**DGM MES MAMPAD COLLEGE (AUTONOMOUS)**

CURRICULUM AND SYLLABI

FOR

**M Sc Zoology**

**(w.e.f. 2022 admission)**

2022

**List of the members of Board of Studies in Life Science (UG and PG)**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Name | Designation | Institution |
| 1 | Dr. C. K. Abdul Rabbi Nistar | Associate Professor, Chairman, BoS | MES Mampad College  Mampad College PO |
| 2 | Dr. K. S. Anoop Das | Assistant Professor | MES Mampad College  Mampad College PO |
| 3 | Dr. L. K. Sreekala | Assistant Professor | MES Mampad College  Mampad College PO |
| 4 | Dr. K. U. Muhammed Abdul Rafeeq | Assistant Professor | MES Mampad College  Mampad College PO |
| 5 | Dr. K. M. Remia | Assistant Professor | MES Mampad College  Mampad College PO |
| 6 | Ms. Shamiyath A | Assistant Professor | MES Mampad College  Mampad College PO |
| 7 | Dr. Dollymol. M.A. | Assistant Professor | MES Mampad College  Mampad College PO |
| 8 | Dr. K. Mohammed Ismail | Associate Professor, Rtd. HOD | MES Mampad College  Mampad College PO |

**External experts**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Name | Designation | Institution |
| 1 | Dr. C. O Joshi | Associate Professor, Department of Zoology | Christ College, Irinjalakuda |
| 2 | Dr. C. M. Abdul Salam | HOD, Associate Professor, Department of Botany | Unity Womwn’s College Narukara, Manjari |

**Meritorious alumnus as member**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Name | Designation | Institution |
| 1 | Dr. Muhamed Jafer Palot | Assistant Zoologist | Zoological Survey of India Western Ghats Regional Centre, Calicut |

**Representative from industry, corporate sector or allied area relating to placement**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Name | Designation | Institution |
| 1 | Dr. Harikumar P S | Senior Principal Scientist & Registrar  Head, Administration and Finance Division | CWRDM  Kunnamagalam, Calicut |

**Expert nominated by vice-chancellor**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Name | Designation | Institution |
| 1 | Dr. George Mathew | HOD, Associate Professsor, Department of Zoology | St. Joseph’s College, Devagiri, Kozhikose |

**CURRICULUM AND SYLLABUS FOR CHOICE BASED CREDIT SEMESTER SYSTEM (CBCSS -2021) M. Sc. ZOOLOGY COURSE**

**w.e.f. 2021ADMISSION**

# 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 |

**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 |

**FIRST & SECOND SEMESTER- PRACTICAL COURSES**

|  |  |  |  |
| --- | --- | --- | --- |
| **Code No. & Title of the Course** | **Credits** | **External**  **Weightage** | **Internal**  **Weightage** |
| ZOL2L01- Biochemistry, Biophysics  and Biostatistics | 4 | 24 | 5 |
| ZOL2L02- Physiology, Molecular  Biology and Cytogenetics | 4 | 24 | 5 |
| ZOL2L03- Ecology, Ethology,  Systematics and Evolution | 4 | 24 | 5 |

**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 | 24 | 5 |
| ZOL4L05- Entomology 1 & II | 4 | 24 | 5 |
| ZOL4L06- Entomology III | 4 | 24 | 5 |
| ZOL4P07- Project Work | 4 | 24 | 5 |
| ZOL4V08- Viva Voce (Project-2 + General-2) | 4 | 24 | 5 |

**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 fourthsemesters.
2. The teacher who gives guidance to project work can select any topic from the syllabi 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 36 for the external examination and 5 for the internal theoryexamination.
4. Weightage for each core and elective practical course shall be 24 for the external examination and 5 for the internal core and elective practicalexamination.
5. Theory examination question paper shall contain14 short answer questions with weightage1each , 7 short essay questions with weightage 2 each and 2 essay questions with weightage 4each.
6. Weightage for the external practical examination can be distributed asfollows:

|  |  |  |
| --- | --- | --- |
| **With submission Weightage** |  | **Without submission Weightage** |
| Major question (1 number) | 8 | Major question(1number) 8 |
| 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 | 24 | Total 24 |

1. No submission is required for the practical in elective course, unless mentioned insyllabus.
2. A candidate has to submit the following at the time of practical examination - ZOL4L04 Whole mount: 4numbers

Slides: Histology: 4 numbers

Slides: Histochemistry: 2 numbers (To test the presence of carbohydrate and

protein. (Control not required)

1. If a candidate fails to submit the field study / tour report, no marks for the record be awarded.
2. 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 to4.
3. 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.
4. One seminar for each course is compulsory.

|  |  |  |
| --- | --- | --- |
| **Criteria for the evaluation of dissertations** |  | **Weightage** |
| 1. Introduction, review of literature etc. |  | 2 |
| 2. Objectives and relevance of the study |  | 3 |
| 3. Methodology |  | 4 |
| 4. Results |  | 3 |
| 5. Discussion and interpretation |  | 4 |
| 6. Conclusions |  | 3 |
| 7. Involvement of the students |  | 1 |
| 8. Style and neatness of the dissertation |  | 1 |
| 9. References |  | 3 |
|  | **Total** | **24** |

**Criteria for the Viva-voce**

|  |  |
| --- | --- |
| **A. Presentation of project work- (POWER POINT Presentation)** | **Weightage** |
| 1. Quality and correctness of slides | 2 |
| 2. Clarity of presentation | 3 |
| 3. Communication skill | 3 |
| 4. Answers to questions | 4 |
| **Subtotal** | **12** |
| **B. General Viva-voce** | **Weightage** |
| 5.Knowledge of the student | 4 |
| 6. Communication skill | 3 |
| 7. Answers to questions | 5 |
| **Subtotal** | **12** |

### GrandTotal 24

# Zoology Program Outcomes:

1. PO1 - Students gain knowledge and skill in the fundamentals of animal sciences, understands the complex interactions among various living organisms
2. PO2 – Analyse complex interactions among the various animals of different phyla, their distribution and their relationship with the environment
3. PO3 – Apply the knowledge of internal structure of cell, its functions in control of various metabolic functions of organisms.
4. PO4 – Understands the complex evolutionary processes and behaviour of animals
5. PO5 – Correlates the physiological processes of animals and relationship of organ systems
6. PO6 – Understanding of environmental conservation processes and its importance, pollution control and biodiversity and protection of endangered species
7. PO7 – Gain knowledge of Agro based Small Scale industries like sericulture, fish farming, butterfly farming and vermicompost preparation.
8. PO8 – Understands about various concepts of genetics and its importance in human health
9. PO9 - Apply ethical principles and commit to professional ethics and responsibilities in delivering his duties
10. PO10 – Apply the knowledge and understanding of Zoology to one’s own life and work
11. PO11 – Develops empathy and love towards the animals

# Program Specific Outcomes:

1. PSO1. Understand the nature and basic concepts of cell biology, genetics, taxonomy, physiology, ecology and entomology
2. PSO2. Analyse the relationships among animals, plants and microbes
3. PSO3. Perform procedures as per laboratory standards in the areas of Taxonomy, Physiology, Ecology, Cell biology, Genetics, tools and techniques of Zoology, Toxicology, Entomology,Nematology Sericulture, Biochemistry, Animal biotechnology, Immunology and research methodology
4. PSO4. Understand the applications of Entomology and Agriculture
5. PSO5. Gains knowledge about research methodologies, effective communication and skills of problem solving methods
6. PSO6. Contributes the knowledge for Nation building.

**AUDIT COURSES**

Each student will 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.

### Ability enhancement course (AEC) – (In the I semester)

1. Documentation and scientific writing
2. Paper review on a topic of choice.
3. Internship for a minimum of 40hours.
4. Industrial or Practical training for a minimum of 40hours.
5. Community linkage programme for a minimum of 40hours.
6. Seminar presentation on a frontier area of biological research. The topic should be from outside the syllabus.

### Professional Competency Course (PCC) (In the II semester)

1. Statistical (SPSS/R/any software relevant to the programme of study) softwares
2. Museum curation skills (Taxidermyetc.)

# MODEL QUESTION PAPER

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

Branch: Zoology Course Code**:** Course Name

Time :**3**hrs MaximumWeightage:30

1. Answer any 4 of the following (Short Answer type questions) (Weightage-2) 1.

2.

3.

4.

5.

6.

7.

4 x 2 = 8

1. Answer any 4 of the following (Short essay type questions) (Weightage-3) 8.

9.

10.

11.

12.

13.

14

4 x 3 = 12

1. Answer any 4 of the following (Long essay type questions) (Weightage-5) 15.

16.

17.

18.

2 x 5 = 10

# FIRST SEMESTER THEORY

**ZOL1C01 - BIOCHEMISTRY AND CYTOGENETICS (90 hrs)**

**COURSE OUTCOMES (COs)**

CO1 Comprehend the importance of molecular structure and interactions present in different biomolecules that aid in functioning and organization of living system.

CO2 Interpret the structure-function relationships of the proteins, carbohydrates, lipids, and nucleic acids.

CO3 Recognize various biochemical changes that obey the basic thermodynamic principles

CO4 Familiar with the enzymes, their salient characteristics including distinctive conformation and remarkable catalytic properties.

CO5 Conceptualize metabolic pathways and their regulation, metabolism of – Carbohydrates, lipids, proteins and nucleic acids.

CO6 Acquire insight into membrane structure and function, structural organization and function of intracellular organelles and organization of chromosomes and genes

CO7 Gain knowledge about the Cellular communication, concepts of various cellular signal transduction pathways and apoptosis

**Part A. Biochemistry (54 hrs)**

### Unit - I - Chemistry and functions of Biomolecules

1. **Introduction (2hrs)**
   1. Macromolecules and their subunits

1.1. Chemical bonds of biomolecules (Covalent and Non-covalent bonds)

### Carbohydrates (8hrs)

* 1. Classification of carbohydrates with examples-
     1. Structure of monosaccharides- glucose, fructose, galactose, mannose and ribose.
     2. Methods of representation of sugars (Ball and stick, projection formula and perspective formula)
     3. Isomerism - Structural isomerism (functional group isomerism) and stereo isomerism (optical isomerism)- mention epimer, anomer and enantiomer with examples, Mutarotation
     4. Biological roles of monosaccharides.
  2. Structure and biological roles of maltose, sucrose,,lactose, trehalose andcellobiose.
     1. Hompolysaccharides - Structure and biological roles of cellulose, starch, glycogen, inulin and chitin
     2. Heteropolysaccharide - Structure and biological roles of hyaluronic acid, chondroitin, chondroitin sulphate, keratan sulphate, heparin andagar-agar.

### Proteins (6 hrs)

* 1. Amino acids
     1. 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)
     2. Amphoteric properties of aminoacids
     3. pK value and Isoelectric point (pI) of aminoacids
     4. Peptide bond and peptides (di, tri, tetra, oligo andpolypeptide).
  2. Structure ofprotein
     1. Primary structure, Secondary structure (Alpha helix, Beta-parallel & antiparallel and Beta-pleated sheet), random coil conformation, Tertiary structure, Quarternarystructure.
     2. . Conformation of Protein- Ramachandran Plot (Details), domains, motifs and folds
     3. Biological roles ofproteins

### Lipids (5 hrs)

* 1. Classification of lipids -Simple lipids (fats, oils and waxes), compound lipids (phospholipids, glycolipids, lipoproteins and sulpholipids) and derivedlipids.
  2. Biological roles of lipids - as food reserves (storage lipids), structural lipids in membrane, as signals, as co-factors, as pigments, as insulators, as vitamin carriersetc
  3. Prostaglandins - Chemical nature andfunctions.
  4. Fatty acids - definition; essential fattyacids
  5. Classification with examples- Saturated, unsaturated, hydroxyl and cyclic fattyacids
  6. Nomenclature of fatty acids - Genevan system

### Nucleic acids (3hrs)

* 1. Structural organization of DNA (Watson -Crickmodel)
  2. Confirmations of DNA (helix A,B,Z, C and P DNA)
  3. Structural organization of t-RNA; brief note onmicro-RNA
  4. Biological roles of nucleotides and nucleicacids

### Unit - II - Enzymes (7 hrs)

1. Classification- (I.U.B.system)
2. Mechanism of enzyme action: Formation of enzyme substrate complex- Michaelis-Menten theory, Fischer's template theory and Koshland's induced fit theory. Factors influencing enzymeaction
3. Enzyme kinetics - Michaelis-Menten equation - derivation; significance of Km and Vmax Values. Lineweaver-Burk equation and double reciprocal plot of enzymereaction.
4. Enzyme inhibition - Competitive, non-competitive and uncompetitive inhibition (distinguish kinetically), suicide inhibition and feedbackinhibition
5. Classification, Structure and functions of Vitamins.Vitamins asco-enzymes.

### Unit - III - Bioenergetics (2 hrs)

1. Laws of thermodynamics and biological system- Enthalpy, Entropy, Free energy concept.
2. Energy of activation, Standard free energychange.
3. Role of ATP as a free energy carrier in the biologicalsystem.

### Unit - IV - Metabolism and biosynthesis of biomolecules

1. **Carbohydrate metabolism (8hrs)**
   1. Glycolysis - (PFK as pacemaker - Hexokinase conformation and change by glucose), Fate of pyruvic acid
   2. Citric acid cycle; Pyruvate dehydrogenase complex and ketoglutarate dehydrogenase complex
   3. Electron transport system and oxidative phosphorylation; Redox potential, Chemiosmotic hypothesis; inhibitors of electron transportchain
   4. Gluconeogenesis, Glycogenesis, Glycogenolysis; regulation of glycogen synthesis and breakdown .
   5. Pentose phosphate pathway (HMP pathway) and itssignificance
   6. Uronic acidpathway

### Amino acid metabolism (4 hrs)

* 1. Biosynthesis and degradation of amino acids - glutamic acid, phenyl alanine,methionine, tryptophan, isoleucine, histidine,valine.
  2. Fate of amino acids in thebody
  3. Transamination, Decarboxylation and deamination reactions in the biologicalsystem.

### Lipid metabolism (5hrs)

* 1. Oxidation of fattyacids
  2. Biosynthesis of fattyacids
  3. Biosynthesis ofcholesterol

### Nucleic acid metabolism (4hrs)

* 1. Biosynthesis and degradation of purines andpyramidines

# Part B. Cytogenetics (36 hrs)

### Introduction to Cytogenetics (1hr)

1. **Membrane structure and function . (4hrs)**
   1. Molecular organization of cell membrane - Lipid bilayer and membrane protein. Molecular models of cellmembrane.
   2. Cell permeability-osmosis, diffusion, ion channels, active transport, membranepumps.
   3. Mechanism of sorting and regulation of intracellulartransport.
   4. Electrical properties ofmembranes.
   5. Microvilli and cell coat.

### Structural organization and function of intracellular organelles- (6hrs)

Nucleus, Mitochondria, Golgi complex, Lysosomes, Endoplasmic reticulum, Ribosomes, Peroxisomes and Cytoskeleton.

