Immunological basis of graft rejection.

Role of cell- mediated responses ; Transplantation antigens ; General immune suppressive therapy.

8.2. Hypersensitivity Reactions.

Allergens ; IgE- mediated (type- I) hypersensitivity ; Antibody- mediated cytotoxic (type- II) hypersensitivity ; Immune complex- mediated (type- III) hypersensitivity.

TDTH- mediated (type- IV) hypersensitivity

8.3. Vaccines.-Active and passive immunization; Whole organism vaccines ; Recombinant vector

vaccines; DNA vaccines ;Synthetic peptide vaccines.

Multivalent vaccines;

8.4. Immunity and malnutrition and immune deficiency diseases.

Immunity and malnutrition; Primary immune deficiency diseases. (a) Burton's disease (b) Di-George syndrome and SCID; Secondary immune deficiency –AIDS;
Transmission of HIV; Vaccines to prevent AIDS ;Autoimmunity (systemic and organ specific brief)

References

1. Abdul K Abbas and Andrew H. Lichtman (2003). Cellular and Molecular Immunity (fifth edition, Elsevier Science,USA).
2. Abdul K Abbas and Andrew H. Lichtman (2004). Basic immunology –Functions and Disorders of the immune system. (second edition, Elsevier Science,USA)
3. Chakraborty ,A.K.(2006).Immunology and Immunotechnology.Oxford University Press.
4. David Male, Jonathan Brastoff, David Roth and Ivan Roitt (2006). Immunology. Mosby, Edinburgh, UK.
5. Godkar, P.B (1998): A Text Book of Medical Laboratory Technology.Bhalani Bhalani Publishing House Mumbai.
6. Hannigan, B.M., Moore, C.B.T. and Quinn, D.G.(2010). Immunology. Viva Books,New Delhi.
7. Helen Chappel and Moused Harney (2006). Essentials of clinical Immunology. 5th ed. Blackwell Scientific Publications.
8. Ivan .M.Roitt(2002). Essentials of Immunology.ELBS, NewDelhi.
9. Janis Kuby (2000) .Immunology.7th ed. W.H. Freeman& Co. NewYork.
10. Joshi K. R and Osamo. N. O (1994) : Immunology. Agro Bios Publishers.Jodhpur.
11. Khan F,H,(2009). Elements of Immunology. Pearson Education ,NewDelhi.
12. Peter Parham (2004): The immune system (Second edition, Garlands, NewYork).
13. Richard, Coico and Geoffrey, Sunshine (2009).Immunology- A short course.Wiley Blackwell. C A, USA.
14. Shetty, N (1993) Immunology: Wiley Eastern Ltd, NewDelhi.

15. Thomas J. Kindt, Barbara, A., Osborne And Richard, A.Goldsby.(2007). Kuby Immunology.6th ed. W.H.Freeman,NewYork.

THIRD SEMESTER				
Course code	ZOL3C08			
Name of the course	DEVELOPMENTAL BIOLOGY & ENDOCRINOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
08	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Know the definition, scope and common terms of developmental biology.	16	U	C	PO1, PO2,	PSO1
CO2	Understand the different aspects embryogenesis and organogenesis	10	U	C	PO1, PO2,	PSO1 PSO4
CO3	Recognize the cellular, molecular and genetic basis of development	15	U	C	PO1, PO2,	PSO1
CO4	Understand the phenomenon of metamorphosis, regeneration and ageing	07	U	C	PO1, PO2,	PSO1
CO5	Appreciate the developmental mechanisms of evolution and environmental regulation of animal development	06	Ap	C	PO1, PO2,	PSO1 PSO4
CO6	Recognize the basic terms, structure, anatomy, physiological effect of endocrine glands and their hormones	20	U	C	PO1, PO2,	PSO1
CO7	Discern the general mechanisms of hormonal action	06	An	C	PO1, PO2,	PSO1
CO8	Understand the role of hormones in male and female reproductive physiology	10	U	C	PO1, PO2,	PSO1

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Part- A - DEVELOPMENTAL BIOLOGY (54 HOURS)**MODULE I: INTRODUCTION TO DEVELOPMENTAL BIOLOGY (16 hrs)**

- 1.1. Cell fate, potency, determination and differentiation, commitment
- 1.2. Specification - autonomous, conditional, syncytial, morphogenetic gradients
- 1.3. Genomic imprinting
- 1.4. The stem cell concept- (Progenitor cells, Adult stem cells, Mesenchymal stem cells, Multipotent adult stem cells, Pluripotent Embryonic stem cells, Stem cell therapy)
- 1.5. Gametogenesis- Spermatogenesis and Oogenesis,
- 1.6. Ultra structure of gametes including cell surface molecules in sperm-egg recognition in animals (sea urchin and mammal)
- 1.7. Zygote formation -Encounter of sperm and egg, Capacitation, Acrosome reaction, Activation of ovum, Amphimixis (mammal)
- 1.8. Prevention of Polyspermy (Fast block and Slow block)
- 1.9. Cleavage, blastulation, gastrulation and formation of germ layers (amphibian and mammal), Embryonic fields

MODULE II: Embryogenesis and Organogenesis (10 hrs)

- 2.1. Axis formation in amphibians - The phenomenon of the Organizer- Nieuwkoop center, primary embryonic induction, mechanism of axis formation
- 2.2. Anterior posterior patterning in Amphibians - Hox code hypothesis
- 2.3. Anterior posterior patterning in *Drosophila* – anterior forming genes (bicoid, hunchback), posterior forming genes (nanos, caudal), terminal forming gene (torso), segmentation genes- gap genes, pair rule genes, segmentation polarity genes, homeotic selector genes, realtor genes
- 2.4. Dorso- ventral patterning in *Drosophila*- dorsal protein gradient
- 2.5. Limb development in chick- Formation of the Limb Bud, Generating the Proximal- Distal Axis of the Limb, Specification of the Anterior-Posterior Limb Axis, Generation of the Dorsal-Ventral Axis
- 2.6. Insect wings and legs formation
- 2.7. Vulva formation in *Caenorhabditis legans*.
- 2.8. Eye lens induction.

MODULE III: Cellular, Molecular and Genetic basis of development (15 hrs)

- 3.1. Induction and competence- cascade of induction; reciprocal and sequential inductive events, instructive and permissive interactions.
- 3.2. Epithelial- Mesenchymal interactions- paracrine factors - The Hedgehog family, The Wnt family, Juxtacrine signaling and cell patterning, notch pathway.
- 3.3. Cellular interactions concerned in fertilization, blastulation, gastrulation and organogenesis.
- 3.4. Molecular basis of cellular differentiation – Cadherins.
- 3.5. Differential RNA processing- X chromosome inactivation- dosage compensation.
- 3.6. Models of cell differentiation- hematopoiesis, myogenesis, differentiation of neural crest cells.
- 3.7. Reversibility of patterns of gene activity-cell fusion, transdifferentiation.

MODULE IV: Metamorphosis, Regeneration and Ageing (7hrs)

- 4.1. Metamorphosis in Amphibians and Insects and their hormonal control
- 4.2. Types of regeneration - Super, Hetero, Epimorphic, Morphallactic and Compensatory regeneration, Histological process during regeneration
- 4.3. Ageing – The biology of senescence, cellular and extra cellular ageing, Genes and ageing, DNA repair enzymes, Ageing and the insulin signaling cascade, The mTOR pathway, Chromatin modification, Wear and tear, Oxidative damage, Mitochondrial genome damage, genetically programmed ageing.

MODULE V: Developmental Mechanisms of Evolution and environmental regulation of animal development (6 hrs)

- 5.1. Evolutionary mechanisms- Heterotopy, Heterochrony, Heterometry, Heterotypy. (Brief)
- 5.2. Environmental regulation of normal development - types of polyphenism
- 5.3. Environmental disruptions of normal development (Teratogenesis) Teratogenic agents
- 5.4. Alcohol, retinoic acid, Bisphenol A(BPA), heavy metals, pathogen, Testicular Dysgenesis Syndrome, DES as an endocrine disruptor, Endocrine disruptors as obesogens
- 5.5. Environmental oestrogens.
- 5.6. Impact of pesticide on development.

Part B- ENDOCRINOLOGY (36 HOURS)

MODULE VI: Introduction to endocrine glands and their Hormones (20hrs)

- 6.1. Hormone secreting organs and tissues -skin, liver, kidney, heart.

- 6.2. General classes of chemical messengers- Peptide, thyroid, steroid hormones, neurotransmitters and pheromones
- 6.3. Physical characteristics of hormones - latency, post-secretory modification and half-life
- 6.4. Synthesis and delivery of hormones- storage, secretion and transportation
- 6.5. Control of hormone secretion.
- 6.6. Physiological roles of hormones.
- 6.7. Neurohormones- Brain hormones and behavior; Gases as neural messengers (NO and CO)
Neuroendocrine pathophysiology
- 6.8. Structure and anatomy of endocrine glands; physiological functions, regulation of hormones and pathophysiology of - (Hypothalamus, Hypophysis, Thyroid, Parathyroid, Adrenal, Pancreas)

MODULE VII: General mechanisms of Hormonal action (6hrs)

- 7.1. Hormone Receptors and transducers;
- 7.2. Regulation of receptor number, receptor activation
- 7.3. Second messengers of hormone action- cAMP, cGMP, inositol triphosphate, diacylglycerol,
- 7.4. Receptor signal transduction
- 7.5. Eicosanoids and hormone action
- 7.6. Endorphins- physiological roles, mechanism of action and pathophysiology

MODULE VIII: Hormones and reproductive physiology of male and female (10 hrs)

- 8.1. Synthesis, chemistry and metabolism of androgens and ovarian steroid hormones
- 8.2. Physiological roles of androgens, estrogens and ovarian steroid hormones
- 8.3. Endocrine control of testicular function
- 8.4. Hormonal regulation of female monthly rhythm
- 8.5. Hormonal factors in pregnancy, parturition and lactation
- 8.6. Pathophysiology of male and females sex hormones

References

Developmental biology

1. Balinsky, B. I.(1981). An introduction to Embryology. Holt Saunders, Philadelphia
2. Berril, N. J. and Karp. G.(1978). Developmental biology. Tata McGraw Hill., New Delhi.

