

Mizoram University

**UG/Bachelor's Degree Programme with Multiple Entry and
Exit Options**

under the

National Education Policy 2020

**Curriculum and Credit Framework for Undergraduate
Programmes (CCFUP)**

in

ZOOLOGY

2023

Undergraduate Zoology Course Structure and Credit Distribution

Semester	Course Code	Course Name	Credits		Total Credits
			Lecture	Practicum	
I	ZOO100	Systematics and Fundamental Concepts	4	-	4
	ZOO101	Non-chordate Biology	4	-	4
		[Minor course from other disciplines]	4	-	4
	ZOO110	Fundamentals of Biology	3	-	3
	ENG150	Communication Skill	3	-	3
	MIZ150	Introduction to Mizo Language			
	HIN150	Devanagaree Lipi			
	VAC100	Universal Human Values	2	-	2
					20
II	ZOO160	Evolution and Ethology	4	-	4
	ZOO161	Chordate Biology and Wildlife	4	-	4
		[Minor course from other disciplines]	4	-	4
	ZOO120	Fundamentals of Biology	3	-	3
	SEC160	Skill Enhancement Course	-	3	3
	VAC120	Understanding India	2	-	2
UG Certificate in Zoology					40
III	ZOO200	Cell Biology	3	1	4
	ZOO201	Anatomy	3	1	4
		[Minor course from other disciplines]	4	-	4
	ZOO210	Fundamentals of Biology	3	-	3
	SEC270	Skill Enhancement Course	-	3	3
	VAC230	Environmental Science	2	-	2
	VAC231	Digital and Technological Solution			
					20
IV	ZOO260	Genetics	4	-	4
	ZOO261	Physiology	3	1	4
		[Minor course from other disciplines]	4	-	4
	ENG250	Grammar and Comprehension Skills	3	-	3
	MIZ250	Mizo Grammar & Writing Skill			
	HIN250	Hindi Kamyuting			
	SEC280	Skill Enhancement Course	-	3	3
	VAC240	Sports and Fitness	2	-	2
	VAC241	Health and Wellness			
	VAC242	Yoga Education			
					20
UG Diploma in Zoology					80
V	ZOO300	Biochemistry	3	1	4
	ZOO301	Embryology	3	1	4
	ZOO302	Endocrinology and Reproduction Biology	3	1	4
		[Minor course from other disciplines]	4	-	4

	ENG350	Writing Skills	2	-	2
	MIZ350	Mizo Language - Status and Development			
	HIN350	Bhasha Shikshan			
	IAF300	Internship/Apprenticeship/Field Project	-	2	2
					20
VI	ZOO360	Molecular Biology	3	1	4
	ZOO361	Parasitology	3	1	4
	ZOO362	Hematology and Immunology	3	1	4
	ZOO363	Entomology	3	1	4
		[Minor course from other disciplines]	4	-	4
					20
		UG Degree in Zoology			120
VII	ZOO400	Applied Zoology	4	-	4
	ZOO401	Cellular Functions	4	-	4
	ZOO402	Animal Biotechnology	4	-	4
		[Minor course from other disciplines]	4	-	4
		[Minor course from other disciplines]	4	-	4
					20
VIII	ZOO460	Biotechniques and Bioinformatics	3	1	4
	ZOO461	Biomolecules and Instrumentations	4	-	4
	RPD470	Research Project/Dissertation	-	12	12
					20
		Bachelor's degree/BSc in Zoology (Honours with Research)			160
OR					
VIII	ZOO460	Biotechniques and Bioinformatics	3	1	4
	ZOO461	Biomolecules and Instrumentations	4	-	4
	ZOO462	Genetic Engineering	4	-	4
	ZOO463	Cellular Oncology	4	-	4
	ZOO464	Molecular Infectiology	4	-	4
					20
		Bachelor's degree/BSc in Zoology (Honours)			160

Systematics and Fundamental Concepts

ZOO100

Credit: 4

Course outcome: Understanding of the basics of zoological studies on classification, historical development, major concepts and applications.

Theory

- Unit 1 Principles of systematics: Linnaean classification and taxonomic hierarchy; binomial and binominal nomenclature: priority, priority and homonymy rules; concept of kingdom and kingdom classifications.
- Unit 2 Aristotle's biology. Discovery of Archaea and development of domain system. Species concepts: biological, morphological, ecological, evolutionary and phylogenetic.
- Unit 3 Speciation: types and examples. *Scala naturae* vs the tree of life. Proteins, DNA and RNA in molecular phylogeny. Cladogram and phylogenetic tree.
- Unit 4 Spontaneous generation – contributions of Francesco Redi, John Needham, Lazzaro Spallanzani, Louis Pasteur. Recapitulation theory vs Von Baer's law. Pangenesis – concept, Galton's and Weismann's experiments.

Suggested readings

1. Kapoor, V. C. (2001). *Principles and Practices of Animal Taxonomy* (2nd edition). Science Publishers Inc.
2. Margulis, L., and Chapman, M. J. (2009). *Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth*. Academic Press.
3. Mayr, E., and Ashlock, P. D. (1991). *Principles of Systematic Zoology* (2nd edition). McGraw-Hill.
4. Moore, J. A. (1993). *Science as a Way of Knowing: The Foundations of Modern Biology*. United Kingdom: Harvard University Press.
5. Wheatley, D. N., Agutter, P. S. (2008). *Thinking about Life: The History and Philosophy of Biology and Other Sciences*. Springer Netherlands.

Non-chordate Biology

ZOO101

Credit: 4

Course outcome: Knowledge on the fundamental nature and diversity of life forms among the invertebrates, their unique behaviours and key biological functions.

