

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

**New Arts, Commerce and Science College, Ahmednagar  
(Autonomous)**

**(Affiliated to Savitribai Phule Pune University, Pune)**



**Choice Based Credit System (CBCS)**

**Master of Science (M. Sc.)**

**Syllabus of**

**M. Sc. II Zoology**

**Implemented from**

**Academic Year 2022 - 23**

**Ahmednagar Jilha Maratha Vidya Prasarak Samaj's**  
**New Arts, Commerce and Science College, Ahmednagar**  
**(Autonomous)**

**Board of Studies in Zoology**

Sr. No.	Name	Designation
1.	Hon. Prof. L.U. Kunjir	Chairman
2.	Hon. Prof. S. N. Pokale	Member
3.	Hon. Dr. A. D. Harkal	Member
4.	Hon. Prof. R. J. Chavan	Academic Council Nominee
5.	Hon. Prof. S. S. Nanware	Academic Council Nominee
6.	Hon. Dr. S. S. Teradalkar	Vice-Chancellor Nominee
7.	Hon. Prof. B. A. Pawar	Alumni
8.	Hon. Mrs. Manjushree Tadvalkar	Industry Expert
9.	Hon. Shri. M. S. Kasture	Member (co-opt)
10.	Hon. Mrs. S. P. Salve	Member (co-opt)
11.	Hon. Shri. G. G. Wakchoure	Member (co-opt)
12.	Hon. Ms. G. R. Devdhe	Member (co-opt)
13.	Hon. Ms. S. S. Mote	Member (co-opt)
14.	Hon. Ms. P. N. Dongare	Member (co-opt)
15.	Hon. Ms. S. J. Wagh	Member (co-opt)

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**Programme Structure and Course Titles**

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	M.Sc. I	I	MSC-ZO 111 T	Anatomy and Physiology of Non-chordates and Cell Biology	04
2.	M.Sc. I	I	MSC-ZO 112 T	Biochemical Techniques and Skills in Scientific Communication	04
3.	M.Sc. I	I	MSC-ZO 113 T	Molecular Biology	02
4.	M.Sc. I	I	MSC-ZO 114 P	Practicals in Anatomy and Physiology of Non-chordates and Cell Biology	02
5.	M.Sc. I	I	MSC-ZO 115 P	Practicals in Biochemical Techniques and Skills in Scientific Communication	02
6.	M.Sc. I	I	MSC-ZO 116 P	Practicals in Molecular Biology	02
7.	M.Sc. I	I	MSC-ZO 117 T (A)	Biochemistry*	02
8.	M.Sc. I	I	MSC-ZO 117 T (B)	Metabolic Pathways*	02
9.	M.Sc. I	I	MSC-ZO 118 P (A)	Practicals in Biochemistry*	02
10.	M.Sc. I	I	MSC-ZO 118 P (B)	Practicals in Metabolic Pathways*	02
11.	M.Sc. I	I	MSC-ZO 119 T	Economic Zoology	02
12.	M.Sc. I	II	MSC-ZO 211 T	Anatomy and Physiology of Chordates and Developmental Biology	04
13.	M.Sc. I	II	MSC-ZO 212 T	Endocrinology and Population Ecology	04
14.	M.Sc. I	II	MSC-ZO 213 T	Biostatistics and Bioinformatics	02
15.	M.Sc. I	II	MSC-ZO 214 P	Practicals in Anatomy and Physiology of Chordates and Developmental Biology	02
16.	M.Sc. I	II	MSC-ZO 215 P	Practicals in Endocrinology and Population Ecology	02
17.	M.Sc. I	II	MSC-ZO 216 P	Practicals in Biostatistics and Bioinformatics	02
18.	M.Sc. I	II	MSC-ZO 217 T (A)	Genetics*	02

19.	M.Sc. I	II	MSC-ZO 217 T (B)	Genetic Toxicology*	02
20.	M.Sc. I	II	MSC-ZO 218 P (A)	Practicals in Genetics*	02
21.	M.Sc. I	II	MSC-ZO 218 P (B)	Practicals in Genetic Toxicology*	02
22.	M.Sc. I	II	MSC-ZO 219 T	Ethology	02
23.	M.Sc. II	III	MSC-ZO 311 T (A)	Animal Physiology I*	04
24.	M.Sc. II	III	MSC-ZO 311 T (B)	Genetics I*	04
24.	M.Sc. II	III	MSC-ZO 312 T	Immunology and Evolution	04
25.	M.Sc. II	III	MSC-ZO 313 T	Histochemistry	02
26.	M.Sc. II	III	MSC-ZO 314 P (A)	Practical in Animal Physiology I*	02
27.	M.Sc. II	III	MSC-ZO 314 P (B)	Practical in Genetics I*	02
28.	M.Sc. II	III	MSC-ZO 315 P	Practical in Immunology and Evolution	02
29.	M.Sc. II	III	MSC-ZO 316 P	Practical in Histochemistry	02
30.	M.Sc. II	III	MSC-ZO 317 T (A)	Mammalian Reproductive Physiology*	02
31.	M.Sc. II	III	MSC-ZO 317 T (B)	Cytogenetics*	02
32.	M.Sc. II	III	MSC-ZO 318 P (A)	Practical in Mammalian Reproductive Physiology*	02
33.	M.Sc. II	III	MSC-ZO 318 P (B)	Practical in Cytogenetics*	02
34.	M.Sc. II	III	MSC-ZO 319 T	Research Methodology	02
35.	M.Sc. II	IV	MSC-ZO 411 T (A)	Animal Physiology II*	04
36.	M.Sc. II	IV	MSC-ZO 411 T (B)	Genetics II*	04
37.	M.Sc. II	IV	MSC-ZO 412 T	Freshwater Biology and Ichthyology	04
38.	M.Sc. II	IV	MSC-ZO 413 T	Forensic Entomology and Animal Tissue Culture	02
39.	M.Sc. II	IV	MSC-ZO 414 P (A)	Practical in Animal Physiology II*	02
40.	M.Sc. II	IV	MSC-ZO 414 P (B)	Practical in Genetics II*	02

41.	M.Sc. II	IV	MSC-ZO 415 P	Practical in Freshwater Biology and Ichthyology	02
42.	M.Sc. II	IV	MSC-ZO 416 P	Practical in Forensic Entomology and Animal Tissue Culture	02
43.	M.Sc. II	IV	MSC-ZO 417 T (A)	Neural Physiology*	02
44.	M.Sc. II	IV	MSC-ZO 417 T (B)	Population Genetics*	02
45.	M.Sc. II	IV	MSC-ZO 418 P (A)	Practical in Neural Physiology*	02
46.	M.Sc. II	IV	MSC-ZO 418 P (B)	Practical in Population Genetics*	02
47.	M.Sc. II	IV	MSC-ZO 419 Pr	Project	02
	<b>Total</b>	<b>04</b>	<b>47</b>		<b>88</b>

**\*Elective Courses: Students need to select any one elective course.**

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**Syllabus of M. Sc. Zoology (Semester-III)**  
**under**  
**Faculty of Science and Technology**

<b>Semester – III</b>	<b>Paper – I</b>
<b>Course Code: MSC-ZO 311 T (A)</b>	<b>Title of the Course: Animal Physiology I</b>
<b>Credits: 04</b>	<b>Total Lectures: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand physiological concepts of Digestion and Respiration.
2. Understand physiological concepts of Circulation, Excretion and Osmoregulation.
3. Understand the concepts of Thermal physiology and Cell Physiology.
4. Understand the molecular and comparative role of various physiological activities in body.

**Detailed Syllabus**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Introduction to Physiological Principles</b> Physiology: Past and Present Physics and Chemistry: The Basis of Physiology. Physiological Regulation, Phenotype, Genotype and the Environment, Physiology and Evolution	<b>(02)</b>
<b>2.</b>	<b>Cell Physiology</b> Membrane structure, Membrane Transport, Structural features of animal cells.	<b>(02)</b>
<b>3.</b>	<b>Physiology of Digestion</b> General Aspects of Digestion. The Mouth: Role of Oral Cavity, Various secretions secreted in Oral Cavity, Simple and Conditioned Salivary reflexes. Pharynx and Oesophagus: Mechanism of Swallowing, Peristalsis,	<b>(10)</b>

Oesophageal Secretion.

Stomach: As temporary food storing organ, Various secretions secreted in Stomach, Influence of various secretions and activities on Physiological activity of Stomach, Vomiting or Emesis, Stimulation and Inhibition of Gastric Secretion.

Pancreatic and Biliary Secretions: Exocrine and Endocrine secretions of Pancreas, Role of Liver in Digestion, Role of Bile juice and Bile salts in digestion and absorption

Small intestine: Role of Segmentation in Digestion, Absorption and Secretion, Absorption of carbohydrate, protein, fat and vitamins.

Large Intestine: Role of Large Intestine in absorption and assimilation

#### 4. **Physiology of Respiration**

(10)

Respiratory anatomy

Respiratory mechanics: Introduction to pressures and interrelationships among pressures, Onset of Inspiration: Contraction of Inspiratory systems, Onset of Expiration: Relaxation of Inspiratory muscles, Airway resistance, Chronic obstructive pulmonary disease, Lung volumes and Capacities, Respiratory dysfunction.

Gas Exchange: Partial Pressure and Partial Pressure gradient, Gas exchange across pulmonary capillaries, Gas exchange across systemic capillaries.

Gas Transport: Transport of O<sub>2</sub>, O<sub>2</sub>-Hb Dissociation curve, Bohr's Effect, Significance of Plateau portion of the O<sub>2</sub>-Hb Curve, Significance of Steep portion of O<sub>2</sub>-Hb Curve, Role of Haemoglobin in O<sub>2</sub> transfer, effect of various factors on % Hb saturation. Transport of CO<sub>2</sub>, Mechanism of Chloride shift. Abnormalities in Arterial PO<sub>2</sub> and in Arterial PCO<sub>2</sub>.

