Semester III
Paper 1- Zo231 Microbiology and Biotechnology **(100 Hours)**

PART.A.Microbiology **(50 hours)**

Module 1 **Introduction to Microbiology** **(7 hrs)**

1.1 Scope and history of microbiology – mention the contributions of important Scientists who developed Microbiology as a major disciple (e.g. Pasteur, Koch etc).

1.2 Microbial diversioty including Extremophiles – brief account.

1.3 Characteristic features of microorganisms –Bacteria, Virus, Fungi & Protozoa. Mention Microalgae. Classification of Bacteria, Virus, Fungi & Protozoa.

1.4 Classification of bacteria, Bergey's Mannual, (self study)

Module 2 **Bacterial Cell structure and function** **(8hrs)**

2.1 Ultrastructure of bacteria – cell membrane, cytoplasmic inclusions, nucleoid etc

2.2 Bacterial Cell Wall- structure; differences between gram positive and negative cell wass, gram staining

2.3. External components & their functions – pili, flagella, fimbriae, capsules, slime layers etc.

Module 3 **Microbial Nutrition and Growth** **(10 hrs)**

3.1 Common nutritional requirements of microorganisms- auto trophy and heterotrophy.

3.2 Types of culture media

3.3 Microbial growth – overview of cell growth, generation time, measurement of growth.

3.4 Typical growth curve, continous culture, effect of environmental factors on growth. Stress response.

Module 4 **Industrial & Environmental Microbiology** **(10hrs)**

4.1. Industrial Microbiology

4.1.1. Concept of fermentation. Types of fermentation – submerged, solid state – mention briefly.

4.1.2. Basis design and types of fermenters.

4.1.3. Products of Industrial Microbiology such as Alcohol, Antibiotics (e.g.Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).

4.1.4. Microbiology of mild& foods. Preservation of milk –Pasteurization techniques. Probiotics.

4.1.5. Microbial spoilage of different types of foods& Food borne diseases (self study)

4.1.6. Beneficial activities of microbes in food (self study)

4.1.7. Microbial quality control and safety of food (self study)

4.2. Environmental Microbiology

4.2.1 Introduction to terrestrial and aquatic microbiology. Principles of Microbial Ecology.

4.2.2. Biogeochemical cycles – nitrogen cycle, sulpher cucle & carbon cycle. Role of microorganisms in the biogeochemical cycles.

4.2.3. Microbiology of waste treatment. Brief account of microbial treatment of waste water and solid wastes

4.2.4. Bioremediation – microbial treatment of radioactive wastes and xenobiotics.

4.2.5. Microbes in decomposition and recycling process (self study)

4.2.6. Symbiotic and asymbiotic N2 –fixation (self study)

Module 5 Medical Microbiology **(15 hrs)**

5.1. Host-microbe interation-process of infection, pathogenecity, virulence & infection, microbial adherence, penetration of epithelial cell layers and events in infection following penetration, Infection of blood, lymphatic system.

5.2. Exotoxins – classification, mechanism of action of exotoxins e.g. Diphtheria, Botulinum, Tetanus, and Cholera toxins.

5.3. Control of Microorganisms – various physical & chemical methods.

5.4. Use of antibiotics and other antimicrobial drugs.

5.5. Drug resistance and emergence of multiple drug resistance – recent cases of TB (XDR, TDR); NDM etc.

5.6. A survey of harmful and beneficial microbes (self study)

Topics for Self Study (not for evaluative purposes)

- Classification of Bacteria, Bergy's manual
- Microbes in decomposition and recycling process
- Symbiotic and asymbiotic N2- fixation
- Microorganisms and food
- Microbial spoilage of different types of foods & Food borne diseases
- Beneficial activities of microbes in food
- Microbial quality control and safety of food

PART.B.Biotechnology **(50 hrs)**

Module 6 Introduction to Biotechnology **(10 hrs)**

6.1. History of Biotechnology (self study). Board areas of BT – traditional and modern; types – plant biotechnology, animal biotechnology and microbial biotechnology.

6.2. Techniques in Biotechnology – brief description of common techniques such as tissue culture, genetic engineering, cloning etc.

Module 7 Molecular Cloning **(15 hrs)**

7.1. Gene cloning – basic steps in gene cloning. Isolation of donor DNA.
7.2. Vectors – types and characteristics e.g. plasmids, phages, hybrid vectors, artificial chromosomes.
7.3. Enzymes used in gene cloning – exonuclease, endonuclease, ligase, reverse transcriptase, polymerase, terminal transferase etc.
7.4. Techniques of gene transfer – calcium chloride transformation, microinjection, electroporation, shotgun cloning, Agrobacterium mediated transfer etc.
7.5. Practical application of genetic engineering – useful products. Application in Medicine, Agriculture, Agriculture and Animal Husbandry, Environment etc. Biotechnology Industry.

Module 8 Recent Trends in Biotechnology **(15 hrs)**

8.1. Synthetic Biology – description and developments in the area.
8.2. Artificial life – concept and achievement
8.3. DNA Barcoding – concept and experimental details with examples.
8.4. GMOs and GM Foods – pros and cons.
8.5. Microbial warfare – bio-weapons and bioterrorism

Module 9 Bioethics **(5 hrs)**

9.1. Ethical, legal and social issues of Biotechnology.

Module 10. Biotechnology in India **(5 hrs)**

10.1. History of biotechnology research in India.
10.2. India's Biotechnology Policy
10.3. Biotechnology Regulatory Agencies in India.
10.4. Comparison with developed countries

References

Microbiology

1. Microbiology – Prescot, Harley and Klein, 6th Edition.
2. Microbiology: An Introduction. Tortora, Funke & Chase. 10th edition (2009). Benjamin Cummings. ISBN: 0321550072.
3. Bacteria: The Benign, the Bad, and the Beautiful. Trudy M. Wassenaar. ISBN: 978-1-1181-0766-9. 2011, Wiley-Blackwell
4. Microbiology. Pelczar, Reid and Chan. Tata-McGrawHill. Reprint 2008. ISBN 0074623206, 9780074623206.
5. Introductory Food Microbiology. H. A. Modi 2007. ISBN 8179102213.
6. Food Microbiology An Introduction by Thomas J Montville, Karl R. Mathews
7. Microbiology by Edward Alcamo Wiley publishing inc ISBN 0-8220-5333-0
8. Alamo, E.I. (2001). *Fundamentals of Microbiology* (6th Ed.). Jones & Bartlett Publishers, Inc., Massachusetts, USA. ISBN: 0 7637 1067 9

