Shri Vile Parle Kelavani Mandal's

MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M.Sc.

Course: Zoology

Semester: I and II

Choice Based Credit System (CBCS) with effect from the Academic year 21-22

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the M.Sc.- Zoology (Oceanography), the learners should be enriched with knowledge and be able to-

PSO-1 Acquire knowledge on the various aspects of Zoology including Developmental Biology, Evolution, Human Genetics, Animal Biotechnology in relation to human therapies.

PSO-2 Understand taxonomical aspects of invertebrates, minor phyla, protochordates and vertebrates.

PSO-3 Grow interest in study of Human evolutionary history and Tree of life.

PSO-4 Enhance skills for analytical techniques like microscopy, spectroscopy, chromatography and imaging techniques.

PSO-5 Develop research aptitude with experimental exposure to applications of model organisms to have in-depth understanding of avenues of developmental biology and Genetics with emphasis to generate interest towards research & development.

PSO-6 Develop research-based thinking and learning with remodeling of career in research fields with emphasis on application based research.

PSO-7 Identify various statistical tools for research in biosciences & have complete know how of its use with elaborate applications.

Preamble

Zoology subject has emerged as a progressive subject in the last decade with innovations in curricular designing unique initiatives which attracted students, which also fits good with autonomy status of college. The fundamental challenge posed to zoologists is to design curricula without dissections, which is the heart of the subject. Although Zoologists have always stood firmly against cruelty to animals and practice conservation but eliminating dissections completely would kill the importance of subject hence use of ICT and simulation techniques is strongly recommended to replace the dissections using actual animal specimens.

Care has also been taken to include a unit on tools and techniques essential for research methodology, bioinformatics and also to assess climate change. Also detailed topics of advanced genetics have been incorporated to make learners acquaint with latest development and its applications in the subject. Possibility cannot be ruled out of that it may give further impetus to Zoology students to get interested in research area of Biological Sciences and take it as their career, which is the fastest growing area of scientific world.

This syllabus is framed by incorporating inputs from all the syllabus committee members out of which some also have international exposures, present and veteran teachers, students, rank holders, people from the industry and interdisciplinary background as well as scientists from esteemed institutes.

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Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Seminar	15 marks
Component 2 (CA-2)	MCQ	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	Unit I	8 & 7 (Offline mode)	15
2	Unit II	8 & 7 (Offline mode)	15
3	Unit III	8 & 7 (Offline mode)	15
4	Unit IV	8 & 7 (Offline mode)	15
5	Unit I, II, III, IV	5 each	15
Total Marks			**75**
Question Number	**Description**	**Marks**	**Total Marks**
1	Unit I	5 (Online mode)	10
2	Unit II	5 (Online mode)	10
3	Unit III	5 (Online mode)	10
4	Unit IV	5 (Online mode)	10
5	Unit I, II, III, IV	5 each	10
Total Marks			**50***

* 50 marks scaled to 75 marks.

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. (2021-22)				**Semester: I**	
Course: Taxonomy I, Type Study and Evolution				**Course Code: PSMAZO105**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. Providing scope to the advanced learners without posing challenges before the average and above average learners.
2. To make the learners understand the principles of taxonomy, levels of organizations, modern classification.
3. To create awareness about diagnostic characters of invertebrates.
4. To orient learners with systematic position of few invertebrate phyla and hierarchy of classification.
5. To expose learners with important organ and organ systems of representative insect (Arthropoda).
6. To give an insight to learners about the expression, perpetuation and adaptations of animals in varied environment during the process of evolution.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learner should be able to appreciate morphological features vis-à-vis ecosystems of invertebrate animals.

CO2: Learners would get trained to identify and classify invertebrate animals based on different body features.

CO3: Learners would get in depth knowledge of organ systems of cockroach to understand its anatomical specialty.

CO4: Learner will be able to gain knowledge of altruism, co evolution and the racial distribution of animals in evolutionary time scale.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Distinguishing Features, Classification – Protista to Aschelminthes	01
2	Distinguishing Features, Classification – Annelida to Echinodermata	01
3	Animal Type Study –I	01
4	Evolution	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Distinguishing Features, Classification – Protista to Aschelminthes** **1.1** Important characters of kingdom Protista, Phyla Porifera, Coelenterata, Platyhelminthes and Aschelminthes. **1.2** Classification up to Class with one example each (Minimum Five characters of each class)	15
	1.3 a) Skeletons in Protozoa b) *Types of foraminiferan shells (minimum four) c) *Canal systems in Porifera/Sponges d) Structure and Mechanism of working of nematocysts e) *Parasitic adaptations in Platyhelminthes	
Module 2	**Distinguishing Features, Classification – Annelida to Echinodermata** **2.1** Important characters of Phyla Annelida, Arthropoda, Mollusca, Echinodermata **2.2** Classification upto Class with one example each (Minimum Five characters of each class)	15
	2.3 a) *Metamerism b) *Typhlosole c) Sensory organs of Arthropoda d) *Pearl formation e) Water vascular system f) *Types of foot in molluscs	
Module 3	**Animal Type Study –I** **3.1** Morphological and anatomical characters of Cockroach **3.2** *Digestive system of Cockroach **3.3** Heart and Circulatory system of Cockroach	15
	3.4 Nervous system of Cockroach **3.5** Reproductive system of Cockroach	
Module 4	**Evolution** **4.1** Racial distribution of Primates and *Homo sapiens* **4.1.1** *Racial Distribution of Primates • Distribution of Prosimians (Lemurs, Lorises, Galagos) • Distribution of Anthropoids (Monkeys and Apes) **4.1.2** Divergence of *Homo sapiens* from Anthropoid **4.2 Racial Distribution of *Homo sapiens*** **4.2.1** *Biological Races in humans • Caucasoid (White) race • Negroid (Black) race	15

	• Capoid (Bushmen/Hottentots) race • Mongoloid (Oriental / Amerindian) race • Australoid (Australian Aborigine and Papuan) race	
	4.3 Importance of Human Genetic Biodiversity (Application – Anthropological, Medical, Cultural) **4.3.1** Parasites and Human Co-evolution **4.3.2** Ectoparasites Co-evolution with Humans (Head Louse, Scabies Mite) **4.3.3** Endoparasites Co-evolution with Humans (Liver fluke, Tapeworm, *Ascaris*) **4.4** Altruism and Evolution **4.4.1** Altruism – Intra-species and Interspecies, Cooperation and its Evolution in Human **4.4.2** Altruism and Evolution in Domesticated Wild Animals **4.4.3** Group Selection and Kin Selection **4.4.4** *Domestication and Behavioural Changes **4.5** Hybrid Evolution **4.5.1** Natural Hybrids – Origin and Evolution of Animal Hybrids, Insects, Snails, Fish, Frog, Lizard **4.5.2** Hybrid Speciation **4.5.3** *Artificial Hybrids – Hybrid Optimization – Bee Colony	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

ZOOLOGY PRACTICAL I
Practical Syllabus for Semester I
(Course codes: PSMAZOP11-PSMAZOP14)

Course code: PSMAZOP11
Course I: Taxonomy I, Type Study and Evolution

1. Identification and Classification giving reasons of – Protista to Annelida
(Entamoeba, Trypanosoma, Nyctotherus, Monocystis, Sycon, Hyalonema, Spongia, Hydra, Aurelia, Sea anemone, Planaria, Liver fluke, Tapeworm, Ascaris, Wuchereria, Nereis, Earthworm, Leech)

2. Identification and Classification giving reasons of – Arthropoda to Echinodermata
(Prawn, Butterfly, Scorpion, Millipede/Centipede, Chiton, Dentalium, Pila, Octopus, Neopilina, Edible Oyster, Starfish, Brittle star, Sea cucumber, Feather star, Sea urchin)

3. Dissection of digestive system of Cockroach using actual specimens if permitted or by ICT (simulation technique)

OR

Identification and Functions of the marked part/s from the photographs/PPT from digestive system of Cockroach

4. Dissection of nervous system of Cockroach using actual specimens if permitted or by ICT (simulation technique)

OR

Identification and Functions of the marked part/s from the photographs/PPT from nervous system of Cockroach

5. Dissection of reproductive system of Cockroach using actual specimens if permitted or by ICT (simulation technique)

OR

Identification and Functions of the marked part/s from the photographs/PPT from reproductive system of Cockroach

6. Mounting of:
a. Salivary glands of Cockroach
b. Mouth parts of Cockroach
c. Gonapophysis of Cockroach (male and female)

7. Study of Animal Behaviour:
a. Altruism in animals- Aggregation in fish
b. Reciprocal Altruism – Vampire Bat

Note-I: Art of dissection to study anatomical specialty of animals is the heart of Zoology subject hence two units per semester of the proposed syllabus are dedicated to the same. It is recommended to be practised with the actual specimens if permitted by concerned regulatory bodies, UGC, University, Wild Life Authorities etc. under Autonomous status of the College, if not permitted should be taught using relevant ICT (simulation techniques) wherever possible.

