4 Years Bachelor of Science (B.Sc.) Programme
B.Sc. second year Zoology

Course Title : **Chordata, Comparative Anatomy and Evolution** **Full Marks: 100**
Course No. : **B.Sc. Zool.201** **Pass Marks: 35**
Nature of Course : **Theory** **Year: II**
Instruction Lectures : **150**

Objectives of the Course:

At the end of course students will be able to:

- Classify various species of Chordates based on important characteristics.
- Understand the origin, evolution and adaptive radiation of various classes.
- Be familiar with the fauna of Nepal and their status.
- Understand fundamental aspects of animal behaviours.
- Know the functional anatomy of each class.
- Be familiar with concepts and principles of evolution and biogeography.

Teaching materials required to fulfill the objectives are boards, charts, flex prints, overhead projector (OHP), power-point projector and other basic teaching materials prepared by teachers and as provided by the campuses.

Group A1: Chordata

Unit	Sub-unit	Description of content of the sub-unit (depth)	Lectures	Text/Ref. for the topics (for detail see the list of text & references)
Agnatha (3 Lectures)	**Characteristics and classification**	Diagnostic characters (especially notochord – vertebral column) and basis of classification.	1	Parker & Haswell Vol. II; Kotpal
	Salient features of *Petromyzon*	Systematic position, distribution, habits and habitat. External features.	1	Parker & Haswell Vol. II; Kotpal
	Salient features of *Myxine*	Systematic position, distribution, habits and habitat. External features.	1	Jordan & Verma; Kotpal

Pisces (12 Lectures)	**Characteristics and classification**	Diagnostic characters and basis of classification (up to orders with important families found in Nepal). .	2	Jordan & Verma; Young; Kotpal
	Origin and evolution	Origin of fishes: Chondrichthyes (cartilaginous) and Osteichthyes (bony fishes), evolution of cartilaginous and bony fishes.	2	Young; Khanna
	Adaptive radiation	Introduction, body forms and swimming, feedings, protective mechanism, accessory respiratory organs.	1	Young; Khanna
	Scales and Fins	Different types of scales and fins, and their function.	1	Jordan & Verma; Khanna
	Parental care	Purpose and various forms of parental care in fishes.	1	Jordan & Verma
	Migration	Introduction; causes and advantages of migration and their types.	1	Jordan & Verma
	Fish identification techniques	Introduction, criteria: external features (body form/shape, features in head, fins, lateral line, scales and other dermal features, pigmentation and colour patterns).	2	Shrestha, J.1995 Shrestha, T.K.
	Endemic species, diversity and distribution of fishes in Nepal	Endemic fishes and their distribution, diversity and distribution of fishes in different ecological regions.	2	Shrestha, J.1995; Bhuju et al.; Majupuriya and Majupuriya
Amphibia (12 Lectures)	**Characteristics and classification**	Diagnostic characters and basis of classification (up to orders with important families found in Nepal).	2	Young; Parker & Haswell; Jordan & Verma
	Origin and evolution	Earliest amphibians, origin and evolution of modern amphibians	2	Young; Kotpal; Dhami & Dhami