3. Deuchar, E. M. Cellular interactions in animal development.
4. Gilbert, S. F.(2003). Developmental Biology. 7th ed. Sinauer Associates Inc.Massachusetts.
5. Hodge, R. Developmental Biology: From a Cell to an Organism.
6. Hopper,A.S.&N.H.Hart.Foundationofanimaldevelopment.
7. Lash, J & J. R. Whittaker. Concepts of development.
8. Muller, W. A. Developmental biology.Springer.
9. Snustad, D. P., J. M. Simmons & J. B. Jenkins. Principles of Genetics.
10. Wolpert, L. Beddington,R.,Jessel,T., Lawrence, P.,Meyerowitz,E.and
11. Smith, J.(2002). Principles of Development. Oxford university press, 2ndedition.
12. Slack, J, (2001). Essential Developmental Biology. Blackwell Publishing,UK.
13. Twyman,R.M.(2001). Instant notes in Developmental Biology. Bios Scientific Publishers Ltd. Oxford.
14. Vasudeva Rao, K.(1994). Developmental Biology-a modern synthesis. Oxford IBH,New Delhi.

Endocrinology

1. 6.Harris, G. W. (1995). Neural control of the pituitary gland, Edward Arnold,London.
2. Bentley, P. J. (1998). Comparative vertebrate endocrinology.3rd ed.Cambridge UniversityPress
3. Bern, H. A. Text book of comparative endocrinology
4. Bolander, F. F.(2006). Molecular endocrinology, Academic press, NewDelhi.
5. Brook, C.G. and Marshall, N.J.(1996).Essential Endocrinology.3rded.Blackwell Science ,London.
6. Brown, J. H. and Wet, G.B. (2000).Scaling in Biology. Oxford University Press, NewYork.
7. Ganong, W. F. (2005). Review of medical physiology, Mc Graw Hill, NewDelhi.
8. Guyton, A.C. and Hall, J. E. (2001). Text Book of Medical Physiology.10thed. Prism Books, Pvt. Ltd. Harcourt Asia Ltd.Indiaed.
9. Hadley, M. E. (2000). Endocrinology, Pearson education, Inc., NewDelhi.
10. Hadley, M.G. (2000). Endocrinology .3rd ed. Prentice Hall International Inc. NewJersey
11. Hazelwood, R. (1990). The endocrine pancreas, EnglewoodCliffs, Prentice Hall,NJ.
12. Horrbin, D. F. Essentials of Biochemistry, endocrinology and nutrition.
13. Nelson R. J. Introduction to behavioral endocrinology

14. Norris D. O. (2005). Vertebrate endocrinology.
15. Prakash Lohr. Hormones and human health
16. Turner, K. and Bagnara, G. (1976). General Endocrinology. W.B. Saunders Company, Philadelphia.
17. Vinzen, G. et al, (1992). Adrenal cortical steroid hormones, Englewood Cliffs, Prentice Hall, NJ.
18. Williams, R. H. (1988). Text Book of Endocrinology. W. B. Saunders Company, Philadelphia.

THIRD SEMESTER				
Course code	ZOL3E09			
Name of the course	MORPHOLOGY AND TAXONOMY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
09	ELECTIVE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the origin and Evolution of insects	5	U	F	PO1, PO2,	PSO3
CO2	Understand the insect classification, Apterygote orders	31	U	F	PO1, PO2,	PSO3, PSO5
CO3	Understand the Exopterygote orders	12	U	F	PO1, PO2,	PSO3
CO4	Understand the Endopterygote orders	15	U	F	PO1, PO2,	PSO3
CO5	Analyze the External Morphology of Insects	36	Ap	F	PO1, PO2,	PSO3, PSO5
CO6	Understand the ecology and behavior of Aquatic insects	7	U	C	PO1, PO2,	PSO3, PSO5
CO7	Understand the ecology of Gall forming and Leaf mining insects	7	U	F	PO1, PO2,	PSO3, PSO5
CO8	Understand the co evolution and Social organization in insects	4	U	C	PO1, PO2,	PSO3, PSO5

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Module 1: Origin and Evolution of Insects**(5 hrs)**

1.1 Origin and evolution of insects: Ancestry of insects based on fossil studies. Phylogeny of insects: Atelocerata hypothesis, Pancrustacea theory. Mention phylogenomics studies.

1.2 Fossil insects. Mention extinct orders: Archodonata, Blattoptera, Coxoptera, Diaphanopteroidea, Glosselytroidea, Meganisoptera, Megaseoptera, Miomoptera, Monura, Palaeodictyoptera, Protelytroptera, Protodiptera, Protorthoptera and Titanoptera.

Module 2: Insect classification**(31 hrs)**

2.1 Mention Apterygota, Exopterygota, Endopterygota, Hemimetaboly and Holometaboly.

(1hr)

Apterygota: Diagnostic characteristics, biology and economic importance of the following Orders: Collembola, Protura, Diplura, Archeognata (Microcoryphia) and Thysanura.

Locomotion in Collembola.

(3 hrs)

Module 3: Exopterygota: Diagnostic characteristics, biology and economic importance of the following Orders and families mentioned under each order. Special topics mentioned under each order. **(12 hrs)**

3.1. Ephemeroptera.

3.2. Odonata- mention dragon flies and damselflies, mouthparts of naiads, mating behavior.

3.3. Isoptera- Castes, Termitarium, economic importance.

3.4. Phasmida.

3.5. Blattaria- Mention economic importance and important species.

3.6. Mantodea & Mantophasmatodea.

3.7. Orthoptera- Families: Acrididae, Tettigoniidae, Gryllidae, Gryllotalpidae.

Stridulatory organs in Orthoptera; Locusts.

3.8. Thysanoptera.

3.9. Hemiptera; Families- Cicadidae, Jassidae, Cercopidae, Membracidae, Aphididae, Nepidae, Gerridae, Pentatomidae, Reduviidae. Medical importance of Reduviidae;

Polymorphism in Aphids; Stridulation in Cicada.

3.10. Psocoptera.

3.11. Phthiraptera- Mention *Pediculus humanus* and its parasitic adaptations.

3.12. Dermaptera- Sexual dimorphism and parental care.

3.13. Plecoptera.

3.14. Embioptera.

3.15. Zoraptera.

Module 4: Endopterygota: Diagnostic characteristics, biology and economic importance of the following Orders and families mentioned under each order. Special topics mentioned under each order **(15 hrs)**

4.1. Coleoptera- Families: Curculionidae, Scarabaeidae, Carabidae, Cerambycidae, Lampyridae, Chrysomelidae, Elateridae, Meloidae. Mention cantharidin and bioluminescence.

4.2. Lepidoptera. Butterflies and Moths. Families: Noctuidae, Sphingidae, Saturniidae, Pyralidae, Papilionidae, Nymphalidae, Hesperidae, Pieridae, Lycaenidae, Geometridae. Migration in butterflies; Butterfly farming; Silkworms.

4.3. Hymenoptera: Families: Vespidae, Sphecidae, Megachilidae, Apidae, Eumenidae, Xylocopidae, Formicidae, Evaniidae, Braconidae, Ichneumonidae, Chalcididae, Eulophidae, Eurytomidae and Pteromalidae. Parasitic hymenoptera and biological control; Honeybees and honey production; Honeybee venom; Swarm intelligence and its application.

4.4. Diptera: Suborders: Nematocera and Brachycera. Families: Muscidae, Culicidae, Calliphoridae, Sarcophagidae, Simuliidae, Tipulidae, Glossinidae, Drosophilidae, Psychodidae. Disease vectors; Dipterans and forensic entomology; Dipterans and bio-surgery; *Drosophila* as experimental model.

4.5. Siphonoptera: Mention plague.

4.6. Strepsiptera. Mention stylopization.

4.7. Neuroptera. Mention Antlions.

4.8. Mecoptera.

4.9. Megaloptera.

4.10. Raphidioptera.

4.11. Trichoptera.

Part B

Module :5 External morphology **(36 hrs)**

5.1. Segmentation and division of the body

5.1.1. General morphology of the Head

5.1.1.1. Opisthognathous, hypognathous and prognathous–

5.1.1.2. Head segmentation- theories about the segmentation of the head

5.1.1.3. Head skeleton- different sutures and sclerites–

5.1.1.4. Tentorium–Modification in head capsules–

- 5.1.1.5.Cephalic appendages– Antenna: structure, function & types
- 5.1.1.6.Gnathal appendages: types, structure &function
- 5.1.1.7.Mouth parts of insects,Cervix
- 5.2.General Morphology of the Thorax
 - 5.2.1.Thoracic segmentation Thoracic skeleton &Endothorax
 - 5.2.2.Thoracic appendages:Modifications of thoracic legs
 - 5.2.3.Wings: origin and evolution of wings, structure, venation, wing coupling apparatus, morphological variations
- 5.3.General Morphology of the Abdomen:
 - 5.3.1.Segmentation,Skeletal composition,
 - 5.3.2.Pre-genital and post genital segments,
 - 5.3.3.Abdominal appendages
 - 5.3.4.External genitalia: male and female

Part C.Ecology and Behaviour of insects

(18 hrs)

Module 6:Aquatic insects.

6.1.Aquatic insects

- 6.1.1.Factors influencing the aquatic life
- 6.1.2.Food capture;modifications
- 6.1.3.Respiration in semi-aquatic and in truly aquatic insects
- 6.1.4.Oviposition methods
- 6.1.5.Anchorage,locomotion
- 6.1.6.Adaptations of swimming forms

Module :7 Gall forming and Leaf mining insects:

- 7.1.Definition and features,Formation, economic importance
 - 7.1.1.Common gall pests
 - 7.1.2.Extent of gall making habits
 - 7.1.3.Gall as dwelling place, the position of gall
 - 7.1.4.Classification of galls by Orders
 - 7.1.5.Adaptation for the gall making habits
 - 7.1.6.Origin and types of galls (open &closed)
 - 7.1.7.Physiology of gall formation
- 7.2.Leaf mining insects

- 7.2.1. Definition and identification
- 7.2.2. Forms of leaf mines, economic importance
- 7.2.3. Extent of the leaf mining habits
- 7.2.4. Feeding habits and frass disposal
- 7.2.5. Ecological aspects of leaf mining

Module 8 Co- evolution and Social insects

- 8.1. Insect-plant interdependence (co-evolution)
- 8.2. Social insects – social organisation
- 8.3. Caste differentiation
- 8.4. Aspects of social behaviour with reference to honey bee, termite and ant
- 8.5. Communication – acoustic, visual, tactile and chemical method (pheromones)
- 8.6. Adaptations of parasitic and predatory insects