II: One long excursion (not exceeding seven days) OR two short excursions (not exceeding two days each) is recommended to make learners understand biodiversity of animals, their ecology, behaviour patterns and functions in original habitat.

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Ayyar, M. Ekambaranath	A manual of Zoology - Part I, Invertebrata	2019	Ananda Book Depot
2	E.L. Jordan and P.S. Verma	Invertebrate Zoology	2009	S. Chand
3	R. L. Kotpal	Modern text book of Zoology – Invertebrates	Eleventh; Edition	Rastogi publication
4	Ruppert, Fox and Barnes	Invertebrate Zoology	7thedition,2003	Cen gage Learning
5	R.P Srivastava	Morphology of the primates and human evolution	2010	PHI
6	S. Prasad.	Animal behavior	1st Ed.	CBS Publishers & Distributors
7	Anis Kumar Ray	Fossil in Earth Sciences	2008	PHI Learning
8	David M. Raup, Stanley.	Principals of paleontology	1978	W.H. Freeman & Co Ltd

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Hyman L.H.	Invertebrate Zoology – Volumes of different Phyla	1991	Oxford University Press
2	E. L. Jordan & P. S. Verma	Invertebrate Zoology	Rev. edition, 2009	Chand publications
3	P. S. Verma	Invertebrate Zoology	2009	Chand publications
4	N.C. Nair *et al.*	A Textbook of Invertebrates	2010	Saras publications
5	S. S. Lal	Practical Zoology: Invertebrate	2016	Rastogi Publications

6	D.T. Anderson	Invertebrate Zoology	2nd edition, 2002	Oxford
7	Richard C. Brusca*et. Al*	Invertebrates	3rd edition, 2016	Oxford
8	H.S Gundevia	Text book of Animal Behaviour	2009	S Chand & Company
9	Jan A. Pechenik	Biology of the invertebrates	7th edition, 2014	McGraw Hill
10	Kenneth Oakley	Animal behavior	Revised	Saras publication
11	Donald R. Prothero	Evolution	2nd Ed.	Columbia University Press
12	Stebbings	Process of organic evolution	1966	Englewood Cliffs: Prentice-Hall
13	William S. Klug, Michael R. Cummings, Charlotte Spencer, and Michael A. Palladino	Evolution of vertebrates by Colbert Concepts of Genetics	9th edition (2008)	Benjamin Cummings
14	Jay M. Savage	Evolution	1971	Holt, Rinehart & Winston of Canada Ltd
15	John D. Morris	Fossil Records	2010	Institute for Creation Research

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Program: M.Sc. (2021-22)				**Semester: I**	
Course: Developmental Biology – I				**Course Code: PSMAZO102**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To introduce the learners to the concept and mechanism of fertilization in non-chordates
2. To enable the students to understand the molecular events of fertilization in depth and theories of ovum activation proposed by various embryologists.
3. To introduce learners to basic concepts of embryonic development to understand aspects of embryogenesis.
4. To comprehend concept of cell commitment and specification.
5. To introduce the learners to the process of early embryonic development to bring out the differences in the pattern of development in few selected non-chordates.
6. To help learners understand the role of specific gene regulation during embryonic development.
7. To understand diverse forms of reproduction, regeneration and development in non-chordates.
8. To understand the mechanism of regeneration
9. To help learners relate applications of developmental biology with forensics and IPM

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The learner will understand the mechanism of and significance fertilization.
CO2: The learner will appreciate the molecular events of fertilization and knowledge of activation of egg in non-chordates.
CO3: Learners would understand basic concepts and aspects of embryogenesis in animals.
CO4: Learners would appreciate role of cellular commitment and specification during embryonic development.
CO5: Learners will appreciate the mechanism of early development and will be able to correlate the many changes observed in the pattern of embryonic development in these invertebrate animals.
CO6: Learners will be able to comprehend the role of certain genes in early embryonic development.
CO7: Learners will appreciate the diversities in reproduction, regeneration and development in invertebrates.
CO8: Learners will comprehend the principles of developmental biology in forensics and IPM.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Phenomenon of Fertilization	01
2	Basic concepts in Developmental Biology	01
3	Non-chordates - Early Development	01
4	Non-chordates Characteristics of Development	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Phenomenon of Fertilization** 1.1 Concept, Mechanism and Significance of Fertilization 1.1.1 Asexual versus Sexual reproduction and their evolutionary significance 1.1.2 *Concept, Basic requirements and Types of fertilization 1.1.3 Mechanism of Fertilization: • Capacitation of Sperm • Recognition of Sperm and Ovum • Acrosome reaction and contact of Sperm with Ovum • Activation of Ovum • Fusion of Sperm and Ovum plasma membrane • Migration of pronuclei and Amphimixis • Post fertilization changes • Significance of Fertilization	15
	1.2 Molecular Events of Fertilization 1.2.1 Fertilizin and Antifertilizin interaction, Binding protein 1.2.2 *Mechanism to block Polyspermy 1.2.3 Role of Calcium ions in fertilization 1.2.4 *Formation of fertilization membrane in Sea urchin 1.3 Theories concerning activation of Ovum by the sperm 1.3.1 Lillie's Bimolecular Theory 1.3.2 Sensitization to Calcium Theory 1.3.3 Loebs's Theory 1.3.4 Monroys's Repressor Theory	
Module 2	**Basic concepts in Developmental Biology** 2.1 Cell fate, lineages, potency and commitment 2.2 Mechanism of developmental commitment 2.3 *Mosaic and regulative development 2.4 Pattern formation and compartments	15
	2.5 Morphogenesis and cell adhesion: 2.5.1 Differential cell affinity 2.5.2 Cell Adhesion Molecules (CAMs): Cadherins and catenins 2.5.3 Sorting out of embryonic tissues and cell recognition **2.6** Cell specification:	

	2.6.1 Autonomous specification 2.6.2 Conditional specification 2.6.3 Syncytial specification	
Module 3	Non-chordates - Early Development 3.1 Development of *Caenorhabditis elegans* 3.1.1 Pattern of Cleavage 3.1.2 Anterior-Posterior, Dorsal-Ventral Axis formation 3.1.3 Autonomous and Conditional Cell Specification 3.1.4 *Process of Gastrulation 3.2 Early Development in Sea urchin 3.2.1 *Pattern of Cleavage 3.2.2 Blastulation 3.2.3 Determination of Cell fate (fate map) and axis specification 3.2.4 Process of Gastrulation: Up to the stage of archenteron invagination	15
	3.3 Early Development in Drosophila melanogaster: 3.3.1 Pattern of Cleavage and Blastulation 3.3.2 Process of Gastrulation 3.3.3 Anterior-Posterior and Dorsal-Ventral pattern formation by morphogenetic protein gradient 3.3.4 Patterns of homeotic gene expression: Homeo selector gene complexes (Hom-C, homeotic gene complex) – Antennapedia and bithorax complexes and their functional domains, Realistor genes: *distal-less* and *wingless* genes	
Module 4	**Non-chordates Characteristics of Development** 4.1 Metagenesis in Obelia and Polyembryony in Liver fluke 4.2 *Regeneration in *Hydra* (Morphallactic), Planaria (Totipotency) and Annelids 4.3 *Parthenogenesis in Aphids 4.4 Gradient Theory: Concept and evolution, double gradient model in insect, animal-vegetal gradient system in Sea-urchin egg	15
	4.5 Metamorphosis in insects – Indirect Development 4.5.1 *Types and genetic control of insect metamorphosis 4.5.2 Eversion and differentiation of imaginal disc 4.5.3 Endocrine regulation of insect metamorphosis	

