

**Mizoram University**  
**Choice-Based Credit and Grading System (CBCS)**  
**for**  
**Under-Graduate**

**Zoology**

**2016**

**Regulations in brief**

- The Under-Graduate course consists of 3 years; each year with 2 semesters.
- Each semester carries 700 marks and the total marks for the entire course is 4400.
- Each paper in science carries 200 marks; 100 for theory and 100 for practical.
- Duration of theory class is 1 hr, and practical is 2 hr.
- Each paper comprises 5 units and total contact hour is 50.
- Two consecutive (one odd + one even) semesters constitutes one academic year.
- Working days in each semester is to be not less than 90 excluding holidays/ sports/ vacations, if any.
- No candidate is allowed to appear in any course more than 3 times, and no candidate is allowed beyond 10 semesters of his/her admission. [AC 24/4/2016: As many attempts as possible within the allotted time frame is allowed]
- University registration will be in the first semester itself.
- Candidate can proceed to next semester irrespective of failure, but on condition that he/she appears for the arrear paper along with the concerned semester examination.
- Candidate is eligible to appear in the end semester examination only if he/she attended a minimum of 75% attendance and 140 credits, with a distribution of credits for different course categories as given in following **Table 1**.
- Eligibility for admission: Pass in higher secondary examination (science) or its equivalent from recognized board.
- Semester 1-4 are general papers (shared with other departments i.e., Botany, Zoology and Chemistry students) and semester 5&6 are core papers, studied by core students only.

**Conduct of exams:** Examinations shall be conducted by the university.

**Credit:** A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit shall mean one hour of teaching (lecture or tutorial) or two hours of laboratory / practical work per week in a semester of 18 weeks.

**Classification of success:**

- A candidate must secure 40% of marks both in theory and practical for each paper.
- A candidate must secure a minimum of 40% marks (equivalent Grade 'C') in each semester.
- The marks obtained in all 6 semesters (in all the courses) shall be taken into account for final result.
- Grades shall be awarded on the basis of marks obtained in each semester.
- Cumulative Grade Point Average (CGPA) shall be awarded on the basis of grades obtained in all semesters.

**Table 1. Course categories and distribution of Credits**

<b>S. No.</b>	<b>Course Category</b>	<b>Credits</b>
1.	Foundation Courses (FC)	20
2.	Major Core Courses (CC)	72
3.	*Elective Core Courses (EC)	48
	<b>Total</b>	<b>140</b>

**Ranking:** Top 10 candidates passed in First Class in the first appearance itself alone are eligible for ranking.

**Continuous Assessment:**

For theory paper

Component	Total marks
Class test (best one out of two)	10
Assignment/seminar/project, etc	10
Regularity in the class	5
<b>Grand Total</b>	<b>25</b>

For practical paper

Evaluation in lab + record	8
End semester test	12
Regularity in the class	5
<b>Grand Total</b>	<b>25</b>

Attendance assessment

Attendance	Marks
90% and above	5
85-89.9%	4
80-84.9%	3
76-79.9%	2
75-75.9%	1

Question pattern

Section	Total question	No to be answered	Mark for each question	Total marks
A. Objective/multiple choice	10 (2 per unit)	10	1	10
B. Short note	10 (2 per unit)	5 (1 per unit)	3	15
C. Descriptive	10 (2 per unit)	5 (1 per unit)	10	50
<b>GTT</b>				<b>75</b>

**Grading and ranking system**

Grade Value	Classification	Annotation	Marks (%)
10	Outstanding	O	89.5-100
9	Excellent	A <sup>+</sup>	79.5-89.4
8	Very Good	A	69.5-79.4
7	Good	B <sup>+</sup>	59.5-69.4
6	Average	B	49.5-59.4
5	Pass	C	39.5-49.4
0	Fail	F	<39.5

**Final Grade Point**

CGPA	Division
8-10	Distinction
6.5-<8	First
5-<6.5	Second
<5	Failed

## Course Structure for Zoology Student

Semester	Course	Course code	Papers	Category	Credit	Continuous Assessment	End-semester	Total
I	English- I	ENG/I/EC/01	History of English	FC	5	25	75	100
	Core Subject 1	ZOO/I/EC/01	Biosystematics and Non-chordate Biology	Core	4	25	75	100
		ZOO/I/EC/02	Practical	Core	2	25	75	100
	Elective Subject 2	Chem	Course I - Theory	EC	4	25	75	100
			Course II - Practical	EC	2	25	75	100
	Elective Subject 3	Geol/Bot	Course I - Theory	EC	4	25	75	100
			Course II - Practical	EC	2	25	75	100
				<b>Total</b>	<b>23</b>	<b>175</b>	<b>525</b>	<b>700</b>
II	English- II	ENG/II/EC/02	History of English	FC	5	25	75	100
	Core Subject 1	ZOO/II/EC/03	Chordate Biology and Anatomy	Core	4	25	75	100
		ZOO/II/EC/04	Practical	Core	2	25	75	100
	Elective Subject 2	Chem	Course III - Theory	EC	4	25	75	100
			Course IV - Practical	EC	2	25	75	100
	Elective Subject 3	Geol/Bot	Course III- Theory	EC	4	25	75	100
			Course IV - Practical	EC	2	25	75	100
				<b>Total</b>	<b>23</b>	<b>175</b>	<b>525</b>	<b>700</b>
III	History of Science			FC	5	25	75	100
	Core Subject 1	ZOO/III/EC/05	Evolution and Ethology	Core	4	25	75	100
		ZOO/III/EC/06	Practical	Core	2	25	75	100
	Elective Subject 2	Chem	Course V - Theory	EC	4	25	75	100
			Course VI - Practical	EC	2	25	75	100
	Elective Subject 3	Geol/ Bot	Course V - Theory	EC	4	25	75	100
			Course VI - Practical	EC	2	25	75	100
				<b>Total</b>	<b>23</b>	<b>175</b>	<b>525</b>	<b>700</b>
IV	Environmental Studies			FC	5	25	75	100
	Core Subject 1	ZOO/IV/EC/07	Endocrinology and Reproduction Biology	Core	4	25	75	100
		ZOO/IV/EC/08	Course VIII - Practical	Core	2	25	75	100
	Elective	Chem	Course VII - Theory	EC	4	25	75	100

