

Department of Zoology
North-Eastern Hill University, Shillong

B. Sc. Zoology (Honours)
Proposed Syllabus
(Under Semester System)
2013

Year	Semester	Title	Marks	Paper	Paper-wise Marks
First Year	1 st Semester	Systematics, Animal Diversity and Evolution	100	Paper 1 (Theory) Paper 2 (Practical)	75 25
	2 nd Semester	Cell Biology and Genetics	100	Paper 3 (Theory) Paper 4 (Practical)	75 25
Second Year	3 rd Semester	Animal Physiology, Endocrinology and Biochemistry	100	Paper 5 (Theory) Paper 6 (Practical)	75 25
	4 th Semester	Developmental Biology, Ecology and Economic Zoology	100	Paper 7 (Theory) Paper 8 (Practical)	75 25
Third Year	5 th Semester	Functional Anatomy, Zoogeography and Adaptations	100	Paper 9 (Theory) Paper 10 (Practical)	75 25
		Cell and Molecular Biology, and Genetics	100	Paper 11 (Theory) Paper 12 (Practical)	75 25
	6 th Semester	Biochemistry, Animal Physiology and Endocrinology	100	Paper 13 (Theory) Paper 14 (Practical)	75 25
		Developmental Biology, Environmental Biology and Biotechnology	100	Paper 15 (Theory) Paper 16 (Practical)	75 25
Total Marks			800		800

Paper 1

Systematics, Animal Diversity and Evolution (Theory)

Marks: 75

Time: 3 Hours

- Unit-I:** Systematics: Definition; Taxonomic hierarchy; Binomial nomenclature; Six-kingdom classification (Bacteria, Protozoa, Fungi, Plantae, Animalia and Chromista); Classification, salient characteristics and examples of Non-chordates (Kingdom Protozoa up to phyla, other major phyla up to classes) and Chordates (up to classes); Introduction to minor phyla.
- Unit-2:** Protozoa: *Paramecium* - Morphology and reproduction; Life cycle and pathogenicity of *Entamoeba histolytica* and *Plasmodium vivax*.
 Porifera: *Sycon* - Skeletal and canal systems.
 Coelenterata: *Obelia* - Morphology and reproduction.
 Helminthes: *Ascaris lumbricoides* - Morphology, life cycle and pathogenicity.
- Unit -3:** Annelida: Leech – Morphology; digestive and urinogenital systems.
 Arthropoda: Cockroach – Morphology; Digestive, respiratory, excretory and reproductive systems.
 Mollusca: *Pila* – Morphology; digestive, respiratory and nervous systems.
 Echinodermata: *Asterias* - Morphology and water vascular system.
- Unit – 4:** Hemichordata: Salient features of *Balanoglossus*.
 Protochordata: Salient features of *Amphioxus*.
Petromyzon – Morphology, Respiratory and reproductive systems.
 Pisces: Labeo - Morphology, digestive and respiratory systems.
 Rabbit - Type study (morphology; digestive, respiratory, circulatory, urinogenital and nervous systems).
- Unit – 5:** Origin of life; Theories of evolution: Lamarckism, Darwinism and Synthetic theory; Evidences of evolution - anatomical, embryological and paleontological; Geological time scale; Introduction to Evolution of man.

Suggested Readings:

1. Ghosh, K. C. and Manna, B. (2004). Fundamentals of Zoology. New Central Book Agency. Kolkata.
2. Hall, B.K. and Hallgrimsson, B. (2008), Strickberger's Evolution, 4th Edition. Jones and Bartlett Publishers.
3. Jordan, E. L. and Verma, P. S. (1993). Chordate Zoology. S. Chand Company Ltd.
4. Jordan, E. L. and Verma, P. S. (19920). Invertebrate Zoology. S. Chand Company Ltd.
5. Kotpal, R. L. (2012). Modern Textbook of Zoology: Invertebrates. R. K. Rastogi Publications.
6. Kotpal, R. L. (2012). Modern Textbook of Zoology: Vertebrates. R. K. Rastogi Publications.
7. Mayer, E. (1980). Principles of Systematic Zoology. Addison-Wesley Publishing Company, Inc.
8. Mayr, E. and Ashlock (1991), Principles of Systematic Zoology, 2nd Edition. McGraw Hill and Company.
9. Minnelli, A. (1993). Biological Systematics. Chapman & Hall.

