SYLLABUS FOR
M. SC. COURSE IN ZOOLOGY

(With effect from the 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

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

POST GRADUATE SYLLABUS

Annexure-I

Department of Zoology

Summary of the course and credits

Semester I [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T**	**Total**	
MSZO101	Core	T	Ecology, Ethology and Conservation Biology	4T	2T	10	40	50	4
MSZO102	Core	T	Basic and Applied Entomology	4T	2T	10	40	50	4
MSZO103	Core	T	Parasitology and Vector Biology	4T	2T	10	40	50	4
MSZO104	Core	T	Fish Biology and Fisheries	4T	2T	10	40	50	4
MSZO105A	Core	P	Ecology and conservation Biology	4P	2P	5	20	25	2
MSZO105B	Core	P	Entomology	4P	2P	5	20	25	2
MSZO106A	Core	P	Parasitology and Vector Biology	4P	2P	5	20	25	2
MSZO106B	Core	P	Fish Biology and Fisheries	4P	2P	5	20	25	2
								Total credit	24

T/P: Theory/Practical

Semester II [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in H)	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 205A	Core	P	Biosystematics	4P	2P	5	20	25	2
MSZO 205B	Core	P	Genetics and Cell Biology	4P	2P	5	20	25	2
MSZO 206A	Core	P	Physiology and Endocrinology;	4P	2P	5	20	25	2
MSZO 206B	Core	P	Microbiology and Immunology	4P	2P	5	20	25	2
								Total credit	24

T/P: Theory/Practical

Semester III [Credits – 24]

Course				Lect. Hr /week	Dur. of Exam (in H)	Marks			Credit
Course code	**Type**	**T/P**	**Name**			**I.A.**	**E.T**	**Total**	
MSZO 301	Core	T	Biochemistry and Toxicology	4T	2T/4P	10	40	50	4
MSZO 302	Core	T	Histology - Histochemistry and Comparative Anatomy	4T	2T/4P	10	40	50	4
MSZO 303A	Core	P	Biochemistry and Toxicology	4P	2P	10	20	25	2
MSZO 303 B	Core	P	Histology, Histochemistry and comparative anatomy	4P	2P	10	20	25	2
MSZO 304Z	GE	T	**Applied Zoology**	2T	1T/2H	5	20	25	2
MSZO 305*	DE	T	Discipline-centric Elective	4T	2T/4H	5	40	50	4
MSZO 306 **	DE	P	Discipline-centric Elective	4T	2T/4H	5	40	50	4
MSZO 307	CE	T/P	Community Engagement ##	N.A.	N.A.	5	20	25	2
								Total credit	24

T/P: Theory/Practical

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

*** Discipline-centric Elective (Student need to take any one of these Discipline-centric Elective)**

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

**** CORSE CODE: MSZO 306-DE1, 306-DE2, 306-DE3, 306-DE4, 306-DE5,**

Community Engagement: Based on Discipline-centric Elective

Semester IV [Credits – 24]

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

MSZO 403 #	DE	T	Discipline-centric Elective *	4T	2T	10	40	50	4
MSZO 404 ##	DE	T	Discipline-centric Elective *	4T	2T	10	40	50	4
MSZO 405 ###	DE	P	Discipline-centric Elective *	8P	2T	10	40	50	4
MSZO 406	Project	T /P	Dissertation $$ (Empirical or Non empirical)	NA	---	---	50	50	4
								Total credit	24

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

$$ Based on Discipline-centric Elective

DE Course Code : MSZO 403-DE1, MSZO 403-DE2, MSZO 403-DE3, MSZO 403-DE4, MSZO 403-DE5,

DE Course Code : MSZO 404-DE1, MSZO 404-DE2, MSZO404-DE3, MSZO 404-DE4, MSZO 404-DE5,

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

Notes on marks distribution:

1. In each course, 20% marks is allotted for Internal Assessment (for both theory and practical's), 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:
    1. 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*
    2. 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*
    3. 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*

SEMESTER – I

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

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

Conecpt of Environment, Composition of Environment, Sources and effects of primary and secondary air pollutants, global warming and green house effects, ozon layer depletion, El-Nino and La Nino, 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.

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

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.

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.

Saharia, V. B. (1998). *Wildlife in India*. Natraj Publishers.

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

Sinclair, A. R. E., Fryxell, J. M. and Caughley, G. (2009). *Wildlife Ecology, Conservation and Management*. Wiley.