	Subject 2		Course VIII - Practical	EC	2	25	75	100	
	Elective Subject 3	Geol/Bot	Course VII -Theory	EC	4	25	75	100	
			Course VIII - Practical	EC	2	25	75	100	
				<b>Total</b>	<b>23</b>	<b>175</b>	<b>525</b>	<b>700</b>	
V	Major Core	ZOO/V/CC/09	Cell Biology	Core	4	25	75	100	
		ZOO/V/CC/10	Practical	Core	2	25	75	100	
	Major Core	ZOO/V/CC/11	Physiology	Core	4	25	75	100	
		ZOO/V/CC/12	Practical	Core	2	25	75	100	
	Major Core	ZOO/V/CC/13	Biochemistry	Core	4	25	75	100	
		ZOO/V/CC/14	Practical	Core	2	25	75	100	
	Major Core (Option A or B)	ZOO/V/CC/15(A)	Applied Zoology	Core	4	25	75	100	
		ZOO/V/CC/16(A)	Practical	Core	2	25	75	100	
		ZOO/V/CC/15(B)	Entomology	"	"	"	"	"	
		ZOO/V/CC/16(B)	Practical	"	"	"	"	"	
					<b>Total</b>	<b>24</b>	<b>200</b>	<b>600</b>	<b>800</b>
	VI	Major Core	ZOO/VI/CC/17	Molecular Biology and Genetics	Core	4	25	75	100
ZOO/VI/CC/18			Practical	Core	2	25	75	100	
Major Core		ZOO/VI/CC/19	Developmental Biology	Core	4	25	75	100	
		ZOO/VI/CC/20	Practical	Core	2	25	75	100	
Major Core		ZOO/VI/CC/21	Parasitology and Immunology	Core	4	25	75	100	
		ZOO/VI/CC/22	Practical	Core	2	25	75	100	
Major Core (Optional A or B)		ZOO/VI/CC/23(A)	Biotechnology and Bioinformatics	Core	4	25	75	100	
		ZOO/VI/CC/24(A)	Practical	Core	2	25	75	100	
		ZOO/VI/CC/23(B)	Ecology and Wildlife	"	"	"	"	"	
		ZOO/VI/CC/24(B)	Practical	"	"	"	"	"	
				<b>Total</b>	<b>24</b>	<b>200</b>	<b>600</b>	<b>800</b>	
<b>Entire Programme</b>				<b>Total</b>	<b>140</b>	<b>1100</b>	<b>3300</b>	<b>4400</b>	

**Points to remember:**

1. The number of classes allocated for theory is 50 hrs, class=1 hrs; each unit = 10 classes. Practical is 2 h.
2. \* Indicates optional (either A or B) for students in the V and VI semesters.

## CBCS Zoology Syllabus

Semester	Course No	Course name	Category	Credit	CA	ESE	Total
I	ZL I	Biosystematics and Non-chordate Biology	EC	4	25	75	100
	ZL II	Practical	EC	2	25	75	100
II	ZL III	Chordate Biology and Anatomy	EC	4	25	75	100
	ZL IV	Practical	EC	2	25	75	100
III	ZL V	Evolution and Ethology	EC	4	25	75	100
	ZL VI	Practical	EC	2	25	75	100
IV	ZL VII	Endocrinology and Reproduction Biology	EC	4	25	75	100
	ZL VIII	Practical	EC	2	25	75	100
V	ZL IX	Cell Biology	CC	4	25	75	100
	ZL X	Practical	CC	2	25	75	100
	ZL XI	Physiology	CC	4	25	75	100
	ZL XII	Practical	CC	2	25	75	100
	ZL XIII	Biochemistry	CC	4	25	75	100
	ZL XIV	Practical	CC	2	25	75	100
	ZL XV A*	Applied Zoology	CC	4	25	75	100
	ZL XVI A*	Practical	CC	2	25	75	100
	ZL XV B*	Entomology	CC	4	25	75	100
	ZL XVI B*	Practical	CC	2	25	75	100
	ZL XVII	Molecular Biology and Genetics	CC	4	25	75	100
	ZL XVIII	Practical	CC	2	25	75	100
VI	ZL XIX	Developmental Biology	CC	4	25	75	100
	ZL XX	Practical	CC	2	25	75	100
	ZL XXI	Parasitology and Immunology	CC	4	25	75	100
	ZL XXII	Practical	CC	2	25	75	100
	ZL XXIII A*	Biotechnology and Bioinformatics	CC	4	25	75	100
	ZL XXIV A*	Practical	CC	2	25	75	100
	ZL XXIII B*	Ecology and Wildlife	CC	4	25	75	100
	ZL XXIV B*	Practical	CC	2	25	75	100

