SYLLABUS FOR
M.Sc. COURSE IN ZOOLOGY
(With effect from Session 2020 – 2022)
[CHOICE BASED CREDIT SYSTEM]

DEPARTMENT OF ZOOLOGY
THE UNIVERSITY OF BURDWAN
BURDWAN, WEST BENGAL 713104
INDIA

The existing M.Sc. syllabus under CBCS system (2020-2022) has been placed in the meeting of Board of Post Graduate Studies in Zoology held on 11/12/2020. Members of PGBS have reorganized and approved the syllabus on 11/12/2020 to place before the meeting of Faculty Council of Science on ...../12/2020. Finally, Faculty Council of Science has approved the syllabus on .....

(Prof. Soumendranath Chatterjee)
Head & Chairman,
PGBS, Dept. of Zoology, BU

Members of the Post Graduate Board of Studies in Zoology (PGBS) in its meeting held on 10-05-2022 have approved minor corrections to be incorporated in the M.Sc. syllabus under CBCS system (2020-2022).

(Prof. Koushik Ghosh)
Head & Chairman,
PGBS, Dept. of Zoology, BU

POST GRADUATE SYLLABUS
Department of Zoology
Summary of the course and credits

Semester I [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in hr)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T.**	**Total**	
MSZO 101	Core	T	Ecology, Ethology and Conservation Biology	4T	2T	10	40	50	4
MSZO 102	Core	T	Basic and Applied Entomology	4T	2T	10	40	50	4
MSZO 103	Core	T	Parasitology and Vector Biology	4T	2T	10	40	50	4
MSZO 104	Core	T	Fish Biology and Fisheries	4T	2T	10	40	50	4
MSZO 105 (Unit I)	Core	P	Ecology and Conservation Biology	4P	2P	05	20	25	2
MSZO 105 (Unit II)	Core	P	Entomology	4P	2P	05	20	25	2
MSZO 106 (Unit I)	Core	P	Parasitology and Vector Biology	4P	2P	05	20	25	2
MSZO 106 (Unit II)	Core	P	Fish Biology and Fisheries	4P	2P	05	20	25	2
								Total credit	24

T/P: Theory/Practical

Semester II [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in hr)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T.**	**Total**	
MSZO 201	Core	T	Biosystematics and Evolutionary Biology	4T	2T	10	40	50	4
MSZO 202	Core	T	Microbiology and Immunology	4T	2T	10	40	50	4
MSZO 203	Core	T	Genetics and Cell Biology	4T	2T	10	40	50	4
MSZO 204	Core	T	Physiology and Endocrinology	4T	2T	10	40	50	4
MSZO 205 (Unit I)	Core	P	Biosystematics	4P	2P	05	20	25	2
MSZO 205 (Unit II)	Core	P	Genetics and Cell Biology	4P	2P	05	20	25	2
MSZO 206 (Unit I)	Core	P	Physiology and Endocrinology	4P	2P	05	20	25	2
MSZO 206 (Unit II)	Core	P	Microbiology and Immunology	4P	2P	05	20	25	2
								Total credit	24

T/P: Theory/Practical

Semester III [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in hr)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T.**	**Total**	
MSZO 301	Core	T	Biochemistry and Toxicology	4T	2T	10	40	50	4
MSZO 302	Core	T	Histology-Histochemistry and Comparative Anatomy	4T	2T	10	40	50	4
MSZO 303 (Unit I)	Core	P	Biochemistry and Toxicology	4P	2P	10	20	25	2
MSZO 303 (Unit II)	Core	P	Histology-Histochemistry and Comparative Anatomy	4P	2P	10	20	25	2
MSZO 304Z	GE	T	Applied Zoology	2T	1T	05	20	25	2
MSZO 305*	DE	T	Discipline-centric Elective	4T	2T	05	40	50	4
MSZO 306**	DE	P	Discipline-centric Elective	8P	4P	05	40	50	4
MSZO 307	CE	T/P	Community Engagement ##	N.A.	N.A.	05	20	25	2
								Total credit	24

T/P: Theory/Practical

CE: Community Engagement Activities; DE: Discipline-centric Elective; GE: Generic elective

*__Discipline-centric Elective (Students need to take any one of these Discipline-centric Electives)__

1. AQUACULTURE AND FISHERIES **(COURSE CODE: MSZO 305-DE1)**
2. ECOLOGY AND ENVIRONMENTAL BIOLOGY (**COURSE CODE: MSZO 305-DE2)**
3. ENTOMOLOGY (**COURSE CODE: MSZO 305-DE3)**
4. MOLECULAR BIOLOGY AND GENETICS **(COURSE CODE: MSZO 305-DE4)**
5. PARASITOLOGY AND MICROBIOLOGY **(COURSE CODE: MSZO 305-DE5)**

__COURSE CODE: MSZO 306-DE1, 306-DE2, 306-DE3, 306-DE4, and 306-DE5__

##**Community Engagement**: Based on Discipline-centric Elective

Semester IV [Credits – 24]

Course				Lect. Hr /week	Dur. Of Exam (in hr)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T.**	**Total**	
MSZO 401	Core	T	Developmental Biology and Stem cell Biology	4T	2T	10	40	50	4
MSZO 402	Core	T	Biostatistics and Computational Biology	2T	1T	05	20	25	2

MSZO 403	Core	P	Developmental and Computational Biology	4P	2P	05	20	25	2
MSZO 404#	DE	T	Discipline-centric Elective*	4T	2T	10	40	50	4
MSZO 405##	DE	T	Discipline-centric Elective*	4T	2T	10	40	50	4
MSZO 406###	DE	P	Discipline-centric Elective*	8P	4P	10	40	50	4
MSZO 407	Term paper / Project Work	T /P	Dissertation$$ (Empirical or Non empirical)	N.A.	N.A.	10	40	50	4
								Total credit	24

*Based on Discipline-centric Elective taken in Semester -III

$$Based on Discipline-centric Elective

#**DE Course Code: MSZO 404-DE1, MSZO 404-DE2, MSZO 404-DE3, MSZO 404-DE4, and MSZO 404-DE5**

##**DE Course Code: MSZO 405-DE1, MSZO 405-DE2, MSZO 405-DE3, MSZO 405-DE4, and MSZO 405-DE5**

###**DE Course Code: MSZO 406-DE1, MSZO 406-DE2, MSZO 406-DE3, MSZO 406-DE4, and MSZO 406-DE5**

Notes on marks distribution:

1. In each course, 20% marks is allotted for Internal Assessment (for both theory and practical), i.e., 10 marks for a paper of 50 marks and 5 marks for a paper of 25 marks.
2. Marks distribution for each paper will be as follows:
   a. For **40** marks of **NON-UNIT** based paper:
   *Four questions (out of six) of **2** marks each, four questions (out of six) of **4** marks each and two questions (out of four) of **8** marks each are to be answered*
   b. For **40** marks of **UNIT** based paper:
   UNIT I (Total Marks 20)*: Four questions (out of six) of **1** mark each, two questions (out of four) of **4** marks each and one question (out of two) of **8** marks are to be answered*
   UNIT II (Total Marks 20)*: Four questions (out of six) of **1** mark each, two questions (out of four) of **4** marks each and one question (out of two) of **8** marks are to be answered*
   c. For 20 marks of **NON-UNIT** based paper:
   *Four questions (out of six) of **1** mark each, two questions (out of four) of **4** marks each and one question (out of two) of **8** marks are to be answered*

POST GRADUATE SYLLABUS IN ZOOLOGY

PO (Program outcome)

(i) M.Sc. program offered by the Department will facilitate enhancement of knowledge, skills and attitude.
(ii) The program will impart training to become independent and support lifelong learning.
(iii) The PG program might help the students to prepare themselves appearing CSIR/UGC-NET, DBT-NET, ICMR-NET, SET, and GATE examinations.
(iv) The program entails development of effective communication regarding the subject concerned.

PSO (Program specific outcome)

(i) The M.Sc. in Zoology course content is suitable for analytical as well as application orientation. The course will enable the students to catch the spirit of the course, generate idea on the content, expand the horizon of knowledge and will create enthusiasm to learn beyond the course content.
(ii) The program might help to develop skills to open-up job opportunities as a taxonomists, entomologist, epidemiologist, fish biologist, wildlife and conservation biologist, and so on.
(iii) The program will be helpful in developing technical skills in advanced areas, e.g., molecular biology, biotechnology, bioinformatics and biostatistics.
(iv) Different DCE courses will help the students to develop understanding on basic as well as advanced areas of studies that include biodiversity conservation, population ecology, restoration ecology, environmental toxicology, animal behaviour, global warming, environmental disaster, disease biology, genetic and epigenetic markers, metabolomics, therapeutic aspects, biocontrol of vectors, integrated pest management, aquaculture management and so on.
(v) The courses will also help the students for skill and entrepreneurship development (e.g., aquaculture, sericulture, apiculture, molecular diagnostics, microbiology and patho-biology) to make them economically independent.
(vi) Knowledge disseminated through the specific program of PG in Zoology will help the students to prosper their carrier in different areas, viz., Scientists (in different disciplines of biology/Zoology), Assistant Teachers in schools, Assistant Professors in college/universities, West Bengal Forest Service, and Indian Forest Service.
(vii) The course will help in choosing the specific research topic in the respective area in future.

SEMESTER – I

MSZO 101: Core Course
(ECOLOGY, ETHOLOGY AND CONSERVATION BIOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units that deal with concept of ecosystem, habitat, niche, population and community ecology. Causes, effects and control of air pollution, and theory of island biogeography will also be presented. The course will offer understanding on behavioral ecology, mechanism of learning, territoriality and foraging behavior, mating behavior, altruism, and conservation biology.

Time: 2 hrs **Full Marks: 50**

UNIT - I: ECOLOGY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Ecosystem 3L
- Structure and function
- Energy flow, Ecological efficiencies
- Cybernatic nature in ecosystem
- Concepts of productivity, Primary productivity and secondary production

Soil as an ecosystem 3L
- Development
- Profile
- Soil aeration and porosity
- Fauna
- Pollution

Habitat and niche 3L
- Concept of habitat and niche
- Niche width and overlap
- Fundamental and realized niche
- Bioinvasion
- Resource partitioning
- Character displacement

Population ecology 5L
- Characteristics of a population
- Population growth control
- Population regulation
- Life history strategies (r and k selection)

Concept of metapopulation – demes and dispersal, interdemic extinctions, age structure populations

Community ecology 4L

Nature of communities, Community structure and attributes
Ecological succession
Level of species diversity and its measurement
Interspecific interactions (competition, herbivory, carnivory, pollination, symbiosis)
Edges and ecotones

Biogeography 3L

Major terrestrial biomes
Geographic origin of species
Theories on biogeoraphic distributions
Theory of island biogeography
Biogeographical zones of India

Environmental pollution 4L

Concept of Environment, Composition of Environment, Sources and effects of primary and secondary air pollutants, global warming and green house effects, ozone layer depletion, El Niño and La Niña, water pollution on terrestrial and aquatic animals and control measures for environmental pollution, anti-pollution laws

Suggested readings

Abbott, L. K. and Murphy D. V. (2007). *Soil Biological Fertility: A key to sustainable land use in Agriculture*. Springer. Online Book –ISBN 978-1-4020-6619-1 (e-book).

Begon, M., Harper, J. L. and Townsend, C. R. (2006). *Ecology: Individuals, Populations and communities*. 4 th ed. Blackwell science.

Chapman, R. L. and Reiss, M. J. (1998). *Ecology – Principles and Applications*. 2nd ed. Cambridge University Press.

Colinvaux, P. (1993). *Ecology 2*. John Wiley and Sons, Inc. New York.

Cunningham, W. P. and Cunningham, M. A., (2007). *Principles of Environmental Science: Inquiry and Applications*. 4th ed. Tata McGraw-Hill Company.

Dash, M. C., (2001). *Fundamental of Ecology*. 2nded. Tata McGraw-Hill Company.

Enger, E. D. and Smith, B. F. (2008). *Environmental Science: A study of Interrelationships*. 11th ed. McGraw-Hill Higher Education.

Faurie, C., Ferra, C., Medori, P. and Devaux, J. (2001). *Ecology-Science and Practice.* Oxford and IBH Publishing Company Pvt. Ltd.

Freedman, B. (1989). *Environmental Ecology*. Academic press, Inc., PP. 424.

Kormondy, E. J. (2002). *Concepts of Ecology*. 4th Indian Reprint, Pearson Education.

Krebs, C. J. (2001). *Ecology*. Benjamin Cummings.

Laveille P. and Spain A. V. (2003). *Soil Ecology*. Kluwer Academic Press. Online Book – ISBN

Leveque, C. (2003). *Ecology: from Ecosystem to Biosphere.* Science Publishers. Inc.

Lomolino, M. V., Riddle, B. R., Whittaker, R. J. and Brown, J. H. (2010). *Biogeography*. 4th Ed. Sinauer Associates.

Mukherjee, B. (1996). *Environmental Biology*. Tata McGraw-Hill Publishing Comp. Ltd.

Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th ed. Thompson Brooks/Cole.

Ricklefs, R. E. and Miller, G. L. (2000). *Ecology*. 4th ed. W. H. Freeman and Company.

Santra, S. (2005). E*nvironmental Science*. New Central Book Agency (P) Ltd.

Smith, R. L. and Smith, T. M. (2001). *Ecology and Field Biology*. Benjamin Cummings Pearson Education.

Smith, T. M and Smith, R. L. (2006). *Elements of Ecology*. 6thed. Pearson Education.

Stiling, P. (2002). *Ecology- Science and Applications*. 2nd ed. Prentice Hall of India.

Unit – II: ETHOLOGY AND CONSERVATION BIOLOGY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Ethology 8L

Introduction to Ethology
Proximate and ultimate reasoning
Development of behavior
Social communication and dominance
Approaches and methods in study of behavior
Altruism and evolution-group selection, kin selection, reciprocal altruism

Learning 4L

Neural basis of learning, memory, cognition, sleep and arousal
Biological clocks: Basic components, functions and regulations

Territoriality and foraging behaviour 4L

Use of space and territoriality
Mating systems, parental investment and reproductive success
Parental care
Aggressive behaviour
Habitat selection and optimality in foraging
Migration, orientation and navigation

Conservation biology 8L

Introduction to biodiversity concepts, significance, magnitude and distribution
Threats to biodiversity, major causes of extinction, IUCN threat categories, Red Data Book/Red List
Megadiversity zones and Hot spots, concepts, distribution and importance
Centres of origin of cultivated crop plants
Uses of biodiversity, flagship species, keystone species, indicator species, umbrella species, strategies for sustainable exploitation of biodiversity.Basic concept of radio and satellite telemetry in monitoring wild animals
Major approaches to management; Indian case studies on conservation/management strategies (Project Tiger, Project Vulture)
Concept of Biosphere Reserve, National Park and Wildlife Sanctuary;Biosphere Reserves of India

***Suggested readings**:*

Agarwal, V. K. (2013). Animal Behaviour (Ethology). 1st ed. S. Chand.

Alcock, J. (2001). *Animal Behaviour: An Evolutionary Approach*. Sinauer Associates. Inc. USA.

Danchin E., Giraldeau L. A., and Cezilly F. (2008). *Behavioural Ecology: An Evolutionary Perspective on Behaviour*. Oxford University Press, USA.

Davies, N. B., Krebs, J. R. and West, S. A. (2012). *An introduction to behavioural ecology*. 4thed. Wiley-Blackwell.

Drickamer, L., Vessey, S. and Jakob, E. (2002). *Animal Behaviour: Mechanisms, Ecology, Evolu*tion. 5th ed. McGraw-Hill.

Dugatkin, L. A. (2009). *Principles of Animal Behavior*. Princeton University Press, United States.

Ghosh, A. (2007). Biodiversity Conservation. APR Publishing Corporation, New Delhi.

Gupta, I. J. and Mondal, D. K. (2005). *Red data Book (Part – 2): Butterflies of India*. ZSI.

GOI, (2005). Biological Diversity Act, 2002 and Rules, 2004 National Biodiversity Authority, Chennai.
IUCN (2020). *The IUCN Red List of Threatened Species. Version 2020-3*. https://www.iucnredlist.org.
Saha GK and Majumdar S. (2016). An Introduction to Wildlife Biology: Indian Perspective. PHI Learning, New Delhi.
Saha GK and Majumdar S. (2007). Threatened Mammals of India-Ecology & Management, Daya Publishing House, New Delhi.
Saharia, V. B. (1998). *Wildlife in India*. Natraj Publishers.
Sinclair, A. R. E., Fryxell, J. M. and Caughley, G. (2009). *Wildlife Ecology, Conservation and Management*. Wiley.
MoEF,(2006). Perspective on Biodiversity: A Vision for Megadiverse Countries. (Desh Deepak Verma, Sujata Arora, R.K. Rai eds.) Ministry of Environment & Forests, New Delhi.
Mittermeier,R.A.,MyersN. and Mittermeier,C. G. (2000). *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions,* Conservation International.
UNITED NATIONS, (1992). Convention on Biological Diversity, New York.
Vié, J.-C., Hilton-Taylor, C., Pollock, C., Ragle, J., Smart, J., Stuart, S.N. and Tong, R. (2008). The IUCN Red List: a key conservation tool. In: J.-C. Vié, C. Hilton-Taylor and S.N. Stuart (eds). The 2008 Review of The IUCN Red List of Threatened Species. IUCN Gland, Switzerland.

MSZO 102: Core Course
(BASIC AND APPLIED ENTOMOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units that deal with understanding insect diversity, basics of entomology, and control of insect pests. Co-evolutionary adaptations between plant and insects will also be emphasized.

Time: 2 hrs **Full Marks: 50**

Unit – I: ENTOMOLOGY-I (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Insect diversity and classification 3L
- Insect diversity and adaptive features
- Outline of classification of Insects up to the orders with examples
- (After Richards and Davies, 1977 with minor revision)

Structure and function 10L
- *External organs*
  - Cuticle: Structure, formation
  - Mouthparts: Mechanics and regulation of feeding
  - Antenna: Sensory structures
  - Eye: Simple and compound, receptor physiology
  - Legs: Mechanics of locomotion
  - Wing: wing coupling, mechanism of flight, Kinematics
- *Internal organs* 6L
  - Alimentary canal: Gut structure, metabolic processes

Circulatory system: Structure, haemolymph
Tracheal system: Components, mechanisms of gaseous exchange
Endocrine systems: Organs, types of hormones
Excretory system: Mechanisms of urine formation
Reproductive system: Male and female internal reproductive organs, sperm transfer, oviposition

Metamorphosis 3L

Hormonal regulation: Chemistry, sources and mechanism of hormone actions

Social orgainsation 3L

Termites and honey bees

UNIT - II: ENTOMOLOGY-II (Credit 2) . Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sound production 2L

Organs and mechanisms

Bioluminescence 2L

*O*rgans and mechanisms of light production

Chemical Communication 2L

Pheromones, kairomones, allomones, synomones

Insect-plants interactions 2L

Plant structure and chemistry
Insects and host-plant interactions

Insect control and management 3L

Insecticides, insecticide resistance, biopesticides
Insect Growth regulators, Sterile Insect technique 4L
Integrated Pest Management: Concept, Economic Injury Level (EIL), Economic threshold (ET) 2L
Transgenic plants

Suggested readings:

Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th ed. Cambridge University Press.

David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.

Gillott, C. (2005). *Entomology*. 3rd ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.

Hoy, M. A. (2003). *Insect Molecular Genetics– An introduction to principles and Applications.* 2nd ed. Academic Press.

Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.

Klowden, M. (2013). *Physiological Systems in Insects,* 3rd ed. Academic Press.

Mullen, G.R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd ed. Academic Press.

Nation, J. L. Sr. (2016). *Insect Physiology and Biochemistry*. 3nd ed. CRC Press. Taylor and Francis
Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management.* Pearson/Prentice Hall.
Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.
Richards, O. W. and Davies, R. G. (1977). *Imms: A General Text Book of Entomology.*10th ed. Vol. 1 and 2. Chapman and Hall.
Romoser, S. W. and Stoffolano, J. G. (1998). *The Science of Entomology*. 4th ed. McGraw Hill.
Schoonhoven, L. M., van Loon J. J. A. and Dicke, M. (2006). *Insect-Plant Biology*. 2nd ed. Oxford University Press.
Speight, M. R., Hunter, M. D. and Watt, A. D. (2008). *Ecology of Insects: Concepts and Applications*. 2nd ed. Wiley-Blackwell.
Srivastava, K. P. and Dhaliwal, G.S. (2013). *A textbook of Applied Entomology.* 1st ed. Kalyani Publishers, New Delhi.
Gupta, A. P. (2009). *Insect hemocytes*: *development, forms, functions and techniques*. Cambridge University Press.