### Organization of chromosomes and genes.(6hrs)

* 1. Structure of chromatin and chromosomes, heterochromatin, euchromatin –unique and repetitiveDNA
  2. Chromosomal changes- euploidy, aneuploidy, chromosomal aberrations- Structural alterations- gene mutations- molecularchanges- deletion, duplication, translocation, inversion and sister chromatid exchange.
  3. Interrupted genes and genefamilies.
  4. Concept of gene- Allele, multiple alleles, pseudoallele, complementationtests.
  5. Extrachromosomal inheritance- inheritance of mitochondrial and chloroplast genes, maternalinheritance.

### Cellular communication (6hrs)

* 1. General principles of cellcommunication
  2. Cell-cell interactions – cell adhesion and roles of different adhesionmolecules
  3. Intercellular attachments- gap junctions, desmosomes, intermediary and tightjunctions.
  4. Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes.
  5. Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins,Adherens.

### Cell signaling (8hrs)

* 1. Signal transduction
  2. Concept ofcell-signaling
  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 guanyl cyclase, cGMP, PKG, Histidine kinase associated receptors
  4. Receptordesensitization
  5. Signaling by nitric oxide, carbonmonoxide
  6. Signalingnetwork

### Apoptosis and its significance (5 hrs)

* 1. Necrosis; Programmed and induced celldeath
  2. Process of apoptosis: Initiation, Execution: cytochrome C, caspases,Phagocytosis
  3. Regulation of apoptosis - Extracellular andIntracellular
  4. Apoptosis in *Caenorhabditis elegans, Drosophila*, mammals and bacterialpopulation
  5. Mechanism of celldeath
  6. Genes involved in apoptosis.

# References Biochemistry

1. David L Nelson & Michael M Cox Lehninger, Principles of Biochemistry, VIth edition, (2013) Mac Millan
2. Robert Harper's Biochemistry, (2012) 29th Edition, K. Murray, Daryl K. Granner, Peter, A. Mayes andVictor,W.RodwellAppletonandLange,PrenticeHallofIndiaPrivatelimited,NewDelhi,
3. Lubert Stryer,(2011) Biochemistry, VII th edition, W.H. Freeman &Co.
4. Eric E. Conn, Paul K. Stumpf, George Bruening, Roy H. Doi, (2007) Outlines of Biochemistry, Vth edition, John Wiley & Sons,Inc.
5. Deb, A.C.(2004) Fundamentals of biochemistry, New Central Book Agency (P)Ltd.
6. Keith Wilson and John Walker (2008) Principles and techniques of Biochemistry and Molecular biology - 6th edn, Cambridge UniversityPress
7. Voet, D. and Voet, J.G. & Pratt (2012). Principles of Biochemistry, John Wiley &sons.
8. Zubay, G (1997 ). Biochemistry, Mc Graw – HillPublications
9. Devlin,T.M. (2010). A Text of Biochemistry with clinical correlations, John Wiley&sons.
10. Lenhninger, A. L. (2008). Principles of Biochemistry. (5th edn). CBS Publishers and Distributors, NewDelhi.
11. Mathews, H. R., Freeland, R. and Miesfeld, R. L. (1997). Biochemistry: A Short Course – Wiley- Liss, Inc.NY.
12. Mary, K. Campbell (1995) Biochemistry. II Ed. Harcourt Bracce and Co.Florida.
13. Murray, Robert, Granner, K. and Harper, Daryl K. (2006). Harper‟s Illustrated Biochemistry. Mc Graw-Hill, NewYork.
14. Nelson, D. L. Cox, M. M. and Lehninger, A. L. (2007). Principles of Biochemistry, 4th Ed. Freeman and Co,NY.
15. Stryer, L. (2011). Biochemistry. 7th Ed. W. H. Freeman & Co. NewYork.
16. Zubay, G. L., Parson, W. W. and Vance, D. E. (1995). Principles of Biochemistry, Brown Publishers, England.

# Cytogenetics

1. Becker, W. M., Reece, J. B. and Poenie, M. F. (1999; 2000). The World of the Cell, 4th edition, Benjamin/Cummings PublishingCo.
2. Benjamin Lewin (2008). Genes IX. Jones & Bartlett Learning Publishers, NewYork.
3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter(2002). Molecular Biology of the Cell. 4th Edition, Garland Science, NewYork.
4. De Robertis, E. D. P. and De Robertis, Jr. E. M. F. (1996). Cell and Molecular Biology,Eighth Edition, B.I. Waverly Pvt Ltd, NewDelhi.
5. Karp, G. (2002). Cell and Molecular Biology. John Wiley, NewYork.
6. Kleinsmith, L. J. and Kish, V. M. (1995). Principles of Cell and Molecular Biology (Second Edition). Harper Collins College Publishers, NewYork.
7. Peter Snustad, D. and Michael J. Simmons (2000). Principles of Genetics. 2nd Ed. John Wiley & SonsInc.
8. Purves W. K., Orians G. H. and Heller H. C. (1995). Life: The Science of Biology, 4th Edition. Sinauer Associates,Sunderland.
9. Robert H. Tamarin (2002). Principles of Genetics, 7th Edition, Tata McGraw-Hill Education Pvt Ltd, NewDelhi.
10. Sheeler, Philip and Donald, E. Bianchi. (1987) Cell and Molecular Biology. III Ed. JohnWiley.
11. Watson J. D., Hopkins N. H., Roberts, J. W., Steits, J. A. and Weiner, A. M. (1987). Molecular Biology of the Gene 4th Edition. The Benjamin Cumming. Publishing Company. Menlo Park, California.

# FIRST SEMESTER THEORY

**ZOL1C02 - BIOPHYSICS AND BIOSTATISTICS (90 Hours)**

**COURSE OUTCOMES (COs)**

CO1 Be familiar with the colloidal System, diffusion and osmosis, pH and bioacoustics

CO2 Understand basic techniques of radiation biology, biophysical methods and electrophysiological methods

CO3 to understand communicate basic principles and applications of SEM &TEM

CO4 Should be able to understand the separation techniques, influence of gravity, nanotechnology

CO5 Understand the Scope and role of statistics and understand the basics of data, statistical methods, probability distributions

CO6 Identify and differentiate the statistical inference, correlation and regression

CO7 Can understand the basics of ecological data analysis

**Part A. Biophysics (54 hrs)**

### Colloidal System (3 hrs)

* 1. Crystalloids andColloids,
  2. Properties of colloids- Kinetic, optical and electrical properties- Electrosmosis, Cataphoresis,Coagulation.
  3. Forms of colloids, Suspensions and Emulsions, preparation and properties ofemulsions.
  4. Biological importance of colloids.

### Diffusion and Osmosis (4hrs)

* 1. Fick's laws and diffusioncoefficient.
  2. Gibb's Donnanequilibrium.
  3. Application of diffusion processes in biology:haemolysis.
  4. Osmosis, Osmotic concentration, Osmotic pressure and osmoticgradient.
  5. Vant Hoff's laws
  6. Electrolytic and ionic balance in biologicalfluid.

### PH (2hrs)

3.1 Dissociation of water.

* 1. Dissociation of a weakacid.
  2. Henderson Hasselbalchequation.
  3. Electrometric determination of pH, pH meter
  4. PH valuecalculation.
  5. Buffer –Importance of buffers inbiology.

### Bioacoustics (5hrs)

* 1. Characteristics ofsound.
  2. Physical basis ofhearing.
  3. Physical organization of ear.
  4. Physical aspects of sound transmission in the ear.
  5. Audible soundfrequency.
  6. Pitch perception and theories.
  7. Infrasonic and ultrasonicsounds.
  8. Echolocation; receiving and analyzing echoes

### Radiation Biology (9 hrs)

* 1. Radioactivity, different types ionizing radiations and theirsources
  2. Radioactive disintegration. Decay curve,half-life.
  3. Biological effects of ionizing radiations – effects at macromolecular,cellular and organ system level, effects of whole body irradiation-Radiationtherapy.
  4. Biological applications ofradioisotopes.
  5. Radiation dosimetry- dose units and dosemeasurement.
  6. Radiation Detectors - GM Counter, Solid and Liquid Scintillation Counter, Proportional counter, Semiconductordetectors.
  7. Autoradiograph

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

* 1. Properties of electromagneticradiations.
  2. Molecular analysis using UV / visiblespectroscopy.
  3. Mass spectroscopy.
  4. NMR and Electron Spin Resonance (ESR) spectroscopy-Applications
  5. Structure determination using X-ray diffractioncrystallography.
  6. Circulardichroism.
  7. Surface Plasma Resonance(SPR)

### Electrophysiological methods (Brief) (3hrs)

* 1. Single neuronrecording.
  2. Patch clamprecording.
  3. ECG.
  4. Brain activityrecording.
  5. Lesion and stimulation ofbrain.
  6. Pharmacologicaltesting.
  7. PET (Positron Emission Tomography), MRI, fMRI,CAT.

### Principles and applications of (8hrs)

* 1. Fluorescent, Interference, Scanning and Transmission electron microscopes (SEM &TEM).
  2. Resolving powers of differentmicroscopes.
  3. Different fixation and staining techniques for EM (freeze-etch and freeze fracture methods for EM-image processing methods inmicroscopy).
  4. Laser and its applications inBiology

### Separation Techniques (10hrs)

* 1. Chromatography - Different types - Adsorption, Partition and Ion exchangechromatography
     1. Column chromatography
     2. Paperchromatography
     3. Thin- layerchromatography
     4. Gel-filtration.

9.1.5. Gas chromatography,

* + 1. Affinitychromatography,
    2. HPLC – Applications of HPLC
  1. Electrophoresis - Applications of HPLC
     1. Paperelectrophoresis
     2. Discelectrophoresis
     3. PAGE, Two dimensional PAGE, HighvoltageElectrophoresis
  2. Isoelectricfocusing.

### Influence of gravity (3hrs)

* 1. Human body posture in the gravitationalfield
  2. Influence of Gforce.
  3. sForce of centrifugal acceleration - importance of aviation and spacetravel
  4. Effect of positive G. Force & negative G.Forces.
  5. Protection against G.Force
  6. Influence of linear acceleration on thebody

### Nanotechnology (2hrs)

* 1. Definition
  2. Nanotechnology and its applications in the field of healthcare.
  3. Role of nanotechnology in environmentalmanagement.

# Part B –Biostatistics (36 hrs)

### Introduction (2hrs)

* 1. Biostatistics:Definition,
  2. Characteristics ofStatistics
  3. Importance and usefulness ofstatistics
  4. Limitations ofStatistics

### Data (5 hrs)

* 1. Types of data: classification based on Source of data, Compilation, Variable, Nature.
  2. Methods of data collection andclassification.
  3. Types of samplingmethods.
  4. Advantages and disadvantages of census and samplingmethod.
  5. Class intervals- exclusive and inclusivemethod
  6. Frequency curve (types. skewness, kurtosis,ogive)

### Statistical Methods: Measures of central tendency and dispersal (4hrs)

* 1. Mean, (raw data, discrete series and continuousseries)
  2. Standard deviation, Standard error, degree of freedom (raw data, discrete series and continuous series)
  3. Quartile deviation- Box- whiskerplot

### Probability distributions (4hrs)

* 1. Basic concepts anddefinition:
  2. Laws ofprobability
  3. Probability distribution: - Binomial, Poisson and Normal

### Statistical inference (problems to be discussed) (7hrs)

* 1. Difference between parametric and non-parametricstatistics;
  2. Testing ofhypothesis
  3. Errors
  4. Confidence interval; levels of significance, Criticalregion;
  5. Normalitytest
  6. t-test, chi-square test, F-test,ANOVA
  7. Kruskal-Wallis,Mann-Whitney

### Correlation and Regression (problems to be discussed) (7hrs)

* 1. Types ofcorrelation.
  2. Methods to measure correlation- Scatterdiagram.
  3. Karlpearson's coefficient of correlation, Spearman'scorrelation
  4. Types of regressionanalysis
  5. Regression equations
  6. Difference between regression and correlationanalysis

### Ecological data analysis (problems to be discussed) (7hrs)

* 1. Alphadiversity

Shannon diversity index, Simpsons Dominance index, Pielou‟s evenness index, Margalef species Richness, Fisher‟s apha,

* 1. Betadiversity

Morisita Horn index, Sorenson index, Bray-Curtis similarity

7.3 Designing Good field studies – Scale of measurement, Statistical inference, Data record

# References

### Biophysics

1. Ackerman, E. (1962).Biophysical Science. Prentice HallInc.
2. Alonso, A and Arrondo, J.L.R (2006) - Advanced techniques in Biophysics,Springer
3. Alok Srivastava and Ipsita Roy-(2009)-Bio-Nano- Geo Sciences- The future challenge-Ane Books Ltd.
4. Baker, E.J and Silverton, R.E. (1978) - Introduction to medical laboratory technology,ELBS
5. Bengt Nolting (2006), Methods in modern Biophysics 2ndedn.Springer.
6. Daniel, M (2002), Basic Biophysics for Biologists. Agro Botanics,Bikaner
7. Das, D. (1991) Biophysics and Biophysical Chemistry, Academic Publishers,Calcutta.
8. Ernster, L (1985), Bioenergetics, Elsevier, NewYork.
9. Frank H. Stephenson (2006)- Calculations for Molecular Biology and Biotechnology-A guide to Mathematics in the laboratory-Academic Press- An imprint ofElsevier.
10. Ghatakk.L. (2011).Techniques and methods in Biology.PHI, Learning Pvt. NewDelhi.
11. Gupta.A. (2009). Instrumentation and Bio-analytical techniques.Pragati Prakashan,Meerut.
12. Hoppe, W, Lohmann,W, Markl,H and Ziegler,H (1983). Biophysics. Springer Verlag,New York.
13. Keith Wilson and John Walker (2008), Principles and techniques of Biochemistry and Molecular biology - 6th edn, Cambridge UniversityPress
14. Marshall, A.G. (1978) Biophysical Chemistry, Principles, Techniques and Applications-John Wiley and Sons, NewYork
15. Mohan P. Arora-(2007), Biophysics -Himalaya PublishingHouse.
16. Muralidharan.V.S. and Subramania, A (2010)- Nanoscience and Technology- Ane BooksLtd.
17. Narayan, P (2000) Essentials of Biophysics. New ageinternational
18. Nagini.S (2009)- Instant Biochemistry-Ane BooksLtd.
19. Roy, R.N (1996)-A text book of Biophysics-New central book AgencyCalcutta.
20. Srivastava, P.K (2006)-Elementary Biophysics, An introduction. Narosa publishing house New Delhi.
21. Subramanian.M.A. (2005). Biophysics: Principles andTechniques.
22. Viswanathan. B (2009)-Nano Materials- Narosa PublishingHouse.

# Biostatistics

1. Agarwal, B.L. (1996) Basic statistics, New Age International(P) Ltd. Publishers, NewDelhi.
2. Bailey, N.T.J. (1981) Statistical methods in Biology. Hodder and Stongtton,London.
3. Campell, R.C. (1978), Statistics for biologists. Blacker and Sons Publishers,Bombay.
4. Gupta, C.B. and Gupta, V. (2002) Statistical methods. Ikas Publishing House, NewDelhi.
5. Rostogi, V. B. (2009) Fundamentals of Biostatistics. Ane's Students Edition, NewDelhi.
6. Magurran AE. 2004. Measuring Biological Diversity. BlackwellPublishing
7. Stephen W,Looney(2008) Methods in Molecular Biology-Biostatistical Methods Springer International Edition
8. Zar, J.H. (2003) Biostatistical Analysis - Fourth edition. Pearson Education. NewDelhi.