\* to be offered as optional, either A or B

## ZL I: Biosystematics and Non-chordate Biology

### Theory

- Unit I. Principles of classification: binominal nomenclature; species concepts; taxonomic hierarchy; five kingdom classification; six kingdom classification; three domains system.
- Unit II. Classification of non-chordates up to classes with their salient features. Protozoa: locomotion (amoeboid, cell crawling, ciliary and flagellar); types of reproduction; conjugation in *Paramecium*.
- Unit III. Origin of Metazoa. Metamerism. Symmetry in animals. Coelom. Corals and coral reefs. Canal system in poriferans. Polymorphism in Hydrozoa.
- Unit IV. Characters and affinities of Ctenophora and Onychophora. Reproductive systems in Platyhelminthes and Nematoda. Annelida: *Pheretima posthuma* – reproductive and excretory systems.
- Unit V. Mollusca: torsion and detorsion in Gastropoda. Arthropoda: *Periplaneta americana* – circulatory and excretory systems; insect metamorphosis and social organisation. Echinodermata: *Asterias* – water vascular system and life history.

### Suggested reading

1. Jordan, E.L., and Verma, P. S. (2010). *Invertebrate Zoology*. S. Chand and Company Ltd, New Delhi.
2. Kotpal, R. L. (2014). *Modern Textbook of Zoology: Invertebrates* (11<sup>th</sup> edition). Rastogi Publications, Meerut, India.
3. Mayr, E., and Ashlock, P. D. (1991). *Principles of Systematic Zoology* (2<sup>nd</sup> edition). McGraw-Hill.
4. Moore, J. (2006). *An Introduction to the Invertebrates* (2<sup>nd</sup> edition). Cambridge University Press.
5. Pechenik, J. (2014). *Biology of the Invertebrates* (7<sup>th</sup> Edition). McGraw-Hill Education.
6. Kapoor, V. C. (2001). *Principles and Practices of Animal Taxonomy* (2<sup>nd</sup> edition). Science Publishers Inc.

## ZL II: Practical

1. Specimen study: one representative from each major phyla of non-chordate.
2. Multimedia demonstration/dissection of digestive system of earthworm.
3. Multimedia demonstration/dissection of nervous system of (either) prawn or cockroach.
4. Preparation and comparison of insect (mosquito, housefly, fruitfly) mouthparts on temporary slides.
5. Description of spicules of sponges, and statocyst of prawn from slide/model.

### Mark distribution of practical for end semester examination

1. Anatomy, display and diagram	20
2. Slide preparation/quadrat and description	20
3. Spotting (5 specimens)	25
4. Laboratory record	10
TOTAL	75

## ZL III: Chordate Biology and Anatomy

### Theory

- Unit I. Classification of Chordata up to classes with salient features. Protochordata: salient features and affinities; embryonic development of *Branchiostoma*; circulatory system of *Herdmania*.
- Unit II. Pisces: types of scales; types of locomotion; types of migration; sense organs in *Scoliodon*. Amphibia: neoteny and paedogenesis; respiratory system and respiration in *Rana tigrina*.
- Unit III. Reptilia: snake venom, poison apparatus and biting mechanism. Aves: affinities; structure, types, uses and development of feathers in *Columba livia*; principle and modes of flight.
- Unit IV. Mammalia: Rabbit – structure of brain; structure of eye; digestive system. Receptor organs. Structure of integuments and types of their derivatives in vertebrates.
- Unit V. Structure and composition of cartilage, bone and ligaments. Dentition in mammals. Modification of heart. Respiratory organs: structure and types of gill, lung and air ducts.

### Suggested reading

1. Jordan, E. L., and Verma, P. S. (2010). *Chordate Zoology*. S. Chand and Company Ltd, New Delhi.
2. Kardong, K. (2014). *Vertebrates: Comparative Anatomy, Function, Evolution* (7<sup>th</sup> edition). McGraw-Hill.
3. Kisia, S. M. (2010). *Vertebrates: Structures and Functions (Biological Systems in Vertebrates)*. Science Publishers, CRC Press.
4. Kotpal, R. L. (2009). *Modern Textbook of Zoology: Vertebrates* (10<sup>th</sup> edition). Rastogi Publications, Meerut, India.
5. Pough, F. H., Janis, C. M., and Heiser, J. B. (2012). *Vertebrate Life* (9<sup>th</sup> Edition). Benjamin Cummings.
6. Sherwood, Y. K. (2012). *Animal Physiology: From Genes to Organisms*. Cengage.

### ZL IV: Practical

1. Museum specimens: representatives from protochordates (1 from each sub-phyla) and chordates (1 from each class).
2. Osteology using pigeon and rabbit
  - a) Atlas, axis and sacral vertebrae.
  - b) Limb bones.
  - c) Skull.
3. Preparation and temporary mounting of
  - a) Filoplume feather
  - b) Scales of fishes.
4. Model demonstration and description of
  - a) Internal ear of *Scoliodon*.
  - b) Hyoid apparatus of frog/toad.
5. Multimedia/model demonstration of circulatory and reproductive systems of rat/mouse.
6. Multimedia/model demonstration of flight muscles.

