

**Tribhuvan University**  
**Institute of Science and Technology**  
**M Sc Zoology**  
**Semester System**  
**Micro-syllabus 2071**

**General Objectives**

- To make the M. Sc. Programme in Zoology more practical and relevant to the professional needs as required by the country.
- To provide the students with advanced knowledge in the area of specialization and upgrading the quality so that M.Sc. students in Zoology could compete academically with other universities of the international level.

**Semester II**

**Course Title: Evolution, Embryology and Ethology**

**Course No: Zoo 551**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 45**

**Full marks: 75**

**Pass marks: 37.5**

**Objectives**

- To help students to know the principles of evolutionary biology.
- To impart knowledge on development systems of chordates.
- To provide knowledge on distribution and behaviour types of animal in nature.

**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.

<b>Unit</b>	<b>Sub-unit</b>	<b>Description of content of the sub-unit (depth)</b>	<b>Lec.hrs</b>	<b>Text/Ref. for the topics</b> (for detail see the list of text & references)
<b>Evolution</b> <b>(12 hrs)</b>	<b>Introduction, evidences, theories &amp; mechanism</b>	Definition, Concept of evolution, Historical development (Period of speculation, Period of observation and inference, Period of experimentation)	1	Futuyma; Ridley.
		Evidences from Classification, Comparative Anatomy/ Morphology, Embryology, Paleontology, Zoogeography, Biochemistry & Physiology and Genetics	2	
		Lamarckian theory, Theory of natural selection, Modern synthetic theory, Germplasm Theory, Mutation theory	2	
	<b>Evolutionary processes in population and species: variation, natural selection and adaptation</b>	Variation: Definition, types, sources and significance.	1	
		Natural selection and Adaptation: Definition, nature, types, natural selection in action, definition of adaptation, types, adaptation in action	2	
	<b>Isolation</b>	Introduction , History, Isolating mechanism – pre mating (geographical, climatic, seasonal, habitat, isolation due to distance, ethological, Mechanical and Physiological Isolation) and post mating (Gametic mortality, Zygotic mortality, Hybrid Inviability, Hybrid Sterility), Role of isolation in evolution.	1	
	<b>Speciation</b>	Introduction , Mode of speciation (Allopatric, Sympatric and Parapatric), Factors (mutation, recombination, migration and gene flow, natural selection), Theories of speciation ( Classical theory of gradualism, Catastrophic mode of Speciation , Founder – flush Speciation theory), origin of species	1	
	<b>Sexual selection</b>	Introduction, sexual characters ( primary and secondary), Theories, Objection	1	
	<b>Basic concepts of molecular evolution</b>	Introduction, evolution of haemoglobin, evolution of cytochrome c, multigene families, nucleic acid phylogeny molecular clock, significance	1	

<b>Biogeography and Distribution (13 hrs)</b>	<b>Zoo-geographical realms (Horizontal or Superficial): Australian, Ethiopian, Palaeartic, Nearctic, Neo-tropical and Oriental with characteristic fauna. Bio-geographic processes. Sub-realms. Patterns of geological distribution of animals</b>	Biogeography: Introduction, regions (Oriental, Palaeartic, Ethiopian, Australian, Neotropical and Nearctic region) Regions: Introduction, physical features, climates, characteristic fauna (fishes, amphibian, reptiles, aves, mammals), their sub-realms with their characteristic fauna of all the regions.	6.5	Verma; Brown & Mank; Arora; Cox & Moore.
	<b>Bathymetric distribution</b>	Introduction about vertical distribution of animals.	0.5	
	<b>Geo-biotic or Terrestrial Realm</b>	Introduction, forest (Tropical Rain Forest, Deciduous Forest and Coniferous Forest with important fauna), Prairie or Grass lands with characteristic fauna, Steppes with characteristic fauna, Desert with characteristic fauna, Tundra with characteristic fauna, Polar regions with characteristic fauna.	1.5	
	<b>Halo-biotic realm</b>	Introduction, Characteristic fauna of Strand zone or intertidal zone, Flat sea or Shallow sea zone, Pelagic zone and Abyssal zone.	1.5	
	<b>Limno-biotic realm</b>	Introduction, Characteristic fauna of Lotic water (Running water), Lentic water (stagnant water), lakes and ponds.	1.5	
	<b>Inter – migration of animals</b>	Introduction, types of migration, initiation of migration, Orientation and navigation, Tools for studying migration.	1.5	
<b>Embryology (10 hrs)</b>	<b>Embryonic cell differentiation</b>	Overview, Stem cells differentiation – Totipotent, Pluorpotent and Multipotent	1	Balinsky.
	<b>Embryonic induction and evocators</b>	Overview, Types – Endogenous and Exogenous induction, organizer, mechanism and theories of neural induction	1	
	<b>Development of brain, eye and heart in vertebrates</b>	Embryonic induction in different chordates, Development of Brain, eye and heart.	3	