MZGT 103: Core Course
(PARASITOLOGY AND VECTOR BIOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units that provide advanced knowledge on general parasitology, host-parasite interactions, important disease causing parasites and their control measures.

Time: 2 hrs **Full Marks: 50**

Unit – I: PARASITOLOGY AND VECTOR BIOLOGY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

General idea 3L

Symbionts, parasites, vectors and hosts, Ecology of parasitism, Immune response to the Parasites, Parasite genomics, protemics and metabolomics

Host-Parasite interaction 8L

Host–parasite interactions, Cytoadherence/colonization and Cell-parasite interactions (Blood and intestinal parasites), virulence factors and pathogenicity islands

Immunological variations in vertebrates and invertebrates and epidemiological surveillance tools and vital statistics

Protozoology 1L

Classification of parasitic Protozoa

Intestinal Sarcodina and Flagellates 3L

General account, morphology, life cycle, pathogenicity and control of *Entamoeba histolytica* and *Giardia lamblia*

Haemoflagellates 4L

Morphological stages, life cycle, clinical features and control of *Trypanosoma cruzi* and *Leishmania donovani*

Haemosporina 2L

Zoonosis 4L

Malarial parasites

Morphology, life cycle, clinical features, treatment, Prevention and control of *Plasmodium vivax*, epidemiology, natural and acquired immunity

Unit – II: **PARASITOLOGY AND VECTOR BIOLOGY (Credit 2)**

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Helminthology 4L

Classification of parasitic helminthes

General characteristics of the Cestoda, Trematoda and Nematoda

Morphology, life history, pathogenicity and control 8L

Paragonimus westermani, Schistosoma haematobium, Taenia saginata, Trichinella spiralis, Dracunculus medinensis

Lymphatic Filarial Parasites 3L

Zoonotic lymphatic filariasis

Vector Biology 10L

Vertical and horizontal transmissions

Cyclo-developmental, propagative and cyclo-propagative transmissions

Biology, importance and control

Anopheles, sandfly, black fly, tabanid fly, ticks and mites

Suggested readings:

Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.

Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley andSons Inc.

Chandra, G. (2000). *Mosquito*. Sree Bhumi Publication Co. Kolkata.

Chatterjee, K. D. (1981).*Parasitology (Protozoology and Helminthology*).13th ed. CBS.

Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.

Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.

Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata.

Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.

Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.

Mullen, G. R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.

Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts' Foundation of Parasitology*. 9th ed. McGraw-Hill International.
Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd ed. McGraw Hill Publishers.
Schmidt, G. D. (1989). *Essentials of Parasitology*. Wm. C. Brown Publishers (Indian print;1990, Universal Book Stall).
Smyth, J. D. (1994). *Animal Parasitology*. 3rd ed. Cambridge University Press.
Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of domesticated animals.* ELBS and Bailliere Tindall. London.

MSZO 104: Core Course
(FISH BIOLOGY AND FISHERIES)
(Credit 4)

Course specific outcome

This course is consisting of two units dealing with classification, structural organization and life processes in fish, as well as basic aspects of diverse culture practices and marine fisheries resources. Students will have an overview of the fish as an organism along with social and economic importance of the fisheries sector.

Time: 2 hrs **Full Marks: 50**

Unit – I: FISH BIOLOGY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Classification of fish 3L

Principles of classification, extinct fish groups, distinctive characters of major fish orders: Cypriniformes, Siluriformes, Clupeiformes, Ophidiiformes, Perciformes, Synbranchiformes, Mugiliformes

Structure, development, comparative account and functions 5L

Integument, scale, bioluminescent organ, electric organs and electroreception, poison gland, swim bladder, Weberian ossicles, digestive system, excretion and osmoregulatory system

Sense organs 6L

Eye and photoreception, olfactory organ and chemoreception, acousticolateralis system (membranous labyrinth and lateral line), special sense organs (Ampullae of Lorenzini, Pit Organs)

Endocrinology 5L

Hypothalamo-hypophyseal system, Pituitary gland (Origin, location, anatomy and functional morphology, hormones), Other endocrine glands (structure and functions): Thyroid, Adrenal, Corpuscles of Stannius, Ultimobranchials, Caudal neurosecretory system and Pineal (Endocrine function of the gonads)

Reproduction and Development 4L

Structure and functions of reproductive organs, gametogenesis, types and modes of reproduction, sexuality (intersex, bisexuality, hermaphroditism); breeding and parental care

Fish migration

Purpose and types of migration in fish, diadromous migration, physiological factors controlling iono- and osmoregulation, energetics, environmental, factors, anthropogenic impacts 2L

Suggested readings:

Bond, C. E. (1996). *Biology of Fishes*.2nd ed. Saunders Pub.

Evans, D. H. (1998).*The Physiology of Fishes*.CRC Press.

Hoar and Randall.*Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)

Jayaram, K. C. (1999). *The Freshwater Fishes of the Indian Region*.Narendra Publishing House, New Delhi.

Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed., Hindusthan Pub.Corp. John Wiley and Sons.

Khanna, S.S., Singh, H.R. (2015). *A textbook of Fish Biology and Fisheries.*3rd ed., Narendra Publishing House, Delhi-110006. India

Lagler, K. F., Bardach, J. E., Miller, R. R. and Passino, D. R. (1977).*Ichthyology*.2nd ed. John Wiley & Sons, New York.

Srivastava, C. B. L. (1999). *Fish Biology*.Narendra Pub. House.

Unit – II: FISHERIES (Credit 2)

Full Marks: 25

Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Concepts of fisheries and aquaculture **6L**

Present status, scope and possibilities of further development

Fisheries resources, Nutritive value of fish

Different culture systems (extensive, intensive, semi-intensive, fresh water, brackish water, coastal, hill stream, cage, pen, and race way)

Inland fisheries **4L**

Cultivable fishes, construction of pond, pond soil and water, carrying capacity, pond management for different stages of carp, induced breeding of prawn and air breathing fish, composite culture of carps and air breathing fish, inland fishing gears and fishing method

Ornamental fish culture and aquarium management **2L**

Design and construction of aquarium, common ornamental fishes, breeding and seed production (live bearers and egg layers), aquarium plants, maintenance and water quality management

Aquaculture biotechnology **6L**

Aquaponics and hydroponics, hybridization and transgenic fish, pearl oyster farming and pearl culture technology, fish oil (composition, extraction and purification)

Marine fisheries **5L**

Resources, marine zonation, principal capture fisheries (Hilsa, Sardine,

Mackerel, Bombay Duck, and Pomfrets), elasmobranch fishery (major groups, fishery methods, importance), molluscan fishery

Suggested readings:

Bardach, J. E. and Ryther, J. H. (1972).*Aquaculture*.John Wiley and Sons.

Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.

Dunham, R. A. (2004). Aquaculture and fisheries biotechnology: genetic approaches. CABI Publishing, Cambridge, USA.

Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. Hindusthan Pub.Corp. John Wiley and Sons.

Lowe, H. (2005). *Beginner's Guide to Aquarium Fish and Fish Care*. Abhishek Press, New Delhi.

Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nded. Blackwell Publishing Ltd.

Reddy, P. V. G. K., Ayyappan, S., Thampy, D. M. and Krishna, G. (2005).T*extbook of Fish Genetics and Biotechnology*. ICAR, New Delhi.

Parker,R. (2012).Aquaculture Science, 3rd ed. Delmar, Cengage Learning, USA.

PRACTICAL PAPERS

MSZO 105 (Unit - I) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

This course will offer basic methods used in ecology and conservation biology. The section will cover analysis of physico-chemical parameters of soil, line transact method and pug mark analysis used in conservation biology, effect of different stimulants on coughing rate and operculum movement in fish.

MSZO-105: ECOLOGY and CONSERVATION BIOLOGY (Credit 2)

1. Quantitative estimation of major physico-chemical components in an ideal aquatic ecosystem: temperature, pH, dissolved oxygen and carbon di-oxide, chloride, hardness and salinity
2. Quantitative estimation of soil edaphic factors and sediment: moisture, pH, phosphates and nitrates
3. Wildlife census techniques: Line transact method, Pug mark analysis
4. Phototaxic movement of earthworm
5. Effects of different stimulants on coughing rate and operculum movement in fish
6. Laboratory records
7. Viva-voce

MSZO 105 (Unit - II) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

This course will offer identification of common pests, insects of medico-legal importance, and social insects aiming at strengthening knowledge on external morphology.

MSZO-105: ENTOMOLOGY (Credit 2)

1. Digestive system of Honey bee
2. Nervous system of Honey bee
3. Mounting and study of:
   Mouthparts of grasshopper, bug, mosquito, house fly, bee
   Wings of Ephemeroptera, Odonata, Dictyoptera, Hemiptera, Diptera, Hymenoptera, and Coleoptera
   Legs: Gressorial, cursorial, saltatorial, fossorial, natatorial, corbiculate, clasporial, and raptorial

Antennae: Filiform, setaceous, plumose, pilose, pectinate, clavate, geniculate, aristate, serrate, and monilifom
Abdominal appendages: Male genitalia

4. Identification of common pests: Paddy (*Nilaparvata lugens*, *Nephotettix* spp., *Leptocorisa* spp., *Scirpophaga incertulas*/*innotata*); Jute (*Apion corchori, Diacrisia obliqua*); vegetables (*Epilachna* sp., *Leucinodes orbonalis*); stored grains (*Sitophilus oryzae*, *Callosobruchus* spp., *Tribolium castaneum*)
5. Identification of forensically important insects: *Musca* sp., *Calliphora* sp., *Sarcophaga* sp., histerid beetle, and staphylinid beetle
6. Social Insects: Morphological studies of social insects (Honey bee and termite)
7. Laboratory records
8. Submission of prepared slides and pests
9. Viva-voce

MSZO 106 (Unit - I) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

This course will offer first-hand knowledge on advanced parasitological techniques used in various clinical laboratories.

MSZO-106: PARASITOLOGY AND VECTOR BIOLOGY (Credit 2) `

1. Smear preparation and staining of parasitic Protozoa
2. Drawing and staining of blood films for parasitic Protozoa and microfilaria
3. Whole mount preparation of trematode and arthropod parasites
4. Staining of scolex and proglottids of cestodes
5. Whole mount preparation of mosquito vectors (*Anopheles, Culex* and *Aedes*)
6. Identification of parasites and vectors (Slides/ Photographs)
7. Retrieval of parasite nucleic acid /protein sequence from Nucleic acid/ Protein Data Base / Parasite Data-Base, Alignment of parasite DNA /Protein sequence
8. Laboratory records
9. Submission of prepared slides
10. Viva-voce

MSZO 106 (Unit - II) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

This course will enable the students for field identification of the common freshwater fish species. In addition, determination of food and feeding habit, histological observations on the tissues and studies on some of the organ systems in fish will help the students to know the fish as an experimental model.

MSZO-106: FISH BIOLOGY AND FISHERIES (Credit 2)

1. Study of bucco-pharynx, gill rakers and gut content analysis in relation to food habits of teleosts
2. Urinogenital, olfactory and digestive systems in teleosts
3. Gas (swim or air) bladder and Weberian ossicles
4. Histological preparation of testis, ovary, kidney, pituitary, hepato-pancreas and intestine of fish
5. Identification of different fish
6. Laboratory records
7. Submission of prepared slides
8. Viva-voce

SEMESTER – II

MSZO 201: Core Course
(BIOSYSTEMATICS AND EVOLUTIONARY BIOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units, Biosystematics and Evolutionary Biology. Unit – I will provide understanding on naming of animals, development of concept on species, ontological issues and status, phylogenetical classification and trees, taxonomic characters, concept of homology and molecular taxonomy. While Unit – II will will deal with important population and quantitative genetic concepts such as genetic drift, natural selection, selective sweep, inbreeding, heritability and quantitative traits. These population and quantitative genetic concepts could be applied to problems related to the genetic dynamics of human evolution.

Time: 2 hrs **Full Marks: 50**

UNIT - I: BIOSYSTEMATICS (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Taxonomic characters 2L
Concept of character, qualitative and quantitative, homology

Species concepts 3L
Biological, Evolutionary; Phylogenetic

Species taxon 2L
Polytypic, categories, intra-populational variations, delimitation criteria

Classification 6L
Phenetics: Concept, phenograms
Cladistics: Concept, homology, homoplasy, cladograms
Evolutionary: Concept of monophyly, paraphyly & polyphyly

Molecular taxonomy 5L
Genomics and Proteomics in taxonomy: Concept and applications
Molecular basis of taxonomy: nuclear DNA, mitochondrial DNA, ribosomal RNA, cytochrome-C, α globin polypeptide chain
Sequence alignment: Pair-wise alignment and multiple sequence alignment, Global and local alignment
Nuclear substitution models
DNA barcoding, Barcode gap, Barcode databases

International Code of Zoological nomenclature (ICZN) 5L
The International Code; interpretations and applications

International Code of phylogenetic nomenclature (PhyloCode) 2L
Principles; important rules and their interpretations

Suggested readings

Anonymous [International Commission on Zoological Nomenclature] (1999). *International Code of Zoological Nomenclature*. 4th edition. International Trust for Zoological Nomenclature, London, xxix + 306 p.

Cantino, P. D. and de Queiroz, K. (2020). International code of phylogenetic nomenclature: PhyloCode. 1st Ed. CRC Press Taylor & Francis Group. Felsenstein, J. (2004). *Inferring Phylogenies*. Sunderland, Massachusetts: Sinauer Associates.

Forey, P. L., Humphries, C. J., Kitching, I.J., Scotland, R. W.; Siebert, D. (1993). *Cladistics – A practical course in systematics*. Oxford University Press.

Hall, B. G. (2004). *Phylogenetic trees made easy: a how-to manual*. Sinauer Associates.

Hennig, W. (1966). *Phylogenetic Systematics.* University of Illinois Press, Urbana, Chicago, London, vii + 263 p.

Kapoor, V. C. and Kapoor, M. (2012). *Theory and Practice of Animal Taxonomy*. Oxford and IBH. 7th ed.

Kitching, I. J., Forey, P. L., Humphries, C. J. and Williams, D. (1998). *Cladistics: Theory and Practice of Parsimony Analysis* (*Systematics Association Special Volumes*). 2nd ed. OUP Oxford.

Lomolino, M. V., Riddle, B. R., Whittaker, R. J. and Brown, J. H. (2010). *Biogeography*. 4th Ed. Sinauer Associates.

Mayr, E. (1997). *This is biology: the science of the living world*. Belknap, Harvard University Press, Cambridge, Mass.

Mayr, E. and Ashlock, P. D. (1991). *Principles of Systematic Zoology.* 2nd ed. McGraw-Hill.

Mishler, Brent D. (2005). The logic of the data matrix in phylogenetic analysis. In:Albert, V.A. (ed.), *Parsimony, Phylogeny, and Genomics*, Oxford University Press, 57-70.

Quicke, D. A. J. (1993). *Principles and Techniques of Contemporary Taxonomy*. Blackie Academic and Professional.

Scott-Ram, N. R. (1990). *Transformed cladistics, taxonomy and evolution*. Cambridge University Press.

UNIT II: EVOLUTIONARY BIOLOGY (Credit 2) **Full Marks: 25**

Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Evolutionary time scale and geological eras **1L**

Origin and early history of life **2L**

Evolution of prokaryotes; Origin and evolution of unicellular eukaryotes – Endosymbiotic theory

Population as unit of evolution **5L**

Populations, gene pool, gene frequency in Mendelian population

Hardy-Weinberg Equilibrium

Major evolutionary forces: Migration; Mutation; Selection (types of selection, selection coefficient, selection in natural populations); Random genetic drift

Species and phylogenetic relationships **2L**

Concepts of species and models of speciation

Phylogenetic relationships; Chromosome phylogeny in *Drosophila* (based on inversion polymorphism)

Chromosomal, allozyme and DNA polymorphisms **2L**

Adaptive genetic polymorphism

Balanced polymorphism and heterosis

Genetic coadaptation and linkage disequilibrium

Evolution at molecular level **4L**

Genomic and proteomic changes
Concepts of neutral evolution and Molecular clock
Molecular phylogeny

Hominid evolution **5L**

Anatomical, geographical and cultural
Ancestry of *Homo sapiens*: molecular phylogenetic relationship
Peopling of continents
Human genome variation
Ancient DNA **4L**

Patterns and trends in evolution

Constructing evolutionary trees, measures of genetic relationship among organisms
Tools of studying human evolution
Cultural evolution

Suggested readings:

Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, D.B. and Patel, N.H. (2007). *Evolution*. CSHL Press.
Brooker. (2011). *Genetics: Analysis and principles*. 4th ed. McGraw-Hill Science.
Dobzhansky, T., Ayala, F. J., Stebbins, G. L. and Valentine, J. W. (1977). *Evolution*. Surjeet Publications, New Delhi.
Futuyama, D. (1997). *Evolutionary Biology*. 3rd ed. Sinauer Associates, INC.
Futuyama, D. (2005). *Evolution*. Sinauer Associates, INC.
Hall, B. K. and Hallgrimson, B. (2008). *Strickberger's Evolution*. 4th ed. Jones and Bartlett.
Hartl, D. L. (2005). *Principles of Population Genetics*. 4th ed. Sinauer Associates.
Minkoff, D. (1983). Evolutionary Biology. 3rd ed. Sinauer Associates, INC.
Page, R. D. M. and Holmes, E. C. (1998). *Molecular Evolution: A Phylogenetic Approach.* Blackwell Science Ltd (2nd Reprint, 2001).
Ridley, M. (1996). *Evolution*. 2nd ed. Blackwell Science Ltd.
Stansfield, W. D. (2001). *Principles of Genetics*. (5thed.). Tata McGraw-Hill. Publ. Co.
Stearns, S. C. and Hoeskstra, R. F. (2005). *Evolution*. Blackwell Science Ltd.
Stebbins, G. L. (1969). *Process of Evolution*. Tata McGraw-Hill.
Volpe, E. P. and Rossenbaum, P. A. (1999). *Evolution*. Mc-Graw Hill Science Engineering.

MSZO 202: Core Course
(MICROBIOLOGY AND IMMUNOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units. The students successfully completing the course will be able to study the microflora of a particular area and its prospects in several fields of environmental, medical and animal microbiology. Students will have the knowledge on diversity of microbes, in-depth knowledge in the structure of a repertoire of microorganisms, metabolism in the cell, microbial physiology, host-microbe interactions, microbial pathogenicity and microbial diseases. Further, they will be able to realize the usefulness of immunology in different research areas. Students might apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.

Time: 2 hrs **Full Marks: 50**

UNIT - I: MICROBIOLOGY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Pioneers of Microbiology 2L

Contributions of Leeuwenhoek, Koch, Pasteur, Jenner and Flemming

Microbial Ecology 3L

Microbial habitat (air, water and soil), Interactions among microbial populations, Microbial community dynamics (Population selection, Succession within microbial communities, Microbial Diversity and stability), Abiotic limitations of microbial growth (Liebig`s Law of Minimum, Shelford`s Law of Tolerance)

Bacteriology 4L

Major characteristics used in bacterial taxonomy, Structure and function of capsule, pili, flagella, cell wall, cell membrane, outer-membrane, plasmid and bacterial chromosome, Bacterial endospore, Control of microbes: Physical and chemical agents, chemotherapeutic agents (sulfa drugs and antibiotics)

Virology 4L

Structural organization of viruses, Prions and viroids, Lytic cycle of bacteriophages with reference to *E. coli* and T4, Lysogeny, lysogenic conversion, induction and significance

Animal and Veterinary Microbiology 3L

Microbial interactions with animals (Marine and freshwater invertebrates, Ruminants), Symbiotic light production, Sulfide based mutualism, Infections of *Escherichia coli*, *Shigella dysenteriae, Streptococcus pyogenes* and

Staphylococcus aureus, Microbial diseases of Cattles and Poultry birds

Insect Microbiology and Insect pathology 3L

Insect-pathogen relationship**,** Factors affecting the pathogenicity of insects, General properties, types and properties o f toxins and mode of action of *Bacillus thuringiensis, Bacillus sphaericus*; Bacterial and viral diseases of silkworm larvae and honey bees; Endosymbionts and their significance 6L

Medical Microbiology

Mode of transmission, pathogenicity and prevention of microbial diseases:

Air-borne (Tuberculosis and Influenza), Food and waterborne (Typhoid andCholera) and Arthropod borne (Dengue, JE and Yellow fever), Coronavirus disease (COVID-19) and herd immunity

Suggested readings:

Alexander, M. (1977). *Introduction to Soil Microbiology*. John Wiley and Sons, New York.

Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.