### Mark distribution of practical for end semester examination

1. From experiment 3 & 4	20
2. From experiment 5 & 6	20
3. Spotting (3 specimens + 2 bones)	25
4. Laboratory record	10
TOTAL	75

## ZL V: Evolution and Ethology

### Theory

- Unit I. The theory of natural selection. Evolution in action: beak variation in Darwin's finches; industrial melanism in peppered moth; sickle cell trait and resistance to malaria; high-altitude adaptation in humans. Concept of speciation.
- Unit II. Prebiotic soup theory and Miller's experiment. RNA World hypothesis. Symbiogenesis and its examples (*Angomonas deanei*, *Mixotricha paradoxa*). Zoo-geological time scale. Cambrian explosion and major fauna. Dinosaurs – major types and extinction.
- Unit III. Major Hominin fossils. Mitochondrial Eve and Y-chromosomal Adam. Out of Africa theory. Zoogeographical realms. Mimicry: aggressive, Batesian and Müllerian. Colouration: aposematism and camouflage.
- Unit IV. Concept of ethology. Types of behaviour – innate, imprinting, and learned (Pavlov's conditioning). Altruism and reciprocal altruism. Communication: infrasound; echolocation; dancing in bees.
- Unit V. Hormonal control of bee society. Parental investment and territoriality in vertebrates. Evolutionary arms race. Hormonal control of behaviour – roles of melatonin, oxytocin, adrenaline and noradrenaline, and steroids. Hormonal basis of sex change.

### Suggested reading

1. Alcock, J. (2013). *Animal Behavior: An Evolutionary Approach* (10<sup>th</sup> edition). Sinauer Associates Inc.
2. Futuyma, D. J. (2013). *Evolution* (3<sup>rd</sup> edition). Sinauer Associates Inc.
3. Hall, B. K., and Hallgrímsson, B. (2013). *Strickberger's Evolution* (5<sup>th</sup> edition). Jones and Bartlett Publishers.
4. Mathur, R., and Singh, S. P. (2008). *Evolution and Behaviour*. Rastogi Publications, Meerut, India.
5. Ridley, M. (2003). *Evolution* (3<sup>rd</sup> edition). Blackwell Publishing Inc.
6. Mandal, F. K. (2012). *Textbook of Animal Behaviour*. PHI Learning Private Limited, New Delhi, India.

### ZL VI: Practical

1. Study of important invertebrate fossils from specimen/models/pictures.
2. Study of important vertebrate fossils from specimen/models/pictures.
3. Technique of paper chromatography with emphasis on Miller's experiment.
4. Study of caste system in insects.
5. Study of important morphological adaptations (volant, aquatic and desert) among vertebrates.

#### Mark distribution of practical for end semester examination

1. Experiment (from 3 or 4)	20
2. Description and diagram (from 5)	20
3. Spotting (5 specimens)	25
4. Laboratory record	10
TOTAL	75

## ZL VII: Endocrinology and Reproduction Biology

### Theory

- Unit I. Endocrine glands and the functions of their hormones (hypothalamus, pituitary, thyroid, pancreas, adrenal, testis, ovary). Endocrine disorders: diabetes mellitus, gigantism, dwarfism and cretinism. Classification of hormones. Transport of hormones.
- Unit II. Hormone receptors: G-protein coupled, steroid, insulin. Mechanism of action of steroid hormones, peptide hormones, and insulin.
- Unit III. Biological rhythms: circadian and circannual; hormonal regulations. Hormonal regulation of calcium homeostasis; glucose homeostasis; parturition.
- Unit IV. Gametogenesis: spermatogenesis and oogenesis; hormonal regulation of gametogenesis. Pheromones and their effects.
- Unit V. Estrous and menstrual cycles: phases and hormonal regulation. Hormonal basis of contraception. Nature, uses and effects of anabolic steroids.

### Suggested reading

1. Hadley, M. E., and Levine, J. (2009). *Endocrinology* (6<sup>th</sup> edition). Pearson.
2. Kronenberg, H. M., Melmed, S., Polonsky, K. S., and Larsen, P. R. (2007). *Williams Textbook of Endocrinology* (11<sup>th</sup> edition). W. B. Saunders Company.
3. Norman, A. W., and Litwack, G. (1997). *Hormones* (2<sup>nd</sup> edition). Academic Press.
4. Norris, D. O. (2006). *Vertebrate Endocrinology* (4<sup>th</sup> Edition). Academic Press.
5. Sastry, K. V. (2009). *Endocrinology and Reproductive Biology*. Rastogi Publications, Meerut, India.
6. Yadav, M. (2008). *Animal Endocrinology*. Discovery Publishing House Pvt Ltd., India.

### **ZL VIII: Practical**

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 from cockroach.