Control of Respiration: Components of Neural Control of Respiration, Role and Mechanism of Inspiratory and Expiratory Neurons in Medullary Center, Influences from Pneumotaxic and Apneustic centers, Influence of Chemical factors on Respiration.

**5. Physiology of Circulation (10)**

Blood composition and function, Hematopoiesis

Blood clotting and its molecular mechanism, Blood pressure, Hypotension and Hypertension.

Anatomy of Heart.

Electrical activity of the heart pace makers, spread of cardiac coupling, action potential of cardiac cells, Role of  $\text{Ca}^{2+}$  in cardiac cells, Electrocardiography.

Mechanical Events of cardiac cycle, Heart sound,

Cardiac output and its control: Relation of cardiac output, heart rate and stroke volume, Effect of Sympathetic and Parasympathetic stimulation on the Heart, Frank- Starling Law of the Heart.

Nourishing the Heart muscle: Role of Atherosclerotic Coronary artery in blood transport to the heart muscles. Thromboembolism, Angina pectoris and Heart Attack

**6. Physiology of Excretion (10)**

Kidneys: Functions, Anatomy and Basic Processes, Nephron as functional unit of kidney.

Glomerular Filtration: Forces involved in Glomerular Filtration, Glomerular Filtration Rate (GFR), Influence and control of various factors on GFR.

Tubular Reabsorption: Various modes of Tubular Reabsorption, Role of Aldosterone, Activation and Functions of Renin-Angiotensin-Aldosterone System, Absorption of Essential molecules and their methods of absorption.

Tubular Secretion: Various modes of Tubular Absorption, Secretion of various molecules and ions.

Urine Excretion and Plasma Clearance: Plasma Clearance Constituents, Urine varying in concentration depending on body's state of hydration, Properties of Descending and Ascending limbs of Henle's Loop, Mechanism of Countercurrent Multiplication, Role of Vasopressin, Regulation  $\text{H}_2\text{O}$  reabsorption, Renal failure, Micturition reflex.



**7. Physiology of Osmoregulation (06)**

Concept of Acid-Base Balance

Fluid Balance: Role of various barriers in fluid balance, Tonicity and Osmolarity, Concept of Osmole, Role of Osmolarity in body fluids, Hypertonicity and Hypotonicity of ECF, Sources of water output and input, Control of water output and input.

Acid-Base Balance: Role of H<sup>+</sup> and OH<sup>-</sup> ions in osmoregulation, Chemical buffer systems, Renal H<sup>+</sup>, HCO<sup>3-</sup> excretion and NH<sub>3</sub> secretion, Respiratory acidosis and Alkalosis.

**8. Thermal Physiology (10)**

Heat Exchange and Thermal Strategies: Controlling Heat fluxes, Role of various physicochemical parameters on Heat Exchange, Thermal strategies applied by Poikilotherms, Homeotherms, Ectotherms, Endotherms and Heterotherms

Coping with a changing body temperature: Macromolecular structure and Metabolism, Effect of temperature on various physiological activities, Life at high and low body temperatures.

Maintaining a Constant Body Temperature: Thermogenesis, Regulating Body temperature, Role of Physiological systems in thermogenesis and Regulation.

**Suggested Reading:**

1. **Lauralee Sherwood (2013), Essentials of Physiology**, IV Edition, Cengage Learning Products.
2. **Christopher D. Moyes, Patricia M. Schulte, (2007), Principles of Animal Physiology** Pearson Education.
3. **Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology**. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
4. **Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology**. XI Edition John Wiley & sons,
5. **Eckert, R. Animal Physiology: mechanisms and Adaptation**. W. H. Freeman and Company, New York.
6. **Hoar, W. S. General and Comparative Animal Physiology**, Prentice Hall of India.
7. **Schiemdt Nielsen, Animal Physiology: Adaptation and Environment**. Cambridge.

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**Syllabus of M. Sc. Zoology (Semester-III)**  
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Semester – III	Paper – II
Course Code: MSC-ZO 312 T	Title of the Course: Immunology and Evolution
Credits: 04	Total Lectures: 60 Hrs.

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the fundamental concepts of immunity.
2. Understand the principle and applications of techniques used in immunology.
3. Understand the concepts of hypersensitivity, tolerance, autoimmunity and immunodeficiency.
4. Understand the basic concepts of organic evolution.
5. Understand the evolutionary forces, isolation mechanisms and speciation.
6. Understand the mechanism of evolution (molecular evolution and human evolution).

### Detailed Syllabus

Unit	Name of Topic	Lectures Allotted
1.	<b>Fundamentals of Immunology</b> Introduction and overview of immune system	(01)
2.	<b>Organs and Cells of Immune System and Their Functions</b> Primary Lymphoid organs - Bone Marrow, Thymus Secondary Lymphoid organs - Lymph node, Spleen, Mucosa-Associated Lymphoid Tissue (MALT), Skin Cells of immune system- Neutrophils, Basophils, Eosinophils, Mast cells, Monocytes, Macrophages, Dendritic cells,	(04)

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- Lymphocytes, Natural Killer cells  
Cytokines and Chemokines
3. **Antigens and Antigenicity (Epitopes, Hapten)** (01)
4. **Major Histocompatibility Complex-** (03)  
Classes, Structure, Function and general organization  
Antigen processing and presentation  
HLA and disease association  
Transplantation - Graft rejection, Immunosuppression
5. **Types of immunity** (03)  
Innate (Phagocytosis, immediate response to infection, Inflammation, NK Cells) and Acquired Active and Passive  
Humoral and Cell Mediated Immunity
6. **T Cell and B Cell** (04)  
Maturation, Activation, Differentiation and Memory  
Clonal Selection  
B and T Cell receptors and Signal Transduction  
Toll like receptors
7. **Immunoglobulins** (04)  
Structure, Function, Classes, Iso, idio and allo types  
Organization of immunoglobulin genes  
Theories and genetic basis of antibody diversity  
Class switching
8. **Complement System** (02)  
Mechanism of its fixation  
Complement activation and function: Classical, Alternative and Lectin pathways
9. **Antigen-Antibody binding** (01)  
Affinity, Avidity, Cross Reactivity  
Antigen-antibody interactions: Agglutination and Precipitation reactions in solution and in gels.
10. **Immunodeficiency Disorders and Treatment** (02)  
Primary Immunodeficiency disorders- Severe combined immunodeficiency (SCID), Wiskott-Aldrich syndrome (WAS), X-
-

- linked agammaglobulinemia, DiGeorge syndrome  
Secondary Immunodeficiency disorders- AIDS and cancer
11. **Hypersensitivity:** Type I,II,III, and IV (01)
12. **Tolerance & Autoimmunity** (02)  
Central and peripheral tolerance  
Concept of Autoimmunity  
Factors contributing to Autoimmunity  
Autoimmune diseases: Diabetes mellitus, Rheumatoid arthritis,  
Myasthenia Gravis and treatment
13. **Immunological memory** (02)  
Vaccines-Types and vaccination  
Principles of monoclonal antibody production (Hybridoma  
technology) and its applications
14. **Origin of life on earth** (05)  
Biochemical Origin of life  
Evolution of prokaryotes  
Origin of eukaryotic cells  
Geological time scale  
An overview of evolutionary thoughts  
Darwinism and theory of natural selection, Neo Darwinism,  
Modern synthetic theory of evolution, Mutation theory
15. **Fossils and Fossils Record** (01)  
Types of fossils, transitional forms, Radioactive dating for fossil  
age determination, Law of superposition
16. **Patterns of Evolution** (03)  
Anagenesis and Cladogenesis  
Phyletic gradualism and punctuated equilibrium  
Monophyletic, Polyphyletic and Paraphyletic Evolution  
Divergent evolution, Convergent evolution, Co-evolution,  
Microevolution, Mega evolution
17. **Elemental Forces of Evolution** (04)  
Mutation  
Selection (types of selection, r and k selection coefficient,  
selection in natural population)

- Recombination  
Genetic drift - Random genetic drift/Sewall Wright effect,  
Founder's principle  
Migration
- 18. Molecular Evolution (02)**  
Gene evolution  
Evolution of gene families, molecular drive  
Assessment of molecular variation
- 19. Isolating Mechanisms (03)**  
Geographic, Reproductive isolation, Role of reproductive isolation- Premating isolation- Climatic, Seasonal, Habitat, temporal, Ethological; Post mating isolation- gametic mortality, zygotic mortality, Hybrid inviability, Hybrid sterility, Hybrid breakdown ; Origin of reproductive isolation- Muller's view, Dobzhansky's view
- 20. Speciation (03)**  
Concept of species  
Species categories  
Types-Allopatric, Sympatric and Parapatric, Peripatric, speciation by hybridization  
Patterns- Gradualism, Punctuated equilibrium, Adaptive radiation  
Rate of speciation  
Factors affecting rate of speciation
- 21. Post-Darwinian concepts of evolution (02)**  
Gradualistic vs. non-gradualistic theories  
Mayr's Founder Principle  
Kimura's neutral theory  
Endosymbiotic theory of Margulis
- 22. Adaptations- (01)**  
Kinds of adaptation, Mimicry (Batesian, Mullerian), Co-adaptation
- 23. Origin and Evolution of Man: (04)**  
Overview of human evolution , Evolution and adaptive radiation in primates, Compelling causes of evolution of man ,Evidences

from molecular biology in support of hominid evolution from apes, Cultural Evolution

**24. Phylogenetic Trees: (01)**

Construction and interpretation, Molecular tools in phylogeny

**25. Overview of extinction (01)**

**Suggested Reading:**

1. **Abul Abbas Andrew H. Lichtman and Shiv Pillai, Basic Immunology**, Elsevier
2. **Ivan Roitt, Jonathan Brostoff, and David Male Immunology**, Elsevier
3. **Kuby Immunology**, Sixth Edition 6th Edition by Thomas J. Kindt (Author), Barbara A. Osborne (Author), Richard A. Goldsby (Author)
4. **A Short Course, Richard Coico, Geoffrey Sunshine, Immunology**: Willey Publication
5. **Dobzhansky Th. (1964): Genetics and the Origin of Species**. Columbia.
6. **Dobzhansky Th. et al. (1976): Evolution**. Surjeet Publ.
7. **Freeman S. and Jon C. Herron (1998): Evolutionary Analysis**. Prentice Hall
8. **Futuyma D. J. (1998): Evolutionary Biology**. Sinauer
9. **Mayr E. (1966): Animal Species and Evolution**. Belknap Press
10. **Strickberger M. W. (2000): Evolution**. Jones and Bartlett
11. **Veer Bala Rastogi, Organic evolution**, Kedarnaath Ramnaath Publishers, Meerut

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Semester – III	Paper – III
Course Code: MSC-ZO 313 T	Title of the Course: Histochemistry
Credits: 02	Total Lectures: 30 Hrs.