	4.5.4 Study of life cycle of Blow fly-applications in Forensics 4.6 Life forms of invertebrates: Amphiblastula larva (Porifera), Planula (Coelenterata), Redia and Cercaria (Platyhelminthes), Nauplius, Zoea, Mysis, Megalopa and Alima *(Crustacea), Glochidium and Veliger (Mollusca), Echinopluteus, Auricularia and Ophiopluteus *(Echinodermata) and Tornaria (Hemichordata) 4.7 Pheromones in Invertebrates - Role as sex attractants and in Integrated Pest Management	

***Seminar Topics**

ZOOLOGY PRACTICAL II
Practical Syllabus for Semester I
(Course codes: PSMAZOP11-PSMAZOP14)

Course code: PSMAZOP12
Course II: Developmental Biology – I

1. To observe sperm and ova in ovotestes of *Achatina fulica* (garden snail) with suitable staining techniques.
2. To observe development of *Caenorhabditis elegans.*
3. To culture *Drosophila* to study its life cycle.
4. To observe stages of *Tribolium* or *Sitophilus to* understand indirect development in animals.
5. To study Gemmule in Sponge.
6. To study larvae of non-chordates:
   - Porifera – Amphiblastula
   - Cnidaria (Coelenterata) – Planula
   - Platyhelminthes – Redia and Cercaria
   - Annelida – Trochophore
   - Mollusca – Glochidium and Veliger
   - Echinodermata – Auricularia, Echinopluteus and Ophiopluteus
   - Hemichordata – Tornaria
7. Temporary mounting of life forms of crustacean (Nauplius, Zoea, Mysis, Megalopa and Alima)
8. To study Life cycle of Lepisma, Cockroach, Butterfly / Moth (Insecta).

Observation should be done by using Permanent slides / Photos / Charts / Preserved specimens / Animal models for studying the developmental aspects.

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Scott F. Gilbert	Developmental Biology	8th Edition, 2006	Sinauer Associates Inc.
2	J.M.W. Slack	Essential Developmental Biology	2nd Edition, 2006	Blackwell Publishing
3	A.K. Berry	Introduction to Embryology	2016	Emkay Publication, Delhi
4	R.L. Kotpal	Modern Text Book of Zoology- Invertebrates	10thEdn, 2013	Rastogi Pub
5	B. I. Balinsky	An Introduction to Embryology	5thEdn, 1981	CBS College Pub
6	B. V. David and T. N. Ananthakrishnan	General and Applied Entomology	2thEdn, 2004	Tata McGraw-Hill

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	L. Wolpert	Principles of Development	4th Edition, 2011	Oxford University Press
2	Jan A. Pechenik	Biology of the Invertebrates	4thEdn, 2000	Tata McGraw- Hill
3	P. S. Dhami and J. K. Dhami	Invertebrate Zoology	3rd Rev.Edn,1974	R. Chand and Co.
4	D. B. Tembhare	Modern Entomology	1st Edn, 1997	Himalaya Publishing House
5	P.S. Verma and V.K Agarwal	Chordate Embryology	2010	S. Chand Publication

PSMAZO102-Additional Reading

- https://phys.org/news/2014-09-blowfly-maggots-physical-evidence-forensic.html
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3296382/
- https://www.canr.msu.edu/resources/pheromone_traps_the_gypsy_moth_e2585

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Program: M.Sc. (2021-22)				**Semester: I**	
Course: Genetics and Animal Biotechnology				**Course Code: PSMAZO106**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To develop the concept in learners understanding importance of genes, genomes for evolution.
2. To comprehend the pattern of genetic relatedness between all species.
3. To understand the contribution of genetic variation in phenotypic expression.
4. To develop the concept of application of genes in modern science and population genetics.
5. To give in-depth knowledge of biological processes through molecular mechanisms
6. To introduce to learners the key species which are used as model organisms in research.
7. To acquaint the learners with special techniques which have been developed for studying these model organisms.
8. To make them aware of the contributions of model organisms to basic biology, genetics, development and diseases.
9. Understanding the principle and application of recombinant DNA in biotechnology.
10. Understanding the molecular techniques involved in diagnosis of diseases.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The Learners will understand the genetic analysis at the gene, genome and population level.

CO2: Learning the flow of genetic information passed in Eukaryotes as well as the complex networking of genes in biological system leading to major phenotypic changes.

CO3: The learner will understand the molecular processes that occur in and between the cells.

CO4: The learner will gain insight in most significant molecular and cell based methods used to expand the understanding of modern biology and Human Genetics.

CO5: The learners will be able to understand the special features of different animals that have made them useful as a model system.

CO6: The learners will become familiar with the specific applications of model organisms for various biological processes.

CO7: The learners will be able to appreciate how experimentation with these organisms have enhanced understanding the basis of human diseases.

CO8: Learners should be able to understand economic, environmental, animal welfare, and societal impacts of animal models and biopharmaceutical production and human therapy management systems.

CO9: The learners are acquainted with good scientific and technical knowledge so as to comprehend, analyse and design novel products and solutions for the health-related problems.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Introduction to Genetics	01
2	Molecular and Human Genetics	01
3	Model organisms and their applications	01
4	Animal biotechnology and Human therapies	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Introduction to Genetics** **1.1: Mendel's laws** 1.1.1 Chromosomal basis of Mendel's Laws 1.1.2 Extension of Mendel's principles: allelic variation and gene function- incomplete dominance and co-dominance 1.1.3 Allelic series, testing gene mutations for allelism **1.2 Genotype to phenotype** 1.2.1 Penetrance and expressivity 1.2.2 Gene interaction 1.2.3 *Epistasis & Pleiotropy	15
	1.3 Gene action 1.3.1 Nature of the gene and its functions: evolution of the concept of the gene 1.3.2 Fine structure of gene (rII locus) **1.4 Sex determination and dosage compensation** 1.4.1Sex determination in nematode, *Drosophila*, amphibia, reptiles, fish, birds, humans **1.5 Gene Regulation** 1.5.1 *Regulation of gene activity in *lac* and *trp*operons of *E. Coli* 1.5.2 General introduction to gene regulation in eukaryotes at transcriptional and posttranscriptional levels 1.5.3 Organization of a typical eukaryotic gene, transcription factors, enhancers and silencers, non-coding genes	
Module 2	**Molecular And Human Genetics** **2.1 Gene Library** 2.1.1 Molecular Analysis of Gene and Gene Products 2.1.2 *Types – Genomic Library, Cdna Library	15

	2.1.3 Construction of Genomic Library – Human Antibody Gene Library 2.1.4 Genomic library – Screening Methods 2.1.5 Applications of Gene Library **2.2 Gene Mapping** 2.2.1 Methods of gene mapping: 3- point test cross in *Drosophila* 2.2.2 Gene mapping in humans 2.2.3 Gene mutation and DNA repair: types of gene mutations 2.2.4 Methods for detection of induced mutations, P- element insertional mutagenesis in *Drosophila* 2.2.5 *DNA damage and repair **2.3 Gene cloning** 2.3.1 Definition, Strategies of Gene Cloning 2.3.2 Techniques in Gene Cloning 2.3.3 Application of Gene Cloning in DNA Analysis in Research 2.3.4 Shotgun Cloning	
	2.4 Human genetics 2.4.1 *Karyotype and nomenclature of metaphase chromosome bands 2.4.2 Molecular basis of chromatin activation and inactivation 2.4.3 Chromosome anomalies and diseases- chromosomal anomalies in malignancy (chronic myeloid leukemia and retinoblastoma) 2.4.4 Human genome and mapping. 2.4.5 Genetics and cancer: oncogenes- tumor inducing retroviruses and viral oncogenes 2.4.6 Chromosome rearrangement and cancer, tumor suppressor genes: Rb gene as 'master brake of cell cycle', P^{53} as 'the guardian of the genome'.	
Module 3	**Model organisms and their applications** 3.1 Introduction: 3.1.1 Concept and Key features of model organisms 3.1.2 *Importance of model organisms 3.2 Daphnia sp. 3.2.1 Genome, epigenetic phenotypic variation	15