9. Madigan, M.T., Martinko, J.M., Dunlap, P.V. & Clark, D.P. (2009). Biology of Microorganisms (12th Ed.). Pearson Benjamin & Cummings, New York, USA. ISBN: 0 321 53615 0, 978 0321 53615 0

Biotechnology

1. Bejamin Lewin – Genes X (2011).
2. James D Watson - Molecular Biology of the Gene (6th Edition)
3. George W Burns, the Science of Genetics, Mae Millan C0 New York.
4. A Gib De Busk, Molecular Genetics, Mae Millan C0 New York.
5. Edgar Altenberg, Genetics, Oxford and IBH Publisher, New Delhi.
6. Janeway, Travens, (1996) Immunobiology Current Biology Ltd., Middle Sex House- 34-42 Cleveland Street, London.
7. Gunther S. Stent & Richard Calender Molecular Genetics, CMS Publishers, 485 Jain Bhawan, Bholanath Nagar, Shahdra, Newdeli
8. Richard Losick, (2004) Molecular Biology& Genes, Pearson Education.
9. Strickberger, M.W. Genetics, Macmillan Publishing Co., Inc., New York.
10. J.M. Walker and R. Rapley, (2002), Molecular Biology and Biotechnology, Purnima Publishing Corporation, New Delhi.

Semester III

Zo232 Ecology, Ethology and Biodiversity Conservation

Part 1: Ecology **(30 hrs)**

Topics for self study

Biotic and abiotic factors and their interactions.

Structure, basic components, their interactions and inter-relations. Fundamental concepts relating to energy – first and second laws of thermodynamics, entropy.

Gaseous and sedimentary cycles.

Characteristics of population: density, natality, mortality, biotic potential, environmental resistance, growth forms, immigration, emigration and migration.

Characteristic: Species diversity, stratification, dominance,boundaries, ecotone and edge effect, ecological indicators.

Module 1 **Ecological Energetics** **(8 hrs)**

1.1. Solar energy and photosynthetic production, efficiency of energy capturing, chemosynthesis

1.2. Energy flow – features of energy flow (unidirectional flow and loss of energy as heat) and pathways of energy flow.

1.3. Productivity – primary production and production efficiency, secondary production, standing crop

1.4. Food chain (graxing, detritus and auxiliary food cains), food, webs, trophic levels and ecological pyramids (pyramid of numbers, pyramid of biomass and pramid of energy (self study)

1.5. Classification of ecosystems based on energy input (natural unsubsidized and subsidized solar powered ecosystems, human subsidisd solar powered ecosystem and fuel powered urban and industrial systems).

Module 2 **Transition and Stability in Communities** **(7 hrs)**

2.1 Succession- Basic types (Primary succession, Seconday succession, Auogenic succession,Allogenic succession, Autotrophic succession, Heterotrophic succession).

2.2. Trends in succession

2.3. Stages of succession – (Nudation, Invasion,Competition and co-action, Reaction, Climax), pulse stability

2.4. Examples of succession – (Succession in aquatic and terrestrial ecosystems)

2.5. Relevance of ecosystem development theory to human ecology, prospects for detritus agriculture, the compartment model.

Module 3 **Concepts of Habitant, Niche and Guild** **(6 hrs)**

3.1. Habitat, microhabitat and niche. different types of niches: spatial niche, trophic niche, species niche, multidimensional niche, fundamental and realized niche.

3.2. Niche overlap, gause's principle, resource partitioning, compression hypothesis, concept of Guild, character displacement, ecological equivalents.

Module 4 **Species Interactins** **(9 hrs)**

4.1. Intra and interspecific interactions, Types of Interspecific interactions – (Positive, Negative and Neutral)

4.2. Positive interactions (commensalism, proto-cooperation, mutualism and pollination).

4.3. Negative interactions (competition, parasitism, amensalism, predation, herbivours carnivory)

4.4. Co-evolution

Part 11: Ethology **(30 hrs)**

Topics for self study

History, development and applications; motivation and models ofmotivation; reflexes imprinting, habituation; neural mechanisms in behavior, hormones and behavior; Sociobiology social groups – merits and demerits, features of organized groups; social groups in mammals, social stress; pheromones and chemical communication.

Module 5 **Learning** **(6 hrs)**

5.1. Classification of learning: Imprinting, habituation, imitation (self study), classical conditioning, instrumental/operant conditioning, cognitive learning, latent learning, insightful learning.

Module 6 **Nervous System and Behaviour** **(8 hrs)**

6.1. Stimulus filtering, sign stimulus, innate release mechanism and fixed action plans (FAPs).

6.2. Brain centres and learning, neural mechanism of learning and memory.

Module 7 **Complex Behaviour patterns** **(8 hrs)**

7.1. Orientation, Navigation and homing.

7.2. Migration (Fishes and birds)

7.3. Biological rhythms – biological clock,circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.

Module 8 **Environment, genetics and Evolution of behaviour** **(8 hrs)**

8.1. Habitat selection and territoriality.

8.2. The Evolution of communication; Development of bird song.

8.3. The evolution of reproductive behavior and mating systems.

Module 9 **Biodiversity** **(15 hrs)**

9.1. Introduction: Definition, levels of biodiversity (genetic diversity, species diversity and ecosystem diversity), values of biodiversity (self study)

9.2. Diversity indices: Alpha diversity, Beta diversity and Gamma diversity; the species diversity and ecosystem stability.

9.3. Biodiversity in India: Major biogeographic zones of India; India as a mega diversity nation; hot spots biodiversity – characteristics; an outline of the features and biodiversity of hot spots in India (Western Ghats and Eastern Himalaya).

9.4. Features, structure and biodiversity of some of the Indian ecosystems: Terrestrial ecosystems (forest, grassland, desert), Aquatic ecosystems freshwater, marine, esturine).

Module 10 **Conservation Biology** **(13 hrs)**

10.1. Depletion of biodiversity: Current estimates of species loss, causes of biodiversity loss, impacts of biodiversity loss, Strategic species concepts: keystone species, indicator species and umbrella/glagship species.

10.2. Strategies of conservation: in situ and ex situ conservation, Gene Banks, establishment of protected areas, habitat conservation captive public awareness and other relevant measures.

10.3. An evaluation of the "Project Tiger' and " Project Elephant" programmes.

10.4. World conservation strategy (1980O

10.5. National Biodiversity Action Plan 2008: a brief outline of objectives & plans

Module 6 **Nervous System and Behaviour** **(8 hrs)**

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Module 11 International Conventions & Treaties for conservation of Biodiversity (12 hrs)

11.1. Stockholm declaration on human Environment (1972), Convention on Regulation of Antarctic Marine Resources Activities (RAMRA, 1986), Moduleed Nations World Charter for Nature (1982), Kyoto Protocol and Framework Convention on Cllimate Change (UNFCCC), Brundtland Report (1987).