# FIRST SEMESTER THEORY

**ZOL1C03 - ECOLOGY AND ETHOLOGY (90 Hours)**

**COURSE OUTCOMES (COs)**

CO1 Aquired broad-based knowledge of the fundamentals of Ecology, Behavior and Evolution and the relationships among these disciplines.

CO2 Students demonstrated an ability to understand and apply fundamental quantitative skills, including models and statistical analyses, so as to properly interpret published research and apply such skills in their own research.

CO3 Obtained knowledge in Animal behaviour and the evolution of fixed and plastic behaviours, Life history evolution, parental investment, parent-offspring conflict and the evolution of behavior, Cooperative behaviour of animals, with particular emphasis on group living

CO4 Basic behavioural data collection and experimental design, including welfare and ethical implications are conceived

CO5 Conceived the evolution of optimal strategies, using examples from behavioural ecology

**Part-A-Ecology (54 hrs)**

### Introduction (3hrs)

* 1. Habitat and niche
     1. Concept of habitat and niche
     2. Niche width and overlap
     3. Fundamental and realized niche
     4. Resource partitioning
     5. Character displacement
     6. Neuroethology; communication (chemical, acoustic and visual signaling); recognition systems

### Ecosystem (9 hrs)

* 1. Structure and function
  2. Ecosystem energetics
  3. Primary production
  4. Energy flow models
  5. Mineral cycling(CNP)
  6. Trophic levels, Food chain, food web and secondary production
  7. Decomposers and detritivores

### Population Ecology (7hrs)

* 1. Characteristics of a population
  2. Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations

3.3 Sampling methods in the study of behaviour, habitat characterization

* 1. Ground and remote sensing methods
  2. Population growth curves, Life tables, survivorship curves, population regulation, Life history strategies, r and k selection, Demes and dispersal, interdemic extinctions, age structure of populations.
  3. Growth and regulation of human population

### Species interaction (5hrs)

* 1. Types of interactions, interspecific competition
  2. Herbivory, Carnivory, Pollination, Symbiosis; mutualism, commensalisms and proto co- operation

### Community Ecology (4hrs)

* 1. Nature of communities**.**
  2. Characteristics of a biotic community**.**
  3. Species diversity and latitudinal gradients in diversity.

5.4 Edges and ecotones.

### Ecological succession (4hrs)

* 1. Types, mechanisms, changes involved in succession.

6.2 Concept of climax

### Biogeography (6 hrs)

* 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
  2. Observational- For different taxa- Direct Quadrats; fixed-area plots, Avian point counts, Spot mapping, Line transect, Focal Animal Sampling, Visual Encounter Survey, Pollard Walk

### Biogeographical zones of India (4hrs)

(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.

### Applied Ecology (8hrs)

* 1. Carbon credit, Carbon trading, Blue Carbon
  2. Green building technology and its ecological importance.
  3. Discuss the benefits and disadvantages of the idea of(brief)

1. Inter linking of major rivers of India,
2. Sethusamudram ship canal project.
3. Biodiversity with special reference to India-status monitoring and documentation, major drivers of biodiversity change.

### Conservation Biology (4hrs)

* 1. Principles of conservation.
  2. Major approaches to management,
  3. Indian case studies on conservation & management strategy (concepts of project tiger, Biosphere reserves).
  4. Social living: Costs and benefits of group-living (including responses to predators); effect of competition (scramble and contest) on group formation; dominance relationships; eusociality; reciprocity;

# Part B. Ethology (36 hrs)

### Introduction (1hr)

1. **Concepts of Ethology (4hrs)**
   1. Ethology as different from the other schools studying animal behavior like behaviourism.
   2. Behaviour as a reaction to stimuli - sign stimuli, social releasers, Ethograms, super normal stimuli, stimulus filtering.
   3. Concepts of Fixed Action Patterns (FAP), Innate Releasing Mechanism (IRM),Action Specific Energy(ASE),Concepts of Learning and Imprinting.

### Motivating factors (3hrs)

* 1. General factors in motivation; Studies of motivation in guppies;
  2. Mating systems-parental investment and reproductive success

### Conflict behaviour- stress-displacement activities- Ritualization. (2hrs)

1. **Instinctive behaviour & reflex action, neural basis of sleep and arousal.(2hrs)**
2. **Learning**- Neural basis of learning, memory, cognition, sleep and arousal**(3hrs)**

Biological clocks

### Adaptiveness of behaviour (3hrs)

JP Scott‟s categories of behaviour.

### External stimulus - circadian rhythms (3hrs)

8.1- Proximate and Ultimate factors.

8.2-Types of orientation-reafference theory of Von Holst & Mittel Steadt. 8.3-Navigation & migration

### Parental care – (6hrs)

* 1. Mating systems, Parental investment and Reproductive Success.
  2. Development of behavior.
  3. Social communication; Social dominance; Use of space and territoriality; domestication and behavioural changes; Social behaviour of termites &Primates;

### Evolution and advaptiveness of behaviour (4hrs)

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

### Hormones and Behaviour- (5hrs)

Hormones of gonads, adrenal gland, Pituitary gland,-Hormonal effects on different behavioural patterns , Maternal behavour- mechanism of hormonal action.

# References

**Ecology**

1. Ahluwalia and Sunitha Malhorta-Environmental Science-Ane BooksPvt.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 ofWorld Vegetation. New York, NY: Chapman and Hall.
4. Begon,Harper, Townsend- Ecology- Individuals, Populations, and communities- Blackwell Science, Second edition
5. Brewer Richard (1994).The Science of Ecology-Saunders college publishing.
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.
8. David Quammen. 1997. The Song of the Dodo: Island Biogeography in an age of Extinctions. Scribner. ISBN0-684-82712-3
9. Dick Neal- Introduction to population Biology- Cambridge University Press
10. Eugene P.Odum- Fundamentals of Ecology- W.B.Saunders Company.
11. Fred, Van Dyke (2003). Conservation biology-foundation concepts, applications-Mc Graw Hill, New Delhi.
12. MacArthur, R. H. and Wilson, E. O.(1967). The Theory of Island Biogeography. Princeton, N.J.: Princeton University Press.
13. Magurran, A. E.(2004). Measuring biological diversity. Oxford: Blackwell Publishing. ISBN 0-632-05633-9
14. May and Mc Lean- Theoretical Ecology principles and applications-Oxford University Press
15. Peter.S.(2002). Ecology- Theories and Applications. Prentice Hall of India.
16. Whittaker, Robert H. Communities and Ecosystems New York: MacMillan Publishing Company, Inc.,1975.

# Ethology

1. Chris Barnard (2003): Animal Behaviour: Mechanism, Development, Function and Evolution, Publisher: Pearson Education.
2. David McFarland (1999): Animal Behaviour: Psychobiology, Ethology and Evolution, 3rd Edition. Publisher: Pearson Education.
3. David Mcfarland (2006) A Dictionary of Animal Behaviour. Publisher: Oxford University Press.
4. Goodenough, J; McGuire B. and Robert, W. (1993) Perspectives on Animal Behaviour. John Wiley and Sons,Lond.
5. Graham Scott (2004) Essential Animal Behaviour. Publisher:Wiley-Blackwell
6. Lenher, P. (1996) Handbook of Ethological methods. Cambridge Univ.Press,Lond.
7. Manning, A. (1967) An Introduction to Animal Behaviour. Edward Arnold Pub.,London.
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 of Chicago.

# FIRST SEMESTER PRACTICALS ZOL2L01 - BIOCHEMISTRY

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

# ZOL2L02 - CYTOGENETICS

1. Homogenization, cell fractionation and isolation of nuclearfraction.
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 meioticstages.
5. Study of normal human karyotype (male and female).
6. Studyofgeneticsyndromes-Down‟s,Klinefelter‟s,Turner‟sandEdward‟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),Biochemicalmethods,NewAgeInternational,NewDelhi.
4. Keith Wilson and John Walker (2008), Principles and techniques of Biochemistry and Molecular biology - 6th edn, Cambridge UniversityPress.
5. Jayaraman, J.(1981) Laboratory Manual in Biochemistry, Wiley EasternLtd.
6. Thimmaiah ,S.K.(2004). Standard methods of Biochemical analysis. Kalyani Publishers,Ludhiana.
7. Sawhney, S.K.and Singh Randhir (2006).Introductory Practical Biochemistry. Narosa Publishing House, NewDelhi.
8. Winchester.A.M.(1964). Laboratory Manual Genetics. Brownca Publishers,Dubuque,Iowa.
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 ofpH
2. Paper chromatography of aminoacids
3. Separation and identification of amino acids inmixtures
4. Thin layerchromatography.
5. Gelelectrophoresis.
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 Cameralucida.

### Biostatistics

1. Preparation of frequency table with givendata
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 keepprint.
4. Computation of measures of central dispersion anthropometric data of School children. (prepare same in Excel and keep print outs and add steps forexcel)
5. Simulation of binomial and poison distributions.
6. 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 forexcel).
7. 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).
8. 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 forexcel)
9. Designing of an flowchart for the ecological field studies (The key dichotomy is whether or not you are studying events you can control)

### 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 Norstrant Reinholdco.
4. Hoppe, W (1988). Biophysics, SpringerVeilag.
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 andSons.

# ZOL2L03 - Ecology and Ethology

### Part A. Ecology

1. Identification of marine planktons.
2. Quantitative estimation of marine planktons.
3. Estimation of BOD in polluted water sample.
4. Estimation of nitrates-nitrogen in water samples.
5. Separation and identification of soil arthropods using Berlese funnel.
6. Determination of moisture content of soil sample.
7. Determination of water holding capacity of soil sample.
8. Testing the transparency of water using Secchi disc
9. Determination of primary productivity in pond water using light and dark bottle.
10. Determination of population size ;Students determine the size of arthropod populations by using various sampling designs and methods to estimate population size: (a) transect record (in two 30 cm wide zones along both sides of a 20 m long transect students record all visually detectable arthropods (morphospecies identity and number of individuals) also considering distance perpendicular to the line). From these data they estimate the size of the whole arthropod population present on site. (b) Knocking (the arthropod assemblage from individual shrubs is collected in this way); and (c) quadrate study (the abundance of arthropods is determined in 45x45 cm rectangular quadrats placed randomly in the field).
11. Study of various Animal sampling techniques - Fruit bait traps, light trap and other sampling methods
12. Advanced data handling, analysis and visualization (‘data science’). With softwares such as BioDiversity Pro or EstimateS
13. Study of termitorium / ant colony
14. 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)
15. 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 under taken. 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.
16. Designing of an flowchart for the ecological field studies

### 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:

1. NC Aerry, N.C. (2010) - A manual of environmental analysis . Ane books privatelimited.
2. Goodenough, J; McGuire B. and Robert, W. (1993) Perspectives on Animal Behaviour. John Wiley and Sons,Lond.
3. Manning, A. (1967). An Introduction to Animal Behaviour. Edward Arnold Pub.,London.
4. Manning, A. and Dawkins,M.S.(1995).An introduction to Animal Behaviour, CambridgePress.
5. Bonnie,J, Plager and Ken Yamkawa (2003). Exploring Animal Behaviour in Laboratory and Field. Academic press.
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 THEORY ZOL2C04 - PHYSIOLOGY (90 Hours)

**COURSE OUTCOMES (COs)**

CO1 Perform human salivary amylase activity by colorimetric method, Qualitative demonstration of digestive enzymes in cockroach, Peptic value calculation, GI tract movements and its regulation by hormones, Obesity and BMR.

CO2 Perform urea and ammonia estimation, Understand different types of excretory organs, Structure and anatomy of Mammalian kidney and bladder, Urine formation, Osmoregulation and Renal clearance.

CO3 Determine Respiratory quotient of aquatic animal; understand the anatomy of respiratory organs, Mechanism of Pulmonary and Alveolar Ventilation and its neuro-physiological control, Pulmonary volumes and capacities and Oxygen Dissociation Curve.

CO4 Describe the structure, organization and functional areas of Human brain and its Protection, Diseased states of Brain, Memory, PNS and ANS, Spinal cord and Mechanism of Reflex action.

CO5 Understand Special Senses- Vision-Structure of Eyeball and mechanism of Image formation; Taste- Primary sensation, Structure of Taste buds and physiology of Taste; Smell- Olfactory receptors and physiology of smell.

CO6 Understand Tactile responses- Mechanoreceptors, Pain receptors and Thermal receptors

CO7 Understand the structure and physiological anatomy of myogenic heart and its neural regulation, Cardiac cycle, Blood volumes, Coronary blood flow and heart diseases.

CO8 Describe Lymph channels, composition and function of Lymph, RBC enumeration, ESR, Hemoglobin estimation, Blood clotting time calculation and WBC differential count.

CO9 Understand Body temperature and its Regulation, Acclimatization.

### Nutrition (10hrs)

* 1. Constituents of normal diet and their dailyrequirements.
  2. Physiological calorie value of foodstuffs.
  3. Antioxidant nutrients.
  4. Movements of GI tract: deglutition, gastric motility and emptying, intestinal motility and defecation.
  5. The role of hormones and neurotransmitters in the control of gastrointestinalmotility.

1.6 Energy balance and obesity-causes andconsequences.

1.7. BMR and its significance.

### Excretory System (12hrs)

* 1. Introduction: Brief description of different types of excretory organs in different animal groups (flame cells, green glands, malpighiantubules).
  2. Functional anatomy of mammalian kidney, nephron and juxtaglomerular apparatus structure, parts andfunction.
  3. Urine formation (glomerular filtration, tubular reabsorption and tubularsecretion)
  4. Regulation of water balance -Mechanism of concentration of urine – Counter Current system (counter current multiplier and counter currentexchanger)**.**
  5. Renal regulation of acid- base balance & electrolytebalance**.**
  6. Structure of urinary bladder, micturition reflex andmicturition**.**
  7. Renal clearance – definition, concept and significance; clearance value of urea,creatinine, phosphate, potassium, chloride and sodium.

### Respiratory system (10hrs)

* 1. Introduction: Brief description of major respiratory organs (tracheal system, book lungs, gills and ctenidia)**.**
  2. Physiological anatomy and histology of respiratory passage andlungs.
  3. Mechanism of pulmonary ventilation (inspiration & expiration).
  4. Alveolar ventilation, dead space and its effect on alveolarventilation**.**
  5. Role of surfactant in alveolarexpansion**.**
  6. 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 lungcapacity)**.**
  7. Exchange of gases- partial pressures involved-lung andtissues.
  8. Oxygen dissociation curve – factors affecting binding of oxygen to haemoglobin (PO2, PCO2, CO, pH, body temperature, diphosphoglyceric acid level, foetal haemoglobin and also myoglobin).Pulse oximetry

3.8. Neural and chemical regulation of respiration: Respiratory centres & factors regulating respiration.

### Nervous system (21 hrs)

* 1. Organisation of humanbrain.
     1. Cerebrum and cerebrallobe.
     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, wernick’s area, Brodman map, cerebral dominance.
     3. Cortical white matter- commissures, association fibers, projection fibers,corpus callosum and fornix, basal nuclei-organisation andfunction.
     4. Brain stem- organisation and function.
     5. Cerebellum- structure andfunction.
     6. Diencephalon – organisation andfunction.
  2. Functional brain systems - Limbic system and reticularformation.
  3. Protection of brain – Meninges, cerebrospinal fluid- formation and function, blood brain barrier and itsfunction.
  4. Diseased states of brain - schizophrenia, Alzheimer’s disease, Senile dementia & Parkinso’s disease.
  5. Memory- definition, types of memory- short term, intermediate long term and long term memory, consolidation ofmemory.
  6. PNS and Autonomic nervoussystem.
  7. Spinal cord – structure.
  8. Reflex action, reflex arc, monosynaptic and polysynaptic reflexes, inverse stretch reflex and golgi tendonorgan.