	3.2.2 Advantage and limitations 3.2.3 Model for studies in toxicology 3.3 ***Drosophila melanogaster*** 3.3.1 Genome, advantages and limitations 3.3.2 Model for cytogenetics, development, neuroscience, human diseases and therapeutic drug discovery	
	3.4 *Danio rerio* (Zebra fish) 3.4.1 Genome, advantages and limitations 3.4.2 Insights on embryology, ageing and toxicology 3.5 *Mus musculus* (Mouse) 3.5.1 Biology, life cycle, genomics, advantages and limitations 3.5.2 Model for studies on physiology, development, ageing human diseases (Cancer and Diabetes) and behaviour research 3.5.3*Transgenic and germline transgenic mouse models, Genetically engineered mouse models (GEMMs): Knock-In and Knock-out mouse models	
Module 4	**Animal biotechnology and Human therapies** 4.1 Animal biotechnology 4.1.1*****Transgenic animals and their applications: Mice as model system for human diseases and as test case model, Cows, pigs, sheep, goats as biopharmaceuticals Gene Editing, IPR issues and regulations for transgenic animals 4.1.2 Recombinant DNA technology to prevent animal diseases 4.1.3 Conservation biology-Embryo transfer, cryopreservation	15
	4.2 Human therapies 4.2.1 *Tissue engineering: Skin, liver, pancreas 4.2.2 *****Xenotransplantation 4.2.3 Antibody engineering 4.2.4 Cell adhesion based therapies: Integrins, Inflammation, Cancer and metastasis 4.2.5 Site directed mutagenesis	

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ZOOLOGY PRACTICAL III
Practical Syllabus for Semester I
(Course codes: PSMAZOP11-PSMAZOP14)

Course code: PSMAZOP13
Course III: Genetics and Animal Biotechnology

1. Make a temporary squash preparation of onion/garlic root tip cells to study stages of Mitosis
2. Make a temporary squash preparation of testis of cockroach/ grasshopper/ Tradescantia young anther to study stages of meiosis
3. Make a temporary preparation of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus larva
4. Cloning in India – e.g. Garima – First Cloned Buffalo, Noori – Pashmina Goat
5. Study of Syndromes – Cockayne Syndrome (CS), Proteus Syndrome, Muenke Syndrome
6. Identification of Transgenic animal models used in biopharmaceuticals: Mice, Cows, pigs, sheep, goats.
7. Demonstration of plasmid isolation (Mini preparation) using standard kit.
8. Demonstration of Restriction digestion using suitable enzymes from standard kit.

Suggested Reading

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Benjamin Lewin	Genes IX	9th edition (2008)	Jones and Barlett Publishers Inc
2	Snustad D. Peter and Simmons J. Micheal	Principles of Genetics	4th edition, (2006)	John Wiley and Sons. Inc.
3	R. E. Spier, J. B. Griffiths, W. Berthold	Animal Cell Technology – Products of today, prospects of tomorrow	2013	Butterworth – Heinman Publishers
4	De Robertis	Cell Biology	1987	Lea & Febiger, U.S.
5	Monroe W. Strickberger	Genetics	3rd edition, (1968)	Macmillan Publishing Co.
6	Griffiths, J.F., Gelbart, M., Lewontin, C. and Miller	Modern Genetic Analysis: Integrating Genes and Genomes	1999	W. H. Freeman and Company, New York, USA
7	Watson *et al.* Vol I & II	Molecular Biology of gene	7th Ed.	Pearson Education
8	R.P Srivastava	Morphology of the primates and human evolution	2010	PHI

9	Peter Russell	Essential Genetics	2nd Ed., 2006	Tata McGraw Hill edition
10	Peter Russell David Plummer	An Introduction to Practical Biochemistry	3rd Ed	Tata McGraw Hill
11	Colin Rateledge and Bjorn Kristiansen	Basic Biotechnology	2nd Edition	Cambridge Univ. Press
12	S. S. Purohit	Biotechnology – Fundamentals and applications	3rd Edition	Agrobios, India.
13	Bernard R. Glick and Jack J. Pasternack	Molecular Biotechnology – Principles and applications of recombinant DNA	3rd Ed.	ASM Press, Washington DC.

References:

Sr. No.	**Author**	**Title**	**Edition/ Year of Publication**	**Publisher**
1	Daniel J. Fairbanks, W. Ralph Andersen	Genetics	1999	Brooks/Cole Pub Co
2	Eldon J. Gardner, D.P. Snustad, M.J. Simmons, and D. Peter Snustad	Principles of Genetics	8th edition, (1991)	John Wiley and Sons. Inc.
3	David Freifelder	Microbial Genetics	1987	Jones & Bartlett
4	Leon A. Snyder, David Freifelder, Daniel L. Hartl	General Genetics	1985	Jones and Bartlett
5	P.K. Gupta	Genetics	2009	Rastogi Publications
6	Klug & Cummings	Concepts of Genetics	Seventh Edition	Pearson Education (LPE)
7	Craig *et al*.	Molecular Biology	2nd Ed.	Oxford University Press
8	Darnell, Lodish and Baltimore	Molecular cell biology	1995	W.H. Freeman & Co Ltd
9	David M. Raup, Stanley	Principals of paleontology	1978	W.H. Freeman & Co Ltd
10	H.S Gundevia	Text of Animal Behaviour	2009	S Chand & Company
11	Donald R. Prothero	Evolution	2nd Ed.	Columbia University Press
12	Anis Kumar Ray	Fossil in Earth Sciences	2008	PHI Learning

13	Monroe W. Strickberger	Genetics	3rd Ed., 2015	Pearson Education India
14	Alexander N. Glazer and Hiroshi Nikaido	Microbial Biotechnology – Fundamentals of applied microbiology	2nd Ed., 2007	W. H. Freeman and Co, New York.
15	R. S. Crespi	Patents – a basic guide to patenting biotechnology	1988	Cambridge Univ. Press
16	D.J. Taylor, N.P.O. Green, G.W. Stou	Biological Science	3rd Ed.	Cambridge Univ. Press
17	S.K. Swahney, Randhir Singh	Introductory Practical Biochemistry	2001	Narosa Publ
18	Johan E. Smith	Biotechnology	3rd Edition	Cambridge Univ. Press
19	Gerald Karp.	Cell and Molecular Biology- Concepts and Experiments	8th Ed.	John Wiley & Co.
20	Wilson and Walker	Principles and Techniques of Practical Biochemistry	5th Ed.	Cambridge Univ. Press

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Program: M.Sc. (2021-22)				**Semester: I**	
Course: Analytical techniques				**Course Code: PSMAZO107**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To provide the basic knowledge of the different radioactivity and imaging techniques as well as nanotechnology techniques important in Life sciences.
2. To acquaint learners of spectroscopic, chromatographic techniques.
3. To provide information of applications of techniques.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learners would be trained in basic principles and applications of the major separation and imaging techniques.

CO2: Learners would be equipped with sufficient knowledge to operate modern instruments as well as various equipment used in research institutes as also of various industries based on biological sciences.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Spectroscopic techniques	01
2	Chromatographic techniques	01
3	Radioactivity and imaging techniques	01
4	Nanotechnology techniques	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	Spectroscopic techniques: Design of spectrophotometers- Single beam, Double beam and split beam. Errors in spectrophotometric analysis. Applications- Basic concepts or principles, Overview of components, calibration and Applications of- UV-visible spectroscopy;	15
	Flame Photometry; Fluorimetry and Phosphorimetry (Spectro fluorimeters and phosphorimeters); IR-Single beam, double beam and FTIR, Raman spectroscopy; NMR; MS; AAS	
Module 2	Chromatographic techniques: Introduction to Chromatography- a) separation procedure b) development procedure classification terminology **Basic concepts in chromatography**: requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively), qualitative and quantitative analysis**. (2L)** **Concept of plate and rate theories in chromatography**: efficiency, resolution, selectivity and separation capability. Van Demeter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions**. (2L)**	15
	High Performance Liquid Chromatography: Principles, Instrumentation, operation, calibration, accuracy and applications. Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. **(5L)** **Supercritical Liquid Chromatography:** Properties of SFE/SFC, Instrumentation, operation, advantages and applications. **Gas Chromatography**: Principles, Instrumentation of GC with special reference to sample injection systems – split/split less, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, operation, calibration, accuracy and Applications. **(5L)** Processing Chromatography data: Chromatogram, Chromatography software.	
Module 3	Radioactivity and imaging techniques: **Interaction of Radiation with Matter** Radioactive decay, Photoelectric effect, Compton Effect, Pair production, Ionisation of matter, Energy absorbed from X- rays, X –	15