11.2. Earth summit (1992) – detailed study – Ratio Declaration on Environment and Development, Agends 21,Forest Principles, Convention on Biological diversity.

11.3. Species based treaties: Migratory Bird Treaty Act (MBTA) of 1918, International Convention for the Regulation of Whaling (ICRW), Washington, 1946,Convention for the Conservation of Antarctic Seals, 1972, Convention on International Trade on Endangered Species (CITES, 1975),

11.4. Ecosystem based treaty: Ramsar Convention (1981) – Ramsar sites in India and Kerala.

References

Ecology & Biodiversity

1. Beck, W.S., Liem, K.F. & Simpson, G.G. (1991). *Life: An Introduction to Biology* (3rd Ed.). Harper Collins Publishers, New York, pp 1361. ISBN: 0 06 500009 9.
2. Bharucha, E. (2005). *Textbook of Environmental Studies*. Universities Press (P) Ltd, India, pp 276. ISBN 81 7371 540 8.
3. Chapman, J.L. & Reiss, M.J. (). *Ecology: Principles and Applications* (2d Ed.). Cambridge University Press, UK. ISBN: 0 521 00575 2.
4. Charry, S.N. (2008). *Environmental Studies*. MacMillan India Ltd. ISBN: 10: 0230 63531 8, 13: 987 0230 6351 9.
5. Cunningham, W.P. & Cunningham, M.A. (2003). *Principles of Environmental Science inquiry and Applications*. Tata McGraw Hill Publishing Company Ltd, New Delhi. ISBN 0 07 058112 6.
6. Donald Van DeVeer & Christine Pierce (). *The Environmental Ethics & Policy Book* (3rd Ed.). Wadsworth-Thomson Learning, Canada. ISBN: 0 534 56188 8.
7. Emmel, T.C. (1976). *Population Biology*. Harper & Row Publishers, New York. ISBN 0 06 041904 0.
8. Gaston, K.J. & Spicer, J.I. (1998). *Biodiversity: An Introduction*. Blackwell Science Ltd.,London. ISBN 0 632 04953 7.
9. Hickman, C.P., Roberts, L.S., Larson, A. & Anson,H. (2004).*Integrated Principles of Zoology*. McGraw Hill Company, New Delhi, pp872. ISBN: 0 07 243940 8.
10. Kormondy, E.J. (2008). *Concepts of Ecology*. Dorling Kindersely (India) Pvt. Ltd., pp 576. ISBN 81 317 0744 X.

11. Odum, E.P & Barrett, G.W. (2006). *Fundamentals of Ecology*. Thomson/Brooks and Cole, India, pp 598. ISBN: 81 7648 552 7.
12. Pianka, E. R. (2000). *Evolutionary Ecology*. Sixth Edition. Benjamin-Cummings, Addison-Wesley-Longman, San Francisco, pp 528. ISBN: 10: 0321042883.
13. Rajalekshmi. V. (2004). *Environment and Sustainable development*. APH Publishing Corporation, New Delhi, ISBN: 81 7648 552 7.
14. Richard Brewer (). *The science of Ecology* (2nd Ed.).Saunders College Publishing, USA. ISBN: 0 03 096575 6.
15. Russell, P.J., Starr, C., Wolfe, S.L., Hertz, P.E. & Mcmillan, B. (2009). *Ecology*. Cengage Learning Private Limited, pp 532. ISBN-13: 9788131508503.
16. Townsend, C.R., Harper, J.L. & Begon, M. (2000). *Essentials of Ecology*. Blackwell Scientific Publishers, Massachusetts, pp 552. ISBN: 0 632 04348.
17. Eldon, D.E. & Bradley, F.S. (2006). *Environmental Science – A study of Interrelationships* (12th Ed). McGraw-Hill Higher Edition. ISBN: 007252829x.
18. Manuel C. & Molles Jr. (2009) *Ecology: Concepts and Applications* (5th Ed). McGraw-Hill International Education. pp 604. ISBN-13: 9780070171688

Ethology

1. Alcock, J. (2001): *Animal Behaviour- An Evolutionary Approach* (7th Ed.) Sinaur Associates, Inc. ISBN-10: 0878930116
2. Bear, F.M., Connors, B.W. & Paradiso, M.A. (2001). *Neuroscience, exploring the brain* (2nd Ed). Lippincott Williams & Wilkins, Baltimore, pp 855. ISBN: 0 683 30596 4
3. Gleitman, H., Fridulund, A.J. & Reisberg, D. (1998). *Psychology* (2nd Ed.). W.W Norton & Company, Inc., New York, pp 849. ISBN: 0 393 97364 6.
4. Bradbury, J.W. & Vehrencamp, S.L. (1998). *Principles of animal communication* (2nd Ed). Sinauer Associates, Inc., Sunderland, Massachusetts, USA.
5. Clutton-Brock, T.H. (1991). *The evolution of parental care*. Princeton University Press, Princeton, NJ, USA. Pp 368. ISBN: 9780691025162
6. Eibl-Eibesfeldt, I. (1970). Ethology: *The Biology of Behavior* (1st Ed). Holt, Rinehart and Winston, Inc., New York. ISBN-10: 0030731305
7. Gould, J.L. (1982). *Ethology: The mechanisms and Evolution of Behaviour*. W. W. Norton & Company, Inc., New York. ISBN-10: 0393014886
8. Gadagkar, R. (1998). Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, Hyderabad, India. ISBN(13) : 9788173711145
9. Goodenough, J., McGuire, B. & Wallace, R.A. (1993) *Perspectives on Animal Behavior*. John Wiley & Sons, Inc., New York.
10. Halliday,T.R.& Slater,P.J.B. (Eds.) (1983). *Animal Behaviour Vol.2: Communication*. Blackwell Scientific Publications, Oxford.
11. Halliday,T.R.& Slater,P.J.B. (Eds.) (1983). *Animal Behaviour Vol.3: Genes, Development and Learning*. Blackwell Scientific Publications, Oxford.
12. Hauser, M.D. (1996). *The evolution of communication*. MIT Press, Cambridge, Mass. USA. pp 760. ISBN 0-262-08250-0

13. Krebs, J.R. & Davies, N.B. (1993). *An Introduction to Behavioural Ecology* (3rd Ed.). Blackwell Scientific Publications, pp 420. ISBN-10: 0632035463
14. Manning, A. & Dawkins, M.S. (1998). *An Introduction to Animal Behaviour.* (5th Ed.) Cambridge: Cambridge University Press. ISBN 0521578914
15. Slater, P. & Halliday, T. (Eds.). (1994): *Behaviour and Evolution* (1st Ed.) Cambridge University. Press. Pp 348.