	Adaptive radiation	Introduction, various types of adaptation in amphibians: terrestrial, aquatic, burrowing, cave, volant and arboreal.	2	Young; Parker & Haswell; Sanmbasivia, Rao & Chellappa;
	Metamorphosis and neoteny	Metamorphosis- Types and factors affecting metamorphosis; Neoteny and paedogenesis. Types and significance of neoteny.	2	Jordan & Verma; Kotpal
	Parental care	Purpose and various forms of parental care in amphibians.	2	Jordan &Verma; Kotpal
	Endemic species, diversity and distribution of amphibians in Nepal	Endemic amphibians and their distribution, diversity and distribution of amphibians in different ecological regions.	2	Shah and Tiwari; Shrestha,T.K.; Bhuju et al.
Reptilia (12 Lectures)	**Characteristics and classification**	Diagnostic characters and basis of classification (up to orders with important families found in Nepal).	2	Young; Parker & Haswell, Jordan & Verma; Dhami & Dhami
	Origin and evolution	Amphibian origin, Stem reptile (Cotylosauria), Ancestry through *Seymouria*, *Limnoscelis and Diadectes.* Evolutionary tree.	2	Young; Dhami & Dhami
	Adaptive radiation	Introduction, Various types of adaptations in reptiles: arboreal, aerial, amphibious, fossorial and desert.	1	Jordan & Verma; Dhami & Dhami; Sanmbasivia, Rao & Chellappa
	Affinities of *Sphenodon*	Introduction, features of S*phenodon*, affinities of *Sphenodon* (Rhyncocephalia) with amphibian, Dinosaurs, Chelonia, Lacertilia and Crocodilia.	1	Parker & Haswell; Kotpal
	Poisonous and non-poisonous snakes	Introduction, poison apparatus (poison glands, poison ducts, and fangs), distinction between	2	Kotpal; Dhami & Dhami;

		poisonous and non- poisonous snakes.		Jordan & Verma
	Biting mechanism of snakes.Nature of snake's venom and its action. First-aid treatment on snake bite	Biting mechanism. Types of venom, symptoms of snake bite. First aid treatment of snake bite (psychological and medical).	2	Jordan & Verma; Dhami & Dhami; Kotpal
	Endemic species, diversity and distribution of reptiles in Nepal	Endemic reptiles and their distribution, diversity and distribution of reptiles in different ecological region.	2	Shah and Tiwari; Shrestha,T.K; Bhuju et al.
Aves (15 Lectures)	**Characteristics and classification**	Diagnostic characters and basis of classification (up to orders with important families found in Nepal).	2	Jordan & Verma; Dhami & Dhami
	Origin and evolution	Introduction, origin and evolution of birds. *Archaeopteryx* and its characters. Proaves. Concept of monophyletic and diphyletic origin. Birds as glorified reptiles.	2	Young; Kotpal; Dhami & Dhami
	Adaptive radiation	Introduction, types of adaptation in birds (morphological, anatomical, physiological and behavioral modifications).	2	Jordan & Verma; Dhami & Dhami
	Feathers. Flight and perching mechanism	Types of feathers. Flight muscles and mechanism. Perching muscles and mechanism.	2	Jordan & Verma
	Migration	Introduction, migratory and resident birds, kinds of migration, modes of flight in migration, problems of migration (navigation, origin, stimulus or cue). Advantages and disadvantages of avian migration.	2	Kotpal; Jordan & Verma
	Palate	Introduction, kinds of palate-dromaeognathous,	1	Kotpal;

		schizognathous, aegithognathous, desmognathous; importance of palate in bird classification.		Jordan & verma
	Endemic species, diversity and distribution of birds in Nepal	Endemic birds and their distribution, diversity and distribution of birds in different ecological regions.	2	Grimmet et al.; Flemming; Bhuju et al. Primack et al.
	Pheasants of Nepal	Pheasant species and their distribution in Nepal.	1	Grimmet et al.
	Important bird areas (IBAs) of Nepal	Introduction and characteristics of IBA. IBAs of Nepal and their significance.	1	Baral & Inskipp Primack et al.
Mammalia (12 Lectures)	**Characteristics and classification**	Introduction, diagnostic characters and basis of classification (up to orders with important families found in Nepal).	2	Dhami & Dhami
	Origin and evolution	Introduction, amphibian ancestry, reptilian ancestry, ancestral mammal-like reptiles, true mammals.	2	Young; Kotpal; Dhami & Dhami
	Adaptive radiation	Introduction, mammalian adaptations; adaptive radiation in limb structure and tooth in mammals.	2	Young; Kotpal; Dhami & Dhami
	Stomach	Introduction, types of stomach in mammals.	2	Dhami & Dhami; Jordan & Verma
	Dentition	Introduction, teeth and dentition, function, differentiation of teeth, succession of teeth, kinds of teeth, dental formula with common examples (man, dog, rat, cow, rabbit, elephant and kangaroo).	2	Kotpal; Jordan & Verma
	Endemic species, diversity and distribution of mammals in Nepal	Endemic mammal and their distribution in Nepal, Diversity and distribution of mammals in different ecological regions.	2	Baral & Shah; Bhuju et al. Primack et al.