10. Pough, F.H., Janis, C.M. and Heiser, J. B. (2012). Vertebrate Life, 9th Edition. Pearson Benjamin Cummings.
11. Raven, P. H. (2005). Biology. McGraw Hill Education Ltd.
12. Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V. and Jackson, R.V. (2011). Campbell Biology. Pearson Benjamin Cummings.
13. Ruppert, E. E., Fox, R. S. and Barnes, R. D. (2006). Invertebrate Zoology: A Functional Evolutionary Approach, 7th Edition. Cengage Learning India.
14. Sadava, D., Hillis, D. M., Heller, H. C. and Berenbaum, M.R. (2011). Life: The Science of Biology, 9th Edition. Sinauer Associates Inc. Publishers.
15. Sinha, A.K., Adhikari, S. and Ganguly, B. B. (2012). Biology of Animals, Vol. I & II. New Central Book Agency. Kolkata.
16. Sinha, A.K., Adhikari, S. and Ganguly, B. B. (2012). Fundamentals of Biology, New Central Book Agency, Kolkata.
17. Young, J. Z. (2004). Life of Vertebrates, 3rd Edition, Oxford University Press.

Paper 2 (Practical)

Systematics, Animal Diversity and Evolution

Marks: 25
Time: 4 Hours

A. Dissections:

1. Nervous system of cockroach.
2. Reproductive system of cockroach.
3. Digestive system of *Channa/ Labeo/common carp*.
4. Afferent brancial system of *Channa/ Labeo/common carp*.
5. Demonstration of dissections of arterial, digestive and urinogenital systems of albino rat/albino mouse/chicken.

B. Mounting:

1. General protocol for preparation of permanent microscopic slides: Basic concepts of fixation, staining, dehydration, clearing and mounting.
2. Permanent stained preparations of the following:
 - i) *Paramecium/Euglena* (whole mount)
 - ii) *Obelia* Colony
 - iii) Parapodium of *Nereis*
 - iv) Gemmules of sponge (whole mount)
 - v) Blood film of a vertebrate (single stain)

C. Osteology - Mammalia:

1. Vertebrae
2. Limb bones and girdles
3. Skull

D. Study of Prepared Slides:

1. T/S of Earthworm through typhlosolar region
2. T/S of male and female *Ascaris*
3. T/S of *Amphioxus* through branchial region
4. T/S of stomach, intestine, liver, pancreas, lung, kidney and gonads of a vertebrate.

E. Study of Museum Specimens:

1. Representatives from Non-chordates and Chordates.
2. Study of fossils.
3. Evidences of evolution through chart and models.

Distribution of Marks

1. Dissection	6
2. Mounting	3
3. Spotting	
a) Museum specimens	6
b) Osteology	3
c) Prepared slides	3
4. Laboratory Record	4
Total	25

Paper 3

Cell Biology and Genetics (Theory)

Marks: 75

Time: 3 Hours

- Unit-1:** Prokaryotic and eukaryotic cells. Ultrastructure and function of plasma membrane, mitochondria, endoplasmic reticulum, Golgi complex, ribosomes, centrioles and lysosomes. Cytoskeleton: Introduction to microtubules and microfilaments.
- Unit-2:** Nuclear envelope and nucleolus. Chromatin: Chemical composition and organization of Euchromatin and heterochromatin; Chromosome: Morphology, primary constriction, secondary constriction, and satellite bodies; Classification on the basis of position of centromere; Polytene and lampbrush chromosomes.
- Unit -3:** Cell cycle: Phases and regulation; Mitosis, meiosis, synaptonemal complex. Cancer: Characteristics of cancer cells, classification according to tissue types; Common carcinogens. Immunity: innate and acquired; Active and passive immunity; cells and organs of immune system.
- Unit-4:** Mendel's experiments and principles of inheritance; Concept of genotype, phenotype, dominance, recessiveness, co-dominance and incomplete dominance; Back cross and Test cross. Chromosomal theory of inheritance; Multiple alleles (ABO blood groups in man); Gene interactions: Complementary, supplementary, inhibitory and duplicate types; Pleiotropic genes and lethal genes (Tay Sachs disease and sickle cell anemia).
- Unit - 5:** Linkage and crossing over. Sex determination: Chromosomal and genic balance theories, environmental factors. Chromosomal aberrations: Structural (deletion, duplication, inversion and translocation) and numerical (euploidy and aneuploidy).

Suggested Readings:

1. Albert, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. (2007). Molecular Biology of the Cell, 5th Edition. Garland Publishing, London.