Atlas, R. M. and Bartha, R. (1997). *Microbial Ecology: Fundamentals and Applications.,* 4th ed. Benjamin/ Cummings.

Black, J. G. (2011). *Microbiology: Principles and Explorations.* 8th ed. John Wiley and Sons, New York.

Campbell, R. (1983). *Microbial Ecology*. 2nd ed. Oxford, Blackwell.

Davis, B. D., Dulbecco, R., Eisen, H.N. and Ginsberg, H.S. (1990). *Microbiology.,*4th ed. Harper and Row.

Dimmock, N. J. and Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th ed. Blackwell Scientific Publications. London.

Holt, J.G., Krieg, N.R., Sneath, P.H.A. Staley, J.T. and Williams, S.T. (1994). *Bergey's Manual of Determinative Bacteriology*. 9th ed. Baltimore (MD): Williams and Wilkins.

Maloy, S. R., Cronan, E. J. and Freifelder, D. (1994). *Microbial Genetics*. 2nd ed. Jones and Bartlett.

Pelczar, M. J., Reid, R. D. and Chan, E. C. (1993). *Microbiology.* 5th ed. Macmillan. London.

Pinehuk, G. (2003). *Schaum's outline Series: Theory and Problems of Immunology*. McGrawHill.

Presscott, L. M., Harley, J. P. and Klein, D. A. (2011). *Microbiology*, 8th ed. McGrawHill, New York.

Schlegel, H. G. (1993). *General Microbiology*. 7th ed. Cambridge University Press.

Slonczeweski, J.L. and Foster, J.W. (2009). *Microbiology- An Evolving Science.* Norton.

Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L. (1986). *General Microbiology.* 5th ed. Macmillan.

Talaro, K. and Talaro, A. (1999). *Foundations in Microbiology*.3rd ed. Dubuque, McGraw Hill.

Tortora, G. J., Funke, B. R., and Case. C. L. (2008). *Microbiology. An Introduction*. 9th ed. Benjamin/Cummings Publishing. Menlo Park Calif.

Voyleys, B. A. (2002). *The biology of viruses*, 2nd ed. McGraw-Hill.

UNIT - II: IMMUNOLOGY (Credit 2) **Full Marks: 25**

Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Overview of Immune System 2L

Innate and Adaptive Immunity

Specificity, diversity, Self *vs.* non-self discrimination, Antigen and Antibody, Memory Cells and Tissues of the Immune system, Anatomy and Functions of lymphoid tissues, antigens and antibodies, MHC molecules, Cytokines, complement system 3L

Innate Immunity

Nature and types of Pathogens associated molecular patterns - PAMP and DAMP, Recognition, cell associated pattern recognition receptor- Toll like Receptors (TLRs) structure and signalling, & sensors, cellular components, soluble effectors molecules

Inflammation reaction - Inflammasome — 6L

Adaptive immunity

Interaction between innate and adaptive immunity

Antigen Presentation and association with major histocompatibility complex (MHC), polymorphism of MHC genes

Antigens: B cells and T cell antigens, different types of epitopes, T cell epitope and T cell receptors

Immunoglobulins: Isotypic, allotypic and idiotypic variations

Generation of antibody diversity; Clonal selection theory, concept of antigen specific receptor

Organization and expression of immunoglobulin genes: generation of antibody diversity — 1L

Activation of T-Lymphocytes, MHC restriction — 2L

Hyperactivation of Immune System

Allergens and Hypersensitivity, Allergy, aetiology of Asthma, Genetics of hypersensitivity, Cytokine storms — 2L

Immunologic Tolerance and Autoimmunity

Autoimmune disorders – Rheumatoid arthritis, Systemic lupus erythematosus, Inflammatory bowel disease — 2L

Immunity to Tumors

Tumour microenvironment and immune cells- TAM, T reg cells and others, Immune check point inhibitors — 2L

Transplantation Immunology

Different types grafting, Graft rejection, *Graft versus host disease* (*GvHD),Genetics of*HLA typing and disease association — 5L

Immunotechnology

Vaccine – different types of vaccine, strategies of vaccine development - subunit vaccine, mRNA vaccine and others

Hybridoma technology

Antibody engineering

Immunoassays- Types and applications

Immunophenotyping

Suggested readings

Abbas, A. K., Lichtman, A. H. and Pillai, S. (2018). *Cellular and molecular Immunology*. 9th ed. Elsevier.

Abbas, A. K. and Lichtman, A. H. (2019). *Basic Immunology*. 6thed. Elsevier.

Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2019). Immunology. 8thed. W. H. Freeman and Co.

Murphy, K and Casey W. (2016). *Janeway's Immunobiology*. 8thed.Garland Science.

Roitt, I. M. and Delves, P. J. (2017). *Roitt's Essential Immunology*. 13th ed. Blackwell Science Ltd.

Wilson and Walker's (2018). *Principles and Techniques of Biochemistry and Molecular Biology.8th ed.*Cambridge University Press.

MSZO203: Core Course
(GENETICS AND CELL BIOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units. Students will learn about the overview of Mendelian genetics and its extension and inheritance biology; variations and mutation; karyotyping; banded chromosomes and individual characterization of the human chromosomes. Advanced areas like gene therapy, cancer therapy techniques, personalized medicine and pharmacogenomics, genetic screening and counseling, as well as basic concept about databases will also be covered. Further, students will learn about the overview of cellular structure and division, cytoskeleton and cellular transport, cell signaling, molecular mechanisms apoptosis, cellular senescence, chaperones, exosome biogenesis and function, transcriptomics, along with metabolome and metabolic disorders.

Time: 2 hrs **Full Marks: 50**

UNIT - I: HUMAN GENETICS AND GENOMICS STUDY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Overview of Mendelian genetics and its extension and inheritance biology 1L

Variations and Mutations 3L

Allelic frequencies, Genetic polymorphism-SNPS, factors responsible for stable polymorphism; DNA markers and populations differences; Genetic markers-STS, VNTRs, RFLP, AFLP

Cytogenetics 2L

Karyotyping; banded chromosomes and individual characterization of the human chromosomes; numerical chromosomal abnormalities; structural chromosomal abnormalities; somatic cell hybridization and use of somatic cell

Human genome project 3L

Human genome project and characteristics of human genome as eukaryotic genomic organization, Objectives and organization of human genome project, mapping strategies; Diversity and organization of human genome

Model organisms 3L

Genetics of *Drosophila*, Zebra Fish, Sex determination of *Drosophila* and man

Mitochondrial genome

Mitochondrial genome organization and disorder associated with mitochondrial DNA 2L

Epigenetic modifications and disorders

Genetic disorders and Twin Study and Gene therapy 1L

Monogenic diseases – Thalassemia, Albinism, Hemophilia, Colour blindness, Polygenic diseases- Hyperlipidemia, Diabetes mellitus 3L

Genetic basis of Myocardial Infarction, Genetic basis of neurodegenerative disorders

Cancer Biology and Genomics

Types, driver and passenger mutation;somatic mutations, genomic instability, cancer therapy 1L

Techniques in Genomic study 3L

Gel Electrophoresis, PCR, ARMS PCR, MLPA, RT-PCR, Sanger sequencing, NGS, genome-wide association studies (GWAS) and personalized medicine and pharmacogenomics

Genetic screening and counselling 2L

Prenatal and Post-natal screening of genetic diseases, amniocentesis, chronic villus sampling, family screening for genetic diseases; scope and methods of genetic counselling 1L

Databases and societies for Genomic study

dbSNP, hGVS, OMIM, HUGO and HGVS

Suggested readings:

Brown, T. A. (2006). *Genomes 3*. 3rd ed. Garland Science.

Griffiths, A. J. F., Wessler, S. R., Lewontin, R. C. and Carroll, S. B. (2008). *Introduction to genetic analysis*. 9th ed. W. H. Freeman and Company, New York.

Griffiths, A. J. F. (2002). *Modern Genetic Analysis: Integrating Genes and Genomics*. 2nd ed. W. H. Freeman and Company, New York.

Hartl, D. L. and Jones, E. W. (1998). *Genetics, Principles and analysis*. 4th ed. Blackwell Scientific, Oxford.

Hartl, D. L. and Jones, E. W. (2005). *Genetics: analysis of genes and genomes*. 6th ed. Jones and Bartlett Publishers, Sudbury, Mass.

Hartl, D. L. and Jones, E. W. (2006). *Essential Genetics: a genomics perspective.* 4th ed. Jones and Bartlett Publishers, Boston.

Lewin, B. (2008). *Genes IX*. Jones and Bartlett Publishers.

Watson, J. D., Baker, T. A. and Bell, S. P. (2007). *Molecular Biology of the Gene*. 6th ed. Benjamin Cummings.

Malacinski, G. M. (2003). *Essentials of Molecular Biology*. 4th ed. Jones and Bartlett.

McConkey, H. (1993). *Human Genetics: The molecular Revolution*. Jones and Bartlett Publishers.

Snustad, D. P. and Simmons. M. J. (2004). *Principles of Genetics.* 4th ed. John Wiley and Sons.

Stansfield, W. D. (1991). *Schaum's Outline Series: Theory and Problems of Genetics*. 3rd ed. McGraw-Hill.

Strachan, T. and Read, A. P. (2004). *Human Molecular Genetics-3.* Garland Science.

Strickberger M.W. (1985). *Genetics*. 3rd ed. Prentice Hall of India Pvt. Ltd., New Delhi.

Tamarin, R. H. (2004). *Principles of Genetics*. Tata McGraw-Hill Publishing Comp. Ltd.

Twyman R.M. (2003). *Advanced Molecular Biology*. Viva Books.

UNIT - II: CELLULAR PROCESS, OMICS STUDY AND APPLICATION (CREDIT 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Overview of cellular structure and division	2L
Cytoskeleton and cellular transport: Structure and function of microtubules, dynamic instability, MAPs, molecular motors	2L
Cell signalling: Cell surface and intracellular receptors, ligands, cell signaling pathways (MAPK, TGFB, NfKB) and cross talk mechanisms; Role of calcium and NO in signal transduction	2L
Cytotoxicity: Carcinogens, mutagens, teratogens	1L
Apoptosis:Molecular mechanisms, regulations	1L
Autophagy, cellular senescence, Chaperones	1L
Exosome biogenesis and function and molecular cargo	
Study of Transcriptomics	
Gene regulation, non-Coding RNAs: sncRNA miRNA, LncRNA	2L
Study of Metabolomics: Metabolome and Metabolic disorders	1L
Methods in Cellular Process study and application	2L
Two hybrid screening, Co-Immunoprecipitation study, Western blotting, Nucleic Acid Hybridization Assays, Gel retardation assay, Cloning of Gene and generation of Recombinant DNA, Preparation and screening of genomic and cDNA library, somatic cloning, Gene knockout procedure, Cre-Lox P, CRISPER-CAS system and generation of transgenic animal, Ethics and rule	5L
Techniques in cellular process	
Primary culture and cell lines, organoid culture, MTT assay, cancer lines, Cell freezing, Confocal and Atomic force microscopy, Flow cytometry, Micro-array, National and global Cell repositories – ATCC, NCCS	3L
Cell synchronization, Fluorescence plus Giemsa staining technique, average generation time	1L
Databases for cellular process study: Geo databases, Pathway analysis and databases, miRBase	2L

Suggested readings:

Alberts, B., Johnson, A.Lewis, J., Raff, M., Roberts, K. and Walter, P. (2008). *Molecular Biology of the Cell*. 5th Ed. Garland Publishing House.
Becker. (2009). *The World of the Cell*. 7th ed. Benjamin-Cummings.
Clark, D. P. (2005). *Molecular Biology*. Elsevier.
Cooper, G. M. (2004). *The Cell*. 3rd ed. ASM Press.
Harvey, L. (2004). *Molecular Cell Biology*. 5th ed. W.H. Freeman.
Karp, G. (2008). *Cell and Molecular Biology: Concepts and experiments*. 5th ed. John Wiley.
Malacinski, G. M. (2003). *Essentials of Molecular Biology*. 4th ed. Jones and Bartlett.
Phillips, R., Kondev, J. and Theriot, J. (2008). *Physical Biology of the Cell*. Garland Science.

MSZO 204: Core Course
(PHYSIOLOGY AND ENDOCRINOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units. Students will learn about the concepts homeostasis, acclimatization and adaptation. A comparative account of circulation, respiration, excretion, osmoregulation, and thermoregulation will be provided. Genesis of membrane potential, nerve impulse conduction and role of neurotransmitters will be covered. Endocrinology section deals with roles of chemical messengers in the control of homeostatic systems. It elaborates the chemical nature and its biological role of the cellular regulators, receptors. Endocrine physiology of various glands including neurohypohysial hormones, thyroid, pancreatic, adrenal, reproductive and GI tracts and understanding of endocrine disorders.

Time: 2 hrs **Full Marks: 50**

UNIT - I: PHYSIOLOGY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Basic concepts **2L**

Homeostasis, acclimatization and adaptation

Circulation **5L**

Composition of blood and its corpuscular elements: ultrastructure, pigments, and their formation
Hemostasis: platelet activation cascades, regulation
Lymph: composition and dynamics
Cardiac cycle and basic principle of ECG

Respiration **5L**

General idea: Total and partial air pressure
Gas solubility and diffusion in air and water
In Aquatic animals: Gill architecture in fish; ram ventilation, dual pump, gas exchange (counter current mechanism)
In Terrestrial animals: Lung ventilation (amphibians, reptiles, birds and mammals) Lung mechanics (human): Respiratory muscles, lung volumes, elastic properties, compliance, surface tension, pulmonary surfactants
Regulation (human): Respiratory centers, receptors, integration

Excretion and Osmoregulation **6L**

In terrestrial vertebrate (mammals): Structure and functions of kidney, Urea cycle and Aquaporins
Ultrastructure of nephron
Urine formation – Glomerular filtration and tubular reabsorbtion,
In aquatic vertebrate (fish): Importance of kidney as osmoregulatory organ
External osmoregulatory organs: Salt glands, Fish gills

Water and electrolyte balance (Na^+, K^+, Mg^{2+}), Acid-base regulation

Thermoregulation **4L**

Endothermy and Ectothermy

Thermoregulatory organs, responses to high and low temperature

Thermogenesis, Characteristics of fever

Neural Control **3L**

Sensory

Neuron: types; synapse (excitatory and inhibitory post-synaptic potential)

Genesis of membrane potential

Neurotransmitters (Acetylcholine, GABA, nitric oxide), chemical transmission through synapse

Suggested readings:

Koppen, B. M. and Stanton, B. A. (2009). *Berne and Levys' Physiology*. 6th ed. Mosby.

Ganong, W. F. (2003). *Review of Medical physiology*. 21st ed. McGraw Hill.

Chaudhuri, S. K. (2000). *Concise Medical Physiology*. New Central Book Agency (P) Ltd.

Hill, R.W., Wyse, G.A. and Anderson, M. (2008). *Animal Physiology*. 2nd ed. Sinauer Associates Inc.

Hoar, W. S. (1984). *General and comparative Physiology*. 3rd ed. Prentice-Hall of India.

Randall, D., Burggren, W. and French, K. (2002). *Eckert's Animal Physiology – Mechanisms and Adaptation*. 5th ed. W. H. Freeman.

Sherwood, L. (2004). *Human Physiology: From cells to systems*. 5th ed. Thomson Brooks Cole.

Schmidt Nielsen, K. (1994). *Animal Physiology: Adaptation and Environment*. Low Price Cambridge Edition.

Willmer,P., Stone, G. and Johnston, I. (2004). *Environmental Physiology of Animals*. 2nd ed. Wiley Blackwell.

UNIT - II: ENDOCRINOLOGY (Credit 2)

Full Marks: 25

Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Hormones **4L**

Characteristics and chemical classification of hormones, concept of receptors

Neuro-endocrine components in vertebrates

Hypothalamic and Pituitary hormones in vertebrates: Chemical nature and regulations **2L**

Thyroid hormones: biosynthesis and functions **3L**

Pancreatic hormones **5L**

Structure and biosynthesis and function: insulin and glucagon

Adrenal hormones

Structure, biosynthesis and functions of adreno-cortical hormones **5L**

Structure, biosynthesis and functions of adreno-medullary hormones

Reproductive hormones

Ovarian and testicular hormones and their functions

Biosynthetic pathway of ovarian and testicular steroidogenesis **3L**

Hormonal regulation of oestrous and menstrual cycle, and pregnancy

Hormones of the GI tract **3L**

Structure, functions and regulation of gastrin, rennin, secretin,

cholecystokinin and grehlin

Endocrine disorders

Diabetes, adrenocortico-disorders, hypo- and hyper-thyroidism, thryrotoxicosis and Infertility

Suggested readings:

Bolandar, M. (2001). *Molecular Endocrinology*. Elsevier Science.

Greenspan, F. S. and Gardener, F. G. (2003). *Basic and Clinical Endocrinology*. 7th ed. McGraw Hill.

Hadley, M. E. (2000). *Endocrinology*. 5th ed. Pearson Education.

Norris, D. O. (2006). *Vertebrate Endocrinology*. 4th ed. Academic Press.

Melmed, S., Polonsky, K. S., Larsen, P. R. and Kronenberg, H. M. (2011). *Williams Textbook of Endocrinology.* 12th ed. Saunders.

PRACTICAL PAPERS

MSZ0 205 (Unit - I) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

This course will help to develop idea on dichotomous key construction. Identification of taxa using key and phylogenetic tree construction will be emphasized.

MSZ0 205: BIOSYSTEMATICS (Credit 2)

1.
   a. Identification of specimens of major orders of class Insecta using the key
   b. Construction of dichotomous key from the provided dataset
   c. Construction of trees from the provided morphological dataset using suitable software (Mesquite, TnT) and their interpretation
   d. Retrieval of nucleotide sequences from data bases, sequence alignment
   e. Construction of trees from the molecular data using suitable software (MEGA) and their interpretation
2. Laboratory records
3. Viva-voce

MSZ0 205 (Unit - II)Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

Students will be able to learn wide variety of Cell Biology and Genetics techniques lik human peripheral blood lymphocyte isolation and culture, karyotyping; Mitotic index an mitotic abnormalities; MTT test, Trypan blue and Apoptosis test; Identification of mutan of Drosophila; polytene chromosomes preparation; DNA extraction and quality-quanti analysis; PCR and RT PCR techniques; determination of the molecular weight of th protein using SDS PAGE; cancer cell culture and counting of colony, scratch wound assa Flow cytometry-based apoptosis and cell cycle analysis and Identification of cancer cel and stages.

MSZ0 205: GENETICS AND CELL BIOLOGY (Credit 2) **Time: 2 hrs**
Full Marks: 25

1. Separation of peripheral lymphocyte and lymphocyte culture G Banding
2. Study of the Mitotic index and mitotic abnormalities in *Allium cepa* root apical meristem cells
3. MTT test, Trypan blue and Apoptosis test
4. Identification of mutants of *Drosophila*
5. Study of polytene chromosomes of Chironomid larvae
6. DNA extraction and study of the DNA quality and quantity (UV spectroscopy and

agarose gel electrophoresis
7. PCR
8. Demonstration of RT PCR and calculation of Fold change of gene expression (delta CT method)
9. Demonstration of SDS PAGE and determination of the molecular weight of the protein
10. Demonstration of cancer cell culture and counting of colony
11. Demonstration of scratch wound assay – for invasion and metastasis
12. Demonstration of Flow cytometry-based apoptosis and cell cycle analysis
13. Identification of cancer cells and stages
14. Laboratory records
15. Viva-voce

MSZO 206 (Unit - I) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

Students will learn about the basic Physiology and Endocrinology techniques like hemoglobin content, C.T. and B.T. in human blood; estimation of fasting and PP blood Sugar; estimation of blood Cholesterol; identification of abnormal RBC, TC - DC; pulse rate and blood pressure; estimation of steroid and thyroidhormone by ELISA; ovariectomy, orchidectomy and their effects in laboratory animals; estimation of ascorbic acid; identification of stages of estrous cycle in rat.

MSZO 206: PHYSIOLOGY AND ENDOCRINOLOGY (Credit 2) **Time: 2 hrs**

Full Marks: 25

1. Determination of haemoglobin percent, C.T. and B.T. in human blood
2. Estimation of fasting and PP blood Sugar in human by GOD-POD method
3. Biochemical estimation of blood Cholesterol
4. Preparation of blood film and identification of abnormal RBC (inclusion body), TC -DC
5. Measurement of pulse rate and blood pressure in human
6. Estimation of steroid and thyroid hormone by ELISA
7. Demonstration of ovariectomy, orchidectomy and their effects in laboratory animals
8. Quantitative estimation of ascorbic acid content of ovary as an assay of LH
9. Demonstration of Adrenalectomy in rat
10. Identification of stages of oestrous cycle by vaginal smear preparation in rat
11. Laboratory records
12. Viva-voce

MSZO 206 (Unit - II) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

Students will study different techniques used in microbiology like sterilization techniques, culture media preparation, preparation of plates, slants and stabs, isolation and enumeration of bacteria from soil, water and air, various staining techniques, phenotypic and biochemical properties of different bacterial strains. The objectives of this laboratory course are to develop an understanding about practical aspects of the components of the immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells etc. and how they can be used in respective research work.