### Special senses (16hrs)

* 1. **Vision:**
     1. Structure of eyeball
     2. Fluid systems of theeye
     3. Layers of Retina and photoreceptors (rods &cones)
     4. Brief notes on the neuronal cell types and neural circuitary of the retina and visual pathways from retina to visualcortex
     5. Imageformation
        1. Formation of image on the retina.
        2. A brief general account of electrophysiology ofvision
        3. Photochemistry of vision & colour vision

### Taste:

* + 1. Primary sensations of taste (agents and site ofsensation)
    2. Taste buds (location, structure, receptors and nervesupply)
    3. Physiology of taste (receptor stimulation, generation of nerve impulse by taste buds and its transmission to CNS)

### Smell:

* + 1. Olfactory membrane and receptorcells
    2. Physiology of olfaction (stimulation of olfactory cells and transmission of smell signals to CNS)

1. **Tactile response:** (brief note**)(4hrs)**
   * 1. Mechanoreceptors and theirstimulation
     2. Pain receptors and theirstimulation
     3. Thermal receptors and theirstimulation

### Cardiovascular system(8hrs)

* 1. Introduction: Brief description of vertebratehearts
  2. Structural organization of myogenic heart (in humanbeings).
  3. Physiological anatomy of cardiac muscle – specializedtissue**.**
  4. Heart as apump.
  5. Cardiaccycle**.**
  6. Neural and chemical regulation of heartfunction**.**
  7. Blood volume and bloodpressure**.**
  8. Physiological anatomy of coronary blood flow, coronary blood flow and itscontrol**.**
  9. Ischemic heart disease – mentioncauses.

### Lymphatic System (5hrs)

* 1. Lymph channels of thebody**.**
  2. Composition and formation oflymph**.**
  3. Functions of lymph and lymphatic system including role of it in controlling Interstitial fluid protein concentration, interstitial fluid volume and interstitial fluidpressure.

### Environmental Physiology (4hrs)

* 1. Thermalregulation.
     1. Comfort zone, normal body temperatures (oral, skin &core).
     2. Temperature regulating mechanism (hot & cold), mention the role of hypothalamus, thyroid and adrenalglands.
     3. 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):FundamentalsofBiochemistry(2002):NewCentralBookAgency(P)LTD,India.
5. Prosser & Brown.(1973). Comparative Animal Physiology. W.B.Sauders andCo.
6. William S. Hoar.(1966). Comparative Animal Physiology . Prentice Hall, Inc.USA.
7. Kunt-Schmidt-Nielsen.(1994).Animal Physiology, Adaptation and Environment.Cambridge UniversityPress.
8. Jensen D. (1976): Principles of Physiology, Appleton Century Crafts,N.Y.
9. Lonco,G.N.(1993):PhysiologicalAnimalEcology.Longman Scientific and TechhnicalEssex.
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. Blackwall Scientific 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

**ZOL2C05 - MOLECULAR BIOLOGY (90 Hrs)**

**COURSE OUTCOMES (COs)**

CO1 Developing academically sound future researchers and intellectuals in the area of molecular biology

CO2 Understand how protein or enzymes of our body are synthesizing through detailed study of gene expression mechanisms

CO3 Understand how human genome is organized through the study of special features, components and complexity of eukaryotic genome

CO4 Provide knowledge about organization of different gene families in different organelles and organ systems and its expression in man

CO5 Understand about transposons and its role in gene expression in both prokaryotes and eukaryotes

CO6 Help to learn about how genetic variation occur through recombination

CO7 Understand about E.coli bacterial genome and different methods of its genetic transfer

CO8 Got a thorough knowledge about cancer biology and its new therapies like immunotherapy and gene therapy.

### DNA replication (11Hrs)

* 1. Semidiscontinuous synthesis-Okazakifragments
  2. Replication origin and replicationfork
  3. Unit of replication, extra chromosomal replicon of bacterial Tiplasmid
  4. Enzymes/proteins of replication- Primase, Replisomes, Helicase, DNA polymerases, Single strand binding proteins, Topoisomerases andLigase;
  5. Fidelity ofreplication
  6. Replication of the ends of eukaryotic chromosome – role oftelomerase
  7. Models of DNA replication –Rolling circle model and looped rolling circle model, D-loop model,θ-model.
  8. Inhibitors of DNA replication – Methotrexate andFluorodeoxyuridylate

### Safeguard systems of DNA (5Hrs)

* 1. Restriction: significance, role and features of Type I, II & III restrictionenzymes
  2. Modification: enzymes andsignificance
  3. Repair:
     1. Major kinds of damage to DNA andcauses
     2. Repair mechanisms: Direct reversal, Mismatch repair, Excision repair, Recombination repair, SOSresponse

### Transcription of mRNA in prokaryotes and eukaryotes (10Hrs)

* 1. Structural organisation and life span of mRNA; monocistronic and polycistronicmRNA
  2. Transcription in prokaryotes andeukaryotes
     1. Promoter (mention Pribnow, TATA, CAAT and GC box), enhancer and silencersites
     2. Transcription factors; Transcription activators andrepressors
  3. Characteristic features of RNA polymerases of phages, prokaryotes and eukaryotes and theirfunctions
  4. Post transcriptional modification ofRNA
     1. Capping
     2. Polyadenylation
     3. Splicing
  5. RNA editing: site specific deamination and role ofgRNAs
  6. mRNAtransport

### Genetic code (5Hrs)

* 1. Characteristics of geneticcode
  2. Start codons and stopcodons
  3. Degeneracy of the code: Wobble hypothesis and isoacceptortRNAs
  4. Special features of the genetic code in mitochondria, mitochondrialtRNA
  5. Variations in the genetic code in *Mycoplasma* and*Tetrahymena*
  6. Point mutations that alter genetic code (missense, nonsense &frameshift)

### Ribosome: The site of protein synthesis: (2Hrs)

* 1. Structure
  2. Composition; Reconstitutionexperiments
  3. Activecentres
  4. Biogenesis of ribosome ineukaryotes

### Translation in prokaryotes and eukaryotes: (8Hrs)

* 1. Aminoacylation of tRNA & initiation, elongation and termination of proteinsynthesis
  2. Aminoacyl tRNA synthetases & initiation, elongation and terminationfactors
  3. Translationalproof-reading
  4. Differences in protein synthesis between prokaryotes andeukaryotes
  5. Translational inhibitors in prokaryotes and eukaryotes – role of tetracycline, streptomycin, neomycin, chloramphenicol, erythromycin, puromycin and diphtheriatoxin
  6. Post- translational modification of proteins: protein folding (role of chaperones) and biochemicalmodifications

### Control of gene expression at transcription and translation level: (9Hrs)

* 1. Regulation of gene expression in Phages – alternate patterns of gene expression for control of lytic and lysogenic cycle in λphage
  2. Regulation of gene expression in bacteria – basic features of tryptophan, arabinose and galactoseoperons
  3. Regulation of gene expression in eukaryotes–
     1. Role of chromatin in regulating geneexpression
     2. Activation and repression of transcription
     3. Regulation of translation by genearrangement
     4. Regulation of translation by alternate pathways of transcriptsplicing
     5. Antisense RNA strategies for regulating geneexpression
     6. si RNA and mi RNA inregulation

### Eukaryotic genome: (5 Hrs)

* 1. Special features of eukaryoticgenome
  2. Features, components and reassociation kinetics of Unique, Moderately repetitive and Highly repetitiveDNA
  3. Junk DNA, Satellite DNA and SelfishDNA
  4. Cot value and complexity ofgenome
  5. Organisation of human genome (briefaccount)

### Interrupted genes (4Hrs)

* 1. Definition and explanation
  2. Organisation and special features of interruptedgenes
  3. Evolution of interruptedgenes

### Gene families: (6Hrs)

* 1. Definition and concept
  2. Classification with example
     1. Simple multigene family - organisation of rRNA gene in*Xenopus*
     2. Complex multigene family - organisation of histone genes in sea urchin and tRNA genes in *Drosophila*
     3. Developmentally controlled complex multigene family e.g., globingene
        1. Globin genes and itsproducts
        2. Organisation of globin genes and its expression inMan
        3. Evolution of globingenes
     4. Concept of an evolutionaryclock
     5. Pseudogenes

### Transposable genetic elements - Transposons (6Hrs)

* 1. Definition, features andtypes
  2. Transposition andmechanism
  3. Transposons in bacteria
     1. ISelements
     2. Tn family
     3. Mu phage as a transposableelement
  4. Transposons in eukaryotes
     1. SINE, Alu family; LINE,L1
     2. P elements in*Drosophila*
     3. Transposons inMaize
  5. Retroviruses and transposition

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

* 1. Genetic recombination – types withexample
     1. Site specificrecombination
     2. Non-homologousrecombination
     3. Homologous and site specific recombination
  2. Molecular mechanism involved in homologous recombination of DNA in eukaryotes- Holliday model: Holliday intermediate, heteroduplex DNA, geneconversion
  3. Role of Rec A protein in geneticrecombination

### Microbial genetics (5 Hrs)

* 1. Prokaryotic genome- *Escherichia coli* genome – basicfeatures
  2. Methods of genetic transfers in bacteria– transformation (in *Streptococcus pneumonia*), conjugation and sexduction,transduction
  3. Brief note on mapping genes by interrupted mating (inbacteria)

### Organelle genome (4Hrs)

* 1. Chloroplast genome: specialfeatures
  2. Mitochondrialgenome
     1. Special features of yeast mitochondrial genome, petitemutants
     2. Special features of human mitochondrialgenome.

### Cancer (5Hrs)

* 1. Genetic rearrangements in progenitor cells, oncogenes, protooncogenes and tumour suppressorgenes
  2. Virus-inducedcancer
  3. Alteration of cell cycle regulation incancer
  4. Interaction of cancer cells with normalcells
  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. PearsonEducation
2. Benjamin Lewin (2008): Genes, Vol. IX, Boston, Jones,Bartlet.
3. Brown, T.A. (2006): Genomes 3.Garland Science, NewYork.
4. Elliott, W. H and Elliott, D. C. (1997): Advanced Molecular Biology, Viva Books, NewDelhi
5. Freifelder, D. (2003): Molecular Biology, Narosa Publishing House, NewDelhi
6. Gupta,P.K.(2005):CellandMolecularBiology,RastogiPublications,NewDelhi
7. Kothekar,V.(2004):IntroductiontoBioinformatics.DHRUVPublications,Delhi.
8. Kumar, H. D. (2001): Molecular Biology, Vikas publications, NewDelhi
9. Malacinski, G. M. (2005): Essentials of Molecular Biology, Narosa Publishing House,New Delhi
10. Mayers, R.A (Ed) (1995). Molecular Biology and Biotechnology: A Comprehensive Desk Reference.VCH Publishers, Inc., NewYork
11. Russel, P. J. (2009): Cell and Molecular Biology, Cengagelearning
12. Tropp, B. E. (2008): Molecular Biology, Jones andBartlet.
13. Veer Bal Rastogi (2008): Fundamentals of Molecular Biology, Ane BooksIndia
14. Watson, J. D. (1998): Molecular Biology of the gene, Benjamin Publishinghouse.
15. Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R.. (2006).Molecular Biology of the Gene, PearsonEducation.
16. Benjamin Lewin (2006). Essential Genes, Pearson,London.
17. Brown, T.A.(2000). Essential Molecular Biology. IInd ed. OxfordOUP.
18. Sinden, Richars,R.(2006). DNA structure and function. California, AcademicPress,.
19. Snustad, D.P. and Simmons, M.J.(2000). Principles of Genetics. 2nd ed. John Wileyand Sons Inc.

# SECOND SEMESTER

**ZOL2C06 - SYSTEMATICS AND EVOLUTION (90 Hours)**

**COURSE OUTCOMES (COs)**

CO1 Imparted knowledge of Systematics and Taxonomy and understand about the species concept in different levels and classification

CO2 Acquired Knowledge of how Taxonomic Collections and the Process of identification are made

CO3 Understand the Zoological Nomenclature and taxonomic procedures

CO4 Understand the Role of Newer trends in systematics

CO5 Understand the patterns and processes of evolution above the species level

CO6 Appreciate the differences between the three methods of phylogenetic analysis: evolutionary systematics, phenetics, cladistics.

**Part –A: Systematics (54 Hrs)**

### I. Introduction (1 hr)

1. **Definition and basic concepts in Systematics and Taxonomy (4hrs)**
   1. Levels ofTaxonomy
      1. Alpha, Beta and Gammataxonomy
   2. Importance and applications oftaxonomy
   3. Goals oftaxonomy
   4. Definition ofsystematics
   5. Definition ofclassification

### Species (4hrs)

* 1. Monotypicspecies
  2. Polytypicspecies
  3. Ecospecies andCenospecies
  4. Morphospecies
  5. Superspecies
  6. Species as a PopulationComplex

### Species Concepts (6hrs)

* 1. Typological SpeciesConcept
  2. Nominalistic SpeciesConcept
  3. Biological Species Concept
  4. Evolutionary SpeciesConcept
  5. Difficulties in the application of the biological speciesconcept

### Classification (7hrs)

* 1. Uses ofClassification
  2. Purpose of Classification
  3. Theories ofClassification
     1. Essentialism (b) Nominalism (c) Empiricism (d) Cladism (e) Evolutionary Classification
  4. Hierarchy ofCategories
  5. The objectives ofclassification

### Taxonomic Collections and the Process of identification ( 8hrs)

* 1. Taxonomic collections: Types of collections, Value ofCollection
  2. Purpose of scientificcollection
  3. Preservation ofSpecimens
  4. Labeling
  5. Curating ofcollections
  6. Curating oftypes
  7. Identification- Methods ofidentification
  8. Use of keys, types ofkeys.
  9. Merits and demerits of differentkeys

6.9.1 Description and publication

### .Taxonomic Characters ( 6hrs)

* 1. Nature of taxonomic characters
  2. Taxonomic characters andadaptation
  3. Kinds of taxonomiccharacters
     1. Morphological (b) Physiological (c) Ecological (d) Ethological and (e) Geographical characters
  4. Taxonomic characters andclassification
  5. Taxonomic characters andevolution
  6. Functions of taxonomiccharacters

### Zoological Nomenclature ( 6hrs)

* 1. Brief History ofnomenclature
  2. International Code of ZoologicalNomenclature
  3. The nature of scientificnames
  4. Species and infraspecies names
  5. Gender of genericnames
  6. Synonyms andHomonyms
  7. The Law of Priority
  8. Rejection of names
  9. Type method and different kinds oftypes