Theory

- Unit 1 Locomotion in Protozoa: amoeboid, cell crawling, ciliary and flagellar. Structure of *Euglena*. *Paramecium*: conjugation and kappa particles. Reproduction in *Amoeba*.
- Unit 2 Phyla of invertebrates with their salient features. Metamerism. Symmetry in animals. Coelom. Canal system in poriferans.
- Unit 3 Corals and coral reefs. Polymorphism in Hydrozoa. Torsion and detorsion in Gastropoda. Reproductive and excretory systems of earthworm.
- Unit 4 Circulatory and excretory systems of *Periplaneta*. Insect metamorphosis. Social organisation in insects. *Asterias* – water vascular system and life history.

Suggested readings

1. Giribet, G., Brusca, R. C., Moore, W. (2022). *Invertebrates* (4th edition). Oxford University Press Inc.
2. Jordan, E. L., Verma, P. S. (2022). *Invertebrate Zoology* (Library Edition). S. Chand and Company.
3. Kotpal, R. L. (2020). *Modern Textbook of Zoology: Invertebrates* (12th edition). Rastogi Publications.
4. Pechenik, J. (2014). *Biology of the Invertebrates* (7th Edition). McGraw-Hill Education.
5. Wisner, M. F. (2010). *Protozoa and Human Disease*. Garland Science Taylor and Francis Group.

Fundamentals of Biology

ZOO110 or ZOO120 or ZOO210

Credits: 3

Course outcome: Introduction to the study of organisms in biology, historical and concept developments, and the milestones in the developments of biological principles and discoveries.

Theory

- Unit 1 Contributions of Aristotle in biology. Development of physiology from Galen to William Harvey. Germ theory of diseases: works of Girolamo Fracastoro, Louis Pasteur and Robert Koch. Origin of evolutionary theories: Lamarckism and natural selection.
- Unit 2 Discovery of cell: contributions of Robert Hooke and Antonie van Leeuwenhoek. Origin of cell theory: Matthias Schleiden, Theodor Schwann and Rudolf Virchow. Birth of genetics: Mendel's experiments and laws.
- Unit 3 Discovery of antibiotics: Salvarsan, Prontosil (sulfonamide), penicillin, and streptomycin. Discoveries of DNA as a genetic material and the helical structure. Development of the Human Genome Project. Cloning – Dolly, and ethical issues.

Suggested readings

1. Lutz, P. L. (2002). *The Rise of Experimental Biology: An Illustrated History*. Springer.
2. Magner, L. N. (2002). *A History of the Life Sciences*. CRC Press.
3. Olby, R. C. (1994). *The Path to the Double Helix: the Discovery of DNA*. Dover Publications Inc.
4. Rosen, W. (2018). *Miracle Cure: The Creation of Antibiotics and the Birth of Modern Medicine*. Penguin.
5. Serafini, A. (2013). *The Epic History of Biology*. Springer.

Evolution and Ethology

ZOO160

Credit: 4

Course outcome: Comprehension of the biological properties of organisms based on evolutionary principles, their adaptive behaviours and survival strategies.

Theory

- Unit 1 The theory of natural selection; modern synthesis. Industrial melanism in peppered moth; sickle cell trait and resistance to malaria; high-altitude adaptation in humans. Prebiotic soup theory and Miller's experiment.
- Unit 2 RNA World hypothesis. Symbiogenesis (*Angomonas deanei*, *Mixotricha paradoxa*). Major hominin fossils. Mitochondrial Eve and Y-chromosomal Adam: Out of Africa theory.
- Unit 3 Mimicry: aggressive, Batesian and Müllerian. Colouration: aposematism and camouflage. Types of behaviour – innate, imprinting, and learned (Pavlov's conditioning). Altruism and reciprocal altruism.
- Unit 4 Infrasound; echolocation; dancing in bees. Evolutionary arms race. Hormonal control of behaviour – roles of melatonin, oxytocin, adrenaline and noradrenaline, and steroids. Hormonal basis of sex change.

Suggested readings

1. Futuyma, D. J. (2017). *Evolution* (4th edition). Sinauer Associates Inc.
2. Hall, B. K., and Hallgrimsson, B. (2013). *Strickberger's Evolution* (5th edition). Jones and Bartlett Publishers.
3. Mathur, R., and Singh, S. P. (2008). *Evolution and Behaviour*. Rastogi Publications, Meerut, India.
4. Mandal, F. K. (2012). *Textbook of Animal Behaviour*. PHI Learning Private Limited, New Delhi, India.
5. Rubenstein, D. R., Alcock, J. (2018). *Animal Behavior: An Evolutionary Approach* (11th edition). Sinauer Associates Inc.

Chordate Biology and Wildlife

ZOO161

Credit: 4

Course outcome: Knowledge on the fundamental nature and diversity of life forms among the chordates, their unique behaviours and key biological issues.

Theory

- Unit 1 Classification of Chordata up to classes with salient features. Protochordata: salient features and affinities; embryonic development of *Branchiostoma*; larval development and metamorphosis in *Herdmania*.
- Unit 2 Types of scales in Pisces; sense organs in *Scoliodon*. Amphibia: Neoteny and paedogenesis; parental care. Snake venom, poison apparatus and biting mechanism.
- Unit 3 Structure, types and development of feathers in *Columba livia*; principle and modes of flight. Bird migration – patterns and types. Reproductive system of rabbit.
- Unit 4 Threats to wildlife. Extinction – definition, causes, Lazarus taxa. IUCN Red List. Recent extinct animals: dodo, Tasmanian tiger, the great auk. The World Wide Fund for Nature: Development and roles.