2. Bruce, A., Dennis, B., Karen, H., Alexander, J., Julian, L., Martin, R., Keith, R. and Peter W. (2009). *Essential Cell Biology*, 3rd Edition. Garland Publishing, London.
3. De Robertis, E. D. P. and De Robertis, L. M. F. (1987). *Cell and Molecular Biology*, 8th Edition. Lea and Febiger International Edition.
4. Gardener, E. J., Simmons, M. J. and Snustad, D. P. (2005). *Principles of Genetics*, 8th Edition. John Wiley and Sons.
5. Hardin, J., Bertoni, G. P. and Kleinsmith, L. J. (2012). *Becker's World of the Cell*. 8th Edition. Pearson, Benjamin Cummings.
6. Karp, G. (2010). *Cell Biology*, 6th Edition, John Wiley & Sons, Inc.
7. Klug, Cummings, Spencer and Palladino (2012). *Concepts of Genetics*, 10th Edition. Benjamin Cummings.
8. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott. M. P. (2012). *Molecular Cell Biology*, 7th Edition. W.H. Freeman.
9. Pierce, B. (2012.). *Genetics: A Conceptual Approach*, 4th Edition. W.H. Freeman.
10. Strickberger, M. W. (2006). *Genetics*, 3rd Edition. Macmillan Publishing Company.

Paper 4 (Practical)

Cell Biology and Genetics

Marks: 25

Time: 4 Hours

1. Study of cell organelles from slides/models/charts.
2. Preparation and study of different stages of mitosis in onion root tip.
3. Preparation (demonstration only) and study of different stages of meiosis from grasshopper testis using permanent slides.
4. Study of chromosome types from slides/photographs.
5. Preparation and study of polytene chromosomes from *Chironomus* larva.
6. Study of phenotypic variations in a natural population (at least 3 characters).
7. Determination and study of multiple alleles (ABO blood groups) and Rh factor.

Distribution of Marks

1. Cell Biology	7
2. Genetics	7
3. Spotting	3
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 5

Animal Physiology, Endocrinology and Biochemistry (Theory)

Marks: 75

Time: 3 Hours

- Unit-1:** Physiology of digestion and absorption of carbohydrates, proteins and lipids; Vitamins: Types, sources and their significance. Respiration: Breathing and gaseous exchange in vertebrate lung. Composition and functions of blood; Types of heart in vertebrates; Structure of mammalian heart.
- Unit-2:** Structure of mammalian kidney and nephron; Physiology of urine formation. Ultrastructure of skeletal muscle; Mechanism of skeletal muscle contraction. Ultrastructure of neuron; Nerve impulse conduction and synaptic transmission; Reflex action.
- Unit-3:** Structure and functions of major endocrine glands: Hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenals, testis and ovary. Introduction to neuroendocrine system in insects.
- Unit-4:** Classification and significance of carbohydrates, proteins and lipids. Amino acids: Essential and non-essential. Glycolysis and TCA cycle; β -Oxidation of fatty acids.
- Unit-5:** Enzymes: Properties, classification and nomenclature; Active site and mechanism of enzyme action; Factors affecting enzyme activity; Co-factors and co-enzymes. Nucleic acids: Nucleosides, nucleotides and polynucleotides; Double helical structure of DNA and structure of RNA.

Suggested Readings:

1. Berg, J., Tymoczko, J., and Stryer, L. (2012). Biochemistry, 7th Edition, W. H. Freeman.
2. Campbell, M. K. and Farrell, S. O. (2010). Introduction to Biochemistry. Cengage Learning India.
3. Hadley, M. E. & Levine (2007). Endocrinology, 6th Edition. Pearson, Benjamin Cummings.
4. Hall, J. E., (2011). Guyton and Hall Textbook of Medical Physiology, 12th Edition (Indian print). Saunders, Elsevier Inc.
5. Hill, R. W., Wyse, G. A. and Anderson, M. (2012). Animal Physiology, 3rd Edition, Sinauer Associates Inc.
6. Melmed, S., Polonsky, K. S., Larsen, P. R., and Kronenberg, H. M., (2011). William's Textbook of Endocrinology, 12th Edition. Saunders.
7. Murray, R. K. *et al.*, (2011). Harper's Illustrated Biochemistry, 29th Edition. McGraw Hill, Lange Publication.
8. Nelson, D. L. and Cox, M. (2012). Lehninger Principles of Biochemistry, 6th Edition, W. H. Freeman.
9. Norman, A. W. and Litwack, G. (1997). Hormones, 2nd Edition, Academic Press, Elsevier Inc.
10. Norris, D. O. (2007). Vertebrate endocrinology. 6th Edition. Academic Press, Elsevier Inc.
11. Prosser, C. L. (1991). Comparative Animal Physiology. W. B. Saunders & Company.
12. Randall, D. and Burggren, W. (2001). Eckert Animal Physiology, 5th Edition. W.H. Freeman.
13. Schmidt-Nielsen, K. (2002). Animal Physiology: Adaptation and Environment. Cambridge University Press.