### Newer trends in systematics (4hrs)

* 1. DNA Bar coding
  2. Molecularsystematics
  3. Chemo taxonomy andserotaxonomy
  4. Cytotaxonomy
  5. Numerical taxonomy
  6. Cladistics

### Ethics related to taxonomic publications (4hrs)

* 1. Authorship of taxonomicpapers
  2. Correspondence
  3. Suppression ofdata
  4. Undesirable features of taxonomicpapers
  5. Taxonomist and usercommunities

### Taxonomic impediments (4hrs)

* 1. Impediments in taxonomic collections andmaintenance
  2. Shortage of manpower
  3. Lack of funding for taxonomicresearch
  4. Lack of training and libraryfacilities

11-5 Impediments in publishing taxonomic work

11.6 Solutions to overcome the impediments

1. Improve international co-operation (b) Development of taxonomiccenters

(c) Need for efficient international networking (d) the desired end product

### Part- B Evolution ( 36Hrs)

**I. Natural Selection: (7hrs)**

* 1. Mechanism of natural selection- directional, disruptive and stabilizingselection
  2. Natural selection in islands
  3. Sexual selection; intrasexual and intersexual selection- secondary sexual characteristics-sexy son hypothesis, good genehypothesis

### The Mechanisms (7hrs)

* 1. Population genetics- populations, gene pool, gene frequency, Hardy-Weinberg law, founder principle, bottleneck effect and genetic drift as factors inevolution
  2. Evidence for evolution: DNA evidence, fossil evidence, embryological evidence, geological evidence, evolution in action, imperfection ofevolution
  3. Co-evolution: microevolution, macroevolution, convergent evolution (homoplasy), divergent (parallel)evolution

### Tempo of evolution (5hrs)

* 1. Gradualism Vs punctuatedequilibrium
  2. Anagenesis Vs Cladogenesis

### Molecular evolutions (8hrs)

* 1. Neutral theory of molecularevolution
  2. Moleculardivergence
  3. Moleculardrive
  4. Molecular clocks, genetic equidistance, human mitochondrial molecularclock
  5. Phylogenetic relationships- Homology, homologous sequence of proteins and DNA, orthologous and paralogous evolution, nucleotide sequenceanalysis

### Evolutionary trends (9hrs)

* 1. Biochemical evolution- Collapse oforthogenesis
  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 mitochondrialEve
  3. Can evolution explain language? Communication, speech, language and self awareness in primates.

# References

**Part** -**A Systematics**

1. David.M.H, Craig Mortiz and Barbara K.M (1996) Molecular Systematics. Sinauer Associates,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/.../](http://www.vcru.wisc.edu/spoonerlab/.../) Bar Codes %20 and % 20 wild% 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. Kapoor V.C (1998) Theory and practice of animal taxonomy.Oxford & IBH, Publi.Co New Delhi
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. 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 ofIndia
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/.../](http://www.vcru.wisc.edu/spoonerlab/.../) Bar Codes %20 and % 20 wild % 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 andapplications
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 andcontrols.
4. Digestion in a vertebrate and calculation of pepticvalue.
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 aquaticanimal.
7. Determination of the rate of salt loss and gain in an aquatic animal (fish orcrab).
8. Estimation of urea and ammonia in human urine. Titrimetricmethod.
9. Rate of glucose – absorption – calculation of Coricoefficient.
10. EstimationofhaemoglobinofFish/Man–Sahli‟smethod.
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 humanblood.
14. Determination of lactic acid in muscletissue.
15. Differential count of humanWBCs
16. Haematocrit and ESR of humanblood.
17. WBC totalcount

### References:

1. Oser B. L.(1965). Hawk‟s Physiological chemistry, McGraw Hill BookCompany
2. Hill R.W., Wyse G.A. (1989), Animal Physiology 2nd edition. Harper CollinsPublishers
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/ generic / species level- minimum 15specimens.
3. Preparation of dichotomous (simple bracket) keys to selected families withreference
4. to insect orders Orthoptera, Hemiptera, Coleoptera, Diptera and Hymenoptera (minimum five specimens from eachorder)

### Evolution

1. Exercises in convergentevolution.
2. Exercises in divergentevolution.
3. Sympatric and Allopatricspeciation.
4. Exercises in co-evolution.
5. Calculation of genotype / gene frequency based on Hardy –Weinbergequilibrium.

### THIRD SEMESTER THEORY ZOL3C07 – IMMUNOLOGY (90 Hours)

**COURSE OUTCOMES (COs)**

CO1 Explain Hematopoiesis and its regulation, Study of cells of immune system such as T and B lymphocytes and perform its separation.

CO2 Understand Antigens and epitopes; Antibodies and production of Monoclonal antibodies, production and preparation of antiserum and new trends of antibody engineering; Demonstration of agglutination reaction, Immuno-electrophoresis and ELISA technique.

CO3 Understand B-cell and T-cell response, Enumerate different cytokines and related diseases and activation and regulation of Complement system.

CO4 Describe organization and distribution of MHC ant its role in antigen presentation; Grafts and graft rejection and its immunological perspective.

CO5 Understand allergens and hypersensitivity reactions, Immunization and Vaccination, different vaccines and its functioning, understand immune deficiency diseases, AIDS and its vaccines and Autoimmunity

1. **Introduction (1hour)**
2. **Hematopoiesis (7 hours)**
   1. Hematopoiesis – Lymphoid and myeloidlineages.
   2. Hematopoietic growthfactors.
   3. Genes that regulate hematopoiesis.
   4. Regulation ofhematopoiesis.
   5. B- Lymphocytes, T- lymphocytes and Antigen presentingcells.

### Antigens (8hours)

* 1. Immunogenicity,Antigenicity.
  2. Factors that influenceimmunogenicity.
  3. Adjuvants.
  4. Haptens.
  5. Epitopes.
  6. Properties of B-cell and T- cellepitopes.

### Immunoglobulins (Antibodies) (10hours)

* 1. Structure and function of Antibody molecules.
  2. Generation of Antibodydiversity.
  3. Immunoglobulin gene.
  4. Antigenic determinants of immunoglobulin - (a) Isotype (b) Allotype (c)Idiotype.
  5. B-cell receptor(BCR).
  6. MonoclonalAntibodies.
  7. Production of Monoclonal Antibodies (Hybridomatechnology).
  8. Clinical uses of Monoclonal Antibodies.
  9. AntibodyEngineering.

### Antigen Antibody interactions (10hours)

* 1. Strength of antigen – antibody interactions.(a) Antibody affinity (b) Antibodyavidity.
  2. Cross-reactivity.
  3. Precipitation reactions.
  4. Immunotechnics – ELISA, RIA, WesternBlot, Immunoelectrophoresis, Flow cytometry and fluorescence.

### Generation of B-cell and T-cell responses.( 9hours)

* 1. Humoralimmunity.
  2. Cellularimmunity.
  3. T- Cell receptor, TCR-CD3complex.
  4. Activation, maturation and differentiation ofB-Cells.
  5. Activation, maturation and differentiation of T-Cells.

### Immune effector mechanism.( 7hours)

* 1. Cytokines.
  2. Properties ofcytokines.
  3. Cytokineantagonists.
  4. Cytokine secretion by TH1 andTH2-cells.
  5. Cytokine related diseases. (a) Bacterial septic- shock (b) chaga’s disease) (c) lymphoid and myeloidcancers.
  6. Therapeutic uses ofcytokines.
  7. Toll- likereceptors.
  8. Pandemic Corona- Immune responses- Cytokine storm and hyper inflammation (Brief notes)

### The Complement system.( 6hours)

* 1. The complementcomponents.
  2. The functions of complementcomponents.
  3. Complement activation (a) Classical pathway (b) Alternate pathway (c) Lectinpathway.
  4. Regulation of complementsystem.
  5. Biological consequences of complementactivation.
  6. Complementdeficiencies.

### Major Histocompatibility Complex (MHC) (8hours).

* 1. General organization and inheritance ofMHC.
  2. MHC molecules andgenes.
  3. Cellular distribution ofMHC.
  4. Antigen- processing and presentation- Exogenous and Endogenouspathways.
  5. Presentation of non- peptideantigens.

### Transplantation immunology (8 hours)

* 1. Auto graft, Allograft, Isograft andxenograft
  2. Immunological basis of graftrejection.
  3. Role of cell- mediatedresponses.
  4. Transplantation antigens.
  5. General immune suppressivetherapy.

### Hypersensitivity Reactions. (5hours)

* 1. Allergens.
  2. IgE- mediated (type- I)hypersensitivity.
  3. Antibody- mediated cytotoxic (type- II)hypersensitivity.
  4. Immune complex- mediated (type- III)hypersensitivity.
  5. TDTH- mediated (type- IV)hypersensitivity

### Vaccines. (5hours)

* 1. Active and passiveimmunization.
  2. Whole organismvaccines.
  3. Recombinant vectorvaccines.
  4. DNAvaccines.
  5. Synthetic peptidevaccines.
  6. Multivalentvaccines.

### Immunity and malnutrition and immune deficiency diseases. (6hours)

* 1. Immunity andmalnutrition.
  2. Primary immune deficiency diseases. (a)Burton‟s disease (b) Di-George syndromeand SCID.
  3. Secondary immune deficiency -AIDS.
  4. Transmission ofHIV.
  5. Vaccines to preventAIDS.
  6. Autoimmunity (systemic and organ specificbrief)

# References

1. Abdul K Abbas and Andrew H. Lichtman (2004). Basic immunology –Functions and Disorders of the immune system. (second edition, Elsevier Science,USA)
2. Abdul K Abbas and Andrew H. Lichtman (2003). Cellular and Molecular Immunity (fifth edition, Elsevier Science,USA).
3. Godkar, P.B (1998): A Text Book of Medical Laboratoy Technology.Bhalani Bhalani Publishing House Mumbai.
4. Janis Kuby (2000) .Immunology.7th ed. W.H. Freeman& Co. NewYork.
5. Joshi K. R and Osamo. N. O (1994) : Immunology. Agro Bios Publishers.Jodhpur.
6. Chakraborty ,A.K.(2006).Immunology and Immunotechnology.Oxford UniversityPress.
7. Peter Parham (2004): The immune system (Second edition, Garlands, NewYork).
8. Ivan .M.Roit(2002). Essentials of Immunology.ELBS, NewDelhi.
9. Shetty, N (1993) Immunology: Wiley Eastern Ltd, NewDelhi.
10. Richard, Coico and Geoffrey, Sunshine (2009).Immunology- A short course.Wiley Blackwell. C A, USA.
11. David Male, Jonathan Brastoff, David Roth and Ivan Roitt (2006). Immunology. Mosby, Edinburgh, UK.
12. Hannigan, B.M., Moore, C.B.T. and Quinn, D.G.(2010). Immunology. Viva Books, NewDelhi.
13. Khan F,H,(2009). Elements of Immunology. Pearson Education ,NewDelhi.
14. Thomas J. Kindt, Barbara, A., Osborne And Richard, A.Goldsby.(2007). Kuby Immunology.6th ed. W.H.Freeman,NewYork.
15. Helen Chappel and Moused Harney (2006). Essentials of clinical Immunology. 5th ed. Blackwell Scientific Publications.

# THIRD SEMESTER THEORY

# ZOL3C08–DEVELOPMENTAL BIOLOGY & ENDOCRINOLOGY (90 Hours)

**COURSE OUTCOMES (COs)**

CO1 Integrating knowledge in various aspects and process in development of organisms and expose the learners to the new developments in embryology and its relevance to man.

CO2 Provide advanced knowledge about growth and development of multicellular organisms.

CO3 Understand how fertilization occur, how fertilized egg divide in regulated manner to grow into full size body, how the cells formed in this process communicate in meaningful way to become different from each other, thus assembling into tissues and complex organs.

CO4 Understand about stem cells and its importance in various therapies like replacement of cartilage in arthritis.

CO5 knowledge about influence of environmental disruptions in reproduction and development.

CO6 All these knowledge have important role in infertility management and birth defect regulation

CO7 Help to learn about major endocrine glands of our body

CO8 Understand about location of various glands, its structure, secretory role, mechanism of action, its importance etc.

CO9 Understand about the role of each hormone for managing health issues related to metabolism, excretion, nervous communication, reproduction etc.

**Part- A - DEVELOPMENTAL BIOLOGY (54hrs)**

### Introduction: Basic concepts of development (6hrs)

* 1. Cell fate, potency, determination anddifferentiation.

1.2 Commitment

* 1. Specification - autonomous, conditional, syncytial.
  2. Genomic equivalence and cytoplasmicdeterminants
  3. Morphogeneticgradients
  4. GenomicImprinting
  5. The stem cell concept- Progenitor cells, Adult stem cells, Mesenchymal stem cells, Multipotent adult stem cells, Pluripotent Embryonic stem cells, Stem celltherapy.

### Gametogenesis, fertilization and early development (10hrs)

* 1. Production of gametes- Spermatogenesis and Oogenesis, Ultra structure ofgamates
  2. Cell surface molecules in sperm-egg recognition in animals (sea urchin andmammals)
  3. Zygoteformation-
     1. Encounter of sperm andegg
     2. Capacitation
     3. Acrosomereaction
     4. Activation ofovum

2.3.5 Amphimixis

2.3.6. Prevention of Polyspermy (Fast block and Slow block)

* 1. Cleavage and blastulaformation
  2. Gastrulation and formation of germ layers inamphibia
  3. Embryonicfields

### Embryogenesis and Organogenesis (10hrs)

* 1. Axis formation in amphibians - The phenomenon of the Organizer- Nieuwkoop center, primary embryonic induction, mechanism of axisformation
  2. Anterior posterior patterning in Amphibians - Hox codehypothesis
  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, realistorgenes
  4. Dorso- ventral patterning in *Drosophila-* dorsal proteingradient
  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
  6. Insect wings and legsformation
  7. Vulva formation in *Caenorhabditiselegans.*
  8. Eye lensinduction.

### Cellular and Molecular basis of development (7hrs)

* 1. Induction and competence- cascade of induction- reciprocal and sequential inductive events, instructive and permissiveinteractions.
  2. Epithelial- Mesenchymal interactions- paracrine factors - The Hedhog family, The Wnt family, Juxtacrine signaling and cell patterning, notchpathway.
  3. Cellular interactions concerned in fertilization, blastulation, gastrulation andorganogenesis.

4.5. Molecular basis of cellular differentiation – Cadherins.

### Genetic basis of development (8hrs)

* 1. Differential gene transcription –Promoters and Enhancers, DNA methylation, Transcription factors, Silencers andInsulators.
  2. Differential RNA processing- X chromosome inactivation- dosagecompensation.
  3. Control of gene expression at the level of translation-Differential mRNA longevity, selective inhibition of mRNA translation, Selective activation of mRNA translation, micro RNAs, Control of RNA expression by cytoplasmiclocalization.
  4. Post translational regulation of geneexpression.
  5. Models of cell differentiation- hematopoiesis, myogenesis, differentiation of neural crest cells.
  6. Reversibility of patterns of gene activity-cell fusion,transdifferentiation.

### Metamorphosis, Regeneration and Ageing (7hrs)

* 1. Metamorphosis in Amphibians and Insects and their hormonalcontrol
  2. Types of regeneration - Super, Hetero, Epimorphic, Morphallactic and Compensatory regeneration, Histological process duringregeneration
  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.