	rays Scattering, X - rays transmission through the medium, Interaction of charged particle and neutrons with matter. Acute exposure and chronic exposure L D 50/60. Production of Isotopes, Synthesis of labelled compounds **Detection and measurement of radiation & measuring instruments** Ionisation of gases, Fluorescence and Phosphorescence, G.M. Counters, Scintillation Detectors, Liquid scintillator, Pocket Dosimeters, TL Dosimeters and their use in personnel monitoring badges, Advantages and disadvantages of various detectors, appropriateness of different types of detectors for different types of radiation measurement. Physical and chemical characteristics of radionuclides used in nuclear medicine, Criteria for selection of the radionuclides for diagnosis and therapy. Chemistry of 99mTc, labelling, Use of Radioisotopes in Biological Science Safety aspects	
	IMAGING TECHNIQUES: Basic Principles, Instrumentation, working and applications of: Flow Cytometry, Inspissator. Medical Imaging: Introduction, principle and applications of: X-Rays, CT Scan, MRI, SPECT, PET, ultrasound systems, colour flow imaging applications (Doppler), Autoradiography, Neutron Activation Analysis, RIA, Radiolabelled antibodies/ receptors LASERS	
Module 4	Nanotechnology techniques: Nanotechnology: Definition, Different classes of nanomaterials, synthesis of nanomaterials, nano structures and **applications,** Nanophotonics, Imaging & diagnostic techniques from nano to Micro scale Characterization using optical and chromatography techniques	15
	Microscopy: Scanning Probe Microscopes - scanning tunnelling microscope (STM), atomic force microscope (AFM), magnetic force microscope (MFM), scanning near field microscope (SNOM), Electron Microscopy: SEM, TEM, CCD camera and application Diffraction Techniques: X-ray diffraction (XRD) Photoluminescence Spectroscopy: X-ray and UV photoelectron spectroscopies (XPS)/Auger electron spectroscopy	

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	E.B. Podgorsak Technical Editor	Radiation oncology physics: A Handbook for teachers and students	2005	IAEA publications
2	Upadhyay, Upadhyay & Nath	Biophysical chemistry	2016	Himalaya Publishing House Pvt. Ltd.
3	Robert E Henkin, Mark A Boles, Gary Dillehay, James R Halama, Stephen M Karesh, Robert Wargner and Michael Zimmer	Nuclear Medicine -Vol I	1996	Mosby
4	Keith Wilson and John Walker	Principles and Techniques of Biochemistry and Molecular Biology	2010	Cambridge University Press
5	Edited by David J. Scott, Stephen E. Harding and Arthur J. Rowe	Analytical Ultracentrifugation Techniques and Methods	2007	American Chemical Society
6	John G. Webster	Medical Instrumentation applications and design	4th Ed.	Wiley
7	Katzir A.	Lasers and Optical Fibers in Medicine	1993	Academic Press, Inc.

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Editors- Ian D. Wilson, Michael Cooke, Colin F. Pool	Encyclopedia of Separation Sciences	2000	Academic Press
2	F.M. Khan	The Physics of radiation Therapy	5th Ed.	Lippincott Williams and Wilkins
3	W. R. Hendee, E.R. Ritenour	Medical Imaging Physics	2002	Wiley-Liss
4	Guy, D. ffytche	An Introduction to The Principles of Medical Imaging	2008	Imperial College Press
5	Khandpur	Biomedical Instrumentation Technology and applications	1st ed., 2004	McGraw – Hill
6	R. S. Khandpur	Hand Book of Bio-Medical Instrumentation	2003	McGraw Hill Publishing Co. Ltd.

7	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer	Biomedical Instrumentation and Measurements	1980	Prentice-Hall of India Pvt.Ltd
8	M. Arumugam	Bio-Medical Instrumentation	2003	Gomathi Sekar

ZOOLOGY PRACTICAL IV
Practical Syllabus for Semester I
(Course codes: PSMAZOP11-PSMAZOP14)

Course code: PSMAZOP14
Course IV: Analytical techniques

1. Identification of Photographs of Different Imaging Techniques.
2. Separation of amino acids by ion exchange chromatography using cation exchanger.
3. Separation and identification of amino acids by 2D paper chromatography
4. SDS polyacrylamide slab/Agarose gel electrophoresis of proteins.
5. Synthesis of nanoparticles
6. Characterization of nanoparticles by UV spectroscopy.
7. HPLC demonstration.
8. HPTLC demonstration using any extract
9. FTIR Demonstration
10. Industrial / Research Institutes visit and report submission.

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Program: M.Sc. (2021-22)				**Semester: II**	
Course: Taxonomy II, Type Study and Paleontology				**Course Code: PSMAZO205**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To create awareness about diagnostic characters of Minor Phyla and Protochordates.
2. To orient learners with systematic position of chordates and hierarchy of classification.
3. To expose learners with important organ and organ systems of representative mammalia (rat).
4. To help students to solve biological problems, that impact our lives and to understand similarities and differences between human and other species with respect to body form, behaviour, adaptation, distribution pattern, physiology.
5. To help learner understand that fossil records provide history of earth as they occur in a particular order.
6. To impart the learner with knowledge of preserving endangered species by the technique of biomaterial banking and assisted reproductive technology, through the concept of frozen zoo.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learner should be able to appreciate morphological features vis-à-vis ecosystems of Minor Phyla and Protochordates.

CO2: Learners would get trained to identify and classify chordate animals based on different body features.

CO3: Learners would get in depth knowledge of organ systems of Rat to understand its anatomical specialty.

CO4: The learner will be able to distinguish scientific and unscientific arguments and that how science generates knowledge besides learning to apply evolutionary principles to understand aspects of evolution.

CO5: Learner will be acquainted with techniques of dating fossils, formation of fossils and the fact that all living organism cannot be fossilized.

CO6: The learner will use fossil evidences to trace evolution of various species. The concept of Frozen zoo will foster the need of hour for conservation of endangered species.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Distinguishing Features, Classification – Protochordates and Minor Phyla	01
2	Distinguishing Features, Classification – Chordates	01
3	Animal Type Study –II	01
4	Evolution and Fossils	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Distinguishing Features, Classification – Minor Phyla and Protochordates** 3.1 Important characters of Minor phyla Cheatognatha, Sipunculoidea and Brachiopoda Classification upto Class with one example each (Minimum Five characters of each class) 3.2 *Important characters of Phylum Hemichordata	15
	3.3 Important characters of sub-phyla Urochordata and Cephalochordata 3.4 Classification up to Class of minor phyla and Protochordates with one example each (Minimum Five characters of each class)	
Module 2	**Distinguishing Features, Classification – Chordates** **2.1** Important characters of sub-phylum vertebrata – Agnatha (with one example) **2.2** Important characters of sub-phylum vertebrata – Gnathostomata (a) Important characters of Super Class- Pisces (with one example) (b) Important characters of Class- Amphibia (with one example) (c) Important characters of Class- Reptilia (with one example) (d) Important characters of Class- Aves (with one example) (e) *Important characters of Class- Mammalia (with one example)	15
	2.3 a) *Comparison between Chondrichthyes and Osteichthyes b) Scales in fishes c) *Parental care in amphibians d) Adaptive radiation in reptiles e) Adaptation to flight in birds f) *Aquatic mammals g) Types of fins	
Module 3	**Animal Type Study –II** **3.1** Morphological and anatomical characters of Rat (*Rattus spp.)* **3.2** *Digestive system of Rat **3.3** Heart and Circulatory system of Rat	15
	3.4 Nervous system of Rat **3.5** Urinogenital system of Rat	
Module 4	**Evolution & Fossils** **4.1 Human evolution** 4.1.1 Human Evolutionary History and Placing Humans on Tree of Life	15

	4.1.2 Genomics and Humanness; Current Issues in Human Evolution 4.1.3 *Brief Accounts of *Parapithecus*, *Propliopithecus*, *Dryopithecus*, *Ramapithecus*, *Australopithecus*, Neanderthal, Cromagnon and Modern man **4.2 Fossil dating** 4.2.1 *Geological timescale – Eras, Periods and Epochs 4.2.2 Major Events in Evolutionary Time Scale 4.2.3 Significance of Fossils and Fossilization 4.2.4 Fossil dating – Types: Absolute and Relative Dating 4.2.5 *Process of C-14 Carbon Dating	
	4.3 Frozen zoo 4.3.1 Concept of Frozen Zoo to Save Endangered Species 4.3.2 Techniques to Create Offspring from Cells of Endangered Species, Nuclear transfer, Mixing cells, Creating Sperms and Eggs 4.3.3 Current Status of Frozen Zoo	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