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 behavior
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
Megadiversity zones and Hot spots, concepts, distribution and importance.
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 strategy (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*. 4th ed.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.

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

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 organsation 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, EIL, ET	
Transgenic plants	2L

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)

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 donovoni, Haemosporina*

Zoonosis 2L

Malarial parasites 4L

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 and Sons 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)

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, Acoustico-lateralis system (membranous labyrinth and lateral line), Special sense organs (Ampullae of Lorenzini, Pit Organs)

Endocrinology 5L

Hypothalamo-hypophyseal system, Pituitary (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-osmoregulation, Energetics, Environmental, Factors, Anthropogenic Impacts 2L

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, Rex 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.

T. V. R. Pillay, M. N. Kutty (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.

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

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, 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, Pomfrets) Elasmobrach fishery (major groups, fishery methods, importance), Molluscan fishery

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.

PRACTICAL PAPERS
MSZO- 105A Core Course
(Credit 2) **Full Marks: 25**

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

Time: 2 hrs
Full Marks: 25

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. Wild life 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

PRACTICAL PAPERS
MSZO- 105B Core Course
(Credit 2) **Full Marks: 25**

MSZO-105B: ENTOMOLOGY (Credit 2) **Time: 2 hrs**
Full Marks: 25

1. Digestive system of Honey bee
2. Nervous system of Honey bee
3. Mounting:
   Mouthparts of grasshopper, bug, mosquito, house fly, bee
   Wings of Ephemeroptera, Odonata, Dictyoptera, Hemiptera, Diptera, Hymenoptera, Coleoptera
   Legs: Gressorial, cursorial, saltatorial, fossorial, natatorial, corbiculate, clasporial, raptorial
   Antennae: Filiform, setaceous, plumose, pilose, pectinate, clavate, geniculate, aristate, serrate, 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* sp., *Tribolium castaneum*); identification of forensically important insects: *Musca, Calliphora, Sarcophaga,* histerid beetle, staphylinid beetle
5. Social Insects: Morphological studies of social insects (Honey bee and termite)
6. Laboratory records
7. Submission of prepared slides and pests
8. Viva-voce

PRACTICAL PAPERS

MSZO- 106A Core Course

(Credit 2) **Full Marks: 25**

MSZO-106A: PARASITOLOGY AND VECTOR BIOLOGY (Credit 2) **Time: 2 hrs**

Full Marks: 25

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 Stegomyia)
6. Identification of parasites and vectors (Slides/ Photographs)
7. Retrievalof 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

PRACTICAL PAPERS

MSZO- 106B Core Course

(Credit 2) **Full Marks: 25**

MSZO106B: FISH BIOLOGY AND FISHERIES (Credit 2)

Time: 2 hrs

Full Marks: 25

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

MSZO201: Core Course
(BIOSYSTEMATICS AND EVOLUTIONARY BIOLOGY)
(Credit 4)

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, intrapopulational 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 & Molecular clock
- Molecular phylogeny

Hominid evolution — 5L
- Anatomical, geographical and cultural
- Ancestry of *Homo sapiens*: molecular phylogenetic relationship
- Peopling of continents
- Human genome variation

Patterns and trends in evolution — 4L
- 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., 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*. (5th ed.). 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.

MSZO202: Core Course
(MICROBIOLOGY AND IMMUNOLOGY)
(Credit 4)

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 the 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 of toxins and mode of action of *Bacillus thuringiensis, Bacillus sphaericus*; Bacterial and viral diseases of silkworm larvae and honey bees; Endosymbionts and their significance

Medical Microbiology 6L

Mode of transmission, pathogenicity and prevention of microbial diseases: Air-borne (Tuberculosis and Influenza), Food and waterborne (Typhoid and Cholera) and Arthropod borne (Dengue, JE and Yellow fever)

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, Cells and Tissues of the Immune system, Anatomy and Functions of lymphoid tissues, antigens and antibodies, MHC molecules, Cytokines, complement system

Innate Immunity — 3L

Nature and types of Pathogen 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

Adaptive immunity — 6L

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 type of epitope, 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

Activation of T-Lymphocytes, MHC restriction — 1L

Hyperactivation of Immune System — 2L

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

Immunologic Tolerance and Autoimmunity — 2L

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)