Suggested readings

1. Jordan, E. L., and Verma, P. S. (2013). *Chordate Zoology* (14th edition). S. Chand and Company Ltd.
2. Kent, G. C. (2018). *Comparative Anatomy of the Vertebrates* (9th edition). McGraw-Hill Education.
3. Kotpal, R. L. (2019). *Modern Textbook of Zoology: Vertebrates* (12th edition). Rastogi Publications.
4. Pough, F. H., and Janis, C. M. (2019). *Vertebrate Life* (10th Edition). Oxford University Press.
5. Winter, M. (2016). *Wildlife Biology*. Syrawood Publishing House.

Cell Biology

ZOO200

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Understanding of the properties and functions of cells and their components, their multiplications and molecular regulations.

Theory

- Unit 1 Cell theory – development, tenets and limitations. Structure of prokaryotic and eukaryotic cells. Cell membrane structure: fluid mosaic model. Membrane transport: simple, facilitated and active transports.
- Unit 2 Structure and functions of mitochondria, ribosomes, endoplasmic reticulum, Golgi complex, lysosome and peroxisome.
- Unit 3 Cytoskeletons: microfilaments, intermediate filaments and microtubules. Extracellular matrix. Nuclear envelope: structure and transport of molecules.
- Unit 4 Stages of cell cycle; cell cycle checkpoints; regulation of cell cycle through cyclin-CDK complexes. Meiosis. Types and characteristics of cancer; carcinogens.

Practicum

1. Study of cell organelles from slides/models.
2. Study of stages of mitosis from permanent slides.
3. Study of stages of meiosis from permanent slides.
4. Squash preparation of onion root tip for mitosis.
5. Squash preparation of gametes for mitosis.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2022). *Molecular Biology of the Cell* (7th edition). W. W. Norton & Co Inc.
2. Gupta, P. K. (2017). *Cell and Molecular Biology* (5th edition). Rastogi Publications.
3. Karp, G. (2020). *Cell and Molecular Biology* (9th edition). John Wiley & Sons Inc.
4. Lodish, H., Berck, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., and Matsudaira, P. (2016). *Molecular Cell Biology* (8th edition). W. H. Freeman.
5. Verma, P. S., and Agarwal, P. S. (2021). *Cell Biology, Cytology, Biomolecules and Molecular Biology*. S. Chand and Company Ltd.

Anatomy

ZOO201

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Knowledge on the key structural features of animals underpinning the functional roles of various body parts.

Theory

- Unit 1 Digestive system of *Branchiostoma*. Circulatory system of *Herdmania*. Respiratory system of pigeon. Internal ear of *Scoliodon*.
- Unit 2 Receptor organs. Structure and types of integuments in vertebrates. Structure and composition of cartilage, bone and ligaments.
- Unit 3 Rabbit – structure of brain; structure of eye; digestive system. Muscle – types and ultrastructures.
- Unit 4 Dentition in mammals – structure of teeth; types of teeth; dental formula; development. Heart – structure in mammals; modifications in vertebrates.

Practicum

1. Preparation of temporary mount and description of: a) filoplume, contour and down feathers b) scales (at least two) of fish
2. Dissection/multimedia demonstration of respiratory organs of chicken.
3. Dissection/multimedia demonstration of digestive organs of chicken/rat/mouse.
4. Dissection/multimedia demonstration of flight muscles of chicken.
5. Osteology of pigeon/chicken/rabbit/rat/mouse: a) Atlas, axis and sacral vertebrae; b) Limb bones; c) skull

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Jordan, E. L., and Verma, P. S. (2013). *Chordate Zoology* (14th edition). S. Chand and Company Ltd.
2. Kardong, K. (2018). *Vertebrates: Comparative Anatomy, Function, Evolution* (8th edition). McGraw-Hill Education.
3. Kent, G. C. (2018). *Comparative Anatomy of the Vertebrates* (9th edition). McGraw-Hill Education.
4. Kotpal, R. L. (2019). *Modern Textbook of Zoology: Vertebrates* (12th edition). Rastogi Publications.
5. Pough, F. H., and Janis, C. M. (2019). *Vertebrate Life* (10th Edition). Oxford University Press.

Genetics

ZOO260

Credit: 4

Course outcome: Develop insights into the principles of biological functions including the historical development and concepts of genetics, cellular processes and heritable diseases.

Theory

- Unit 1 Mendelian inheritance; incomplete dominance; co-dominance. Cytoplasmic inheritance. Pleiotropism and allelism; epistasis; multiple alleles.
- Unit 2 Crossing over. Genetic recombination. Sex linkage and non-disjunction. Linkage maps. Chromosomal mutations.
- Unit 3 Sex determination: genotypic and environmental. Conjugation, transformation and transduction in bacteria. Transposons – types and effects.
- Unit 4 Concept of transgenesis. Stem cells. Pedigree analysis. Genetic disorders: Down, Klinefelter and Turner syndromes; haemophilia.

Suggested readings

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2022). *Molecular Biology of the Cell* (7th edition). Garland Publishing, London.
2. Gupta, P. K. (2017). *Cell and Molecular Biology* (5th edition). Rastogi Publications.
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M., and Killian, D. (2019). *Concepts of Genetics* (11th edition). Pearson Education
4. Krebs, J. E., Goldstein, E. S., and Kilpatrick, S. T. (2017). *Lewin's Genes XII*. Jones & Bartlett Publishers.
5. Lodish, H., Berck, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., and Matsudaira, P. (2016). *Molecular Cell Biology* (8th edition). W. H. Freeman.

Physiology

ZOO261

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Understanding the fundamentals of body functions such as digestion, respiration, excretion, movements and sensation.

