

SIDO KANHU MURMU UNIVERSITY, DUMKA



**CBCS BASED COURSE CURRICULUM
(ZOOLOGY)**

For

**POSTGRADUATE
PROGRAMME**

[M.Sc. (Zoology)]

ACADEMIC SESSION

w.e.f. 2021-2023

**UNIVERSITY DEPARTMENT OF ZOOLOGY
S.K.M.UNIVERSITY, DUMKA - 814101
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Recast on 07.09.2020

M.Sc. Zoology

Choice Based Credit System

Academic Session 2017-19

Total no. of credits = 72

Some Important Regulations of CBCS for Students made by University

Duration of the course:

Minimum duration for completion of a two year Post Graduate Programme is four semesters.

Normal	Duration	4	Semesters
Maximum	Duration	8	Semesters

1. Semester is used to mean a half yearly term or term of study including examinations, vacations and semester breaks. As academic year consists of two semesters.

Odd Semester (I & III): July to December

Even Semester (II & IV): December to May

A semester normally extends over a period of 16 class weeks. Each week has 30 hours of instruction spread over the week.

2. Attendance: A student shall be permitted to appear for the semester examination, only if he/she secures not less than **75 % attendance** in each semester. Condonation of shortage of attendance of each week a maximum of 12 days for a maximum of two spells within a programme may be granted as per the existing University rules. **A student who is not eligible for such condonation shall repeat the course along with the subsequent batch.**

3. Examination and Evaluation

Evaluation will be done on a continuous basis, three times during each semester.

For the purpose of uniformity, particularly for interdepartmental transfer of credits, there shall be a uniform procedure of examination to be adopted by all teachers.

There will be two mid-term/ sessional tests and one End semester examination in each course during every semester.

4. Mid term /Sessional Test I will be held during the sixth week of the semester for the syllabi covered till then.
5. Mid –Term / Sessional Test II will be held during eleventh week for the syllabi covered between 7th and 11th week.
6. Mid term / Sessional Tests(of one to two hours duration) may employ one or more assessment tools such as objective tests,assignments,paper presentation, laboratory work, etc suitable to the course. This requires an element of openness. The students are to be informed in advance about the nature of assessment. **Students shall compulsorily attend the two sessional tests failing which they will not be allowed to appear for end semester examination.** A student can not repeat sessional Sessional Tests. However, if for any compulsive reason a student could not attend the test, the prerogative of arranging a special test lies with the teacher provided the concerned student reports the matter to the course teacher within one week of the date on which the test was conducted. In case of students who could not attend any of the sessional tests due to medical reason or under extraordinary circumstances, a separate shall be conducted before the End Semester Examinations by the concerned faculty member.
7. **The mid term sessional tests will carry 30 % of total marks** for the course. The marks of the two Sessional Tests (**Best of Two**) shall be taken into account for the computation of Grades.
9. There shall be **one End Semester Examination of 3 hours** duration carrying **70% of Marks** in each course covering the entire syllabus prescribed for the course. The end semester examination is normally a written / Laboratory –based examination. The mode of end semester examination and evaluation will be decided by teacher in consultation with the Departmental committee. Model Question Paper for each course has to be prepared by the teacher and same should be forwarded to the Head of the Department. The end semester examination schedule will be prepared by the Head of the Department/College and displayed on the notice board at least one week before the examination with intimation to the controller of Examinations. The course faculty must evaluate the answer scripts and submit the results to the Head of the Department before the Departmental/Class committee meeting. The Head of the Department will fix the date for Departmental committee meeting to finalize the results **or the University will take care of all such proceedings of end semester examination.**
10. End semester practical examination shall normally be held before the theory examinations
11. The result of mid-semester examination shall be notified by the concerned course teacher(s) within ten days of the examination.
12. Evaluation of Project Report/Dissertation and Viva voce:

The students will submit Dissertation on completion of course of SEM-IV

The distribution of marks for the dissertation will be as below:

Written Exam=25 Marks **PPT and Project =50 Marks**

Viva Voce=25Marks **Total =100 Marks**

Dissertation/Project report must be submitted by the candidates in the department one week before the commencement of the end semester examination and it will be valued jointly by the supervisor and one other examiner within the department/University) nominated by the departmental council. Students may be asked to make a presentation before the faculty members and students.

13. Pass Marks

A candidate has to secure a minimum of 45% of marks (Sessional test marks and End – Semester examination marks separately) in the course taken, to pass in that course.

Candidate securing below 45% marks shall be deemed to have failed in that course.

Improvement is allowed for the end semester examination. Candidates who have passed in theory papers are allowed to appear again for theory paper/papers only once in order to improve his/her marks, by paying the fee prescribed from time to time within a maximum period prescribed thereto, counting from his/her first semester of his/her admission. If candidates improve his/her marks, then improved marks will be taken into consideration for award of grading only. Such improved marks will not be counted for the award of Prizes/Medals, Rank and Distinction. If the candidate does not show improvement in marks, his/her previous marks will be taken into consideration.

No candidate will be allowed to improve marks in Practicals, Project, Viva –voce, Field work.

14. Award of Grades, SGPA, CGPA

Grade –Letter is a index to indicate the performance of a student in a particular course (Paper).It is the indicated by grade letter O, A, B, C, D, E, F. There is range of marks for each grade letter.

Grade Point is weight age allotted to each grade letter depending on the marks awarded in a course / paper

Award of Grades

Range of % of Marks	Grade Letter	Grade Point
85 to 100	O	10
70 to 84	A	9
60 to 69	B	8
55 to 59	C	7
50 to 54	D	6
45 to 49	E	5
Less than 45	F	0

15. Semester Grade Point Average (SGPA)

Credit Point for the paper-No. Of credits assigned for the paper xGrade point secured for that course / paper. SGPA indicates the performance of a student in a given semester. SGPA is calculated by dividing the total credit points earned by the student in all the courses by the total number of credits assigned to the courses/papers in a semester.

Note:-SGPA is computed only if the candidate passes in all the papers (gets a minimum 'E' Grade in all the papers)

16. Cumulative grade point average (CGPA)

'Cumulative Grade Point Average'(CGPA) is the value obtained by dividing the sum of credit points in all the Courses taken by a student for the entire Program by the total number of credits. CGPA shall be rounded off to two decimal places. CGPA indicates the broad level of academic performance of a student in a program. An overall letter grade (Cumulative Grade) for the entire programme shall be awarded to a student depending on his/her CGPA.The final result at the end of all the semesters is declared in the form of CGPA.

Note: - CGPA is calculated only when the candidate passes in all the papers of all the semesters.

Example:

I. Semester

Total Credit Points=24(total credits) x8(Grade Point) =192

SGPA=192/24=8

II. Semester

Total Credit Points=24(total credits) x7(Grade Point) =168

SGPA=168/24=7

III. Semester

Total Credit Points=20(total credits) x8(Grade Point) =160

SGPA=160/20=8

IV. Semester

Total Credit Points=16(total credits) x9(Grade Point) =144

SGPA=144/16=9

CGPA=Total Credit Points of all Semesters/Total Credits =

$(192+168+160+144)/(24+24+20+16)=664/84=7.90$

17. Pattern of questions

17.1 Questions shall be set to assess knowledge acquired, standard application of knowledge, application of knowledge in a new situations, critical evaluation of knowledge and ability to synthesize knowledge. The question setter shall ensure that questions covering all the skills are set. He/ She shall also submit a detailed scheme of evaluation along with the question paper.

17.2. A question paper shall be judicious mix of objective type, short answer type, and long answer type questions.

Pattern of questions and Marks:

Part A (Compulsory)

Objective Type: Multiple Choice Questions (No. 1 questions):

2x10=20 Marks

Part B

Short notes

Four questions (Out of six questions):

4x5=20 Marks

Part C

Three Questions (Out of five questions)

3x10=30Marks

GT =70 Marks

17.3 Components of continuous internal assessment (Sessional Test I and Sessional Test II) will be:

Two tests 30 Marks (Best of two)

(a) Short answer type/Multiple Choice Test

1x5= 05 Marks

(b) Short notes 02 out of 04

2.5x2=05 Marks

(c) Long answer type questions (2 out of 4)

5x2 =10 marks

Total= 20 Mark

(d) Seminar

= 05 Marks

(e) Attendance(follow the % rule)

= 05 Marks

GT=30 Marks

Credits & Courses:

(a) A candidate who successfully completes the entire core courses, the project prescribed, the optional and supportive courses, and acquires not less than 72 credits and puts in the minimum of residence time will be eligible for receiving the degree.

(b) One credit means one teaching period per week for one semester(16 weeks) for theory courses and one laboratory session of two periods / week for one semester. One teaching period is of 60 minutes duration.