14. Sherwood, L., Klandorf, H., and Yanchey, P. (2010). Textbook of Animal Physiology. Cengage Learning.

Paper 6 (Practical)

Animal Physiology, Endocrinology and Biochemistry

Marks: 25

Time: 4 Hours

1. Preparation of haemin crystals from human blood.
2. Determination of clotting time of human blood.
3. Oxygen consumption in fish with reference to body weight.
4. Study of histology of endocrine glands from permanent slides (pituitary, thyroid, thymus, pancreas, adrenal, testis and ovary).
5. Detection of carbohydrates, lipids and proteins (at least 3 tests each).
6. Estimation of ascorbic acid by titration method.

Distribution of Marks

1. Physiology	7
2. Biochemistry	7
3. Spotting	3
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 7

Developmental Biology, Ecology and Economic Zoology (Theory)

Marks: 75

Time: 3 Hours

- Unit-1:** Gametogenesis: Spermatogenesis and oogenesis; Fertilization; Parthenogenesis. Types of eggs; Cleavage and types of cleavage; Process of blastulation, fate map and Gastrulation in frog up to the formation of three germinal layers; Metamorphosis in insects and frog.
- Unit- 2:** Ecology: Concepts, subdivisions, scope and importance; Levels of organization in the biosphere. Structure of ecosystem - Ecological factors (biotic and abiotic); Trophic structure: Food chains, food webs and energy flow; Trophic relationships – ecological pyramids. Productivity.
- Unit 3:** Ecological niche. Population: Growth and regulation. Concepts of biotic community. Inter and intraspecific interactions. Resources (renewable and non-renewable) and their management. Environmental pollution (air, water and soil).
- Unit 4:** Pisciculture: Culturable fish species of India; Culture and management of fish with reference to composite fish culture; Induced breeding.

Sericulture: Different species of silk moth; Life history of *Bombyx mori* and methods of culture; Product of sericulture and its economic importance.

Unit 5: Apiculture: Species of honey bees; Life history and social organization; Methods of bee keeping, economic importance.
Integrated pest management (physical, chemical, hormonal and biological).

Suggested Readings:

1. Ayyar, T. V. R. (1984). Handbook of Economic Entomology. International Books and Periodical Supply Service.
2. Balinsky, B. I. (1981). An Introduction to Embryology, 5th Edition. Saunders College Publishing, Holt-Saunders.
3. Beeby, A. and Brennan, M. A. (2008), First Ecology - Ecological Principles and Environmental Issues, 3rd Edition. Oxford University Press, India.
4. Cain, M. L., Bowman, W. D. and Hacker, S. D. (2011). Ecology, 2nd Edition. Sinauer Associates, Inc. Publishers.
5. Carlson, B. M. (2006). Foundations of Embryology. McGraw Hill Education (India) Ltd.
6. Gilbert, S. F. (2010). Developmental Biology, 9th Edition. Sinauer Associates, Inc. Publishers
7. Gupta, S. K. and Gupta, P. C. (2003). General and applied Ichthyology (Fish & Fisheries). S. Chand & Co.
8. Kalthoff, K. (2000). Analysis of Biological Development, 2nd Edition. McGraw-Hill Professional.
9. Kendeigh, F. C. (1984). Ecology with Special Reference to Animal and Man. Prentice Hall Inc.
10. Kormondy, E. J. (1996). Concepts of Ecology, 4th Edition. Prentice Hall of India Pvt. Ltd.
11. Little, V. A. (1972). General and Applied Entomology, 3rd Edition. Oxford and I. B. H. Publishing Co.
12. Odum, E. P. & Barrett, G. W. (2006). Fundamentals of Ecology. 5th Edition. Cengage Learning India.
13. Odum, E. P. (1971). Fundamentals of Ecology, 3rd Edition. W. B. Saunders Company.
14. Ricklefs, R. E. (2010). Economy of Nature, 6th Edition. W.H. Freeman.
15. Sharma, P. D. (1990). Ecology and Environment, 7th Edition. Rastogi Publications.
16. Shukla, G. S. and Upadhyay (2003). Economic Zoology, 4th Edition. Rastogi Publications.
17. Stiling, P. D. (2012). Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.
18. Wolpert, L. and Tickle, C. (2011). Principles of Development, 4th Edition. Oxford University Press.

Paper 8 (Practical)

Developmental Biology, Ecology and Economic Zoology

Marks: 25

Time: 4 Hours

1. Study of the types of eggs in vertebrates.
2. Study of larval forms (crustacean, molluscan and echinoderm) from permanent slides.
3. Study of the stages of development of frog from permanent slides in whole mount/sections (cleavage, blastula and gastrula).
4. Preparation of permanent slides of non-chordate larval forms (Mysis, Nauplius, mosquito larva).
5. Study of metamorphosis in Amphibia (using Charts/Models).
6. Estimation of dissolved oxygen in water samples.
7. Estimation of carbon dioxide in water samples.
8. Estimation of total alkalinity in water samples.
9. Qualitative study of plankton from fresh water samples.
10. Study of the life cycle of silk moth.
11. Study of different castes of honey bee.
12. Identification of Indian major carps and common exotic carps.