Theory

- Unit 1 Extracellular and intracellular digestions. Digestion of carbohydrates, proteins and fats. Respiration: mechanism in gills and lungs. Types of respiration – external, internal, and cutaneous.
- Unit 2 Open and closed circulation. Mammalian heart: myogenic and neurogenic; pacemaker; cardiac cycle. Kidney: structure and function. Micturition. Types of excretion: ammonotelic, uricotelic and ureotelic.
- Unit 3 Osmoregulation in marine and terrestrial vertebrates. Muscle proteins. Mechanism of muscle contraction – sliding filament theory; cross-bridge model.
- Unit 4 Types and structures of neurones. Resting and action potentials; propagation of nerve impulse. Major neurotransmitters. Structure of synapse. Synaptic transmission.

Practicum

1. Study of histological slides of stomach, intestine, lung, kidney and liver of any mammal.
2. Preparation of haemin crystals.
3. Measurement of blood pressure, pulse rate and oxygen level under rest and physical activity.
4. Demonstration/model study of heart and circulatory system of chicken/rat/mouse.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Goyal, K. A., and Sastry, K. V. (2017). *Animal Physiology* (7th edition). Rastogi Publications, Meerut.
2. Hill, R. W., Wyse, G. A., and Anderson, M. (2019). *Animal Physiology* (5th edition). Sinauer Associates, Inc.
3. Kardong, K. (2018). *Vertebrates: Comparative Anatomy, Function, Evolution* (8th edition). McGraw-Hill.
4. Moyes, C. D., and Schulte, P. M. (2015). *Principles of Animal Physiology* (3rd edition). Benjamin Cummings.
5. Yancy, P. H., Sherwood L., and Klandorf, H. (2014). *Animal Physiology: From Genes to Organisms* (2nd edition). Cengage Learning, Inc.

Biochemistry

ZOO300

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Comprehension of the biological activities in animals in terms of chemical processes and interactions.

Theory

- Unit 1 Carbohydrates and lipids: classification and significance. Classification, structure and properties of proteins. Types and properties of vitamins.
- Unit 2 Types and properties of enzymes. Mechanism of enzyme action. Enzyme inhibition; Michaelis-Menten equation. Coenzymes. Ribozymes.
- Unit 3 Glycolysis: reactions and significance. Glycogenesis. Glycogenolysis. Gluconeogenesis. β -oxidation of fatty acids. Lipogenesis.
- Unit 4 Oxidative phosphorylation: tricarboxylic cycle; electron transport chain, ATP synthesis. Urea cycle. Ketogenesis.

Practicum

1. Estimation of proteins by biuret or Lowry's method.
2. Estimation of ascorbic acid from citrus fruit by titration.
3. Detection of carbohydrates, proteins and lipids (at least 2 tests each).
4. Demonstration of salivary amylase activity, with effect of pH and temperature.

Mark distribution of practicum for end semester examination

1. Major experiment (1 or 2)	25
2. Minor experiment (3 or 4)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Berg, J. M., Stryer, L., and Tymoczko, J. L. (2019). *Biochemistry* (9th edition). W.H. Freeman & Company.
2. Nelson, D. L., and Cox, M. (2017). *Lehninger Principles of Biochemistry* (7th edition). W.H. Freeman & Company.
3. Rajtogi, S. C. (2019). *Biochemistry* (4th edition). New Age International Publishers.
4. Satyanarayana, U. (2020). *Biochemistry* (5th edition). Elsevier.
5. Voet, D., Voet, C., and Pratt, C. W. (2016). *Fundamentals of Biochemistry: Life at the Molecular Level* (5th edition). John Wiley & Sons Inc.

Embryology

ZOO301

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Knowledge on the fundamental processes and roles of reproduction in animals, how the developmental stages are maintained and regulated.

Theory

- Unit 1 Structure of spermatozoon and ovum. Gametogenesis: spermatogenesis and oogenesis; hormonal regulation of gametogenesis. Types of eggs and patterns of cleavage.
- Unit 2 Fertilization: external and internal. Process of fertilization and prevention of polyspermy. Blastulation and gastrulation in frog. Fate maps. Parthenogenesis.
- Unit 3 Types and functions of placenta in mammals. Extra-embryonic membranes in chick. Concept of organizer and induction. Regeneration in invertebrates and vertebrates.
- Unit 4 Amphibian metamorphosis and hormonal regulation. Functions of homeotic genes. *Hox* genes and their functions in *Drosophila*. Concepts and models of ageing.

Practicum

1. Study of cleavage, blastula and gastrula of frog from specimen/model.
2. Study of different stages of development of chick embryo.
3. Preparation of whole mount of chick embryo (any stage).
4. Study of regeneration from slide/multimedia.
5. Culture/study of life cycle of *Drosophila*.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Barresi, M. J. F., and Gilbert, S. (2020). *Developmental Biology* (12th edition). Sinauer Associates, Inc.
2. Sadler, S. L. (2019). *Langman's Medical Embryology* (13th edition). Wolters Kluwer India Pvt. Ltd.
3. Sastry, K. V., and Shukla, V. (2018). *Developmental Biology* (2nd edition). Rastogi Publications.
4. Verma. P. S., and Agarwal, V. K. (2010). *Chordate Embryology: Developmental Biology*. S. Chand and Company Ltd., New Delhi.
5. Wolpert, L., Smith, J., Jessell, T., Lawrence, P., Roberson, E., and Meyerowitz, E. (2018). *Principles of Development* (5th edition). Oxford University Press.

Endocrinology and Reproduction Biology

ZOO302

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: An insight into the scientific knowledge of bodily functions in animals and the ways by which chemical signals are used for such functional coordination.