#### **Mark distribution of practical for end semester examination**

1. Identification with diagram (from 2 or 3)	20
2. Identification with diagram (from 4 or 5)	20
3. Spotting (5 specimens)	25
4. Laboratory record	10
TOTAL	75

## ZL IX: Cell Biology

### Theory

- Unit I. Cell theory – tenets and limitations. Structure of prokaryotic and eukaryotic cells. Cell membrane – fluid mosaic model; membrane transport (simple, facilitated and active transports).
- Unit II. Structure, composition and functions of ribosomes, endoplasmic reticulum, Golgi complex, lysosome and peroxisome.
- Unit III. Structure and functions of mitochondria; cytoskeletons: microfilaments, intermediate filaments and microtubules. Endocytosis. Phagocytosis.
- Unit IV. Extracellular matrix. Cell-cell interactions: adhesion and junctions. Nuclear envelope: structure and transport of molecules. Nucleolus. Chromosome structure. Karyotype.
- Unit IV. Stages of cell cycle; regulation of cell cycle through cyclin-CDK complexes. Meiosis. Types and characteristics of cancer; carcinogens.

### Suggested reading

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2014). *Molecular Biology of the Cell* (6<sup>th</sup> edition). Garland Publishing, London.
2. Gupta, P. K. (2008). *Cell and Molecular Biology*. Rastogi Publications, Meerut, India.
3. Karp, G. (2013). *Cell and Molecular Biology* (7<sup>th</sup> 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. (2012). *Molecular Cell Biology* (7<sup>th</sup> edition). W. H. Freeman.
5. Verma, P. S. (2010). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*. S. Chand and Company Ltd, New Delhi.
6. Wood, E. J., and Smith, C. A. (2005). *Cell Biology* (2<sup>nd</sup> edition). BIOS Scientific Publishers.

### **ZL X: Practical**

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

#### **Mark distribution of practical for end semester examination**

1. Slide preparation and identification	20
2. Histology	10
3. Spotting (5 slides/models)	25
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XI: Physiology

### Theory

- Unit I. Digestion and absorption of food: extracellular and intracellular digestions; digestion of carbohydrates, proteins and fats. Respiration: mechanism in gills and lungs; types of respiration – external, internal, and cutaneous.
- Unit II. Open and closed circulation; structure of heart: myogenic and neurogenic; pacemaker; cardiac cycle. Blood coagulation. Blood groups. Structure and function of haemoglobin.
- Unit III. Structure and function of kidney: urine formation; physiology of micturition. Osmoregulation in marine and terrestrial vertebrates. Nitrogenous wastes: ammonotelic, uricotelic and ureotelic.
- Unit IV. Types of muscles and ultrastructures; muscle proteins; mechanism of muscle contraction – sliding filament theory; cross-bridge model. Muscle fatigue. Isotonic and isometric contractions.
- Unit V. Types and structures of neuron; resting and action potentials; propagation of nerve impulse; major neurotransmitters; structure of synapse; synaptic transmission.

### Suggested reading

1. Hill, R. W., Wyse, G. A., and Anderson, M. (2008). *Animal Physiology* (2<sup>nd</sup> edition). Sinauer Associates, Inc.
2. Goyal, K. A., and Sastry, K. V. (2008). *Animal Physiology*. Rastogi Publications, Meerut, India.
3. Kardong, K. (2005). *Vertebrates: Comparative Anatomy, Function, Evolution* (4<sup>th</sup> edition). McGraw-Hill.
4. Moyes, C. D., and Schulte, P. M. (2013). *Principles of Animal Physiology* (2<sup>nd</sup> edition). Benjamin Cummings.
5. Randall, D., Burggren, W., and French, K. (2001). *Eckert Animal Physiology* (5<sup>th</sup> edition). W. H. Freeman and Company.
6. Yancy, P. H., Sherwood L., and Klandorf, H. (2012). *Animal Physiology: From Genes to Organisms* (2<sup>nd</sup> edition):. Cengage Learning, Inc.

### ZL XII: Practical

1. Study of histological slides of stomach, intestine, lung, kidney and gonads of mammals.
2. R.B.C. and W.B.C. total count.
3. Estimation of haemoglobin and determination of ABO and Rh blood groups.
4. Preparation of haemin crystals.
5. Stained preparations of smooth and skeletal muscles.
6. Demonstration of salivary amylase activity, with effect of pH and temperature.

#### Mark distribution of practical for end semester examination

1. Experiment	20
2. Slide preparation and identification	15
3. Spotting (4 slides/models)	20
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XIII: Biochemistry

### Theory

- Unit I. Carbohydrates and lipids: classification and significance. classification, structure and properties of amino acids and peptides.
- Unit II. Types, properties and kinetics of enzymes; inhibition; Michaelis-Menten equation; coenzymes; ribozyme. Types and properties of vitamins.
- Unit III. Glycolysis: reactions and significance. Glycogenesis. Glycogenolysis. Gluconeogenesis.
- Unit IV. Oxidative phosphorylation: tricarboxylic cycle; electron transport chain, ATP synthesis. HMP shunt.
- Unit V.  $\beta$ -oxidation of fatty acids. Lipogenesis. Urea cycle. Ketogenesis. Nucleic acids and their metabolism.

### Suggested reading

1. Garrett, R. H., and Grisham, C. M. (2008). *Biochemistry* (4<sup>th</sup> edition). Brooks Cole.
2. Gupta, S. N. (2009). *A Textbook of Biochemistry*. Rastogi Publications, Meerut, India.
3. Nelson, D. L., and Cox, M. (2008). *Lehninger Principles of Biochemistry* (5<sup>th</sup> edition). W.H. Freeman & Company.
4. Purohit, S. S. (2009). *Biochemistry: Fundamental and Application*. Agrobios, India.
5. Stryer, L., Berg, J. M., and Tymoczko, J. L. (2006). *Biochemistry* (6<sup>th</sup> edition). W.H. Freeman & Company.
6. Voet, D., and Voet, C. (2004). *Biochemistry* (3<sup>rd</sup> edition). John Wiley & Sons Inc., New Jersey, USA.