References

1. Ananthakrishnan, T.N. (1992): Dimensions of Insect-Plant Interactions, Oxford & IBH Publishing Co. Pvt. LTD.
2. Aswathy, V.B. (1998) Introduction to General and Applied Entomology. ISBN.
3. Borror, D.J. and DeLong, D.M. (1964). An Introduction to the study of Insects. Holt Rinehart and Winston, New York.
4. Carde, R.T. and Bell, W.J. (1995): Chemical Ecology of Insects-2. Chapman and Hall, New York
5. Essig, E. O. (1974): College Entomology. Mac Millon Co. London

6. Richard, W. and Davies, R.G.G. (1977). *Imm's general text book of Entomology*, 10th edition, Chapman & Hall.
7. Mani, M.S. (1974): *Modern classification of Insects*. Satish Book Enterprise., Agra.
8. Mani, M.S. (1982): *A general text book of entomology*, Oxford & IBH, New Delhi.
9. Nayar, K.K., Ananthakrishnan, T.N., & David, B.V. (1976). *General and Applied Entomology*, Tata Mac Grew Hill. New Delhi.
10. Ross, H.H. *et al.*, *A general text book of entomology*, John Wiley Sons NY. Scientific Publishers, Jodhpur.
11. Snodgrass, R, E. (1935): *Principles of Insect Morphology*. MacGrawHill Book.
12. Tembhare, D.B., *Modern Entomology*, Himalaya publishing House
13. Wilson, E.O. (1972): *The Insect societies*. Belknap, Harvard University Press.
14. Wheeler, W. C., M. Whiting, Q. D. Wheeler, and J. M. Carpenter. (2001). The phylogeny of the extant hexapod orders. *Cladistics* 17:113-169.
15. Gillot, C. (2005). *Entomology*. 3rd ed. Springer.
16. Romoser, W.S. and Stoffolano, J.G. (1994). *The Science of Entomology*. 3rd ed. WCB Publishers, Oxford, England.
17. Wigglesworth, V.B. (1964). *The life of Insects*. Heindenfield and Necolson, London.

Web sources:

18. https://en.wikipedia.org/wiki/Category:Extinct_insect_orders (Extinct insect orders)
- <http://science.sciencemag.org/content/346/6210/763> (Phylogenomics studies)

THIRD SEMESTER PRACTICALS

ZOL4L04 – IMMUNOLOGY

1. Study of cells of immunesystem.
2. Histology of organs of immunesystem.
3. Bleeding of animals and preparation of serum.
4. Separation of lymphocytes.
5. Demonstration of agglutination reaction.
6. Immunoelectrophoresis.
7. Demonstration of ELISA technique.
8. Production of antibodies.
9. Preparation of antiserum.
10. Titration of antiserum.

References

1. Talwar, G.P. and Gupta, S.K.(2002). A hand book of practical and clinical immunobiology. 2nd ed. CBS Publishers,India.
2. Wilson.K. and Walker,J. (1995). Practical Biochemistry- Principles and Techniques. Cambridge University Press.

THIRD SEMESTER PRACTICALS

ZOL4L04- Developmental Biology & Endocrinology

1. Induced ovulation in fish.
2. Identification of different developmental stages of frog - Egg, blastula, gastrula, neurula, tadpole external gill and internal gill stage.
3. Vital staining of chick embryo.
4. Preparation of temporary/permanent whole mounts of chick embryo of the following stages to study the extent of development of the circulatory and nervous system in detail in 20, 24, 33, 48 & 72 hours of incubation.
5. Tracing the development of stained parts. Candling, identification of blastoderm, window preparation - staining using stained agar strips and following the development.
6. Preparation of stained temporary/permanent mounts of larvae.

7. Experimental analysis of insect development -*Drosophila*.
8. Regeneration studies in frog tadpole tail.
9. Demonstration of sperm of rat/calotes/frog.
10. Morphological and histological studies of different types of placenta in mammals.
11. Hormones in Amphibian metamorphosis - Thyroxine/Iodine solution.
12. Culture of early chick embryo invitro.
13. Study of invertebrate/vertebrate larval forms (minimum 7).
14. Observation of the mid-sagittal sections and cross sections of the chick embryo through head/ heart region of 24, 48 & 56 hours of incubation.

References

1. Adamstone, E. B. and Waldo Shumway (1954). 3 Ed. A Laboratory Manual of Vertebrate Embryology. John Wiley & Sons, Inc.
2. Roberts Rugh (1961). Laboratory Manual of Vertebrate Embryology. Indian Ed., Allied Pacific Pvt. Ltd.
3. Browden, L. W., Erikson, C. A., and Jeffery, R. W. (1991). Developmental Biology. Ed., Saunders College Publi., Philadelphia.
4. Zarrow, M. X., Yochim, J. M., Mc Carthy, T. L. and Sanborn, R. C. (1964).
5. Experimental Endocrinology: A source book of basic Techniques. Academic Press, New York.
6. Thomas, J. A. (1996). Endocrine methods. Academic press, New York.
7. Humason, G. L. (1962). Animal Tissue techniques. W. H. Freeman & Co.

THIRD SEMESTER PRACTICALS ELECTIVE
COURSE- ENTOMOLOGY –I ZOL4L05 -
MORPHOLOGY & TAXONOMY

1. Study of the sclerites of head and thorax of different Orders of insects: Grasshopper, Cockroach, Housefly, Honeybee.
2. Study of the different types of antennae- prepare permanent slides of at least 5 types of antennae (To be submitted during practical examination).
3. Adaptive radiation of pterygote mouth parts (Adult & Larval)
4. Adaptive radiation of pterygote legs- prepare permanent slides of at least 5 types of legs.
5. Wings: their shape variation in the venation of pterygote wings.

6. Study of different types of genitalia.
7. Mounting of stinging apparatus – Honeybee
8. Morphological studies of different castes of social insects- Honeybee, Ants and Termites
9. Studies of (a) Honey bee and hives (b) Termitarium and termites.
10. Dissection of alimentary canal and associated glands- Oryctes grub, Iphita and Cricket
11. Dissection of reproductive system in insects- Iphita, Cockroach and grasshopper.
12. Dissection of nervous system- Oryctes grub, Iphita and Cricket.
13. Dissection of stomatogastric nervous system (oesophageal, sympathetic, single recurrent nerve and paired recurrent nerves in Cockroach.
14. Preparation of dichotomous keys of the following orders up to families. Each order should contain a minimum of 5 species: Orthoptera, Hemiptera, Hymenoptera, Lepidoptera and Coleoptera.

References

1. Borror, D.J. and DeLong, D. H. (1964). An Introduction to the study of Insects. Holt Rinehart and Winston, New York.
2. Pedigo, L.P. (1996). Entomology and Pest Management Practice. Hall India Pvt. Ltd, New Delhi.
3. Mani. M.S. (1962). General Entomology. Oxford and IBH, New Delhi.
4. Nair, K.K., Ananthkrishnan, T.N. and David, B.V. (1976). General and applied Entomology. Tata Mc Graw Hill, New Delhi.

FOURTH SEMESTER				
Course code	ZOL4C10			
Name of the course	BIOTECHNOLOGY& MICROBIOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
10	CORE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand modern biotechnology tools and applications	24	U	F	PO1, PO2,	PSO1, PSO4
CO2	Understand applications of biotechnology in health care	16	U	F	PO1, PO2,	PSO1
CO3	Comprehend biotechnological applications in agriculture and environment.	8	U	C	PO1, PO2,	PSO1
CO4	Enumerate the principles and applications of Nanobiotechnology, IPR, Biosafety and Bioethics	6	U	C	PO1, PO2,	PSO1
CO5	Appreciate the general characters and classification of microbes	12	Ap	F	PO1, PO2,	PSO1
CO6	Understand microbial nutrition and growth	12	U	C	PO1, PO2,	PSO1
CO7	Know microbial diseases	4	R	F	PO1, PO2,	PSO1
CO8	Understand the tools, techniques and applications in microbiology	10	Ap	P	PO1, PO2,	PSO1, PSO4

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

M - Metacognitive

Part - A. BIOTECHNOLOGY (54 HOURS)**Module-I : Biotechnology-Tools and techniques****(24 hrs)****1. Introduction to Recombinant DNA technology- (8 hrs)**

1.1. Restriction enzymes-Endonucleases and Ligases

1.2. Vectors

1.2.1. Cloning vectors–Plasmids: pBR322 and pUC19, Ti and Ri plasmids, Phages: λ gt10 and M13 vector, Cosmids: general features, Phagemids: general features, Viruses: SV40 and CaMV Transposones; Ac transposon and Ds transposon of Maize, P-element of *Drosophila*

1.2.2. Artificial chromosomes: BAC, YAC and MAC.

1.2.3. Shuttle vectors: applications and example

1.2.4. Expression vectors: mention commonly used promoters in expression vectors (Nopaline synthase (*nos*) promoter from T-DNA, 35 S RNA promoter of CaMV, Polyhedrin promoter from Baculovirus.

1.2. Steps involved in cloning(8hrs)

1.2.1. Construction of chimeric DNA (Blunt end ligation, cohesive end ligation, homopolymer tailing, use of linkers)

1.2.2. Selection of transformed cells –blue white selection method, colony hybridization, Plaque hybridization

1.2.3. Amplification – Multiplication, Expression, and integration of the DNA insert in host genome

1.2.4. Methods of gene transfer. Chemical transfection methods- Calcium phosphate precipitation, PEG, Dextran mediated transfer; Physical methods -Electroporation, DNA micro injection, shot gun method, lipofection method; Biological methods- virus mediated engineered embryonic stem cell method; Selection and screening of recombinants, Insertional activation-blue white screening; Gene Cloning -Generation of cDNA and genomic library, Chromosome walking, Chromosome jumping, DNA foot printing.

1.3. Basic techniques in Biotechnology (8hrs)

1.3.1. Polymerase Chain Reaction-Basic PCR – raw materials and steps involved; Inverse PCR, Anchored PCR, Asymmetric PCR, PCR for mutagenesis and Real Time PCR

1.3.2. Applications of PCR in Biotechnology and genetic engineering.

1.3.3. DNA sequencing – Maxam and Gilbert's chemical degradation method, Sanger's

dideoxynucleotide synthetic method. Automated DNA sequencers.

1.3.4. Protein sequencing methods

1.3.5. Blotting techniques- Southern blot, Northern blot, Western blot, Dot blot and Slot blot.

1.3.6. Production, Labelling and applications of Molecular probes.

1.4. FISH, McFISH and GISH

Module II. Animal biotechnology and health care

(16 hrs)

2.1. Animal cell and tissue culture

2.1.1. Culture methods – Culture media- natural and artificial; primary explanation techniques, various methods of cell and tissue culture, Cryopreservation and maintenance of cell line.