Group A2: Group A2: Ethology

Unit	Sub-unit	Description of content of the sub-unit (depth)	Lect.	Text/Ref. for the topics
Ethology (10 Lectures)	**Introduction to Ethology**	Introduction, purpose of ethological study, brief description of processes of animal behaviour: physiological process, social process, behavioural ecological and evolutionary process.	1	Drickamer et al.; Manning & Dawkins
	Development of behaviour	Introduction, instinct, instinct and learning in biological setting, genetics and behavior, nervous system & behaviors, hormones and behavior development, experience and imprinting.	2	Manning & Dawkins; Kotpal
	Social behaviour	Introduction, social units (solitary, pair, family, harem, matriarchy, oligarchy, arena, hierarchy, aggregation, caste system), advantage and disadvantage of group living, social dominance, primate social organization.	2	Manning & Dawkins; Kotpal
	Courtship and Mating	Introduction, purpose of courtship, courtship and mating systems in vertebrates.	1	Drickameret al; Kotpal; Arora
	Learning behaviour	Introduction, types of learning, habituation, classical and operant conditioning, comparison between classical & operant learning, other aspect of learning (advanced learning, insight learning and latent learning). Memory- short term, intermediate and long term memory.	2	Drickamer et al.; Manning & Dawkins; Kotpal
	Communication in animals	Introduction, means of communication (odor, sound, touch, vision, etc.) with examples.	2	Drickamer et al.;

Group B1: Comparative Anatomy of Chordata

(Comparative study in vertebrates (fishes, amphibian, reptilian, birds and mammals)

Unit	Sub-unit	Description of content of the sub-unit (depth)	Lect.	Text/Ref. for the topics
Exoskeleton (5 Lectures)	**Integument and its derivatives**	Introduction. Integument- structure and function. Derivatives – epidermal glands, epidermal scales & scutes, dermal scales & scutes, digital cornifications, horns, feathers, hairs. Integument in different classes of chordates.	5	Kotpal; Jordan & Verma
Endoskeleton (9 Lectures)	**Axial and appendicular skeleton**	Introduction to endoskeleton. Axial skeleton- Skull, vertebral column, ribs and sternum. Appendicular skeleton- limbs and girdles.	9	Jordan & Verma; Kotpal
Digestive organs (6 Lectures)	**Alimentary canal and associated glands**	Introduction. Alimentary canal, Associated digestive glands- salivary glands, liver, pancreas, etc.	6	Jordan & Verma; Kotpal
Respiratory organs (6 Lectures)	**Skin, gills and lungs. Air sacs**	Respiratory organs in vertebrates: gills, air bladder, skin, air sacs and lungs.	6	Jordan & Verma; Kotpal
Circulatory organs (8 Lectures)	**Hearts and aortic arches. Portal systems**	Hearts- structure of hearts in vertebrates. Aortic arches- structure of aortic arches in vertebrates. Portal systems- renal portal and hepatic portal veins.	8	Jordan & Verma; Kotpal
Urino-genital organs (8 Lectures)	**Kidney and its ducts, gonads and their ducts**	Introduction Vertebrate kidneys and their ducts. Gonads and their ducts.	8	Jordan & Verma; Kotpal
Brain and sense organs (8 Lectures)	**Vertebrate brain, ear and eye**	Comparative study of brain in vertebrates. Photoreceptor or eyes and ears in vertebrates.	8	Jordan & Verma;