### ZL XIV: Practical

1. Detection of carbohydrates, proteins and lipids (at least 2 tests each).
2. Estimation of ascorbic acid from citrus fruit by titration.
3. Estimation of proteins by biuret methods.
4. Estimation of proteins by Lowry's method.
5. Estimation of total carbohydrates/glucose/amylose.

#### Mark distribution of practical for end semester examination

1. Experiment (from 2 or 3)	20
2. Experiment (from 4 or 5)	20
3. Identification of 3 samples (from 1)	15
3. Laboratory record	10
4. Viva voce	10
TOTAL	75

## ZL XV A: Applied Zoology

### Theory

- Unit I. Apiculture: classifications and types of bees, structure and composition of hive, rearing method and economic importance. Sericulture: culturable silkworms, rearing method and economic importance.
- Unit II. Types of pesticides; pest control (natural, chemical and biological controls); integrated pest management. vermicomposting - vermicomposting species; methods.
- Unit III. Fish farm: structure; maintenance of ponds; physico-chemical properties of water. Integrated fish farming.
- Unit IV. Adaptation in fishes (deep sea and hill streams). Important cultivable fishes. Predatory and weed fishes and their control. Threatened and endangered species.
- Unit V. Breeding in fishes - natural and induced breeding; ecological and hormonal influence on maturation and spawning. Fish seed production and transport; preservation and processing techniques. Ornamental fish.

### Suggested reading

1. Jhingran, V. G. (2002). *Fish and Fisheries of India*. Hindustan Publishing Corporation, Delhi, India.
2. Nelson, J. S. (2006). *Fishes of the World* (4th edition). John Wiley & Sons, Inc., New Jersey, USA.
3. Pandey, K., and Shukla, J. P. (2007). *Fish and Fisheries* (2<sup>nd</sup> edition). Rastogi Publications, Meerut, India.
4. Pandey, B. N., Trivedi, S. P., Jaiswal, K., and Kaur, N. (2009). *Fish and Fisheries*. Sarup Book Publishers.
5. Shammi, Q. J., and Bhatnagar, S. (2010). *Applied Fisheries*. Agrobios, India.
6. Thangadurai, D., and Hall, S. G. (2010). *Fisheries, Aquaculture and Biotechnology*. Agrobios, India.

### **ZL XVI A: Practical**

1. Morphometric and meristic studies of commercially available fish.
2. Qualitative and quantitative studies of planktons.
3. Dissection to display internal organs and analysis of gut contents of fish.
4. Slide preparation of scales of fish.
5. Field visit to fish farm.

#### **Mark distribution of practical for end semester examination**

1. Experiment (from 1 or 2)	20
2. Experiment (from 3 or 4)	20
3. Field visit report	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XV B: Entomology

### Theory

- Unit I. Insecta: classification with general characters; methods of collection and preservation; Identification of major insect pests.
- Unit II. Insect physiology: digestive, respiratory and reproductive organs; body wall and mouthparts; respiration.
- Unit III. Social behaviour and caste system in insects; metamorphosis: hemimetabolous, holometabolous and ametabolous with examples; hormonal regulation of metamorphosis.
- Unit IV. Insect hormones: types, mechanism of action, biological effects and their applications; economically important insects: honey bee, lac, silkworm.
- Unit V. Parasitic and predatory insects and their effects; control of insect pests and parasites (natural, chemical, biological and integrated methods).

### Suggested reading

1. Agarwal, S. (2009). *Applied Entomology*. Oxford Book Company.
2. Chapman, R. F. (2008). *The Insects: Structure and Function*. Cambridge University Press.
3. Footitt, G., and Adler, P. H. (2009). *Insect Biodiversity*. Blackwell Publishing Ltd., UK.
4. Gillott, C. (2005). *Entomology* (3<sup>rd</sup> edition). Springer, the Netherlands.
5. Gullan, P. J., Cranston, P. S., and McInnes, K. H. (2010). *Insects: an Outline of Entomology* (4th edition). Wiley-Blackwell.
6. Kotpal, R. L. (2009). *Modern Textbook of Zoology: Invertebrates* (10<sup>th</sup> edition). Rastogi Publications, Meerut, India.

### ZL XVI B: Practical

1. Study of important insects from specimens/permanent slides/models.
2. Dissection and display of endocrine glands.
3. Dissection and display of reproductive, nervous and digestive systems of cockroach.
4. Preparation of mouthparts of housefly and mosquito.
5. Identification of locally available insects, at least up to order.
6. Collection, preservation and display of insects.