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the Histochemistry of biomolecules.
2. Understand the methods in Histochemistry.
3. Understand the concept of histopathology and its significance.

### Detailed Syllabus

Unit	Name of Topic	Lectures Allotted
1.	<b>Introduction, Scope and applications of Histochemistry in research and medicine</b>	(01)
2.	<b>Staining</b> Staining methods histochemical and immunohistological methods) dye, types and dye binding reactive groups, mordants and mordanting	(02)
3.	<b>Histochemistry</b> Histochemical Techniques for Carbohydrates- Basic Principle, mechanism and applications Glycogen (periodic acid/Shift method (PAS) Alcian Blue technique for Acid Mucopolysaccharides  Histochemical Techniques for Proteins- Basic Principle, mechanism	(20)

and applications

Bromophenol Blue method

Congo red method

Sakaguchi's technique for Arginine-rich proteins.

Histochemical Techniques for Lipids- Basic Principle, mechanism and applications

Sudan Black-B Method

Nile Blue Technique for Neutral and Acidic lipids

Oil red O method

Histochemical Techniques for Nucleic Acids- Basic Principle and mechanism

Methyl green- Pyronin Y for nucleic acids

Feulgen reaction for Deoxyribonucleic acid (DNA)

Toluidine Blue Techniques for (RNA)

Enzyme Histochemistry

Localization of enzyme in tissue, Alkaline and Acid phosphatase, Malate dehydrogenase, Van Kossa Silver Nitrate technique for Calcium.

**4. Histopathology:**

**(05)**

Morphological alteration in cell due to disease, type of degeneration, hyaline and fatty degeneration. Pathogenesis and histopathology of Liver Cirrhosis and Atherosclerosis, Neuropathology of alcoholism and Methanol poisoning.

**5. Immunohistochemistry:**

**(02)**

Principle, methods of application of immunohistochemistry and immunofluorescence techniques.

Application of histochemistry for detection of various types of Carcinoma.



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**Suggested Reading:**

1. **Histochemistry** Vol. I II III A G E pearse Churchill Livingstone NY
2. **Histochemistry in Focus**,A source book of Technics and Research needs (2007),
3. **Shyamasundari and K.Hanmantha Rao**, MJP Puplishers,Chennai.
4. **Histological and histochemical methods: Theory and practice**, J.A.Kiernan
5. **An introduction to Functional Histology**, Bourne, G.H. (1988), Churchil, London.
6. **Histochemical Techniqes**, Cassilmann,W.G.B (1988), Methuen, London
7. **Techniques in life sciences**, D.B Tembhare,Himalaya publishing house



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<b>Semester – III</b>	<b>Paper – IV</b>
<b>Course Code: MSC-ZO 314 P(A)</b>	<b>Title of the Course: Practical in Animal Physiology I</b>
<b>Credits: 02</b>	<b>Total Practical: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the laboratory practices in physiology.
2. Understand the methods of estimation of different physiological parameters.
3. Understand the aspects of human physiology.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Qualitative survey of digestive enzymes in any vertebrate	(01)
2.	Estimation of salivary amylase activity.	(01)
3.	Estimation of abnormal and normal constituents of urine	(01)
4.	Estimation of chloride from haemolymph/ cow urine	(01)
5.	Estimation of Serum Uric Acid	(01)
6.	Total count of R.B.C. from human Blood	(01)
7.	Differential count of W.B.C. from human blood	(01)
8.	Estimation of Haemoglobin and carrying capacity of blood	(01)
9.	Measurement of blood pressure	(01)
10.	Hematin crystal formation	(01)
11.	Effect of temperature on the heart beat	(01)
12.	Effect of temperature on the rate of oxygen consumption	(02)
13.	Measurement of respiratory quotients.	(01)

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<b>Semester – III</b>	<b>Paper - V</b>
<b>Course Code: MSC-ZO 315 P</b>	<b>Title of the Course: Practical in Immunology and Evolution</b>
<b>Credits: 02</b>	<b>Total Lectures: 60 Hrs.</b>

### Course Outcomes (COs)

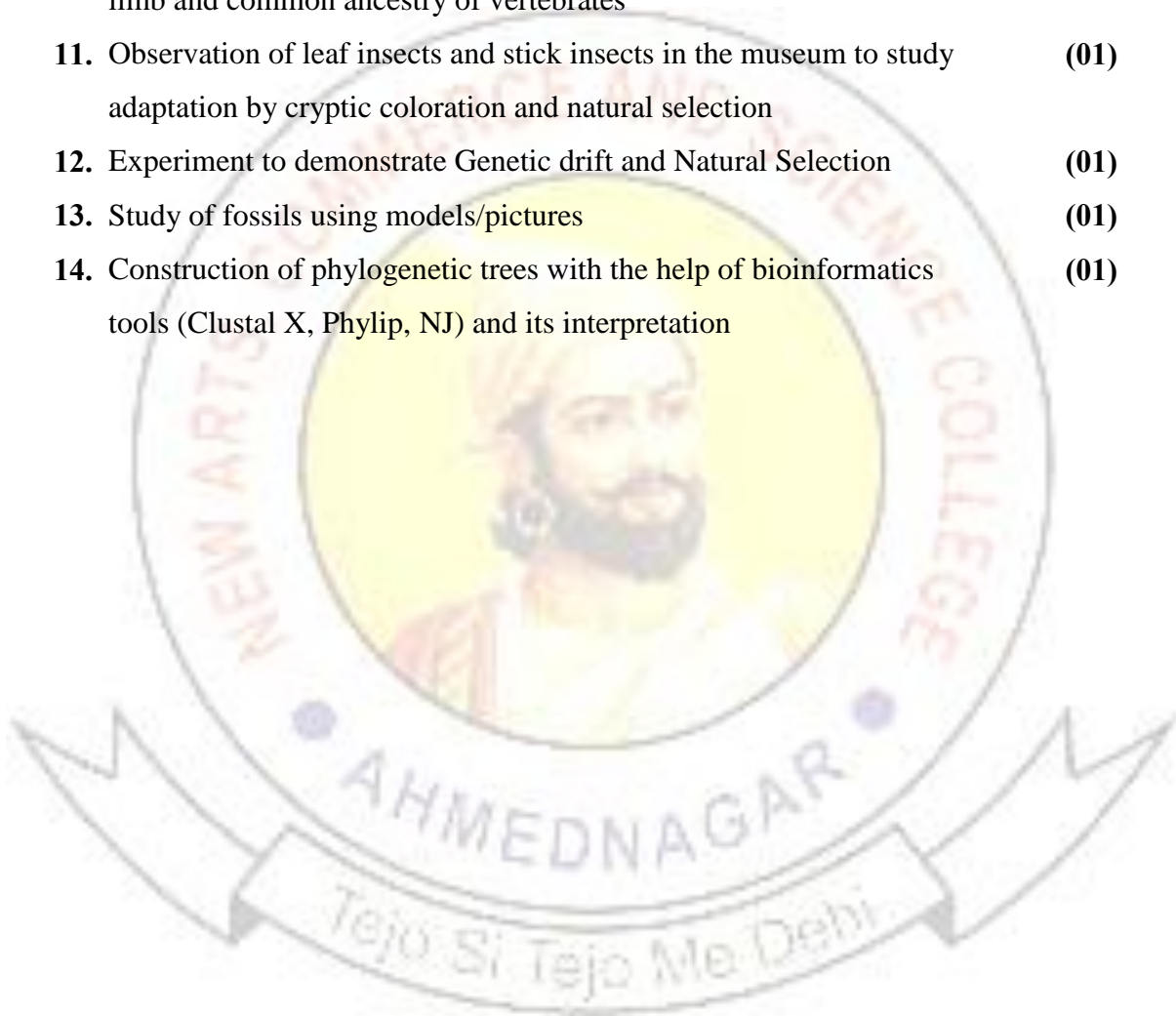
After the successful completion of this course students are able to ---

1. Understand the different techniques in immunology.
2. Understand the microscopic structures of lymphoid organs.
3. Understand the process of evolution using evidences.
4. Understand the use of bioinformatics tools in evolution.