Zo233 Immunology and Developmental Biology **(100 Hrs)**

Immunology **(40 hrs)**

Module 1 **Introduction to Immune System** **(4 hrs)**

1.1 Types of immunity, innate and acquired immunity; passive and active immunity; humoral and cell-mediated immunity.

1.2 Organs of immune system: Primary and Secondary lymphoid organs.

1.3 Brief account on immune cells: types and production.

Module 2 **Immunogens (Antigens)** **(7 hrs)**

2.1 General properties, Structure and function, variability and diversity.

2.2 Factors affecting antigenicity.

2.3 Epitopes and Haptens.

2.4 Adjuvants and their role in enhancing immunogenecity.

Module 3 **Immunoglobulins (antibodies)** **(8 hrs)**

3.1 General Properties-Structure and functions

3.2 Different classes of immunoglobulines (1gA, 1gD,1gE,1gG and 1gM)

3.3 Genetic basis of antibody diversity:
Immunoglobulin gene organization; Gene rearrangement and expression.
3.3.1 Somatic recombination: V (D) J recombination and functional diversity
3.3.2 Somatic hyper mutation
3.3.3 Class switching

3.4 Polyclonal and Monoclonal antibodies

3.5 Hybridoma technology –technique and applications

Module 4 **Antigen-antibody interactions** **(6 hrs)**

4.1 Primary and secondary immune responses

4.2 Theories of antibody formation (Directive theory, clonal selection theory etc.)

Module 5 **Complement System** **(4 hrs)**

5.1 Complement systems-General features

5.2 Classical pathway and alternate pathway complement receptors, biological effect of complements.

Module 6 **Transplantation** **(7 hrs)**

6.1 Classification of grafts

6.2 Major Histocompatibility Complex (MHC) and MHC proteins; role in tissue transplantation; Mechanism of graft retention and rejection.

6.3 General immunosuppressive therapy.

Module 7 **Defects in Immune Mechanisms** **(4 hrs)**

7.1 Defective innate immune mechanisms

7.2 Auto immune diseases

Developmental Biology **(60 Hrs)**

Module 1 **Introduction** **(4 hrs)**

1.1 Definition, history, Scope of embryology and Practical applications (self study)

1.2 The evolution of developmental patterns in unicellular protest; origin of sexual reproduction. Developmental patterns among animals-brief survey (asexual means; parthenogenesis; sexual means; gonochorism, hermaphroditism, metamorphosis, uterine development in mammals)

Module 2 **Fertilization** **(8 hrs)**

2.1 Events in fertilization

2.1.1 Cytoplasmic changes

2.1.2 Nuclear changes

2.2 Prevention of polyspermy

2.3 Significance of fertilization

Module 3 **Developmental Model Systems** **(16 hrs)**

3.1 Early development of *Drosophila*-Egg, cleavage, mid-blastula transition, gastrulation

3.2 Early development of *Caenorhabditis elegans*-Egg, cleavage and gastrulation.

3.3 Genetic control of development and embryonic axis formation.

3.3.1 Gene action in development of Drosophila:- Maternal effect genes; Segmental genes (gap genes, pair-rule gene and segment polarity gene) and Homeotic genes (homeobox and homeodomains)

3.3.2 Hox cluster genes in vertebrates

Module 4 **Embryonic Induction** **(10 hrs)**

4.1 Types of embryonic induction – Primary, Secondary and Tertiary Induction (Experiments of Spemann and Mangold)

4.2 Mechanism of axis formation in amphibians; Niewkoop centre.

4.3 The functions of organizer; the diffusible proteins of the organizer 1; the BMP inhibitors.

4.4 Stem cells, totipotency, plury potency

Module 5 **Medically assisted human reproductive technologies** **(12 hrs)**

5.1 Conventional in vitro fertilization and embryo transfer (IVF-ET) – general protocol (Patient selection, manipulation of menstrual cycle, superovulation, oocyte retrieval, preparation of semen sample, IVF treatment, embryo transfer.

5.2 Gametic Intrafallopian Transfer (GIFT)

5.3 Zygotic Intrafallopian Transfer (ZIFT)

5.4 Tubal Embryo stage Transfer (TET)

5.5 Intra-cytoplasmic sperm injection (ICSI)

5.6 Intra Uterine Insemination (IUI)

Module 6 **Cloning experiments in animals** **(10 hrs)**

6.1 Genomic equivalence; multiple potencies; differential gene expression.

6.2 Amphibian cloning, cloning mammals, human cloning-prospects and demerits.

References

Developmental Biology

1. Scott, F. Gilbert, (2000) Developmental biology, Sinauer Associates, Inc., Publishers, Massachusetts.
2. V.R. Walvekar, M.J.Jassawalla, P.H.Anjaria and R.J. Wani, Reproductive Endocrinology- A Clinical approach.
3. K. Vasudeva Rao, Developmental Biology – a modern synthesis.
4. R.M. Twyman, Developmental Biology
5. Lewis Wolpert, et al., (2000) Principles of Development, Oxford University Press.
6. Balinsky, B.I, An Introduction to Embryology
7. D.J.Bejley, J.A. Firth, J.R.F.Houtt, Human Reproduction and Developmental Biology

Immunology

1. Roitt, L, Brostoff, J and Male, D., Immunology
2. Ashim K Chakravarthy, Immunology
3. M.K. Majumdar, Microbiology and immunology
4. Kudy (2000) Immunology. W.H. Freeman and Company.
5. Lydyard, P.M., Whelan, A., and M.W.Fanger (2002). Instant Notes in Immunology, Viva Books Private Limited.
6. Janeway, Travens, (1996) Immunobiology. Current Biology Ltd., Middle Sex House 34-42 Cleveland Street, London.

PRACTICALS

Zo234 Microbiology, Biotechnology, Ecology, Immunology and Developmental Biology

Microbiology and Biotechnology

1. Techniques for Isolation of bacteria-serial dilution, pour plate, spread plate techniques.
2. Enumeration of bacteria from water and soil
3. Motility Testing – hanging drop method.
4. Gram staining of bacteria
5. Determination of quality of milk-methylene blue reductase test.
6. Biochemical tests – catalase test, kovac's oxidase test, gas production etc.
7. Isolation of DNA from plant/animal tissue.
8. Plasmid isolation
9. Detection of coliform bacteria by H_2S paper strip method for monitoring water quality.
10. Culturing of paramecium to observe ciliary movement.