ZOOLOGY PRACTICAL I
Practical Syllabus for Semester II
(Course codes: PSMAZOP21-PSMAZOP24)

Course code: PSMAZOP21
Course V: Taxonomy II, Type Study and Paleontology

1. Identification and Classification giving reasons of – Minor Phyla and Protochordates (Sagitta, Sipunculus, Lingula, Balanoglossus, Herdmania, Amphioxus, Doliolum, Salpa)

2. Identification and Classification giving reasons of – Agnatha and Gnathostomata (Labeo, Sting ray, Ichthyophis, Salamander, Frog, Chelonia, Lizard, Naja, Turtle/Tortoise, Ostrich, Penguin, Parakeet, Hedgehog, Dolphin, Bat)

3. Dissection of digestive system of Rat using actual specimens if permitted or by ICT (simulation technique)

OR

4. Identification and Functions of the marked part/s from the photographs/PPT from digestive system of Rat

5. Dissection of nervous system of Rat using actual specimens if permitted or by ICT (simulation technique)

OR

6. Identification and Functions of the marked part/s from the photographs/PPT from nervous system of Rat

7. Dissection of urinogenital system of Rat using actual specimens if permitted or by ICT (simulation technique)

OR

8. Identification and Functions of the marked part/s from the photographs/PPT from urinogenital system of Rat

9. Fossil study:

a. Body Fossils – A Wall of Large Dinosaur Bones from the Jurassic Period, Turritella Snail Shells from the Miocene Age

b. Molds and Casts – Ammonite, Trilobites

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	K. K. Chaki, G. Kundu, S. Sarkar	Introduction to General Zoology, Volume II	4th Rev Ed.	New Central Book Agency
2	F. B. Mondal	Vertebrate Zoology	2013	Oxford & IBH Publishing Co Pvt.Ltd
3	Anis Kumar Ray	Fossil in Earth Sciences	2008	PHI Learning
4	John Morris	Fossil Records	2010	Institute for Creation Research
5	William S. Klug, Michael R. Cummings, Charlotte Spencer, and Michael A. Palladino	Evolution of vertebrates by Colbert Concepts of Genetics	9th edition (2008	Benjamin Cummings

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	R. L. Kotpal	Modern Text Book of Vertebrates	11th Ed.	Rastogi Publication
2	Alexander, R.M.	The Chordata	1975	Cambridge University Press, London

3	Barrington, E.J.W.	The biology of Hemichordata and protochordata	1965	Edinburgh; London: Oliver and Boyd, cop.
4	Romer, A.S.	Vertebrate Body	III Ed.	W.B. Saunders Co., Philadelphia
5	Waterman, A.J.	Chordata-structure and function	1971	Macmillan Co., New York
6	Smyth	Amphibia and their ways	1961	The Macmillan Co., New York
7	Jordan and Verma	Chordate Zoology	2013	S. Chand and Co
8	Donald R. Prothero	Evolution	2nd Ed.	Columbia University Press
9	Savage	Evolution	2nd Revised edition, 1971	Holt, Rinehart & Winston of Canada Ltd

PSMAZO201-Additional Reading

- http://www.ucmp.berkeley.edu/chordata/chordata.html
- http://animaldiversity.org/accounts/Chordata/
- https://manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylumchordata
- http://www.nhptv.org/wild/chordata.asp
- https://www.shapeoflife.org/phylum-chordata-advanced

Note-I: Art of dissection to study anatomical specialty of animals is the heart of Zoology subject hence two units per semester of the proposed syllabus are dedicated to the same. It is recommended to be practised with the actual specimens if permitted by concerned regulatory bodies, UGC, University, Wild Life Authorities etc. under Autonomous status of the College, if not permitted should be taught using relevant ICT (simulation techniques) wherever possible.

II: One long excursion (not exceeding seven days) OR two short excursions (not exceeding two days each) is recommended to make learners understand biodiversity of animals, their ecology, behaviour patterns and functions in original habitat.

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Program: M.Sc. (2021-22)				**Semester: II**	
Course: Developmental Biology - II				**Course Code: PSMAZO202**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To introduce to the learner to the diverse concepts of Induction and Competence
2. To help learners understand genetic basis of Metamorphosis.
3. To acquaint the learner with concept of embryonic cell commitment and determination.
4. To help the learners understand differential role of cells during embryonic development.
5. To acquaint the learner with the concept of germ cell migration in chordates.
6. To familiarize the learner with details of stem cells.
7. To introduce to the learner the impact of environment on development and its evolutionary aspects.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: The learner will gain knowledge of embryonic induction and competence in chordates.

CO2: The learner will be able to differentiate types of metamorphosis in chordates.

CO3: Learner should be able to appreciate morphological features vis-à-vis ecosystems of invertebrate animals.

CO4: The learners will get an idea of embryonic cell commitment and their determination to progress the development of organs and organ systems.

CO5: The learner will acquire the knowledge of cyto-differentiation as the embryonic development proceeds.

CO6: The learner shall comprehend details of germ cell migration.

CO7: The learner will be able to understand the importance of stem cells.

CO8: The learner will be acquainted with environmental impact on development and evolution of animals.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Aspects of Embryonic Induction, Competence and Metamorphosis	01
2	Embryonic Aspects of Cell Commitment, Determination and Cytodifferentiation	01
3	Developmental Biology - Germ cells, Stem cells and Induced breeding	01
4	Animal Development – Impact of Environment and Evolution	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Aspects of Embryonic Induction, Competence and Metamorphosis** 1.1 *Concept and types of embryonic inductions. 1.2 Embryonic induction in Prechordates: Ascidians and Amphioxus 1.3 Induction of vertebrate lens and mesoderm 1.4 Neural induction in vertebrates – Cyclostomes, bony fishes, frogs, reptiles, birds and mammals	15
	1.5 Evocation, Secondary and tertiary induction in vertebrates 1.6 Molecular basis of competence, reciprocal action, fields and morphogenetic patterns 1.7 Physiological and hormonal control of metamorphosis, *Retrogressive (Ascidian) and *Progressive (Amphibians)	
Module 2	**Embryonic Aspects of Cell Commitment, Determination and Cytodifferentiation** **2.1** Characteristics and *types of differentiation. **2.2** Chemical basis of differentiation. **2.3** *Role of cleavage nuclei and egg cytoplasm in *Xenopuslaevis*	15
	2.4 Molecular events of differentiation: 2.4.1. Differentiation at genome level. 2.4.2. Transcriptional level control. 2.4.3. Translational level control. **2.5** Tissue maintenance and replacement during differentiation. **2.6** Differentiation at the microenvironment level.	
Module 3	**Developmental Biology - Germ cells, Stem cells and Induced breeding** **3.1** Introduction to germ cells, Germ cell migration – Zebra fish, Frogs, Lizard, Chick and Mouse. 3.2 *Stem cells – embryonic stem cells, induced pluripotent stem cells, adult stem cells. 3.2.1 Regeneration therapy – cardiac, bone and neuronal regeneration.	15

	3.2.2 Cryopreservation of stem cells - Concept, Tools, techniques and application.	
	3.3 *Induced breeding in Fish - technique and application. 3.4 Concept of artificial insemination in cattle and technique of production and *applications of test tube baby and GIFT	
Module 4	**Animal Development – Impact of Environment and Evolution** **4.1** Environmental cues and impact on development – Predator induced polyphenisms – amphibian, temperature and sex – fish, turtle and alligator. **4.2** Teratogenesis – Alcohol, retinoic acid, endocrine disruptors – diethylstibestrol, plastics – nonylphenol, bisphenol A and heavy metals as teratogens and *Effects of endocrine disruptors.	15
	4.3 Developmental constraints on evolution – Physical, morphogenetic and phyletic 4.3.1 Modularity of development – Example - duffy blood group substance and stickleback fish. **4.4** Aging and Senescence – Causes, consequences, and therapeutics. 4.4.1*Environmental and Epigenetic causes of Aging – Plastics, Pesticides, Heavy metals. **4.5** Promoting longevity: Role of Telomerase, an overview.	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

ZOOLOGY PRACTICAL II
Practical Syllabus for Semester II
(Course codes: PSMAZOP21-PSMAZOP24)

Course code: PSMAZOP22
Course VI: Developmental Biology-II

1. Identification of fish developmental stages–egg, larva, juvenile (fry, fingerling and adult).
2. Measurement of fish ova diameter using oculometer.
3. Preparation of temporary slides of whole mount of 24/36/48 hours of chick embryos.
4. Study of metamorphosis in Ascidian and amphibia.
5. To study morphogenetic movement in chick embryo using vital stain.
6. Isolation of limb bud and eye vesicle and its chorioallantoic grafting in chick embryo.
7. Study of Stem cells from chick embryo – staining and Identification of cells.
8. Study of mammalian placentae according to histology: Epithelio-chorial, Syndesmo-chorial, Endothelio-chorial, Haemo-chorial and Haemo-endothelial.