MSZO 206: MICROBIOLOGY AND IMMUNOLOGY (Credit 2) **Time: 2 hrs**

Full Marks: 25

1. Microbiology
    a. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria
    b. Preparation of slant and stab
    c. Pure culture techniques: Spread plate, pour plate and streak plate
    d. Study on the colony morphology
    e. Simple staining of bacteria and study of cell types; differential staining: Gram staining
    f. Biochemical tests for characterization: Catalase, nitrate reduction, indole production, methyl red and Voges–Proskauer test
    g. Preparation of sanitizer
    h. Laboratory records
    i. Viva-voce
2. Immunology Practical
    a. Identification and demonstration of Primary and secondary lymphoid organ and Preparation of cell suspension from the lymphoid tissue (primary/secondary) of mouse for the estimation of live and dead cells
    b. Separation of macrophages from the peritoneal exudates and Characterization of nonspecific esterase activity in macrophages
    c. Separation PBMC from Human blood
    d. Determination of antibody titer by immunodiffusion methods
    e. Agglutination and precipitation techniques
    f. Demonstration of ELISA methods
    g. Identification of different immune cells and section of immune organs
    h. Laboratory records
    i. Viva-voce

SEMESTER – III

MSZO 301: Core Course
(BIOCHEMISTRY AND TOXICOLOGY)
(Credit 4)

Course specific outcome

The objectives of this course are to build upon advance level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various biochemical methodologies associated within the context of each topic. Understanding the Laws of thermodynamics and their applications; pH and buffers; classification, structure and importance of carbohydrates, protein and lipids; enzyme kinetics and mechanisms action; carbohydrate, amino acid and lipid metabolism and metabolic disorders and concept of integration of metabolic pathways; energy transduction and ATP synthesis; oxidative stress and lipid peroxidation; free radicals and free radical scavengers; and techniques of analytical Biochemistry. Understanding the harmful effects of different types of chemical on man, animals and environment, mechanism of their action; detoxification mechanisms

Time: 2 hrs **Full Marks: 50**

UNIT - I: BIOCHEMISTRY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Laws of thermodynamics and their applications **1L**

Concept of free energy and calculations based on free energy change

pH and Buffers **1L**

Bronsted-Lowry concept of acids and bases, buffers, biological buffer systems: the phosphate buffer system, the bicarbonate buffer system

Carbohydrates **2L**

Overview of classification and importance, asymmetry, optical isomerism, mutarotation

Protein structure **3L**

Primary structure, peptide bond

Secondary structure

α-helix, β-pleated sheet and bends

Prediction of secondary structure, Ramachandran plot

Tertiary structure

Forces stabilizing tertiary structure

Domains and motifs

Quaternary structure **2L**

Lipids

Lipid digestion, absorption and transport, Ketone bodies

Biological roles of lipids, Emulsification, Surface Tension, Hydrolysis, Saponification, Rancidity, Hydrogenation **4L**

Enzymes

Enzyme kinetics

Thermodynamics of enzyme-substrate interactions, Binding energy in catalysis; Fundamental principles of reaction Kinetics and equilibria of activation energy, Overview of Michaelis-Menten equation, related calculations and Lineweaver-Burk plots

Mechanisms of enzyme action

Active site, substrate binding, transition state analogues and abzyme

Acid-base and covalent catalysis (chymotrypsin, carboxypeptidase) **4L**

Concepts of regulation of enzyme activity, Multisubstrate systems and their kinetics, Multienzyme complexes

Metabolism

Glycogen breakdown, glycogen synthesis, regulation of glycogen metabolism, Glycolysis-an overview; Krebs cycle and its regulation; Cori cycle, glyoxylate cycle; glucuronic acid cycle; gluconeogenesis and its regulation; pentose phosphate pathway, regulation and significance, Concept of Integration of metabolic pathways **1L**

Energy transduction and ATP synthesis

Glucose and fatty-acids as energy source, electron transport chain, oxidative phosphorylation **1L**

Metabolic disorders **1L**

Regulation of amino acid and lipid metabolism and metabolic disorders

Oxidative stress and lipid peroxidation

Free radicals and Free radical scavengers (Polyphenols, vitamins C & E, glutathione, catalase, superoxide dismutase); lipid peroxidation **5L**

Analytical Biochemistry

Differential centrifugation, ultracentrifugation, chromatography, electrophoresis, spectrophotometry, application of spectroscopic techniques to study biomolecular interaction, UV-Vis spectroscopy, fluorescence spectroscopy, IR, GC-MS, protein separation and characterization, X-ray crystallography, NMR, enzyme assays, isolation, purification and criteria for determining purity of enzymes

Suggested readings:

Bajpai, P.K. (2006). *Biological Instrumentation and Methodology.* 1st Ed. S. Chand & Company Ltd.

Berg, J. M., Tymoczko, J. K. and Stryer, L. (2007). *Biochemistry*. 6th ed. W. H. Freeman and Company.

Cantor, C.R. & Schimmel, P.R. (2003). *Biophysical chemistry* (3 vol. set). W. H. Freeman & Co.

Das, D. (2009). *Biophysics & Biophysical Chemistry*. Academic Publishers.

Devlin, T. M. (Ed.). (2002). *Textbook of Biochemistry with clinical correlations*. 5th ed. Wiley-Liss.

Friefelder, D. (1982). *Physical Biochemistry.* W. H. Freeman & Co. (Reprint 1999).

Hames, B.D., Hooper, N.M. & Houghton, J.D. (2002). *Instant notes in Biochemistry.* 2ndEd.Viva Books Private Limited.

Haynie, D. T. (1998). *Biological Thermodynamics*. Cambridge University Press (South East Asian Reprint 2007)

Mathews, C. K., Van Holde, K. E. and Ahern K. G. (2001). *Biochemistry*. 3rd ed. Person Education.

Metzler, D. E. (2003). *Biochemistry: The Chemical reactions of living cell*. Vol. 1 and 2. Academic Press.

Murray, R. K., Granner, P., Mayes A. and Rodwell, V. W. (2003). *Harper's Illustrated Biochemistry*. 25th ed. McGraw-Hill.

Nelson, D. L. and Cox. M. M. (2004). *Lehninger's Principles of Biochemistry*. 2nd ed. Macmillan Worth Publishers.

Sharma, B. K. (1991). *Techniques in Microscopy and Cell Biology*. Tata-McGraw Hill.
Switzer, R. L. and Garrity, L. F. (1999). *Experimental Biochemistry*. W. H. Freeman and Company.
Voet, D., Voet, J. G. and Pratt C. W. (1999). *Fundamentals of Biochemistry*. Upgraded edition. John Wiley and Sons.
Wilson, K., & Walker, J. (eds.) (2001). *Principles & Techniques of Practical Biochemistry.* 5th Ed. Cambridge University Press.

UNIT - II: TOXICOLOGY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Concept of toxicology 2L

Fundamentals of toxicology 4L

Types of toxic substances (including natural toxins, concept of xenobiotics, mutagens,clastogens, teratogens, carcinogens)
Disposition and biotransformation (phase I and phase II reactions)
Drugs as toxic substance (Paracetamol, Aspirin, Thalidomide)

Effects of toxic substances 3L

Biochemical and physiological effects
Interactive effects: additive effects, potentiation and synergism

Toxicity tests

Dose, dosage, dose response 3L
Acute toxicity tests: Bioassay, LC_{50} and LD_{50}, Probit analysis and significance
Chronic toxicity tests: Methods and significance; Mutagenicity testing (Ames test) 4L

Pesticides

Concept and classification
Insecticides and herbicides: Types (including bioinsecticides), sources, effects and degradation kinetics
Mechanism of action: Organochlorine, Organophosphate, Carbamates, Paraquat, Phenoxy herbicides 4L

Metal toxicity

Source, exposure, disposition and effects of heavy metals (Cd, Hg, Pb) and lighter elements (As, Se), Metal chelation 4L

Applied toxicology

Environmental toxicology
Occupational and industrial toxicology
Clinical toxicology
Forensic toxicology

Suggested readings:

De, A. K. (2000). *Environmental chemisrtry.* 4thed. New Age International (P) Ltd. Publishers.
Duffus, J.H. and Worth H.G.J. (Ed.) (2006). *Fundamental Toxicology*. RSC publishing.
Klaassen, C. D. (Ed.) (1996). *Casarett and Daul's Toxicology: The Basic Science of Poisons*. 5th ed. McGraw-Hill, New York.
Lu, F. C. (1996). *Basic Toxicology: Fundamentals, Target organs and Risk Assessment*. 3rd ed. Taylor and Francis.
Pandey, K., Shukla, J. P. and Trivedi, S. P. (2005). *Fundamentals of Toxicology*. New Central Book Agency (P) Ltd. Kolkata.
Plant, N. (2003). *Molecular Toxicology*. 1st Ed. Bios Scientific Publishers.

Stine, K. E. and Brown, T. M. (2006). *Principles of Toxicology*. 2nd Ed. CRC, Taylor and Francis Group, New York.
Timbrell, J. (2002). *Introduction to Toxicology*. 3rd Ed., Taylor and Francis, London.
Walker, C. H., Hopkin, S. P., Sibly, R. M. and Peakall, D. B. (2000). *Principles of Ecotoxicology*. 2nd ed. Taylor and Francis, London.

MSZO 302: Core Course
(HISTOLOGY–HISTOCHEMISTRY AND COMPARATIVE ANATOMY)
(Credit 4)

Course specific outcome

The students will be able to identify the basic structure of cells, tissues and organs and describe their contribution to normal vs. disease function. The student will be able to interpret light- and electron-microscopic histologic and histochemical images and identify the tissue source and structures. Students will be acquainted with the comparative account of different systems in invertebrates, organs of vertebrates, modifications in different systems in vertebrates for different modes of life.

Time: 2 hrs **Full Marks: 50**

UNIT - I: HISTOLOGY–HISTOCHEMISTRY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Fixation and Tissue preparation for histology — 3L
- Purpose of tissue fixation, Types of fixation
- Mechanism of tissue Fixation
- Fresh-frozen sections; Decalcification

Embedding — 2L
- Gum-sucrose/gelatin and paraffin wax embedding

Microtomy — 2L
- Methods. problems and remedies of microtomy including cryostat freezing microtome

Biological dyes and stains — 2L
- Characteris features of biological dyes and stain; Properties, source and use of haematoxylin, eosin, basic fuchsin, acid fuchsin, and carmine
- techniques for staining of bacteria, fungi and Protozoa

Principles and methods of histochemical localization and identification of the following: — 6L
- Carbohydrate moieties
  - Glycogen and glycoproteins with oxidizable vicinal diols by Periodic acid Schiff method
  - Glycoproteins with carboxyl groups and/or O-sulphate esters by Alcian blue methods
- Protein end groups
  - General proteins by Bromophenol blue method
  - $-NH_2$ groups by Nihydrin-Schiff method
  - –SS groups by Performic acid –Schiff and performic acid – alcian blue methods

Lipid moieties
General lipids by Sudan black B method
Neutral lipids by total Sudan III and Sudan IV methods
Nucleic acids
Methyl green pyronin for DNA and RNA
Feulgen reaction for DNA
Enzymes
Acid and alkaline phosphatases by Metal precipitation and Azo dye methods

Immunohistochemistry 2L
Basic principle, essential requirements, types and applications

Fluorescence histochemistry 2L
Basic principles and applications

Preparation of biological material for TEM and SEM 4L

Applications of electron microscopy in histochemistry, immunocytochemistry and autoradiography 2L

Suggested readings:

Bancroft, J. D. and Gamble, M. (2002). *Theory and practice of Histological Technique*. Churchill Livingstone.

Bloom, W. and Fawcett, D. W. (1998). *A Textbook of Histology*. 12th sub ed. W.B. CRC Press.

Fawcett, D. W. (2001). *Bloom and Fawcett: Concise Histology*. Arnold.

Friefelder, D. (1982). *Physical Biochemistry*. W. H. Freeman and Co. (Reprint 1999).

Junqueira, L. C. and Carneiro, J. (2005). *Basic Histology: Text and Atlas*. 11th ed. McGraw Hill Lange Med. Pub.

Kiernan, J. A. (1999). *Histology and Histochemical Methods: Theory and Practice*. 3rded, Butterwork Heinemann.

Leeson, T. S., Leeson, C. R. and Paparo, A. A. (1988). *Text/Atlas of Histology*. 1st Ed. W. B. Saunders Company.

Ross, M, H., Reith, E. J. and Romell, L, J. (1998). *Histology: a text and atlas*. 2nd ed. Williams and Wilkins.

Ross, M. H. and Reith, E. (1985). *Histology: A Text and Atlas*. Harper and Row Publishers.

Sharma, B. K. (1991). *Techniques in Microscopy and Cell Biology*. Tata-McGraw Hill.

Stoward, P. J. and Everson Pearse, A. G. (1991). *Histochemistry: Theory and Practical*. 4th ed. Churchill Living Stone.

Weesner, F. M. (1965). *General Zoological Techniques*. The William and Wilkins Company.

UNIT - II: COMPARATIVE ANATOMY (Credit 2)

Full Marks: 25
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Comparative study of invertebrates 8L
Digestive system
Nervous system
Excretory system
Reproductive system and larval forms

Comparative study of vertebrates 4L
Stomach and Intestine
Respiratory organs
Heart
Brain and sensory organs

Comparative modifications in vertebrates 10L

Aquatic
Terrestrial
Aerial
Arboreal
Fossorial

Development and comparative account in vertebrates 3L

The integument and its derivatives (except glands)

Suggested readings:

Anderson, D. T. (Ed.) (2001). *Invertebrate Zoology*. 2nd ed. Oxford University Press.

Barnes, R. D. and Ruppert, E. E., (1996). *Invertebrate Zoology*. 6th ed. Brooks Cole. Ruppert, E. E., Fox, R. and Barnes R. D. (2003). *Invertebrate Zoology: A Functional Evolutionary Approach*. 7th ed. Brooks Cole.

Barrington, E. J. W. (1981). *Invertebrate Structure and function*. 2nd ed. ELBS and Nelson.

Brusca, R. C. and Brusca, G. J. (2002). *Invertebrates*. 4th ed. Sinauer Associates.

Hildebrand, M. (1995). *Analysis of Vertebrate Structure*. John Wiley and Sons.

Kardong, K. V. (2002). *Vertebrates: Comparative anatomy, function evolution*. Tata McGraw Hill.

Kent, G. C. and Carr, R. K. (2001). *Comparative anatomy of the Vertebrates*. 9th ed. Mc Graw Hill.

Meglitsch, P. A. and Schram, F. R. (1991). *Invertebrate Zoology*. Oxford University Press.

Pechenik, J. A. (1998). *Biology of the Invertebrates.* 4th Ed. McGraw Hill.

Romer, A. S. and Parsons, T. S. (1986). *The vertebrate body.* 6th ed. Saunders College Publishing.

Weichert, C. K. and Presch, W. (1984). *Elements of Chordate Anatomy*. Tata-McGraw Hill Pub. Comp.

PRACTICAL PAPERS

MSZO 303 (Unit - I) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

The course is designed to provide a broad exposure to all basic techniques (Biochemical) used in current Modern Biology research. The goal is to impart basic conceptual understanding of the principles of these techniques and emphasize on the Biochemical utility. At the end of the course, the student is expected to have enough understanding of all the analytical techniques such that the barrier to implement the same is abated to a great extent. Students will learn the quantitation of proteins, lipid, nucleic acids, enzyme activity, lipid peroxidation, assessment of toxicity, secondary metabolites and antioxidants by various methods; morphological deformities, determination of LC_{50} and LD_{50}, Probit analysis, etc.

MSZO 303 (Unit - I): BIOCHEMISTRY AND TOXICOLOGY (Credit 2)

1. Studies on quantitation of proteins by various methods: Lowry, Bradford, and UV spectrophotometry
2. Quantitation of Nucleic acids (DNA/RNA)

3. Preparation of extract for enzyme assay and Study of the enzyme (LDH/Alkaline phosphatase, catalase, amylase) activity
4. Electrophoretic analysis of total Protein in tissue extracts
5. TLC for separation of steroid and other secondary metabolites
6. DPPH and FRAP assay
7. Lipid Peroxidation Assay
8. Estimation of Lipid profile from blood
9. Determination of LC_{50} and LD_{50}, Probit analysis
10. Evaluation of toxicity through assay of
    (a) Cytochrome P-450 and
    (b) Acetylcholinesterase
    (c) Catalase
11. Assessment of toxicity through behavioural studies
    (a) Crawling activity
    (b) Climbing activity
12. Morphological deformities (study of symmetry) in biological organisms
13. due to toxicant exposure
14. Laboratory records
15. Viva-voce

MSZO- 303 (Unit - II) Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome

The objective of this laboratory course is to introduce students to conduct experiments in Histology-histochemistry. The course is designed to teach students the utility of set of experimental methods in a problem-oriented manner. Students will learn the anatomy (different systems) of different animals viz., *Channa* sp., *Vespa* sp. and prawn.

MSZO 303: HISTOLOGY–HISTOCHEMISTRY & COMPARATIVE ANATOMY (Credit 2)

Histology & Histochemistry

1. Fixation, dehydration, embedding, section cutting, staining and mounting of different animal tissues (Haematoxylin and Eosin, Mallory's Triple)
2. Identification of histological preparations of animal tissues
3. Demonstration of different microscopes
4. Histochemical reactions for: Carbohydrates, protein, lipid, DNA/RNA and alkaline phosphatases
5. Submission of permanent slides prepared for histological and histochemical studies of different tissues
6. Laboratory records
7. Viva-voce

Comparative Anatomy

1. Study of Anatomy

a. Afferent branchial system of *Channa* sp.
b. Ninth (IX) and tenth (X) cranial nervous system of *Channa* sp.
c. Digestive and nervous system of *Vespa* sp.
d. Nervous system of prawn

2. Laboratory records
3. Viva-voce

MSZO 304Z: GENERAL ELECTIVE
(APPLIED ZOOLOGY)
(Credit 2)

Course specific outcome

Understanding scope and prospects of Zoology in different areas like Entomology, Aquaculture, Ecology, Ethology, Medical Entomology, Human genetics, Nanomedicine, Immunodiagnostics, Toxicology, Mosquito borne, Microbial, and metabolic diseases and community health.

Time: 2 hrs **Full Marks: 25**

GE: APPLIED ZOOLOGY

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

1. Aquaculture management 4
2. Diabetes: Causes and management 2
3. Ecology and Ethology 2
4. Human genetics and Diseases 2
5. Immunodiagnostics 2
6. Insect Diversity; social insects 2
7. Medical Entomology 2
8. Microbial diseases and community health 3
9. Mosquito and Mosquito borne diseases 2
10. Nanomedicine: Nanotechnology, Biology and Medicine 2
11. Toxicology in everyday life 2

Suggested readings:

Abbas, A. K., Lichtman, A. H. and Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.

Alcock, J. (2001). *Animal Behaviour: An Evolutionary Approach*. Sinauer Associates. Inc. USA.

Berg, J. M., Tymoczko, J. K. and Stryer, L. (2007). *Biochemistry.* 6th ed. W. H. Freeman and Company.

Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes*. Narendra Publishing House. New Delhi.

Dugatkin, L. A. (2009). P*rinciples of Animal Behavior*. Princeton University Press, United States.

Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2003). *Immunology*. 5th ed. W. H. Freeman and Co.

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.

Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.

Klaassen, C. D. (Ed.) (1996). *Casarett and Daul's Toxicology: The Basic Science of Poisons*. 5th ed. McGraw-Hill, New York.

McConkey, H. (1993). *Human Genetics: The molecular Revolution.* Jones and Bartlett Publishers

Mullen, G. R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.

Nelson, D. L. and Cox. M. M. (2004). *Lehninger's Principles of Biochemistry*. 2nd ed., Macmillan worth Publishers.

Pillay, T. V. R. (1993). *Aquaculture.* Fishing News Books.

Presscott, L. M., Harley, J. P. and Klein, D. A. (2011). *Microbiology*. 8th ed. McGrawHill, New York.

Ricklefs, R. E. and Miller, G. L. (2000). *Ecology.* 4th ed. W. H. Freeman and Company.