2.1.2. Cell and tissue engineering, Organoculture

2.13. Biotechnology for human and animal welfare.

2.2. Gene products in medicine- Humulin, Erythropoietin, Growth hormone, Interferon, DNA Vaccines.

2.3. Disease diagnosis

2.4. Gene therapy

2.5. Transplantation of bone marrow, artificial skin,

2.6. DNA fingerprinting.

2.7. Forensic medicine

2.8. In vitro fertilization and embryo transfer in human.

2.9. Biosensors and Biochip.

2.10. Gene Silencing techniques, Antisense RNA, RNAi, Gene knockouts.

2.11. Transgenic animals for human welfare- production and applications.

2.11.1. Cloning procedures (adult DNA cloning, Therapeutic cloning, Embryo cloning)–

2.11.2. Advantages and disadvantages of cloning

Module III. Biotechnology in industry, Agriculture and Environment

(8 hrs)

3.1. Fermentation technology – Stages of fermentation- Fermentation products (antibiotics, alcohol, vitamins and fuels). Enzyme engineering and application

3.2. Pollution control – cleaner technologies, toxic site reclamation, removal of oil spill by bacteria, reducing of pesticides and fertilizers, biosensors, bio-monitoring.

3.3. Restoration of degraded lands - reforestation using micro propagation, development of stress tolerant plants, Bioremediation.

3.4. Agricultural Biotechnology (3hrs)

- 3.4.1. Biofertilizers (Nif genes, Rhizobium, Azotobacter, Azospirillum, Mycorrhizae-VAM)
- 3.4.2. Insect pest control (Pheromones, hormone mimics & analogues)
- 3.4.3. Biopesticides (Baculovirus, Bacillus thuringiensis, NPV)
- 3.4.4. Terminator Gene technology.
- 3.4.5. Major Biotechnological firms in India and their contributions.

Module IV. Nanobiotechnology, IPR, Biosafety and Bioethics (6 hrs)

- 4.1. Nanobiotechnological devices, nanobiosensors, Drug delivery technology, Personalized nanomedicine.
- 4.2. Intellectual property rights, Types of patents, trademarks, copy rights, trade secrets
 - 4.2.1. Intellectual property protection in India.
 - 4.2.2. Introduction to the history of GATT, WTO, WIPO and TRIPS,
 - 4.2.3. Indian patent Act 1970; recent amendments, Protection of new GMOs. patenting of biological materials, Current issues (Rice, Neem, Curcumin)
- 4.3. Biosafety concepts and issues.
 - 4.3.1. Biosafety protocol 2000.
- 4.4. The ethical and social implications - (3hrs)
 - 4.4.1. Principles of bioethics, Human rights, Ethics of Genetic engineering, Social impacts.
 - 4.4.2. Release of GEOs-Use of herbicide resistant plants-Human genome alterations by biotechnology
 - 4.4.3. Social acceptance of medical and Industrial biotechnology, Transgenic crops, Acceptance of GM foods. Human safety.

Part-B-MICROBIOLOGY (36 Hours)

Module: V General characters and classification of microbes (12 hrs)

- 5.1. General characters of Microbes: bacteria, Virus, Fungi (2hrs)
 - 5.1.1. Contributions of Louis Pasteur, Robert Koch, Alexander Flemming and Edward Jenner.
 - 5.1.2. General structural properties
 - 5.1.3. Types of virus: DNA viruses, RNA viruses, and enveloped viruses.
- 5.2. Microbial Taxonomy and Phylogeny (5hrs)
 - 5.2.1. Major characteristics (classic and molecular), Numerical taxonomy, Taxonomic ranks, Phylogenetic studies, Phenetic classification
 - 5.2.2. Bergey's Manual (mention major groups)
 - 5.2.3. Bacterial cell structure and function (5hrs)

- 5.3.1. Plasma membrane and internal system - Cytometrix, inclusions, ribosomes, nucleoid
- 5.3.2. Bacterial cell wall Peptidoglycan -structure-Components external to cell wall; pili and fimbriae, capsule and slime layers,
- 5.3.3. Gram positive and gram negative cell wall- Mechanism of gram staining
- 5.3.4. Flagella and motility

Module VI: Microbial nutrition and Growth (12 hrs)

- 6.1. Nutritional requirements, (3hrs)
 - 6.1.1 Nutritional types (Auto, Hetero, Chemo, Phototrophs & Obligate parasites)
 - 6.1.2. Culture media and types of media.
 - 6.1.3 Mixed microbial population and pure cultures.
- 6.2. Microbial growth (5hrs)
 - 6.2.1 Growth curve –synchronous growth
 - 6.2.2 Continuous culture
 - 6.2.3 Influence of environmental factors on growth
 - 6.2.4 Measurement of growth, Measurement of cell numbers- Petroff, Hassner counting Chamber, Spread plate and pour plate techniques
 - 6.2.5 Measurement of cell mass-Turbidity and microbial mass measurement
- 6.3. Utilization of energy(4hrs)
 - 6.3.1 Biosynthetic process-peptidoglycan synthesis, amino acid synthesis,
 - 6.3.2. Non synthetic processes -Bacterial motility and transport of nutrients. (biochemical reactions not required).

Module VII: Microbial diseases (4 hrs)

- 7.1. Human diseases caused by bacteria- Typhoid, Cholera, Tetanus, Leprosy, Tuberculosis and Pneumonia.
- 7.2. Human diseases caused by viruses- AIDS, Rabies, Measles, Swine Flu, Bird flu, SARS
- 7.3. Fungal diseases-Candidiasis

Module VIII :Tools techniques and applications in Microbiology. (10 hrs)

- 8.1. Preparation of culture medium.
 - 8.1.1. Methods of isolation
 - 8.1.2. Pure culture techniques
 - 8.1.3. Microbial strain identification

8. 2. Control of microorganisms, physical, chemical and anti-microbial agents

8.2.1. Disinfectants

8.2.2. Physical- Heat, filtration and radiation.

8.2.3.- Chemical agents - Phenol and Phenolic compounds, alcohols, halogens and aldehydes.

8.2.4.. Antibiotics- Penicillin, Cephalosporins, Chloramphenicol, Tetracyclines

8.2.5. Microbial drug resistance.

8.3. Microbial fermentation (2hrs)

8.3.1 Lactic acid fermentation - Homolactic and heterolactic fermenters, Mention dairy products -cheese and yogurt

8.3.2 Alcoholic fermentation.

8.4. Microbial Bioremediation

8.4.1. Microbiological analysis of drinking water.

8.4.2 Biogas plant.

References

Part- A- Biotechnology

1. Alphey - DNA sequencing-Bios Scientific publishers-
2. Bernard R. Glick and Jack J. Pasternak-Molecular Biotechnology-Principles and applications of recombinant DNA- ASM press WashingtonD.C.
3. Charles Hardin (2008): Cloning, Gene expression, and Protein purification- Experimental procedures and process rationale - Oxford University Press.
4. Chatterji, A.K.(2007). Introduction to environmental biotechnology-Prentice Hall of India
5. Colin Ratledge and Bjorn Kristiasen-Basic Biotechnology - Cambridge University press.
6. Dale. J.W. and Malcom von Scantz. From genes to genome- Concepts and Applications of DNA Technology
7. Dominic, W.C. Wong-The ABCs of gene cloning-Springer international edition
8. Dubey, R.C. -A text book of biotechnology-S. Chand & Co.
9. Emmanuel. C., Rev. Fr. Ignacimuthu. S. and Vincent. S. Applied Genetics: Recent Trends and Techniques, MJP Publishers, Chennai
10. Gupta. P.K. -Elements of biotechnology-Rastogi publications.
11. Singh, B.D.(2002).Biotechnology-Kalyani publishers.
12. Sobti, R.C. and Suparna, S. Pachauri-Essentials of Biotechnology-Ane Books Pvt.Ltd.
13. Wilson and Walker (2008): Principles and techniques of Biochemistry and Molecular biology-

Cambridge low price editions.

14. Ausubel, F.M., Brent, R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith, J.A. and Struhl, K. (2002). Short Protocols in Molecular Biology. John Wiley and Sons, Inc.
15. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. And Watson, J.D. (2000). Molecular Biology of the cell. Garland Science, New York.
16. Brown .T.A. (2002). Genomes II ed. John Wiley and Sons, New York.
17. Freshney, Ian R. (2006). Culture of Animal Cell. 5th ed. Wiley-Liss Publications.
18. Glick, B.R. and Pasternak, J.J. (1998). Molecular Biotechnology-Principles and Applications of Recombinant DNA.

Part B- Microbiology

1. Gandhi-Microbiology and Immunology notes and cases-Blackwell publishing
2. Hans G. Schlegel (2008): General Microbiology-Cambridge low price editions.
3. Chakraborty, P.A. (2009). Text Book of Microbiology. New Central Book Agency. New Delhi.
4. Arora, D.R. and Arora, B. (2008). Text Book of Microbiology. CBS Publishers & distributors. New Delhi.
5. Mansi. Fermentation, Microbiology and Biotechnology-Taylor and Francis
6. Pelczar, M.J, Chan, E.C.S. and Krieg, N.R. (1998)-Microbiology-TM H edition
7. Prescott, L.M., Harley, J. P. and Klein. D.A. (2008). Microbiology. 7th ed. McGraw- Hill Inc. New York.
8. Rao, A.S. - Introduction to microbiology-Prentice Hall of India.
9. Ingraham, J.L. and Ingraham, C.A. (2000). Microbiology. 2nd ed. Brooks/Cole-Thomson Learning, MA, USA.
10. Harvey, R.A. and Champe, P.A. (2001). Microbiology. Lippincott, Williams and Wilkins.
11. Harma, R. and Kanika, J. (2009). Manual of Microbiology. Tools and Techniques. Ane Books Pvt. Ltd, New Delhi.
12. Madigan, M.T., Martinko, J.M. and Parker, J. (2000). Biology of Micro organisms. Prentice Hall International Inc.
13. Talase, Park, Kathalee, N. and Talaro, Arthur. (2002). Foundations of Microbiology. McGraw Hill Higher Education, New York.
14. Wheelis, Mark (2010). Principles of Modern Microbiology. Jones and Barlett Publishers, New York