Courses are divided into 5 categories

1. Core courses-Compulsory and total credits=48
2. Elective courses-May be chosen by the student from options offered by the department. Total credits for Elective Courses are 16.
3. Supportive Courses-This may be taken from other disciplines. Total credits for supportive courses are 6.
4. Self Study courses-A Department may allow students to choose three additional courses to enable them to acquire extra credits through self study (Not to be taken into account for awarding grades/Class).Maximum 9 credits (3x3=9)-not mandatory
5. Soft Skills- minimum 8 credits-
Internship- minimum 2 credits- carried out in an organization recommended by the department during summer vacation of the first year.
6. Project-6 credit (Compulsory)

1st Semester

Core	Paper-I	4 Credits	64 Hours
Core	Paper-II	4 Credits	64 Hours
Core	Paper-III	4 Credits	64 Hours
Core	Paper-IV	4 Credits	64 Hours

Ist Semester-Core Papers
Paper I : Foundation of Zoology
(A) Systematics and Taxonomy
(B) Tools and Techniques
Paper II
(A) Structure & Function of Invertebrates
(B) Comparative study of Chordates
Paper III
(A) Cancer
(B) Reproductive Biology
Practical IV

Ist Semester detailed curriculum

Paper I- Foundation of Zoology

70+30

Systematics & Taxonomy and Tools and Techniques

Course objectives: The primary objective of the course is to impart appreciation for different life forms on earth and drive home the relationship between different living forms both at the genetic and the ecological level. It will provide an opportunity to have a novel branch of science dealing with identification and assigning exact position in animal kingdom.

The course has been designed to make the students acquainted with some sophisticated instruments and their working principle.

Section-A

Systematics and Taxonomy:

Course contents:

Theory

Unit-1: Definition and basic concepts of biosystematics & taxonomy,

importance and application of biosystematics in biology

Unit-2: Species concepts-Species category, subspecies and other infra specific categories.

Unit-3: Theories of biological classification, hierarchy of categories.

Unit-5: Taxonomic procedures-Taxonomic collection, preservation, curation, process of identification.

Unit-6: Taxonomic Keys- Different kinds of taxonomic keys, their merits and demerits.

Unit-7: Concepts of chemotaxonomy, cytotaxonomy & molecular taxonomy.

Unit-8: International code of Zoological nomenclature (ICZN)-formation of scientific names of various taxa.

Section-B

Tools and Techniques:

Unit-1: General principle & application of Microscope and Imaging Techniques: Light & Contrast Microscope, Fluorescence Microscope, Scanning Electron, Microscope, Transmission Electron Microscope, Positron Emission Tomography, X-ray, Ultrasound

- Unit-2:** Principles and uses of analytic instruments: pH meter, Colorimeter, Spectrophotometer, Beer-Lambert Law
- Unit-3:** Histological techniques for animal tissues: Fixation, use of microtomes, Section cutting, Dehydration, staining.
- Unit-4:** PCR-Polymerase chain reaction.
- Unit-5:** Radioisotope: Unit of radioactivity, and applications of radioisotopes
- Unit-6:** Radio immune assays(RIAs)
- Unit-7:** Enzyme linked Immunosorbant Assay(ELISA), Basic ELISA protocol, Hormonal assay for pregnancy test.
- Unit-8:** Separation techniques: Centrifugation- Centrifuges and their types
- Unit-9:** Chromatography: Theoretical basis, Column Chromatography, Paper Chromatography, Thin layer Chromatography(TLC), Introduction to FPLC & HPLC
- Unit-10:** Electrophoresis- Separation of DNA by agarose gel electrophoresis.

Suggested readings:

Biosystematics:

1. *Barnes & Gray (ed): Bioinformatics for geneticists, Wiley (2003)*
2. *Lesk: Bioinformatics, Oxford (2003, Indian ed)*
3. *Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)*

Tools and Techniques:

1. Boyer: *Mordern and Experimental Biochemistry* (1993, Benjamin-Cummings)
2. Pearse: *Histochemistry-Theoretical and applied, Vol. I-III* (1980-1993, Churchill-Livingstones)
3. Plumer: *An Introduction to Practical Biochemistry* (1989, McGraw Hill)
4. Wilson and Walker: *Experimental Biochemistry* (2006), Cambridge

Course Learning outcomes: The students would develop a sense of classical zoology with admixture of knowledge of modern equipments. Both will enable the students to develop a sense of research aptitude and excel in evaluating biochemical changes.

Paper II- Animal Diversity & Comparative Anatomy: 70+30

Course objectives: The course has underscored the analytical study of animal diversities with emphasis on the functional aspects of non chordates physiology and comparative aspects of different systems of chordates.

Section-A

Course contents:

Theory

Animal Diversity:

Structure & Function of Invertebrates

Unit-1: Locomotion: Flagellar movement in Protozoa, Ciliary movement in Protozoa Hydrostatic movement in Annelida

Unit-2: Nutrition & Digestion: Filter feeding in Polychaeta, Filter feeding in Mollusca

Unit-3: Respiration: Organs of respiration-Gills, Lungs and Trachea and mechanism of respiration, Respiratory pigments

Unit-4: Excretion: Organs of excretion- Coelomoducts, Nephridia and Malpighian tubules, mechanism of excretion

Unit-5: Nervous system: Primitive nervous system-Coelenterate and Echinodermata Advanced Nervous System-Annelida, Arthropod Crustacean & Insects) and Molluscs (Cephalopod)

Unit-6: Invertebrate larvae: Larval forms of Crustacea, Larval forms of Echinoderms Trochophore Larva

Unit-7: Salient features and affinities of: Rotifera, Placozoa Mesozoa, Sipuncula Phoronida

Section-B

Comparative Anatomy of vertebrates:

Unit-1: Classification of Vertebrates

Unit-2: Transition from agnatha to gnathostomata

Unit-3: Evolution of Heart and aortic arches

Unit-4: Comparative account of Respiratory organs.

Unit-5: Evolution of urinogenital system in vertebrate series.

Unit-6: Comparative account of brain in vertebrates.

Suggested readings:

Non Chordate/ Invertebrate:

1. Barnes, R.D. Invertebrate Zoology -(W.B. Saunders Co.)
2. Hyman,L.H. : Ihe Invertebrates Vi. I & II (Mc graw Hill)
3. Invertebrate structure and function : Barrington (Nelson)
4. Kotpal,Agarwal & Khetrapal : Modern Textbook of Zoology: Invertebrate (Rastogi publication)
5. R.L.Kotpal : Invertebrate series – Protozoa to Minor phyla : (Rastogi publication)

Chordate: (comparative)

1. The Chordates - Alexander, R.M. (Cambridge University Press)
2. The Chordates - Monaith, A. R. (Cambridge University Press)
3. Chordata - Structure and Function - Waterman, A. J. (Mac Millan Co.)
4. Young,J.Z. : Life of Vertebrates (Oxford University Press)
5. Hildebrand : Analysis of vertebrates Structure (Wiley)
6. Kingsley : Outline of Comparative anatomy (Central Book Depot)
7. George C.Kent & Larry Miller : Comparative Anatomy of the Vertebrates (W.C.B Publisher)
8. Noble,G.K.,The Biology of the Amphibia(Ney York)
9. Protochordata – O.P.Saxena (S.Chand & Com.LTD)
- 10.**Kenneth V. Kardong: Vertebrates Comparative Anatomy, Function, Evolution, 4th ed. McGraw Hill**
- 11.Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press. 2. Pough H. Vertebrate life, VIII Edition, Pearson International. 3. Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub. Co. 4. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

Course Learning Outcomes: The students get an opportunity to in understanding the animal diversities on the earth with up-gradation of their previous understanding in this field. This course study provides a strong substratum to build wide spectrum knowledge of zoology.

Course objectives: The malady of cancer is fast increasing in the population keeping people in constant stress, however, the understanding of early symptoms, cyto-physiology of cancer cell, cure and prevention can be proved an asset for amelioration of society.

On the other hand, the mammalian reproductive physiology will give students an opportunity in understanding the interplay female hormones in Pregnancy, Parturition and Lactation. Besides, the objective of Developmental Biology course is to provide four-dimensional thinking of students to truly understand the patterns and process of embryonic development, body plan, fate map, induction, competence etc.