Smith, T. M and Smith, R. L. (2006). *Elements of Ecology*. 6th ed. Pearson Education.
Stiling, P. (2002). *Ecology- Science and Applications*. 2nd ed. Prentice Hall of India.
Timbrell, J. (2002). *Introduction to Toxicology*, 3rd Ed. Taylor and Francis, London.
Tortora, G. J., Funke, B. R., and Case. C. L. (2008). *Microbiology. An Introduction*. 9th ed. Benjamin/Cummings Publishing.
Vogel, F. and Motulsky, A. G. (1999*). Human Genetics*. Springer.

MSZO 305: DISCIPLINE-CENTRIC ELECTIVE PAPERS
(Credit 4)

Time: 2 hrs **Full Marks: 50**

MSZO 305 (DE-1): AQUACULTURE AND FISHERIES (Credit 4)

Course specific outcome

The course will develop understanding on economic importance of fishes; different aspects of fish breeding and diverse culture practices. Some advanced areas like genome manipulation techniques and fish biotechnology will also be undertaken.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Inland fisheries resources in India and their principal species 4L

Food fishes and their economic importance 6L

Indian Major carps: *Catla, Labeorohita, Cirrhinusmrigala*
Exotic carps: *Hypophthalmicthys molitrix, Ctenopharyngodonidella, Cyprinus carpio*
Cat fishes: *Clariasbatrachus, Heteropneustesfossilis, Ompokbimaculatus, Pangasius* sp.
Other groups: *Anabas testudineus, Channa striatus, Etroplussuratensis*

Fish breeding 10L

Neuro-endocrine control of fish reproduction
Ecological requirements for gonad maturation and induced breeding
Induced breeding in carps and catfishes (Stripping); Multiple breeding of carps
Cryopreservation of gametes and embryo

Fish culture practices 20L

Breeding hapa, breeding pool, Carp hatchery (Glass jar, Chinese)
Collection of spawn, fries and fingerlings and their subsequent transport
Culture of air-breathing fishes
Integrated aquaculture: crop-livestock-fish farming
Rice-field aquaculture; *Pokkali*
Cage culture, pen culture, recirculating systems, Biofloc culture
Wastewater aquaculture: Problems, biotic community and health issues,

treatment of raw sewage, sewage utilization in aquaculture, Aquaculture-based sewage treatment plant

Invasive alien fish species: Impact, management

Cold water fisheries: resources, management and development, Mahaseer and Trout fishery, *Jhora* fishery

Diversification of aquaculture

Genome and fish biotechnology 10L

Sex Determination,Selective breeding (Intergeneric, interspecific) and Hybridization (inbreeding, outbreeding, cross-breeding), Jayanti rohu

Androgenesis and Gynogenesis

Polyploidy, broiler fish, super males and super females

Sex reversal, sterile fish, Monosex culture

Molecular markers, DNA barcoding, Zebra fish as a model organism

Transgenesis

Transgene delivery, integration, expression

Suggested readings:

Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Willey and Sons.

Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.

Dunham, Rex A. (2004). Aquaculture and fisheries biotechnology: genetic approaches. CABI Publishing, Cambridge, USA.

Bond, C. E. (1996). *Biology of Fishes*. 2nd ed. Saunders Pub.

Chakrabarti, N. M. (1998). *Biology, Culture and Production of Indian Major Carps – A Review*. Narendra Publishing House. New Delhi.

Chakraborti, N.M.; Chakraborty, P. P. and Mandal, S. C. (2010). *Biology, Breeding and Farming of Important Food Fishes.* Narendra Publishing House. New Delhi.

Evans, D. H. (1998).*The Physiology of Fishes*. CRC Press.

Hoar and Randall. *Fish Physiology,* Volumes I-XV (1969-onwards, Academic Press)

ICAR (2011).*Hand Book of Fisheries and Aquaculture*. 2nd Ed. ICAR, New Delhi

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd ed. Hindusthan Pub. Corp.

Kumar, R. (2011). *Biotechnology and Genetics in Fisheries and Aquaculture*. Arise Pub., Delhi.

Pillay,T. V. R. and Kutty, M. N. (2005). *Aquaculture: Principles and Practices*. 2nd ed. Blackwell Publishing Ltd.

Reddy, P. V. G. K., Ayyappan, S., Thampy, D. M. and Krishna, G. (2005). T*extbook of Fish Genetics and Biotechnology*. ICAR, New Delhi.

Singh, K. K. (2011). *Fish Genetics*. Sonali Publication, New Delhi.

Srivastava, C. B. L. (1999). *Fish Biology.* Narendra Pub. House.

Woynarovich, A., Moth-Poulsen, T. and Péteri, A. (2010). *Carp polyculture in Central and Eastern Europe, the Caucasus and Central Asia: a manual*. *FAO Fisheries and Aquaculture Technical Paper.* No. 554. Rome, FAO. 2010. 73p.

Parker,R. (2012). *Aquaculture Science*. 3rd ed. Delmar, Cengage Learning, USA.

MSZO 305 (DE-2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

Course specific outcome

Development of concept on population ecology, metapopulation and metacommunity; conservation of nature and natural resources; working experience on analytical models and simulation/computation models (e.g., prey-predator, plant-insect, population growth).

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Evolution of the biosphere 5L

The biosphere, structure and composition of atmosphere, general circulation of atmosphere, prevailing and adiabatic lapse rate, climate and vegetation

Development and evolution of ecosystems 6L

Ecosystem development, cybernetic nature of ecosystem and stability in the ecosystem, concept of climax, entropy law, energy transfer across trophic levels, energy budget, ecosystem services, Structure and function of some Indian ecosystems: terrestrial (Forest, grassland) and aquatic (freshwater, marine and estuarine)

Concept of productivity 5L

Biomass, Primary and secondary productivity, trophic structure and ecological pyramids, ecological efficiencies

Population ecology 6L

Population parameters and demographic techniques, Population growth-intrinsic rate of natural increase, 'r' and 'k' selection, theta logistic model, time-lag model, stochastic model, metapopulation 10L

Behavioural ecology

Territorial behaviour and habitat, Behavioural ecology of sex, signals and mating, colonizing stability, Evolutionary stable strategy (ESS) and game theory,distance movements and dispersal, altruism and reciprocal altruism, eusociality, chronobiology, colouration and mimicry

Chemical ecology 4L

Pheromones, allelochemicals and environment, semiochemicals, biochemical basis of food selection by insects, feeding attractants and oviposition stimulants

Environmental microbiology

Classification, characteristics, occurrence, distribution and ecological importance of microorganism; Photoautorophs, chemolithotrophs, organotrophs, parasites and their environmental importance; Detection of microbial toxins; Brief account of important viral, bacterial and fungal diseases of plants and their ecosystem level effects, Rhizospheres, 6L

Sedirophores/siderophores

Disaster Management

Major types of disasters: Earthquake, Flood, Tsunami, Nuclear, Chemical disasters, Biological disasters;. Disaster Hazard, Risk and Vulnerability Profile of India; Disaster management: Approaches, Policy objectives, cycles, risk assessment and vulnerability mapping; Disaster response: Central, State, District and Local administration; Disaster and health scenario 8L

Suggested readings:

Barton, L. L. and Northup, D. E. (2011). *Microbial Ecology*. Wiley-Blackwell.

Begon, M., Harper, J. L. and Townsend, C. R. (2006). *Ecology: Individuals, Populations and communities*. (4thed.). Blackwell science.

Brewer, R. (1994). *The Science of Ecology*. Saunders College Publishing, 2nd ed.

Chapman R. L. and Reiss, M. J. (2000). *Ecology – Principles and Applications*. Cambridge Low Price Edition.

Colinvaux, P. (1993). *Ecology 2*. John Wiley and Sons, Inc. New York, pp. 688.

Cunningham, W. P., Cunningham, M. A., and Saigo, B. W. (2003). *Environmental Science: A Global Concern*. 7th ed. McGraw-Hill Higher Education.

Dugatkin, L. A. (2004). *Principles of Animal Behaviour*. W. W. Norhon and Company.

Faurie, C., Ferra, C., Medori, P. and Devaux, J. (2001). *Ecology - Science and Practice*. Oxford and IBH Publishing Company Pvt. Ltd.

Freedman, B. (1989). *Environmental Ecology*. Academic press, Inc., PP. 424.

Jørgensen, S. E., Fath, B. and Bastianoni, S. (2011). *Ecological Modelling*. WIT Press.

Krebs, J. R. and Davis, N. B. (1991). *Behavioural Ecology: An Evolutionary Approach*. Oxford, UK: Blackwell Scientific Publications.

Kormondy, E. J. (2007). *Concepts of Ecology*. 4th ed. Indian reprint, Pearson Education.

McArthur, J. V. (2006). *Microbial Ecology: An Evolutionary Approach*. Academic Press Inc.

Odum, E. P. (1971). *Fundamentals of Ecology*. W. O. Saunders company, Philadelphia.

Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th ed. Thompson Brooks/Cole.

Ricklefs, R. E. and Miller, G. L. (2000). *Ecology*. 4th ed. W. H. Freeman and Company.

Wilson, E. O. (2000). *Sociobiology: The New Synthesis*. 25th Anniversary Ed. The Beknap Press of Harvard University Press.

MSZO 305 (DE-3): ENTOMOLOGY
(Credit 4)

Course specific outcome

It gives an overview of Insect Biology and its variation. Development of concept on integument proteins and chitin metabolism, and on various systems digestive, respiratory, nervous, and reproduction.

Time: 2 hrs **Full Marks: 50**

Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Biology, Physiology and Biochemistry of Insects

Biology of the orders 8L

Collembola, Orthoptera, Thysanoptera, Hemiptera

Cuticle 8L

Proteins: classes, interactions, sclerotisation and tanning

Chitin metabolism

Digestive system 8L

Molecular mechanism of digestion

Role of microorganisms in digestion

Respiratory system 8L

Gaseous exchange: terrestrial, aquatic, endoparasitoid

Nervous system 8L

Basic components: CNS, brain, neural control of circadian rhythm

Reproductive system and *Reproduction* 10L

Male and female reproductive system

Atypical methods of reproduction

Hormonal control: yolk synthesis and ovulation

Mating systems

Suggested readings:

Chapman, R. F. (1998). *The Insects: Structure and Function.* 4th Ed. Cambridge University Press.

Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th ed. Cambridge University Press.

David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.

Gilbert, L. I. (Ed.) (2012). *Insect Molecular Biology and Biochemistry*. Academic Press.

Gillott, C. (2005). *Entomology*. 3rd Ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.

Klowden, M. (2013). *Physiological Systems in Insects,* 3rd ed. Academic Press.

Nation, J. L. Sr. (2016). *Insect Physiology and Biochemistry*. 3nd ed. CRC Press. Taylor and Francis Richards O.W. and Davies, R.G. (1977). *Imms: A General Text Book of Entomology.* 10th ed. Vol.1 and 2. Chapman and Hall.

Rockstein, M. (1978). *Biochemistry of Insects.* Academic Press.

Rockstein, M. (Ed.) (1973). *The Physiology of Insecta.Vol.I.* 2nd ed. Academic Press.

Snodgrass, R.F. (1935). *Principles of Insect Morphology.* Tata McGraw-Hill Publishing Company Ltd.

Srivastava, K. P. (1988). *A textbook of Applied Entomology.* Vol. I. 2nd ed. Kalyani Publishers, New Delhi.

Wigglesworth, V. B. (1972). *Principles of Insect Physiology.* ELBS (Methuen and co.)

MSZO 305 (DE-4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

Course specific outcome

Understanding human genome, genomic instability, genetic/epigenetic markers, metabolomics and disease biology; skill development on molecular biology techniques, detection of genetic disorders and cancer.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Classical Genetics and Inheritance Biology **10L**

Basics of inheritance

Mendelian analysis of inheritance and extension to Mendel's Laws; Linkage and Gene Mapping in Eukaryotes; Eukaryote Model Systems for Genetic Analysis *Drosophila, C. elegans,* Zebra fish*;* Extra-nuclear inheritance: Maternal effects mitochondrial inheritance. Multiple allelism, allelic series; Gene interactions and modifying genes; Pleiotropy; Polygenic inheritance; Multifactorial inheritance Linkage and crossing over; LOD score; Quantitative traits and loci Genetic and Physical mapping; heredity and environment 4L

Gene and genome organisation 8L

Comparative genomics, prokaryotic genome**,** Eukaryotic genomes: Yeast, mice rice

Concept of gene, Fine structure of gene

Exons, introns, UTRs; Split genes; pseudogenes; overlapping genes and multi-gene families; Viral,; repetitive DNA, satellite DNAs and interspersed repeated DNAs, LINES, SINES, Alu family, Transposable genetic elements Retrotransposons 8L

Microbial genetics 8L

Viral genetics: Mapping, phenotypes, genetic recombination, genetic fine structure; HIV and SARS-Cov-2: Structure, life cycle, course of infection; Bacterial genetics: plasmids, methods of gene transfer in bacterial transformation conjugation, transduction; bacterial recombination 2L

Drosophila genetics 8L

Basics of setting up *Drosophila* crosses; Mutagenesis and isolation of new variants; Generation of Transgenic *Drosophila*; Advanced *Drosophila* genetics Mitotic recombination, Generation and analysis of somatic and germ-line clones RNAi based screening of gene functions 2L

Drosophilagenome project

Epigenetic inheritance

Overview of DNA and histone modifications, Techniques to study epigenetic modifications: sodium bisulphite based DNA sequencing, chipSeq

Cancer Genetics

Somatic Mutations and affected pathways, Oncogenes and TSGs, LOH TCGAdatabase, oncomiR

Suggested readings:

Alberts, B., Johnson, A. Lewis, J., Raff, M., Roberts, K. and Walter, P. (2008). *Molecular Biology of the Cell*. 5th ed. Garland Science.

Brooker. (2011). *Genetics: Analysis and principles*. 4th ed. McGraw-Hill Science.

Brown, T. A. (2006). *Genomes 3*. 3rd ed. Garland Science.

Clark, D. P. and Pazdernik, N.J. (2012). *Molecular Biology*. 2nd ed. Academic Cell.

Clark, D.P. (2009). *Understanding the Genetic Revolution.* Academic Press.

Cooper, G. M. (2004). *The Cell*. 3rdedn. ASM Press.

Hancock, J.T. (2008). *Molecular Genetics.* Viva Book Private Ltd.

Hartl, D. L. and Jones, E. W. (1998). *Genetics, Principles and analysis.* 4th ed. Blackwell Scientific, Oxford.

Hartl, D. L. and Jones, E. W. (2005). ***Genetics: analysis of genes and genomes.* 6th ed.** Jones and Bartlett Publishers, Sudbury, Mass.

Hartl, D. L. and Jones, E. W. (2006). *Essential Genetics: a genomics perspective*. 4thed.. Jones and Bartlett Publishers, Boston.

Hartwell, L., Hood, L., Goldberg, M., Reynolds, A. E. and Silver, L. (2010).*Genetics: From genes to Genomes.* 4th ed. McGraw Hill.

Harvey, L. (2004). *Molecular cell Biology*. 5th ed. W.H.Freeman.

Karp, G. (2008*). Cell and Molecular Biology: Concepts and experiments*. 5th ed. John Wiley.

Kendrew, S. J. (Ed.) (1994). *The Encyclopedia of Molecular Biology.* Blackwell Science.

Lewin, B. (2008). *Genes IX*. Jones and Bartlett Publishers.

Watson, J. D., Baker, T. A. and Bell, S. P. (2007). *Molecular Biology of the Gene*. 6th ed. Benjamin Cummings.

Malacinski, G. M. (2003). *Essentials of Molecular Biology.* 4th ed. Jones and Bartlett.

McConkey, H. (1993). *Human Genetics: The molecular Revolution.* Jones and Bartlett Publishers.

Pollard, T. D., Earnshaw, W. C. and Lippincott-Schwartz, J. (2007). *Cell Biology*. 2nd ed. Saunders.

Snustad, D. P. and Simmons. M. J. (2004). *Principles of Genetics*. 4th ed. John Wiley and Sons.

Stansfield, W. D. (1991). *Schaum's Outline Series: Theory and Problems of Genetics.* 3rd ed. McGraw-Hill.

Strachan, T. and Read, A. P. (2004). *Human Molecular Genetics-3*. Garland Science.

Strickberger M.W. (1985). *Genetics.* 3rded, Prentice Hall of India Pvt. Ltd., New Delhi.

Tamarin, R. H. (2004). *Principles of Genetics.* Tata McGraw-Hill Publishing Comp. Ltd.

Twyman, R.M. (2003). *Advanced Molecular Biology*. Viva Books.

Vogel, F. and Motulsky, A. G. (1999*). Human Genetics*. Springer.

MSZO 305 (DE-5): PARASITOLOGY and MICROBIOLOGY
(Credit 4)

Course specific outcome
Strengthening knowledge-base on hosts, parasites and microbes; understanding disease causing vectors and their control measures.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Bacterial Nutrition 5L

Nutrition and nutritional types of bacteria; types of culture media: natural, synthetic, semi-synthetic and selective media; composition and principles of : nutrient agar, MacConkey Agar, triple-sugar-iron agar, *Pseudomonas*isolation agar, blood agar, XLD agar, Mannitol salt agar

Bacterial Growth 5L

Phases of growth, kinetics of growth, generation time, batch culture, continuous culture and synchronous culture, Chemostat and Turbidostat, pure culture techniques, preservation of bacteria, environmental factors influencing growth (temperature, pH, salt concentration, oxygen, osmotic concentration) 5L

Systemic Microbiology

Classification, phenotypic, biochemical and toxin features, pathogenesis and laboratory diagnosis of: *Staphylococcus*, *Streptococcus*, *Escherichia coli*, *Klebsiella* and *Proteus*, *Pseudomonas*

Genome organization and mode of replication of animal and human infecting viruses 5L

Rabies virus, Poliovirus, Coronaviruses, Dengue virus, Poxvirus and HIV

Immunopathogenesis of Malaria

Host cell-parasite interactions; Factors affecting natural immunity in host's body against malaria (Glucose 6 phosphate dehydrogenase deficiency, Sickle cell trait, HBE, Duffy negativity, ovalocytosis); Role of immune cells; Adaptive immunity 5L

Mode of transmission, pathogenicity and prevention of bacterial diseases:

Anthrax, Tetanus, Diphtheria and Botulism 5L

Mode of transmission, pathogenicity and prevention of viral diseases

Corona Virus diseases (COVID-19), Common cold, Herpes simplex virus, Mumps, Measles and Rabies 5L

Molecular parasitology and Microbiology

Basic techniques for molecular analysis of parasitic and microbial systems: Isolation of DNA and RNA from bacteria, protozoan and helminth parasites, Hybridization, ELISA, DNA sequencing, Blotting techniques, Amplification of DNA by Polymerase Chain Reaction, DNA probes in diagnosis and epidemiology of Leishmaniasis, Malaria, Lymphatic filariasis 15L

Suggested readings:

Alexander, M. (1977). *Introduction to Soil Microbiology*. John Wiley and Sons.

Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan and Co.

Atlas, R. M. and Bartha, R. (1997). *Microbial Ecology: Fundamentals and Applications*. 4th ed. Benjamin/ Cummings. Menlo Park, California. (Indian Print: Pearson Education)

Black, J. G. (2011). *Microbiology: Principles and Explorations*. 8th ed. John Wiley and Sons.

Campbell, R. (1983). *Microbial Ecology*. 2nd ed. Oxford, Blackwell.

Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S. (1990). *Microbiology*. 4th ed. Harper and Row. New York.

Dimmock, N. J. and Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th ed. Blackwell Scientific Publications, London.

Freifelder, D. *Molecular Biology*. Narosa Publishing House, New Delhi.

Hyde, J. E. (1990). *Molecular Parasitology*. Open University Press. London.

Maloy, S. R., Cronan, E. J. and Freifelder, D. (1994). *Microbial Genetics*. 2nd ed. Jones and Bartlett, Boston.

Pelczar, M. J., Reid, R. D. and Chan, E. C. (1993). *Microbiology*. 5th ed. Tata Mc Graw Hill.

Presscott, L. M., Harley, J. P. and Klein, D. A. (2011). *Microbiology*. 8th ed. McGraw-Hill, New York.

Schlegel, H.G. (1993). *General Microbiology*. 7th ed. Cambridge University Press.

Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L. (1986). *General Microbiology*.

Talaro, K. and Talaro, A. (1999). *Foundations in Microbiology*. 3rd ed. McGraw-Hill.

Tortora, G. J., Funke, B. R., and Case. C. L. (2008). *Microbiology. An Introduction*. 9th ed. Benjamin/Cummings Publishing.