	<b>Embryo transfer.</b>	Male and female infertility, treatment for infertility, IVF, process of embryo transfer, success rate, ethical consideration.	2	Keith & Persaud; Singh.
	<b>Haemolytic diseases in the newly born human babies.</b>	Erythroblastosis Fetalis Causes, treatment. Concept of secondary response.	1	
	<b>Recent developments in embryology.</b>	Gamete intra- fallopian transfer (GIFT), Zygote intra-fallopian transfer (ZIFT) Donor insemination (DI), Egg donation, Surrogacy, Sub-zonal insemination (SUZI) or Micro- insemination sperm transfer (MIST), amniocentesis	2	
<b>Ethology (10 hrs)</b>	<b>Stereo- and Acquired types.</b>	<b>Behavior Studied Approach:</b> Introduction on 1. Theory of Evolution by Natural Selection, 2. Comparative Method, 3. Theories of genetics and Inheritance, 4. Behavioral Ecology, 5. Sociobiology <b>Genetically controlled behavior or Instinctive behavior or Natural Behavior</b> (Stereo=tape player !) Info on IRM (Innate releasing mechanism), FAP (Fixed action pattern) and MAP (Modal action patterns). Instinct or instinctive behavior, Cooper experiment (1957)- Mason wasp. Genetics and behavior, Hormones and early development, Aggressive behavior of Sticklebacks fish, Nature/Nurture Epigenesis <b>Acquired Behavior:</b> Types of learning- 1. Habituation, 2. Classical and operant conditioning (Pavlov dog expt.), 3. Operant Conditioning (rat/Skinner box expt.), Comparison in classical and operant conditioning, Other aspects of learning (7 types with examples of each categories) <b>Introduction on:</b> Phylogeny of learning (Protozoa-Mammals), Neural Mechanism of learning (Brain and specific site of response), Concept of Memory	0.5	Alcock; Hinde .
			2	
			1.5	
	1			
	<b>Social behavior</b>	<b>Social group:</b> types, advantages, evidences, introduction of some characteristics: Hierarchy: Leadership, dominance \ dominance chart, Monogamy, Polygamous, Polyandry social systems	1	

	<b>Reproductive behavior (courtship, Parental care, and role of Pheromones)</b>	Sexual selection, Courtship, display, Inter and Intra-sexual selection, Bruce effect, Parental care, Seasonality and timing in animals' Reproduction basically among Birds and mammals. Pheromones and reproduction, Olfactory system and pheromones, Triggers of Innate Behavior	1.5	Alcock; Hinde.
	<b>Agnostic behavior</b>	<b>Form of agonistic behavior:</b> 1. Territorial, 2. Dominance, 3. Sexual, 4. Parental 5. Parent offspring (weaning, disciplinary), 6. Predatory (including cannibalism), 7. Anti-predatory. Ways of expression, Factors in aggression: 1. Internal factors - a. Limbic system, b. Hormones, c. Genetics, 2. External Factors - a. Learning and experiences, b. Pain and frustration c. Social factors	1	
	<b>Migratory behavior</b>	<b>Migration</b> - Definition, Preparation phase, Evolution of Migration, Migration pattern and species, examples. <b>Orientation and Navigation-</b> Definition, features and properties to orient and navigate	1.5	

## References

- Alcock, John (1993). Animal Behavior: An evolutionary approach, Fifth edition. Sinauer Associates. Inc. MA, USA.
- Andrew, Ferguson (1980) Biochemical systematics and evolution, Blackie Publ., London
- Arora. Organic evolution, Himalaya Publication.
- Balinsky, B.I. 1970. An Introduction to Embryology. W.B. Saunders, London.
- Beach, F.A. (1952). Patterns of Sexual Behaviour, Eyre and Spottis Woode, London.
- Brown, H. J. & Mank. Biogeography
- Charles, R.H. (1982). Fundamental concepts in the design of experiments, Holt, Rinechart and Wintson, New York.
- Cox, C.B. & Moore, P.D. Biogeography.
- Dobzhansky, T. (1976). Genetics and Origin of species, Columbia University, USA.
- Dobzhansky, T., Ayala, F.J., Stebbins, G.L and J.W. Valantine (1976). Evolution, Surjeet Publ. New Delhi.