Section-A

Course contents:
Cancer:

Theory

- Unit-1:** Types of cancer and carcinogenic agents
- Unit-2:** Probable causes, symptoms , cytology and physiology of cancer cells.
- Unit-3:** Oncogenes, Tumor Suppressor Gene
- Unit-4:** Stages of cancer : Breast and Uterus
- Unit-5:** Treatment of Cancer: Surgery, Chemotherapy, Radiation, Palliative treatment
- Unit-6:** Concept of programmed cell death (Apoptosis)

Section-B

Reproductive Biology:

- Unit-1:** Anatomy – Human male and Female reproductive organs/system. Accessory sex organs, Histophysiology of ovary and testis
- Unit-2:** Semen composition, formation and assessment of sperm functions
- Unit-3:** Physiology, biochemistry of follicular growth, Corpus luteum structure and function and atresia
- Unit-4: Pregnancy:** Hormonal regulation of implantation & pregnancy, Differentiation of cytotrophoblast to syncytiotrophoblast, Maternal - Fetal unit and hormone synthesis, Placental hormones
- Unit-5: Parturition:** Stages of parturition, Hormonal interplay, Progesterone block theory
- Unit-6: Lactation:** Structure and function of Mammary glands , Physiology of lactation, Significance of various hormones in lactation, Milk let-down reflex
- Unit-7: Contraception:** Methods, Control of fertility and role of hormones in contraception & birth control pills, Menopause

Suggested readings:

Reproductive Biology:

1. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
2. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
3. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.
5. Regulation of Implantation and Establishment of Pregnancy in Mammals, Editors: Rodney D Geisert, Fuller W. Bazer, ISBN 978-3-319-15856-3, Springer International Publishing, 2015.
6. Kovac CS and Kronenberg HM, Maternal-fetal calcium and bone metabolism Department of Zoology, University of Delhi 91 during pregnancy, puerperium and lactation. Endocrine Review 18: 832–872, 1997.
7. Implantation and early development, Editors: Hilary Critchley, Ian Cameron and Stephan Smith, ISBN 9781107784680, Cambridge University press, 2014.
8. Implantation, Biological and Clinical Aspects, Editors: Michael G. Chapman, J. GeddisGrudzinskas, Tim Chard, ISBN 978-1-4471-3531-9, Springer-Verlag, 1988.

Cancer:

1. The Biology of Cancer: Second International student edition. Robert A Weinberg: W.W. Norton & Company
2. *Treatment of cancer, 5th edition: Patprice, Karol Sikora & Tim Illidge*

Course Learning Outcomes: The contents of this course study enable the students to unravel the mystery of cancer to some extent. This also enables the students to explore the ongoing research in the field of oncology and find new vistas in the challenging offshoots of scientific exploration and investigation for the common good of mankind. Besides, comprehensive knowledge of reproductive biology enables the students to establish and develop idea of hormonal regulation pregnancy, parturition and lactation- unique in class mammalia.

Practical IV

70+30

List of Practical:

Structure & Function of Invertebrates

1. Dissection-

Nervous system of Earthworm, Prawn, Pila, Unio, (Specimen/CD-rom or Video demonstration)

2. Mounting-

Gills of Pila, Trachea of Insect, Nephridia of Earthworm, Malpighian tubule of Cockroach, (Specimen/CD-rom or Video demonstration)

3. Spotting

Slides- (Permanent/CD-rom or Video demonstration and light microscopic observations and comment.)

Malarial parasite, Leishmania, T.S.Hydra, T.S of Earthworm, Gill of Unio, Trachea of Cockroach, Nephridia of earthworm, Malpighian tubule of Cockroach, Crustacean larvae, Larval forms of common helminth parasites. Specimens-observation and comment

Sycon, Aurelia, Fasciola, Taenia, Ascaris, Earthworm, Aphrodite, Prawn, Pila, Unio, Octopus, Sepia, Balanoglossus

Chordates

List of Practical

1. Dissection-

General anatomy of Scoliodon and Labeo rohita, (CD-rom or Video demonstration)

2. Mounting-

Scales of fishes, feathers in birds, blood film, Pecten in bird, (CD-rom or Video demonstration and light microscopy-use of techniques of microphotography)

3. Spotting-

A. Slides-Mammal-

Integument, Kidney, Pancreas, Liver, Spleen, Thymus,

(CD-rom or Video demonstration and light microscopy-use of techniques of microphotography)

B.Specimens-observation and comment upon

Scoliodon, Labeo, Lung fish, Ichthyophis, Salamandra, Hyla, Wall lizard, Krait, Cobra, Pigeon, Rat (CD-rom or Video demonstration and specimen study) C.Osteology-Skull of Dog and Man.

1.Tools and Techniques

Comment upon one of the following

- (i) Principles and use of light contrast fluorescence, scanning electron microscopy and transmission electron microscopy
- (ii). Principles and uses of analytic instruments-Monopan balance, pH meter, colorimeter, Spectrophotometer, Centrifuge and ultracentrifuge.
- (iii). Principles and use of microtomes and section cutting, (iv).Principles and use of PCR-Polymerase chain reaction.
- (v).Principles and uses of Radio immune assays
- (VI).Principles and uses of Techniques of animal tissue culture (VII).Principles and uses of Thin layer Chromatography (TLC) (VIII).Principles and uses of Electrophoresis

Cancer

- 1 Study of cytological atlas of breast cancer -comment upon the photograph provided.
3. Study of cytological atlas on uterine cancer.
 - 3 Blood picture showing-stages of leukemia

Reproductive Biology

Histology of ovary and testes
Assessment of sperm functions
Pregnancy test

Model of questions
1. Dissection-
2. Mounting-
3. Spotting- (Slides-3 Specimens-2 C.Bone-1)
4. Taxonomy-
5 Tools and Techniques
6 Quantitative Biology
7. Reproductive Biology
5. Viva-
6. collection/Record-

P.G. 2nd Semester

Semester-II

Core	Paper-V	4 Credits	64 Hours
Core	PaperVI	4 Credits	64 Hours
Core	Paper-VII	4 Credits	64 Hours
Core	Paper-VIII	4 Credits	64 Hours

2nd Semester

Paper V

Skill development programme B. Quantitative Biology C. Bioinformatics

Paper VI

(A) Immunology

(B) Histochemistry

Paper VII

(A) General and Comparative Endocrinology

(B) Cell Biology

(C) Biochemistry

Practical Paper VIII

2nd Semester detailed Curriculum

Paper V

Skill Development Program

70+30

Course objectives: The chief objectives of imparting education to the students are creation of job and to provide opportunity for earnings so as to lead a respectful and decent life. This course is meant to impart knowledge to students on the most important skill which is required in this era for any scientific worker. Particularly becoming conversant with computer handling can enhance the chances of self employment and also enable the students to make use of this indispensable acumen in other fields of Zoology like: computational biology, molecular biology, bioinformatics etc.

The other sections deal with biostatistics and bioinformatics with an idea to infuse significance of statistics in biological science and establishing interrelationship of different organisms through Genomics and Proteomics. Especially, biostatistics or quantitative biology has become an integral part of modern research.

Course Contents:

Theory

Section-A

Basics of Computer & Internet:

Unit-1: Computer and its application, Basic components of computer – hardware (CPU, input] storage devices)

Unit-2: Software, System software (operating systems), Operating software

Unit-3: Introduction of MS office – Word, Excel and Power point

Unit-4: Internet protocol and information technology, Basic of home pages, Web page, Uniform Resource Locator.

Unit-5: Concepts of digital Library.

Section-B

Quantitative Biology:

Unit-1: Biostatistics and its application, Sampling, data collection, tabulation, diagrammatic and graphical presentation of data.

Unit-2: Mean, Standard deviation and standard error.

Unit-3: Test of significance of large and small samples – Student T-Test.

Unit-4: Chi square test.

Unit-4: Correlation, Regression

Unit-5: ANOVA

Section-C

Bioinformatics:

Unit-1: Introduction and scope of bioinformatics

Unit-2: Genomics and Proteomics

Unit-3: Principles of bioinformatics and its application

Suggested readings:

1. Latest software and articles available on University internet sites and subscribed sites.
2. Latest e-books and the text books available in the Department and University Library.
3. Bioinformatics: Sequence and Genome Analysis, Mount, D. W. (2nd Ed., 2001), Cold Spring Harbor Laboratory Press, New York, USA.
4. Principles of Biostatistics, Pagano M., Gauvreau, K, (2000), Duxbury Press, USA.
5. Bioinformatics for Dummies, Claverie J. M., Notredame C., (2nd Ed., 2007), Wiley Publishing, Inc., New York, US.

Course Learning Outcomes: The course contents show relevance of fulfilling the objectives of course contents. It enables the students to have unique combinations exposure to course contents and enable them to have confidence to meet the challenge after completion of post graduation.

This course is meant to impart knowledge to students on the most import skill which is required in this era for any scientific worker. The course is designed in such a way that the students get the confidence to use computer programs for the daily design of experiments, data collection, and analysis of results. The mandatory practical exercises in the available state of computer laboratory in the campus as ICT Lab. will benefit students to learn all that they require to use their computer for the study of science.

The capacity building in quantitative biology will strengthen the research base by way of data interpretation capability of the students. The in-depth knowledge of molecular biology gets further augmented by exposure of highly relevant section of bioinformatics.

Paper VI

Immunology and Biochemistry 70+30

The lecture-discussion part is conceptualized with the aim that students are taught the basics of immunology so as to develop understanding of the subject such as how does the immune system work? What are the molecular and cellular components and pathways that protect an organism from various antigenic agents. This comprehensive course answers these questions as it explores the structure, function and genetics of the components of immune system.