Group B2: Evolution and Biogeography

Unit	Sub-unit	Description of content of the sub-unit (depth)	Lect.	Text/Ref. for the topics
Evolution (12 Lectures)	**Principles of organic evolution**	Introduction, brief account of basic causes and principles of organic evolution (variability, heritability, competition & selection)	1	Verma & Agarwal Singh & Chatirvedi
	Basic patterns of evolution- sequential and divergent evolution, micro, macro, mega and quantum evolution	Progressive and retrogressive. Divergent, convergent, parallel evolution, co-evolution, micro, macro, mega and quantum evolution	2	Verma & Agarwal Singh & Chaturvedi
	Modern synthetic theory of evolution	Brief review of evolutionary theories and their criticism. Detail description of modern synthetic theory.	2	Verma & Agarwal Singh & Chatirvedi
	Variation- types and causes	Types and causes (somatic, germinal, genetic, continuous and discontinuous)	1	Verma & Agarwal
	Isolation- mechanisms, types and origin	Types of isolation, isolating mechanism and its type (pre and post zygotic), origin of isolation	2	Verma & Agarwal Singh & Chatirvedi
	Speciation- types and modes	Introduction, nature of speciation, types and modes of speciation (instantaneous, gradual speciation: allopatric and sympatric)	2	Verma & Agarwal Primack et al.
	Population genetics and evolution: population, gene pool and gene frequency, Hardy-Weinberg Law, genetic equilibrium and genetic drift	Introduction, concept of population, gene pool and gene frequency, Hardy-Weinberg Law, genetic equilibrium and genetic drift.	2	Verma & Agarwal Primack et al.

Biogeography (12 Lectures)	**Concept of biogeography and distribution:**	Introduction, detail description of geographic, bathymetric and geological distribution of animals	2	Sanmbasivia, Rao & Chelllappa,
	Biogeographic patterns:	Introduction, concept and types of animal distribution - cosmopolitan, endemic, disjunct /discontinuous, bipolar distribution, factors affecting distribution	2	Sanmbasivia, Rao & Chelllappa,
	Biogeographic process:	Introduction, concept of dispersal- different modes, means and barriers of dispersal, and vicariance	1	Sanmbasivia, Rao & Chelllappa,
	Zoogeographic realms:	Geographic range, sub realms, physical features and representative fauna of major realms.	3	Sanmbasivia, Rao & Chelllappa,
	Theory of Island biogeography	Introduction, basic concept and history, equilibrium theory of Island biogeography, criticism of the theory.	2	MacArthur & Wilson; Lomolino; Riddle & Brown
	Zoogeographic affinities of fauna of Nepal	Zoogeographic position, Faunal characteristics, Affinities with Palaerctic and Indo-Malayan fauna	2	Suwal & Verheught; Majupuria & Majupuria

Text Books (latest eds.) and **Suggested Readings:**

Alcock, J. Animal Behavior: An Evolutionary Approach. Sinauer Associates.

Arora, M. P. 2003. Animal Behaviour. Himalayan Publishing House.

Baral, H.S. & Inskipp,C. 2006. Important Bird Areas of Nepal. Himalayan Nature

Baral, H.S. and Shah, K.B. 2008. Wild Mammals of Nepal. Himalayan Nature, Kathmandu.

Bhuju, U.R., Shakya, P.R., Basnet, T.B. & Shrestah, S. 2007. Nepal Biodiversity Resource Book. ICIMOD, MOEST, UNEP.

Darlington, P.J. Jr. 1952. Zoogeography: The Geographical Distribution of Animals. John Willey & Sons, New York.

Darwin, C. 1859. On the Origin of Life by means of Natural Selection. John Murray, London.

Dhami, P.S. and Dhami, J.K. A Textbook of Zoology, vol. II & III. Pradeep Pub., New Delhi.

Drickamer, L.C., Vessey, S.H. and Jakob, E. Animal Behavior: Mechanisms, Ecology, and Evolution. Fifth edition. McGraw-Hill Publishers.