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

UNIT I: HUMAN GENETICS AND GENOMICS (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, 2L

Cytogenetics:

karyotyping; Banded chromosomes and individual characterization of the human chromosomes; numerical chromosomal abnormalities; structural chromosomal abnormalities; somatic cell hybridization and use of somatic cell 3L

Human genome project

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 3L

Model organisms:

Genetics of Drosophila, Zebra Fish, Sex determination of Drosophila and human 2L

Mitochondrial genome 1L

Mitochondrial genome organization and disorder associated with mitochondrial DNA 3L

Epigenetic modifications and disorders

Genetic disorders and Twin Study and Gene therapy:

Monogenic diseases – Thalassemia, albinism, Hemophila, Colour Blindness, 1L
Polygenic diseases- Hyperlipidemia, Diabetes mellitus, Genetics Myocardial Infarction, Genetic basis of neurodegenerative disorders*;* 3L

Cancer Biology and Genome – types, driver and passenger mutation. Somatic mutations, genomic instability, cancer therapy.

Techniques in Genome study: 2L

Gel Electrophoresis, PCR, ARMS PCR, MLPA, RT PCR, Sanger Sequencing, NGS, genome-wide association studies (GWAS) and personalized medicine and pharmacogenomics . 1L

Genetic screening and counselling

Prenatal and Post-natal screening of genetic diseases, Amniocentesis,Chronic Villous sampling, Family screening for genetic diseases; Scope and methods of genetic counselling,

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 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	2L
and NO in signal transduction	1L
Cytotoxicity: Carcinogens, mutagens, teratogens,	1L
Apoptosis (molecular mechanisms, regulations),	1L
Autophagy, cellular senescence, Chaperons	
Exosome biogenesis and function and molecular cargo,	
Transcriptomics: Gene regulation, non-Coding RNAs: sncRNA miRNA, LncRNA,	2L
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
Techniquesin 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 1L
Cell synchronization, Fluorescence plus Giemsa staining technique, average generation time,	2L

Databases for cellular process study: Geo databases, Pathway analysis and databases, miRBase

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.

MSZO204: Core Course
(PHYSIOLOGY AND ENDOCRINOLOGY)
(Credit 4)

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

Sensory **3L**

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- 205A Core Course

(Credit 2) **Full Marks: 25**

MSZ0 205A: BIOSYSTEMATICS (Credit 2) **Time: 2 hrs**

Full Marks: 25

1. Taxonomy
    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

PRACTICAL PAPERS

MSZ0- 205B Core Course

(Credit 2) **Full Marks: 25**

MSZ0 205B: 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 the polytene chromosome of Chironomid larvae
6. DNA extraction and study of the DNA quality and quantity (UV spectroscopy and agarose gel electrophoresis)
7. PCR, Demonstration of RT PCR and calculation of Fold change of gene expression (delta CT method)
8. Demonstration of SDS PAGE and determination of the molecular weight of the protein
9. Demonstration of cancer cell culture and counting of colony
10. Demonstration of scratch wound assay – for invasion and metastasis
11. Demonstration of Flowcytometry based apoptosis and cell cycle analysis
12. Identification of cancer cells and stages
13. Laboratory records
14. Viva-voce

PRACTICAL PAPERS

MSZO- 206A Core Course

(Credit 2) **Full Marks: 25**

MSZO- 206A: 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

PRACTICAL PAPERS

MSZO- 206B Core Course

(Credit 2) **Full Marks: 25**

MSZO- 206B: 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's
    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 immune cells from Human blood

d. Polarization Macrophage
e. Determination of Antibody Titer by immunodiffusion methods
f. Agglutination and precipitation techniques
g. Demonstration of ELISA methods
h. Identification of different immune cells and section of immune organs
i. Laboratory records
j. Viva-voce

SEMESTER – III

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

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; Kreb's 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

Energy transduction and ATP synthesis: 1L

glucose and fatty-acids as energy source, electron transport chain, oxidative phosphorylation,

Metabolic disorders 1L

Regulation of amino acid and lipid metabolism and metabolic disorders

Oxidative stress and lipid peroxidation: 1L

Free radicals and Free radical scavengers (Polyphenols, vitamin C & E, glutathione, catalase, superoxide dismutase); lipid peroxidation

Analytical Biochemistry 5L

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:

Berg et al: Biochemistry (5th ed 2001, Freeman)
Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
Mathews et al: Biochemistry (3rd ed 1990, Benjamin/Cummings)
Segal Biochemical calculations (2nd ed 1976, John Wiley)
Watson et al: Molecular Biology of the Gene (2nd ed 1976, Benjamin/Cummings)
Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
Rawn: Biochemistry (1989, Neil Patterson)
Primrose et al: Principals of gene manipulation (6th ed 2001, Blackwell Scientific)
Sambrook & Russell: Molecular Cloning (2001, Cold spring Harbor)

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 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)

Pesticides 4L

Concept and classification

Insecticides and herbicides: Types (including bioinsecticides), sources, effects and degradation kinetics

Mechanism of action: Organochlorine, Organophosphate, Carbamates, Paraquat, Phenoxy herbicides

Metal toxicity 4L

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

Applied toxicology 4L

Environmental toxicology

Occupational and industrial toxicology

Clinical toxicology

Forensic toxicology

Suggested readings:

De, A. K. (2000). *Environmental chemisrtry.* 4th ed. 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)

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**

Characteristics 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
- –NH2 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 application

Preparation of biological material for TEM and SEM **4L**
Applications of 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*. 3rd ed, 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 10L
- Digestive system
- Nervous system
- Excretory system
- Reproductive system and larval forms

Comparative study of vertebrates 8L
- Stomach and Intestine
- Respiratory organs
- Heart
- Brain and sensory organs

Adaptive modifications in vertebrates 3L
- Aquatic
- Terrestrial
- Aerial
- Arboreal
- Fossorial

Development and comparative account in vertebrates 4L
- 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. 8

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- 303A Core Course
(Credit 2) Full Marks: 25

MSZO- 303A: BIOCHEMISTRY AND TOXICOLOGY (Credit 2) **Time: 2 hrs**
Full Marks: 25

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 due to toxicant exposure
13. Laboratory records
14. Viva-voce

PRACTICAL PAPERS

MSZO- 303B Core Course

(Credit 2) **Full Marks: 25**

MSZO- 303B: HISTOLOGY -HISTOCHEMISTRY AND COMPARATIVE ANATOMY (Credit 2) **Time: 2 hrs** **Full Marks: 25**

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. Demonstration of Immunohistochemistry
6. Submission of permanent slides prepared for histological and histochemical studies of different tissues
7. Laboratory records
8. 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)

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

GE: APPLIED ZOOLOGY **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

1.	Aquaculture management	2
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
12.	Stem cell and regenerative Medicine	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
(Credit 4)

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

MSZO 305 (DE1): AQUACULTURE AND FISHERIES (Credit 4)

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, Labeo rohita, Cirrhinus mrigala*

Exotic carps: *Hypophthalmicthys molitrix, Ctenopharyngodon idella, Cyprinus carpio*

Cat fishes: *Clarias batrachus, Heteropneustes fossilis, Ompok bimaculatus, Pangasius* sp.

Other groups: *Anabas testudineus, Channa striatus, Etroplus suratensis*

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 gamets 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 10L

Genome and fish biotechnology

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, Zebrafish 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.

T. V. R. Pillay, M. N. Kutty (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.; 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 (DE2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

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 tropic levels, energy budget, ecosystem services, Strcucure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (frershwater, marine and eustarine)

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, Sedirophores/siderophores 6L

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*. (4th ed.). 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 (DE3): ENTOMOLOGY
(Credit 4)

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, sclerotization 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 (DE4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

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

CLASSICAL GENETICS AND INHERITANCE BIOLOGY **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

Basics of inheritance 10L

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, Zebrafish;* 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

Gene and genome organization 4L

Comparative genomics, prokaryotic genome**,** Yeast, Mice, rice genome.

Concept of gene, Fine structure of gene 8L

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

Microbial genetics 8L

Viral genetics: Mapping, phenotypes, genetic recombination, genetic fine structure; HIV and Sars Cov2: Structure, life cycle, course of infection; Bacterial genetics: plasmids, methods of gene transfer in bacterial transformation, conjugation, transduction; bacterial recombination

Drosophila genetics 10L

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; *Drosophila* genome project

Epigenetic inheritance 8L

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

Cancer Genetics 2L

Somatic Mutations and affected pathways, Oncogenes and TSGs, LOH, TCGA database, 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*. 3rd edn. 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* (4th ed.). 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.* 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.
Vogel, F. and Motulsky, A. G. (1999*). Human Genetics*. Springer.