Theory

- Unit 1 Hormones: classification and transport. Structure and functions of hypothalamus, pituitary, thyroid, pancreas, adrenal, testis, ovary. Types of hormone receptor.
- Unit 2 Endocrine disorders: diabetes mellitus, gigantism, dwarfism and cretinism. Mechanism of action of steroid hormones and peptide hormones. Anabolic steroids.
- Unit 3 Biological rhythms: circadian and circannual; hormonal regulations. Hormonal regulation of calcium homeostasis; glucose homeostasis; parturition.
- Unit 4 Invertebrate endocrine glands and their functions. Pheromones and their effects. Estrous and menstrual cycles: phases and hormonal regulation. Hormonal basis of contraception.

Practicum

1. Study of important endocrine glands from permanent slides/models.
2. Dissection/multimedia display/demonstration of endocrine glands (adrenal, thyroid, pancreas and gonads) in rat/mouse.
3. Study of surgical techniques and effects of castration/vasectomy/ovariectomy in rat/mouse.
4. Dissection/multimedia demonstration of reproductive system in rat/mouse.
5. Dissection or demonstration of reproductive organs and endocrine glands of cockroach.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Litwack, G. (2022). *Hormones* (4th edition). Academic Press.
2. Melmed, S., Koenig, R., Rosen, C., Auchus, R., and Goldfine, A. (2020). *Williams Textbook of Endocrinology* (14th edition). Elsevier.
3. Norris, D. O., and Carr, J. A. (2021). *Vertebrate Endocrinology* (6th Edition). Academic Press.
4. Sastry, K. V. (2018). *Endocrinology and Reproductive Biology*. Rastogi Publications.
5. White, B., Harrison, J. R., and Mehlmann, L. (2018). *Endocrine and Reproductive Physiology*. Elsevier.

Molecular Biology

ZOO360

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Understanding the molecular components of cells, their organisations and functional roles, and how biomolecules maintain structural and functional integrity of cells.

Theory

- Unit 1 Structure and types of DNA. Structure and types of RNA. Chromosomes: chromatin (euchromatin and heterochromatin). Higher order of chromosome organization – nucleosomes; special types of chromosomes (polytene and lampbrush chromosomes).
- Unit 2 DNA replication: Meselson and Stahl experiment; mechanism in prokaryotes. Prokaryotic and eukaryotic gene structure. Transcription in prokaryotes.
- Unit 3 Central dogma of molecular biology. Genetic code. Translation. Concept of operon: lac operon.
- Unit 4 Karyotype and karyotyping. Point mutation – spontaneous and induced. DNA damage and repair. Molecular concept of ageing.

Practicum

1. Study of chromosome structure and aberrations from permanent slides/models.
2. Preparation/description of polytene chromosome from dipteran larvae.
3. Preparation of sex chromatin.
4. Quantitative estimation of DNA/RNA.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2022). *Molecular Biology of the Cell* (7th edition). Garland Publishing, London.
2. Gupta, P. K. (2017). *Cell and Molecular Biology* (5th edition). Rastogi Publications.
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M., and Killian, D. (2019). *Concepts of Genetics* (11th edition). Pearson Education
4. Krebs, J. E., Goldstein, E. S., and Kilpatrick, S. T. (2017). *Lewin's Genes XII*. Jones & Bartlett Publishers.
5. Lodish, H., Berck, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., and Matsudaira, P. (2016). *Molecular Cell Biology* (8th edition). W. H. Freeman.

Parasitology

ZOO361

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Knowledge on the major types of parasites and how they affect the lives of other animals, with the origin of diseases that they cause.

Theory

- Unit 1 Introduction to protozoology and parasitology. Life cycle and pathogenicity of *Plasmodium falciparum*. Structural variations in trypanosomatids. Life cycle and pathogenicity of *Trypanosoma brucei* and *Leishmania donovani*.
- Unit 2 Life cycle and pathogenicity of *Entamoeba histolytica*. Structure, life cycle and pathogenicity of *Trichomonas vaginalis*. Structure, life cycle and pathogenicity of *Giardia duodenalis*.
- Unit 3 Human *Taenia*: general life cycle and pathogenicity. Parasitic adaptations in cestodes. Life cycle and pathogenicity of *Fasciola hepatica*. Structures and functions of miracidia and cercaria.
- Unit 4 Life cycle and pathogenicity of *Schistosoma mansoni*. Life cycle and pathogenicity of *Ascaris lumbricoides*. Morphology and sexual dimorphism in nematodes.

Practicum

1. Systematic study of common protozoans from permanent slides/models.
2. Systematic study of important helminth parasites from specimens and permanent slides.
3. Recovery, processing and identification of helminths from fowl intestine.
4. Preparation and study of blood film.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Apurba, S. S., and Bhat, S. (2020). *Essentials of Medical Microbiology* (3rd edition). Jaypee Brothers Medical Publishers
2. Chatterjee, K. D. (2019). *Parasitology Protozoology and Helminthology* (13th edition). CBS Publishers & Distributors Private Limited.
3. Cox, F. E. G. (1993). *Modern Parasitology: A Textbook of Parasitology* (2nd edition). Blackwell Science Ltd.
4. Roberts, L. S., and Janovy, J. Jr. (2012). *Foundations of Parasitology* (9th edition). McGraw Hill.
5. Suryawanshi, V. D., and Kharate, D. S. (2021). *Advances in Parasitology Protozoology & Helminthology*. OrangeBooks Publication.

Haematology and Immunology

ZOO362

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Understanding the fundamental feature of the defensive property of animals against infection, the components of the defense and their roles.

Theory

- Unit 1 Haematopoiesis and diversity of blood cells. Blood coagulation. Principles and roles of ABO and Rh blood types. General structure of haemoglobin. Structure of haem and gaseous exchanges.
- Unit 2 Tissue cells in immunity. Innate immunity: defensins, phagocytes and phagocytosis, complement pathway. Acquired immunity: antibody- and cell-mediated immune systems.
- Unit 3 Components of immune system: antigen, hapten, epitope, paratope. Structure of typical immunoglobulin. Types of antibodies. Antigen-antibody interactions. Principle of vaccination.
- Unit 4 Structures and functions of major histocompatibility complex. Types of hypersensitivity. Acquired immunodeficiency – HIV infection.