### Detailed Syllabus (Any 12)

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Techniques in immunology: RIA, ELISA, Immunofluorescence	(01)
2.	Double diffusion or Ouchterlony technique (using kit).	(02)
3.	Demonstration of Immuno-electrophoresis (using kit).	(02)
4.	Histology of lymphoid organs: skin, spleen, thymus, ileum lymph node and bone marrow.	(01)
5.	To study the differential count of WBCs.	(01)
6.	Cell counting and viability testing using Spleenocytes (from goat spleen)	(02)

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7. To estimate the antigen concentration by rocket electrophoresis (using kit). (02)
  8. Study of sympatric species- *D. melanogaster* and *D. ananassae* (01)
  9. Study of homology and analogy from suitable specimens (01)
  10. Observation of forelimbs and hindlimbs of vertebrates (Frog, *Calotes*, Bird and mammal) to study common pattern of pentadactyl limb and common ancestry of vertebrates (01)
  11. Observation of leaf insects and stick insects in the museum to study adaptation by cryptic coloration and natural selection (01)
  12. Experiment to demonstrate Genetic drift and Natural Selection (01)
  13. Study of fossils using models/pictures (01)
  14. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation (01)



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<b>Semester – III</b>	<b>Paper - VI</b>
<b>Course Code: MSC-ZO 316 P</b>	<b>Title of the Course: Practical in Histochemistry</b>
<b>Credits: 02</b>	<b>Total Lectures: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the histological structures of various organs.
2. Understand the methods in Histochemistry.
3. Understand the methods of tissue labeling.
4. Understand the procedure for the preparation of histological slides.

**Detailed Syllabus (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Study of different types of tissue with the help of permanent slides	(01)
2.	Block preparation and sectioning and staining	(05)
3.	Effect of fixatives, fixation of tissues	(01)
4.	Comparative study of effect of fixative on a given tissue	(01)
5.	Muco polysaccharide staining, AB pH 1.5, 2.5	(01)
6.	Proteins and lipid staining by Sudan black B	(02)
7.	Nucleic acid staining: Methyl Green, Pyronine, Feulgen Stain	(02)

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Semester – III	Paper – VII
Course Code: MSC-ZO 317 T(A)	Title of the Course: Mammalian Reproductive Physiology
Credits: 02	Total Lecture hours: 30 Hrs.

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the anatomy and physiology of male and female reproductive system.
2. Understand the reproductive cycle and its hormonal regulation.
3. Understand the concepts in reproductive physiology.
4. Understand the recent advances in reproductive physiology.

### Detailed Syllabus:

Unit	Name of Topic	Lectures Allotted
1.	<b>Introduction to Mammalian Reproductive Physiology</b> Reproductive Pattern -Environmental factors and breeding, continuous and seasonal breeders.	(02)
2.	<b>Male Reproductive System</b> Anatomy and physiology of Male Reproductive System and its hormonal control. Male secondary sex characters.	(03)
3.	<b>Female Reproductive System-</b> Anatomy and physiology of Female Reproductive System and its hormonal control. Female secondary sex characters.	(03)

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4. **Sexual Cycles:** (03)  
Puberty, Oestrous and Menstrual cycles and its hormonal regulation.  
Ovarian cycle and its hormonal regulation.
5. **Fertilization and Pregnancy** (03)  
Gamete Transportation, Acrosomal reaction,  
Conception and blastocyst formation, Implantation and delayed  
implantation, Hormonal regulation of pregnancy.
6. **Placenta** (01)  
Formation, types and functions.
7. **Parturition** (02)  
Process of birth and role of hormones.
8. **Lactation** (03)  
Anatomy and growth of mammary glands, lactogenesis and  
galactopoiesis.  
Hormonal regulation and suckling reflex.
9. **Reproductive Dysfunctions** (02)  
Aging and reproduction. Climacteric, anatomical, endocrine and genetic  
disorders.  
**Infertility:** Causes and treatment.
10. **Contraceptive Technologies** (03)  
Introduction to contraceptive technologies; Immunocontraception.  
Antibody Mediated infertility; Surgical methods; Oral contraceptives;  
Implants; Intrauterine uterine device (IUD); Physical and chemical  
methods; Demographic terminology used in family planning.
12. **Assisted Reproductive Technologies** (04)  
Role of assisted reproductive technologies in infertile human and  
animals  
Constraints in assisted reproductive technologies  
Culture techniques for farm animals' embryos  
Induced breeding  
*In Vitro* fertilization (IVF)  
Intracytoplasmic sperm injection  
Intrafallopian transfer of gametes(GIFT)  
Intrafallopian transfer of zygote(ZIFT)
-

Intrauterine transfer of embryo(IUT)

Transgenic mammals and their uses

**13. Prenatal Diagnostic Tests**

**(01)**

Foetal ultra-sonography, Amniocentesis, Chorionic villi sampling, polar body biopsy

**Suggested reading**

1. **Austin C.R. and Short R.V., Reproduction in mammals** Books 1-5, Univ. of Cambridge
2. **Mac E. Hadley, Jon E. Levine**, Endocrinology,
3. **Guyton and Hall**, Principles in Animal Physiology (IX Edition), McGraw Hill Publication.
4. **Hogarth P.H. biology of Reproduction**, Blackie and Son, Glasgow, London.
5. **Nalbandov, AV, Reproductive Physiology**, Lea and Febiger, Philadelphia
6. **Turner and bagnara .General Endocrinology** Sixth Edition, W.B. Saunders Company,



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<b>Semester – III</b>	<b>Paper – VII</b>
<b>Course Code: MSC-ZO 317 T(B)</b>	<b>Title of the Course: Cytogenetics</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 30 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the chromosomal basis of heredity and variation.
2. Understand the inheritance of quantitative traits.
3. Understand the chromosomal basis of sex determination.

**Detailed Syllabus:**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Organization of genomes</b> Prokaryotes - Bacteriophages, Bacteria, Viruses Eukaryotic organelle genomes Eukaryotic nuclear genomes (Genetic features, C-value paradox, Types of coding and noncoding sequences and Split Genes) Mobile genetic elements in Prokaryotes (bacteria) and Eukaryotes ( <i>Drosophila</i> , maize and humans).	<b>(06)</b>
<b>2.</b>	<b>Molecular Mechanisms of cell division</b> Molecular Regulation of cleavage. Molecular organization of centrosome and spindle. Dynamic instability of microtubules during metaphase and anaphase. Role of Motor proteins and segregation of chromosome.	<b>(04)</b>
<b>3.</b>	<b>Chromosomal basis of sex determination in <i>C. elegans</i>, <i>Drosophila</i> and Man</b>	<b>(04)</b>

Molecular basis of sex determination in *C. elegans*, *Drosophila* and Man.

Molecular basis of dosage compensation in *C. elegans*, *Drosophila* and Man.

Molecular interaction and regulation of male and female reproductive cells, cell migration and Cell affinity.

**4. Chromosomal Theory of Inheritance (04)**

Experimental evidence linking the inheritance of genes to chromosomes, Molecular organization of prokaryotic and eukaryotic chromosomes, chromomere, kinetochores, centromeres, telomeres, heterochromatin/euchromatin; Linkage, Recombination and crossing over Early evidence for linkage and genetic recombination, crossing over as the physical basis of recombination, cytological demonstration of crossing over, genetic recombination and construction of genetic maps, interference and coincidence.

**5. Effects of radiations on chromosomes (03)**

Types of radiations

Radiation detection

Dosimetry

Ultraviolet radiations and their importance

Ionizing radiations and their cytogenetic effects – Target theory and its modified concepts.

**6. Numerical variations in chromosomes (04)**

Aneuploidy – cytogenetic consequences with examples from *Drosophila* and Man

Euploidy – cytogenetic consequences. Ex. *Raphanobrassica*, Wheat.

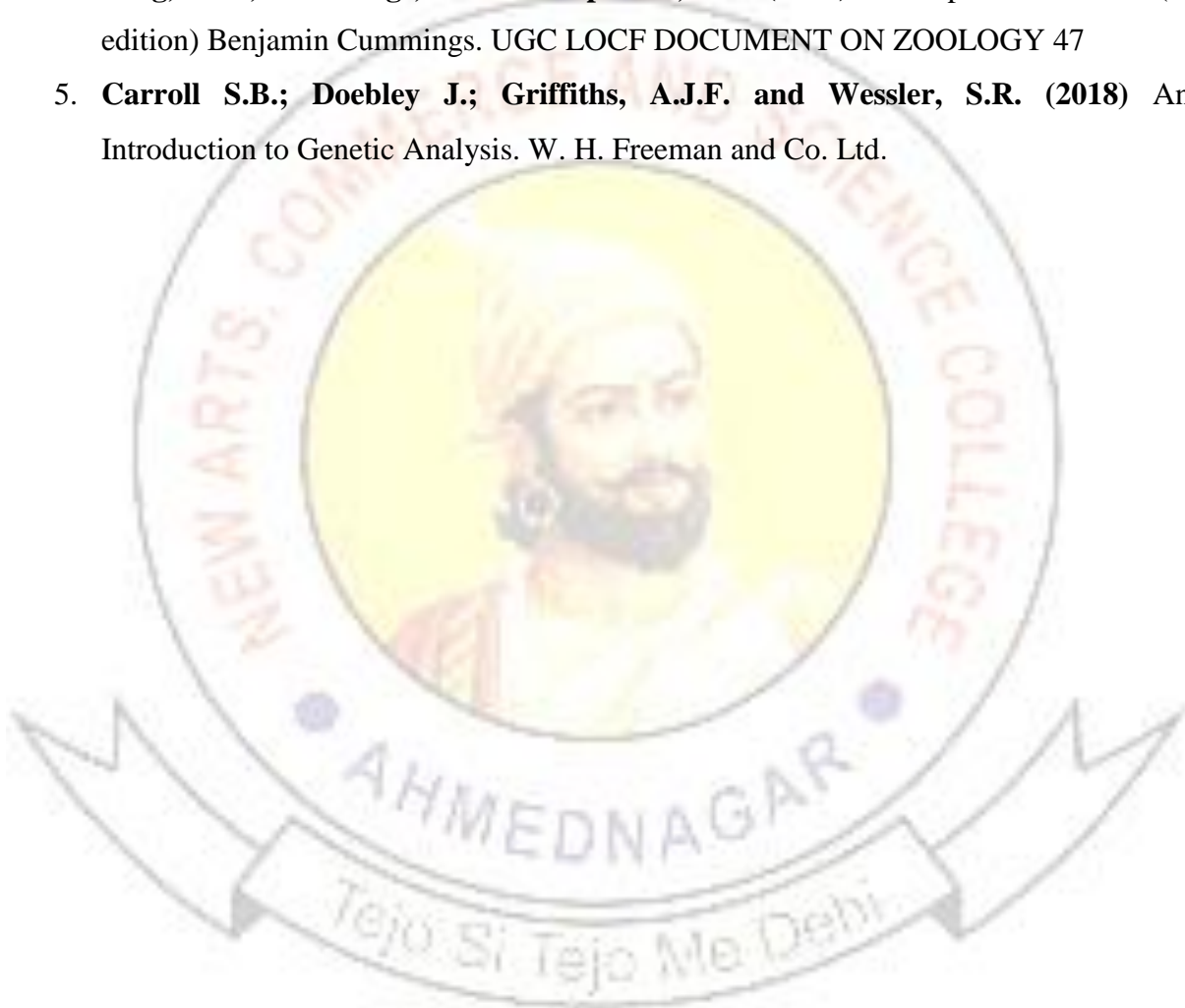
Special chromosomes: B Chromosomes, Structural organization and significance of Polytene chromosome.