MSZO 305 (DE5): PARASITOLOGY and MICROBIOLOGY
(Credit 4)

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*

Genome organization and mode of replication of animal and human infecting viruses: Rabies virus, Poliovirus, Coronaviruses, Dengue virus, Poxvirus and HIV

Immunopathogenesis of Malaria 5L

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

Mode of transmission, pathogenicity and prevention of bacterial diseases 5L

Anthrax, Tetanus, Diphtheria and Botulism

Mode of transmission, pathogenicity and prevention of viral diseases 5L

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

Molecular parasitology and Microbiology 20L

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

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 PRACTICAL'S
(Credit 4)

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

MSZO 306 (DE1): AQUACULTURE AND FISHERIES (Credit 4)

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 (DE2): ECOLOGY AND ENVIRONMENTAL BIOLOGY (Credit 4)

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 (DE3): ENTOMOLOGY (Credit 4)

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*, *Nilaparvata lugens*, *Nephottetix* spp., *Sogatella furcifera*, *Recilia dorsalis*, *Cofana spectra*, Rice seed bug/Gundhi bug (*Leptocorisa* spp.), White fly (*Bemisia tabaci*), mustard aphid (*Lipaphis erysimi*), *Dysdercus* spp., *Thrips tabaci*, *Amritodus atkinsoni*, 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 (DE4): MOLECULAR BIOLOGY AND GENETICS (Credit 4)

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 . doubling time measurements,
8. PCR and primer designing
9. Extraction of RNA and, RNA quality check by Gel Electrophoresis, qPCR
10. Western blotting
11. Flowcytometry 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 (DE5): PARASITOLOGY AND MICROBIOLOGY (Credit 4)

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. Demonstration of Sandwich ELISA method
11. Immunofluorescence
12. 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
13. Laboratory records
14. Viva-voce

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

Full Marks: 25

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

SEMESTER – IV

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

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; genetical methods,
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. 2 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: UNIT II: STEM CELL AND REGENERATIVE MEDICINE (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

Molecular Events for cellular signalling network and polarization of cells - Stem Cell Signaling and molecular switches - Asymmetric Cell Divisions of Stem/Progenitor Cells, Microenvironmental Modulation of Stem Cell Differentiation and nature of stem cells – multipotent and pluripotent	3L
Principles of stem cell biology and regeneration and regeneration therapy, Regeneration of Hydra and higher vertebrate	2L
Types of stem cell: based on availability and nature – Mesenchymal Stem Cells, Embryonic Stem Cells, Foetal Stem Cells, Stem cells from adult organs,	3L
Hematopoietic Stem Cells and erythropoiesis: stages and features. Isolation of hematopoietic stem Cells – bone marrow and peripheral blood.	3L
Pluripotent stem cell culture, characterization of pluripotency and differentiation into different lineages- Isolation and In vitro differentiation of the mesenchymal Stem Cells: Adipogenic, osteogenic, neurogenic differentiation	5L
Development of induced pluripotent stem cells (iPSc). Role of different transcription factors for iPSC development	1L
Umbilical Cord cell banking procedure and autologous stem cell therapy	2L
Application of stem cell differentiation and regeneration therapy: Gastrointestinal, Liver, Kidney, Heart, Spinal Cord, Lung Regeneration, Eye Diseases and Disorders	1L
Different Animal sources for matrix construction and tissue engineering - Large scale manufacturing of cells, tissues and organs,	2L
Role of Model Organisms in Heart Regeneration and Repair	

Suggested readings:

B. Alberts A. Johnson, J.Lewis, M. Raff, K.Roberts, and P. Walter, Molecular biology of cell, 2008, Garland Science, Taylor & Francis Group.
P. J. Russell, P.E. Hertz, C. Starr, S. L. Wolfe and B. McMillan, Cell and Molecular Biology, 1st edition 2009 Cengage Learning. 1. R. Lanza, J. Gearhart et al (Eds), Essential of Stem Cell Biology. (2009), Elsevier Academic press.