Distribution of Marks

1. Developmental Biology	6
2. Ecology	6
3. Spotting (slides/charts/models)	5
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 9

Functional Anatomy, Zoogeography and Adaptations (Theory)

Marks: 75

Time: 3 Hours

- Unit - 1:** Protozoa: Locomotion and nutrition.
 Porifera: Canal and skeletal systems.
 Cnidaria: Polymorphism in *Siphonophora*; Corals and coral reefs.
 Morphological and physiological adaptations of parasitic helminthes.
 Annelida: Excretory system.
- Unit - 2:** Onychophora: General organization and affinities.
 Arthropoda: Types of mouth parts and feeding in insects; Vision in insects.
 Mollusca: Torsion and detortion in Gastropoda.
 Echinodermata: Comparative study of water vascular system.
- Unit - 3:** Hemichordata: Affinities of *Balanoglossus*
 Protochordata: Affinities of *Amphioxus*.
 Retrogressive metamorphosis in *Ascidia*.

Agnatha: Comparative study of *Petromyzon* and *Myxine*.

Pisces: Scales and fins in fishes; Accessory respiratory organs; Migration of fishes.

Dipnoi: General characters and affinities.

- Unit - 4:** Amphibia: Parental care.
 Reptilia: Poisonous and nonpoisonous snakes; Poison apparatus and mechanism of biting.
 Aves: Flight adaptations and migration in birds.
 Mammalia: Affinities of Monotremata and Marsupialia; Dentition in mammals. Comparative anatomy of kidney in vertebrates.

- Unit - 5:** Zoogeography: Concepts and Zoogeographic realms. Patterns and regulation of behaviour: genetic and hormonal; Colouration and mimicry.
 Adaptations in vertebrates: Aquatic, desert, arboreal, cursorial and deep sea adaptations.

Suggested Readings:

1. Agarwal, V. K. (2010). Animal Behaviour (Ethology). S. Chand & Co.
2. Brusca, R. C. and Brusca, G. J. (2003). Invertebrates, 2nd Edition. Sinauer Associates, Inc. Publishers.
3. Hall, B.K. and Hallgrimsson, B. (2008). Strickberger's Evolution, 4th Edition. Jones and Bartlett Inc.
4. Jordan, E. L. and Verma, P. S. (1992). Invertebrate Zoology. S. Chand Company Ltd.
5. Jordan, E. L. and Verma, P. S. (1993). Chordate Zoology. S. Chand & Co.
6. Kardong, K. V. (2006). Vertebrates: Comparative Anatomy, McGraw Hill Education (India) Ltd.
7. Kotpal, R. L. (2012). Modern Textbook of Zoology: Invertebrates. R. K. Rastogi Publications,
8. Kotpal, R. L. (2012). Modern Textbook of Zoology: Vertebrates. R. K. Rastogi Publications,
9. Lull, R. S. (1984). Organic Evolution. Seema Publication, New Delhi.
10. Manning, A. and Dawkins, M S. (2012). An Introduction to Animal Behaviour, 6th Edition. Cambridge University Press.
11. Pough, F. H., Janis, C. M. and Heiser, J. B. (2012). Vertebrate Life, 9th Edition, Pearson Benjamin Cummings.
12. Ruppert, E. E., Fox, R. S. and Barnes, R. D. (2006). Invertebrate Zoology: A Functional Evolutionary Approach, 7th Edition. Cengage Learning India.
13. Sinha, A. K., Adhikari, S. and Ganguly, B. B. (2010). Biology of Animals, Vols. I & II. New Central Book Agency. Kolkata.
14. Sinha, A. K., Adhikari, S. and Ganguly, B.B. (2010). Fundamentals of Biology. New Central Book Agency. Kolkata.
15. Young, J. Z. (2004). Life of Vertebrates, 3rd Edition, Oxford University Press.

Paper 10 (Practical)

Functional Anatomy, Zoogeography and Adaptations

Marks: 25
Time: 4 Hours

A. Dissections:

1. Nervous system in prawn/earthworm.
2. Accessory respiratory organs in teleost fish.
3. Digestive system in albino rat/ albino mouse/chicken.
3. Reproductive system in albino rat/ albino mouse/chicken.

B. Mounting (Permanent):

1. Cyclops.
2. Setae of earthworm.
3. Spicules of sponge.
4. Scales (cycloid, ctenoid and placoid) of fishes.
5. Feathers of birds (filoplumes, down feathers, barbs and barbules).