Practicum

1. Study of major blood cells from slide/model.
2. Determination of blood types.
3. R.B.C. total count.
4. W.B.C. total count.
5. Estimation of haemoglobin.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Delver, P. J., Martin, S. J., Burton, D. R., and Roitt, I. (2017). *Roitt's Essential Immunology* (13th edition). Wiley-Blackwell.
2. Hoffman, R., Benz Jr, E. J., Silberstein, L. E., Heslop, H., Anastasi, J., and Weitz, J. (2017). *Hematology: Basic Principles and Practice* (7th edition). Elsevier Health Sciences.
3. Prchal, J. T., & Levi, M. M. (2021). *Williams Hematology* (10th edition). McGraw-Hill Companies.
4. Punt, J., Stranford, S. A., Jones, P., and Owen, J. A. (2013). *Kuby Immunology* (8th edition). WH Freeman.
5. Singh, T. (2017). *Atlas and Text of Hematology*. Avichal Publishing Company.

Entomology

ZOO363

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Knowledge on the biology and diversity of insects, their uniqueness among the life forms, and their influences on other animals.

Theory

- Unit 1 Insecta: classification with general characters; methods of collection and preservation; Insect physiology: digestive, respiratory and reproductive organs; body wall and mouthparts; respiration.
- Unit 2 Social behaviour and caste system in insects; Insect hormones: types, biological effects and their applications. Hormonal regulation of metamorphosis.
- Unit 3 Economically important insects: honeybee, lac, silkworm. Medically important insect: Diptera (mosquitoes), Hemiptera (bed bugs), Phthiraptera (sucking lice), Siphonaptera (fleas), Acarina (mites, and ticks).
- Unit 4 Parasitic and predatory insects and their roles; control of insect pests (natural, chemical, biological and integrated methods). Biotechnology and insect pest management.

Practicum

1. Study of important insects from specimens/permanent slides/models.
2. Study of insect endocrine glands from slide or models.
3. Preparation of temporary mount of mouthparts of housefly/mosquito.
4. Morphology and morphometry of mosquito.
5. Identification of locally available insects, at least up to order.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Chapman, R. F. (2013). *The Insects: Structure and Function* (5th edition). Cambridge University Press.
2. Service., M (2012). *Medical Entomology for Students* (5th edition). Cambridge University Press.
3. Gillott, C. (2018). *Entomology* (3rd edition). Springer.
4. Gullan, P. J., Cranston, P. S., and McInnes, K. H. (2010). *Insects: An Outline of Entomology* (4th edition). Wiley-Blackwell.
5. Kotpal, R. L. (2019). *Modern Textbook of Zoology: Invertebrates* (12th edition). Rastogi Publications.

Applied Zoology

ZOO400

Credit: 4

Course outcome: Information on the basics of zoology for the welfare of human lives, the uses and roles of animals for the sustenance of other organisms.

Theory

- Unit 1 Apiculture: Types of bees, structure and composition of hive, rearing method and economic importance. Sericulture: culturable silkworms, rearing method and economic importance.
- Unit 2 Types of pesticides; pest control (natural, chemical and biological controls); integrated pest management. Vermicomposting: vermicomposting species; methods.
- Unit 3 Fish farm: structure; maintenance of ponds. Integrated fish farming. Breeding in fishes – natural and induced breeding; ecological and hormonal influence on maturation and spawning. Important cultivable fishes.
- Unit 4 Population: characteristics, dynamics; species richness and diversity; Sorensen's and Shannon-Weaver model. Wildlife: management and conservations; remote sensing; human-animal conflicts.

Suggested readings

1. Jhingran, V. G. (2002). *Fish and Fisheries of India*. Hindustan Publishing Corporation, Delhi, India.
2. Kumar, A., Desmukh, N. Z., Kumar, D., and Goswami, R. (2020). *Applied and Economic Zoology*. Daya Publishing House.
3. Mathur, R. (2019). *Wildlife Conservation and Management*. Rastogi Publications, Meerut, India.
4. Upadhyay, V. B., Shukla, G. S. (2014). *Applied and Economic Zoology*. Rastogi Publications, Meerut, India.
5. Winter, M. (2016). *Wildlife Biology*. Syrawood Publishing House.

Cellular Functions

ZOO401

Credit: 4

Course outcome: An in-depth knowledge on the critical biological functions that are requisite of normal cellular functions, and maintenance of life processes.

Theory

- Unit 1 Endocytosis; pinocytosis; phagocytosis; autophagy; exocytosis. P-type pumps, F-type pumps, ABC transporters. Aquaporins and bacteriorhodopsin.
- Unit 2 Protein import into mitochondrion and plastids. Vesicular transport. Protein sorting. Molecular chaperones.
- Unit 3 Structure and function of motor proteins: myosins; kinesins; dyneins. Structure and function of cilia and flagella; centrosomes; basal bodies. Nonmuscle motility: actin polymerisation.
- Unit 4 Mechanism of cytokinesis. Cell cycle checkpoints. Cyclins and CDKs. Cyclin-CDK regulation of cell cycle; transcriptional regulation of cell cycle – cell cycle inhibitors; structure and function of telomere; shelterin.

Suggested readings

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2022). *Molecular Biology of the Cell* (7th edition). Garland Publishing, London.
2. Gupta, P. K. (2017). *Cell and Molecular Biology* (5th edition). Rastogi Publications.
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M., and Killian, D. (2019). *Concepts of Genetics* (11th edition). Pearson Education
4. Krebs, J. E., Goldstein, E. S., and Kilpatrick, S. T. (2017). *Lewin's Genes XII*. Jones & Bartlett Publishers.
5. Lodish, H., Berck, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., and Matsudaira, P. (2016). *Molecular Cell Biology* (8th edition). W. H. Freeman.