FOURTH SEMESTER				
Course code	ZOL4E11			
Name of the course	ENTOMOLOGY – II - ANATOMY AND PHYSIOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
11	ELECTIVE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Recognize histology, hormonal control and function of integument in insects	6	U	F	PO1,	PSO3
CO2	Understand the structure, anatomy and functioning of the digestive system in insects; nutritional requirements and unique features of digestion in insects	13	U	F	PO1,	PSO3 PSO4
CO3	Understand the structure, types and functioning of the ventilatory and circulatory systems in insects	14	U	F,C	PO1,	PSO3 PSO4
CO4	Enumerate the different types of excretory system, the types and physiology of excretion and dietary problems in insects	6	U	C	PO1,	PSO3
CO5	Appreciate the anatomy, physiology and functioning of brain and sense organs in insects	14	Ap	F	PO1,	PSO3
CO6	Understand the structure and components of muscular system and different adaptations for locomotion (aquatic and terrestrial- wing and leg)	14	U	F,C	PO1,	PSO3
CO7	Understand the histomorphology, role of endocrine and exocrine glands and mechanism of hormone action	8	U	F	PO1,	PSO3

CO8	Understand the different aspects of reproductive system, embryogenesis and morphogenesis	15	U	P	PO1	PSO2
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Abbreviations used:**CL - Cognitive level***R: Remember, U: Understand**Ap :Apply , An: Analyze**E:Evaluate, C : Create***KC- Knowledge category***C - Conceptual**F - Factual**P - Procedural**M - Metacognitive***MODULE I: The Integument****(6 hrs)**

- 1.1. Histology-basic components, chemical and physical properties of integument
- 1.2. Moulting and sclerotisation
- 1.3. Hormonal control and function of integument

MODULE II: Nutrition, Digestion and Assimilation**(13 hrs)**

- 2.1. Nutritional requirement- water, minerals, vitamins, carbohydrates, proteins, fatty acids, sterols, nucleic acids, inorganic salts and micro-organisms. Nutrition for growth, development and reproduction
- 2.2. Anatomy and histology of gut
- 2.3. Digestive enzymes – carbohydrases, proteases, lipases
- 2.4. Role of microbiota in digestion
- 2.5. Physiology of digestion
- 2.6. Digestion of wood, keratin, wax and silk
- 2.7. Extra intestinal digestion.

MODULE III: Ventilatory and Circulatory systems**(14 hrs)**

- 3.1. Structure of trachea, tracheole, air-sacs, spiracles
- 3.2. Types of ventilatory process - passive, active and bulk flow
- 3.3. Respiratory pigments in insects
- 3.4. Cyclic release of carbon dioxide and nervous control of ventilation
- 3.5. Ventilation in aquatic insects, endoparasitic insects and during moulting
- 3.6. Cellular elements and composition of haemolymph
- 3.7. Dorsal vessels, accessory pumping sinuses and diaphragm
- 3.8. Course of circulation of haemolymph
- 3.9. Heart beat rate and control of heartbeat

MODULE IV: Excretory system**(6 hrs)**

- 4.1. Malpighian tubules-anatomy & histology - Hemipteran, Coleopteran and Lepidopteran types
- 4.2. Physiology of excretion
- 4.3. Nitrogenous excretion-synthesis of uric acid, formation of excreta
- 4.4. Dietary problems - salt and water balance-control

MODULE V: Nervous system (14 hrs)

- 5.1. Anatomy and histology of brain, ganglia and nerves
- 5.2. Reception and transmission of stimuli, production and control of nerve impulses and transmission.
- 5.3. Sense organs - anatomy, histology and physiology of mechanoreceptors - tactile senses, proprioceptors, sound perception, chemoreceptors, photoreceptors, thermoreceptors and hygroreceptors
- 5.4. Mechanism of sound and light production in insects.

MODULE VI: Muscular system and Locomotion (14 hrs)

- 6.1. Histomorphology of muscles, skeletal muscles, visceral muscles
- 6.2. Muscle development and maintenance
- 6.3. Excitation of muscle fibres, activation of muscle fibres, role of fast and slow axons
- 6.4. Role of Neuromuscular junctions in locomotion
- 6.5. Basic structure of insect leg- terrestrial and aquatic adaptations
- 6.6. Maintenance of stance and patterns of movements (terrestrial and aquatic systems)
- 6.7. Structure of wings, modifications, mechanism of wing movement
- 6.8. Aerodynamics and control of wing beat.

MODULE VII: Endocrine and exocrine glands (8 hrs)

- 6.9. Histomorphology of neuro secretory cells and endocrine glands (corpora cardiaca, corpora allata and prothoracic glands)
- 6.10. Hormones and their functions
- 6.11. Mechanism of hormone action
- 6.12. Pheromones and their function

MODULE VIII: Reproductive system, Embryogenesis and morphogenesis (15 hrs)

- 6.13. Development of primordial germ cells
- 6.14. Reproductive system- male and female structure

- 6.15. Fertilization and oviposition
- 6.16. Formation of blastoderm and extraembryonic membranes
- 6.17. Sex determination and parthenogenesis
- 6.18. Differentiation of germ layers
- 6.19. Segmentation, appendage formation, organogenesis
- 6.20. Polyembryony, paedogenesis, viviparity, oviparity, eclosion,
- 6.21. Postembryonic development-hatching, larval development and control, polyphenism, diapause.

References:

1. Beament, J.W.L., Treherne, J. E. and Wigglesworth, V.B.(1972). *Advances in Insect Physiology*, Academic press, London
2. Bursell, E (1970): *An Introduction to Insect physiology*, Academic Press
3. Chapman. R.F.(1998): *The Insects: Structure and Function*. 4th ed. ELBS, London.
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FOURTH SEMESTER				
Course code	ZOL4E12			
Name of the course	ENTOMOLOGY – III - AGRICULTURAL, MEDICAL & FORENSIC ENTOMOLOGY			
Course No	Course Category Core/Compli/ Elective	Number of Credits	Number of hours of Lectures/week	Total marks (Int+Ext)
12	ELECTIVE	4	3	100 (Internal 20+ External 80)

COURSE OUTCOMES

CO	CO Statement	Hrs	Cognitive Level (CL)	Knowledge Category (KC)	PO	PSO
CO1	Understand the classification of insects pests, types of damage caused by to plants and other basic concepts on the subject	10	U	F	PO1, PO5	PSO3
CO2	Recognize the pests to major local crops, their life cycle control measures and types of damage	20	U	F	PO1, PO5	PSO3 PSO5
CO3	Understand the different principles of Insect pest management	10	U	F,C	PO1, PO5	PSO3, PSO5
CO4	Understand the different chemical control methods of insect pests	20	U	F	PO1, PO2 PO5	PSO3
CO5	Understand the different methods of Biological control and Integrated Pest Management	5	U	F	PO1, PO5	PSO3 PSO5
CO6	Recognize the effect of insecticides on environment	10	U	F,C	PO1, PO2 PO5	PSO3 PSO5
CO7	Recognize insect vectors of human diseases and their biology	10	U	F	PO1, PO5	PSO3
CO8	Understand the basics of forensic Entomology	5	U	P	PO1, PO5	PSO3 PSO5

Abbreviations used:

CL - Cognitive level

R: Remember, U: Understand

Ap :Apply , An: Analyze

E:Evaluate, C : Create

KC- Knowledge category

C - Conceptual

F - Factual

P - Procedural

*M - Metacognitive***MODULE I: Insect Pests****(10 hrs)**

- 1.1. Types of damage to plants by insects (Injury by chewing insects, piercing and sucking insects, internal feeders, subterranean insects, to stored products and indirect effect of feeding)
- 1.2. Classification of insect pests (Regular pests, Occasional pests, Seasonal pests, persistent pests, sporadic pests, major pests, minor pests, potential pests, key pests)
- 1.3. Causes for insect assuming pest status
- 1.4. Concepts of Economic levels, Economic injury levels, Economic threshold level
- 1.5. Pest surveillance and forecasting pest outbreak
- 1.6. Estimation of damage caused by insects to crops

MODULE II: Insect pests of crops**(20 hrs)**

- 2.1. Identification, life history, damage and control of major pests of:
 - 2.1.1.Paddy** (17 major pests including stem borers, army worm, rice thrips, gall midge, mealy bug, BPH, green & white leaf hoppers, rice caseworm, rice leaf roller, rice hispa, rice ear head bug, root weevil, rice grasshoppers)
 - 2.1.2.Sugarcane** (Major pests including shoot, inter node & top borers, white grub, leaf hopper, sugarcane scale, mealy bug, whiteflies, Termites, Black winged bug)
 - 2.1.3.Cotton** (Major pests - Aphid, leaf hopper, thrips, whitefly, Pink spotted and American boll worms, stem weevil, Red and Dusky cotton bugs, leaf roller)
 - 2.1.4.Coconut** (7 pests - Rhinoceros beetle, red palm weevil, black-headed caterpillar, white grub, Scale insect, Lace wing bug, coconut skipper)
 - 2.1.5. Pulses** (8 pests - Gram pod borer, plume moth, red gram pod fly, pod borer, spotted pod borer, Blue butterflies, bean aphid, whitefly)
 - 2.1.6. Common vegetables
 - 2.1.6.1. Brinjal (shoot & fruit borer, stem borer, spotted leaf beetle, grey weevil, Pumpkin beetle)
 - 2.1.6.2. Tomato (serpentine leaf miner, fruit borer)
 - 2.1.6.3. Gourds (fruit flies, snake gourd semi looper, spotted beetle, Pumpkin beetle)
 - 2.1.6.4. Bhendi (Earias, leaf hopper, Red cotton bug, Gram pod borer)
 - 2.1.6.5. Cruciferous vegetables (diamond black moth, cabbage borer, leaf webber, Cabbage green semi looper, Cabbage aphid)
 - 2.1.7. Fruit trees

- 2.1.7.1. Mango (hopper, flower webber, Leaf webber, gall midges, Nut weevil, stem borer, red tree ant)
 - 2.1.7.2. Cashew (tree borers, Hairy caterpillar, Tea mosquito bug, Apoderus, Leaf miner)
 - 2.1.7.3. Banana (rhizome weevil, banana aphid, spittlebug)
 - 2.1.7.4. Citrus (Fruit sucking moth, citrus butterfly)
 - 2.1.8. Spices
 - 2.1.8.1. Pepper (pollu beetle, shoot borer, Marginal gall thrips)
 - 2.1.8.2. Cardamom (cardamom thrips, rhizome borer, cardamom whitefly, hairy caterpillars, Eupterote and Pericallia)
 - 2.1.8.3. Turmeric and Ginger (Leaf roller, shoot borer)
 - 2.1.9. Stored Products
- Identification, nature of damage & control of Insect pests of Stored Products: rice weevil, sweet potato weevil, lesser grain borer, tobacco beetle, drug store beetle, pulse beetle, Angoumois grain moth, potato tuber moth, Red flour beetle, rice moth)

MODULE III: Principles of Insect pest management

(10 hrs)

- 3.1 Prophylactic methods
- 3.2. Curative or direct methods
 - 3.2.1. Cultural methods
 - 3.2.2. Mechanical methods
 - 3.2.3. Physical methods
 - 3.2.4. Legal methods
- 3.3. Autocidal control- Sterile male technique and other methods, Chemosterilants, Methods of sterilization, Application, Dynamics, Advantages and disadvantages. Examples of autocidal control.
- 3.4. Insect growth regulators (IGRs) – Brief note on Insect growth hormones and mimics (JH mimic & ecdysone agonists) and chitin synthesis inhibitors as insect control agents,
- 3.5. Behavioural (pheromonal) control- (Brief note on Trail, Alarm, Aggregation and sex pheromones and the behaviour produced, Mode of application, Pest management with pheromones, Advantages and disadvantages, Examples).
- 3.6. Insect attractants: definition, types of attractants, applications in insect pest

mangement, examples, advantages and disadvantages.