Immunology

1. Antigen-antibody interaction in vitro and identification of blood groups.
2. Blood film preparation and identification of cells.
3. Detection of pregnancy using kits.
4. Immunodiffusion and Immunoelectrophoresis
5. Demonstration of phagocytes in insect hemocytes.

Developmental Biology

1. Induced ovulation and artificial fertilization
2. Preparation of temporary whole mounts of chick blastoderm
3. Vital staining of chick blastoderm and tracing the development of stained parts (window method)
4. Effect of drugs on heart beat of chick embroyo.
5. Study of different types of eggs: insect egg, frog's egg, hen's egg, mammalian egg-models/charts
6. Morphological and histological studies of different placental types of mammals (3 numbers)
7. Identification of cross sections of chick embryo through heart, eye and ear.

Ecology

1. Estimation of pyramid of numbers and biomass in a small ecosystem.
2. Estimation of Primary productivity using dark and light bottles.
3. Description of ecological adaptations of any 10 organisms.
4. Habituation in pila/ Alarm response in fishes / Maize learning in rats.
5. Study of Biodiversity indices:
   (a) Population
   (b) Density and relative density,
   (c) Frequency and relative frequency,
   (d) Abundance and distribution,

(e) Modified similarity index
(f) Shannon-Wiener Index

6. Composition assessment of the taxonomic diversity/biodiversity in a habitat (eg. Grass land, arid land, wet land)
7. Assessment of Invertebrate and Vertebrate diversity in Your locality (e.g. campus).
8. Quantitative estimation of planktons.
9. Poster Presentation on a relevant topic (e.g.International conventions and treaties, species interactions, biodiversity loss, etc.).
10. Mounting cercaria of flukes in aquatic birds.

Semester IV
Special Subject: Endocrinology

Zo241 Vertebrate Endocrinology **(100hrs)**

Module 1 Introduction **(5 hrs)**

1. Historical perspective
2. General Classes of chemical messengers
   Peptide hormones, steroid hormones, bioamines, eicosanoids, chalones, neurotransmitters, neuropeptides, neurosteroids, neurohormones, lumones, phytohormones, synthetic hormones.

Module 2 Vertebrate endocrine glands **(30 hrs)**

1. Morphology and anatomy of endocrine glands
2. Biosynthesis of hormones (Mention key enzymes)
3. Functions of hormones
4. Disorders of hormonal imbalance
5. Hypothalamus and its secretions
6. Hypothalamo hypophysical interaction
7. Eicosanoids - Biochemistry and biological action. Prostaglandins, prostacyclins, thromoboxanes, leukotrienes.
8. Evolution of endocrine glands-a brief account.

Module 3 Mechanism of hormone action **(30 hrs)**

1. General and Molecular mechanism of action of amines, polypeptide and steroid Hormones
2. Hormone receptors
   Receptors as mediators of endocrine signals
   Classification of endocrine receptors
   Measurement of receptor ligand interaction
1. Cell surface receptors (Mode of action of peptide hormones)
   Receptor structure
   Regulation of receptor number
2. Second messengers of hormonal action

Cyclic nucleotides; Inositol triophosphate; Diacyl glycerol; Genomic action of cAMP

3. Signal transduction
   G proteins and dual control of adenylate cyclase; Receptor crosstalk
6. Receptor with tyrosine kinase activity, serine and threonine kinase activity
7. Receptors that are protein phosphatases
8. Receptors coupled with ligand gated ion channels
9. Direct membrane action of steroid hormones-non genomic action

Module 4 Cell growth factors **(5 hrs)**

1. Types of growth factors-mechanism and its functional role in cellular activities: Somatomedins-IGC; Epidermal Growth factor (EGF) family; Transforming Growth factor β family (TGF β); Platelet derived growth factor (PDGF); Fibroblast growth factor (FGF).
2. Nerve Growth factor (NGF); Hepatocyte Growth factor (HGF)

Module 5 Hormones and Cancer **(10 hrs)**

1. Relationship of hormones to carcinogens and development of cancers from inappropriate hormonal treatment.
2. Hormone related treatment of cancer
3. Oncogenes and hormonal function
4. Hormone receptor status of Breast Cancer
5. Ectopic production of hormones by tumour cells

Module 6 Functional Endocrinology **(10 hrs)**

1. Role of hormones in behaviour of animals
2. Hormonal control of reproduction
3. Hormonal involvement in evolution
4. Influence of hormones in developmental process

Module 7 Endocrine methodology **(10 hrs)**

1. Methods and techniques in endocrine research
2. Histological and cytological methods; Surgical methods; Bioassays
3. Radio isotopic studies-RIA, ELISA, EIA
4. Nucleic acid approaches in endocrinology
5. Recombinant DNA techniques and genetic engineering

References

1. Endocrinology-Mac.E.Hadley, Prentice Hall. International 2000
1. Williams Text Book of Endocrinology edited by Jean D. Wilson and Daniel W. Foster, Saunders Company 8th Edn. 1992.
2. Hormones from Molecular to disease Elby-Elienne-Erulie Bautieu and Paul A. Kelly 1990.
3. Endocrinology-Basic and Clinical Principle-P. Michael Corn and Shlomo Mel Med. Humana Press The Totowa. 1997
4. Vertebrate Endocrinology-Daniel O.Norris Academic Press. 3r edn. 1997.

5. General and Comparative Endocrinology, Turner and Bangara, Saunders Company
6. Comparative Endocrinology-P.J. Bentley, 1997
7. Hormones and Evolution-Barrington, 1979.
8. Hormones-Anthony-W.Norman and Gerald Litwark-Academic Press. 1997.

Special Subject: Endocrinology

ZO242 Physiology of Reproduction (With special reference to mammals) (100hrs)

Module 1. Foetal and Embryonic Gonads and Genital Ducts (20 hrs)

1. 1. Comparative anatomy of genital system in vertebrates
1. 2. Origin of primordial germ cells
1.3. Differentiation of the testis: Germinal epithelium, interstitial tissue, Foetal androgens and role
1.4. Differentiation of ovary: Foetal estrogens and role
1.5. Origin and differentiation of the genital ducts: Wolffian duct, mullerian duct
1.6. Hormonal basis of sex differentiation
1.7. Histology, cytology and endocrinology of the foetal gonads
1.8.Disorders of sexual differentiation development: True hermaphroditism, Pseudohermaphroditism, Chromosomal errors and sex determination – Penile agenesis, Double Penis, Bifid Penis, Micropenis, Acruate Uterus, Double uterus.