Futuyma, Douglas J. (1998). *Evolutionary Biology* (3rd Edition), Sinauer Associates, New York.

Futuyma, Douglas J. (2005). *Evolution*, Sinauer Associates, New York

Gupta, P.K. (Reprint 1998). *Genetics*, Rastogi Pub., Meerut.

Hinde, A. Robert (1970). *Animal Behavior: A synthesis of ethology and comparative psychology*, Second edition. McGraw-Hill Inc. USA.

Keith, M. & Persaud, T.V.N. (2013). *The Developing Embryo*. 9<sup>th</sup> edition.

Laurence, D. Mueller (2005). *Evolution and Ecology of the Organism*, Prentice Hall, New York .

Manning, (1967). *An Introduction to Animal Behaviour*, Arrol, London.

Michael R. Rose and Moore, J.R. (1979). *Ideas in modern biology*, Nati. History Press.

Ridley, M. (1993). *Evolution*, BlackWell Science Massachusetts, USA.

Ridley, M. (2003). *Evolution* (3rd edition), Blackwell Publishers, New York .

Sather and Gallont (1973) *Biology, The Behavioural View*, Exington Mars, USA.

Singh, I. (2012) *Human embryology*

## Semester II

**Course Title: Ecology & Natural Resources**

**Course No: Zoo 552**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 45**

**Full marks: 75**

**Pass marks: 37.5**

### Objectives

- To impart advance knowledge to the M. Sc. students with ecological principles and their functional aspects.
- To explore the knowledge of natural resources

<b>Unit</b>	<b>Sub-unit</b>	<b>Description of content of the sub-unit (depth)</b>	<b>Lec.hrs</b>	<b>Text/Ref. for the topics</b>
<b>Ecological Limiting Factors</b> (5 hrs)	<b>Concept of limiting factors</b>	Basic knowledge about ecological limiting factors, their importance and suitable examples	0.5	Smith; Odum; Krebs; Begon et al.
	<b>Liebig's law of minimum</b>	Statement, examples and criticism	1	
	<b>Shelford law of tolerance</b>	Statement, Examples (specific level of tolerance in organism)	1	
	<b>Combine concept of limiting factors</b>	Statement of combine concept (Law of minimum and law of tolerance)	1	
	<b>Physical limiting factors</b>	Role /importance of soil, water, temperature (more detail) ,light, humidity ,wind for the organism more emphasis with animals at least one suitable example.	1.5	
<b>Ecological Energetics</b> (8 hrs)	<b>Nature of energy</b>	Energy, ecosystem energy, sources, laws of thermodynamics	1	Smith; Odum; Krebs; Begon et al.
	<b>Primary production: measurement and factors affecting primary productivities</b>	Primary production, production process, biomass production and accumulations Factors affecting Primary Productivities Methods of measurement of primary productivities in aquatic and terrestrial ecosystem	3	
	<b>Secondary production</b>	Concept, measurement and factors affecting Secondary Productivities, Concept and types of ecological efficiency	1	
	<b>Primary and secondary productivities in terrestrial and aquatic environments</b>	Primary and Secondary productivities in terrestrial and aquatic environments	1	Odum; Smith; Sutherland; Krebs.
	<b>Energy flow and models of energy flow</b>	Concepts of energy flow, food chain and food webs Models of energy flow: overview of concepts, energy flow models: Single channels, double channels and Universal	2	
<b>Population Ecology</b> (8 hrs)	<b>Properties of populations: Density: measurement of density; patterns of dispersion,</b>	Introduction, density and patterns of dispersion, Dispersal movements: emigration and immigration, Age structure, sex ratio, Nataliy, Mortality and survivorship curves.	2	Odum; Smith; Sutherland; Krebs.