**7. Qualitative traits and Quantitative Traits and their inheritance (05)**

Polygenic inheritance, continuous discontinuous variation, Genetic variance, heritability & QTL mapping; Extra-nuclear Inheritance in nature: Mitochondrial and Chloroplast genes, maternal inheritance, Transposable elements/jumping genes.

**Suggested Readings:**

1. **Gardner, E.J. et al. (2006)** Principles of Genetics (John Wiley).
2. **Russell, P.J. (2010)** Genetics (Benjamin Cummings).
3. **Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008).** Principles of Genetics. (VIII edition) Wiley India. 4. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. (V edition) John Wiley and Sons Inc.
4. **Klug, W.S., Cummings, M.R. and Spencer, C.A. (2012).** Concepts of Genetics. (X edition) Benjamin Cummings. UGC LOCF DOCUMENT ON ZOOLOGY 47
5. **Carroll S.B.; Doebley J.; Griffiths, A.J.F. and Wessler, S.R. (2018)** An Introduction to Genetic Analysis. W. H. Freeman and Co. Ltd.



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<b>Semester – III</b>	<b>Paper – VIII</b>
<b>Course Code: MSC-ZO 318 P (A)</b>	<b>Title of the Course: Practical in Mammalian Reproductive Physiology</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the anatomy of male and female reproductive system.
2. Understand the types of contraceptive devices.
3. Understand the methods of reproductive operations in rat.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Anatomy of male and female reproductive system in rat/Mouse	<b>(01)</b>
2.	Study of histological slides of male reproductive System-Testis, Vas deferens, Epididymis, Prostate, Seminal vesicle, Cowper's gland rat/Mouse	<b>(01)</b>
3.	Study of histological slides of female reproductive System-Ovary, Uterus, fallopian tube	<b>(01)</b>
4.	Vaginal smear technique in Rat	<b>(01)</b>
5.	Study of contraceptive devices	<b>(01)</b>
6.	Demonstration of Orchiectomy in rat/Mice	<b>(01)</b>
7.	Demonstration of Ovaerectomy in rat/Mice	<b>(01)</b>
8.	Visit to artificial insemination Centre	<b>(01)</b>
9.	To study types of placenta	<b>(01)</b>
10.	E-demonstration of IVF( <i>in vitro</i> fertilization)	<b>(01)</b>

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<b>Semester – III</b>	<b>Paper – VIII</b>
<b>Course Code: MSC-ZO 318 P (B)</b>	<b>Title of the Course: Practical in Cytogenetics</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

After the successful completion of this course students are able to ---

1. Understand the patterns of inheritance in *Drosophila*
2. Understand the method of karyotype preparation.
3. Understand the applications of statistics in genetics.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Preparation culture of <i>Drosophila</i> .	(02)
2.	External Morphology of male and female <i>Drosophila</i>	(01)
3.	Genetic crosses using <i>Drosophila</i> to understand the pattern of inheritance.	(01)
4.	Karyotyping (normal male/normal female)	(01)
5.	Identification of chromosome anomalies using Idiograms– Autosomal disorders (Down Syndrome / Edward's syndrome)	(01)
6.	Identification of chromosome anomalies using Idiograms – X-linked disorders – (Klinefelter's syndrome / Turner's syndrome)	(01)
7.	Screening for Barr bodies using human epithelial cells.	(01)
8.	Construction of pedigrees and identification of mode of inheritance of a trait.	(01)
9.	Estimation of risk analysis using pedigrees	(01)
10.	Application of statistical techniques on quantitative traits	(02)

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<b>Semester – III</b>	<b>Paper – IX</b>
<b>Course Code: MSC-ZO 319 T</b>	<b>Title of the Course: Research Methodology</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 30 Hrs.</b>

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the fundamentals of biological research methodologies.
2. Understand the opportunities in research and development.
3. Understand the ethical aspects of research.

### Detailed Syllabus:

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Meaning of Research in Biological Sciences</b> Purpose, Characteristics and Types of Research, Process of Research, Defining objectives, Designing Hypothesis, Types of Hypotheses, Methods of testing Hypotheses, Research plan and its components, Methods of Research (Survey, Observation, Case study, experimental, historical and comparative methods), Difficulties in Biological research.	<b>(06)</b>
<b>2.</b>	<b>Identification and formation of the research problem. Elements in research methodology</b> Research design (CRD, RBD, LSD). Scientific database: Science Direct and Pubmed.	<b>(02)</b>
<b>3.</b>	<b>Data Collection</b> Meaning, Methods and Tools of Data Collection Hypothesis Sampling, Data Processing, Analysis and Interpretation of Data.	<b>(02)</b>

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- 4. Databases and research metrics (03)**  
Databases, Indexing databases, Citation databases: (Web of Science, Scopus, etc.) Research Metrics (Impact Factor of the journal as per Journal Citation Report, SNIP, SIR, IPP, Cite Score), Metrics: (h-index, g - index, i10 index, altmetrics)
- 5. Research Funding : (03)**  
Examinations for research fellowship in India, Agencies and Scheme in India: UGC, DBT, DAE, DRDO, ICMR, MoES ( at least 02 schemes of each agency)
- 6. Experimentation on animals (04)**  
Animal handling and ethics, Maintenance of animals, Various routes of injections and sample collection, CPCSEA guidelines; Institutional ethics committees, Ethical consideration in research on human beings
- 7. Working in Laboratory (04)**  
Good laboratory practice; Safety and bio- and radio- hazards, disposal of biological and chemical wastes, Accuracy of liquid transfer, Preparation of Reagents, chemicals, buffers, General safety and precautions, Handling of Instruments.
- 8. Ethics in research (06)**  
Ethics: Define Ethics, Moral philosophy and moral judgements with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Publication ethics (Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. ), Conflicts of interest, Publication misconduct.

**Suggested readings:**

1. **Dawson, C. (2002). Practical research methods.** UBS Publishers, New Delhi.
2. **Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual.** West Africa Rice Development Association, Hong Kong.
3. **Kothari, C.R. (1985): Research Methodology: Methods and Techniques,** Wiley Eastern.

4. **Dominowski, R.L. (1980): Research Methods**, Prentice Hall Inc., New Jersey.
5. **Mishra, R.P. (1980): Research Methodology**, Handbook Concept Publishing Company, New Delhi. 4. IIPS (1996): Research Methodology, IIPS, Mumbai.
6. **Research and Writings – By-P. Ramdas**, A.Wilson srnai M.J.Publisher (2009).
7. **Scientific thesis writings and Paper presentations-N.Gurumani**. M.J.Publisher (2010).
8. **Anderson, Durston&Polle 1970: Thesis and assignment**, writing Wiley Eastern Limited M. Sc. [II] Zoology Savitribai Phule Pune University 23
9. **G. Vijayalakshmi and C. Sivapragasam. (2008) Research Methods –Tip & Techniques**, MJP Publishers, Chennai. [WWW.mjppublishers.com](http://WWW.mjppublishers.com)
10. **Malter K, 1972: Statistical analysis in Biology**, Chapman Hall, London. 1
11. **Cohen, L. Lawrence, M., & Morrison, K. (2005). Research Methods in Education** (5th edition). Oxford: Oxford University Press.
12. **Leedy, P. D. (1980). Practical Research: Planning and design**. Washington: Mc Millan Publishing Co., Inc.
13. **Singh, Y. K. (2006). Fundamental of Research Methodology and Statistics**. New Delhi. New International (P) Limited, Publishers



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<b>Semester – IV</b>	<b>Paper – I</b>
<b>Course Code: MSC-ZO 411 T(A)</b>	<b>Title of the Course: Animal Physiology II</b>
<b>Credits: 04</b>	<b>Total Lecture hours: 60 Hrs.</b>

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the levels of adaptations in animals.
2. Understand the physiological significance of environment.
3. Understand the aspects of stress physiology.
4. Understand the mechanism of sensation in animals.