Flemming, R. L. 1985. Birds of Nepal. Pub. Robert L. Flemming, Kathmandu.

Grimmett, R., Inskipp, C. and Inskipp, T. 1998. Birds of the Indian Subcontinent. Christopher Helm.

Grimmett, R., Inskipp, C. and Inskipp, T. 2000. Birds of Nepal. Christopher Helm.

Jnawali, S.R. et al. 2011. The Status of Nepal's Mammal: The National Red List Series. DNPWC, Kathmandu.

Jordan, E.L. and Verma, P.S. Chordate Zoology & Animal Physiology. S. Chand, New Delhi.

Kardong, K.V. Vertebrates: Comparative Anatomy, Function and Evolution. McGraw-Hill Higher Education.

Kent, G.C. and Carr, R.K. Comparative Anatomy of the Vertebrates. The McGraw-Hill Companies.

Kotpal, R.L. Modern Text book of Zoology: Vertebrates. Rostogi Pub., Meerut India.

Lomolino, M.V., Riddle, B.R. and Brown, J.H. 2006. Biogeography. 3rd edition. Sinaeur, Sunderland, MA.

Lull, R.S. 1926. Organic Evolution. Macmillan, New York.

MacArthur, R.H. and Wilson, E. O. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton.

Majupuriya T.C. and Majupuriya R. K. 2006. Wildlife and Protected Areas of Nepal. S. Devi, Saharapur; India.

Manning, A. & Dawkins, M. S. 1998. An Introduction to Animal Behaviour. Cambridge University Press.

Parker, T.J. & Haswell, W.A. A Text Book of Zoology, Vol. 2. The McMillan Press Ltd. London, U.K.

Prmak, . R. Poudel, P. K. & Bhattaria, BP. 2013. Conservation Biology: a primer for Nepal, Drimland Publication

Romer, A.S. 1970. The Vertebrate Body, 4th ed. W.B. Saunders, Philadelphia.

Sanmbasivia, I., Rao, APK & Chelllappa, S. Animal Physiology and Ecology. S. Chanda and Company

Schleich, H.H. and Kastle, W. (editors). 2002. Amphibians and Reptiles of Nepal: Biology, Systematics, Field Guide. A.R.G. Gantner

Shah, K.B. and Tiwari, S. 2004. Herpetofauna of Nepal: A Conservation Companion. IUCN Nepal.
Shah, K.B. et al., 2003. Snakebite Management Guidelines. Min. of Health, Dept. of Health Services, EDCD, Nepal.
Shrestha, J. 1981. Fishes of Nepal. CDC, Tribhuvan University, Kathmandu, Nepal.
Shrestha, J. 1995, 'Enumeration of the Fishes of Nepal'. In Biodiversity Profile Project (BPP)Publication No.10. Kathmandu: HMG/N Department of National Parks and Wildlife Conservation, Ministry of Forest and Soil Conservation
Shrestha, J. 2001. 'Taxonomic Revision of Fishes of Nepal'. In Jha, P.K., Karmacharya, S.B., Baral, S.R., and Lacoul, P. (eds) Environment and Agriculture: At the Crossroad of the New Millennium, 171- 180. Kathmandu: Ecological Society (ECOS)
Shrestha, T K. 2001. Birds of Nepal. Vol.I & II, B.Shrestha, Kathmandu.
Shrestha, T.K. 1997. Mammals of Nepal. B. Shrestha, Kathmandu.
Shrestha, T.K. 2008. Ichthyology of Nepal. Himalayan Ecosphere, Kathmandu.
Singh, H. Chatturvedi, CM. 1999. Organic evolution, Anmol publications, New Delhi, India.
Suwal, R.N. and W.J.M. Verheught 1995. Enumeration of the mammals of Nepal. Biodiversity Profile Project Publication No. 6 Department of National Parks and Wildlife Conservation, Kathmandu.
Verlag, Germany.
Verma, P.S. & Agarwal, V.K. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand. S, Kathmandu
Young, J.Z. The Life of Vertebrates. The Oxford University Press.