C. Study of Permanent Slides and Specimens:

1. Histology: T/S of stomach, intestine, liver, kidney, spleen and gonads of fish/Aves/mammals.
2. Permanent slides of representatives from Protozoa to Echinodermata (sections and whole mounts).
3. Adaptive modifications of beak and feet in birds using charts and models.

Distribution of Marks:

1. Dissection	7
2. Mounting	4
3. Spotting	6
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 11

Cell and Molecular Biology, and Genetics (Theory)

Marks: 75
Time: 3 Hours

Unit-1: Genome organization in virus, bacteria and eukaryotes. Central dogma of molecular biology; DNA replication in prokaryotes; Transcription and translation in prokaryotes; Genetic code. Regulation of gene expression in prokaryotes: *lac* operon.

Unit -2: Fine Structure of gene: Cistron, recon and muton; Split genes and overlapping genes; Transposons. Gene mutation: Types and mutagenic agents; DNA

damage and repair. Detection of mutation in *Drosophila* (Muller's *CIB* method).

- Unit-3:** Extra-nuclear inheritance: Kappa particles in *Paramecium*. Sex-linked inheritance in *Drosophila* (eye color) and man (colour blindness); Dosage compensation and Lyon's hypothesis. Non-disjunction of sex chromosomes in *Drosophila*; Human karyotype; Sex determination in man; Genetic disorders in man – Down's, Turner's and Klinefelter's syndromes, Phenylketonuria, Hemophilia.
- Unit-4:** Humoral and cell mediated immunity; Characteristics of antigens; Antibodies: Structure, classes and functions; Antigen-antibody interaction; Major histocompatibility complex; Introduction to cytokines.
- Unit-5:** Principles and applications of biological techniques: Light and electron microscopy; Centrifugation; Chromatography (paper, gel filtration and ion-exchange).

Suggested Readings:

1. Albert, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J. D. (2007). Molecular Biology of the Cell, 5th Edition. Garland Publishing, London.
2. Brown, T. A. (2006). Genomes 3. Garland Science.
3. Cooper, G. M. and Hausman, R. E. (2009). The Cell: A Molecular Approach, 5th Edition. Sinauer Associates Inc. Publishers.
4. Delves, P. J., Martin, S. J., Burton, D. R. and Roitt, I. M. (2011). Roitt's Essential Immunology, 12th Edition. Wiley-Blackwell.
5. Gardener, E. J., Simmons, M. J. and Snustad, D. P. (2005). Principles of Genetics, 8th Edition. John Wiley and Sons.
6. Hardin, J., Bertoni, G. P. and Kleinsmith, L. J. (2012). Becker's World of the Cell, 8th Edition. Benjamin Cummings.
7. Karp, G. (2010). Cell Biology, 6th Edition. John Wiley & Sons, Inc.
8. Khan, F. H. (2010). Immunology. Pearson Education India.
9. Klug, W. S., Cummings, M. R., Spencer, C. A. and Palladino, M. A. (2012). Concepts of Genetics, 10th Edition. Benjamin Cummings.
10. Krebs, J., Goldstein, E. and Kilpatrick, S. (2011). Lewin's Genes X. Jones & Bartlett Learning.
11. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M P. (2012). Molecular Cell Biology, 7th Edition. W.H. Freeman.
12. Owen, J., Punt, J. and Stranford, S. (2012). Kuby Immunology, 7th Edition. W. H. Freeman & Company.
13. Pathak, S. and Palan, U. (2012). Immunology, 11th Edition. Science Publishers.
14. Pierce, B. (2012). Genetics: A Conceptual Approach, 4th Edition. W.H. Freeman
15. Strickberger, M. W. (2006). Genetics, 3rd Edition. Macmillan Publishing Company.
16. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, 6th Edition. Pearson, Benjamin Cummings.
17. Wilkins, K. and Walker, J (2012). Practical Biochemistry: Principles and Techniques. Cambridge University Press.

Paper 12 (Practical)

Cell and Molecular Biology, and Genetics

Marks: 25
Time: 4 hours

1. Separation and identification of amino acids by paper chromatography.
2. Demonstration of antigen-antibody interaction *in vitro*: Single radial immuno-diffusion in agarose gel.
3. Study of nucleic acids from models/charts.
4. Calorimetric estimation of DNA and RNA.
5. Preparation and identification of meiotic stages from grasshopper testis.
6. Karyotyping of normal human chromosomal complement from supplied photographic plates.
7. Karyotyping of chromosomal complement of Down's/Turner's/Klinefelter's syndrome from supplied photographic plates.
8. Demonstration of electrophoretic separation of DNA/protein.