Course contents: Theory

Section-A

Immunology:

- Unit-1:** History and scope of Immunology, Architecture of immune system lymphoid organs, thymus, bone marrow, spleen, lymph nodes, immune cells
- Unit-2:** Antigens, haptens
- Unit-3:** Concept of Innate and acquired immunity, Antigen, Antigen antibody interaction, Complement system and immune response, antibody class switching, functions of T-cells and B-cells
- Unit-4:** Structure and function of antibodies, Organization and expression of Ig gene, its diversity, Gene rearrangement
- Unit-5:** Cytokines : Structure and function
- Unit-6:** T-Cell receptor and B-Cell receptor
- Unit-7:** Immunodeficiency Diseases
- Unit-8:** Concept of vaccination, Histocompatibility

Section-B

Biochemistry:

- Unit-1:** Bioenergetics: Concept of free energy, Laws of thermodynamics applied in biochemical system, Role of high energy phosphates in bioenergetics and energy capture.
- Unit-2:** Carbohydrates: Classification, Isomerism alpha & beta anomers-D & L forms, optical isomers
- Unit-3:** Carbohydrate metabolism: Glycolysis, glycogenesis, glycogenolysis Gluconeogenesis, Pentose Phosphate pathway
- Unit-4:** Proteins: Amino acids, Formation of peptide bonds and polypeptide

chain, Molecular configuration of secondary, tertiary and quaternary structure of protein, Ramachandran Plot

Unit-5: Lipid: Classification, fatty acids, β -Oxidation

Unit-6: Enzymes and co enzymes, Enzyme kinetics (Derivation of Michaelis-Menten equation, Michaelis-Menten and Lineweaver-Burk Plot, enzyme regulation and inhibition)

Unit-7: Isozymes: LDH and MDH

Unit-8: Enzyme deficiency: Inborn error of metabolism: Alkaptonuria, Phenylketouria, Lesh-Nyhal syndrome

Suggested readings:

Immunology:

1. Kuby Immunology, Richard, Thomas, Barbara, Janis , W. H. Freeman and Company [Latest edition].
2. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, Garland Science Publishing [Latest edition].
3. Essentials of Immunology, David, Brostoff and Roitt, Mosby & Elsevier Publishing [Latest edition].
4. Fundamentals of Immunology by William E. Paul, Lippincott Williams & Wilkins Publishing [Latest edition].
5. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Elsevier Publishing [Latest edition].

Biochemistry:

1. Cox, M.M and Nelson, D.L. (2008). **Lehninger Principles of Biochemistry**, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). **Harper's Illustrated Biochemistry, XXVIII** Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
5. 4. Practical Biochemistry – Principles and Techniques, Wilson and Walker, Cambridge University Press, Cambridge [Latest edition].

Course Learning Outcomes: At the end of the course, the students should be able to:

The course encourages the students for research and development opportunities for therapeutic intervention arising from recent advances in immunology.

1. Upon completion of the course students have a sound understanding of the essential elements of the immune system, preparing them to engage further in this rapidly evolving field.
2. The students will be able to identify the cellular and molecular basis of immune responsiveness and understand how the innate and adaptive immune responses coordinate to fight invading pathogens.
3. It help in understanding strategies essential for generating or suppressing immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.
5. Design new methods to improve existing vaccines and other immunotherapeutic strategies.
6. At the same time knowledge of biochemistry enable the students to understand the entire molecular biology in analytical way.
7. They are able to reveal and correlate the entire phenomenon in respect of structure and function of biomolecules and metabolic pathway in a vivid way.
8. This seems to be the genesis of all molecular biology. The students are seen to have more confidence and speculate the teaching with greater degree of interaction.

Endocrinology, Cytology & Histochemistry

Course Objectives: The course has been designed to throw light upon the comparative aspects of endocrine glands of different class of vertebrates to find and establish phylogenetic relationship. The wide range of hormones has been incorporated to make a coherence with respect to interplay of hormones in metabolic pathways. Some brain hormones have been given special attention in order to make the students understand common brain related diseases like Parkinson and Alzheimer.

Emphasis on membrane structure and function including membrane potential, cytoskeleton and cell signaling has been given in cell biology as a corollary to the teaching at graduation level.

Course Contents: Theory**Endocrinology:****Section-A****General and Comparative Endocrinology:**

Unit-1: Phylogeny of endocrine glands (Pituitary, Thyroid, Adrenal, Pancreas)

Unit-2: Biosynthesis of Thyroid Hormones, Steroid Hormones and Catecholamines

Unit-3: Renin-Angiotensin system, GIT Hormones

Unit-4: Diabetes mellitus(type I & II), Addison's Disease, Cushing syndrome

Unit-5: Neuroendocrine system and neurohormones (octapeptides)

Unit-6: General principles of hormonal actions.

Unit-7: Hormonal regulations: carbohydrates, Protein, Lipid metabolism

Unit-8: Pineal: Melatonin secretion, circulation and site of action, Pineal rhythm and biological clock

Unit-9: Brain hormones: Serotonin, Dopamine, Glutamate, Norepinephrine, and biological clock, Endorphin, Enkephalin

Section-B**Cell Biology:**

Unit-1: Cytoskeleton: Organization of cortical cytoskeleton, Structure and dynamics of microfilaments, Intracellular motility and cell locomotion, Role of microtubules in cell shape and mitosis

Unit-2: Bio membranes-Molecular organization-Fluid mosaic model, Transport across the cell membrane

Unit-3: Molecules and ions movement: Diffusion, Donnan Equilibrium, Facilitated diffusion, Active transport, Membrane potential, Nernst equation

Unit-4: Cell cycle and its regulation:

Unit-5: Cyclin and CDK interplay, Entry and exit from cell cycle, Checkpoints

Unit-6: The energy transducers of the cell: Mitochondria structure, ATP synthesis: Krebs cycle, Electron transport chain, Oxidative Phosphorylation, Glycerophosphate and malate shuttle

Unit-7: Ultra structure of chromatin fibre, Chromosome movement

Unit-8: Cell signaling, Key concepts of cellular signaling, Second messenger system, G-protein coupled receptors, Receptor tyrosine kinases, MAP kinase cascade

Unit-9: Viruses and bacteria: phi X 174, SV40 and HIV, E. coli

Section-C

Histochemistry:

1. Histochemistry of mucopolysaccharides (PAS, Alcian Blue)
2. Alkaline Phosphatase
3. Sudan Test
4. Fuelgen Test

Suggested readings:

Endocrinology:

1. Review articles published in various journals: "Endocrine Reviews/General and Comparative Endocrinology/Journal of Endocrinology/ International Review of Cytology/Molecular and cellular endocrinology/The journal of Clinical Endocrinology and Metabolism/Indian Journal Endocrinology and Metabolism.
2. Endocrinology by L.J. De Groot, 5th ed., 2006 (Recent edition if published).
3. Vertebrate Endocrinology by David O. Norris Elsevier Academic press, 2007 (recent edition if published).
4. Hand Book of Physiology published by American physiological Society by Oxford University Press, Section 7: Multiple volumes set, 1998.
5. Comparative Vertebrate Endocrinology by P.J. Bentley, Cambridge University Press, 1998.

Cytology:

1. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: *Molecular Biology of the Cell*, IV Edition.
3. Cooper G. M. and Robert E. Hausman R. E. *The Cell: A Molecular Approach*, V Edition, ASM Press and Sinauer Associates.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). **Cell and Molecular Biology**. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
5. Karp, G. (2010) **Cell and Molecular Biology: Concepts and Experiments**. VI Edition. John Wiley and Sons. Inc.
6. Lewin B. (2008). *Gene XI*, Jones and Bartlett
7. McLennan A., Bates A., Turner, P. and White M. (2015). *Molecular Biology IV Edition*. GS, Taylor and Francis Group, New York and London
8. *Cell Physiology* : Geese

Course Learning Outcomes: This course will help in advancing our knowledge on comparative endocrinology to reveal the course of evolution of endocrine system in different vertebrate groups. It also enables the students to develop a concept of endocrine control of metabolism and significance of hormones as neurotransmitter.

Additionally the cell biology included in this paper further enables the students to venture out in some interesting fields like bioenergetics, cell signaling membrane transport system etc. Biomolecules staining techniques as histochemistry further encourages the students to get ready for research activity.

List of Practical

Immunology

- (I). Determination of human blood group
- (II) Principles of Dot ELISA
- (III) Experiment to show Radial Immunodiffusion (RID) technique for estimation of antigen antibody contents in the samples.

General and Comparative Endocrinology

- (I). Surgical techniques-
Thyroidectomy, Adrenalectomy, Castration in rat in Rat
- (II) Study of vaginal smear stages of oestrous cycle in rat
- (II) Use of Micrometer in measuring Thyroidal cell height.

Cell Biology

- 1 Demonstration of Mitochondria in human buccal epithelium-vital staining by Janus green.
- 4. Demonstration of salivary gland chromosome in Chironomous larva.
- 5. Demonstration of different stages of mitosis in onion root tip-by acetocarmine
- 6. Meiosis in grasshopper testis

Histochemistry

- 1. Histochemical demonstration -PAS, Alcian blue, Feulgen, Sudan black.