	Age structures, Sex ratios, Natality and mortality, Emigration and immigration			Odum; Smith; Sutherland; Krebs.
	Measurement of density	Absolute Density: Total count, quadrat, transects, Mark-Recapture methods, Measuring Relative Density: Traps, fecal pellets, vocalization frequency, catch per unit efforts, number of artifacts, Questionnaires, percentage ground cover, roadside count.	2	
	Concept of population Growth and regulation,  Concept of Carrying Capacity	Concept of population growth, net reproductive rate ( $R_0$ ) and Intrinsic rate of increase ( $r$ ), phases of population growth (exponential phase, transitional phase and plateau or stationary phase). <b>Population dynamics:</b> exponential population growth, Logistic growth and Time lags; $r$ and $K$ strategy.	2	
		<b>Population regulation:</b> Density dependent regulation, density independent regulation, population fluctuation and cycles. Concept of carrying capacity and environmental resistance, Natural regulation of population size: Density dependent school, density independent school and intrinsic regulation school.	2	Odum; Smith; Sutherland; Krebs.
<b>Community Ecology</b> (10 hrs)	Community concept	Concept about biotic community (definition and examples)	1	Odum; Smith; Sutherland; Krebs.
	Community characteristics	Species diversity, Dominance, Keystone species, Growth form and structure, Dynamisms(change in community structures), Relative abundance, Trophic structures		
	Community structure	Introduction, Horizontal and vertical stratification: examples: Zonation in aquatic habitats (Littoral, Limnetic, profound zones), Forest communities ( Trees, Shrubs, Herbaceous vegetation Herbs under tree, insects pests, Forest	1	

		floor decaying matter (litter),soil insects ,bacteria ,fungi etc which participate in decomposition Subterranean sub division having rich humus , fungi, bacteria, soil nematodes,protozoa etc.		
	<b>Dominance</b>	Concept of ecological dominance and its ecological significance, indices	1	
	<b>Species richness</b>	Concept, trends in species richness: (***)species area curve )	1	
	<b>Equitability</b>	Concept, ecological significance , index to calculate evenness ( *** evenness index)	1	
	<b>Heterogeneity</b>	Concept and ecological significance of environmental heterogeneity and species richness		
	<b>Community classification</b>	Concept , classification based on temperature and rainfall- [ tropical ,temperate, deserts, tundra] , based on types of habitats[ Terrestrial , aquatic)	1	Odum; Smith; Sutherland; Krebs.
	<b>Ecotypes</b>	Concept explanation with examples , ecological significance ( significance in natural selection)	1	
	<b>Ecotones</b>	Introduction Boundaries of ecotones: Natural & Human generated <b>Scale of Ecotone:</b> Biome ecotone, Landscape ecotone, Patch ecotone, Ecological characters of ecotones and tools to detects the ecotones (GIS, remote sensing)	1	
	<b>Edge effect</b>	Introduction, ecological characters , types(natural and induced), examples	1	
	<b>Ecological indicator</b>	Concept , significance and suitable examples of indicator species	1	
	<b>Trophic relation in community</b>	Introduction, food web and food chain with examples.	1	
<b>Ecological Interaction</b> (3 hrs)	<b>Positive and Negative interactions</b>	Mutualism, Commensalism, Proto-cooperation, Neutralism, Predation, Parasitism, Competition, Antibiosis	1	Krebs; Odum;
	<b>Co-evolution</b>	Introduction, types, example	0.5	

	<b>Group selection</b>	Introduction, examples	0.5	Miller
	<b>Evolution of ecosystem</b>	Strategy of ecosystem development, concept of climax, evolution of ecosystem	1	
<b>Natural Resources</b> (11 hrs)	<b>Renewable and Non-renewable resources</b>	Resources, Human ingenuity, Economics, Cultural beliefs, types, Perpetual, Renewable and non- Renewable. Glimpse of World Population and of Nepal.	1	
		<b>Forest:</b> Importance, Classification, Value, Info on Sustainable forest Management (SFM), Forest Resources, Forest categories and protected areas, major forest types as per Ecological Zones of Nepal,	2	
		<b>Wildlife:</b> Status, importance, value (ecological, cultural, commercial), and local usage, ecological distribution in Nepal, human influence on wildlife.	2	
		<b>Rangelands:</b> Rangeland resource, zonal categories, Biodiversity and Endemism	1	
		<b>Water, Sun and Air resources:</b> Introduction, usage and impact.	1	
	<b>Major Human impacts on Environment</b>	<b>Deforestation,</b> human induced vegetation change, optimistic results of human intervention, global examples (Agroforestry and management)	1.5	
	<b>Soil:</b> Properties, Types, categories in Nepal. Soil erosion and type, landslide, type, cause, impact, mitigation and preventive measures and practices in Nepal.	1.5		
	<b>Ozone-layer depletion:</b> Introduction, Ozone Layer Protection, International - Vienna Convention and the Montreal Protocol	1		

### References (Latest editions)

- Chalise, M.K. (2013). Mountain Ecology and Natural Hazards. A book for part of M.Sc.. Ecology. Nepal Biodiversity Research Society, Lalitpur. p. 95+6. Reprinted 2nd edition 2014.HMG 2002.
- Chalise, M.K. (2013a). Wildlife Ecology and Policies of Nepal. A book for part of M.Sc.. Ecology. Nepal Biodiversity Research Society, Lalitpur. p. 67+7. Reprinted 2nd edition 2014.