### Detailed Syllabus:

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Adaptation:</b> Levels of Adaptation Mechanisms of Adaptations Significance of body size	<b>(05)</b>
<b>2.</b>	<b>Physiological adaptations to different environments</b> Marine Shores and Estuaries Freshwater Extreme Aquatic Environments Terrestrial life Extreme terrestrial environments Parasitic habitats	<b>(10)</b>

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**3. Stress & Adaptive Physiology: (12)**

Basic concepts of environmental stress and strain; concept of elastic and plastic strain; stress resistance, stress avoidance and stress tolerance.

Homeostasis and regulation: tolerance and resistance, concept of acclimatization and acclimation, regulatory mechanism of body temperature.

Physiological response to oxygen deficient stress

Physiological response to body exercise

Biological clock and their regulation: Circadian rhythms lunar and tidal rhythm, circa annual rhythm, photoperiodism.

The Autonomic nervous system & HPA axis coordinate the stress response to an acute threat. The HPA axis modulates the immune system. Chronic stress causes deleterious effects. Plasma glucocorticoid concentration shows seasonal variations.

**4. Bioluminescence and Animal Electricity Bioluminescence: (05)**

Phyletic distribution, structure of luminescent organs, biochemical and molecular mechanism. Animal electricity: electro receptors electro organs and their structure and functions.

**5. Buoyancy (04)**

Definition, density reduction, Gas floats with examples, Swim bladder with example.

**6. Energy metabolism: (10)**

Metabolic rate, Energy storage: Fat and glycogen

Effect of O<sub>2</sub> concentration: acclimation to low O<sub>2</sub> level, anaerobic metabolism, lactic acid and glycolysis,

Problem of diving and deep sea hydro thermal vent,

Metabolic rate and body size: mammals, birds, marsupials & monotremes,

Energy cost of locomotion: running, swimming, flying, Effect of high altitude.

**7. Sensory Physiology: (14)**

Receptor types, receptor potential and receptor adaptation

Photoreceptors: Eye-structure and physiology of vision

Auditory Receptors: Ear-Hearing and equilibrium, sound waves and its characters, structure of ear and physiology of hearing and equilibrium

Chemoreceptors: Taste and smell and its mechanism

Tactile receptors: Tactile sensation / response and its mechanism

Baroreceptors and its mechanism.

**Suggested Reading:**

1. **Lauralee Sherwood (2013), Essentials of Physiology**, IV Edition, Cengage Learning Products.
2. **Christopher D. Moyes, Patricia M. Schulte, (2007), Principles of Animal Physiology** Pearson Education.
3. **Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology**. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
4. **Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology**. XI Edition John Wiley & sons,
5. **Eckert, R. Animal Physiology: mechanisms and Adaptation**. W. H. Freeman and Company, New York.
6. **Hoar, W. S. General and Comparative Animal Physiology**, Prentice Hall of India.
7. **Schiemdt Nielsen, Animal Physiology: Adaptation and Environment**. Cambridge.

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<b>Semester – IV</b>	<b>Paper – II</b>
<b>Course Code: MSC-ZO 412 T</b>	<b>Title of the Course: Freshwater Biology and Ichthyology</b>
<b>Credits: 04</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the abiotic factors of freshwater ecosystem in relation to fresh water biota.
2. Understand the diversity and distribution of animal biota of freshwater ecosystem.
3. Understand the basics of ichthyology.
4. Understand the physiological and anatomical systems of fishes.

**Detailed Syllabus:**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Introduction to freshwater habitats.</b> Lotic habitat: Major rivers in India Lentic habitat: Lakes, ponds, wetlands and ephemeral water bodies. Thermal stratification in lakes.	<b>(02)</b>
<b>2.</b>	<b>Physico-chemical conditions of freshwater and its implications on freshwater biota.</b> Physical conditions: Water current, water colour, turbidity and temperature. Chemical conditions: pH, carbon dioxide, dissolved oxygen, hardness, acidity and alkalinity, nitrate, phosphate and sulphates.	<b>(07)</b>
<b>3.</b>	<b>General characters of plankton with special emphasis on the</b>	<b>(04)</b>

- 
- characters used in taxonomy and reproduction:**  
Rotifera, Copepoda, Cladocera and Ostracoda.
4. **Introduction to minor phyla:** (02)  
Gastrotricha, Bryozoa and Tardigrada (water bears).
5. **Diversity and economic importance of freshwater Crustacea and Mollusca.** (02)
6. **Locomotory and Respiratory adaptation in freshwater insect orders:** (02)  
Ephemeroptera, Odonata, Plecoptera, Coleoptera, Diptera and Hemiptera.
7. **Diversity and distribution of vertebrates in the freshwater bodies of India. (Excluding fishes)** (02)
8. **Adaptive physiology of freshwater fauna:** (06)  
Osmotic and ionic, thermal, respiratory, reproductive and life cycle, mechanical, locomotory and sensory adaptations.
9. **Anthropogenic impact on freshwater:** (03)  
Waste and pollution, sewage and silage, mining waste, agricultural chemicals, industrial outflows and invasions.  
Eutrophication : Causes and problems.
10. **Classification and diagnostic characters (up to orders) of extant Cyclostomata, Chondrichthyes and Osteichthyes (9 major orders of fishes)** (04)
11. **Phylogeny of fishes** (01)
12. **External morphology, body form, appendages, pigmentation, skin and scales. Principles of morphometry, Locomotion** (02)
13. **Endoskeleton:** (02)  
Skull, axial and appendicular skeleton
14. **Food and feeding habits, Digestive system and its anatomical modifications.** (03)
15. **Respiration:** (02)  
Structure and functions of gills; adaptations for air breathing; role of air bladder. Respiratory functions of food.
16. **Excretion and Osmoregulation:** (03)  
Mesonephric kidney; Nitrogen (ammonia, urea, TMAO) excretions;
-

water and salt and balance in steno-and euryhaline fishes. Role of skin and gills.

17. **Catadromous and anadromous fishes.** (01)
18. **Reproduction:** (04)  
Structure of gonads, gametogenic cycles; spawning, Parental care.
19. **Nervous system and Sense organs:** (03)  
Organization of the central and peripheral nervous systems. Eye, lateral line organs and chemoreceptors.
20. **Endocrine organs:** (03)  
Functions of the pituitary, thyroid, inter-renal and chromaffin tissues, ultimaobranchial and corpuscles of Stannius
21. **Economic Importance of fishes.** (02)

#### Suggested Reading:

1. **Limnology: lake and river ecosystem, Robert G. Wetzel.** Academic Press, 3rd edition.
2. **Treatise of Limnology. Hutchinson G. E.** John Wiley Publication, New York (3 volumes).
3. **Field Guide to freshwater invertebrates of North America.** Thorp and Rogers. Academic press.
4. **Environmental Physiology of Animals.** Pat Wilmer, Graham Stone and Ian Johnston. Wiley-Blackwell; 2nd edition.
5. **Current status of freshwater resources of India.** Kailash Chandra, Gopi K.C., Rao D.V., Valarmathi K. and Alfred J.R.B. Zoological survey of India, 2017.
6. **Freshwater Ecology: Concepts and Environmental Applications of Limnology.** Academic press, 2nd edition.
7. **Bal, D. V. & K.V.Rao (1984). Marine Fisheries.** Tata McGraw-Hill, New Delhi.
8. **Bone, Q., N.B. Marshall & J.H.S. Blaxter (1995). Biology of Fishes, Edn.2,** Blackie, Academic & Professional (Chapman & Hall), London.
9. **Hoar, W.S. & D.J. Randall, (1969). Fish Physiology.** Vols.I onwards, Academic Press, New York.
10. **Jayaram, K.C. (1981). The freshwater fishes of India.** Pakistan, Bangladesh, Burma and Sri Lanka- A Handbook. Zool. Survey of India, Academic Press, New York.

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<b>Semester – IV</b>	<b>Paper – III</b>
<b>Course Code: MSC-ZO 413 T</b>	<b>Title of the Course: Forensic Entomology and Animal Tissue Culture</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 30 Hrs.</b>

### Course Outcomes (COs)

After the successful completion of this course students are able to ---

1. Understand the importance of insects in forensics.
2. Understand the various tools and techniques used in forensic technology.
3. Understand the laboratory organization and basic preparation for animal tissue culture.
4. Understand the methods and significance of animal tissue culture.

### Detailed Syllabus:

Unit	Name of Topic	Lectures Allotted
1.	<b>Introduction to Forensic Entomology</b> Definition, General aspects of Forensic Entomology, Applications of forensic Entomology, Insects of Forensic Importance.	<b>(02)</b>
2.	<b>Insects as Evidence</b> General Classification of Dipteran insect Life cycle of Dipteran insect (Blow Fly/Flesh Fly), General Classification of Coleopteran insect. Life cycle of Coleopteran insect (Beetles) Applications of various stages of insect development in forensics.	<b>(05)</b>
3.	<b>Insects as tool for Forensic</b>	<b>(03)</b>

Collection of entomological evidence during legal investigations,  
ground-crawling arthropods on and around the body,  
Entomological samples from the body,  
Entomological samples during autopsy, from enclosed structures &  
aquatic habitats.

**4. Insects of Forensic Significance (05)**

Laboratory rearing of insects of forensic significance:

Larval rearing, rearing containers, monitoring growth, larval dispersal in  
laboratory, adult emergence.

Rearing aquatic insects, unique species requirements, rearing beetles in  
the laboratory, factors that influence insect succession on carrion.