Module 2.Physiology of Female Reproduction–I. Ovary & Reproductive cycles (12 hrs)

2.1. Anatomy of female reproductive system- Gross anatomy and histology of ovary
2.2. Ovarian hormones
2.3. Folliculogenesis and oogenesis and their hormonal control
2.4. Ovulation- Luteinization, Atresia
2.5. Reproductive cycles- Estrus and menstrual cycles- structural changes and hormonal control

Module 3. Physiolog of female reproduction– II. Implantation, Pregnancy and Parturition (12 hrs)

3.1. Nidation, Desidualization
3.2. Placentation- Types, Placental hormones and their regulation
3.3. Physiology of pregnancy - Endocrine basis
3.4. Development of foetal membranes- Amnion, chorion, allantois and yolk sac
3.5. Physiology of parturition and endocrine control

Module 4. Physiology of female reproduction–III Mammary gland & Lactation (6 hrs)

4.1. Infantile mammary gland, Pubertal changes in mammary gland, Structure of adult mammary gland
4.2. Synthesis, composition and secretion of milk- galactopoesis- Milk let down
4.3. Hormonal regulation of lactation

Module 5. Physiology of Male reproduction: I. Testis, Reproductive tract and Accessory Reproductive Glands **(15 hrs)**

5.1. Anatomy of male reproductive system- Testis, Vasa efferentia, Epididymis, Vas Deferns, Ejaculatory ducts, Urethra, Penis
5.2. Accessory sex glands- Seminal vesicles, Prostate gland and Cowper's glands- Structure, cytology and functions
5.3. Histology of testis- Sertoli cells, Leydig cells and rete testis – structure and functions
5.4. Male sex act
5.5. Temperature regulation of testicular function
5.6. Testicular hormones- Androgens

Module 6. Physiology of Male Reproduction - Spermatology **(10 hrs)**

6.1. Spermatogenesis and its hormonal control
6.2. Structure of a typical mammalian sperm, Comparative morphology of sperms of mammals.
6.3. Physiological maturation of sperm – initiation of motility and capacitation
6.4. Sperm motility and energetic- Factors affecting sperm motility
6.5. Biochemistry of semen

Module 7. Reproductive Behaviour **(7hrs)**

6.1. Concept of puberty
6.2. Adolescence- Somatic changes , psychological changes and hormonal changes
6.3. Senescence
6.4. Menopause

Module 8. Fertility regulation and Reproductive toxicology **(8 hrs)**

8.1. Disorders of male and female reproductive systems- Sexual dysfunction
8.2. Infertility in males and females – causes and curative measures
8.3. Birth control devices
8.4. Reproductive toxicology – effects of chemicals, drugs and alcohol on reproduction
8.5. Fertility regulation in farm animals

Module 9. Reproductive Health **(10 hrs)**

9.1. Sex Education and its importance
9.2. Adolescent sexual activity and adolescent stress management
9.3. Sexual harassment and its impacts
9.4. Sexually transmitted diseases

References:

1. Essentials of Medical Physiology, Leonard R. Johnson (Ed.), Academic Press.
2. Physiology of reproduction – Vol.I & II. Edited by E. Knobi & J.D. Neill. Raven Press, New York. 1994.

3. Human Reproductive Biology – R.E. Jones, Academic Press, London . 1997.
4. Comparative Endocrinology and Reproduction – Joy KP. Krishna A, Haldar L, Narosa Publishing HJouse, New Delhi. 1999.
5. Male infertility and Sexual Dysfunction – W.J.G. Hellstrom, Springer-Verlag, New York. 1997.
6. Reproduction in Mammals. Vol.I and II. Edited by C.R. Austine & R.V. Short Cambrige University Press, London. 1986.
7. Principles of Vertebrate Reproductive Biology – HBD Sarkar, Himalaya Publishing House. 1993.
8. Current Concepts in Fertility Regulation. Edited by C.P. Puri and P.F. A. Van Look. Wiley Eastern Ltd. 1994.
9. Principles of Anatomy and Physiology , Vol II; G.I. Tortora and B.H. Derrickson , John Wiley& Sons Inc.

Semester IV
Special Subject: Endocrinology
Practical I

Zo243 Physiology of Reproduction with special reference to Mammals

1. Histology of testes of fish, Calotes. Frog, chick and rat (any two animals)
2. Histology of ovary of fish, calotes, frog, chick and rat (any two animals)
3. Dissection of male and female reproductive system of frog, calotes, chick and rat.
4. Vaginal smear of rat
5. Sperm smear of any one vertebrate
6. Demonstration of induced ovulation in any one vertebrate

Zo244 Endocrinology

Vertebrate Endocrinology

7 Dissection of endocrine glands in fish, frog, calotes, chick and rat (any two animals)
8. Demonstration of glandectomy experiments in any two vertebrates
9. Simple experiment to study the effect of thyroxine, insulin and cortisol on blood glucose/total protein in fish/frog
10. Preparation of single cell suspension of any one tissue for in vitro study
11. Histological study of endocrine gland using haematoxylin eosin stain in any two vertebrates.
12. Disorders of endocrine glands (5 numbers for short notes)

Special Subject: Fish Biology and Fishery Science
Zo 241: Ichthyology

Module 1. Classification and distribution of fishes **(10hrs)**

1.1 Scope and history of Ichthyology (self study)
1.2 Geographical distribution of fishes in marine and freshwater habitats
1.3 Distribution of fishes in marine and freshwater habitats in India and Kerala
1.4 Classification of fishes upto family – distinguishing characters with examples
1.5 Barcoding in fish taxonomy

Module 2. Adaptation of fishes to special conditions **(10hrs)**

1.2 Deep sea fishes
1.3 Cave dwelling fishes
1.4 Hill stream fishes
1.5 Air-breathing fishes
1.6 Venomous fishes
1.7 Larvicidal fishes and biological control
1.8 School in gin fishes

Module 3. Functional morphology and bionomics of fishes **(15hrs)**

3.1 Gross external anatomy of fishes
3.2 Body form diversity
3.3 Fins- type, structure, function and modifications
3.4 Skin- Structure and function
  3.4.1. Scalation – types of scale, structure, development and modifications
  3.4.2. Colouration – types of chromatophores, biological significance

Module 4. Food, feeding, digestion and growth in fishes **(10hrs)**

1.1 Basic anatomy of digestive system of a acartilaginous and a bony fish
1.2 Food and feeding habits- natural food, feeding habits and adaptations; feeding in relation to season, growth, sex and breeding; gastro-somatic index
1.3 Digestion, absorption and utilization of food
1.4 Growth in fishes- length and growth relationship, growth curve and growth studies using scales and condition factor.