ICIMOD (1995). Rehabilitation of degraded lands in mountain ecosystem of the Hindu Kush Himalayan region. Proc. Int. Workshop. Edited by. Pei Shengji, ICIMOD/KIB/CAS. ISBN: 92-9115-404-0. Nepal.

Krebs, C. J. Ecology, Harper International Ed., New York.

Miller, J.K. Living in the Environment, Wordsworth Pub. Co. Belmont, California.

Nepal Biodiversity Strategy. His Majesty's Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu.

Odum, E. P. Fundamentals of Ecology, W. B. Saunders Company, Philadelphia and London.

Pradhan, B.K. 2007. Disaster Preparedness for Natural Hazards: Current Status in Nepal. ICIMOD, ISBN 9789291150304. P.96

Ramade, F. Ecology of Natural Resources, John Wiley, New York.

Sharma, C.K. 1990. Geology of Nepal Himalaya and Adjacent Countries. Kathmandu.

Smith, R. L. Ecology and Field Biology. Harper Collins.

Stiling ,P Ecology -Theories and Applications,4<sup>th</sup> edition Prentice –hall of India Private Limited ,New Delhi.

## Semester II

**Course Title: Research Methodology I & Biostatistics**

**Course No: Zoo 553**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 45**

**Full marks: 75**

**Pass marks: 37.5**

### Objectives

- To impart knowledge to the students with the importance of research and research methodology.
- To make the students acquaint with the use of Biostatistics in research fields in Zoology.

<b>Unit</b>	<b>Sub-unit</b>	<b>Description of content of the sub-unit (depth)</b>	<b>Lectures</b>	<b>Text/References</b>
<b>Research Methodology</b> (10 hours)	<b>Introduction</b>	Research: purpose, characteristics, research & knowledge, steps in research process, scientific communication	1	Bailey; Gupta; Kothari; Singh.
	<b>Identification of the research problem</b>	Identification of research problem, stating the problem, characteristics of good research problem, ways of formulating research problem	1	
	<b>Literature review Referencing</b>	Systematic literature review, strategies for writing literature review (why, how, what), sources of literature  Referencing (why, style, in-text citation, reference listing). Referencing software- EndNote, RefWorks	1	
	<b>Research objectives</b>	Meaning, characteristics, need and types of research objectives, stating research objectives	1	
	<b>Hypothesis</b>	Introduction, importance of research hypothesis, characteristics of testable hypothesis, sources and types of hypothesis	1	
	<b>Research design</b>	Important features, concepts relating to research design, basic principles of research design, concept of different research designs, Important experiment designs: Informal experimental designs (Before-and-	2	

		after without control design, After-only with control design, Before-and-after with control design) & Formal experimental designs (Completely randomized design, Randomized block design, Latin square design & Factorial designs)		
	Sampling Methods. Sampling and sample size	Sampling, methods and sample size	1	
	Data Sources, Analysis, Interpretation, and Presentation	Data Sources, Analysis (softwares & tools), Interpretation and Presentation (tables & charts)	2	
<b>Biostatistics</b> (35 hours)	Introduction and concepts	Introduction to biostatistics and scopes	1	Bailey; Bishop; Gupta.
	Sampling techniques. Sampling distribution.	What, how, when, why (definition and implications, types of sampling/design with examples)	2	
	Frequency distribution.	What, how, why (definition/introduction, univariate frequency distribution, bivariate frequency distribution, frequency distribution table, and application and examples)	1	
	Presentation of data.	What, how, when, why (Tabular presentation and graphical presentation of data – bar diagram, histograms, pie chart, line graphs and examples)	1	
	Measures of Central tendency.	Introduction; Mean, Median, and Mode and Construction of formula; partition value, uses, Examples	3	
	Measures of Variation	Variance and standard deviation; calculation steps and examples	2	
	Probability	Introduction to probability, application and examples	2	
	Correlation	Introduction, types, uses, methods of studying correlation: scatter diagram method, Karl Pearson's	3	