R. Lanza and I. Klimanskaya, Essential Stem Cells Methods. (2009), Academic Press
Lanza et al. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Fetal Stem Cells (v. 1).Academic Press (September 28, 2004)
Anthony Atala, James A. Thomson. Principles of Regenerative Medicine. Academic Press; 1 edition (December 4, 2007)
Atala A. Foundations of Regenerative Medicine: Clinical and Therapeutic Applications. Academic Press; 1 edition (August 28, 2009)
Hossein Baharvand (Editor), Nasser Aghdami (Editor). Regenerative Medicine and Cell Therapy (Stem Cell Biology and Regenerative Medicine). Humana Press; 2013 edition (August 8, 2012)
Marek LosAndrzej HudeckiEmilia Wiechec(Editors), Stem Cells and Biomaterials for Regenerative Medicine. Academic Press (2018)
David Warburton (Editor). Stem Cells, Tissue Engineering and Regenerative Medicine. World Scientific. (2015).

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

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

UNIT I: BIOSTATISTICS AND COMPUTATIONAL BIOLOGY (Credit 2) **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

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-paramatric 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*

Linear regression — 2L

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

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

Concept of Computational operation — 5L

Basics of computers, CPU, input and output devices, operating systems (Windows, LINUX/UNIX),GUI, flowchart and programing concept, server and grid computation,
Computer networks and internet, search engine, Boolean Operators — 6L

Bioinformatics

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

***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*. 4th ed.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., 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 PAPERS

MZGP- 402B Core Course

(Credit 2) **Full Marks: 25**

DEVELOPMENTAL BIOLOGY & COMPUTATIONAL BIOLOGY **Time: 2 hrs**
(Credit 2) **Full Marks: 25**

Group A: Developmental Biology

1. Culture and Regeneration of Hydra
2. Study of imaginal discs and development of (wing/leg) from Drosophila larva
3. Study of normal developmental (WM) stages of insect, fish, frog, chick and mouse (slide based)
4. Identification of whole mounts and histological sections of embryos, larvae, pupae and nymphs
5. Labelling chick notochord using immune-cytochemistry
6. Study of external influences on development (anuran amphibian/chicks/fish)
7. Isolation and characterization of Hematopoietic Stem cells from Peripheral blood /Rat Bone marrow
8. Isolation of Mesenchymal stem cells from Umbilical cord /adipose tissue
9. Identification of different types of stem cells (Chart based/Microscopical observation)
10. Characterization of different types of Hematopoietic cell lineage – From Peripheral Blood - Flow cytometric method (Demonstration)
11. Submission of preparations of WM different stages of development.
12. Submission of stem cell/Animal Regeneration preparation
13. Laboratory records
14. 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 403: Discipline-centric Elective
(Credit 4)

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

MSZO 403 (DE1): AQUACULTURE AND FISHERIES
(Credit 4)

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, prebiotics and 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 R. W. Hardy (2002). *Fish Nutrition*. Academic Press, Californiaand 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.
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 Pub. House.
Srivastava, C. B. L. (2006). *A Text Book of Fishery Science and Indian Fisheries*.KitabMahal. Allahabad.
Tacon, A.G.J.; Metian, M.; 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 403 (DE2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

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 *8L*

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 6L

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.

Air pollution 8L

Amosphere 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 lean and 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

6L

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)

Environment & Human health : Allergy and immunity

7L

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

Environmental movement and legislation

8L

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.

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

Application in Environment management: Remote Sensing and GIS

2L

Principles and concept of remote sensing; Introductory image processing techniques; Application of remote sensing; GIS technology; Applications of GIS

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 403 (DE3): ENTOMOLOGY
(Credit 4)

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

Perception — 4L
- Chemoreceptors: Gustatory and olfactory
- 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 403 (DE4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

Time: 2 hrs **Full Marks: 50**
MOLECULAR BIOLOGY **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 4L
DNA Repair mechanisms
Prions 2L
Gene Identification and Exon trapping 2L
Cell signaling pathways
$Ca^{2+,}$ NO signaling, JAK-STAT pathway, Ras pathways and cross talk mechanisms 5L
Analysis of Gene Expression 4L
GFP as reporter, Gene fusion, Construction of the reporter gene 3L
Proteomics 2L
Yeast two hybrid assay, 2-D PAGE, protein array, MS for protein identification
Protein tagging

Suggested readings:

Alberts, B., Johnson, A. Lewis J., Raff, M., Roberts K., Walter P. (2008). Molecular Biology of the Cell. 5th Ed. Garland Publishing House.
Cooper, G. M. (2004). *The Cell*. 3rd edn. 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* (4th ed.). 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*.5th edn., John Wiley.
Kendrew, S. J. (Ed.) (1994). *The Encyclopedia of Molecular Biology.* Blackwell Science.
Lewin, B. (2008). *Genes IX*. Jones and Bartlett Publishers.