Voyleys, B. A. (2002). *The Biology of viruses*. 2nd ed. McGraw-Hill.

MSZO 306: DISCIPLINE-CENTRIC ELECTIVE PRACTICALS
(Credit 4)

Time: 4 hrs **Full Marks: 50**

MSZO 306 (DE-1): AQUACULTURE AND FISHERIES (Credit 4)

Course specific outcome
The course will introduce systematic identification of the fish so as to enable the students to determine taxonomic position of the fish species. Further, it will help to build-up confidence to produce carp and catfish seeds by induced breeding technique. Students will also have an exposure to some basic analytical techniques like paper chromatography and TLC.

Time: 4 hrs **Full Marks: 50**

1. Anatomy of different organ systems of fish
2. Surgical ablation of gonad in a live fish
3. Techniques of induced breeding (collection and preservation of carp pituitary gland, preparation of gland extract)
4. Induced breeding in common cat fishes by synthetic hormones and *in vitro* fertilization (stripping), study of developmental stages
5. Studies of life histories of cultivated freshwater fishes, preparation and mounting of the various stages and their identification
6. Detection of food and feeding habit by analyzing gill rakers, buccopharynx and gut content
7. Systematic identification of fishes
8. Separation of amino acids by paper and thin layer chromatography
9. Laboratory records
10. Viva-voce

MSZO 306 (DE-2): ECOLOGY AND ENVIRONMENTAL BIOLOGY (Credit 4)

Course specific outcome
Determination of primary productivity, nitrate, phosphorous and silica of aquatic ecosystem, study of population dispersion and association, construction of life table, hands on training of different protocols of biodiversity measurement, different ecotypes showing the modifications of different species according to their adaptation, and different instruments used in ecology and environmental biology.

Time: 4 hrs **Full Marks: 50**

1. Sampling and measurement of factors
    a. Light; illumination and intensity; Transparency (Secchi disc method)
    b. Primary productivity in an aquatic system (light and dark bottle method)

c. Total dissolved solids, total phosphorous, nitrates and total silica in fresh waters
d. Moisture and ash contents of the stored-grains, insects and fresh water snails

2. Population ecology
    a. Population dispersion and species association
    b. Life table estimation
    c. Biodiversity measurements
3. Field reports / Project reports
4. Ecotypes of terrestrial, freshwater and marine habitats
    a. Characterization and identification of different ecotypes inhabiting terrestrial, freshwater and marine habitats
    b. Identification of different tools/instruments used in Ecology and Environmental sampling and analysis
5. Laboratory records
6. Viva-voce

MSZO 306 (DE-3): ENTOMOLOGY (Credit 4)

Course specific outcome
Systematic identification of exopterygote insects, pests, vectors; training on field entomology; development of knowledge on haemocytes, salivary and gut enzymes.

Time: 4 hrs **Full Marks: 50**

1. Anatomy
    a. Cockroach: Stomato-gastric nervous system
    b. Dragon fly: Digestive and Nervous systems
    c. Study of body parts (mount preparation): Antenna, mouth parts, wings, legs, spiracles, tympanum, external genitalia
2. Taxonomy
    a. Identification (up to family) with reasons of Apterygote and Exopterygote insects
    b. Identification of insects (up to genus/species level) of economic importance: Lice (*Pediculus*, *Pthirus*, *Haematopinus*, *Menopon*, *Lipeurus*,*Columbicola*), *Cimex*, *Nilaparvatalugens*, *Nephotettix* spp., *Sogatellafurcifera*, *Recilia dorsalis*, *Cofana spectra*, Rice seed bug/Gundhi bug (*Leptocorisa*spp.), White fly (*Bemisiatabaci*), mustard aphid (*Lipaphiserysimi*), *Dysdercus*spp., *Thrips tabaci*, *Amritodusatkinsoni*, encrusted lac of lac insect, *Bombyx mori* (adult, cocoon)
3. Physiology
    a. Preparation of insect blood smear and identification of haemocytes
    b. Detection of amino acids, sugars by paper chromatography and TLC
    c. Quantitative analysis of salivary and gut enzymes

d. Biochemical estimation of trehalose, total glucose and total lipids from haemolymph

4. Field Entomology
    a. Methods of insect collection and preservation of Apterygote and Exopterygote insects
    b. Submission of collected Apterygote and Exopterygote insects
5. Morphometry
    a. Use of micrometers and camera lucida
6. Laboratory records
7. Viva-voce

MSZO 306 (DE-4): MOLECULAR BIOLOGY AND GENETICS (Credit 4)

Course specific outcome
Students will learn basic molecular biology techniques including *Drosophila* culture maintenance, Culture of cancel cell lines, PCR and primer designing, Extraction of RNA and qPCR, Western blotting, Flow cytometry-based apoptosis and cell cycle analysis.

Time: 4 hrs **Full Marks: 50**

1. *Drosophila* culture maintenance and polytene chromosome preparation
2. Study of transcriptional activity in polytene chromosome upon heat shock induction.
3. Demonstration allograft mice tumour generation
4. Demonstration of Dalton's lymphoma cell lines
5. Separation of peripheral lymphocyte, lymphocyte culture, metaphase chromosome preparation
6. Isolation of cells, nucleus and mitochondria
7. Culture of cancel cell lines – starch wound assay,doublingtimemeasurements,
8. PCR and primer designing
9. Extraction of RNA and qPCR
10. Western blotting
11. Flow cytometry based apoptosis and cell cycle analysis
12. Searching and accesses of TCGA database, oncomiR
13. Identification and analysis of different cellular process, tumour subtypes and grading
14. Laboratory records
15. Viva-voce

MSZO 306 (DE-5): PARASITOLOGY AND MICROBIOLOGY (Credit 4)

Course specific outcome
Students will be acquainted with the standard methods for the isolation, identification and culturing of microorganisms and will be able to comprehend the ubiquitous nature of microorganisms and identify the different groups of microorganisms from different habitats like air, water, soil and their applications. They will carry out experiments to evaluate microbial quality of water and milk samples, antibiotic profiling of bacterial strains, physiological, bio-chemical and molecular properties of bacterial strains.

Time: 4 hrs **Full Marks: 50**

1. Determination of bacterial load of water /soil /food samples by standard plate count method
2. Determination of potability of water (presumptive test)
3. Microbiological examination of curd sample
4. Enrichment culture of spore formers
5. Microbiological examination of milk (Methylene blue reductase test)
6. Antibiotic sensitivity test
7. Study on physiological and bio-chemical characteristics: starch hydrolysis, gelatin hydrolysis, fat hydrolysis, tryptophan hydrolysis, urea hydrolysis, citrate utilization
8. Cell culture techniques, transfection and infection of cells
9. Isolation of plasmid DNA from bacteria & Agarose gel Electrophoretic separation of DNA
10. Field -Visit
    a. Methods of bacteria isolation and preservation
    b. Study of bacterial diversity of soil/water samples of a rice-field/forest/river/sea
11. Laboratory records
12. Viva-voce

MSZO - 307: Community Engagement (CE) (Credit 2)

Course specific outcome
This course will create a partnership between the communities and the students. Students will become aware about their social and moral responsibilities.

Full Marks: 25

COMMUNITY OUTREACH: (*Students will undertake any community service based on their Major Elective*)

SEMESTER – IV

MSZO 401: Core Course
(DEVELOPMENTAL BIOLOGY AND STEM CELL BIOLOGY)
(Credit 4)

Course specific outcome

This course is consisting of two units. Developmental Biology unites the various disciplines Cell Biology, genetics and morphology. Molecular cell biology deals with how the individual components like the inducing factors, their receptors, signal transduction pathways and transcription factors. It emphasizes the function and activities of individual genes to form complex morphology. On the other hand, it is essential for biologists to understand how a single cell develops into a multicellular organism which involves complex process. On completion of a course on Stem cell Biology, students should be able to understand modern approaches including the logic of experiments and the inferences drawn from them; Develop key skills in imaging and manipulating stem cells in modern research.

Time: 2 hrs **Full Marks: 50**

UNIT - I: DEVELOPMENTAL BIOLOGY (Credit 2) **Full Marks: 25**
Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Overview 2L
Determination, specification
Genomic equivalence, potency, Induction, competence
Lateral inhibition, morphogen gradients, morphogenetic field

Molecular components 3L
Transcription factors, signaling systems, inducing factor families,
Cytoskeleton, cell adhesion molecules, ECM

Techniques and experimental embryology 2L
Cell labelling; genetic techniques
Model organisms - *Dictyostelium, C. elegans, Drosophila*

Embryonic stem cells and applications 4L

Pattern Formation
Drosophila: pattern formation: dorsal-ventral, anterior-posterior segmentation genes, homeotic genes
C. elegans: Programmed cell death, vulva development
Vertebrates: Development and patterning of vertebrate limb, homeobox genes in patterning

Organogenesis
Nervous system: 2L
Neurogenesis, gliogenesis, neural crest cells

Mesodermal organs 2L

Somitogenesis, myogenesis, germ cell determination and migration

Endodermal organs 2L

Gut - cytodifferentiation

Environmental regulations 2L

Phenotypic plasticity, polyphenism, Epigenetic regulation of development

Evo-Devo concepts

Heterochrony, Heterotopy, Heterometry, Heterotypy 2L

Evolution of complexity

Suggested readings:

Arias, A. M. and Stewart, A. (2002). *Molecular Priciples of Animal Development*. 1st ed. Oxford University Press.

Balinsky (1981). *Introduction to Embryology.* 5th ed. Holt Rinehart & Winston.

Browder, L. W. (1984). *Developmental Biology*. 2nd ed. CBS College Publishing.

Carlson, B. M. (1999). *Patten's Foundations in Embryology*. 6th ed. McGraw Hill.

Gilbert S. F. (1999). *Embryology*. Sinauer Associates, Sunderland, Massachusetts.

Gillbert, S.F. (2006). *Developmental Biology*. 8th ed. Sinauer Associates.

Kalthoff, K., (2001). *Analysis of Biological Development*. 2nd ed. McGraw Hill.

Moody, S.A. (Ed.) (2007). *Principles of Developmental Genetics*. Academic Press.

Shostak, S. (1991). *Embryology – An Introduction to Developmental Biology*. Harper Collins.

Slack, J. M. W. (2006). *Essential Developmental Biology*. 2nd ed. Blackwell Publishing.

Twyman, R.W. (2001). *Instant Notes-Developmental Biology*. Viva Books Private Ltd.

Wilt, F. H. and Hake, S. C. (2004). *Principles of Developmental Biology*. W. W. Norton Company.

Wolpert, L. (2007). *Principles of Development*. 3rd ed. Oxford University Press.

UNIT - II: STEM CELL BIOLOGY (Credit 2) **Full Marks: 25**

Lectures: 25

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Introduction to Development 3

Early development: fertilization, totipotency, and pluripotency

Gastrulation and lineage commitment in the early embryo

Introduction to Stem Cell Biology 3

Definition, Types, The Embryonic Stem Cell: The Human Embryonic Stem Cell and The Human Embryonic Germ Cell, The Adult Stem Cell, Hematopoietic Stem Cells

Pluripotency and Reprogramming in vitro 4

Establishment of embryonic stem cells (ESCs)

Characterization of pluripotent stem cells (PSCs)

Molecular mechanisms underlying pluripotency

Induction of pluripotency

Adult Stem Cells and Regeneration	4
Tissue regenerative capacity	
Regeneration in hydra, zebrafish, axolotl, and mammals	
Facultative stem cells	
Trans differentiation	
De-Differentiation and plasticity	
Leveraging Tools to Study Stem Cell Biology	4
Editing the stem cell genome	
In vivo tools in stem cell biology	
Computational tools to dissect stem cell heterogeneity	
In vitro cultures of adult stem cells to analyze the differentiation capacity	
Clinical Applications of Stem Cell Biology	5
Autoimmune Diseases and the Promise of Stem Cell-Based Therapies	
Stem Cells and Diabetes	
Rebuilding the Nervous System with Stem Cells	
Can Stem Cells Repair a Damaged Heart?	
Use of Genetically Modified Stem Cells in Experimental Gene Therapies	1
Ethical Issues in Stem Cell Research	1

Suggested readings:

Alberts, B., Johnson, A. Lewis J., Raff, M.RobertsK. and Walter P. (2008). *Molecular Biology of the Cell*. 5th Ed. Garland Publishing House.

Russell, P. J., Hertz, P.E., Starr, C., Wolfe S. L. and McMillan, B. (2009). *Cell and Molecular Biology*. 1st ed. Cengage Learning.

Lanza, R., Gearhart J. et al (Eds), (2009). *Essential of Stem Cell Biology*. Elsevier Academic press.

Lanza, R. and Klimanskaya, I. (2009). *Essential Stem Cells Methods*. Academic Press.

Lanza et al (2004). *Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells*. Volume 2- Adult &Fetal Stem Cells (v. 1). Academic Press.

Atala, A. and Thomson J. A. (2007). *Principles of Regenerative Medicine*. Academic Press. 1 ed. Atala, A. (2009). *Foundations of Regenerative Medicine: Clinical and Therapeutic Applications*. Academic Press. 1 ed.

Hossein B. and Nasser, A. (Editors) (2013). *Regenerative Medicine and Cell Therapy (Stem Cell Biology and Regenerative Medicine)*. Humana Press.

Andrzej M. L. and Wiechec H. E. (Eds) (2018). *Stem cells and biomaterials for Regenerative Medicine*. Academic Press.

Warburton D. (Editor) (2015). *Stem Cells, Tissue Engineering and Regenerative Medicine*. World Scientific.

MSZO 402: Core Course
(BIOSTATISTICS AND COMPUTATIONAL BIOLOGY)
(Credit 2)

Course specific outcome

Students will be introduced to the basic concepts of statistics and computational methods and its significance in Biological data analysis. They will learn the role of bioinformatics to characterize and manage the different types of Biological data. Introduction to the biological databases, basics of sequence alignment and overview about protein structure prediction will also be provided.

Time: 2 hrs **Full Marks: 25**

Lectures: 25

MSZO 402: BIOSTATISTICS AND COMPUTATIONAL BIOLOGY (Credit 2)

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Biostatistics

Sampling, data and central tendency — 2L

Data types, Sampling, Frequency distribution, Quartile and percentile, Parameters and Statistics, Mean, Median, Mode, different types of distribution, Standard deviation and error, Coefficient of variation, Skewness and Kurtosis — 4L

Hypothesis testing

Parametric and Non-parametric tests, one sample hypothesis, two sample hypothesis, Multi-sample hypothesis: The Analysis of Variance, Single factor analysis of variance, confidence limits for population mean; *Power and sample size , Homogeneity of variances* — 2L

Linear regression

Regression vs. Correlation, Correlation coefficient, Simple linear regression equation, Testing the significance of relation (r^2) — 2L

Testing for goodness of fit

Chi-Square goodness of fit, Heterogeneity Chi-Square, Odds ratio Chi-Square analysis of contingency table — 2L

Multiple comparisons

Tukey test, Bonferroni and Benjamini Hochberg test, Concept of multivariate analysis — 2L

Survival analysis — 5L

Concept of life tables, censored data, Estimation of survival function, Kaplan – Meier analysis

Concept of Computational operation

Basics of computers — 6L

CPU, input and output devices, operating systems (Windows, LINUX/UNIX), GUI, flowchart and programming concept, server and grid computation;

Computer networks and internet, search engine, Boolean Operators

Bioinformatics

Concept and types of Databases, Nucleic acid sequences databases, SNP database, Genome database, Protein databases, structures and interacting proteins databases, Protein motifs, folds and domains databases,
Sequence alignments (BLAST and Clustal W)
Concept of health-informatics and nutrigenomics

***Suggested readings*:**

Attwood T. (2007). *Introduction to Bioinformatics*. 1st ed. Pearson Education.
Bailey, N. T. J. (1995). *Statistical Methods in Biology*. 3rd ELBS ed.
Boyer, R. (2000). *Modern Experimental Biology*. Pearson Education. English Universities Cambridge Low-price Ed.
Das S. (2006). *Unix – Concepts and Applications*. 4thed.Tata McGraw-Hill.
Forthofer, N. and Lee, E. S. (2006). *Introduction to Biostatistics: A Guide to Design, Analysis and Discovery*. Academic Press.
Gun A. M., Gupta, N. K. and Dasgupta, B. Fundamentals of Statistics. Volume 1. World Press.
Kanetkar Y. P. (2008). Let Us C. 8th ed. Infinity Science Press.
Lipschutz, S. (2011). *Data structure with C*. 1st ed. McGraw Hill Education (India) Private Limited.
Selvin, S. (2004). *Biostatistics: How it works*? Pearson Education.
Sinha P. K. and Sinha P. (2011). *Computer Fundamentals*. 6th ed. Bpb Publications.
Sokal, R. R. and Rohlf, F. J. (1995). *Biometry: the principles and practice of statistics in biological research*. 4th ed. W. H. Freeman and Company, New York.
Zar J. H. (1999). *Biostatistical Analysis*. 5th ed. Pearson Education (India) Ltd.

PRACTICAL PAPER

MZGP 403: Core Course
(Credit 2)

Time: 2 hrs **Full Marks: 25**

Course specific outcome
This course deals with hands on training on various models (insects, fish, frog, chick, mouse) of developmental biology particularly of embryonic stages through slide preparation. It also includes specific studies on model organs: imaginal discs and notochord. Hands on training on sequence alignment, prediction on phylogeny; prediction on protein structure.

MZGP 403: DEVELOPMENTAL BIOLOGY &COMPUTATIONAL BIOLOGY (Credit 2)

Group A: Developmental Biology

1. Study of imaginal discs and development of (wing/leg) from Drosophila larva
2. Study of normal developmental (WM) stages of insect, fish, frog, chick and mouse

(slide based)

3. Identification of whole mounts and histological sections of embryos, larvae, pupae and nymphs
4. Labelling chick notochord using immune-cytochemistry
5. Study of external influences on development (anuran amphibian/chicks/fish)
6. Isolation and characterization of Hematopoietic Stem cells from Peripheral blood /Rat Bone marrow
7. Identification of different types of stem cells (Chart based/Microscopical observation)
8. Characterization of different types of Hematopoietic cell lineage – From Peripheral Blood - Flow cytometric method (Demonstration)
9. Submission of preparations of WM different stages of development.
10. Submission of stem cell/Animal Regeneration preparation
11. Laboratory records
12. Viva-voce

Group B: Computational Biology

1. Handling of DOS, Unix commands and Windows operation: File management, Network commands and configuration
2. Sequence retrieval – nucleotide and protein
3. Sequence alignment, BLAST search, BLAT search
4. Protein pattern search, Motif search
5. Laboratory records
6. Viva-voce

MSZO 404: DISCIPLINE-CENTRIC ELECTIVE PAPERS
(Credit 4)

Time: 2 hrs **Full Marks: 50**

MSZO 404 (DE-1): AQUACULTURE AND FISHERIES
(Credit 4)

Course specific outcome

This is in continuation of the previous course MSZO 305-DE1. This section will help to develop concepts on nutrition and feed management of the fish for intensification of the culture system. In addition, different aspects of farm maintenance, disease and health management, development strategies along with determination of freshness of fish will be introduced.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Nutrition and supplementary feeding 15L

Nutritional requirements (carps)
Intermediary metabolism and bioenergetics
Feed types, composition, ingredients, formulation
Functional feed additives: Probiotics, prebioticsand immune-stimulants
Feeding schedules, feed dispensing methods
Storage and quality control of feed

Fish Farm and Maintenance

Design and Construction of Aquafarms, Pond: Types, Physico-chemical parameters of soil and water, Management of pH, free CO_2, dissolved O_2, alkalinity, hardness and NH_3 in intensive aquaculture, Productivity of freshwater bodies 15L
Pond fertilization
Aquatic weeds, insects, predatory and weed fishes: different types and methods of control
Pollution: sources, effects and control

Fish disease, control and prevention

Common diseases of Finfish: Causative organisms, effects and control 10L
Shrimp diseases and treatment
Disease diagnosis and quarantine measures
Fish Immunity: Non-specific, innate and adaptive immunity, vaccination

Spoilage of fresh water and brackish water fishes

Post-mortem changes and rigor mortis, chemical and microbial spoilage,
Amino acid changes and breakdown products indicative of spoilage 6L

Development strategies

Conservation of fish genetic resources (threats, IUCN categories, impact of anthropogenic factors, *in-situ* and *ex-situ* conservation), Responsible Fishing, Fisheries Act, Role of Central and State Governments 4L
Fisheries Education in India, Fish marketing: imports and exports, Fish

Farmers' Development Agencies, NFDB

Suggested readings:

Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*.John Willey and Sons.