Distribution of Marks

1. Cell biology & Genetics	7
2. Molecular Biology	6
3. Spotting	4
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 13

Biochemistry, Animal Physiology and Endocrinology (Theory)

Marks- 75
Time – 3 Hours

- Unit-1:** Chemical foundations of physiology: Concept of normal, molar, and molal solutions; Acids, bases, pH and buffers; Diffusion and osmotic pressure. Enzyme kinetics: Michaelis-Menten equation and its relation to enzyme activity; Significance of K_m and V_{max} ; Enzyme inhibition (reversible and irreversible).
- Unit -2:** Carbohydrates: Linear and ring forms of monosaccharides (Pentose and Hexose); Polysaccharides (starch, glycogen and hyaluronic acid); Glycogenesis and glycogenolysis. Electron transport system and oxidative phosphorylation. Amino acids, peptides and proteins: levels of organization, Transamination, deamination and urea cycle.
- Unit -3:** Structure and functions of haemoglobin; Blood coagulation: Coagulation factors and mechanism. Cardiac cycle. Blood pressure and its regulation.

Mechanism of gaseous exchange through gills and lungs. Osmoregulation in fish.

Unit-4: Neurosecretory cells; Types of neurohormones; Endocrine and paracrine hormones; Placental hormones; Hormones of gastrointestinal tract; Pheromones. Biosynthesis of thyroid hormones. Mechanism of hormone action: Peptide/protein and steroid hormones.

Unit -5: Reproductive cycles (estrous and menstrual) in mammals; Hormonal regulation of spermatogenesis and oogenesis in humans; *In vitro* fertilization and embryo transfer technology; Pregnancy hormones; Lactation; Contraceptive methods for males and females.

Suggested Readings

1. Berg, J., Tymoczko, J. and Stryer, L. (2012). Biochemistry, 7th Edition, W. H. Freeman.
2. Campbell, M. K. and Farrell, S. O. (2010). Introduction to Biochemistry. Cengage Learning India.
3. Chaudhury, S. K. (1996). Practice of Fertility Control: A Comprehensive Textbook. B. I. Churchill Livingstone Pvt. Ltd, India.
4. Hadley, M. E. and Levine, M. (2007). Endocrinology, 6th Edition. Pearson, Benjamin Cummings.
5. Hafez, E. S. E. and Evans, T. N. (1973). Human Reproduction: Contraception and Conception. Harper and Row, New York.
6. Hall, J. E. (2011). Guyton and Hall Textbook of Medical Physiology, 12th Edition. Saunders, Elsevier Inc. (Indian print).
7. Hill, R. W., Wyse, G. A. and Anderson, M. (2012). Animal Physiology, 3rd Edition, Sinauer Associates Inc.
8. Hoar, W. S. (1983). General and Comparative Physiology. Prentice Hall of India. Pvt. Ltd.
9. Knobil, E. and Neill, J. D. (2006). The Physiology of Reproduction, Vol. 2. Elsevier Publication.
10. Kronenberg, H. M., Larsen, P. R., Melmed, S. and Polonsky, K. S. (2012). William's Textbook of Endocrinology. Saunders, Elsevier Inc.
11. Lehninger Principles of Biochemistry. Nelson, D. L. and Cox, M. (2012). 6th Edition. W.H. Freeman.
12. Murray, R. K., Bender, D., Botham, K. M., Kenelly, P. J., Rodwell, V. and Weil, P. A. (2012). Harper's Illustrated Biochemistry, 29th Edition. McGraw Hill, Lange publication.
13. Norman, A. W. and Litwack, G. (1997). Hormones, 2nd Edition. Academic Press, Elsevier Inc.
14. Norris, D. (2007). Vertebrate Endocrinology, 6th Edition. Academic Press, Elsevier Inc.
15. Prosser, C. L. (1991). Comparative Animal Physiology. W. B. Saunders & Company.
16. Randall, D. and Burggren, W. (2001). Eckert Animal Physiology, 5th Edition. W.H. Freeman.
17. Sherwood, L., Klandorf, H. and Yancey, P. (2010). Textbook of Animal Physiology. Cengage Learning India.

Paper 14 (Practical)

Biochemistry, Animal Physiology and Endocrinology

Marks: 25
Time: 4 Hours

1. WBC count in human blood.
2. RBC count in human blood.
3. Estimation of glucose by colorimetric method.
4. Estimation of protein by colorimetric (Lowry's/Biuret) method.
5. Estimation of hemoglobin in human blood.
6. Study of human salivary amylase activity in relation to temperature.
7. Dissection and display of pituitary and gonads in a teleost.
8. Dissection and display of endocrine glands in albino mouse/rat.
9. Microtomy: Preparation of histological slides of vertebrate tissues - liver, kidney, gonads, intestine and adrenal (minimum four slides of different tissues).