Animal Biotechnology

ZOO402

Credit: 4

Course outcome: Knowledge on the uses and features of various scientific methods in the study of animals, and how they are used for human welfare.

Theory

- Unit 1 Concept of cell culture: types of animal cell lines; sterilisation methods; culture media; culture process.
- Unit 2 Assisted reproductive technology: Cryopreservation; intracytoplasmic sperm injection; in vitro fertilisation. Concept of stem cells and its application.
- Unit 3 Genetically modified animals – Principle, techniques, and notable examples. Cloning – Principle, techniques, and notable examples.
- Unit 4 Car T cell therapy. CRISPR and management of genetic diseases. Bioterrorism and biological weapons.

Suggested readings

1. Kammermeyer, K., and Clark, V. L. (2019). *Genetic Engineering Fundamentals: An Introduction to Principles and Applications*. CRC Press.
2. Lewis, R. (2020). *Human Genetics: Concepts and Applications* (12th edition). McGraw Hill.
3. Rastogi, S. C. (2019). *Bioinformatics Concepts Skills And Applications* (2nd edition). CBS Publishers & Distributors Pvt. Ltd.
4. Srivastava, A. K., and Singh, R. K. (2018). *Animal Biotechnology*. Rastogi Publications.
5. Tourte, Y., and Tourte, C. (2019). *Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications*. Science Publishers Inc.

Biotechniques and Bioinformatics

ZOO460

Credit: 4 [Theory 3 + Practicum 1]

Course outcome: Understanding the various technologies developed for investigating cellular process and the methods by which the cellular molecules are investigated.

Theory

- Unit 1 Concept of gene cloning. Enzymes in genetic engineering (restriction enzymes and DNA ligase). Gene library: Construction and application. Principles, types and applications of polymerase chain reaction technology.
- Unit 2 Blotting: western, northern and southern. Genome sequencing technologies: Sanger and next generation sequencing. DNA fingerprinting. Gene therapy: Basics of gene editing techniques, CRISPR-cas9.
- Unit 3 Basic on internet and database, Journal indexing Scopus and impact factor. Search engines; Genome and proteome databases: Gen Bank, PDBe and Pubmed; NCBI.
- Unit 4 Human genome project. Comparison of prokaryotic and eukaryotic genome, DNA barcoding: Principles and application. Phylogenetic analysis: Principle and application.

Practicum

1. Demonstration of PowerPoint presentation, word processing and statistical applications in MS Word and Excel.
2. Retrieval and comparison (BLAST) of nucleotide sequences.
3. Retrieval and comparison (BLAST) of protein sequences.
4. Phylogenetic analysis.
5. Comparative study of genomes of prokaryote and eukaryote.

Mark distribution of practicum for end semester examination

1. Experiment	25
2. Slide preparation/spotting (2 slides/models)	20
4. Laboratory record	10
5. Viva voce	20
TOTAL	75

Suggested readings

1. Kammermeyer, K., and Clark, V. L. (2019). *Genetic Engineering Fundamentals: An Introduction to Principles and Applications*. CRC Press.
2. Lewis, R. (2020). *Human Genetics: Concepts and Applications* (12th edition). McGraw Hill.
3. Rastogi, S. C. (2019). *Bioinformatics Concepts Skills And Applications* (2nd edition). CBS Publishers & Distributors Pvt. Ltd.
4. Srivastava, A. K., and Singh, R. K. (2018). *Animal Biotechnology*. Rastogi Publications.
5. Tourte, Y., and Tourte, C. (2019). *Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications*. Science Publishers Inc.

Biomolecules and Instrumentations

ZOO461

Credit: 4

Course outcome: Knowledge on the fundamental components of life forms and the types and uses of mechanical tools to study them.

Theory

- Unit 1 Carbohydrates – classification and general functions; structure of simple sugars; stereoisomerism; glycosidic bonds. Classification, structure and general functions of lipids; structure, biosynthesis and functions of cholesterol.
- Unit 2 Covalent bond, ionic bond, Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction. Chemical and biological properties of water. Classification and functions of vitamins, neurotransmitters, hormones, melanin, chlorophyll, anthocyanin, carotene.
- Unit 3 Principles and applications of light, fluorescence, confocal, electron microscopes. Freeze-etch and freeze fracture. ELISA, RIA, western blot, immunoprecipitation. Single neuron recording, patch-clamp recording, ECG, brain activity recording, PET, MRI, fMRI, CAT.
- Unit 4 Principles and biological applications of spectroscopy (mass, Raman, NIR, FTIR, NMR). Protein sequencing by MALDI-TOF. Principles and biological applications of chromatography (TLC, GC, HPLC).

Suggested readings

1. Katoch, R. (2014). *Analytical Techniques in Biochemistry and Molecular Biology*. Springer.
2. Kammermeyer, K., and Clark, V. L. (2019). *Genetic Engineering Fundamentals: An Introduction to Principles and Applications*. CRC Press.
3. Rastogi, S. C. (2019). *Bioinformatics Concepts Skills And Applications* (2nd edition). CBS Publishers & Distributors Pvt. Ltd.
4. Tourte, Y., and Tourte, C. (2019). *Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications*. Science Publishers Inc.
5. Wilson, K., Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.

Genetic Engineering

ZOO462

Credit: 4

Course outcome: Comprehension of the methods and tools used to analyse cellular components, the way they are experimentally changed and made use of.