De Silva, S. S. and Anderson, T. A. (1995). *Fish Nutrition in Aquaculture*. Chapman and Halll, London.

Allen Davis (2015). Feed and Feeding Practices in Aquaculture. Woodhead Publishing, an imprint of Elsevier Ltd.

Guillaume, J., Kaushik, S., Bergot, P. and Metailler, R. (2001). *Nutrition and Feeding of Fish and Crustaceans*. Springer and Praxis, U. K.

Halver, J. E. and Hardy, R. W. (2002). *Fish Nutrition*. Academic Press, California and London.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd ed. Hindusthan Pub. Corp.

Jobling, M. (1994). *Fish Bioenergetics*. Chapman and Hall.

Lovell, T. (1998). *Nutrition and Feeding of Fish*. Springer.

Merrifield, D. L. and Ringø, E. (2014). *Aquaculture Nutrition: Gut Health, Probiotics and Prebiotics*. Wiley-Blackwell.

Noga, E. J. (2010). *Fish Disease Diagnosis and Treatment*. 2nd Ed. Willey Blackwell.

Pillay, T. V. R. and Kutty, M. N. (2005). Aquaculture Principles and Practices. 2nded. Blackwell Publishing Ltd.

Srivastava, C. B. L. (1999). *Fish Biology*. Narendra Pub. House.

Srivastava, C. B. L. (2006). *A Text Book of Fishery Science and Indian Fisheries*. Kitab Mahal. Allahabad.

Tacon, A.G.J., Metian, M. and Hasan, M.R. (2009). Feed ingredients and fertilizers for farmed aquatic animals: sources and composition. *FAO Fisheries and Aquaculture Technical Paper*. No. 540. Rome, FAO. 2009. 209p.

Parker,R. (2012). Aquaculture Science. 3rd ed. Delmar, Cengage Learning, USA.

MSZO 404 (DE-2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

Course specific outcome

Impact of alien species on ecosystem, biomonitoring of ecosystem through natural agents, impact of different toxicants and heavy metals on ecosystem health, causes, effects and control of air, water and noise pollution, causes of allergy and its control, different laws relating to maintenance of natural ecosystem, role of GIS in to monitor ecosystem health.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Stress on ecosystem and function *7L*

Ecosystem health and stress, Biological invasion, biological indicators and their use in monitoring pollution, bioaccumulation and biomagnifications

Ecotoxicology

Pollutant interaction with biological system at different levels; Bioconversion of pollutants: active vs. inactive process; enzymic degradation by monooxygenesis;role of cytochrome P450 and its multiple forms. Mercury, lead, chromium, arsenic, and nitrate toxicity; pesticide toxicity; Cellular/Tissue injury: altered membrane permeability, free radical formation, lipid peroxidation, lysosomal degradation, superoxide dismutase; Food additives *8L*

Water pollution

Types, sources and consequences, ecological and biochemical aspects, types and characteristics of domestic, industrial, agricultural wastes–their effects on water bodies: chemical and bacteriological sampling and analysis; water quality parameters; criteria and standards, sewage and waste water treatment; Control of water pollution — 6L

Air pollution

Atmosphere and its functions, Gas laws governing the behaviour of pollutants in atmosphere, natural and anthropogenic sources of atmospheric pollutants, significance of these pollutants and their reactions in the atmosphere; National and international standards for monitoring air quality; Diseases caused by air pollution; Air pollution control equipments, objectives and types of control equipments, efficiency of separating devices, control of particulate emission settlers, cyclones, filters, and scrubbers; control of sulphur dioxide from leanand rich waste gases (recovery of sulphur and sulphuric acid);control of NOx through absorption and other newer methods; control of vehicular emission (catalytic conversion devices); Indoor air pollution and its control — 8L

Sound pollution

Measurement and analysis of sound; A weighted sound level, Equivalent sound pressure level (Leq), Noise pollution level (NPL), Sound exposure level (SEL), Traffic noise index (TNI), Day-Night level, noise criteria curves; Prediction of traffic noise-nomograph method; Noise control and abatement measures; sound absorption coefficient (ast) — 6L

Allergy and immunity

Basic concept on allergy, types of allergy, mechanism of allergic reactions, airborne allergens and its role in nasobronchial allergy; diagnostic tests; prophylactic measures — 7L

Environmental movement and legislation

Silent valley project, Narmada valley project, Teheri dam project

Definition of environment and pollutants, central and state boards for the prevention and control of environmental pollution, powers and functions of pollution control boards, penalties and procedure, duties and responsibilities of citizens for environmental protection — **8L**

Wildlife Protection Act, 1972, The Water (Prevention and Control of Pollution) Act, 1974, Prevention and Control of Air Pollution Act, 1981, Forest Conservation Act, 1981, Environment (protection) Act, 1986, Hazardous waste (Management and Handling) Rules, 1989, Bio-Medical Waste (Management and Handling) Rules, 1998

Issues involved in enforcement of environmental legislation, public awareness, public interest litigations (PILs) and its role in control of environmental pollution in India

Remote Sensing and GIS

Principles and concept of remote sensing; introductory image processing techniques; application of remote sensing; GIS technology; applications of GIS — *2L*

Suggested readings:

Agarwal, S. K. (2009).*Noise pollution.* APH Publishing Corporation.

Andel, J. V. and Aronson, J. (2012). *Restoration Ecology: The New Frontier*. 2nd ed. Wiley-Blackwell.
Begon, M., Harper, J. L. and Townsend, C. R. (1996). *Ecology: Individuals, Populations and communities*. 3rd ed. Blackwell science.
Begon, M., Harper, J. L. and Townsend, C. R. (2005). *Ecology: From Individuals to Ecosystems*. 4th ed. Wiley Blackwell.
Chapman R. L. and Reiss, M. J. (2000). *Ecology – Principles and Application*. Cambridge Low Price Edition.
Colinvaux, P. (1993). *Ecology 2*. John Wiley and Sons, Inc. New York. Eastern economy Edition.
Das, R. C. and Behera, D. K. (2008). *Environmental Science*.
Freedman, B. (1989). *Environmental Ecology*. Academic press, Inc.
Kormondy, E. J. (2002). *Concepts of Ecology*. 4th Indian Reprint. Pearson Education.
Odum, E. P. (1971). *Fundamentals of Ecology*. W. O. Saunders company, Philadelphia.
Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th ed. Thompson Brooks/Cole.
Patwardhan, A. D. (2008). *Industrial Waste Water Treatment*. Eastern Economy Edition.
Sinclair, A. R. E., Fryxell, J. M. and Caughley, G. (2006). *Wildlife Ecology, Conservation and Management*. 2nd ed. Wiley-Blackwell.

MSZO 404 (DE-3):ENTOMOLOGY
(Credit 4)

Course specific outcome

It gives an overview on the variation of biology of different orders of insects. Development of concept on insect development, exocrine system, immune system, perception, gall formation mechanism.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Biology of the orders 5L
Lepidoptera, Coleoptera, Diptera, Strepsiptera and Hymenoptera

Development 4L
Homeotic gene complex and development
Programmed cell death in insects

Endocrine system 5L
Prothoracicotropic hormone
Ecdysteroids: biosynthesis and mode of action
Juvenile hormones: biosynthesis and mode of action
Hormonal control of diapause

Immune system
Insect haemocytes and their role in immunity 5L
Eicosanoid and Phenoloxidases
Immune recognition and suppression
Cell mediated and humoral immunity

Perception
Chemoreceptors: Gustatory and olfactory 4L
Mechanoreceptors: Structure and functions of cuticular, subcuticular

Gall formation 2L

Types of galls
Mechanism of galls formation
Importance of galls

Suggested readings:

Beckage, N. E. (Ed.) (2008). *Insect Immunology*. Academic Press.
Chapman, R. F. (1998). *The Insects: Structure and Function*. 4th Ed. Cambridge University Press.
Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th ed. Cambridge University Press.
David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.
Gilbert, L. I. (Ed.) (2009). *Insect Development: morphogenesis, molting and metamorphosis*. Academic Press.
Gilbert, L. I. (Ed.) (2012). *Insect Endocrinology*. Academic Press.
Gillott, C. (2005). *Entomology*. 3rd Ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).
Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.
Klowden, M. (2013). *Physiological Systems in Insects,* 3rd ed. Academic Press.
Nation, J. L. Sr. (2016). *Insect Physiology and Biochemistry*. 3nd ed. CRC Press. Taylor and Francis Group.
Richards O.W. and Davies, R.G. (1977). *Imms: A General Text Book of Entomology*. 10th ed. Vol.1 and 2. Chapman and Hall.
Rockstein, M. (1978). *Biochemistry of Insects*. Academic Press.

MSZO 404 (DE-4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

Course specific outcome
Understanding Cellular organization, genome, epigenetics, Gene Expression, Cytoskeleton and cellular transport, Cell signaling pathways and cross talk mechanisms.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Cellular organization 20L

Membrane structure and transport of small molecules, electrical properties of membrane, nucleus, mitochondria, Golgi bodies, peroxisomes, Cytoskeleton and cellular transport: components of cytoskeleton, structure and function of microtubules, intermediate filaments, microfilaments, dynamic instability, MAPs, molecular motors, Protein trafficking 4L

Chromosome

Telomere and centromere structure,
DNA renaturation kinetics, DNA methylation and acetylation 2L

Junk DNA, selfish DNA, non-coding RNA 2L

RNA processing and editing, mRNA decay

Ribosome structure and control and processing of protein synthesis and transport

DNA Repair mechanisms 4L

Prions

Gene Identification and exon trapping 2L

Cell signaling pathways 2L

Ca^{2+},NO signaling,JAK-STAT pathway, RAS pathways and cross talk mechanisms

Analysis of Gene Expression 5L

GFP as reporter, gene fusion, construction of the reporter gene

Proteomics 4L

Yeast two hybrid assay, 2-D PAGE, protein array, MS for protein identification 3L

Protein tagging 2L

Suggested readings:

Alberts, B., Johnson, A. Lewis J., Raff, M.,RobertsK.andWalterP. (2008). *Molecular Biology of the Cell*. 5th Ed. Garland Publishing House.

Cooper, G. M. (2004). *The Cell*. 3rdedn. ASM Press.

Hancock, J.T. (2008). *Molecular Genetics.* Viva Book Private Ltd.

Hartl, D. L. and Jones, E. W. (1998). *Genetics, Principles and analysis.* (4thed). Blackwell Scientific, Oxford.

Hartl, D. L. and Jones, E. W. (2005). ***Genetics: analysis of genes and genomes. 6th ed.*** Jones and Bartlett Publishers, Sudbury, Mass.

Hartl, D. L. and Jones, E. W. (2006). *Essential Genetics: a genomics perspective* (4thed.). Jones and Bartlett Publishers, Boston.

Hartwell et al. (2001) *Genetics: From genes to Genomes.* McGraw Hill.

Harvey, L. (2004). *Molecular cell Biology*. 5th ed. W.H. Freeman.

Karp, G. (2008*). Cell and Molecular Biology: Concepts and experiments*.5thedn., John Wiley.

Kendrew, S. J. (Ed.) (1994). *The Encyclopedia of Molecular Biology.* Blackwell Science.

Lewin, B. (2008). *Genes IX*. Jones and Bartlett Publishers.

MSZO 404 (DE-5): PARASITOLOGY and MICROBIOLOGY (Credit 4)

Course specific outcome

Strengthening knowledge-base on hosts and their helminth parasites; updated knowledge on taxonomy of helminthes; understanding disease causing helminthes and their control measures.

Time: 2 hrs **Full Marks: 50**

Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Microenvironment and the phases of parasitism 5L

The vertebrate alimentary canal, blood, tissues and the other habitats

Parasite host specificity 2L

Protozoan Parasites 3L

Origin and evolution of parasitic Protozoa

Flagellates General morphology and morphological stages 15L

Life cycle and pathogenicity of *Trypanosoma brucei gambiense*, *Trichomonas vaginalis*

Physiology and biochemistry of Haemoflagellates

Apicomplexa

Ultrastructure of apical complex 10L

Biology and pathogenicity of *Toxoplasma gondii*, *Babesia bigemina*

Malaria and Malarial Parasites

General Biology, Characteristics of Species and Indian vectors of *Plasmodium* 12L

Causes, clinical symptoms, pathogenesis and treatment of malignant malaria

Clinical course and different clinical manifestations

Chemotherapy and general management of patients - Stable and unstable malaria - Epidemic and endemic situations - Autochthonous, imported, transfusion and other types

Principles of malaria control - Malaria control programmes and strategies - NMCP, NMEP, MPO, PfCP, UMS, RBM, EMCP, NVBDCP 3L

General morphology with special reference to parasitic forms

Structure, Life cycle and pathogenicity of *Balantidium coli*

Suggested readings:

Bird, A. F. (1971). *The structure of Nematodes*. Academic Press, New York.

Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd ed. Academic Press, New York.

Bogitsh, B. J., Carter, C. E. and Oltomann, T. N. (2006). *Human Parasitology*. 2nd ed. Academic Press, New York.

Bush, A. O., Fernández, J. C., Esch, G. W. and Seed, J. R. (2001). *Parasitism*. Cambridge University Press. U. K.

Cheng, T. C. (1986). *General Parasitology Academic Press*. 2nd ed. Inc. Orlando. U.S.A.

Dawes, D., Bakers, J. R. and Muller, R. (Eds.). *Advances in Parasitology* (yearly volumes). Academic Press, New York.

Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.

Hyman, L. H. (1951). *The Invertebrates* (Vol-I). Mc.GrawHill Book Company.

Noble, E. R. and Noble, G. A. (1989). *Parasitology. The Biology of animal Parasites*. 6th ed. Lea and Febiger, Philadelphia.

Schmid, G. D. (1989). *Essentials of Parasitology.* Wm. C. Brown Publishers (Indian Reprint; 1990. Universal Book Stall).

Smyth, J. D. (1994). *Animal Parasitology*. 3rd ed. Cambridge University Press.

Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of domesticated animals*. ELBS andBailliere Tindall, London.

MSZO 405: DISCIPLINE-CENTRIC ELECTIVE PAPERS
(Credit 4)

Time: 2 hrs **Full Marks: 50**

MSZO 405 (DE-1): AQUACULTURE AND FISHERIES
(Credit 4)

Course specific outcome

This course will present the vast marine and brackish water fisheries resources. Basic concepts on marine fisheries, fish resources, conventional as well as modern fishing methods, and nutritive value of the fish will be focused. Further, culture and preservation/processing of the high-valued fish resources are highlighted.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Marine and Brackish Water Fisheries

Marine fisheries in India 2L
- EEZ: potentials and exploitation, CRZ, Aquaculture authority
- Pelagic, demersal and deep-sea fisheries
- Factors affecting marine fisheries in east and west coast

Marine biology and oceanography in relation to fisheries 2L

Principal marine fisheries and exploited species 8L
- Oil sardine and lesser sardines, Indian mackerel, bombay duck, pomfrets, shrimps, molluscs

Fishing crafts and Gears 4L
- Types of Indigenous crafts and gears, designing
- Modernization of craft, Preservation
- Non-conventional fishing methods: electro fishing, light fishing, hydro-acoustic devices
- Remote Sensing and GIS: mapping of potential fishing zone

Life in sea 2L
- Phytoplankton, Zooplankton
- Nekton and fisheries

Shrimp culture 6L
- Breeding, hatchery management and culture technology of *Penaeus monodon*
- Introduction of *Litopenaeusvannamei*

Fluctuation in marine fisheries 2L
- Causes of fluctuation, overfishing problem
- Rational exploitation of fisheries

Preservation and processing 3L
- Bio-chemical composition of fish
- Drying and salting, Chilling and freezing, Smoking and canning, Food poisoning by fish

Present status of brackish water fish farming in India 8L
- Brackish water resources, Coastal aquaculture, mixed culture of brackish water fish species (Mariculture: Cultivable fin-fishes, Cultivable crustaceans,

Cultivable molluscs), Culture of Seaweeds
Estuarine fisheries

Fish in human nutrition 5L

Nutritive and therapeutic value of fish: Fish Proteins, oils and fatty acids, Fish as a source of vitamins and minerals

Fish products and by-products, Marketing of fish and aquaculture products 2L

Conservation of marine environment through establishing National marine reserves 2L

Suggested readings:

Bal, D. V. and Rao, K. V. (1984). *Marine Fisheries*.Tata McGraw Hill Pub. C Ltd.

Bardach, J. E. and Ryther, J. H. (1972).*Aquaculture*.John Willey and Sons.

Chandy, M. (1994).*Fishes*.NBT. New Delhi.

Jhingran, V. G. (1991). *Fish and Fisheries of India*.3rd ed. Hindusthan Pub.Corp.

Khanna, S. S. and Singh, H. R. (2003).*A Text Book of Fish Biology and Fisheries*.Narendra Publishing House. New Delhi.

T. V. R. Pillay, M. N. Kutty (2005). Aquaculture Principles and Practices. 2nd ed. Blackwell Publishing Ltd.

Srivastava, C. B. L. (1999). *Fish Biology*.Narendra Publishing House. New Delhi.

Srivastava, C. B. L. (2006). *A Text Book of Fishery Science and Indian Fisheries*.KitabMahal. Allahabad.

MSZO 405 (DE-2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

Course specific outcome

This course will cover species diversity study for conservation biology, conservation of natural resources, present status of sanctuary and national park in conservation, sustainable development, environmental management, environmental ethics, community study in hydrothermal vent, study of island biogeography and metacommunity concept.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Population in communities 8L

Species diversity, diversity indices, ecological guild, ecotone and edge effect, Interspecific competition and co-existence, ecotypes, keystone species, Island Biogeography, hydrothermal vent, Metacommunity concept

Resources 10L

Definition, category, concept and scarcity of resource; Conventional and non-conventional energy sources: Fossil fuels-coal, oil and nature gas: hydroelectric power: tidal, wind, geothermal energy: biomass: solar collectors, photovoltaics, solar ponds: nuclear-fission and fusion, magneto hydrodynamic power (MHD). Rainwater harvesting and ground water resource and management; Impending water crisis and the Indian scenario; Concept of Integrated Water Resources Management (IWRM),

Soil degradation, soil erosion and soil conservation 6L

Conservation and management

Diversity in biogeographical regions and marine forms, theories on biodiversity dispersion, Megadiversity zones and Hot spots, concepts, distribution and importance. Principles of conservation, conservation of natural resources, biomimetics, models of wildlife management and conservation with special emphasis on Eastern Himalaya, Terai Wildlife &Sundarban Biosphere Reserve,economics of ecosystem and biodiversity (TEEB), ecological principles of pest management. Restoration ecology: disturbance and its impact on the structure and functioning of terrestrial and aquatic ecosystems 8L

Evolutionary Ecology

Natural Selection and its ecological significance, modern concept of species, adaptation; Significance of mutation, isolating mechanism and ecological role and other evolutionary processes in ecology.

Ecological modelling 6L

Environmental ethics

Definition, history, scope and basic concepts; Anthropocentrism, biocentrism and ecocentrism; Deep ecology; Ecofeminism; Ecocentrism in indigenous societies and culture

Environmental Management 6L

Environmental Impact Assessment (EIA), general guidelines for the preparation of environmental impact statement (EIS), scope and types of environmental audit, cost benefit analysis, environmental management plan (EMP), international organization for standardization (ISO), ISO 14000 standards and certification, environmental clearance for establishing industry, environmental safety, risk management and emergency preparedness, international summit and treaties, important dates dedicated to environmental management 6L

Environmental policy

Goals and objectives of environmental education; components of environmental education; Environmental education in India; Value education, objectives, environmental values, valuing nature and cultures Social forestry, economical and legal aspects, environmental laws- role of government, Scheme of labelling of environment friendly products (Ecomark), media and voluntary groups, Green bench, Ecotourism

Suggested readings:

Begon, M., Harper, J. L. and Townsend, C. R. (2006). *Ecology: Individuals, Populations and communities*. 4thed. Blackwell science.

Berryman, A. A., Kindlmann, P. (2008). *Population Systems: A General Introduction*. Springer Science and Business Media.

Bill, F. (1989). *Environmental Ecology*. Academic Press, Inc.

Brewer, R. (1994). *The Science of Ecology.* Saunders College Publishing, 2nd ed. Cambridge University Press.

Case, T. J. (2000). *An Illustrated Guide to Theoretical Ecology*. Oxford Univ. Press.

Chapman R. L. and Reiss, M. J. (2000). *Ecology – Principles and Application*. Cambridge Low Price Edu. 2nded.

Colinvaux, P. (1993). *Ecology 2.* John Wiley and Sons, Inc. New York, pp. 688.