Biochemistry

- 1. Estimation of blood glucose by electronic glucometer/colorimeter or spectrophotometer
- 2. Test of urine for-urea, proteins, ketones and sugar
- 3. Colorimetric estimation of Plasma protein
- 4. Separation of Amino acids in a mixture by paper chromatography
- 5. Test of pepsin, trypsin enzyme activity.

Model of questions
1. Immunology-
2. Endocrinological experiment
3. Cell Biology
4.Histochemical test-
5 Biochemistry
6. Viva-
7. Record-

3rd Semester

Semester-III

Open Elective	Paper-IX	4 Credits	64 Hours
Core	Paper- X	4 Credits	64 Hours
Core	Paper-XI	4 Credits	64 Hours
Practical	Paper-XII	4 Credits	64 Hours

3rd Semester
Theory Paper IX- Open Elective-MLT, Cytogenetics & Rec. DNA, Fisheries
Theory Paper-X Core
(A)Genetics and Molecular Biology
(B)Population Biology, Population Genetics and Evolution
Theory Paper-XI Core
(A).Physiology
(B) Devlopmental Biology
Practical Paper XII (Core)

3rd Semester detailed curriculum

Paper IX: Open elective:

FM 70+30

In all **eight** questions are to be set and **five** questions are to be answered. Question number 1 is compulsory of very short type (2 marks each) and includes 7 questions (2x7=14 Marks) , two short notes (7x2=14 Marks) eig 5 Long questions are to be set of which three are required to be answered (14x3=42Marks)

Total = Q1 is Compulsory

Choose any one (For students other than Zoology):

Open Elective Paper:

A. Medical Laboratory techniques (MLT)

70+30

Course Objectives: As mentioned the open elective is to be pursued by the students of other subjects of science stream and therefore it has been designed in such a way as to develop interest in the field of paramedical science. The objective is to infuse some important aspects pathological tests and imaging techniques that are generally witnessed by people around in the home and society. Such students will be an asset to the society under unprecedented outbreak of epidemics and disaster management

Course Contents:

Theory **Section-A**

1. Hemopoietic tissue, Hemopoetin and Hemopoesis
2. Blood composition
3. Blood Group and Blood transfusion
4. Blood as a Circulatory Fluid & the Dynamics of Blood & Lymph Flow
5. Methods of Measuring Blood Pressure
6. Blood cells
7. Hb % analysis
8. Blood smear preparation
9. TC/DC

Section-B

Unit-1: Serum analysis: Glucose, Uric acid, Kidney function test, Liver, function test, Thyroid panel test

Unit-2: ELISA technique: Theory, Kit study, ELISA plate reader

Unit-3: Spectroscopy: Principle and use.

Unit-4: Medical Imaging techniques using photographs and reports: X-ray, PET, MRI, Ultra sound

Suggested readings:

1. Text Book of Medical Laboratory Technology (latest edition): Praful B Godkar & Darshan P. Godkar. Bhalani Publishing House, Mumbai India.
2. A text Book of Physiology: A. K. Jain (latest edition) Avichal Publishing Company, New Delhi
- 3.

Course Learning Outcome: This course enables the students to undertake paramedical course after completion of post graduation and get respective job in hospitals and private clinic. Thus the passed out students can embark upon path of finding economic stability and settled life in future.

Paper IX

Genetic Engineering:

70+30

Course Objectives: Major objective of this open elective paper is to introduce to the students contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organisms. The student should be able to understand gene manipulation approaches ranging from bacteria to mammals.

Course Contents:

Theory

Unit-1: Scope and history of recombinant DNA technology.

Unit-2: Tools and techniques: Plasmids and other vehicle, Genomic DNA, Handling of DNA, RNA and cDNA and techniques required for establishing a Recombinant DNA Tech. Laboratory.

Unit-3: Gene Cloning and cloning vectors for E.coli., Applications of gene cloning in research in biotechnology and medicine

Unit-4:Basic prerequisites of genetic engineering, Restriction enzymes, DNA ligases, Polymerases

Unit-5: Cloning vehicles: Plasmids, Cosmids, Phase vectors

Unit-6: Gene libraries: construction and analysis of cDNA library

Unit-7: Transgenic animals.

Suggested readings:

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA [Latest edition].
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK.
3. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA [Latest edition].

Course Learning Outcomes: After successful completion of the course the candidate should be able to design and comprehend experimental strategies for alteration of genes and gene products in variety of organisms.

C. Paper IX Fish Biology and Fisheries

FM:70+30

Course objectives: The classical zoology in the field of fish biology has been underscored. The students who have inclination in this field and have sense of inquiry about the fish world will get an opportunity of fulfilling their desire by selecting this elective paper. Besides, fisheries has been incorporated to give an overview on pisciculture which will give an opportunity to utilize this experience and employment generation.

(Group A)

1. Classification of fishes up to orders.
2. Origin and evolution of fishes.
3. Skin and scales in fishes
4. Electric organs in fishes.
5. Colouration and light production in fishes.
6. Swim bladder in fishes.
7. Hill stream fishes.

(Group-B)

1. Fish seed collection.
2. Fish culture techniques - Induced breeding and hybridization

3. Aquaculture culture of carps – Qualities of cultivable indigenous and exotic species - Preparation and management of nursery and rearing ponds
 - Management of pond and polyculture
 - Air breathing fish culture – Breeding of *Clarias batrachus*
 - Larval rearing and culture of *Clarias*
4. Estuarine fisheries
5. Fish diseases and parasites.
6. Crafts gears in fishing.
7. Fish preservation
8. Fish by products.
9. Larvivorous fishes and public health.

Course Learning Outcomes: This paper gears up the students to explore employment opportunity by self employing themselves through highly lucrative business of fish farming

Paper X (core)

70+30

Genetics, Molecular Biology , Basics of Biotechnology & Evolution

Course Objectives: This combination of course is offered as a core course that provides fundamental knowledge about the functional aspects of genes including replication, transcription and translation.

Major objective of this core paper is to introduce to the students contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organisms. The student should be able to understand standard and system-specific gene manipulation approaches ranging from bacteria to mammals.

Having a composite idea of genetics and molecular biology seems necessary to explain the evolution of species along with biochemical evolution and therefore this section has been incorporated to make a good combination.

Course contents:

Theory Section-A

Genetics and Molecular Biology:

Unit-1: DNA types, molecular organization, DNA replication, DNA

Polymerase, Primosome, Process of replication in ssDNA, dsDNA, Circular DNA Role of Rec A Protein, Site specific recombination

Unit-2: RNA Polymerase: Transcription and Post transcriptional changes in RNA **Capping, tailing & splicing**, Genetic Code

Unit-3: Gene Mutation: Molecular mechanism, types, Mutagens, DNA repair, Gene, Expression, Transcription in prokaryotes, Transcription in Eukaryotes

Unit-4: Translation in prokaryotes, Translation in eukaryotes,

Unit-5: Gene regulation, Lac operon, Tryptophan operon, Repressor Post transcriptional control

Section-B

Basics of Biotechnology:

Unit-1: Basic principles of genetic engineering and Tissue culture, Scope and history of recombinant DNA technology

Unit-2: Prerequisites for genetic engineering: Restriction enzymes, Vector Type Probes

Unit-3: Tools and techniques: Plasmids and other vehicles, genomic DNA, handling of DNA, RNA and cDNA and techniques required for establishing Recombinant DNA Tech. Laboratory, Gene Cloning.

Unit-4: Transgenic animals.

Section-C

Evolution:

Unit-1: Hardy Weinberg law of genetic equilibrium and factors of its destabilization.

Unit-2: Origin of basic biomolecules, Evolution of prokaryotes and Eukaryotes

Unit-3: Microevolution: Theories of evolution, Lamarckism, Neo Lamarckism
Darwinism, Neo Darwinism

Unit-4: Speciation: Allopatric, Sympatric

Unit-5: Biochemical Evolution: Metabolic pattern changes (Autotrophic, Heterotrophic, Anaerobic and Aerobic)

Unit-6: Origin & Evolution of Man, Peopling of continents, Role of behavior in evolution

Suggested readings:

1. Principles of Genetics, Snustad and Simmons, John Wiley & Sons, USA [Latest edition] .
2. Modern Genetic Analysis: Integrating Genes and Genomes, Griffiths, J.F., Gilbert, M., Lewontin, C. and Miller, W. H. Freeman and Company, New York, USA [Latest edition] .
3. Genetics, J. Russell, Benjamin-Cummings Publishing Company, San Francisco, California, USA [Latest edition] .
4. Molecular Biology - Glick College Zoology: Boolotian and Stiles (Mac Miilan) S.B.
5. Molcular Biology & Biotechnology - R. A. Meyers (ed)
6. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y.,USA.
7. Beauchamp, T.I. and Childress, J.F. (2008). Principles of Biomedical Ethics. VI Edition, Oxford University Press.
8. King M. - Species Evolution, The Role of Chromosomal change, The cam, Univ, Press.
9. Strick Berger, M.W. Evolution, Jones & Bartett. Publishers, Boston, London.
10. Introduction to Evolution - Moody (Indian Ed) Envolution - Savege - (Holt, Reimhart, Winston)

Course study Outcomes: After successful completion of the course the candidate should be able to design and comprehend experimental strategies for alteration of genes and gene products in variety of organisms. Not only this, the molecular explanation evolution can be better explained during the course of teaching by such stuffs.