Distribution of Marks

1. Biochemistry and Physiology	6
2. Endocrinology	6
3. Microtomy	5
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
Total	25

Paper 15

Developmental Biology, Environmental Biology and Biotechnology (Theory)

Marks: 75
Time: 3 Hours

- Unit-1:** Patterns of cleavage; Morphogenetic movements (epiboly, invagination, ingression, involution and delamination); Embryonic induction and concept of Organizer; Gastrulation in chick up to formation of three germinal layers.
- Unit 2:** Foetal membranes and types of placenta in mammals; Organogenesis of the vertebrate eye; Regeneration in invertebrates and vertebrates; Teratogenesis and developmental birth defects. Concepts of Ageing.
- Unit – 3:** Salient features of aquatic and terrestrial ecosystems. Liebig's law of limiting factors and Shelford's law of tolerance. Biogeochemical cycles: carbon, phosphorus and nitrogen cycles. Ecological succession. Major Biomes.
- Unit – 4:** Environmental concerns: Radioactive pollution; Biological indicators; Biomagnification; Anthropogenic activity and environment: Ozone depletion; Green house effect and global warming; Acid rains.

Wild life conservation: *In situ* (sanctuaries, national parks and biosphere reserves) and *ex situ* (botanical and zoological gardens, Germplasm Bank).

Unit - 5 Biotechnology & Genetic Engineering

Introduction to genetic engineering; Restriction enzymes. Cloning vectors: Plasmid, cosmid, λ phage, shuttle vectors; Expression vectors. Introduction in to host cells: Transformation, transduction; Particle gun. Southern blotting; PCR; DNA Fingerprinting; Genomic library and cDNA library; Application of recombinant DNA technology. Ethical issues and Biosafety regulations.

Suggested Readings:

1. Balinsky, B.I. (1981). An introduction to Embryology, 7th Edition. Cengage Learning India.
2. Beeby, A. and Brennan, M. A. (2008). First Ecology - Ecological Principles and Environmental Issues, 3rd Edition, Oxford University Press, India.
3. Brown, T. A. (2006). Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell.
4. Cain, M. L., Bowman, W. D. and Hacker, S. D. (2011). Ecology, 2nd Edition. Sinauer Associates, Inc. Publishers
5. Carlson, B. M. (2006). Foundations of Embryology. McGraw Hill Education (India) Ltd.
6. Gilbert, S. F. (2010). Developmental Biology, 9th Edition. Sinauer Associates, Inc. Publishers.
7. Kalthoff, K. (2000). Analysis of Biological Development, 2nd Edition, McGraw-Hill Professional.
8. Kendeigh, F C. (1984). Ecology with Special Reference to Animal and Man. Prentice Hall Inc.
9. Odum, E. P. (1971). Fundamentals of Ecology, 3rd Edition. W. B. Saunders Company.
10. Odum, E. P. and Barrett, G. W. (2006). Fundamentals of Ecology, 5th Edition, Cengage Learning India.
11. Primrose, S. B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics, 7th Edition. Wiley-Blackwell.
12. Ratledge, C. (2006). Basic Biotechnology. John Wiley and Sons.
13. Ricklefs, R. E. (2010). Economy of Nature, 6th Edition. W.H.Freeman.
14. Sharma, P. D. (1990). Ecology and Environment, 7th Edition. Rastogi Publications.
15. Shyam, D. and Rosencranz, A. (2001). Environmental Law and Policy in India. Oxford University Press.
16. Stiling, P. D. (2012). Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.
17. Thieman, W. J. and Palladino, M.A. (2008). Introduction to Biotechnology, 2nd edition. Cengage Learning India.
18. Wolpert, L. and Tickle, C. (2011). Principles of Development, 4th Edition, Oxford University Press.

Paper 16 (Practical)**Developmental Biology, Environmental Biology and Biotechnology**Marks: 25
Time: 4 Hours

1. Permanent preparation of whole mount of chick embryo.
2. Study of regeneration in *Hydra/Planaria*.
3. Study of whole mount /sections of different developmental stages of chick embryo from permanent slides.
4. Community analysis.
5. Qualitative analysis of aquatic communities from different water bodies.
6. Estimation of total hardness of water samples.
7. Quantitative estimation of Plankton.
8. Analysis of community similarities and species diversity indices.
9. Field trip and submission of Field Report.

Distribution of Marks

1. Developmental Biology	5
2. Environmental Biology	5
3. Spotting	4
4. <i>Viva Voce</i>	5
5. Laboratory Record	3
6. Field Report	3
Total	25