MSZO 403 (DE5): PARASITOLOGY and MICROBIOLOGY
(Credit 4)

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 2L

Parasite host specificity 3L

Protozoan Parasites 15L

Origin and evolution of parasitic Protozoa

Flagellates

General morphology and morphological stages

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

Apicomplexa 10L

Ultrastructure of apical complex

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

Malaria and Malarial Parasites 12L

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

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.

General morphology with special reference to parasitic forms 3L

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 and Bailliere Tindall, London.

MSZO 404: Discipline-centric Elective
(Credit 4)

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

MSZO 404 (DE1): AQUACULTURE AND FISHERIES
(Credit 4)

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 *Litopenaeus vannamei*

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 404 (DE2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

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

Environmental Resources: Sources, types & management 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, magnetohydrodynamic 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

Conservation and management 6L

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

Evolutionary Ecology 8L

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.

Environmental ethics 6L

Definition, history, scope and basic concepts; Anthropocentrism, biocentrism and ecocentrism; Deep ecology; Ecofeminism; Ecocentrism in indigenous societies and culture,

Environmental Management

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 6L

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. 2nd ed.

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 404 (DE3): ENTOMOLOGY
(Credit 4)

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-insecticidal methods: Insect attractants, repellents and antifeedants

Medical-Veterinary Entomology

Insects of medical-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 — 10L

Application of molecular tools in insect ecology

***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 Grassberger M. (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. and Castner, 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 **e**d. 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. (1988). *A textbook of Applied Entomology.* Vol. II 2nd ed.

MSZO 404 (DE4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

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

MOLECULAR DIAGNOSTICS **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,

EGFR mutation detection for Lung cancer subtype, Cervical cancer subtyping, immunophenotyping and leukaemia types. Oncomine and Oncotype DX testing ,	5L
Diagnosis of Monogenic disorders Thalassemia and others, rare genetic disorders – ARMS PCR, GAP PCR, MLPA	2L
Arthritis test (Gout testing)	5L
Cardiac marker test – Troponin detection	4L
Prenatal diagnosis and Non-invasive prenatal testing, triple marker test	3L
Clinical exome and ClinVar data base ,	2L
	2L

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 404 (DE5): PARASITOLOGY and MICROBIOLOGY
(Credit 4)

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.

Helminthology 10L

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 *Aspidogaster conchicola*.

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*.

Acanthocephala: General organization and morphology, lifecycle of *Moniliformis* — 8L

Biology, Pathogenicity and Control

Opisthorchis sinensis, *Diphyllobothrium latum, Hymenolepis nana; Echinococcus granulosus*, *Ancylostoma duodenale, Loa loa*

Gastrointestinal nematode infection in man and ruminants and their antihelmintic treatment — 12L

Helminthology

Biology, pathogenicity and control of *Schistosoma mansoni*

Human lymphatic filariasis and its transmission dynamics

Chemotherapy and chemoprophylaxis: selective treatment, mass drug administration and medicated salt — 10L

Vector Biology

Biology, importance and control: *Chrysops,* tse-tse fly, mosquitoes (*Stegomyia* 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 405: DISCIPLINE-CENTRIC ELECTIVE PRACTICAL'S
(Credit 4)

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

MSZO 405 (DE1): AQUACULTURE AND FISHERIES
(Credit 4)

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 405 (DE2): ECOLOGY AND ENVIRONMENTAL BIOLOGY
(Credit 4)

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 by Thin Layer Chromatography (TLC) and Gas Chromatography (GC)
    c. 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 it's 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 405 (DE3): ENTOMOLOGY
(Credit 4)

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 405 (DE4): MOLECULAR BIOLOGY AND GENETICS
(Credit 4)

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 405 (DE5): PARASITOLOGY AND MICROBIOLOGY
(Credit 4)

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 406
Term paper / Project work
(Credit 4)

Full Marks: 50

TERM PAPER / PROJECT WORK (BASED ON MAJOR ELECTIVES): Full Marks: 50
[Regularity: 10**; Submission** (not less than 10,000 words excluding references): **25;**
Seminar **Presentation and Discussion**: **15]**