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Patten	Chick embryology	1929	P. Blakiston's Son & Co.
2	Balinsky	An Introduction to Embryology	2012	Cengage Learning India
3	William S. Hoar	General and Comparative Physiology	1975	Prentice Hall
4	Nelsen OE.	Comparative embryology of the vertebrates 1 – 2	1953	Mc Graw – Hill Book company, New York
5	Scott F.	Developmental Biology	11th Ed.	Sinauer Associates Inc
6	R. L. Kotpal	Modern Text Book of Vertebrates	11th Ed.	Rastogi Publication

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Withers	Comparative Animal Physiology	1992	Brooks/Cole
2	Giese	Animal Physiology	1959	Annual Review of Physiology Vol. 21:547-576 https://doi.org/10.1146/annurev.
3	Jordan and Verma	Chordates	2013	S. Chand and Co

4	Parker and Haswell	Chordates	2019	Alpha Edition
5	P. S. Dhami and J. K. Dhami	Chordate Zoology	2006	R Chand & Co-New Delhi
6	A.K. Berry	Introduction to Embryology	2016	Emkay Publication, Delhi-51
7	P.S. Verma and V.K Agarwal	Chordate Embryology	2010	S. Chand Publication

PSMAZO202-Additional Reading:

- http://www.eurekaselect.com/node/156190/related-ebooks
- https://embryo.asu.edu/pages/sperm-capacitation
- https://www.sciencedirect.com/book/9780124366435/handbook-of-stem-cells
- https://ivf.net/ivf/a-textbook-of-in-vitro-fertilization-and-assisted-reproduction-the-bourn-hall-guide-to-clinical-and-o418.html
- https://www.britannica.com/science/teratogenesis
- https://link.springer.com/chapter/10.1007/978-3-642-45532-2_15
- Sex pheromones in amphibians-a review Vet. Med-Czech, 50,2005(9); 385-389

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. (2021-22)				**Semester: II**	
Course: Biotechnology, Techniques in Research and Sustainability				**Course Code: PSMAZO206**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. To provide the learners thorough knowledge on the genome organization, gene expression and its control in prokaryotes and eukaryotes
2. To acquaint learners with the basic tools and techniques used in biotechnology.
3. To provide learners the knowledge on the applications of biotechnology in industries, medicines, agriculture and environment.
4. To create awareness of the various techniques used for gene transferring in biotechnology field.
5. To provide general information about tools and techniques used in biotechnology.
6. To provide the information about the concept and causes of Climatic change.
7. To make the student aware of the climatic change and current environmental picture of the Earth.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learners will be able to understand the processes for harnessing the potentials of living systems for betterment of mankind.

CO2: Learners will have an understanding of the processes and techniques used in development of biotechnology products.

CO3: Learners will gain knowledge on the application of biotechnology in industries, medicines, agriculture and environment.

CO4: Learner should be able to explain the basic principles of techniques used in genetic engineering.

CO5: The learner will understand current challenges of climatic changes and environmental issues.

CO6: Learner will understand the importance of the green audit.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Techniques in Biotechnology	01
2	Applications of Biotechnology	01
3	Genome management	01
4	Climate Change and Sustainability	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**Techniques in Biotechnology** **1.1: Genome Organization:** 1.1.1: *Organization of genome in prokaryotes and eukaryotes, C- value paradox and genome size. 1.1.2: Complexity of viral, bacterial and eukaryotic genomes, Cot curves, repetitive and non- repetitive DNA sequences **1.2: DNA replication, Gene expression in prokaryotes and eukaryotes:** 1.2.1: *Transcription and translation in prokaryotes. 1.2.2: Transcription and translation in eukaryotes.	15
	1.3: Control of gene expression in prokaryotes & Eukaryotes: 1.3.1: Small regulatory RNAs, small nuclear ribonucleoproteins(snRNPs), Transcription level control, RNA processing, Translational level control, post-translational control. 1.3.2: Gene silencing, miRNA, RNA silencing pathways and DNA methylation. **1.4: Methods in Biotechnology:** 1.4.1: Cloning using plasmid pBR322, pUC18, pUC19, detection of recombinants by blue-white screening, cloning in bacteriophage, cosmid, BAC and YAC vectors. 1.4.2: Chromosome walking, RAPD, AFLP, Microarrays,	
Module 2	**Applications of Biotechnology** **2.1: Industrial Biotechnology** 2.1.1 Microbial fermentation, Microbial growth kinetics, Design of a fermenter, Organisms used in large scale fermentation. 2.1.2 Production of antibiotics-Cephalosporin, erythromycin; amino acids-proline, glutamate **2.2: Medical Biotechnology:** Molecular approaches in diagnosis and treatment 2.2.1 *Peptide vaccines: synthetic drugs (engineered proteins)	15

	2.2.2 Genetic immunization: Antisense DNA, Therapeutic ribozymes 2.2.3 Anti-idiotypic vaccine for cancer treatment 2.2.4 *Monoclonal antibodies (mAbs) and their therapeutic applications.	
	2.3: Environmental Biotechnology 2.3.1 Effluent treatment, Bioremediation, phytoremediation, Biosensors, Biofuels. 2.3.2 Cartagena Protocol on Biosafety- General features with respect to objectives, the precautionary principle and live modified organisms (LMO)	
Module 3	**Genome management** **3.1 The Basic tools of genetic engineering** 3.1.1 Gene transfer techniques: Protoplast fusion, calcium phosphate, precipitation, electroporation, liposome, ligand mediated, gene gun or biolistic approach, viral mediated 3.1.2 Selection and screening of recombinants 3.1.3 *****Nucleic acid probes and hybridization, Southern blotting and Northern blotting; Western blot	15
	3.2 Cloning Vectors 3.2.1 *****Retrovirus and SV40 vectors 3.2.2 Special purpose vectors- Expression vectors, Secretion vectors, Shuttle or bi-functional vectors, single stranded phage	
Module 4	**Climate Change and Sustainability** 4.1 Climate change 4.1.1 Introduction 4.1.2 *Indicator Species of Climate Change 4.1.3 Vulnerability and Adaptations	15
	4.2 Greenhouse effect 4.2.1 Greenhouse Gases 4.2.2 Increase in Greenhouse Gas Concentrations 4.2.3 *Global Warming Potential of Greenhouse Gases 4.3 *Green audit: Energy audit, Waste disposal audit, Water audit, Carbon audit 4.4 *Impact of climate change on aquatic and terrestrial organisms	

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

ZOOLOGY PRACTICAL III
Practical Syllabus for Semester II
(Course codes: PSMAZOP21-PSMAZOP24)
Course code: PSMAZOP23

Course VII: Biotechnology, Techniques in Research and Sustainability

1. Quantitative estimation of DNA in a suitable tissue by diphenyl amine method.
2. Quantitative estimation of RNA in a suitable tissue by orcinol method.
3. Preparation of beads by immobilization of yeast cells in calcium alginate and bioassay
4. Biosensor based test- Pregnancy / ELISA for detection of HIV.
5. To estimate the Amount of Dust (Particulate Matter) Deposition on the Leaves of Roadside Plants.
6. Study of Animals Acting as Climate Change and Global Warming Indicators
   Green turtle
   Birds – Sparrow
   Polar bear
   Coral reef
   Butterflies
7. Environment Audit report (Green Audit / EIA of Small Selected Area)
8. Detection of Sodium/Potassium from sample using Flame Photometer.
9. Determine LC_{50} of the given pollutant by probit method using Daphnia as animal model.