		coefficient of correlation (properties, assumptions, interpretation, computation), Probable error, correlation in bivariate frequency table, Rank correlation method (limitation, computation), examples	
	<b>Regression</b>	Introduction, linear & non-linear regression, lines of regression, coefficient of regression, uses & examples	2
	<b>Hypothesis testing.</b>	What (definition and types), How (different tests), types of errors, Parametric and Non-parametric tests	2
	<b>Chi-square test.</b>	Components, construction of formula; test conditions, Degree of freedom, P value/Confidence level, Calculated value, Tabulated value, Decision and Examples Contingency Table ----- types and examples	3
	<b>Student t-test</b>	Components, construction of formula; Assumptions, Degree of freedom, P value/ Confidence level, Calculated value, Tabulated value, Decision and Examples	3
	<b>F-test</b>	Components, construction of formula; Assumptions, Degree of freedom, P value/Confidence level, Calculated value, Tabulated value, Decision and Examples	1
	<b>Analysis of Variance (ANOVA)</b>	Models – One way Model, Two way Model and Three way Model and their constructions with description of each term Work out examples for each model with steps	7
	<b>Experimental design</b>	What (classification, types and examples – Simple design CRD, RBD, LSD, simple factorial), Complex Design (Split Plot Design, Balanced Incomplete Block Design, Nested Design) Others: What should a researcher prepare for an experimental design? – Recognition and statement of problems	2

		<ul style="list-style-type: none"> <li>- Selection of response (output) variables</li> <li>- Choice of input variable</li> <li>- Choice of factors and levels</li> <li>- Choice of design</li> <li>- Performing experiment</li> <li>- Data analysis</li> <li>- Data base decision making</li> </ul>		
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### References

Bailey, N.T.J. (1995). Statistical Methods in Biology, London.

Bishop, O.N. (1984). Statistics for Biology, Longmann, New York.

Gupta, S.C. (1995). Fundamentals of Statistics Latest Ed., Indira Gupta (Ed.) Himalayan Pub. House Bombay, India.

Hicks, R.C. (1982). Fundamental Concepts in the Design of Experiments. Holt. Rinehart and Winston, NY.

Kothari, C.R. (1990). Research Methodology, Second Ed. VishwaPrakashan, India.

Singh, M.L. (1998). Understanding the Research Methodology Statistical Methods.

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## Semester II

**Course Title: Cell & Molecular Biology and Genetics**

**Course No: Zoo 554**

**Nature of the Course: Theory**

**Credits: 3**

**Lecture hrs: 45**

**Full marks: 75**

**Pass marks: 37.5**

### Objectives

- To impart advance knowledge of present day in molecular and cell Biology.
- To provide knowledge on some important aspects of Genetics.

Units	Sub-units	Detail description of the sub-units	Lec. hrs.	References
Cell Biology (10 hrs)	Structure and function of cell membrane	Molecular models of cell membrane: Danielli and Davson, Robertson, Fluid Mosaic. Organization of plasma membrane- major lipids, membrane proteins, mobility of membrane components. Basic functions	1	DeRobertis and De Robertis Jr ; Roy and De.
	Membrane transport principle	Nature of molecules, Feature of membrane transport, membrane transporters- pores, carrier proteins and channels, principles of Active and passive transport	1	
	Vesicle transport by secretion and endocytosis	Endocytosis- Pinocytosis: fluid phase and receptor mediated, Phagocytosis: Zipper hypothesis and clathrine mediated endocytosis Exocytosis - secretion of macromolecules-exocytotic pathway	1	
	Cell metabolism	Catabolic and anabolic cell metabolism, cellular respiration, Glycolysis: Reaction steps and stoichiometry of glycolysis. Stages of cell respiration ( 1. Oxidative decarboxylation of pyruvate to acetylc CoA 2. Citric acid cycle (Krebs's cycle) and 3. Oxidative phosphorylation	1	
	Signal molecules	Overview of cell signaling, Modes of cell signaling Signal molecules – Hormones, Growth factors, Neurotransmitters	1	Berridge
	Receptors in membrane	Major types – G-protein coupled, ion-channel, Tyrosine Kinases linked, Intrinsic enzymatic activity	1	