Theory

- Unit 1 DNA modifying enzymes; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing. Labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes.
- Unit 2 Northern, Southern and colony hybridization; fluorescence *in situ* hybridization. Chromatin immunoprecipitation; DNA-protein interactions - electromobility shift assay; DNase foot printing.
- Unit 3 Plasmids; bacteriophage; pUC19 and bluescript vectors, phagemids; lambda vectors; insertion and replacement vectors; cosmids; YACs; BACs; vaccinia/bacculo and retroviral vectors; expression vectors.
- Unit 4 Methods of DNA delivery. Recombinant DNA technology. Applications of genetic engineering in agriculture, industry and pharmacy.

Suggested readings

1. Brown, T.A. (2016). *Gene Cloning and DNA Analysis: An Introduction* (7th edition). Wiley-Blackwell.
2. Kammermeyer, K., and Clark, V. L. (2019). *Genetic Engineering Fundamentals: An Introduction to Principles and Applications*. CRC Press.
3. Rastogi, S. C. (2019). *Bioinformatics Concepts Skills And Applications* (2nd edition). CBS Publishers & Distributors Pvt. Ltd.
4. Tourte, Y., and Tourte, C. (2019). *Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications*. Science Publishers Inc.
5. Wilson, K., Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.

Cellular Oncology

ZOO463

Credit: 4

Course outcome: Critical knowledge on the fundamental principles behind cancer and the development of cancerous cells, the roles of various factors in the disease.

Theory

- Unit 1 Properties and types of cancer cells; cancer stem cells. Group I carcinogens – carcinogenic chemicals, viruses, organisms. Mechanism of radiation-induced cancer. DNA methylation and histone modification. Mechanism of metastasis. Principle and application of Ames test.
- Unit 2 History and carcinogenicity of benzo(a)pyrene, diethylstilbestrol; mustard gas. Retinoblastoma, Philadelphia chromosome; Rous sarcoma virus; Epstein–Barr virus; human papillomavirus; Kaposi sarcoma-associated herpesvirus. Angiogenesis.
- Unit 3 Genetic rearrangements in progenitor cells; proto-oncogenes. Platelet-derived growth factor, tyrosine-protein kinases, Src, p53, Raf kinase, Ras proteins, AP-1 transcription factors, c-Myc; Knudson hypothesis; p53, BRCA1, BRCA2, retinoblastoma protein.
- Unit 4 Anticancer genes and their actions. Molecular mechanism of radiotherapy. Chemotherapy – alkylating antineoplastic agent; antimetabolites; anti-microtubule agents; anticancer viruses; topoisomerase inhibitors; cytotoxic antibiotics; Bcr-Abl tyrosine-kinase inhibitors.

Suggested readings

1. DeVita, V. T., Lawrence, T. S., Rosenberg, S. A. (2015). *Cancer: Principles & Practice of Oncology* (10th edition). Wolters Kluwer.
2. Kleinsmith, L. J. (2016). *Principles of Cancer Biology*. Pearson.
3. Pecorino, L. (2016). *Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics* (4th edition). Oxford University Press.
4. Tannock, I., Hill, R., Bristow, R., Harrington, L. (2013). *Basic Science of Oncology* (5th edition). McGraw-Hill
5. Weinberg, R. A. (2013). *The Biology of Cancer* (2nd edition). Garland Science.

Molecular Infectiology

ZOO464

Credit: 4

Course outcome: Methodical understanding of cellular activities and interaction in various infections, and the effects of the infectious agents on the cellular components.

Theory

- Unit 1 Host-parasite interaction. Koch's postulates. Structure, transmission, and pathology of HIV, *Variola*, *Flavivirus*, Ebola; SARS coronavirus. Immune response during tuberculosis, fungal, protozoan and HIV infections; viral-induced cell transformation.
- Unit 2 Prions: structure, function, pathology. History, biology and pathogenicity of *Mycobacterium tuberculosis*; *Staphylococcus aureus*, *Clostridium botulinum*, *Helicobacter pylori*, *Yersinia pestis*; *Rickettsia prowazekii*; *Naegleria fowleri*. Bacterial secretion systems. Mechanism of bacterial infection.
- Unit 3 Structure and function of membrane attack complex. Adaptation in *Trypanosoma* – variant surface glycoproteins. Structure and functions *Plasmodium falciparum* knob, circumsporozoite protein, merozoite surface proteins, RIFINs, PfEMP1, SURFIN, STEVOR, PfMC-2TM; role of Duffy antigen in malaria.
- Unit 4 Immune evasion in *Leishmania*. *Taenia solium* in neurocysticercosis. Life cycle and carcinogenicity of *Schistosoma haematobium*, *Clonorchis sinensis*, *Opisthorchis viverrini*. Life cycle and host manipulation by *Toxoplasma gondii*, chordodid worms, *Leucochloridium*, acanthocephalans.

Suggested readings

1. Bennett, J. E., Dolin, R., Blazer, M. R. (2014). *Mandell, Douglas and Bennett's Principles and Practice of Infectious Diseases Vol 1 & 2* (8th edition). Elsevier Health.
2. Carroll, K. C., Hobden, J. A., Miller, S., Mietzner, T. A., Morse. S. A. (2015). *Jawetz, Melnick & Adelberg's Medical Microbiology* (27th edition). McGraw-Hill.
3. Hawley, L. B., Clarke, B., Ziegler, R. J. (2013). *Microbiology and Immunology* (5th edition). Lippincott Williams and Wilkins.
4. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., Stahl, D. A. (2017). *Brock Biology of Microorganisms* (14th edition). Pearson.
5. Procop, G. W., Koneman, E. W. (2016). *Koneman's Color Atlas and Textbook of Diagnostic Microbiology* (7th edition). Lippincott Williams and Wilkins.