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

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

3.9. Microbial control of crop pests by employing Bacteria, Virus and Fungi Classification of entomophagous Bacteria, Virus, Fungi, Mode of action, formulation, Application, Examples

MODULE IV: Chemical Control

(20 hrs)

4.1. Insecticide formulation (Brief note on Emulsifiable concentrates, Water miscible liquids, Wettable powders, Water soluble powders, Oil solutions, Flowable powders, Aerosols, Granulars, Fumigants, Ultra-low volume concentrates, Fogging concentrates, Dusts, Poison baits and Slow release insecticides)

4.2. Classification of insecticides.

4.2.1. Based on mode of entry.

4.2.2. Based on mode of action.

4.2.3. Based on chemical nature

4.3. Chemistry, toxicology & mode of action of following class of insecticides; mention examples for each class.

4.3.1. Synthetic Organic compounds.

4.3.1.1. Organochlorine insecticides.

DDT., BHC, Cyclohexane group (special reference to endosulfan; examples: heptachlor, aldrin).

4.3.1.2. Organophosphorous insecticides (examples: TEPP, Dichlorvos, monocrotophos, parathion).

4.3.1.3. Carbamates (special mention of carbofuran; examples: Carbaryl, procymidone)

4.4. Inorganic compounds as insecticides - arsenic compounds, fluorides, sulphur compounds

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

4.6. Botanical insecticides- chemical properties, mode of action and toxicity of the following: Nicotine, Rotenone, Pyrethrum and Neem

4.7.Synthetic pyrethroids – definition, uses as insecticides, mode of action (examples: Pyrethrin, allethrin)

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

MODULE V.Biological control (5 hrs)

History of biological control, Ecological basis of biological control.

5.1. Natural enemies (Parasites, Parasitoids, Predators), Feasibility of bio control.

5.2. Applied biological control (Conservation and Enhancement, Importation and Colonization, Mass culture and release).

5.3. Importance of systematics, Advantages and disadvantages of biological control.

5.4. Important biocontrol projects undertaken in India by employing parasites and predators.

5.5.Integrated Pest Management- Definition, IPM in Agroecosystem, Kinds of pest, (Key pests, Occasional pests, Potential pests, Migrant pests) Establishing the need to take action, Guidelines for developing IPM, Tactics in IPM, IPM of Rice

MODULE VI Insecticides and Environment (10 hrs)

6.1.Insecticide resistance -Genetic, Physiological and biochemical mechanism

6.2.Pesticides and the environment- its impact on wildlife and human health

6.3Microbial and environmental degradation of pesticides

MODULE VII. Medical entomology (10 hrs)

7.1.Insect vectors of human diseases and their biology: (Malaria, Lymphatic filariasis, Dengue, Chikungunya, Zika, Yellow fever, West Nile virus, River Blindness, African sleeping sickness, American sleeping sickness, Kala Azar, Plague, Typhus): Mosquitoes (Anopheles, Aedes, Culex, Mansonia); Sand fly, Flea, Assassin bug, Black fly, Tse Tse fly, Head louse.

7.2. Mosquito control- Larval and adult control-Chemical, Biological and environmental.

7.3. Insects related to Myiasis

7.4. Poisonous insects: Bees, wasps and ants-Anaphylaxis.

7.5. Maggot therapy (Use of maggots intreatment.

MODULE VIII.Forensic Entomology (5 hrs)

8.1.Introduction to Forensic entomology

8.2. Insects used in forensic entomology (Dipterans and coleopterans)

- 8.3. Succession of insect fauna on a cadaver.
- 8.4. Methods of forensic entomology: Detection of time of death, mode of death and place of death. Case histories (at least 3).
- 8.5. Forensic entomology in India.

References

Agricultural Entomology

1. Ananthakrishnan, T.N. (1977): Insect and Host Specificity, Mc Millan Co, India Ltd.
1. Ananthakrishnan, T.N.(1992).Emerging trends in Biological Control of Phytophagous Insects. Oxford and IBH Publishing Co. Pvt. Ltd.,NewDelhi.
2. Atwal, A.S., Agricultural Pests of India and South East Asia. Kalyanai Publishing,New Delhi.
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4. D'Brien, R.D. (1967): Insecticide- action and metabolism, Academic Press,N.Y.
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8. Hill, D.S. and Waller, Insect Pests of Agriculture and theirControl
9. Hill, D.S., AgriculturalEntomology
10. Hill, D.S., Agricultural Insect Pests of the Tropics and their controlC.V.P.
11. Matsumura, F. (1975): Toxicology of Insecticides –Plenum
8. Metcalf. G.L.and Flint.W.P.(1962). Destructive and Useful Insects, their Habits and Control.Tata Mc Graw Hill Publishing.Co.Ltd.N.Y.
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10. Moriarty, F., (1975): Organochlorine insecticides persistant organic pollutants, Academic Press, INC,London
11. Nair, M.R.G.K. (1975): Insect and Mites of Crops in India, ICAR, NewDelhi.
12. O'Brian, R.D. and Yamanots, I.(1970): Biochemical Toxicology of Insecticides, Academic Press INC,London
13. Pedigo,L.P.(1996):Entomology andPestManagementPractice.HallIndiaPvt.Ltd.NewDelhi.
14. Perry, A.S., Yamamoto, I., Ishaaya, I. and Perry, R. (1998): Insecticides in Agriculture

and Environment – Retrospects and Prospects, Narosa Publishing House, New Delhi

17. Pradhan, S. (1969), Insect pests of Crops, National Book Trust, New Delhi.
18. Romoser, W.S. and Stoffalano, J.G. (1994). The Science of Entomology. 3rd Edn. Wm. C. Brown Publishing
19. Srivastava, K.P. (1996): A Text Book of applied Entomology .Vol. I&II, Kalyani publishers, Ludhiana.
20. Thacker, J.R.M. (2002). An Introduction to Arthropod Pest Control. Cambridge University Press, UK.
21. Vasantharaj David and Kumaraswami, Hand Book of Economic Zoology.
22. Walter, G. (2003). Insect Pest Management and Ecological Research, Cambridge University Press, UK.
23. Wilkinson, C.F. (1976): Insecticide Biochemistry and Physiology – Plenum Press N.Y.

Medical entomology

1. Kettle D.S. (1995). Medical and Veterinary Entomology. 2nd Ed. CAB International.
2. Jeremy Farrar et al (2015). Manson's Tropical Diseases, 23rd Edition. Elsevier. Pp.1552
3. Sun, Xinjuan; Jiang, Kechun; Chen, Jingan; Wu, Liang; Lu, Hui; Wang, Aiping; Wang, Jianming (2014). A systematic review of maggot debridement therapy for chronically infected wounds and ulcers. *International Journal of Infectious Diseases* **25**:32–7
4. Mike Service (2008). Medical Entomology for students. 4th ed. Cambridge University Press. UK.

Forensic Entomology

1. Kenneth G.V. Smith (1987). A manual of Forensic Entomology .Cornell Univ Pr. Pp.225.
2. Sumodan P.K. (2002). Insect Detectives. *Resonance*.
3. Gennard, D.E. (2007). Forensic Entomology.-An Introduction. John Wiley.
4. Wall, Richard and Shearer, David. (1998). Veterinary Entomology. Chapman & Hall, London.
5. Smith, K.V.G. (1986). A Manual of Forensic Entomology. British Museum Natural History.
6. David, B.V. and Ananthakrishnan, T.N. (2004). General and Applied Entomology. 2nd ed. Tata McGraw Hill publishing Co. Ltd. New Delhi.

FOURTH SEMESTER PRACTICALS

ZOL4L04 -BIOTECHNOLOGY

1. Isolation of plasmid DNA.
2. Isolation of total RNA from tissues
3. Separation of DNA by electrophoresis.
4. Bacterial transformation.
5. PCR
6. Cell immobilization.

ZOL4L04 – MICROBIOLOGY

1. Selective isolation and enumeration of bacteria.
2. Bacterial staining technique
 - a. Simple staining of bacteria.
 - b. Negative staining
 - c. Hanging drop technique.
 - d. Gram staining.
 - e. Endospore staining.
3. Turbidity test for contamination of milk.
4. Preparation of media and sterilization.eg: Nutrient agar, mac conkey agar,
5. Cultivation of yeast and molds
6. Bacteriological analysis of water e.g., fecal pollutants.
7. Antibiotic sensitivity test.
8. Maintenance of *E. coli* culture (shake and surface cultures) and quantitative evaluation (number of cells/ml) of a given sample of culture by dilution and plating.

ZOL4L04 - MICROTÉCHNIQUE AND HISTOCHEMISTRY

1. Preparation of stained and unstained whole-mounts.
2. Identification of the various tissues of animals in serial sections prepared using nuclear and cytoplasmic stains.
3. Processing a few types of tissues for the histochemical staining-Staining of serial sections to show the presence of
 - a) Carbohydrates by PAS method
 - b) Proteins by Mercuric bromophenol blue method
 - c) Fats by Sudan Black B method

d) DNA by Feulgen Technique.