#### Mark distribution of practical for end semester examination

1. Experiment/dissection	20
2. Spotting and identification (4 specimens)	20
3. Submission of collection	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XVII: Molecular Biology and Genetics

### Theory

- Unit I. Structure and types of DNA and RNA. Chromosomes: chromatin (euchromatin and heterochromatin). Higher order of chromosome organization – nucleosomes; special types of chromosomes (polytene and lampbrush chromosomes).
- Unit II. DNA replication: semiconservative and mechanism in prokaryotic cells. DNA repair: nucleotide excision; base excision; mismatch; double strand breakage.
- Unit III. Gene expression: central dogma of molecular biology; transcription. Genetic code. Translation. Concept of operon: lac operon.
- Unit IV. Mendelian genetics; incomplete dominance; co-dominance. Chromosome theory of inheritance. Cytoplasmic inheritance. Pleiotropism and allelism; epistasis; multiple alleles.
- Unit V. Linkage, crossing over and recombination of genes. Chromosomal sex determination. Sex-linked inheritance and non-disjunction. Mutation: causes and types. Genetic disorders: Down, Klinefelter and Turner syndromes, and haemophilia.

### Suggested reading

1. Albert, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2014). *Molecular Biology of the Cell* (6<sup>th</sup> edition). Garland Publishing, London.
2. Gupta, P. K. (2009). *Genetics*. Rastogi Publications, Meerut, India.
3. Krebs, J. E., Goldstein, E. S., and Kilpatrick, S. T. (2013). *Lewin's Genes XI*. Jones & Bartlett Publishers.
4. Lodish, H., Berck, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., and Matsudaira, P. (2012). *Molecular Cell Biology* (7<sup>th</sup> edition). W. H. Freeman.
5. Snustad, D. P., and Simmons, M. J. (2011). *Principles of Genetics* (6<sup>th</sup> edition). John Wiley & Sons Inc.
6. Watson, J. D., Baker, T. A., Bell, S. P., and Gann, A. (2013). *Molecular Biology of the Gene* (7<sup>th</sup> edition). Benjamin Cummings.

### ZL XVIII: Practical

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 RNA.
5. Quantitative estimation of DNA.

#### Mark distribution of practical for end semester examination

1. Experiment	20
2. Slide preparation and identification	20
3. Spotting and identification (3 slides/models)	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XIX: Developmental Biology

### Theory

- Unit I. Structure of spermatozoon and ovum. Types of eggs. Fertilization *in vivo* and *in vitro*. Parthenogenesis. Patterns of cleavage.
- Unit II. Blastulation and gastrulation in frog. Fate maps. Types and functions of placenta in mammals. Extra-embryonic membranes in chick.
- Unit III. Concept of organizer and induction. Morphogenetic fields and gradients. Invagination, ingression, involution and delamination.
- Unit IV. Metamorphosis in insects and amphibians and their hormonal regulation. Regeneration in invertebrates and vertebrates. Hox genes and their functions in *Drosophila*.
- Unit V. Concepts and models of ageing. Congenital disorders. Concept of transgenesis. Stem cells.

### Suggested reading

1. Gilbert, S. (2010). *Developmental Biology* (9<sup>th</sup> edition). Sinauer Associates, Inc.
2. Mitchell, B., Sharma, R., and Britton, R. (2009). *Embryology*. Churchill Livingstone.
3. Parasher, Y. K. (2009). *Developmental Biology*. Campus Books International.
4. Sadler, S. L. (2010). *Langman's Medical Embryology* (11<sup>th</sup> edition). Lippincott.
5. Verma, P. S., and Agarwal, V. K. (2006). *Chordate Embryology: Developmental Biology*. S. Chand and Company Ltd., New Delhi.
6. Wolpert, L., Smith, J., Jessell, T., Lawrence, P., Roberson, E., and Meyerowitz, E. (2006). *Principles of Development* (3<sup>rd</sup> edition). Oxford University Press, USA.

### ZL XX: Practical

1. Study of cleavage, blastula and gastrula of frog from specimen/model.
2. Permanent preparations of invertebrate larvae (*Zoea*, *Mysis*, *Nauplius*, *Glochidium*, etc.).
3. Study of different stages of development of chick embryo.
4. Preparation of whole mount of chick embryo (different stages).
5. Demonstration of regeneration in *Planaria/Hydra* or tail of tadpole/lizard.

#### Mark distribution of practical for end semester examination

1. Experiment	20
2. Slide preparation and identification	20
3. Spotting and identification (3 slides/models)	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XXI: Parasitology and Immunology

### Theory

- Unit I. Introduction to parasitology and definition of terminologies. Life history, mode of infection and pathogenicity of protozoans: *Trypanosoma brucei*, *Leishmania donovani* and *Plasmodium falciparum*.
- Unit II. Life history, mode of infection and pathogenicity of *Taenia solium/saginata*; parasitic adaptations in cestodes. Life history, mode of infection and pathogenicity of *Fasciola hepatica*.
- Unit III. Life history and pathogenicity of *Schistosoma mansoni*; parasitic adaptations in trematodes. Life history and pathogenicity of *Ascaris lumbricoides*; parasitic adaptations in nematodes.
- Unit IV. Cells of the immune system; cytokines. Immunity: innate and acquired. Components of immune system: antigen, hapten, epitope, paratope. Principle of vaccination. clonal selection theory.
- Unit V. Structure and types of antibodies. Antigen-antibody interactions. Major histocompatibility complex. Hypersensitivity.