### Environmental regulation of animal development (4hrs)

* 1. Environmental regulation of normal development - types ofpolyphenism
  2. Environmental disruptions of normal development (Teratogenesis) Teratogenic agents - Alcohol, retinoic acid, Bisphenol A(BPA), heavy metals, pathogen, Testicular Dysgenesis Syndrome, DES as an endocrine disruptor, Endocrine disruptors asobesogens
  3. Environmentaloestrogens.
  4. Impact of pesticide ondevelopment.

### Developmental Mechanisms of Evolutionary change-(2hrs)

Heterotopy, Heterochrony, Heterometry, Heterotypy. (Brief)

# Part B- ENDOCRINOLOGY (36 hrs)

### Endocrine glands and their Hormones (Brief account) (5hrs)

* 1. Hormone secreting organs and tissues -skin, liver, kidney,heart.
  2. General classes of chemical messengers- Peptide, thyroid, steroid hormones, neurotransmitters and pheromones
  3. Synthesis and delivery of hormones- storage, secretion andtransportation
  4. Control of hormonesecretion.
  5. Physical characteristics of hormones - latency, post-secretary modification and half-life
  6. Physiological roles ofhormones.

### General mechanisms of Hormonal action (5hrs)

* 1. Hormone Receptors andtransducers;
     1. Types of receptors- g protein coupled receptors, steroid receptors and nitric oxide receptors,
     2. Regulation of receptor number, receptoractivation
  2. Second messengers of hormone action- cAMP, cGMP, inositol triphosphate, diacylglycerol,
  3. Receptor signaltransduction
  4. Eicosanoids and hormoneaction

### Anatomy of endocrine glands; structure, physiological functions, and control of secretion of their hormones and pathophysiology (13hrs)

* 1. Hypothalamus
  2. Hypophysis
  3. Thyroid
  4. Parathyroid
  5. Adrenal
  6. Pancreas

### Hormones and male reproductive physiology (7hrs)

* 1. Synthesis, chemistry, and metabolism ofandrogens
  2. Endocrine control of testicularfunction
  3. Physiological roles of androgens andestrogens
  4. Pathophysiology

### Hormones and female reproductive physiology (3hrs)

* 1. Synthesis, chemistry, and metabolism of Ovarian steroidhormones
  2. Physiological roles of Ovarian steroidhormones
  3. Hormonal regulation of female monthlyrhythm
  4. Hormonal factors in pregnancy, parturition andlactation

### Neurohormones (3hrs)

* 1. Gases as neuralmessengers
  2. Endorphins- physiological roles, mechanism of action andpathophysiology
  3. Brain hormones andbehaviour
  4. Neuroendocrinepathophysiology -Location, hormone, and functions of the pineal gland.

# 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., NewDelhi.
3. Deuchar, E. M. Cellular interactions in animaldevelopment.
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 ofdevelopment.
8. Muller, W. A. Developmental biology.Springer.
9. Snustad, D. P., J. M. Simmons & J. B. Jenkins. Principles ofGenetics.
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, NewDelhi.

# Endocrinology

1. Bentley, P. J. (1998). Comparative vertebrate endocrinology.3rd ed.Cambridge UniversityPress
2. Bern, H. A. Text book of comparative endocrinology
3. Bolander, F. F.( 2006). Molecular endocrinology, Academic press, NewDelhi.
4. Ganong, W. F. (2005). Review of medical physiology, Mc Graw Hill, NewDelhi.
5. Hadley, M. E. (2000). Endocrinology, Pearson education, Inc., NewDelhi.
6. 6.Harris, G. W. (1995). Neural control of the pituitary gland, Edward Arnold,London.
7. Hazelwood, R. (1990). The endocrine pancreas, EnglewoodCliffs, Prentice Hall,NJ.
8. Horrbin, D. F. Essentials of Biochemistry, endocrinology andnutrition.
9. Prakash Lohr. Hormones and humanhealth
10. Nelson R. J. Introduction to behavioralendocrinology
11. Norris D. O. (2005). Vertebrateendocrinology.
12. Vinzen, G. et al, (1992). Adrenal cortical steroid hormones, Englewood Cliffs, Prentice Hall,NJ.
13. Brown, J. H. and Wet, G.B. (2000).Scaling in Biology. Oxford University Press, NewYork.
14. Williams, R. H.(1988). Text Book of Endocrinology. W. B. Saunders Company,Philadelphia.
15. Turner,K. and Bagnara, G. (1976). General Endocrinology.W.B. SaundersCompany,Philadelphia.
16. Brook, C.G. and Marshall, N.J.(1996).Essential Endocrinology.3rded.Blackwell Science ,London.
17. 17.Guyton, A.C. and Hall, J. E. (2001). Text Book of Medical Physiology.10thed. Prism Books, Pvt. Ltd. Harcourt Asia Ltd.Indiaed.
18. Hadley, M.G. (2000). Endocrinology .3rd ed. Prentice Hall International Inc. NewJersey

# THIRD SEMESTER THEORY ELECTIVE COURSE- ENTOMOLOGY-I

**ZOL3E09 -MORPHOLOGY AND TAXONOMY (90 Hours)**

**COURSE OUTCOMES (COs)**

CO1 Understand the origin and evolution of insects

CO2 Understand about the basic classification Insects

CO3 Explain the salient features of external morphology of insects

CO4 Detailed description of insects ecology and behavior are conceived

### Introduction (5hrs)

* 1. Origin and evolution of insects: Ancestry of insects based on fossil studies. Phylogeny of insects: Atelocerata hypothesis, Pancrustacea theory. Mention phylogenomicsstudies.
  2. Fossil insects. Mention extinct orders: Archodonata, Blattoptera, Coxoplectoptera, Diaphanopterodea, Glosselytrodea, Meganisoptera, Megasecoptera, Miomoptera, Monura, Palaeodictyoptera, Protelytroptera, Protodiptera,Protorthoptera andTitanoptera.

### Insect classification (31 hrs)

* 1. Introduction to classification of insects. Mention Apterygota, Exopterygota, Endopterygota, HemimetabolyandHolometaboly. **(1hr)**
  2. **Apterygota:** Diagnostic characteristics, biology and economic importance of the following Orders: Collembola, Protura, Diplura, Archeognata (Microcoryphia) and Thyasanura. LocomotioninCollembola. **(3hrs)**
  3. **Exopterygota**: Diagnostic characteristics, biology and economic importance of the following Orders and families mentioned under each order. Special topics mentioned under eachorder. **(12hrs)**

1. Ephemeroptera.
2. Odonata-mention dragon flies and damsal flies, mouthparts of naiads, matingbehavior.
3. Isoptera- Castes, Termitarium, economicimportance.
4. Phasmida.
5. Blattaria- Mention economic importance and importantspecies.
6. Mantoidea &Mantophasmatodea.
7. Orthoptera- Families: Acrididae, Tetrigidae, Tettigonidae, Gryllidae, Gryllotalpidae. Stridulatory organs in Orthoptera;Locusts.
8. Thysanoptera.
9. Hemiptera; Families- Cicadidae, Jassidae, Cercopidae, Membracidae, Aphididae, Nepidae,Gerridae, Pentatomidae, Reduviidae. Medical importance of Reduviidae; Polymorphism in Aphids; Stridulation inCicada.
10. Psocoptera.
11. Phthiraptera- Mention *Pediculus humanus* and its parasiticadaptations.
12. Dermaptera- Sexual dimorphism and parentalcare.
13. Plecoptera.
14. Embioptera.
15. Zoraptera.
    1. **Endopterygota:** Diagnostic characteristics, biology and economic importance of the following Orders and families mentioned under each order. Special topics mentioned under eachorder. **(15hrs)**
16. Coleoptera- Families: Curculionidae, Coccinellidae Scarabaeidae, Carabidae, Cerambicidae, Lampyridae, Chrysomelidae, Elateridae, Meloidae. Mention cantharidin andbioluminescence.
17. Lepidoptera. Butterflies and Moths. Families: Noctuidae, Sphingidae, Saturnidae, Pyralidae, Papilionidae, Nymphalidae, Hesperiidae, Pieridae, Lycaenidae, Geometridae .Migration in butterflies; Butterfly farming; Silkmoths.
18. Hymenoptera: Families: Vespidae, Sphecidae, Megachilidae, Apidae, Eumenidae, Xylocopidae, Formicidae, Evanidae, Braconidae, Ichneumonidae, Chalcididae, Eulophidae, Eurytomidae and Pteromalidae. Parasitic hymenoptera and biological control; Honeybees and honey production; Honeybee venom; Swarm intelligence and itsapplication.
19. Diptera: Suborders: Nematocera and Brachycera. Families: Muscidae, Culicidae, Calliphoridae, Sarcophagidae, Simulidae, Tipulidae, Glossinidae, Drosophilidae, Psychodidae. Disease vectors; Dipterans and forensic entomology; Dipterans and bio-surgery; *Drosophila* as experimentalmodel.
20. Siphonoptera: Mentionplague.
21. Strepsiptera . Mentionstylopization.
22. Neuroptera. MentionAntlions.
23. Mecoptera.
24. Megalaoptera.
25. Raphidioptera.
26. Trichoptera.

### External morphology (36hrs)

* 1. Segmentation and division of thebody
  2. General morphology of theHead
     1. Opisthognathous, hypognathous and prognathous–
     2. Head segmentation- theories about the segmentation of thehead
     3. Head skeleton- different sutures and sclerites–
     4. Tentorium–
     5. Modification in head capsules–
     6. Cephalic appendages–
        1. Antenna: structure, function & types
        2. Gnathal appendages: types, structure &function
        3. Mouth parts ofinsects
     7. Cervix
  3. Thorax
     1. Thoracicsegmentation
     2. Thoracicskeleton
     3. Endothorax
     4. Thoracicappendages
        1. Modifications of thoraciclegs
        2. Wings: origin and evolution of wings, structure, venation, wing coupling apparatus, morphologicalvariations
  4. Abdomen
     1. Segmentation
     2. Skeletalcomposition
     3. Pregenital and post genitalsegments
     4. Abdominalappendages
  5. External genitalia: male andfemale

### Ecology and Behaviour (18hrs)

* 1. Aquaticinsects
     1. Factors influencing the aquatic life
     2. Food capture;modifications
     3. Respiration in semi-aquatic and in truly aquatic insects
     4. Oviposition methods
     5. Anchorage,locomotion
     6. Adaptations of swimming forms
  2. Gall forminginsects:
     1. Definition and features
     2. Formation, economic importance
     3. Common gallpests
     4. Extent of gall makinghabits
     5. Gall as dwelling place, the position ofgall
     6. Classification of galls byOrders
     7. Adaptation for the gall makinghabits
     8. Origin and types of galls (open &closed)
     9. Physiology of gallformation
  3. Leaf mininginsects
     1. Definition and identification
     2. Forms of leaf mines, economicimportance
     3. Extend of the leaf mininghabits
     4. Feeding habits and frassdisposal
     5. Ecological aspects of leafmining
  4. Insect-plant interdependence(co-evolution)
  5. Social insects – socialorganisation
  6. Castedifferentiation
  7. Aspects of social behaviour with reference to honey bee, termite andant
  8. Communication – acoustic, visual, tactile and chemical method(pheromones)
  9. Adaptations of parasitic and predatoryinsects

# 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 AppliedEntomology.ISBN.
3. Borror, D.J. and Delong,D.M.(1964). An Introduction to the study of Insects. Holt Reineheart and Winston, NewYork.
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, NewDelhi.
9. Nayar, K.K., Ananthakrishnan, T.N., & David, B.V. (1976).General and Applied Entomology, Tata Mac Grew Hill. NewDelhi.
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.MacGrawHillBook.
12. Tembhare, D.B., Modern Entomology, Himalaya publishingHouse
13. Wilson, E.O. (1972): The Insect societies. Belknap, Harward UniversityPress.
14. Wheeler, W. C., M. Whiting, Q. D. Wheeler, and J. M. Carpenter. (2001). The phylogeny of the extant hexapod orders. Cladistics17:113-169.
15. Gillot, C.(2005).Entomology. 3rded.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:**

1. https://en.wikipedia.org/wiki/Category:Extinct\_insect\_orders (Extinct insectorders)
2. <http://science.sciencemag.org/content/346/6210/763>(Phylogenomicsstudies).

# THIRD SEMESTER PRACTICALS ZOL4L04 – IMMUNOLOGY

1. Study of cells of immunesystem.
2. Histology of organs of immunesystem.
3. Bleeding of animals and preparation ofserum.
4. Separation oflymphocytes.
5. Demonstration of agglutination reaction.
6. Immunoelectrophoresis.
7. Demonstration of ELISA technique.
8. Production ofantibodies.
9. Preparation ofantiserum.
10. Titration ofantiserum.

### 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 UniversityPress.

# 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 gillstage.
3. Vital staining of chickembryo.
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 ofincubation.
5. Tracing the development of stained parts. Candling, identification of blastoderm, window preparation - staining using stained agar strips and following thedevelopment.
6. Preparation of stained temporary/permanent mounts oflarvae.
7. Experimental analysis of insect development *-Drosophila*.
8. Regeneration studies in frog tadpoletail.
9. Demonstration of sperm ofrat/calotes/frog.
10. Morphological and histological studies of different types of placenta inmammals.
11. Hormones in Amphibian metamorphosis - Thyroxine/Iodinesolution.
12. Culture of early chick embryo invitro.
13. Study of invertebrate/vertebrate larval forms (minimum7).
14. Observation of the mid-sagittal sections and cross sections of the chick embryo through head/ heart region of 24, 48 & 56 hours ofincubation.

### 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, NewYork.
6. Thomas, J. A. (1996). Endocrine methods. Academic press, NewYork.
7. Humason, G. L. (1962). Animal Tissue techniques. W. H. Freeman &Co.

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

1. StudyofthescleritesofheadandthoraxofdifferentOrdersofinsects:Grasshopper,

Cockroach, Housefly, Honeybee.

1. Study of the different types of antennae- prepare permanent slides of at least 5 types of antennae (To be submitted during practical examination).
2. Adaptive radiation of pterygote mouth parts (Adult &Larval)
3. Adaptive radiation of pterygote legs- prepare permanent slides of at least 5 types oflegs.
4. Wings: their shape variation in the venation of pterygotewings.
5. Study of different types ofgenitalia.
6. Mounting of stinging apparatus –Honeybee
7. Morphological studies of different castes of social insects- Honeybee, Ants andTermites
8. Studies of (a) Honey bee and hives (b) Termitarium andtermites.
9. Dissection of alimentary canal and associated glands- Oryctes grub, Iphita andCricket
10. Dissection of reproductive system in insects- Iphita, Cockroach andgrasshopper.
11. Dissection of nervous system- Oryctes grub, Iphita andCricket.
12. Dissection of stomatogastric nervous system (oesophageal, sympathetic, single recurrent nerve and paired recurrent nerves inCockroach.
13. 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.
14. Study of the different types of mouthparts- prepare permanent slides of at least 5 types of muthparts (To be submitted during practical examination).
15. *Dissection of sound-producing organs of Orthopterans – Tympanum on fore tibia of Grylloidea*

### References

1. Borror, D.J. and Delong, D. H. (1964). An Introduction to the study of Insects. Holt Reineheart and Winston, NewYork.
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, NewDelhi.
4. Nair, K.K., Ananthakrishnan, T.N. and David, B.V. (1976). General and applied Entomology. Tata Mc Graw Hill , NewDelhi.