	<b>Second messenger</b>	Important second messengers – cAMP, cGMP and Phospholipids	1	Berridge
	<b>Role of signal molecules in gene activation</b>	Signal transduction cascade, Response to signaling – alteration of gene expression, physical and biochemical response.	1	
	<b>Signaling pathways</b>	Important signaling pathways - MAP kinase, NF-kB, and Hedgehog, Interaction between signaling pathways	1	
	<b>Cell cycle</b>	Overview of cell division, Phases – Mitotic (M) and Interphase (G1, S and G2) Cell cycle control, Molecular mechanism of cell cycle regulation.	1	DeRobertis and De Robertis Jr.
<b>Genetics</b> (11hrs)	<b>Mendelian and Non-Mendelian – Sex linked traits</b>	Mendelian Sex linked traits: Gene Vs Allele, single & multiple gene, sex determination, understanding probabilities, Punnett Square	2	Singh; Verma & Agarwal; Gupta; Jones and Karp.
		Non-Mendelian – Sex linked traits - codominance, recombination, epistasis, cytoplasmic inheritance	3	
	<b>Genetic variability</b> <b>General concept of Karyotype Analysis</b>	Genetic variability. Karyotype Analysis-Human genome. Turner's syndrome, sickle cell anemia, cystic fibrosis	1	
	<b>Genetic linkage and Linkage maps</b>	<b>Genetic linkage:</b> Concept of genes present on same chromosome or different chromosome. <b>Linkage maps:</b> LOD score method for estimating recombination frequency (drosophila, human).	2	
	<b>Gene and Chromosome mutations</b>	<b>Gene mutation</b> - Missense, Nonsense Insertion, Deletion, Duplication, Frameshift, Repeat expansion. <b>Chromosome Mutation</b> - Chromosome Structure Chromosome Structure Changes ( <i>Translocation: Deletion: Duplication: Inversion: Isochromosome:</i> ) Chromosome Number Changes <i>aneuploidy polyploidy</i> . Transgenic animals	1	
	<b>Population Genetics: Inheritance of qualitative traits</b>	<b>Population Genetics:</b> gene/allele frequency, natural selection, mutation, gene flow gene pool, genetic drift, adaption and speciation.	2	
	<b>Gene and Genotypic frequency</b>	Calculation by using formulae; $p + q = 1$ and $p^2 + 2pq + q^2 = 1$	1	Singh; Verma & Agarwal; Gupta;

	Hardy and Weinberg principle	Law and equilibrium. Genotype Vs phenotype,	1	Jones and Karp.
<b>Molecular Biology</b> (12 hrs)	Structure and Properties of Nucleic Acids	Organization of DNA and RNA in Eukaryotic Chromosomes. Types of Nucleic Acids: Deoxyribonucleic acid-DNA and Ribonucleic acid-RNA. Structure of DNA: Chemical composition of DNA and Molecular Structure of DNA. Replication of DNA. Structure and types of RNA: Messenger RNA (mRNA, Ribosomal RNA (rRNA) and Transfer RNA (tRNA).	2	DeRobertis and De Robertis Jr ; Rostogi; Turner et al.
	Central Dogma: Transcription and Translation	The Central Dogma: Definition and process. Transcription and Translation. Mechanism and Process of DNA Synthesis: Replication, Reverse Transcription, DNA Repair. Stages of DNA Replication: Initiation, Elongation and Termination. RNA Synthesis and protein Synthesis.	2	
	Structure of Eukaryotic chromosome : Satellite DNAs, Micro-Macro satellite DNA, Nuclear gene, Repeated DNA sequence, Mobile DNA	Structure of Eukaryotic chromosome: Structure and Structural Arrangement of Eukaryotic chromosome DNA Packing System. Satellite DNAs, Micro-Macro satellite DNA, Nuclear gene, Repeated DNA sequence, Mobile DNA or Transposons, types and Evolution of Transposons.	1	
	Molecular Techniques: RFLP, RADP, DdNA Amplification.	RFLP: Definition, Method, and Application, RADP: Defintion, Method, Applications Limitations., DdNA Amplification.	1	
	PCR technology and its application	Principles, The Cycling Reactions: Three Major Steps in PCR, PCR Reactions Components, Application of PCR. Technology	1	
	DNA Sequencing	Definition. Types: The Chemical Method (Maxam-Gilbert method) and The Chain Termination Method (Sanger dideoxy method).	1	DeRobertis and De Robertis Jr ;