### Suggested reading

1. Chatterjee, K. D. (2009). *Parasitology Protozoology and Helminthology*. CBS Publishers & Distributors Private Limited.
2. Cox, F. E. G. (1993). *Modern Parasitology: A Textbook of Parasitology* (2<sup>nd</sup> edition). Blackwell Science Ltd.
3. Delver, P. J., Martin, S. J., Burton, D. R., and Roitt, I. (2010). *Roitt's Essential Immunology* (11<sup>th</sup> edition). Wiley India Pvt Ltd.
4. Roberts, L. S., and Janovy, J. Jr. (2008). *Foundations of Parasitology* (8<sup>th</sup> edition). McGraw Hill.
5. Smyth, J. D. (1995). *Introduction to Animal Parasitology*. Hodder and Stoughton.
6. Yadav, P. R. (2009). *A Textbook of Parasitology*. Campus Books International.

### ZL XXII: Practical

1. Systematic study of common protozoan from permanent slides/models.
2. Systematic study of important helminth parasites from specimens and permanent slides.
3. Study of special morphological adaptations in cestodes, trematodes and nematode.
4. Recovery, processing and identification of helminths from fowl intestine.
5. Preparation and study of blood film by double staining.

#### Mark distribution of practical for end semester examination

1. Experiment	20
2. Slide preparation and identification	20
3. Spotting and identification (3 slides/models)	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XXIII A: Biotechnology and Bioinformatics

### Theory

- Unit I. Principles and applications of polymerase chain reaction; DNA fingerprinting; western, northern and southern blotting; genome sequencing.
- Unit II. Concepts of genetic engineering; concept of gene cloning; enzymes in genetic engineering (restriction enzymes and DNA ligase).
- Unit III. Elementary knowledge on gene library; applications of genetic engineering in agriculture and medicine; gene therapy.
- Unit IV. Historical concept of bioinformatics; basic operating systems; search engines; data bases; genomic and protein sequence retrieval.
- Unit V. Genome and proteome databases: Gen Bank, PDBe and Pubmed; NCBI genome database; BLAST(N), BLAST(P); introduction to phylogenetics analysis – MEGA.

### Suggested reading

1. Gupta, P. K. (2009). *Animal Biotechnology*. Rastogi Publications, Meerut, India.
2. Nicholl, D. S. T (2002). *An Introduction to Genetic Engineering* (2<sup>nd</sup> edition). Cambridge University Press
3. Pandey, B. N., Trivedi, S. P., Jaiswal, K., and Sharma, Y. K. (2009). *Bioinformatics Biotechnology and Bio-Remediation*. Sarup Book Publishers.
4. Roy, D. (2010). *Biotechnology (Cytogenetics, Biotechnology and Bioinformatics)*. Alpha Science International Ltd.
5. Sharma, V (2008). *Bioinformatics*. Rastogi Publications, Meerut, India.
6. Tourte, Y., and Tourte, C. (2005). *Genetic Engineering and Biotechnology: Concepts, Methods and Agronomic Applications*. Science Publishers Inc.

### ZL XXIV A: Practical

1. Demonstration of powerpoint presentation, word processing and statistical applications in MS Word and Excel.
2. Internet browsing for scientific repositories.
3. Types and uses of search engines.
4. Genomic and proteomic data banks.
5. Phylogenetic analysis.

#### Mark distribution of practical for end semester examination

1. Internet experiment	20
2. Data application	20
3. Identification of database/repository	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75

## ZL XXIII B: Ecology and Wildlife

### Theory

- Unit I. Concept of ecology; concept and types of ecosystem; trophic structure: food chain and food webs; energy flow; trophic relationships; ecological pyramids; intraspecific and interspecific interactions.
- Unit II. Abiotic environment: biogeochemical cycles (nitrogen, carbon, sulfur and phosphorus cycles); hydrological cycle.
- Unit III. Laws of tolerance and limiting factors; biotic community concept; community developments: ecological succession; greenhouse effect; global warming.
- Unit IV. Population: characteristics (mortality, natality, density), growth curves; community: species richness and species diversity; Sorensen's and Shannon-Wiever indices; factors affecting species diversity.
- Unit V. Conservation of natural resources; wildlife management and conservation; international and national programmes/organizations; anthropogenic activity and environment.

### Suggested reading

1. Brown, M. (2010). *Ecology* (9<sup>th</sup> edition). Apple Academic Press Inc.
2. Kormondy, E. J. (1996). *Concepts of Ecology* (4<sup>th</sup> edition). Prentice Hall of India Pvt. Ltd.
3. Nagi, S. S (2008). *India's Forests, Forestry & Wildlife*. Indus Publishing Company.
4. Odum, E., Barrett, G. W., and Brewer, R. (2004). *Fundamentals of Ecology* (5<sup>th</sup> edition). Brooks Cole.
5. Sharma, P. D. (2009). *Ecology and Environment*. Rastogi Publications, Meerut, India.
6. Smith, R. L., and Smith, T. M. (2008). *Elements of Ecology* (7<sup>th</sup> Edition). Pearson Higher Education.

### ZL XXIV B: Practical

1. Study of texture, pH, and conductivity of soil.
2. Estimation of organic and phosphorus contents of soil.
3. Estimation of dissolved oxygen in water samples.
4. Determination of free carbon dioxide of water samples.
5. Determination of hardness and alkalinity of water samples.
6. Field visit to farm/zoo/park/sanctuary.

#### Mark distribution of practical for end semester examination

1. Experiment 1	20
2. Experiment 2	20
3. Field visit report	15
4. Laboratory record	10
5. Viva voce	10
TOTAL	75