Submission:

Stained/unstained Whole mounts – 4 numbers

Double stained serial histology slides- 4

numbers Histochemical slides - 2 numbers

References

1. Ausubel, F.M., Brecht R, Kingston, R.E., Moore, D. D., Seidman, J. G., Smith, J.A. and Struht, K. (2002): Short protocols in Molecular Biology. John Wiley & Sons, Inc.
2. Sambrook, J. & Russell, D.W. (2001): Molecular cloning: A laboratory manual. CSHL Press, NY
3. Kannan, N. (2003). Lab Manual in General Microbiology. Panima Publishing Company, India.
4. Cappuccino, J.G. and Sherman, N. (2007). Microbiology-A laboratory Manual Benjamin-Cummings Publishing Company. USA.

FOURTH SEMESTER PRACTICALS

ELECTIVE COURSE- ENTOMOLOGY III

ZOL4L06 - AGRICULTURAL, MEDICAL AND FORENSIC ENTOMOLOGY

1. Field observation, identification and collection of insect pest of paddy, coconut, sugarcane, cotton, pulses, vegetables, fruit trees spices and forest trees.
2. Field observation, identification and collection of insect pest of Man and domestic animals
3. Field observation, identification and collection of insect damages to crops
4. Study of life histories of insect pests
5. Laboratory rearing of insect pests (any two)
6. Observation of laboratory rearing of Parasitoids and Predators
7. Identification of insecticide appliances
8. Field study of insecticide application
9. Field study to observe and collect insect pollinators, parasitoids and predators, scavengers and weed killers
10. Estimation of LD 50 values for some insect pests

Field report- Each student shall submit a field report consisting of the areas visited like paddy fields, coconut groves, sugarcane fields, cotton fields, fields of pulses and vegetables, fruits, parasitoids and predator breeding stations, beekeeping stations, sericulture institutes,

Toxicology laboratories etc.

(The field report with the dated signature of the teacher concerned and duly certified shall be submitted at the time of practical examination along with practical record. No marks shall be awarded for the record without field report).

References

1. Atwal, A.S. (1988). Agricultural pests of India and South East Asia. Kalyani Publishers, New Delhi.
2. Kettle, D.S. (1995). Medical and Veterinary Entomology. CAB International.
3. Mike Service. (2008). Medical Entomology for students. 4th ed. Cambridge University Press, UK.
4. Thacker, J.R.M. (2002). An Introduction to Arthropod Pest control. Cambridge University Press.
5. Tonapi, G.T. (1994). Experimental Entomology. An aid to Field and Laboratory.
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MODEL QUESTION PAPERS
AND
BLUE PRINTS

(1 Page)

Question paper Code

Name.....

Reg.No.....

**FIRST SEMESTER M.Sc. DEGREE EXAMINATION, ZOOLOGY
ZOL1C01-BIOCHEMISTRY AND CYTOGENETICS**

Time: 3 Hours

Maximum Weightage: 30

Part A

**Answer any *four* questions. Each carries 2 weightage
(4 x 2 = 8 weightage)**

1. Mention the structure of Lysosomes.
2. Write the structure of Maltose.
3. Mention the Lineweaver-Burk equation.
4. Comment on the laws of thermodynamics.
5. Mention the cytochrome system.
6. Mention the structure of chloroplast genes.
7. Comment on PFK?

Part B

**Answer any *four* questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

8. Mention the roles of Cadherins.
9. Mention the tertiary structure of proteins.
10. Mention the biological roles of lipids with suitable examples.
11. Mention the structure of Glycogen.
12. Describe the JAK-STAT signaling pathway.
13. Mention the structure of chromatin.
14. Mention the process of apoptosis.

Part C

**Answer any *two* questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

15. Discuss the factors affecting the enzyme activity and add a note on its inhibition.
16. Discuss the structure and functions of Heteroglycans.
17. Discuss the Chemiosmotic hypothesis and oxidative phosphorylation.
18. Describe the molecular organization of cell membrane.

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL1C01--BIOCHEMISTRY AND CYTOGENETICS										
Total Mark: 30 Weightage										
Question Paper			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			26 Hrs	10Hrs	3Hrs	15 Hrs	18 Hrs	8 Hrs	6 Hrs	4 Hrs
			16 Weightage	6 Weightage	2 Weightage	9 Weightage	11 Weightage	5 Weightage	4 Weightage	2 Weightage
Expected Weightage >>>>										
I	2	1						2		
		2	2							
		3		2						
		4			2					
		5				2				
		6						2		
		7					2			
II	3	8					3			
		9	3							
		10	3							
		11	3							
		12					3			
		13							3	
		14								3
III	5	15		5						
		16	5							
		17				5				
		18					5			
Actual Weightage >>>>			16	7	2	9	11	4	3	3

N.B: 0.611 weightage allotted to every 1 teaching hour

(2 Pages)

Question paper Code

Name.....

Reg.No.....

**FIRST SEMESTER M.Sc. DEGREE EXAMINATION, ZOOLOGY
ZOL1C02-BIOPHYSICS AND BIOSTATISTICS**

Time: 3 Hours

Maximum Weightage: 30

Part A

**Answer any *four* questions. Each carries 2 weightage
(4 x 2 = 8 weightage)**

1. Explain Cataphoresis.
2. Mention any two applications each of NMR and ESR
3. Mention any four applications of HPLC
4. Explain any two applications of nanotechnology from a biological perspective.
5. Draw and label the structure of human ear.
6. What are the characteristic features of a normal distribution?
7. Write short notes on ANOVA

Part B

**Answer any *four* questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

8. Justify the significance of buffers in biology.
9. Comment on Patch clamp recording.
10. Explain the working principle of 2D PAGE
11. Mention the biological effects of ionization radiation.
12. How do the different G forces affect a living body?
13. Calculate the mean and standard deviation of the given data

Class Interval	Frequency
0-10	7
10-20	11
20-30	25
30-40	13
40-50	5

14. Differentiate between the three different indices indicated under Simpson's D.

Part C

**Answer any *two* questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

15. Write a essay on the different types of microscopic techniques. Explain with neat and labelled diagrams.
16. Enumerate and explain the different types of separation techniques based on biophysical principles.
17. Explain the different types of sampling methods. Mention the assumptions and conditions suitable for each type along with advantages and disadvantages..
18. Calculate the Pearson's Correlation coefficient for the following data and draw inferences about the data based on that statistic. Support your arguments with a scatter plot.

A	10	12	15	17	19	21	23	27	28
B	5	5	7	9	10	11	12	14	15

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL1C02--BIOPHYSICS AND BIostatISTICS										
Total Mark: 30 Weightage										
Question Paper			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I 9 Hrs 6 Weightage	MOD II 17Hrs 10Weightage	MOD III 10Hrs 6Weightage	MOD IV 8 Hrs 5 Weightage	MOD V 10 Hrs 6 Weightage	MOD VI 15Hrs 9Weightage	MODVII 14 Hrs 9Weightage	MOD VIII 7 Hrs 4Weightage
Expected Weightage >>>>										
I	2	1	2							
		2		2						
		3			2					
		4				2				
		5					2			
		6						2		
		7							2	
II	3	8	3							
		9		3						
		10			3					
		11				3				
		12					3			
		13						3		
		14								3
III	5	15		5						
		16			5					
		17						5		
		18							5	
Actual Weightage >>>>			5	10	10	5	5	10	7	3

N.B: 0.611 weightage allotted to every 1 teaching hour

(2 Pages)

Question paper Code

Name.....

Reg.No.....

**SECOND SEMESTER M.Sc. DEGREE EXAMINATION
ZOL2C05 - MOLECULAR BIOLOGY**

Time: 3 Hours

Maximum: 30 Weightage

Part A

**Answer any *four* questions. Each carries 2 weightage
(4 x 2 = 8 weightage)**

1. Write short notes on evolutionary clock
2. Write short notes on DNA Polymerases
3. Explain RNA editing
4. Differentiate between simple and complex multigene family.
5. What is the role of N and Q proteins in determining the lytic or lysogenic fate of a bacteriophage?
6. Explain the basic features of arabinose operon.
7. Justify the importance of antisense RNA in gene expression.

Part B

**Answer any *four* questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

8. Enlist the characteristic features of the genetic code in mitochondria.
- 9.
10. Give an account of Post transcriptional modifications
11. Briefly explain structure and composition of Prokaryotic and Eukaryotic Ribosome
12. Elucidate the Role of Rec A protein in genetic recombination.
13. Demonstrate the interrupted mating (in bacteria) method used for mapping genes.
14. Explain how cell regulation differs in cancerous cells when compared to normal cells.

Part C

**Answer any *two* questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

15. Write an essay on the special features of eukaryotic genome.
16. Write an essay on different types of DNA damages.
17. Explain the mechanism of translation in Prokaryotes.
18. Compare and contrast the transposons in bacteria and eukaryotes with suitable examples.

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL2C05--MOLECULAR BIOLOGY										
Total Mark: 30 Weightage										
Question Paper			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			20 Hrs	16Hrs	20Hrs	09 Hrs	10 Hrs	5 Hrs	5 Hrs	5 Hrs
Expected Weightage >>>>			12Weightage	10 Weightage	12 Weightage	6 Weightage	6 Weightage	3 Weightage	3 Weightage	3 Weightage
I	2	1	2							
		2		2						
		3			2					
		4	2							
		5				2				
		6				2				
		7				2				
II	3	8	3							
		9		3						
		10			3					
		11			3					
		12						3		
		13							3	
		14								3
III	5	15	5							
		16		5						
		17			5					
		18					5			
Actual Weightage >>>>			12	10	13	6	5	3	3	3

N.B: 0.611 weightage allotted to every 1 teaching hour

(2 Pages)

Question paper Code

Name.....

Reg.No.....