Role of aquatic insects in forensic investigations, Soil environment and  
forensic entomology, entomo-toxicology, molecular methods for  
forensic entomology

**5. Introduction, Apparatus and Applications of Animal Tissue Culture (02)**

Laboratory organization: Apparatus and equipment used in animal tissue  
culture: Laminar Airflow, CO<sub>2</sub> incubator, microscopes, refrigerator and  
deep freezers. Sterilization techniques.

**6. Media for Animal Tissue Culture (04)**

Growth media and cell culture, different type of basal salt solution  
(BSS), natural & synthetic media, minimal essential medium (MEM),  
antibiotic media, serum dependent defined media, serum independent  
defined media (for specific cell types), pH, trace ions, CO<sub>2</sub>, O<sub>2</sub> tension,  
ascorbic acid, vitamins and coenzymes. Advantages and disadvantages  
of serum containing & serum free media.

**7. Cell culture: (methods, types, cell lines) (04)**

Types of animal cell culture: cell lines monolayers, suspension, clonal  
culture, mass culture, micro carrier culture (monolayer), selection of cell  
lines. Characteristics of cell lines, primary & secondary cell lines: define  
& indefinite cell lines, organ culture method: - Plasma clot, Raft  
method, Agar gel, Grid method.

**8. Cryopreservation (03)**

Introduction, methods of cryopreservation, selection of material,  
addition of cryoprotectors, cryopreservation's of animal stock cell



maintenance of cell lines, precaution during cryopreservation, importance of cell banks.

**9. Application of Animal cell culture (02)**

Vaccines, Interferon, Monoclonal antibodies production, Hybrid antibodies, Recombinant proteins, etc.

**Suggested readings:**

1. **Culture of Animal Cell**, R. I. Freshney (Wiley-Liss)
2. **Animal Cell Culture**, Practical Approach, R. W. Jhon (Masters Oxford)
3. **Biotechnology**, U. Satyanarayana (Books & allied Pvt. Ltd.)
4. **Methods in Cell Biology** (Vol. 57), Animal Cell culture Methods: J. P. Manthon and D. Barnes (Eds) (Academic Press)
5. **A textbook of Biotechnology**, R. C. DUBEY
6. **Forensic Entomology**: Jason H Byrd & James L Castner
7. **Insect Biology** : Hovard Evan
8. **Fundamentals of Entomology**, Richard J. Flzinga Prentice hall of India pvt ltd, (1978)
9. **Entomology & death**- A procedural guide, Catts E.P & Haskell NH; Joyce's print shop (1990)
10. **A manual of Forensic Entomology** Smith DGV; Ithaca NY Camstock Univ. Press, USA (1986)
11. **General text book of Entomology**, O.W. Richards & R.G. Davis; Chapman & hall ltd, (1973)
12. **Forensic Science -2008**, Embar-Seddon, A and Pass A (Ed), Volumes 1-3 (page 365, 366,)

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<b>Semester – IV</b>	<b>Paper – IV</b>
<b>Course Code: MSC-ZO 414 P(A)</b>	<b>Title of the Course: Practical in Animal Physiology II</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the physiological mechanism in different animals.
2. Understand the effect of stress on physiology of animals.
3. Understand the methods for estimating physiological parameters.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Body size and oxygen consumption in aquatic animals	(01)
2.	Effect of salinity on oxygen consumption in aquatic animals.	(01)
3.	Absorption spectra of blood pigment.	(01)
4.	Osmotic stress and volume change in earthworm.	(01)
5.	Effect of temperature on water loss in cockroach.	(01)
6.	Carbohydrates in mammalian gut.	(01)
7.	Detection of allantoin in mammalian urine.	(01)
8.	Glomerular filtration rate by creatinine clearance.	(01)
9.	Effect of starvation on liver and muscle glycogen in mouse.	(02)
10.	Induction of heat shock puff in salivary gland chromosomes of <i>Drosophila</i> .	(01)
11.	Estimation of blood Sodium, potassium, Calcium.	(01)
12.	Estimation of blood alkaline & acid phosphatases.	(01)
13.	Normal & abnormal constituents of human urine.	(01)

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<b>Semester – IV</b>	<b>Paper – V</b>
<b>Course Code: MSC-ZO 415 P</b>	<b>Title of the Course: Practical in Freshwater Biology and Ichthyology</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand methods for estimation of abiotic factors of freshwater ecosystem.
2. Understand the secondary producers of local freshwater ecosystem.
3. Understand the adaptations of freshwater biota.
4. Understand the general physiological aspects of fish.
5. Understand the biological dimension of fish for culture and rearing.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Estimation of total carbon dioxide and chloride form given water sample.	<b>(01)</b>
2.	Estimation of phosphates forms given water sample.	<b>(01)</b>
3.	Estimation of total nitrate from given water sample.	<b>(01)</b>
4.	Estimation of calcium and total hardness of given water sample.	<b>(01)</b>
5.	Estimation of total alkalinity of given water sample.	<b>(01)</b>
6.	Collection, preservation and identification of zooplankton from freshwater habitat. (Prepare permanent slides and Identify up to genus level using taxonomic key).	<b>(01)</b>
7.	A qualitative and quantitative analysis of zooplankton from a given freshwater sample using Lackey's drop count method/ Sedgwick rafter	<b>(01)</b>

- counting cell.
8. Identification of economically important freshwater crustaceans and fishes. (01)
  9. Study of locomotory and respiratory adaptations in aquatic insects and larvae (*Ranatra*, *Notonecta*, *Gerris*, *Belostoma* and *Dytiscus*). (01)
  10. Study of aquatic and semiaquatic adaptations in amphibians and reptiles. (01)
  11. Estimation of primary productivity with dark and light bottle method. (01)
  12. To prepare and maintain a culture of paramecium, *Daphnia* and *Hydra*. (02)
  13. A Compulsory visit to local freshwater body and preparation of report on physicochemical conditions and faunal organisms. (01)
  14. Identification of freshwater fishes using fin formula (01)
  15. General external characters, fins and scales (permanent slides & temporary preparations); morphometric measurements (01)
  16. Classification of fishes (12-18 representatives of different orders); use of diagnostic keys (01)
  17. Pharyngeal basket and skull of lamprey; endoskeleton (9 articulated and disarticulated) of carp (01)
  18. Length-weight relationship, conditions factors, gonosomatic and hepatosomatic indices of any one species (01)
  19. Adaptations of fishes (adhesive organs, accessory respiratory organs, stomachless fishes, spiral valve, electric organs. (01)
  20. Digestive, and reproductive systems of carp/catfish/*Tilapia*. (01)
  21. Cranial nerves (V, VII, IX & X) and eye ball musculature and innervations in *Scoliodon* and carp/catfish (01)
  22. Histology of digestive, respiratory, excretory, reproductive and endocrine organs (01)
  23. Chromatophores and their responses to external agent (01)
  24. Satiation index (e.g. *Gambusia*-mosquito larvae system) (01)
  25. Setting up of an aquarium and study of breeding behaviour of Gourami, Siamese fighter, swordtail/*Tilapia* (01)
  26. Visit to fish farm/fish market. (01)

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<b>Semester – IV</b>	<b>Paper – VI</b>
<b>Course Code: MSC-ZO 416 P</b>	<b>Title of the Course: Practical in Forensic Entomology and Animal Tissue Culture</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the tools and techniques used in forensics entomology.
2. Understand the life cycle of different insect used in forensics.
3. Understand the organization of animal tissue culture laboratory.
4. Understand the methods in animal tissue culture.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Tools and techniques used in forensic entomology	<b>(01)</b>
2.	Identification, Classification and life cycle of insects used in forensics	<b>(02)</b>
3.	Collection and identification of insects developmental stages from local slaughter house and submission of report	<b>(02)</b>
4.	Visit to Forensic Laboratory	<b>(01)</b>
5.	Study of any one legal case resolved using forensic entomological evidences.	<b>(01)</b>
6.	Understanding apparatus and equipment in animal tissue culture lab	<b>(01)</b>
7.	Sterilization techniques used in animal tissue culture lab	<b>(01)</b>
8.	Preparation of nutrient media for animal tissue culture	<b>(01)</b>
9.	Principle and use of inverted microscope in animal tissue culture lab	<b>(01)</b>
10.	Visit to animal tissue culture lab	<b>(01)</b>
11.	Aseptic transfer technique	<b>(01)</b>

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<b>Semester – IV</b>	<b>Paper – VII</b>
<b>Course Code: MSC-ZO 417 T(A)</b>	<b>Title of the Course: Neural Physiology</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 30 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the central nervous system in animals.
2. Understand the structure and function of nerve cell.
3. Understand the mechanism of neural communication.
4. Understand the applications of neural physiology.

**Detailed Syllabus:**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Brain and spinal cord: Diversity in animals</b> Invertebrate Nervous system: Organization of neurons in brain and ganglia of invertebrates nerve net, nerve plexus and ganglionated nervous system (Hydra, Starfish, and Earthworm). Functional organization of the human central nervous system, subdivisions of the CNS – spinal cord, medulla, pons, cerebellum, midbrain, diencephalon and cerebral hemispheres; Various lobes of the brain – fore brain, mid brain and hind brain.	<b>(10)</b>
<b>2.</b>	<b>Neuron Structure and Function</b> Structural and functional diversity of neuron, electrical signals in neuron and their properties Structure and function of typical vertebrate motor neuron <b>Types of Nervous System Cells:</b> Neuronal, Glial, Ependymal and Schwann Cell.	<b>(04)</b>

**3. Neural Communication****(10)**

Neurotransmitters – Catecholamine's, amino acidergic and peptidergic neurotransmitters and their biosynthesis.

Neurotransmitter receptor: Ionotropic receptors (nicotinic receptors of acetylcholine) and Metabotropic receptors (Dopamine and muscarinic receptors of acetylcholine).