# FOURTH SEMESTER THEORY

**ZOL4C10- BIOTECHNOLOGY& MICROBIOLOGY (90 hours)**

**COURSE OUTCOMES (COs)**

CO1 Demonstrate Isolation of Plasmid DNA, Familiarize different vectors; Demonstrate Cloning, Demonstrate Electrophoresis of DNA, PCR and Bacterial transformation, Detailing on molecular probes and molecular markers

CO2 Demonstrate Electrophoresis, Blotting techniques, FISH and GISH, Detailing on DNA Hybridization, DNA sequencing and detection and applications of markers.

CO3 Understand about DNA markers, DNA isolation, DNA fingerprinting, Gene therapy and applications of biotechnology in Transplantation, Antenatal diagnosis and Forensic medicine.

CO4 Understand Transfection methods, Transgenic animals. IVF, Gene silencing and Pollution control using biotechnology

CO5 Detection of bacterial strain by gram staining, Isolation and enumeration of bacteria

CO6 Understand microbes and its growth, diseases caused by microbes and its control.

CO7 Perform testing of contamination of milk and sterilization procedures, Quantitative and qualitative analysis of microbes, Water quality analysis and culture maintenance of E.Coli.

**Part - A. BIOTECHNOLOGY (54 Hrs)**

### Introduction (1hr)

Definition, branches, scope and importance

### Vectors (5hrs)

* 1. Cloning vectors–
     1. Plasmids: pBR322 andpUC
     2. Phages: λgt10 and M13vector
     3. Cosmids: generalfeatures
     4. Phagemids: generalfeatures
     5. Viruses: SV40 andCaMV
     6. Transposones; Ac transposon and Ds transposon of Maize, P-elementof

*Drosophila*

* + 1. Artificial chromosomes: BAC, YAC andMAC.
  1. Shuttle vectors: applications andexample
  2. Expression vectors: mention commonly used promoters in expression vectors (Nopaline synthase (*nos*) promoter from T-DNA, 35 S RNA promoter of CaMV, Polyhedrin promoter fromBaculovirus

### Different steps involved in *in vivo* cloning(3hrs)

* 1. Construction of chimeric DNA (Blunt end ligation, cohesive end ligation, homopolymer tailing, use oflinkers)
  2. Selection of transformed cells –blue white selection method, colony hybridization, Plaque hybridization
  3. Amplification – Multiplication, Expression, and integration of the DNA insert in host genome

### Molecular probes (3hrs)

* 1. Production
  2. Labelling
  3. Applications
  4. FISH, McFISH andGISH

### Genomic and cDNA library (4hrs)

* 1. Construction
  2. Screening –By DNA hybridization, Screening by immunological assay, and screening by protein activity.(Refer unit 4-Molecular Biotechnology by Glick and Pasternak-ASM press)
  3. Blotting techniques- Southern blot, Northern blot, Western blot, Dot blot and Slotblot.
  4. Chromosomewalking

### Polymerase Chain Reaction (3hrs)

* 1. Basic PCR – raw materials and stepsinvolved
  2. Inverse PCR, Anchored PCR, Asymmetric PCR, PCR for mutagenesis and Real Time PCR
  3. Applications of PCR in Biotechnology and geneticengineering

### Molecular markers: detection and applications (3hrs)

* 1. RFLP
  2. AFLP
  3. RAPD
  4. Minisatellites (VNTR)
  5. Microsatellites (SSR)
  6. SNPs

### Isolation, sequencing and synthesis of genes (3hrs)

* 1. Isolation (for specific proteins and tissue specificproteins)
  2. DNA sequencing – Maxam and Gilbert’s chemical degradation method, Sanger’s dideoxynucleotide syntheticmethod.
  3. Synthesis of gene-Chemical synthesis of tRNA gene, Synthesis of gene from mRNA, Gene synthesismachines

### Transfection methods and transgenic animals (3hrs)

* 1. Definition, Methods - Electroporation, DNA micro injection, Calcium phosphate precipitation, Dextran mediated transfer, shot gun method, virus mediated, lipofection method, engineered embryonic stem cellmethod
  2. Transgenic animals for humanwelfare

### Biotechnology - Animal and human health care (4hrs)

* 1. Vaccines
  2. Diseasediagnosis
  3. Genetherapy
  4. Transplantation of bone marrow, artificialskin,
  5. Antenataldiagnosis
  6. DNA fingerprinting
  7. Forensicmedicine
  8. Covid 19- Epidemiology, Prevention mechanisms

1. ***In vitro* fertilization (3hrs)**
   1. *In vitro* fertilization and embryo transfer inhuman
   2. *In vitro* fertilization and embryo transfer in livestock

### Animal cell and tissue culture (3hrs)

* 1. Culture media – natural andartificial
  2. Culture methods – primary explantation techniques, various methods of cell and tissue culture
  3. Tissue and organculture

### Gene Silencing techniques (2hrs)

* 1. AntisenceRNA
  2. RNAi
  3. Gene knockouts and Knock outmouse

### Cloning- (2hrs)

* 1. Cloning procedures (adult DNA cloning, Therapeutic cloning, Embryo cloning)–
  2. Advantages and disadvantages ofcloning

### Environmental biotechnology (3hrs)

* 1. Pollution control – cleaner technologies, toxic site reclamation, removal of oil spill, reducing of pesticides and fertilizers, biosensors,biomonitoring.
  2. Restoration of degraded lands - reforestation using micro propagation, development of stress tolerant plants

### Agricultural Biotechnology (3hrs)

* 1. Biofertilizers
  2. Insect pest control (Pheromones, hormone mimics &analogues)
  3. Biopesticides (Baculovirus, *Bacillus thuringiensis*,NPV)

### Intellectual property rights (3hr)

* 1. Intellectual propertyprotection,
  2. Patents, copy right, trade secrets,trademarks
  3. GATT and TRIPS, patenting of biologicalmaterials,
  4. International co-operation, obligation with patent applications, implications of patenting- current issues

### The ethical and social implications - (3hrs)

* 1. Ethics of Genetic engineering - Social impacts - Human safety-Virus resistant plants- Animals andethics-
  2. Release of GEOs-Use of herbicide resistant plants-Human genome alterations by biotechnology
  3. Social acceptance of biotechnology-Transgenic crops - Social acceptance of medical biotechnology- Acceptance of GM crops for food and pharmaceutical production, Social acceptance of Industrialbiotechnology.

### Part-B-MICROBIOLOGY (36 Hours)

1. **Introduction- (1hr)**
   1. History and scope ofmicrobiology
   2. Contributions of Louis Pasteur, Robert Koch, Alexander Flemming and EdwardJenner.

### Microbial Taxonomy and Phylogeny (3hrs)

* 1. Major characteristics (classic andmolecular)
  2. Numerical taxonomy
  3. Taxonomicranks
  4. Phylogeneticstudies
  5. Pheneticclassification
  6. Bergey’s Manuel (mention majorgroups)

### Bacterial cell structure and function (5hrs)

* 1. Plasma membrane and internal system - Cytometrix, inclusions, ribosomes,nucleoid
  2. Bacterial cell wall Peptidoglycan -structure-
  3. Gram positive and gram negative cell wall- Mechanism of gramstaining
  4. Components external to cell wall; pili and fimbriae, capsule and slime layers, Flagella and motility

### Microbial nutrition (4hrs)

* 1. Nutritionalrequirements,
  2. Nutritional types (Auto, Hetero, Chemo, Phototrophs & Obligateparasites)
  3. Culture media and types ofmedia.
  4. Mixed microbial population and purecultures.

### Microbial growth (4hrs)

* 1. Growth curve -synchronousgrowth
  2. Continuous culture
  3. Influence of environmental factors ongrowth
  4. Measurement ofgrowth
  5. Measurement of cell numbers- Petroff, Hassuer counting Chamber, Spread plate and pour platetechniques
  6. Measurement of cell mass-Turbidity and microbial massmeasurement

### Utilization of energy(3hrs)

* 1. Biosynthetic process-peptidoglycan synthesis, amino acidsynthesis,
  2. Non synthetic processes -Bacterial motility and transport of nutrients.(biochemical reactions not required).

### Viruses (3hrs)

* 1. General structuralproperties
  2. Types: DNA viruses, RNA viruses, and envelopedviruses

### Microbial diseases (4hrs)

* 1. Human diseases caused by bacteria- Typhoid, Cholera, Tetanus, Leprosy, Tuberculosis and Pneumonia.
  2. Human diseases caused by viruses- AIDS, Rabies, Measles, Swine Flu, Bird flu,SARS
  3. Fungal diseases-Candidiasis

### Control of microorganisms (4hrs)

* 1. Disinfectants; A - physical- Heat, filtration and radiation. B- Chemical agents - Phenol and Phenolic compounds, alcohols, halogens andaldehydes.
  2. Antibiotics- Penicillin, Cephalosporins, Chloramphenicol,Tetracyclines
  3. Microbial drugresistance.

### Microbial fermentation (2hrs)

* 1. Lactic acid fermentation - Homolactic and heterolactic fermenters, Mention dairyproducts

-cheese and yogurt

* 1. Alcoholicfermentation.

### Environmental microbiology (3hrs)

* 1. Microbiological analysis of drinkingwater.
  2. MicrobialBioremediation
  3. Biogas plant.

### References

**Part- A- Biotechnology**

1. Alphey - DNA sequencing-Bios Scientificpublishers-
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 UniversityPress.
4. Chatterji, A.K.(2007). Introduction to environmental biotechnology-Prentice Hall ofIndia
5. Colin Ratledge and Bjorn Kristiasen-Basic Biotechnology - Cambridge Universitypress.
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 internationaledition
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-Rastogipublications.
11. Singh, B.D.(2002).Biotechnology-Kalyanipublishers.
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 priceeditions.
14. Ausubel, F.M., Brebt,R., Kingston, R.E., Moore, D.D., Seidman, J.G., Smith,J.A. and Struht,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, NewYork.
16. Brown .T.A. (2002).Genomes II ed. John Wiley and Sons, NewYork.
17. Freshney, Ian R.(2006). Culture of Animal Cell. 5thed. Wiley-LissPublications.
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-Blackwellpublishing
2. Hans G. Schlegel (2008): General Microbiology-Cambridge low priceeditions.
3. Chakraborty.P.A.(2009). Text Book of Microbiology. New Central Book Agency. NewDelhi.
4. Arora, D.R. and Arora, B.(2008).Text Book of Microbiology. CBS Publishers& distributers. New Delhi.
5. Mansi. Fermentation, Microbiology and Biotechnology-Taylor andFrancis
6. Pelczar, M.J, Chan, E.C.S. and Krieg, N.R.(1998)-Microbiology-TMHedition
7. Prescot, L.M., Harley, J. P. and Klein. D.A. (2008). Microbiolgy. 7th ed. McGraw- Hill Inc. New York.
8. Rao, A.S. - Introduction to microbiology-Prentice Hall ofIndia.
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 andWilkins.
11. Harma, R. and Kanika,J.(2009). Manual of Microbiology.Tools and Techniques.Ane Books Pvt. Ltd, NewDelhi.
12. Madigan, M.T., Martinko,J.M.and Parker, J.(2000).Biology of Micro organisms. Prentice Hall InternationalInc.
13. Talase, Park, Kathelee, N. and Talaro, Arthur.(2002).Foundations of Microbiology. McGraw Hill Higher Education, NewYork.
14. Wheelis,Mark(2010).PrinciplesofModernMicrobiology.JonesandBarlettPublishers,NewYork.

# FOURTH SEMESTER ELECTIVE COURSE- ENTOMOLOGY – II ZOL4E11- ANATOMY AND PHYSIOLOGY (90 Hours)

**COURSE OUTCOMES (COs)**

C01 gained the knowledge about the external morphology of the insect body and their appendages and functions.

C02 acquired the knowledge to understand the various modification and adaptations such as head, legs, wings, antennae, mouthparts, abdomen, sense organs.

C03 Developed a sound knowledge on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

C04 Gained hands-on-training on the different internal systems such as digestive system, circulatory system, reproductive system and nervous system.

C05 Understand the different types of system and their modifications in insects.

C06 Understand the different types of nutrition and diet

C07 Become familiar with the physiological systems in insects as outlined

C08 Identify the influence that neural and hormonal controls have within each system.

### The Integument (6hrs)

* 1. Histology-basiccomponents
  2. Chemical and physicalproperties
  3. Moulting andsclerotisation
  4. Hormonal control andfunction

### Nutrition (5hrs)

* 1. Nutritional requirement- water, minerals, vitamins, carbohydrates, proteins, fatty acids, sterols, nucleic acids, inorganic salts andmicro-organisms.
  2. Nutrition and growth, development,reproduction

### Digestion and Assimilation (8hrs)

* 1. Anatomy and histology ofgut
  2. Digestive enzymes – carbohydrases, proteases,lipases
  3. Physiology ofdigestion
  4. Digestion of wood, keratin, wax andsilk
  5. Extra intestinaldigestion.
  6. Role of microbiota indigestion

### Circulatory system (8 hrs)

* 1. Cellular elements inhaemolymph
  2. Composition ofhaemolymph
  3. Dorsal vessels, accessory pumping sinuses anddiaphragm
  4. Heart beat rate and control of heartbeat
  5. Course of circulation ofhaemolymph

### Excretory system (6hrs)

* 1. Malpighian tubules-anatomy & histology - Hemipteran, Coleopteran and Lepidopterantypes
  2. Physiology ofexcretion
  3. Dietary problems - salt and water balance-control
  4. Nitrogenous excretion-synthesis of uric acid, formation ofexcreta

### Ventilatory system (6 hrs)

* 1. Structure of trachea, tracheole, air-sacs,spiracles
  2. Types of ventilatory process - passive, active and bulkflow
  3. Respiratorypigments
  4. Cyclic release of carbondioxide and nervous control ofventilation
  5. Ventilation in aquatic insects, endoparasitic insects and duringmoulting

### Nervous system (14 hrs)

* 1. Anatomy and histology of brain, ganglia andnerves
  2. Reception and transmission of stimuli, production and control of nerve impulses and transmission.
  3. Sense organs - anatomy, histology and physiology of mechanoreceptors - tactile senses, proprioceptors, sound perception, chemoreceptors, photoreceptors, thermoreceptors and hygroreceptors
  4. Sound production and lightproduction.

### Muscular system (8hrs)

* 1. Histomorphology of muscles, skeletal muscles, visceralmuscles
  2. Neuromuscularjunctions
  3. Excitation of muscle fibres, activation of muscle fibres, role of fast and slowaxons
  4. Muscle development andmaintenance

### Endocrine and exocrine glands (8hrs)

* 1. Histomorphology of neurosecretory cells and endocrine glands (corpora cardiaca, corpora allata and Prothoracicglands)
  2. Hormones and theirfunctions
  3. Mechanism of hormoneaction
  4. Pheromones and theirfunction

### Reproductive system and morphogenesis (9hrs)

* 1. Development of primordial germcells
  2. Reproductive system- structure-male andfemale
  3. Fertilization and oviposition
  4. Formation of blastoderm and extraembryonicmembranes
  5. Sex determination andparthenogenesis

### Embryogenesis (6hrs)

* 1. Differentiation of germlayers
  2. Segmentation, appendage formation,organogenesis
  3. Polyembryony, paedogenesis, viviparity, oviparity,eclosion,
  4. Postembryonic development-hatching, larval development and control, polyphenism, diapause.