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Course Title : Chordata, Comparative Anatomy and Evolution **Full Marks: 50**
Course No. : B. Sc. Zool. 202 **Pass Marks: 20**
Nature of Course : Practical **Year: II**

Practical course Zoo. 201

(One practical period is of three hours)

Units	Sub-units	Detail description of the sub-units	No. of Practical periods	Remarks
Museum specimens		Identification, classification, sketches, general characters and biological importance of agnatha, fishes, amphibian, reptile, aves and mammal (At least five in each class)	**10**	
Methods		Sampling, **c**ollection, transportation, preservation, identification and tagging	**5**	
Dissection	Fishes	• General anatomy, • Digestive organ, • Afferent and efferent branchial arteries, • Brain and cranial nerves. • Eye muscles.	**3**	
	Amphibian/reptile/bird/ .mammal	• **G**eneral anatomy, • Digestive organ, • Urinogenital organ, • Arterial and venous systems, • Brain and cranial nerves • Air sacs of bird	**12**	
Mounting	Scales	• Placoid, cycloid and ctenoid	**3**	
		• Ampulla of lorenzini and weberian ossicle of any fish	**3**	

		• Pecten of bird		
Study on specimens/models/ charts		• Scales of reptiles; • Feathers of birds; • Gills of fishes; • Lungs of vertebrates (amphibians, reptiles, birds and mammals); • Heart and Brain of vertebrates.	**5**	
Histology/ Microtomy/ Microphotography	Permanent slide study	• Comparative study of slides of TS/VS of vertebrates (skin, liver, intestine, pancreas, kidney, ovary, testis, stomach, lung and spinal cord).	**4**	
Osteology		• Comparative study of axial and appendicular skeleton of vertebrates (frog, *Calotes*/*Varanus*, fowl, rabbit, etc.).	**5**	
Fossil study		• Study of any two fossils (if available)	**2**	
Case study and report writing		• Visit (visit to zoological museum/zoo/protected areas/ natural habitats- forest/lake or river, etc.) to survey of any group of vertebrates and prepare reports on the fauna	**7**	Throughout the session and submit report
Practical record		• Each student should prepare a practical record based on their study		Throughout the session

Practical Books:

Verma, P.S. A Manual of Practical Vertebrate Zoology. S. Chand and Co. Ltd., New Delhi, India.

Lal, S.S. A Text Book of Practical Zoology: Vertebrate. Rastogi Pub., Meerut, India.

Shakya, S.R. 2010. B. Sc. Zoology Practical Chordates. A complete Zoology Laboratory Manual for BSc Second Year. Sukunda Pustak Sadan.

Sample of Question Paper

Tribhuvan University

Bachelor Level (4 Yrs) Sc. & Tech. **Full Marks : 100**
Course Title : Chordata, Comparative Anatomy and Evolution **Pass Marks : 35**
Course No. : B. Sc. Zool. 201 **Year : II**

Candidates are required to give their answers in their own words as far as practicable. The figures in the margin indicate full marks. Illustrate your answers with suitable diagrams wherever necessary.

Group A (A1 & A2)

Attempt any two questions 2x10=20

1. *****
2. *****
3. *****

Group B (B1 & B2)

Attempt any two questions 2x10=20

4. *****
5. *****
6. *****

Group C

Attempt any eight questions (out of 10) 8x5=40

7. to 16.

Give very short answers of any eight (out of 10) of the followings: 8 x 2.5=20

a) to j)

Practical Question Structure

Topics	Marks
Dissection ……	10
Permanent preparation…….	5
Spotting …….. …….	8
Case study report ……	7
Collection …….	5
Practical records……	10
Viva……..	5
TOTAL……	**50**