Agonist and antagonist for neurotransmitters: Acetylcholine, Dopamine, GABA and Glutamate, Neuropeptide (Endorphin and Enkephalin).

Chemical basis of neural transmission – Resting membrane potential: Nernst's potential, Goldman's equation, Action potential and propagation- Hodgkin and Huxley's model, Voltage clamp experiment Neuromuscular junctions, synapse and synaptic transmission, Synaptic potential and synaptic integration (Electrical and Chemical Synaptic Potential), Excitatory Post Synaptic Potential (EPSP), Inhibitory Post Synaptic Potential (IPSP).

**4. Neuropharmacology and Molecular Pathogenesis (06)**

Neuropharmacology: Introduction, Roles of neurotransmitters, neuropeptides, neurohormones and neuromodulators in neuropharmacology.

Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, Amnesia, etc.

**Suggested readings:**

1. **Lauralee Sherwood (2013), Essentials of Physiology**, IV Edition, Cengage Learning Products.
2. **Christopher D. Moyes, Patricia M. Schulte, (2007), Principles of Animal Physiology** Pearson Education.
3. **Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology**. XI Edition. Hecourt Asia PTE Ltd. W.B. Saunders Company.
4. **Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology**. XI Edition John Wiley & sons,
5. **Eckert, R. Animal Physiology: mechanisms and Adaptation**. W. H. Freeman and Company, New York.
6. **Hoar, W. S. General and Comparative Animal Physiology**, Prentice Hall of India.
7. **Schiemdt Nielsen, Animal Physiology: Adaptation and Environment**. Cambridge

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<b>Semester – IV</b>	<b>Paper – VII</b>
<b>Course Code: MSC-ZO 417T (B)</b>	<b>Title of the Course: Population Genetics</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 30 Hrs.</b>

**Course Outcomes (COs)**

After the successful completion of this course students are able to ---

1. Understand the patterns of inheritance in population.
2. Understand the factors affecting the population genetics.
3. Understand the methods of solving problems in population genetics.

**Detailed Syllabus:**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
<b>1.</b>	<b>Principles of Population genetics</b> Population structure, Random mating population, Concepts of a population (gene pool, deme, and panmictic unit) Genetic and phenotypic variation in a population, allele frequencies and genotype frequencies at a locus Hardy-Weinberg Law- assumptions and implications, the establishment of Hardy-Weinberg equilibrium for single gene locus Extension of Hardy-Weinberg Law for multiple alleles Establishment of Hardy-Weinberg Law for X- linked genes Linkage disequilibrium – haplotypes, coefficient of linkage disequilibrium, coupling gametes and repulsion gametes.	<b>06</b>
<b>2.</b>	<b>Selection, Mutation &amp; Migration Selection</b> Fitness, patterns of natural selection, general selection equation, equilibrium under selection, Selection favoring heterozygotes: stable equilibrium, balanced polymorphism (sickle cell anemia, heterozygote	<b>06</b>



advantage) Selection against heterozygotes: unstable equilibrium (Rh incompatibility); complete elimination of recessive genes, Mutation– influence of mutation on allele frequencies, balance between forward and backward mutation, Genetic load – mutational and segregational Gene flow– Migration - Wahlund effect.

**3. Inbreeding, Genetic Drift and Quantitative inheritance Inbreeding: 06**

Non-random mating, Identity by descent, selfing, Construction of pedigrees- Raw & forked pedigrees - inbreeding coefficient, Effect of inbreeding on genotypic frequencies and inbreeding depression, Genetic Drift- Bottle neck effect- Founder effect, Effective population size, consequences of a decreasing population size, Quantitative Vs qualitative traits- genetic and environmental values- measures of variances.

**4. Genetic Variation and Molecular Evolution 06**

The origin of genomes- Acquisition of new genes by gene duplication and from other species. Origin of non-coding DNA- transposable elements and introns, Molecular phylogenetics- DNA sequence and protein sequence phylogenetics.

Molecular Evolution– neutral theory, Establishment of evolutionary relationship– molecular clock,

Construction of molecular phylogenetic trees – UPGMA, NJ methods.

**5. Quantifying Genetic Variability 06**

Generic structure of natural populations, phenotypic variation, models explaining changes in genetic structure of populations, Factors affecting human disease frequency.

**6. Molecular Population Genetics 03**

Patterns of changes in nucleotide and amino acids sequences, ecological significance of molecular variation.

**Suggested Readings:**

1. **Hedrick P.W.** -Jones & Bartlett, Genetics of Population
2. **Hartl D. L. And Clark A. G., Principle of Population Genetics**, Sinauer Associates
3. **Falconer, D (1995) Introduction to Quantitative Genetics**, 4th edition, Longman, London
4. **Stickberger, M. W (1990) Evolution**, Jones and Bartlett, Boston

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<b>Semester – IV</b>	<b>Paper – VIII</b>
<b>Course Code: MSC-ZO 418 P(A)</b>	<b>Title of the Course: Practical in Neuronal Physiology</b>
<b>Credits: 02</b>	<b>Total Practical hours: 60 Hrs.</b>

**Course Outcomes (COs)**

**After the successful completion of this course students are able to ---**

1. Understand the structure of central nervous system and nerve cell.
2. Understand the methods of dissection of central nervous system of different animals.
3. Understand the methods in neural physiology through e-demonstration.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Temporary Preparation of medullated and non-medullated nerve fibre.	(01)
2.	Study of permanent microscopic slides of Synapse, Cerebellum, Spinal Cord, etc.	(01)
3.	Models/Brain specimen to examine different regions of the brain.	(01)
4.	Study of Neurophysiological disorders.	(01)
5.	Mapping of taste areas on human tongue.	(01)
6.	Study of olfaction in <i>Drosophila</i> .	(01)
7.	Study of novelty, anxiety and spatial learning in mice	(01)
8.	Study of <i>Scoliodon</i> Brain and Cranial nerve	(01)
9.	Study of Nervous system of Earthworm.	(01)
10.	Study of Nervous system of Cockroach.	(01)
11.	Study of Nervous system of Frog.	(01)
12.	e- demonstration of Patch clamp method	(01)
13.	e- demonstration of synaptic transmission	(01)

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<b>Semester – IV</b>	<b>Paper – VIII</b>
<b>Course Code: MSC-ZO 418 P(B)</b>	<b>Title of the Course: Practical Population Genetics</b>
<b>Credits: 02</b>	<b>Total Lecture hours: 60 Hrs.</b>

**Course Outcomes (COs)**

After the successful completion of this course students are able to ---

1. After the successful completion of this course students are able to ---
2. Understand the patterns of inheritance in population.
3. Understand the factors affecting the population genetics.
4. Understand the methods of solving problems in population genetics.

**Detailed Syllabus: (Any 12)**

<b>Unit</b>	<b>Name of Topic</b>	<b>Lectures Allotted</b>
1.	Calculating allele and genotypic frequencies	(01)
2.	Testing of gene frequencies for Hardy-Weinberg equilibrium – monogenic alleles	(01)
3.	Testing of gene frequencies for Hardy-Weinberg equilibrium –multiple alleles and X linked loci	(02)
4.	Testing for deviation of HW equilibrium using chi-square test	(02)
5.	Estimation of mutation rates	(01)
6.	Calculation of gene frequencies under different types of selection	(02)
7.	Construction of pedigrees – raw and forked pedigrees	(01)
8.	Estimation of inbreeding coefficient using pedigrees	(01)

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<b>Semester – IV</b>	<b>Paper- IX</b>
<b>Course Code: MSC-ZO 419 Pr</b>	<b>Title of the Course: Project</b>
<b>Credits: 02</b>	

**Course Outcomes (COs)**

**After the successful completion of the project students are able to ---**

1. Understand the process of defining research problem.
2. Understand the use of research methodologies.
3. Understand the data presentation and analytical skills.

**Guidelines:**

The individual project aims to develop an aptitude for research in zoology and to inculcate proficiency to identify appropriate research topics and presentations. The topics of biological interest and significance can be selected for the project.

1. The project guide and project topic selection process will be initiated at the end of semester second to enable students to initiate a work literature survey and develop a hypothesis.
2. The student will undertake the project under the guidance of the supervisor. The student and the supervisor will meet periodically to review the progress of the project.
3. The head of the department may arrange the presentations of the students to assess the progress of project work.
4. Project topic once chosen previously shall not be repeated by any student.
5. Students and guides are not allowed to compromise their regular theory and practical sessions for project work.

6. Student will maintain the daily diary of project work and submit the same along with the project report to the department.
7. For field visits students need to get the permission from department/ college.
8. A candidate may, however, in certain cases be permitted to work in industrial/ research organization/ Institute/ college on the recommendation of the supervisor for partial project work.
9. The project report will be checked for plagiarism before final submission.
10. The project will be evaluated in 30:70 pattern (30 Internal and 70 External).

**The project report may have the following sections:**

1. Preliminary (Title page, declaration, certificate of the Supervisor, content, etc.)
2. Introduction with relevant literature review
3. Objective
3. Materials and Methods
4. Result
5. Discussion
6. Conclusion / Summary
7. References.

The project report should be submitted on A4 paper, in Times New Roman font, 12 Font size and 1.5 line space in spirally bound form and duly attested by the supervisor and the Head of the Department on the day of practical examination.

**Project Evaluation Criteria:**

Sr. No.	Component	Marks
1.	Topic/Area selected	05
2.	Literature survey	05
3.	Experimentation/Data collection	10
4.	Methodology and compilation	05
5.	Results and conclusion	10
6.	Presentation	05
7.	Total	35

**The external evaluation panel for project:**

1. Head of the Department or Internal Examiner appointed by the Head of the Department.
2. An External Examiner.