Faurie, C., Ferra, C., Medori, P. and Devaux, J. (2001). *Ecology - Science and Practice*. Oxford and IBH Publishing Company Pvt. Ltd.

Freedman, B. (1989). *Environmental Ecology*. Academic press, Inc.

Greipsson, S. (2010). *Restoration Ecology*. Jones and Bartlett Learning.
Hong, S-K, Nakagoshi, N., Fu, B. and Morimoto, M. (2007). *Landscape Ecological Applications in man-influenced area: Linking man and nature systems*. Springer.
Jørgensen, S. E. (2001). *Fundamentals of Ecological Modelling*. Elsevier.
Jørgensen, S. E. (2006). *Eco-Exergy as Sustainablity*. WIT Press.
Jørgensen, S. E. (2009). *Ecological Modelling*. WIT Press.
Kormondy, E. J. (2002). *Concepts of Ecology*. 4thIndian Reprint.
May, R. M. and McLean, A. R. (2007). *Theoretical Ecology: Principles and Applications*. 3rd Ed. (Indian Ed.). Oxford Univ. Press.
Moriarty, F. (1999). *Ecotoxicology: The study of pollutants in ecosystems*. 3rd Ed. Elsevier.
Odum, E. P. (1971). *Fundamentals of Ecology*. W. O. Saunders company, Philadelphia.
Odum, E. P. (1983). *Basic Ecology*. CBS College Publishing.
Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5thed. Thompson Brooks/Cole.
Rajagopalan, R. (2005). *Environmental Studies: from Crisis to Cure.* Oxford Univ. Press.
Sinclair, A. R. E., Fryxell, J. M. and Caughley, G. (2009). *Wildlife Ecology, Conservation and Management.* Wiley.
Smith, R. L. (2002). *Ecology and Field Biology.* Pearson Education (India) Ltd.
Van Dyke, F. (2008). *Conservation Biology: Foundations, Concepts, Application*. 2nd Ed. Springer Science and Business Media.
Zuur, A. F., Ieno, E. N. and Smith, G. M. (2007). *Analysizing Ecological data*. Springer Science and Business Media.

MSZO 405 (DE-3): ENTOMOLOGY
(Credit 4)

Course specific outcome

This content deals with bionomics and management of pests of crops and stored grains, its various control, chemical, biological, hormonal and biotechnological. Concepts of vector transmission and surveillance and applications of molecular tools to study insect genomics and ecology.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Agricultural Entomology
Crop Husbandry 8L
Bionomics and management of pests: paddy, jute, mango, and stored grains
Control and management of insect pests
*Chemical control*Organochlorines, organophosphates, carbamates, pyrethroids and botanicals *(*Azadirachtin*)* 12L
Biological Control: Parasitoids and pathogens
Hormonal control: Insect growth regulators (IGRs)
Genetic control: Methods of genetic manipulation
Biotechnological control
Use of transgenic plants, transgenic agents, Non-insecticidalmethods:Insect attractants, repellents and antifeedants
Medical-Veterinary Entomology
Insects of medico-veterinary importance, transmission cycles, vector incrimination, surveillance, emerging diseases 10L
Flies, fleas - bionomics, public health importance, control

Molecular Entomology

Insect genomics, Insect transposable elements, Micro RNAs
Applications of molecular tools in insect ecology 10L

***Suggested readings*:**

Abrol, D. P. (Ed.) (2013). *Integrated Pest Management: Current Concepts and Ecological Perspective*. Academic Press.

Amendt, J., Goff, M. L., Campobasso, C. P. and GrassbergerM. (Eds.) (2010). *Current Concepts in Forensic Entomology*. Springer.

Atwal, A. S. and Dhaliwal, G.S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

Byrd, J. H.andCastner, J. L.(Eds.) (2009).*Forensic Entomology: The Utility of Arthropods in Legal Investigations*. 2nd ed. CRC Press.

Dent, D. (2000). *Insect Pest Management*. 2nd ed. CABI.

Dhaliwal, G.S. and Singh, R. (2004). *Host plant Resistance to Insects: Concepts and Applications.*Panima Publishing Corporation.

Dorothy, E. G. (2006). *Forensic Entomology*. Wiley.

Gennard, D. (2012). *Forensic Entomology: An Introduction*. 2nd ed.Wiley-Blackwell**.**

Gilbert, L. I. and Gill, S. S. (Eds.) (2010). *Insect Control: Biological and Synthetic Agents*. Academic Press.

Gilbert, L. I. and Gill, S. S. (Eds.) (2010). *Insect Pharmacology – Channels, Receptors, Toxins and Enzymes*. Academic Press.

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – an outline of Entomology*. 4th ed. Blackwell Publishing.

Handler, A. M. and James A. A. (2000). *Insect Transgenesis: methods and Applications*. CRC Press.

Hill, D.S. (1994). *Agricultural Entomology.* Timber Press.

Hoy, M. A. (2003). *Insect Molecular Genetics– An introduction to principles and Applications.*2nd ed. Academic Press.

Ignacimuthu, S. and Jayraj, S. (Eds.) (2007). *Biotechonology and Insect Pest Management.* Elite Publishing House Pvt. Ltd.

Jha, L. K. and Sen Sarma, P. K. (1993). *Agroforestry – Indian Perspective*. Ashish Publishing House.

Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.

Koul, O, Cuperus, G.W. and Elliot, N. (Ed.) (2008) *Area wide pest management Theory and Implementation*. CAB International.

Metcalf, R. L. and Luckmann, W. H. (1994). *Introduction to Insect Pest Management*. 3rd Ed. John Wiley and Sons, Inc.

Mullen, G. R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.

Nation, J. L. (2008). *Insect Physiology and Biochemistry*. 2nd ed. CRC Press. Taylor and Francis Group.

Norris, R. F., Caswell-Chen, E. P. and Kogan M. (2002). *Concepts in Integrated Pest Management*. Prentice Hall

Pedigo, L. P. and Rice E. M. (2009). *Entomology and Pest Management.* Pearson/Prentice Hall.

Pimentel D. (Ed.) (2007). *Encyclopedia of Pest Management.* Vol.II. CRC Press, Taylor and Francis.

Price, P. W.,Denno, R. F., Eubanks, M. D., Finke, D. L. and Kaplan, I. (2011). *Insect Ecology: Behavior*, *Populations and Communities.*Cambridge University Press.

Radclife, E.B., Hutchinson, W.D. and Cancelado, R.E. (2009) *Integrated Pest Management – Concepts, Tactics, Strategies and Case studies.* Cambridge University Press.

Rechcigl J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.

Schoonhoven, L. M., van Loon J. J. A. and Dicke, M. (2006). *Insect-Plant Biology*. 2nd ed. Oxford University Press.

Srivastava, K. P. and Dhaliwal, G. S. (2013). *A textbook of Applied Entomology.* Vol. II. 8thed.

MSZO 405 (DE-4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

Course specific outcome

Understanding basic principles of sensitivity, specificity, application and importance of Molecular diagnosis for the detection cancer, rare genetic and metabolic disorders, infectious diseases; mode of infection and sero- surveillance by various modern diagnostic methods.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Molecular Diagnosis 18L

Introduction and History of diagnostics

Introduction and History of diagnostics of diseases, mode of infection, types of infectious diseases, philosophy and general approach to clinical specimens

Principles of diagnosis and detection 4L

Sensitivity, specificity, PPV and NPV of the test, rapid test, antigen test, antibody test, nucleic acid test

Diagnosis of infectious diseases 5L

Detection of IgG and IgM for infection and sero- surveillance by ELISA,Diagnosis of HIV and HCV by real time PCR, detection of malarial infection by PCR and LDH based ELISA, TrueNAT, CBNAAT method for TB, COVID testing by real time PCR. dengue infection by real time PCR, allergy testing

Molecular Diagnosis of cancer subtyping: IHC based Breast cancer subtype, 5L

EGFR mutation detection for Lung cancer subtype, Cervical cancer subtyping, immunophenotyping and leukaemia types, Oncomine and Oncotype DX testing 2L

Diagnosis of Monogenic disorders

Thalassemia and others, rare genetic disorders – ARMS PCR, GAP PCR, MLPA 5L 4L

Arthritis test (Gout testing) 3L

Cardiac marker test – Troponin detection 2L

Prenatal diagnosis and Non-invasive prenatal testing, triple marker test 2L

Clinical exome and ClinVar data base

Suggested readings:

Watson, J. D., Baker, T. A. and Bell, S. P. (2007). *Molecular Biology of the Gene*. 6th ed. Benjamin Cummings.

Malacinski, G. M. (2003). *Essentials of Molecular Biology.* 4th ed. Jones and Bartlett.

McConkey, H. (1993). *Human Genetics: The molecular Revolution.* Jones and Bartlett Publishers.

Snustad, D. P. and Simmons. M. J. (2004). *Principles of Genetics*. 4th ed. John Wiley and Sons.

Stansfield, W. D. (1991). *Schaum's Outline Series: Theory and Problems of Genetics.* 3rd ed. McGraw-Hill.

Strachan, T. and Read, A. P. (2004). *Human Molecular Genetics-3*. garland Science.

Strickberger M.W. (1985). *Genetics.* 3rd ed. Prentice Hall of India Pvt. Ltd., New Delhi.

MSZO 405 (DE-5): PARASITOLOGY and MICROBIOLOGY
(Credit 4)

Course specific outcome

Strengthening knowledge-base on hosts and their helminth parasites; updated knowledge on taxonomy of helminthes; understanding disease causing helminthes including vector borne diseases and their control measures.

Time: 2 hrs **Full Marks: 50**
Lecture: 50

Four questions (out of six) of 2 marks each, four questions (out of six) of 4 marks each and two questions (out of four) of 8 marks each are to be answered

Introduction to parasites 10L

Introduction to parasites. Mode of transmission, portal of entry and implications of parasitism

Life cycle patterns and morphological adaptation in different group of helminthes

Larval form of different helminthes 10L

Helminthology

Nematoda: Definition of nematodes and their significance, general morphology, biology and life cycle patterns, structure of cuticle, excretory system and its taxonomic importance, reproductive system, copulatory structures: spicules, gubernaculum guiding and accessory pieces, the genital/caudal papillae and bursa, egg formation and types of eggs

Trematoda (Aspidogastrea): morphology, biology and life cycle of *Aspidogasterconchicola*

Trematoda (Digenea): Host and habitat, general morphology, biology and life cycle patterns, ultra-structure of tegument, excretory system and its taxonomic importance, reproductive system and egg formation and types of eggs

Cestodaria: morphology and life cycle of *Amphilina*, *Gyrocotyle*

Eucestoda: Systematic account and diagnostic features of various orders of Eucestoda, general morphology, biology and life cycle of various orders of Eucestoda, ultra-structure of tegument

Monogenea: Morphology, life cycle, reproductive system and economic importance

Type study – *Polystoma*, *Diplozoon*, *Gyrodactylus* 8L

Acanthocephala: General organization and morphology, lifecycle of *Moniliformis*

Biology, Pathogenicity and Control

Opisthorchis sinensis, *Diphyllobothrium latum, Hymenolepis nana, Echinococcus granulosus*, *Ancylostoma duodenale, Loa loa* 12L

Gastrointestinal nematode infection in man and ruminants and their antihelmintic treatment

Helminthology

Biology, pathogenicity and control of *Schistosoma mansoni*

Human lymphatic filariasis and its transmission dynamics 10L

Chemotherapy and chemoprophylaxis: selective treatment, mass drug

administration and medicated salt

Vector Biology

Biology, importance and control: *Chrysops,* tse-tse fly, mosquitoes (*Aedes* and *Culex*), fleas, lice

Suggested readings:

Bird, A. F. (1971). *The structure of Nematodes.* Academic Press, New York.

Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.

Bogitsh, B. J., Carter, C. E. and Oltomann, T. N. (2006). *Human Parasitology*. 2nd Ed. Academic Press, New York.

Bush, A. O., Fernández, J. C., Esch, G. W. and Seed, J. R. (2001). *Parasitism*: Cambridge University Press. U. K.

Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando. U.S.A.

Chowdhury, N. and Toda, I. (Eds) (1994). *Helminthology*. Narosa Publishing House, New Delhi.

Dawes, D., Bakers, J. R. and Muller, R. (Eds). *Advances in Parasitology* (yearly volumes). Academic Press, New York.

Hati, A. K. (2001). *Medical Entomology.* Allied Book Agency, Kolkata.

Hati, A. K. (2001). *Medical Parasitology.* Allied Book Agency, Kolkata.

Hyman, L. H. (1951). *The Invertebrates*. (Vols- II, III) Mc.GrawHill Book Company.

Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.

Roberts, L. S. and Janovy, Jr. J. (2006). *Foundations of Parasitology.* McGraw-Hill International Ed.

Schmid, G. D. (1989). *Essentials of Parasitology*. Wm. C. Brown Publishers (Indian Reprint; 1990. Universal Book Stall).

Smyth, J. D. (1994). *Animal Parasitology.* 3rd ed. Cambridge University Press.

Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of domesticated animals.* ELBS and Bailliere Tindall.

Smyth, J. D. and McManus, D. P. (1989). *The Physiology and Biochemistry of cestodes.* Cambridge Univ. Press.

MSZO 406: DISCIPLINE-CENTRIC ELECTIVE PRACTICAL PAPERS
(Credit 4)

Time: 4 hrs **Full Marks: 50**

MSZO 406 (DE-1): AQUACULTURE AND FISHERIES
(Credit 4)

Course specific outcome
This course will provide hands-on experience on diet preparation, analysis of physiological status of fish and farm management, which might offer the scope of entrepreneurship development.

Time: 4 hrs **Full Marks: 50**

1. Histological studies of different tissues and their identification
2. Determination of physico-chemical parameters of water
3. Diet formulation and preparation of artificial fish feed
4. Analysis of proximate composition (moisture, dry matter, crude protein, ether extract, crude fibre, ash, NFE etc.) of fish tissue and feed samples
5. Quantitative detection of digestive enzymes (protease, α-amylase and lipase)
6. Isolation of fish gut microorganisms and qualitative evaluation of microbial

enzyme-production (protease, α-amylase and cellulase)
7. Identification and mounting of some common freshwater Zooplankton, benthos, aquatic weeds and insects
8. Electrophoretic separation of proteins and nucleic acids
9. Field study/Institute visit and submission of report: Compulsory
10. Laboratory records
11. Submission of prepared slides
12. Viva-voce

MSZO 406 (DE-2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

Course specific outcome
This course will provide hands-on training on isolation of carbohydrates, proteins, lipids, amino acids and phenols from plants, determination of BOD and COD, organic matter determination from soil, isolation, identification and quantification of plant secondary compounds through GC-MS and GC-FID, buccal micronucleus cytome assay to detect gross cytological abnormalities and its association with environmental exposure, fast halo assay to assess DNA damage in oral exfoliated cell and its comparison between exposed versus unexposed individuals, genotyping of polymorphisms providing susceptibility to airborne allergens, air pollution study.

Time: 4 hrs **Full Marks: 50**

1. Quantitative analysis of some inorganic and organic materials in the environment
    a. Chemical oxygen demand (COD)
    b. Biochemical oxygen demand (BOD)
    c. Organic Matter / Organic carbon in the sediment
2. Chemical Ecology
    a. Quantitative analysis of carbohydrates, proteins, amino acids, and polyphenolics by colorimetric/spectrophotometric method
    b. Identification and quantitative analysis of amino acids compounds
    c. by Thin Layer Chromatography (TLC) and Gas Chromatography (GC)
    d. Identification and quantitative analysis of plant secondary compounds by Thin Layer Chromatography (TLC) and Gas Chromatography (GC)
3. Environmental pollution
    a. Buccal micronucleus cytome assay to detect gross cytological abnormalities and its association with environmental exposure
    b. Fast halo assay to assess DNA damage in oral exfoliated cell and it's comparison between exposed versus unexposed individuals
    c. Genotyping of polymorphisms providing susceptibility to airborne allergens (DNA isolation, Polymerase Chain Reactions and RFLP)
4. Field records/Project reports and submission of report: Compulsory Educational tour to National Park / Wildlife Sanctuary / Biosphere Reserve
5. Air sampling and air analysis
    a. Temperatures- Minimum and maximum relative humidity
    b. Particulate matter (Electrostatic method)

c. Nitrogen oxides, sulphur dioxide
d. Hydrocarbons in exhaust gas

6. Laboratory records
7. Viva-voce

MSZO 406 (DE-3): ENTOMOLOGY
(Credit 4)

Course specific outcome
Systematic identification of endopterygote insects, vectors, insects of medico-legal importance; training on field entomology; development of knowledge on polytene chromosomes, genomic DNA isolation, chitosan test, hsp-70 expression.

Time: 4 hrs **Full Marks: 50**

1. Anatomy
    a. Silkworm: Silk gland, digestive and reproductive systems
    b. Blue bottle fly: Digestive and nervous systems
2. Taxonomy
    a. Identification (up to family) with reasons of endopterygote insects
    b. Identification of insects (up to genus) of medical, veterinary and medico-legal importance: Mosquitoes (*Anopheles, Culex* and *Aedes*), sand fly (*Phlebotomus*), black fly (*Simulium*), biting midge (*Culicoides*), housefly (*Musca*), deer fly (*Tabanus*), blow fly (*Lucilia*), dog flea/cat flea (*Ctenocephalides*)
    c. Construction of keys: up to family level for major orders
3. Biochemistry and Physiology
    a. Chitosan test of cuticle
    b. Biochemical estimation of changes (quantitative) in host plant/seed/fruit due to infestation of pest
    c. Study of stress response using transgenic *Drosophila melanogaster* (Dye exclusion method using Trypan blue/ X-gal staining for hsp-70 expression)
    d. Study of exoenzyme producing gut bacteria
4. Cytology and Molecular biology
    a. Preparation of polytene chromosomes from different dipteran insects
    b. Isolation of genomic DNA from insects
    c. Electrophoretic study of haemolymph, ovarian and egg protein
5. Toxicology
    a. Study of LC_{50} of two common insecticides against any two pests
6. Study of pests
    a. Study of life cycle of stored grain pests and agricultural pests (one each)
    b. Study life cycle of insects of medical/veterinary/medico-legal importance (at least 2)
7. Field Entomology
    a. Methods of insect collection, preservation and submission
    b. Study of insect diversity from crop field/grassland/forest floor

8. Visit to institution /field trips
9. Laboratory records
10. Viva-voce

MSZO 406 (DE-4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

Course specific outcome
Students will learn DNA sequencing, PCR, IHC and other modern procedures of molecular diagnosis and will develop skill for analysis of sanger sequence chromatogram, NGS data, application of Bioinformatics, molecular Docking, omics data analysis, etc.

Time: 4 hrs **Full Marks: 50**

1. DNA sequencing procedure and analysis of sanger sequence chromatogram
2. Analysis of NGS data: whole exome data, VCF file, FASTQ file, BAM file, calculation sequence depth and coverage
3. Bioinformatics :Access of OMIM, dbSNP, 1000 Genome, Asian Genome 100K, ClinVar, HbVar, Docking, omics data analysis
4. IHC study to HER2 and ER expression
5. PCR based HPV typing
6. ARMS PCR, GAP- PCR and Sanger sequenced based Thalassemia diagnosis
7. CRP Test
8. Laboratory records
9. Viva-voce

MSZO 406 (DE-5): PARASITOLOGY AND MICROBIOLOGY
(Credit 4)

Course specific outcome
First-hand knowledge on collection, preparation and accurate identification of parasites and their vectors using various updated and advanced techniques used in pathological laboratories.

Time: 4 hrs **Full Marks: 50**

1. Permanent preparation of protozoan parasite
2. Fixation and preservation of helminth parasites
3. Staining and mounting of trematode and cestode
4. Cytochemical and histochemical studies on protozoan and helminth parasites- DNA, polysaccharides, protein, lipid, alkaline and acid phosphatases
5. Clinical parasitological techniques
6. En-face view preparation of nematode parasites
7. Whole mount preparation of arthropod parasites and vectors
8. Isolation of DNA from parasitic helminth
9. Electrophoretic separation of DNA
10. Field visit

a. Methods of parasite collection and preservation
b. Study of parasite diversity in fishes from culture pond/fish market/forest stream

11. Laboratory records
12. Viva-voce

MSZO 407
TERM PAPER / PROJECT WORK
(Credit 4)

Course specific outcome
Hands on training on different methods used in different biological disciplines, development of a preliminary idea in pursuing research in future; learning to write a review article including its references.

Full Marks: 50

MSZO 407: TERM PAPER / PROJECT WORK
(Based on Discipline-centric Elective Papers)

[Division of marks: Internal Assessment: 10; Submission (not less than 10,000 words excluding references): **25; Seminar Presentation and Viva**: **15]**