Physiology and Developmental Biology

Course Objectives: The fundamentals of physiology along with intricacy involved in sustaining the life have given importance in this core paper. This is of utmost importance to understand the functioning of different organ systems which will be very beneficial for future research purpose and even make the students better equipped for dealing with present sporadic epidemiological outbreaks in the world. Neural disorders included in this section will be of additional privilege in enriching the knowledge of the students in neural science.

Besides, some unexplored topics at graduation level in developmental biology have been taken in to consideration for as a corollary to previous teaching.

Course Contents:

Theory Section-A

Physiology:

Unit-1: Digestion: Overview of digestion and absorption of macronutrients

Unit-2: Circulation: ECG and Cardiac Cycle, Haemopoiesis, Homeostasis Blood and Lymph, Blood Clotting: Factors and pathways

Unit-3: Respiration: Role of Haemoglobin in transport of gases, Bohr's effect, Haldane effect, Control of breathing

Unit-4: Excretion: Urine formation, Glomerular filtration, Tubular reabsorption and secretion, Counter current mechanism
Hormonal regulation (ADH & Renin-Angiotensin system)
Acid Base Balance , Ornithine cycle

Unit-5: Nervous system: Axonal transmission, Neurons and their types, Genesis of membrane potential, action potential,

Sodium-potassium pump

Synaptic transmission: Types of synapses and synaptic knobs
Excitatory and inhibitory post-synaptic potential,
Chemical transmission, Neurotransmitters

Sensing stimuli: Photoreception, Chemoreception,
Mechanoreception, Echolocation

Neural disorder: Strokes, Epilepsy, Alzheimer disease,
Huntington disease, Parkinson disease

Autonomic nervous system (Sympathetic and parasympathetic)

Unit-6: Thermoregulation: Heat balance in animals, torpor, aestivation and hibernation, Role of Hypothalamus

Unit-7: Muscle Contraction: Muscle fibre, Myofibrils mechanism, Electric organs(Myogenic lineage) & electric discharge

Section-B

Developmental Biology:

Unit-1:Fertilization: Pre fertilization events, Biochemistry, Post fertilization events

Unit-2:Embryonic induction: Primary organizer, Differentiation, Competence Stem cells and their applications

Unit-3: Ageing: Theories of ageing, Ageing related diseases, Anti-ageing therapy.

Unit-4:Hormonal regulation of metamorphosis in insects and amphibians

Suggested readings:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd. W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
4. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
5. Developmental Biology: Scott F Gilbert [Latest edition].
6. Essentials of Developmental Biology: JMW Slack [Latest edition] .
7. Principles of Development: Louis Wolpert [Latest edition].

Course Learning Outcomes: Scrupulous combination of physiology and developmental biology will enable the students to get access to biological processes as a finishing section of core papers. Particularly the neural sub section and ageing concept are the highlights of this paper.

Practical Paper- XII

70+30

List of Practical

1. Genetics and molecular biology

- (I). Structural traits of Drosophila
- (ii) Isolation of genome DNA
- (iii) Restriction Digestion of DNA
- (iv) Agarose gel electrophoresis of DNA
- (v) Study of chromosomal aberrations-slides
- (vi) Polytene Chromosome
- (vii) Principles and use of tissue culture technique

2. Evolution

- (i) Adaptive modification in feet of birds
- (ii) Adaptive modification in mouth parts of insects
- (iii) Adaptive modification in dentition of mammals
- (iv) Estimation of gene and genotypic frequencies in the light of Hardy – Weinberg law based on ABO blood group data in a large sample of human population or a class room sample

3. Developmental Biology

- (i) Whole mount of chick embryo-18, 24,33,48,72 and 96 hrs.-slides
- (ii) Preparation of whole mounts of chick embryo-18, 24,33,48,72 and 96 hrs.
- (iii) Observation of metamorphosis of Amphibian tadpole larva

4. Physiology:

Salivary Amylase activity, Hb%, Determination of ESR, Bleeding and clotting time, GFR analysis, Cardiac cyclic analysis,

Determination of systolic and diastolic blood pressure by-manual blood pressure instrument /Electronic digital blood pressure instrument.

Determination of rate of oxygen consumption in rat

Model of questions
1. Genetics and molecular biology-
2. Population Biology, Population Genetics
3. Developmental Biology
4. Physiology
5. Viva-
6 Record-

4th Semester

Elective paper	Paper-XIII	4 Credits	64 Hours
Elective paper	Paper-XIV	4 Credits	64 Hours
Practical	Paper-XV	4 Credits	64 Hours
Dissertation	Paper-XVI	4 Credits	64 Hours

4 th Semester	
Select any one special paper	Marks
Theory Paper XIII	(70+30) =100
Theory Paper XIV	(70+30) =100
Practical Paper XV	(70+30) =100
Dissertation-XVI	100

4th Semester detailed curriculum

A. Environmental Biology (Elective Paper/Special paper) 70+30

Course objectives: The objective of this course to make awareness among the young students about the surrounding environment, the impact of climate change and its mitigation, and biodiversity. This will enable them to tide over the adverse environmental situation and participation in disaster management.

Theory Paper XIII

Course contents:

Unit-1: **Concept of productivity**-primary and secondary productivity Plankton community structure and species diversity

Unit-2: Population: Population dynamics, population characteristics, growth curves Population growth curve r- and k-selections and carrying capacity, Biological communities and species interactions, Types of interaction between two

species

Unit-3: Laws of limiting factors

Unit-4: Ecological Succession, Process, Hydrosere, Xerosere

Unit-5: Environmental pollution: Air, Water, Noise, Remedial strategies, Ozone layer and its depletion -Possible effects on plants, animals and man.

Unit-6: Predation: Models of predatory prey dynamics, Role of predation in nature
Parasitism.

Unit-7: Lakes-origin and classification of lakes.

Unit-8: Sustainable development: Concept and definition, Model, Brundtland report
UNDP 17 goals, Agenda 21, Importance

Unit-9: Biogeochemical cycle: Water cycle, Oxygen cycle, Carbon cycle, Nitrogen
Cycle, Phosphorus cycle, Sulfur cycle

Unit-10: Energy Flow: Laws of thermodynamics: Enthalpy and Entropy Energy
transfer in a food chain: Suitable models

Unit-11: Pesticides and their effects: Definition of pesticides, Brief history,
Classification, Metabolism of insecticides: Phase-I and Phase-II reactions
Nano-pesticides, Mode of action, Therapy and antidotes

Theory paper XIV

70+30

Unit-1: Biosphere and Biomes: impact of climate on biome, Major
ecosystems of the world.

Unit-2: Reservoir limnology and its thermal stratification, stratification
And, dynamics of oxygen, nitrogen, phosphorus and inorganic
carbon.

Unit-3: Environmental factors and global environment.

Unit-4: Limnology-Origin and classification of lakes, vertical stratification,
eutrophication

Unit-5: Conservation: Rain water harvesting, wet-lands conservation

Unit-6: Natural disasters and management, Climatic change:

Unit-7: Climate Changes: Global warming, Ozone layer depletion, Acid
rain, Nitrogen deposition, Global climatic pattern, Its impact on

plants, animals and human beings.

Unit-8: Biodiversity: Its threats, conservation and management, Biodiversity act and related International conventions, Natural resource management in changing environment, Molecular ecology, conservation genetics.

Unit-9: Environmental laws for protection of wild life, natural habitats and environment

Unit-10: Major International Conferences on environment:

Unit-11: Waste Management

Unit-12: Bioremediation of organic and inorganic contaminants: Methods & Means, Bioindicators and biomarkers of environmental Major classes of contaminants, Uptake, biotransformation, detoxification, elimination and accumulation of toxicants.

Unit-13: Principle of **remote sensing** and its applications in Environmental Science

Suggested readings:

1. Field Sampling: Principles and Practices in Environmental Analysis. 2004. Conklin, A.R. Jr. CRC Press.
2. Principles and Standards for Measuring Primary Production. 2007. Fahey, T.J. and Knapp, A.K. Oxford University Press, UK.
3. Ecological Modeling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
4. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
5. Principles of Terrestrial Ecosystem Ecology. 2011. Chaplin, F.S., Matson, P.A. and Vitousek, P.M. Springer.
6. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.
7. Freshwater Ecology: A Scientific Introduction. 2004. Closs, G., Downes, B. and Boulton, A. Wiley-Blackwell publisher, Oxford.
8. Krebs. C.J. Ecological methodology, Harper & Row, N. York.
9. Krebs, J.R. and N.B. Davis, Behavioural Ecology, Blackwell, Oxford U.K

Course Learning Outcomes: Students will be exposed to the fundamental aspects of ecology. They will get idea about the impact of anthropogenic activities on the environment. Students will get idea about the natural resources and their conservation. Above all once they finish their course they are supposed become crusaders of sustainability of the environment and its conservation. They would feel connected with the environment.