### Locomotion (6hrs)

* 1. Terrestrial and aquatic, basic stricture of aleg
  2. Maintenance of stance and patterns ofmovements
  3. Patterns of aquaticmovements
  4. Structure of wings, modifications, mechanism of wingmovement
  5. Aerodynamics and control of wingbeat.

# 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, AcademicPress
3. Chapman. R.F.(1998): The Insects: Structure and Function.4thed.ELBS,London.
4. Gilbert, L.I. & Kerkut. G.A. (1985): Comprehensive Insect Physiology, Biochemistry and Physiology, Vol.1-12
5. Pathak, S.C. (Ed) (1986): Recent advances in Insect Physiology, Morphology and Ecology. Today and Tomorrow Publishers, NewDelhi.
6. Patton, R. (1963): Introductory Insect Physiology, Saunders,USA.
7. Richards, O.W. and Davis, R.G. (1977): Imms General Text Book of Entomology. Vol.I. Chapman & Hall,London
8. Rockestein, M. (Ed) (1974): Physiology of Insecta Vol 1.VI. Academic press, NewYork
9. Roeder, K. D. (1953): Insect Physiology, Wiley, NewYork.
10. Simpson Stephen (2005): Advances in Insect Physiology.Elsevier
11. Wigglesworth, V.B. (1972): Principles of Insect Physiology,Methue.
12. James, L.N.(2001). Insect Physiology and Biochemistry.CRC Press, London..
13. Romoser, W.S. and Stoffolano, J.G. (1994). The Science of Entomology.3rded. WCB Publishers, Oxford,England.

# FOURTH SEMESTER THEORY ELECTIVE COURSE-ENTOMOLOGY-III

**ZOL4E12- AGRICULTURAL, MEDICAL & FORENSIC ENTOMOLOGY**

**(90 Hours)**

**COURSE OUTCOMES (COs)**

CO1 Appreciate the influence that insects have (both positive and negative) on human society, including human health, agriculture, and the environment

CO2 Knows the main factors which regulate the insect population dynamics, insect spreading, types of damage to plants by insects and classification of insect pests.

CO3 Familiarize the life history and nature of damage of insect pests that cause loss to major field crops and principles and methods of their effective management.

CO4 Learn about the structure, mode of action, classification and formulation of insecticides and also about insecticide resistance, degradation and impact on human health and wild life.

CO5 Understand the salient features of insects of public health importance and those used in forensic entomology.

### 1: Insect Pests (10 Hrs)

* 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)
  2. Classification of insect pests (Regular pests, Occasional pests, Seasonal pests, persistant pests, sporadic pests, major pests, minor pests, potential pests, keypests)
  3. Causes for insect assuming peststatus
  4. Concepts of Economic levels, Economic injury levels, Economic thresholdlevel
  5. Pest surveillance and forecasting pestoutbreak
  6. Estimation of damage caused by insects tocrops

### 2: Insect pests of crops (20 Hrs)

* 1. Identification, life history, damage and control of major pestsof:
     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 earhead bug, root weevil, rice grasshoppers)
     2. **Sugarcane** (Major pests including shoot, internode & top borers, white grub, leaf hopper, sugarcane scale, mealy bug, whiteflies, Termites, Black wingedbug)
     3. **Cotton** (Major pests - Aphid, leaf hopper, thrips, whitefly, Pink spotted and American boll worms, stem weevil, Red and Dusky cotton bugs, leafroller)
     4. **Coconut** (7 pests - Rhinoceros beetle, red palm weevil, black-headed caterpillar, white grub, Scale insect, Lace wing bug, coconutskipper)
     5. **Pulses** (8 pests - Gram pod borer, plume moth, red gram pod fly, pod borer, spotted pod borer, Blue butterflies, bean aphid, whitefly)

### Commonvegetables

* + - 1. **Brinjal** (shoot & fruit borer, stem borer, spotted leaf beetle, grey weevil, Pumbkin beetle)
      2. **Tomato** (serpentine leaf miner, fruitborer)
      3. **Gourds** (fruiflies, snake gourd semilooprer, spotted beetle, Pumbkinbeetle)
      4. **Bhendi** (Earias, leaf hopper, Red cotton bug, Grampodborer)
      5. **Cruciferous vegetables** (diamond black moth, cabbage borer, leaf webber, Cabbage green semilooper ,Cabbageaphid)

### Fruittrees

* + - 1. **Mango** (hopper, flower webber, Leaf webber, gall midges, Nut weevil, stem borer, red treeant)
      2. **Cashew** (tree borers, Hairy caterpillar, Tea mosquito bug, Apoderus, Leafminer)
      3. **Banana** (rhizome weevil, banana aphid, spittlebug
      4. **Citrus** (Fruit sucking moth, citrus butterfly)

### Spices

* + - 1. **Pepper** (pollu beetle, shoot borer, Marginal gallthrips)

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)

* 1. Identification, nature of damage & control of Insect pests of Stored Products: rice weevil, sweet potato weevil, leser grain borer, tobacco beetle, drug store beetle, pulse beetle, Angoumois grain moth, potato tuber moth, Red flour beetle, ricemoth)
  2. Insects in relation to plant diseases: Virus diseases, Diseases caused by phytoplasma, Bacterial diseases (brief description only)

**3: Productive and beneficial insects (8 hrs)**

* 1. Honey bees, lac insects, silkworm moths.
  2. Insect pollinators, dung beetles.
  3. Other insects of use.

### 4. Principles of Insect pest management (15 Hrs) Ecology based pestmanagement

* 1. Prophylacticmethods
  2. Curative or directmethods
     + Culturalmethods
     + Mechanical methods
     + Physicalmethods
     + Legalmethods

### Biological control

* + - History of biological control, Ecological basis of biologicalcontrol.
    - Natural enemies (Parasites, Parasitoids, Predators), Feasibility ofbiocontrol.
    - Applied biological control ( Conservation and Enhancement, Importation and Colonization, Mass culture andrelease).
    - Importance of systematics, Advantages and disadvantages of biologicalcontrol.
    - Important biocontrol projects undertaken in India by employing parasites and predators.

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

* 1. **Insect growth regulators** (IGRs) – Brief note on Insect growth hormones and mimics (JH mimic & ecdysone agonists) and chitin synthesis inhibitors as insect controlagents,
  2. **Behavioural (pheromonal) control**- (Brief note on Trail, Alarm, Aggregation and sex pheromones and the behaiour produced, Mode of application, Pest management with pheromones, Advantages and disadvantages,Examples).
  3. **Insect attractants**: definition, types of attractants, applications in insect pest mangement, examples, advantages anddisadvantages.
  4. **Insect repellents**: definition, desirable features of good repellent, types of repellents, applications in insect pest management, examples, advantages anddisadvantages.

4.9 **Insect antifeedants**: definition, examples, applications in insect pest management, advantages anddisadvantages

* 1. Microbial control of crop pests by employing Bacteria, Virus and Fungi Classification of entomophagus Bacteria, Virus, Fungi, Mode of action, formulation, Application,Examples
  2. **Integrated Pest Management**- Definition, IPM in Agroecosystem, Kinds of pest, (Key pests, Occassional pests, Potential pests, Migrant pests) Establishing the need to take action, Guidelines for developing IPM, Tactics in IPM, IPM ofRice

### Unit 5: Chemical Control (12 Hrs)

* 1. Insecticide formulation (Brief note on Emulsifiable concentrates, Watermiscible liquids, Wettable powders, Water soluble powders, Oil solutions, Flowable powders, Aerosoles, Granulars, Fumigants, Ultra-low volume concentrates, Fogging concentrates, Dusts, Poison bates and Slow releaseinsecticides)
  2. Classification ofinsecticides.
     1. Based on mode ofentry.
     2. Based on mode ofaction.
     3. Based on chemicalnatureOrganochlorineinsecticidesOrganophosphorous insecticidesCarbamatesInorganic compounds
  3. Fumigants – definition, examples, methods of fumigation, hazards of fumigation,advantages and precautions
  4. Botanical insecticides- chemical properties, mode of action and toxicity of the following: Nicotine, Rotenone, Pyrethrum andNeem
  5. Synthetic pyrethroids – definition, uses as insecticides, mode of action (examples: Pyrethrin, allethrin)
  6. Insecticide synergists – definition, types of synergism, mode of action &examples

### Insecticides and Environment (10hrs)

* 1. Insecticide resistance -Genetic, Physiological and biochemicalmechanism
  2. Pesticides and the environment- its impact on wildlife and humanhealth
  3. Microbial and environmental degradation ofpesticides

### Medical entomology (10hrs)

* 1. Insect vectors of human diseases and their biology: (Malaria, Lymhatic 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.
  2. Mosquito control- Larval and adult control-Chemical, Biological andenvironmental.
  3. Insects related to Myasis
  4. Poisonous insects: Bees, wasps and ants-Anaphylaxis.
  5. Maggot therapy (Use of maggots intreatment.

### Forensic Entomology (5hrs)

* 1. : Introduction to Forensicentomology

8.2 : Insects used in forensic entomology (Dipterans and coleopterans) 8.3: Succession of insect fauna on acadaver.

8.4. Methods of forensic entomology: Detection of time of death, mode of death and place of death. Case histories (at least3).

8.5. Forensic entomology inIndia.

### 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, NewDelhi.
3. Brown, A.W.A. (1978): Ecology of Pesticides, John Wiley Sons,N.Y.
4. D‟Brien, R.D. (1967): Insectcide- action and metabolism, Academic Press,N.Y.
5. Edwards, C.A. (1973): Persistent pesticides in the environment, C.R.C.Press
6. Dent.D.(1991). Insect Pest Management. CABInternational,UK.
7. Harward, R.F. and James, M.T. (1979): Entomology in Human and Animal Health. 7th Edn. Cther Mc Millan PublishingLondon
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
12. 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.
13. Metcalf, R.L. and Luckman, W.H., Introduction to Insect Pest management, 3rd Edn. John Wiley & Sons
14. Moriarty, F., (1975): Organochlorine insecticides persistant organic pollutants, Academic Press, INC,London
15. Nair, M.R.G.K. (1975): Insect and Mites of Crops in India, ICAR, NewDelhi.
16. O‟Brian, R.D. and Yamanots, I.(1970): Biochemical Toxicology of Insecticides, Academic Press INC,London
17. Pedigo, L.P. (1996): Entomology and Pest Management Practice. Hall India Pvt.Ltd. New Delhi.
18. Perry, A.S., Yamamoto, I., Ishaaya, I. and Perry, R. (1998): Insecticides in Agriculture and Environment – Retrospects and Prospects, Narosa Publishing House, NewDelhi
19. Pradhan, S. (1969), Insect pests of Crops, National Book Trust, NewDelhi.
20. Romoser, W.S. and Stoffalano, J.G. (1994). The Science of Entomology. 3rd Edn. Wm. C. Brown Publishing
21. Srivastava, K.P. (1996): A Text Book of applied Entomology .Vol.1&II, Kalyani publishers, Ludhiana.
22. Thacker, J.R.M.(2002).An Introduction to Arthropod Pest Control. CambridgeUniversity Press,UK.
23. Vasantharaj David and Kumaraswami, Hand Book of EconomocZoology.
24. Walter,G. (2003). Insect Pest Management and Ecological Research,Cambridge University Press,UK.
25. Wilkinson, C.F. (1976): Insecticide Biochemistry and Physiology – Plenum PressN.Y.

### Medical entomology

1. Kettle D.S. (1995). Medical and Veterinary Entomology. 2nd Ed. CABinternational.
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. JohnWiley.
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 NaturalHistory.
6. David,B.V. and Ananthakrishnan,T.N.(2004).General and Applied Entomology. 2nd ed. Tata McGraw Hill publishing Co. Ltd.NewDelhi.

# FOURTH SEMESTER PRACTICALS

# ZOL4L04 -BIOTECHNOLOGY

1. Isolation of plasmidDNA.
2. Isolation of total RNA fromtissues
3. Separation of DNA byelectrophoresis.
4. Bacterial transformation.
5. PCR
6. Cell immobilization.

# ZOL4L04 – MICROBIOLOGY

1. Selective isolation and enumeration ofbacteria.
2. Bacterial staining technique
   1. Simple staining ofbacteria.
   2. Negativestaining
   3. Hanging droptechnique.
   4. Gramstaining.
   5. Endosporestaining.
3. Turbidity test for contamination ofmilk.
4. Preparation of media and sterilization.eg: Nutrient agar, mac conkeyagar,
5. Cultivation of yeast andmolds
6. Bacteriological analysis of water e.g., fecalpollutants.
7. Antibiotic sensitivitytest.
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 andplating.

# ZOL4L04 - MICROTECHNIQUE 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 cytoplasmicstains.
3. Processing a few types of tissues for the histochemical staining-Staining of serial sections to show the presenceof
   1. Carbohydrates by PASmethod
   2. Proteins by Mercuric bromophenol bluemethod
   3. Fats by Sudan Black Bmethod
   4. DNA by FeulgenTechnique.

### Submission:

Stained/unstained Whole mounts – 4 numbers Double stained serial histology slides- 4 numbers Histochemicalslides - 2numbers

### References

1. Ausubel, F.M., Brebt 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. & Russel, D.W.(2001): Molecular cloning: A laboratory Manual. CSHL Press,NY
3. Kannan, N.(2003). Lab Manual in General Microbiology. Panima PublishingCompany,India.
4. Cappuccino,J.G. and Sherman,N. (2007). Microbiology-A laboratory Manual Benjamin- Cummings PublishingCompany.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 foresttrees.
2. Field observation, identification and collection of insect pest of Man and domesticanimals
3. Field observation, identification and collection of insect damages tocrops
4. Study of life histories of insectpests
5. Laboratory rearing of insect pests (anytwo)
6. Observation of laboratory rearing of Parasitoids andPredators
7. Identification of insecticideappliances
8. Field study of insecticideapplication
9. Field study to observe and collect insect pollinators, parasitoids and predators, scavengers and weedkillers
10. Estimation of LD 50 values for some insectpests
11. Collection and preservation of insects. {Students shall submit insects belonging to 25 families at the time of practical examination}.

**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).AgriculturalpestsofIndiaandSouthEastAsia.KalyaniPublishers,NewDelhi.
2. Kottle, D.S,(1995). Medical and Veterinary Entomology. CABInternational.
3. Mike Service.(2008).Medical Entomology for students. 4thed. Cmambridge University Press, UK .
4. Thacker, J.R.M.(2002). An Introduction to Arthropod Pest control. Cambridge UniversityPress.
5. Tonapi, G.T.(1994).Experimental Entomology. An aid to Field andlLaboratory.
6. Trigunayat,M.M.(2002).A Manual of practical Entomology. Scientific Publishings.Jodhpur.