Module 5. Excretion and osmoregulation **(5hrs)**

1.1 Brief account of structure and function of kidney
1.2 Hormonal control of excretion and osmoregulation

Module 6. Locomotion **(10hrs)**

6.1 Types of locomotion – swimming and non-swimming
6.2 Body form and locomotion
6.3 Fins and locomotion
6.4 Swim bladder and buoyancy- origin and function
6.5 Weberian ossicles and its significance

(10hrs)

Module 7. Sense organs in fishes

7.1 Later all in essence organs, Ampullae of Lorenzini
7.2 Chemo, mechano, thermo and electro receptors
7.3 Structure of eye and visual pigments

(10hrs)

Module 8. Endocrine glands in fishes

8.1 Structure and function of - Pituitary gland, ultimobranchial gland, caudal neuro secretory cells, urophysis, corpuscles of stannous, inter renal tissue and chromaffin tissue, islets of Langerhans, thyroid gland, gonad and pineai organ

(10hrs)

Module 9. Reproduction in fishes

9.1 Sexuality – hermaphroditism, unisexuality and bisexuality
9.2 Gonads- phases of maturity, length at first maturity, gonado-somatic index, fecundity
9.3 Reproductive behavior- sexual dimorphism, courtship, parental care, nest building

(10hrs)

Module 10. Fish genetics

10.1 Sex determination in fishes
10.2 Recent trends and techniques in hybridization
10.3 Chromosome manipulation in fishes
10.4 Transgenesis in fishes

Special Subject: Fish Biology and Fishery Science
Zo 242: Fisheries and Aquaculture

Fisheries

Module 1. Fishery Science (15hrs)

1. Importance of Fishery Science- Inland fisheries, Marine fisheries, capture fisheries and culture fisheries
2. Inland capture fisheries- Riverine fisheries, reservoir fisheries, cold water fisheries and estuarine fisheries
3. Marine capture fisheries in India- Offshore and deep sea fisheries- fin fish fishery, shell fish fishery (crustacean and molluscan)

Module 2. Methods of fishing (10hrs)

2.1 Indigenous fishing crafts of India- sea fishing crafts- Catamaran, Musula boat, caravel boats, Dinghi, Dug out canoes, plank built canoes, out trigger canoes
2.2 Inland fishing crafts: Dug out and plank built boats
2.3 Mechanised Indian fishing crafts- fishing vessel characteristics
2.4 Indigenous fishing gears in India: Traditional and conventional; sea fishing gears and inland fishing gears

Module 3. Harvest and post-harvest Technology (20hrs)

3.1 Harvesting- precautions obswrved during harvesting, sorting, grading the catch

3.2 Nutritive value of fish and biochemical composition of fish flesh
3.3 Fish spoilage and preservation
3.4 Fish preservation and processing – Icing and freezing, canning, salting, drying, curing, smoking etc
3.5 Fish products and byproducts- Liver oil, meal, manure, glue, isinglass, leather, chitosan, fish maws, fish protein concentrate, fish fins
3.6 Fish food poisoning

Module 4. Fish export and Extension **(5hrs)**

4.1 Transportation and marketing: Overseas market for diversified products and principal world market for diversified sea food products
4.2 Fisheries Extension: extension philosophy and extension methodology
4.3 The status of Indian fishery co-operative movement and fish farmers development agencies

Aquaculture

Module 5. Aquaculture **(10hrs)**

5.1 Scope and objectives of aquaculture; status in India
5.2 Culture systems-
5.2.1 Criteria for space and site selection
5.2.2. Culture systems- pond, bheries, salt pans, tanks, race way, cage, pens etc.
5.3 Hatcheries- different types
5.4 Design and construction of aquafarms

Module 6. Breeding and seed production **(10hrs)**

6.1 Bionomics of cultivable species of fish and shell fish (Mullets, milk fish, pearl spot, carps, Penaeus spp., Macrobrachium spp.)
6.2 Breeding of fishes with special reference to Indian major carps- wet and dry bundh technique for breeding.
6.3 Induced breeding
6.3.1. Induced breeding in Fish- Principle, techniques and advantages of hypophysation, selective breeding and seed production.
6.3.2. Induced breeding in Shrimp- Techniques involved in shrimp breeding and seed production- eye stalk ablation etc.
6.4 Transport of live fishes- fingerlings and breeders
6.5 Cryopreservation of gametes and embryos
6.6 Common fish diseases – viral, fungal, bacterial and parasitic infections.

Module 7. Nutrition in culture fishes **(3hrs)**

7.1 Nutritional requirement of a culture fish
7.2 Feed-Live and formulated
7.3 Procedure of feed formulation

Module 8. Methods of freshwater and brackish water fish culture **(15hrs)**

8.1 Monoculture – Indian major carps (Catla, Rohu, Mrigal), exotic species, Tilapia
8.2 Composite culture
8.3 Culture of air-breathing fishes- ecology of swamps and use in culturing air-breathing fishes
8.4 Shrimp culture: traditional and scientific brackish water culture practices in India with special reference to Kerala.
8.5 Ornamental fish culture- exotic and indigenous species
8.6 Aquarium set up and maintenance; Aquarium plants and aquarium accessories
8.7 Frog culture

Module 9. Mari culture in India **(7 hrs)**

9.1 Sea farming and sea ranching
9.2 Prawn culture
9.3 Pearl culture and culture of edible mollusks
9.4 Turtle farming
9.5 Sea weed cultivation

Module 10. Integrated fish culture **(5 hrs)**

10.1 Paddy cum fish culture
10.2 Fish-livestock farming- manorial value of livestock wastes and their role in recycling for raising fish production
10.3 Sewage fed fish culture

Field Work

1. Visit to freshwater and brackish water fish farms
2. Collection of water and soil samples of fish ponds for analyzing hydrographical parameters

Study tour

Visit to fisheries institute and fishing harbours to study the following:

1. Freshwater and brackish water aquaculture
2. Fishing operations
3. Fish preservation and processing
4. Boat building and net making
5. Fisheries research, survey, education and examination

Special Subject: Fish Biology and Fishery Science
Practical I
Zo 243-Ichthyology

Taxonomy

1. Identification and classification of 10 local fishes (Marine/freshwater) upto species level.
2. Identification and classification of 5 prawns upto species level.

Dissection and Mounting

3. Membranous labyrinth
4. Ampullae of Lorenzini
5. Brain
6. Scales- Placoid, cycloid, ctenoid
7. Digestive system of a fish (cartilaginous or bony fish)
8. Urinogenital system of a teleostean fish
9. Pituitary gland

Fish Physiology

10. Effect of NaCl/KCL on fish chromatophores.
11. Determination of the rate of oxygen consumption of a fish at room temperature.
12. Determination of gonado somatic index.
13. Measurement of fecundity rate in a fish.
14. Qualitative and quantitative analysis of gut content in a herbivorous and carnivorous fish.
15. Determination of gastro somatic index.
16. Smear preparation of fish blood to study the morphology of different cellular elements .
17. Differential count of fish WBC.