Besides it will provide an opportunity in finding place in government bodies which are looking after environmental management and at the same time job opportunity in industrial sector.

Practical XV- Environmental Biology

70+30

List of experiments

(I). Analysis of water

Physicochemical-Temperature, Turbidity, Light penetration, Conductivity, Total suspended solids, Total dissolved solids, pH, Total alkalinity, Carbonates and bicarbonates, Free CO₂, Dissolved O₂, BOD, COD, Nitrate, Chloride, Silicate, Phosphate.

Biological-

Phytoplankton analysis, Biomass estimation, Zooplankton analysis, benthic macro invertebrates

(II). Analysis of soil

Physico chemical-

Sampling, texture, pH, Conductivity, Total alkalinity, Carbonates and bicarbonates, Acidity

Biological

(III).Community analysis of Grass land,

(IV).Study of bio indicators of pollution

(V)Primary productivity-biomass method, light and dark method,

(VI) Tools and techniques of- Flame emission spectrometry, Absorption spectrophotometry, Atomic absorption spectrophotometry, Gas chromatography

Model of questions
1.Physico chemical Analysis of water -
2.Biological Analysis of water -
3.Physicochemical Analysis of soil-
4.Experiments on one of the following (Community analysis/ Study of bioindicators/ Primary productivity)
5.Spotting-(One)-
6.Viva-
7. Record -

Paper XVI : Dissertation: 100 marks

Written test - 25 marks

Project & Presentation (PPT)- 50marks

Viva-voce - 25 marks

B. Hematology (Elective/Special Paper)

Objective: To understand the patho-physiology of any disease requires a comprehensive understanding of in-depth knowledge in the field of hematology. This paper will enable the students as a complementary part of immunology and will be proved helpful in analyzing the related project in better way.

Theory Paper XIII

70+30

Unit-1: Scope, prospects and history of Haematology.

Unit-2: Blood Composition: Mammalian Blood corpuscular composition of Human beings, Erythrocytes (RBC=Red Blood Cell), Leucocytes (WBC=White blood cell)-types, structure and function.

Lymphocytes (T and B type), Monocytes (iii) Neutrophil (IV) Basophil (v) Eosinophil (vi) Macrophages (c). Blood platelets.

Unit-3: Haemopoiesis-process, stem cells of haemopoietic tissue

Unit-4: Structure and function of blood in invertebrates

Unit-5: Comparative account of blood in vertebrates.

Unit-6: Structure and function of lymph glands and lymphoid tissue
Structure and function of Thymus and spleen.

Unit-7: Structure and function of bone marrow: Leucocytosis and leucopaenia

Unit-8: Composition of blood plasma in man and clinical consequences

Unit-1: Anaemia-Definition, types, diagnosis and therapy: Iron metabolism and iron deficiency anemia, megaloblastic anemia, pernicious anemia, aplastic anemia, sickle cell anemia, thalassemia, anemia associated with endocrine glands, erythroblastosis fetalis

Unit-2: Abnormal blood types: Polycythemia, Methemoglobinemia and its causes
Abnormal Haemoglobin, Spherocytosis, Megakaryopoiesis & Platelets disorder, Hemophilia A, and Hemophilia B

Unit-3: Hematocrit & Hb% determination

Unit-4: Blood transfusion and blood groups

Unit-5: Blood coagulation and Hemostasis, Blood coagulation inhibitors

Unit-6: Hemoparasites: Leishmania, Trypanosoma, Malaria Parasite,, Wuchereria-Life cycle and diseases

Unit-7: Serum analysis: Glucose, Urea, Creatinine

Elective Paper Practical XV - Animal Haematology 70+30

List of experiments

- (1). Giemsa/Leishman stained preparation of blood smear slide of Fish/Amphibia/Aves/Mammal
- (2). Interpretation of results on the basis light microscopy of blood smear slide provided.
- (3). Micrometry- Use of Sage and Ocular micrometer
Measurement of length and width and diameter of erythrocytes in the blood smear of slide provided. (Amphibia/Mammal)
- (4). Perform two haematological experiments

List of experiments

- (I). Total erythrocyte count – Amphibia/Mammal
- (II) Total leucocytes count.- Amphibia/Mammal
- (III). Estimation of Haemoglobin- Amphibia//Mammal
- (IV). Differential leucocytes count in the stained blood smear
Fish/Amphibia/Aves/Mammal
- (v) Determination of Packed cell volume (PCV) - Mammal
- (VI). Determination of Bleeding and clotting time.- Mammal
- (VII) Identification of blood group and Rh factor of your own blood
- (VII) Estimation of blood glucose, Urea and Creatinine

Model of questions
1.Preparation of blood smear slide -
2.Interpretation of results -
3.Micrometry -
4Two haematological experiments
5.Spotting -(Two) -
6.Viva-
7.Record -

Reference books:

1. Hematology: basic principles and practice, 7th ed. – by Ronald Hoffman, Edward J. Benz
2. Harrison's Hematology and oncology, 3rd ed, by Dan L. Longo (McGraw-Hill)

Course learning outcomes: Haematology is the most fundamental test of several diseases and diagnosis of the same by examining the referred parameters associated with them. Such students can contribute as teaching faculty after acquiring the postgraduate degree with this special paper. The episodes of pandemic has further underscored the significance of hematological tests

Paper XVI

Dissertation: 100 marks

Written Test - 25 marks

Project and Presentation (PPT)- 50 marks

Viva-voce - 20 marks

PROJECTS

Project-1.

Study of animal biodiversity

(i) **Insects**-beetles, Butter flies and moths

(i) **Fishes**

(iii) **Reptiles**

(iv) **Aves**

(v) **Mammals**

(Of your locality-field survey report supported by still photographs.)

Project-2.

Survey of human population

(i) Survey of human population of your district-various castes, socio economic states, health and education, male and female ratio-, Fertility/Mortality ratio-a brief report on your data.

(ii) Survey of hospitals, private clinics to gather report on health status and diseases prevalent in your locality-field survey and report.

(iii) Identification of malarial, Filaria, Kalaazar, TB, AIDS, anaemia, malnutrition, contaminated water drinking(diarrhoea), prone area of your locality- field survey and report.

(iv).Field survey of human beings(Male Female, Age groups-between10-16,17-22,23-32,32-62) of your locality -Normal hair and baldness,hypertrichosis,Tongue rollers and non rollers of your locality-a brief survey report with suitable proofs of your work.

Systematics and Taxonomy

- Documentation of different animals of Santhal parganas

Project-3

Animal behaviour

(I). Use of Binoculars, Digital still and video camera for still photography and videography in behavioural studies of animals.

(II). Field observation –

1. Watching of bird behaviour-courtship and mating, Nest building, brooding, feeding, etc. a brief pictorial field study

(III) Watching of social life of insects of your locality-a brief pictorial study.

(IV) Report on watching of behavioural studies of your pets and domestic animals

(V) Study trip to Zoo for observing behaviour of animals.

(VI) Study of behaviour of monkeys

Project-4

- Chemical and biological investigation of ponds and other water bodies of your village.
- Waste Management eco-friendly use of renewable source of energy and to develop social forestry scheme at your village
- Innovations in irrigation techniques and use of land for agriculture purpose and Soil testing of your village –brief report
- Introduction of bio fertilizers by the use of Vermiculture technology for your native place.

Project-5

Survey of human population suffering from anaemia, Sickle cell anaemia, malaria, filaria, leukaemia, AIDS of your locality--brief survey report, Blood group survey.