	<b>Restriction and Molecular Genetic Maps</b>	Definition of Restriction Map, Process of Making Restriction Map. Definition and process of making Molecular Genetic Map.	1	Rostogi; Turner et al.
	<b>Types of Cloning</b>	What is cloning, Types of Cloning, Merits and Demerits of Human Cloning.	1	
	<b>Recombinant DNA Technology</b>	What is Recombinant DNA Technology? History and Process of Recombinant DNA Technology.	1	
	<b>Transgenic animals</b>	Concept, Gene Transfer Methods: 1. Microinjection Method, 2. Retroviral Vectors Method, 3. Embryonic Stem Cells Method. Transgenic Animals, Applications or Significance of Transgenic Animal production.	1	
<b>Aging</b> (6 hrs)	<b>Theories of ageing</b>	Definition, senescence, theories of aging; programmed theories (programmed senescence, endocrine, immunology theory), Error theories (wear and tear, rate of living, cross-linking, free radical, error catastrophe and somatic mutation theory).	<b>2</b>	Edward and John; McDonald
	<b>Mechanism of aging- Intracellular, Extracellular and Molecular levels</b>	Aging at the cellular level, validity of cell culture findings, specific cellular changes during aging (membrane changes, nuclear changes, cytoplasmic changes, ribosomal changes, mitochondrial changes, lysosomal changes), age associated changes in cell-cell interaction, the highway to death, pathways of regulating aging process, house keeping mechanism –autophagy	<b>3</b>	
	<b>Mental aspects of aging- psychosocial theories; full life theories and mature life theories</b>	psychosocial theories; full life theories and mature life theories	<b>1</b>	
<b>Introduction of Genetic Diseases</b> (6 hrs)	<b>Cancer</b>	Introduction, causes of cancer-external factors (chemicals, radiation, viruses and life style), internal factors-hormones, immune conditions, and inherited mutations; Theories-cellular change/mutation theories, carcinogens, oncogenes/ protooncogenes; risk factors, molecular basis of cancer, types of cancers-classification of cancer, detection and prevention.	1	Weinberg.

	<b>Apoptosis</b>	Cell death by injury, cell death by suicide, why should a cell commit suicide? What makes a cell decide to commit suicide? necrosis vs apoptosis, stages of apoptosis, apoptosis pathways, major players in apoptosis, apoptosis signaling, regulation of apoptosis, importance of apoptosis.	1	Conradt, and Xue
	<b>Hypertension</b>	Introduction, causes and risk factors of hypertension, genetic mechanism in hypertension, prevention.	1	Richard et al.
	<b>Diabetes</b>	Introduction, types of diabetes, causes and risk factors, biochemical and molecular mechanisms of diabetes.	1	Daniel DaSilveira
	<b>Parkinson's disease</b>	Introduction, primary known causes, pathophysiology, potential mechanisms, catecholamine biosynthesis, PD vs Parkinsonism, clinical features, therapeutic approaches	1	Cavalli et al.
	<b>Alzheimer's disease</b>	Overview, symptoms, risk factors, molecular mechanisms, pathophysiology, pathogenic hypothesis, therapeutic approaches.	0.5	Cavalli et al.; Bndson (eds), Kowall (eds)
	<b>Huntington's disease</b>	Introduction, clinical features, genetics, therapeutic approaches.	0.5	Cavalli et al.

## References

Andreas, Gewies. 2003. ApoReview Introduction to Apoptosis.

Andrew, E. Bndson (eds), Neilw Kowall (eds)-Wiley. The hand book of Alzheimer's disease and other dementias-

Andrew, G Renehan, Catherine Booth, Christopher S Potten. What is apoptosis, and why is it important?

Berridge, M. J. (2009). Cell Signaling Biology, Portland Press Limited.

Conradt, B. and Xue, D. Programmed cell death (October 06, 2005), WormBook, ed. The C. elegans Research Community, WormBook, doi/10.1895/wormbook.1.32.1, <http://www.wormbook.org>.

DeRobertis, D.P. and DeRobertis E.M.F.Jr.(1998). Cell and Molecular Biology, 8<sup>th</sup> Ed. B.I. Waverly Pvt. Ltd., New Delhi.

Edward, L.S. and John, W.K. (1996) (4<sup>th</sup> Ed.) Hand book of the Biology of Ageing, Academic Press.

Edward, L.S. and John, W.K. Hand book of the Biology of Ageing, Academic Press.

Gupta, P.K. (Reprint 1998) Genetics, Rastogi Pub., Meerut.

Jones, R.N. and Karp, A. (1986) Introducing Genetics, John Murray, London.

Rager, B. McDonald. Biology of Aging.

Robert, A. Weinberg. Biology of Cancer.

Rostogi, S.C. (1996) Cell and Molecular Biology, New Age Int. (P) Ltd. Pub., New Delhi.

Roy, S.C. and De, K.K. (1997) Cell Biology, New Central Book Agency, New Delhi.

Singh, B.D.(2007). Fundamentals of Genetics, Kalyani Pub.

Turner, P.C., McLennan, A.G., Bates, A.D., and White, M.R.P. (1998). Instant Notes on Molecular Biology.

Verma, P.S. & Agarwal, V.K.(2000). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology

Watson, J.D., Hopkins, N.H., Roberts, J.W., Steitz, I.A. and Weiner, A.M.(1998) Molecular Biology of the Gene, The Benjamin/Cuming Pub. Comp, USA.