Fish Genetics

18. Sex determination in fishes.
19. Hybridization techniques in fishes.
20. Karyotyping in fishes.

Special Subject: Fish Biology and Fishery Science
Practical II
ZO 244- Fisheries and aquaculture

Fish pond ecology

1. Determination of nutrients in the water samples from freshwater and brackish water ponds (Phosphate/sulphate/nitrate).
2. Determination of free calcium carbonate in the soil sample from freshwater and brackish water ponds.
3. Determination of LC_{50} for fish exposed to a given pollutant.

Fish Pathology

4. Identification of common external fish parasites (at least 5 numbers).
5. Estimation of spoilage in fish by pH method.
6. Determination of bacterial plate count for fish skin, flesh and gut.

Breeding Techniques

7. Mounting of pituitary gland.
8. Preparation of pituitary gland extract.

9. Demonstration of hypophysation technique.
10. Demonstration of artificial insemination.
11. Demonstration of sperm motility in a fish.
12. Preparation of a formulated fish feed.

Fish byproducts

13. Identification and study of fish byproducts
14. Preparation of any one fish by product
15. Estimation of muscle protein
16. Estimation of muscle glycogen

Fishing crafts and gear

17. Identification and study of different types of fishing crafts (Minimum 5 numbers)
18. Identification and study of different types of fishing gears (Minimum 5 numbers)
19. Setting up of an aquarium
20. Study of aquarium accessories
21. Study of common aquarium plants(Minimum 5 numbers)

References

1. Ali, M.(1980) Environmental Physiology of fishes. NATO advanced Study Institute series. Series A: Life sciences, vol. 35, Plenum Press, New York.
2. Bal, D.V. and Rao, K.V.(1989). Marine Fisheries. Tata Mac Graw Hill Publishing Co., Delhi.
3. Biswas, K.P. (1996).A text book of fish, fisheries and technology. Narendra Publishing House,Delhi.
4. Balakrishnan, N. and Thampy D.M. (1990) A text book of marine ecology. Macmillan Co., India Barnes, R.S.K and Mann, K.H.(1980).
5. Fundamentals of aquatic ecosystems. Blackwell Scientific Publications, Oxford and London.
6. Beavan,R.(1990). Freshwater fishes of India Low price Publications , Delhi.
7. Biswas (1993). Manual of methods in fish biology. South Asian Publishers Ltd., Delhi.
8. Boyd, C.E.(1979). Biology of fishes. Saunders Publ.,Philadelphia
9. Boyd, C.E. (1982). Water quality management for pond fish culture: developments in aquaculture and fisheries sciences-9, Elsevier, Amsterdam.
10. Bye, V. J. and Ponniah, A.G. (1983). Application of genetics in aquacvulture. CMFRI special publication, No.13, CMFRI, Cochin.
11. Charles, T. Cutting (1996). Fish processing and preservation. Agro Botanical Publishers, Bikaner.
12. Claude E Boyd, (1984). Water quality management in aquaculture, CMFRI special publication, No.22.
13. Cushing, D.H. 1980. Marine ecology and fisheries. Cambridge University Press.
14. Das, P. and Jhingram, A.G. (1989). Fish genetics in India. Today and tomorro's printers and publishers, New Delhi.
15. Datta Munshi, J.J. and H.M. Dutta. (1995). Fish Morphology: Horizon of new research. Oxford and IBH publishing Co., Pvt. Ltd.

16. Gahlawat, S.K and R.K. Gupta (2007). Manual of experimental Ichthyology, Daya Publishing House, New Delhi.
17. Gerhard Brunner, (1973). Aquarium plants, TFH. Publications, Inc. Ltd, Hong Kong.
18. Gupta, S.K and P.C. Gupta (2006). General and Applied Ichthyology, S. Chand and Co. New Dlhi.
19. Halver J.E. (1977). Fish nutrition. Academic Press, London.
20. Harvey, B.J and Hoar, A.S. (1979). Theory and practice of induced breeding in fish. International Development Research Centre, Ottawa.
21. Hoar, W.S. and Randall, D.J. (1969-1988). Fish Physiology. Vols. I-X., Academic press, New York.
22. Jayaram, K.C. (1981). The freshwater fishes of Indis, Pakistan, Bangladesh, Burma and Srilanka- a hand book. Zoological Survey of India, Calcutta.
23. Jhingram, V.G. (1991). Fish and Fisheries of India. Hindustan Publishing Corporation (India), New Delhi.
24. John, S. Lucas and Paul C. Southgate (2000). Farming aquatic animals and plants. Fishing New Books, Blackwell Publishing Co.,
25. Jorgen Hansen (1979). Making your own aquarium, Bell and Hyman Ltd. London.
26. Lagler, K.F., Bardach, J.E., Miller, R.R., and D.R. May Passino (2003). Ichthyology, John Wiley and sons (Asia) Pvt. Ltd., Singapore.
27. Love R.M.(1970). Chemical Biology of fishes, Academic press, London.
28. Madhusoodana Kurup, B (Ed) (2008). Ornamental fish – breeding, farming and trade. Department of Fisheries, Govt. of Kerala.
29. Nelson, J.S. (2006). Fishes of the world (4th Edition)., John Wiley and sons, New Jersy.
30. Paul, j.B. and John d. Reynold (Eds.) (2002). Handbook of fish biology and fisheries. Blackwell Science Ltd., UK.
31. Pillai, T.V.R., (1993). Aquaculture: Principles and practices, Fishing News Books, USA.
32. Santhosh Kumar and Manju Tembhre, (1998). Anatomy and physiology of fishes, Vikas publishing house Pvt. Ltd, New Delhi.
33. Sreekrishna Y.and Latha Shenoy (2000). Fishing gear and craft technology, ICAR, New Delhi.
34. Stephen Spotte, (1970). Fish and Invertebrate culture- water management in closed system, John Wiley and sons, Inc., New York.
35. www. FISH.BIOL.ORG
36. http://mail.nbfgr.res.in/fbis/

Semester IV
Special Subject- Insect Science
ZO 241 General Entomology **(100hrs)**

Unit 1 Introduction **(5hrs)**

1.1. Origin and evolution of insect.
1.2. Fossil Insects.
1.3. Insect-plant interdependence (Co-evolution).