Project-6

Survey on fish diversity of your locality

Project-7

- Field survey (during rainy season) of nearby by ponds and ditches to observe embryological development of frog.-brief survey report

Project-8

- Field Survey of pests and Pesticides of local area

Project-9

- Vermiculture, Sericulture, Apiculture

Project-10

Pond Biota study of local ponds of the district

Conservation of water and its Management

Blood group sampling of the students and its analysis

Additional Book List - An Easy Access

1. M. Kato - The Biology of Bio-diversity, Springer.
2. J.C. Avise - Molecular Markers, Natural History & Evolution. Chapman & Hall. N. York.
3. E.O. Wilson - Biodiversity, Academic Press, Washington
4. G. G. Simpson - Principles of Animal Taxonomy. Oxford IBH, Publishing Co.
5. E. Mayer. Elements of Taxonomy.
6. E.O. Wilson, The Diversity of Life (The College Edition) W. W. Northern & co.
7. B.K. Tikador - Threatened Animals of India ZSI Publicatio, Calcutta,
8. Batschelet E. Introduction to Mathematics for life Scientist, Springer-Verlag Berlin.
9. Sokal, R.R. and F.J. Rohif, Biometry (Freeman)
10. Sendecor, G.W. & W. G. Cochran. Statistical Methods, Affiliated East west Press, New Delhi.
(Ind. ed)
11. Murray, J. D. Mathematical Biology, Springer - Verlag, Berlin.
12. E.J.W. Barrington - General & Comparative Endocrinology, Oxford, Clarendon Press.
13. P.J. Bentley, Comparative Vertebrate Endocrinology, Cambridge University Press.
14. R.H. Williams - Text Book of Endocrinology. W.B. Saunders.
15. C.R. Martin - Endocrine Physiology, oxford.
16. A Gorbman et al. Comparative Endrocrinology. John Willey & Sons
17. Molecular Cell Biology - J. Darnell! et al, American Book. Inc. U.S.A.
18. Molecular Biology of the Cell-B. Alberts, et. al. Garland Publishing. Inc. New York.
19. Jha, A.P. Genes and Evolution, John Pub. N. Delhi.
20. King M. - Species Evolution, The Role of Chromosomal change, The cam, Univ, Press.
21. Strik Berger, M.W. Evolution, Jones & Bartett. Publishers, Boston, London.
22. Austen, C.R. and Short, R.V. Reproduction in Animals.

23. Schatten & Schatten - Molecular Biology of Fertilization.
24. F.T.Longo - Fertilization, Chapman & Hall
25. R.G. Edwards - Human Reproduction.
26. Introduction to Instrumental Analysis, Robert Brauh, HNI International Editions.
27. A. Biologist's Guide to Principles & Techniques of Practical Biochemistry, K. Willson & K.H.Goulding.
ELBS Ed.
28. Eckert., R. Animal Physiology, Mechanism and Adaptation. (Freeman) New York.
Hochachaka, P.W. and Somero. G.N. Biochemical Adaptation, Princeton, New Jersey.
29. Rummer. L. Practical Biochemistry, Tata Mac Graw.
30. Prosser. C. L Environmental & Metabolic Animal Physiology-Willey-Liss Inc. N.York.
31. Townsend, C.R. and P. Calow-Physiological Ecology. An evolutionary approach to resource, use
Blackwell Sci. Publ. Oxford U.K.
32. Loun, G.N. Physiological animal Ecology Longman, Harios, U.K.
33. Russei - Hunter, W.D. A Biology of Higher Invertebrates.
34. Read, C.P. Animal Parasitism Prentice Hall Inc. New - Jersey.
35. Krebs. C.J.Ecology - Harpar & Row, N.York.
37. Krebs. C.J.Ecological methodology, Harper & Row, N. York.
38. Animal Behaviour, An evolutionary approach, U.S. A.
39. Glutton - Brock, T.H., The evolution of Parental Care, Princeton University Press - U.S.A.
40. Krebs, J.R. and N.B. Davis, Behavioural Ecology, Blackwell, Oxford U.K.
41. Wilson, E.O.-Socio Biology, The New Synthesis Harvard univ. Press, Cambridge Mass USA.
42. Kuby - Immunology W.H.Freeman, USA.
43. W.Paul - Fundamentals of Immunology.
44. I. M. Roitt - Essential Immunology ELBS edition.
45. Introduction to Practical Molecular Biology, P.O. Dabre, John Willey & Sons Ltd. N. York.
46. L.P.Freeman, Molecular Biology of Steroid & Nuclear Hormone Receptors, Birkhansar.
47. G.Litwack, Biochemical Actions of Hormones - Academic Press
48. Animal Diversity - E.D. Hanson. Prentice-Hall of India Pvt. Ltd. N. Delhi.
49. Biology Teachers, Hand Book, Joseph J. Schwab. Supervision, John Willey & Son Inc. (B.S.C.S)
N. York.
50. Biological Science - An inquiry into Life (NCERT) Indian Edition, Harcourt, Brace & World, Inc. N.York.
51. Biological Science: Molecules to Man. Houghton Mifflin Co. Boston Mass. (BSCS Publication) "Blue
version"
52. High School Biology BSCS "Green Version" Rand, Me Nally Co. Chi Caq O.
53. Microbes, their growth, nutrition, interaction [D.V.Health. & Co. Boston. Mass.]
54. Biological Investigations for Secondary School Students. Research Problems in Biology -
Investigations for students -Series 1,2,3 & 4. Double Day & Co. New York.
55. Laboratory Exerciser in Biology - K. Krishna Swami : The Navcheton Press Pvt. Ltd., Naya Bazar, New
Delhi – 6

56. Blaxhall, PC. & K.W. Daisley: Routine haematological methods for assessment of water quality
ASTM. STP. 528, AM. Soc. Test Mater, Philadelphia. (1973)
57. De. Gruchi G.C.-Clinical haematology in Medical Practice. (Eds. D. Penigton, B. Rush and P. Castai di)
(1984)
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59. The Seas : Our Knowledge of life in the Sea and how it is gained. F.S. Russel & C.M. Younge, Warne.
60. Invertebrate Zoology - Barnes, R.D. (W.B. Saunders Co.)
61. Cell and Molecular Biology - De Roberte and De Robertes (Sander's College)
62. Cell Physiology - A. Geese
63. Manual of Laboratory Exp. in Cell Biology (W.C. Brown publishers) Chordate
64. The Chordates - Alexander, R.M. (Cambridge University Press)
65. The Chordates - Monaith, A. R. (Cambridge University Press)
66. Chordata - Structure and Function - Waterman, A. J. (Mac Millan Co.)
67. Animal Physiology - Eckert, R. (W. H. Freeman) Review of Medical physiology, Ganong (Lange)
68. Outlines of Biochemistry- (Wilay) Conn. Stumpi, R.K. Bruening and Doc.
69. Endocrinology - Hadley. General Endocrinology - Bagnara, and Turner (W.B. Saunders)
69. Reproductive Physiology - (Nalbandov, A.V.)
70. Evolution Introduction to Evolution - Moody (Indian Ed) Evolution - Savege - (Holt, Reimhart, Winston)
71. Ecology - Odum (Amerind)
72. Fundamentals of Ecology - Odum - (Saunders)
73. Ecology - Ricklets (W.H. Freeman)
74. Limnology- Welch (Me Graw Hills)
75. Genetics (Mac Millan) - Strikberger
76. Genetics - Farnsworth (Harper & Raw)
77. Biochemistry Stryer, L. (Freeman)
78. Outlines of Biochemistry - Corntel (Willy)
79. Molecular Biology of the Gene - Watson, J.D et al (Benzamin/ Commings)
80. Development Biology - A Modern Sythesis, Rao, K.V. (oxfor, IBM, Publishers)
81. Principles of Gene Manipulation - An introduction to genetic engineering - R.W. Old, and S.B.
Primrose.) (VCH, Publishers)
82. Biology - (Benzamin) Campbell
83. Text book of Zoology, Marshal & Williams
84. Biology the Foudations - (Wordsworth) Wolfe
85. Cell - (Bartlett & Jones) prescott.
86. Molecular Biology of the Cell (Garland) Albearts etal
87. Molecular Cell Biology (Freeman) Lodish eL aj
88. General & Comparative Physiology - Hoar (Prentice Hall)
89. Animal Physiology - Neilsen (Cambridge)
90. Integrated Principles of Zoology - Hickman, Robert and Hickman(Timer - Mirror Mosby

91. Comparative Animal Physiology - Progser (Satish Book Enterprise)
 92. Endocrinology - Hadley'(Prentice Hall)
 93. A Introduction to Empryology - Balinsky (CBS College Publication)
 94. Biology of Developing system - Grant (Holt, Reihart, Winston)
 95. Developmental Biology - Gilbert (Sinour)
 96. Economic Zoology - Shukla & Upadhyaya (Rastogi Publishers)
 97. Text Book of Applied Entomology - Srivastava (Kalyani Pulishers)
 98. Economic Zooiogy - VenKitaraman (Sudarsane Publishers)
 99. Invertebrate Zoology - Sarnes (Half - Sanunder International)
 100. Invertebrate structure and Function - Barrington (Nelson)
 101. College Zoology - Boolootin & Stiles (Mac Millan)
 102. A manual of Zoology - Part - I Invertebrate -Ekambernath I Year (5. Vishwanathan)
 103. A life of Invertebrates - Russel - Hunter (Mac Millan)
 104. Molecular Biology of the Gene - Watson, J.D et al (Benzamin/ Commings)
 105. Principles of Gene Manipulation - An introduction to genetic engineering - R.W. Old, and
 106. Molecular Biology - Glick College Zoology: Boolotian and Stiles (Mac Miilan) S.B.

 - 107 Introduction to Embroyology - Balinsky (CBS College publishers)
 108. Developmental Biology - Biology - Berril, N. J. (Tata- Mc Graw Hill)
 - 109 An outlines of Animal Development, -Davenport (Addison - Werley)
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 113. Molcular Biology & Biotechnology - R. A. Meyers (ed)
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