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott, Zipursky, Darnell	Molecular Cell Biology	5th Edition	WH Freeman
2	Peter J Russell	Genetics – A molecular approach	3rd Edition	Pearson Education Inc.
3	Bernard R. Glick & Jack J. Pasternak	Molecular Biotechnology – Principles and applications of recombinant DNA	3rd Edition	ASM Press.
4	Peter F Stanbury, Allan Whitaker, Stephen J Hall	Principles of Fermentation Technology	2nd Edition	Elsevier Publications
5	S N Jogdand	Medical Biotechnology	2008	Himalaya Publishing House
6	Smith T.M. and Smith R.L.	Elements of Ecology	7th ed., 2009	Pearson Benjamin Cummings

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Gerald Karp.	Cell & Molecular Biology: Concepts & Experiments	6th Edition, 2015	Wiley
2	Colin Ratledge & Bjorn Kristiansen	Basic Biotechnology	3rd Edition	Cambridge University Press
3	Alexander Glazer & Hiroshi Nikaido	Microbial Biotechnology	2ndEdition	Cambridge University Press
4	K G Ramawat & Shaily Goyal	Molecular Biology and Biotechnology	2010	S. Chand
5	Paul D. Leedy	Practical Research Planning and Design	2nd Ed.	Macmillan Publ.
6	Kormondy E.J.	Concepts of Ecology	4th ed. 1996	W.H. Prentice-Hall
7	Pranav Kumar and Usha Mina	Fundamentals of Ecology and Environment	Second edition	Pathfinder Publication New Delhi, India
8	Stiling P.	Ecology: Global insights and investigations	2nd ed. 2015	McGraw-Hill Education
9	S S Bhojwani & M K Razdan	Plant Tissue Culture: Theory and Practice	1996	Elsevier

PSMAZO203-Additional Reading:

- Molecular Biology of the Cell – Alberts *et al*., - Garland Science.
- Molecular Biology of the Gene – Watson *et al.*, Benjamin Publications.
- Genes VIII – Benjamin Lewin – Oxford Press.
- Molecular Biology – Freifelder – Narosa Publication House.
- Textbook of Biotechnology – H K Das – Wiley India Publication.
- The Golden Rice Project http://www.goldenrice.org/
- Aspartame Information Center. www.aspartame.org

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. (2021-22)				**Semester: II**	
Course: Research Methodology				**Course Code: PSMAZO207**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
04	04	-	04	25	75

Learning Objectives:

1. Learners would be exposed to latest research methodology and different biostatistical tests as well as tools relevant in the field of research of Zoology subject.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learners would understand the fundamentals, applications and significance of statistical tools in the field of research.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Research methodology	01
2	Biostatistics- Introduction	01
3	Theory of probability	01
4	Hypothesis testing	01
	Total	**04**
PRACTICALS		**04**

Unit	Topic	No. of Hours/Credits
Module 1	**1. RESEARCH METHODOLOGY** 1.1. Strategies, planning and analysis 1.1.1. Scientific problem 1.1.2. Objectives of research 1.1.3. Short term and long term goals 1.1.4. Research conditions 1.1.5. Research design- characteristics of a good research design, types of research design 1.1.6. Repeatability, reproducibility and reliability 1.1.7. Experimental protocols 1.2. Literature search 1.2.1. Information literacy 1.2.2. Systematic literature search 1.2.3. How to formulate a query: PICO 1.2.4. Search techniques 1.2.5. Methodology filters 1.2.6. Critical appraisal 1.2.7. Impact factor 1.2.8. Medical and scientific internet 1.2.9. Principal bibliographic databases 1.2.10. Citation style 1.2.11. Reference management software e.g. Mendeley, Zoreto	15
	1.3. Ethics in science 1.3.1. Introduction to ethics 1.3.2. Scientific conduct and misconduct 1.3.3. Authorship issues 1.3.4. Plagiarism 1.4. Basic principles of human research ethics- international regulation Ethics of animal research- CPCSEA, Institutional ethics committee, OECD guidelines	
Module 2	**2. BIOSTATISTICS- INTRODUCTION** 2.1. Introduction- definition, scope and limitations 2.2. Measurement scales, variables & their measurements 2.3. Collection of data, classification & tabulation-diagrammatic & graphical representation 2.4. Measures of central tendency -mean, median, mode, geometric mean	15
	2.5. Measures of dispersion- Range, Q.D., M.D., variance, standard deviation 2.6. Correlation and Regression analysis: Correlations and regressions-: Relation between two variables, scatter diagram, definition of correlations & their equations, interpretation of regression coefficients, principles of least squares, Two regression	

	lines, curve fitting Karl Pearson's coefficient of correlation, Spearman's coefficient of correlation 2.7. Sampling-sampling frame, importance of probability sampling, simple random sampling, systemic sampling, stratified random sampling, cluster sampling	
Module 3	**3. THEORY OF PROBABILITY** Random experiments, sample space of an experiment, event, mutually exclusive events, exhaustive events, independent events, additional theory(statement only), conditional probability, multiplication theorem(statement only), Bayes' theorem.	15
	Discrete distribution- Binomial distribution, Poisson distribution Continuous distribution- Normal distribution and its properties, Sampling distribution	
Module 4	**4.** 4.1. HYPOTHESIS TESTING 4.1.1.Null and alternate hypothesis 4.1.2.Type-I & Type-II errors 4.1.3.Level of significance, 4.1.4.Power of test 4.1.5.p value 4.2. PARAMETRIC TESTS 4.2.1.Large sample Tests 4.2.1.1. Testing significance of single population mean 4.2.1.2. Testing significance of single population proportion 4.2.1.3. Testing significance of two population mean 4.2.1.4. Testing significance of two population proportion 4.2.2.Small sample Tests 4.2.2.1. Testing significance of single population mean 4.2.2.2. Testing difference between two independent normal population mean 4.2.2.3. Testing difference between two correlated normal population mean 4.2.2.4. Testing significance of correlation coefficient	15
	4.2.3. $\chi 2$ test 4.2.3.1. Testing single population variance 4.2.3.2. Testing Goodness of fit 4.2.3.3. Testing association between two attributes 4.2.4. F-test- Testing equality of variance 4.2.5. ANOVA- one-way classification, two-way classification 4.3. INTRODUCTION TO NON-PARAMETRIC TESTS 4.3.1. Rank test-sign test 4.3.2. The Wilcoxon Signed-Rank test for location 4.3.2.1. Testing single population mean	

	4.3.2.2. Testing difference between correlated (match pair) population means 4.3.2.3. Testing difference between two independent population means 4.3.3. The Mann-Whitney Test(Mann-Whitney-Wilcoxon test -for equality of medians) 4.3.4. The Kolmogorov-Smirnov Goodness- of -Fit Test 4.3.5. The Kruskal-Wallis One-Way Analysis of Variance by Ranks 4.3.6. The Friedman Two-Way Analysis of Variance by Ranks	

ZOOLOGY PRACTICAL IV
Practical Syllabus for Semester II
(Course codes: PSMAZOP21-PSMAZOP24)

Course codes: PSMAZOP24
Course VII: Research Methodology

1. Numerical problem on
    a. Z-Test
    b. T-Test
    c. Chi-Squares Test
    d. Simple Regression
    e. Correlation
2. Use of excel for hypothesis testing
3. Use of excel for graph preparation
4. ANOVA- one way & two way.
5. Randomized block Design and Latin square

Suggested Readings

Text books:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	C.R. Kothari	Research Methodology	2nd Rev. Ed.	New Age Publishers
2	Edited by Petter Laake, Haakon Benestad and Bjorn Reino Olsen	Research Methodology in medical and Biological sciences	1st Ed., 2007	Academic Press
3	Daniel WW, Cross CL	Biostatistics: A foundation for analysis in health sciences	10th Edn, 2013	Wiley
4	Gupta SP.	Statistical Methods.	4th Edn., 2011	Sultan Chand & Co.
5	Rosner B.	Fundamentals of Biostatistics	7th Edn., 2011	Duxbury Thomson
6	D'Agostino RB., Sullivan LM., Beiser AS	Introductory Applied Biostatistics	2006	Thomson Brooks/Cole

References:

Sr. No.	Author	Title	Edition/ Year of Publication	Publisher
1	Ranjit Kumar	Research Methodology- A step-by-step guide for beginners	2014	Sage Publishers
2	Yogesh Singh	Fundamental of Research Methodology and Statistics	2006	New Age Publishers
3	Pradipkumar Sahu.	Research Methodology: A guide for Researchers in Agricultural Science, Social Science and other related fields.	2006	Springer
4	Zar J.H.	Biostatistical Analysis.	5th Edition, 2010	Pearson Education.
5	Pagano M., Gauvreau K.	Principles of Biostatistics	2nd Edn., 2010	Cengage Learning India