III SEMESTER M.Sc. DEGREE EXAMINATION (CUCSS), Zoology

ZOL2C06 - SYSTEMATICS AND EVOLUTION

Time: 3 Hours

Maximum Weightage: 30

Part A

Answer any four questions. Each carries 2weightage

(4 x 2 = 8 weightage)

1. Explain shortly on the importance of Taxonomy.
2. Distinguish between Biological and Evolutionary species concept.
3. Give an account of taxonomic publications with three important features.
4. How secondary sexual characteristics influence sexual selection
5. Explain co-evolution with examples.
6. Explain Neutral theory of molecular evolution
7. Give an account of molecular clocks

Part B

Answer any *four* questions. Each carries 3 weightage

(4 x 3 = 12 weightage)

8. Discuss the Theories of Classification.
9. Explain different types of Keys.
10. Discuss about ICZN and explain different types of specimens.
11. Explain the important Taxonomic impediments.
12. Discuss biochemical evolution in detail
13. Explain the stages in primate evolution
14. Differentiate between Gradualism and Punctuated equilibrium

Part C

Answer any *two* questions. Each carries 5 weightage

(2 x 5 = 10 weightage)

15. Describe the Newer Trends in Systematics.
16. Discuss about different types of Species with examples.
17. Explain Taxonomic characters and its kinds with special reference to evolution and function
18. Discuss about the evidences for organic evolution

Blue Print for Question Paper Setting / Scrutiny (QP-A)											
PG Programme : ZOOLOGY											
Course and course code: ZOL2C06 - SYSTEMATICS AND EVOLUTION											
Total Mark: 30 Weightage											
Question			Syllabus								
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII	
			16 Hrs	10Hrs	14Hrs	6Hrs	8 Hrs	14 Hrs	14 Hrs	8 Hrs	
			10 Weightage	7 Weightage	8 Weightage	3 Weightage	5	9 Weightage	9 Weightage	4	
Expected Weightage >>>>											
I	2	1	2								
		2				2					
		3		2.00							
		4						2			
		5						2			
		6									2
		7									2
II	3	8	3								
		9			3.00						
		10				3					
		11					3				
		12							3		
		13							3.00		
		14							3		
III	5	15	5								
		16		5							
		17			5						
		18						5			
Actual Weightage >>>>			10	7.00	8.00	3	5	9	9.00	4	

(2 Pages)

Question paper Code

Name.....

Reg.No.....

III SEMESTER M.Sc. DEGREE EXAMINATION (CUCSS), Zoology

ZOL3C07 - IMMUNOLOGY

Time: 3 Hours

Maximum Weightage: 30

Part A

Answer any four questions. Each carries 2weightage

(4 x 2 = 8 weightage)

1. Elucidate the role of APC in the immune system of vertebrates.
2. Write short notes on Haptens.
3. Explain the clinical applications of Monoclonal Antibodies?
4. Explain the association of TCR with CD3 diagrammatically.
- 5 Differentiate between Exogenous and Endogenous pathways.
- 6 Explain the effect of allergens in a body.
7. What is the immunological basis of graft rejection?

Part B

Answer any four questions. Each carries 3 weightage

(4 x 3 = 12 weightage)

8. Give an account of genes that regulate hematopoiesis.
9. Differentiate between T cell and Bcell epitopes.
- 10 .Elucidate the role of follicular dendritic cells in the immunological process.
- 11 Classify the different types of cytokines and their ligands
- 12 Write a short essay on MHC genes.
- 13 Distinguish between synthetic peptide vaccines. and whole organism vaccines.
14. Explain the effect of HIV virus on the immune system of humans.

Part C

Answer any two questions. Each carries 5 weightage

(2 x 5 = 10 weightage)

15. Explain in detail any five Immunotechnics
16. Write an essay on the Hybridoma technology and antibody engineering.

17. Demonstrate Complement activation pathways, their regulation and the effects of complement activation.
18. Compare and contrast the different types of hypersensitivity reactions?

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL3C07–IMMUNOLOGY										
Total Mark: 30 Weightage										
Question Paper			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			9 Hrs 5Weightage	8 Hrs 5 Weightage	10 Hrs 6 Weightage	10 Hrs 6 Weightage	09 Hrs 6 Weightage	13 Hrs 8 Weightage	8 Hrs 5 Weightage	23 Hrs 14Weightage
Expected Weightage >>>>										
I	2	1	2							
		2		2						
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		5						2		
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		7								2
II	3	8	3							
		9		3						
		10				3				
		11					3			
		12						3		
		13								3
		14								3
III	5	15			5					
		16				5				
		17						5		
		18								5
Actual Weightage >>>>			5	5	7	5	5	8	5	15

N.B: 0.611 weightage allotted to every 1 teaching hour

(2 Pages)

Question paper Code

Name.....

Reg.No.....

III SEMESTER M.Sc. DEGREE EXAMINATION (CUCSS), Zoology
ZOL3ET09–ENTOMOLOGY -1 :MORPHOLOGY & TAXONOMY

Time: 3 Hours

Maximum Weightage: 30

Part A

**Answer any four questions. Each carries 2weightage
(4 x 2 = 8 weightage)**

- 1.Explain the types of galls and physiology of gall formation.
2. Write short notes on Apterygotes.
3. Explain the ecological interactions of leaf miners
4. Give an account of Phasmida
5. Explain co-evolution with suitable examples.
6. Give an account of Locusts.
7. Discuss the methods of communication in insects .

Part B

**Answer any four questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

8. Give an account of genes that regulate hematopoiesis.
9. Differentiate between T cell and Bcell epitopes.
- 10 .Elucidate the role of follicular dendritic cells in the immunological process.
- 11 Classify the different types of cytokines and their ligands
- 12 Write a short essay on MHC genes.
- 13 Distinguish between synthetic peptide vaccines. and whole organism vaccines.
14. Explain the effect of HIV virus on the immune system of humans.

Part C

**Answer any two questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

15. Write an essay on important families of Coleoptera.
16. Explain with suitable diagrams external genitalia of male and female insect.?
17. Classify order Odonata down to families with salient features.
18. Explain the origin and morphological features of insect wing. Comment on wing coupling apparatus

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL3E09– MORPHOLOGY AND TAXONOMY(90 Hrs)										
Total Mark: 30 Weightage										
Question			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			5 Hrs	3Hrs	14Hrs	14 Hrs	36 Hrs	5 Hrs	7 Hrs	6 Hrs
			3	2	9	8	22	3	4	4
Expected Weightage >>>>										
I	2	1							2	
		2							2	
		3		2						
		4			2					
		5								2
		6				2				
		7								2
II	3	8				3				
		9	3							
		10					3			
		11					3			
		12					3			
		13					3			
		14						3		
III	5	15					5			
		16				5				
		17			5					
		18					5			
Actual Weightage >>>>			3	2	9	8	22	3	4	4

(2 Pages)

Question paper Code

Name.....

Reg.No.....

**FOURTH SEMESTER M.Sc. DEGREE EXAMINATION, ZOOLOGY
ZOL4E11-ENTOMOLGY II- ANATOMY AND PHYSIOLOGY**

Time: 3 Hours

Maximum Weightage: 30

Part A

**Answer any four questions. Each carries 2weightage
(4 x 2 = 8 weightage)**

19. What is Sclerotisation?
20. Mention the role of hormones in moulting.
21. Explain with any example how microbiota in insect gut aid in digestion.
22. Explain the mechanism of cyclic release of CO₂
23. Draw and label the lepidopteran type malphigian tubules
24. Explain the mechanism of light production in insects
25. Draw and label the terrestrial and aquatic variations from the basic insect leg

Part B

**Answer any four questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

26. Explain the mechanisms of digestion of keratin, wax and silk in insects.
27. Enlist and explain the major classes of digestive enzymes in insects
28. Describe the composition of the insect haemolymph.
29. How does the insect excretory system compensate for salt and water balance problems?
30. Describe the mechanism of hormone action in insects
31. What are the major classes of pheromones in insects and how do they affect insect behaviour.
32. Explain the control of hatching and larval development in insects.

Part C

**Answer any two questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

33. Explain the structure and variations of the tracheolar system and spiracles in insects
34. Give a detailed account of any five sense organs/receptors in insects (use labeled diagrams)

35. Describe the structure, modification of wing and mechanism of wing movement in relation to insect flight.
36. Write an essay on embryogenesis and morphogenesis in insects.

Blue Print for Question Paper Setting / Scrutiny (QP-A)										
PG Programme : ZOOLOGY										
Course and course code: ZOL4E11-ENTOMOLOGY II										
Total Mark: 30 Weightage										
Question Paper			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			6 Hrs 4Weightage	13 Hrs 8 Weightage	14 Hrs 9 Weightage	6Hrs 4Weightage	14 Hrs 8 Weightage	14 Hrs 8 Weightage	8 Hrs 5 Weightage	15 Hrs 9Weightage
Expected Weightage >>>>										
I	2	1	2							
		2	2							
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II	3	8		3						
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		12							3	
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		14								3
III	5	15			5					
		16					5			
		17						5		
		18								5
Actual Weightage >>>>			4	8	10	5	7	7	6	8

N.B: 0.611 weightage allotted to every 1 teaching hour

(2 Pages)

Question paper Code

Name.....

Reg.No.....

**FOURTH SEMESTER M.Sc. DEGREE EXAMINATION, ZOOLOGY
ZOL4E12- AGRICULTURAL, MEDICAL & FORENSIC ENTOMOLOGY**

Time: 3 Hours

Maximum Weightage: 30

Part A

**Answer any four questions. Each carries 2weightage
(4 x 2 = 8 weightage)**

1. Define insect antifeedent with its advantage and disadvantage.
2. Differentiate between Aerosols and Fumigants.
3. Give an account on Carbamates.
4. Explain insecticide resistance
5. Write short notes on Rhizome weevil of Banana.
6. Give an account of pests of Tomato
7. What do you mean by maggot therapy?

Part B

**Answer any four questions. Each carries 3 weightage
(4 x 3 = 12 weightage)**

8. Briefly classify insecticide.
9. Explain integrated pest management.
10. Describe microbial and environmental degradation of pesticide.
11. Give an account on mosquito control by chemical, biological and environmental method.
12. Write short notes on Pest surveillance and forecasting pest outbreak.
13. Briefly explain concept of Economic level and Economic injury level
14. Give an account of Pests of pepper

Part C

**Answer any two questions. Each carries 5 weightage
(2 x 5 = 10 weightage)**

15. Describe the ecology based pest management.

16. Discuss the toxicology and mode of action of Synthetic Organic compounds.
17. Explain the major insect vectors of human disease and their biology
18. Write an essay on pests of Paddy.

Course and course code: ZOL4E12- AGRICULTURAL, MEDICAL & FORENSIC ENTOMOLOGY										
Total Mark: 30 Weightage										
Question			Syllabus							
Sections or Parts	Weightage	Question Numbers	MODULE I	MOD II	MOD III	MOD IV	MOD V	MOD VI	MODVII	MOD VIII
			10Hrs	20Hrs	10Hrs	20 Hrs	5 Hrs	10 Hrs	10 Hrs	5Hrs
			6Weightage	12Weightage	6Weightage	12 Weightage	3	6 Weightage	6 Weightage	4Weightage
Expected Weightage >>>>										
I	2	1								
		2			2					
		3				2				
		4				2				
		5						2		
		6		2						
		7		2						
II	3	8								2
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III	5	14	3							
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		16			5					
		17				5				
		18						5		