UNIVERSITY OF MUMBAI
No. UG/17 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular No. UG/153 of 2017-18, dated 3rd August, 2017 relating to syllabus of the Bachelor of Science (B.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Zoology at its meeting held on 9th April, 2018 have been accepted by the Academic Council at its meeting held on 5th May, 2018 **vide** item No. 4.32 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.Y.B.Sc. in Zoology (Sem -V & VI), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

(Dr. Dinesh Kamble)
I/c REGISTRAR

MUMBAI – 400 032
14th June, 2018

To

The Principals of the affiliated Colleges & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.32/05/05/2018

****

No. UG/17 -A of 2018 MUMBAI-400 032 14th June, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Zoology,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

UNIVERSITY OF MUMBAI

Program: B.Sc.

Course: Zoology

Syllabus for Semester V & VI

(with effect from the academic year 2018-19)

Credit Based Semester and Grading System
- with a Choice for Additional Credits

Syllabus Framing Committee Members' List 2018-2019

Vinayak Dalvie (Convenor)
Capt. Dr. A. A. Dalvi (Co-Convenor)
Dr. Mrinalini Kagwade (Co-Convenor)
Dr. Vinod Ragade (Co-Convenor)
Dr. Sharad Mahajan (Co-Convenor)
Dr. Kishori Sinnarkar (Co-Convenor)
Dr. G. S. Margaj (Co-Convenor)
Dr. Leena Meshram (Co-Convenor)
Dr. Shaila Mane (Co-Convenor)
Dr. Vishakha Shingala (Co-Convenor)
Dr. Snehal Donde
Dr. Shantaj Deshbhratar
Dr. Satish Sarfare
Dr. Gulabrao Raje
Dr. Rupinder Kaur
Mrs. Parimita Sharma
Mr. Deepak Poojary
Dr. Pawankumar Mudbe
Dr. D. V. Pawar
Mr. Ashish Sharma
Mr. Abhimanyu Londhe
Ms. Rajeshree Prasad
Mr. Kaustubh Bargode
Ms. Mahalaxmi Pillai
Mr. Sankalp Bandekar
Mr. Saurabh Kadam

Dr. Ghanashyam K. Amte (Co-Convenor)
Dr. Jayasree Sasangan (Co-Convenor)
Dr. Supriya Deshpande (Co-Convenor)
Mrs. Usha Anilkumar (Co-Convenor)
Dr. Bhavita Chavan (Co-Convenor)
Dr. D. L. Bharamal (Co-Convenor)
Dr. Vasantrao Patole (Co-Convenor)
Dr. Ugeshkumari Singh (Co-Convenor)
Mr. Sachin Gosavi (Co-Convenor)
Dr. Utkarsha Chavan (Co-Convenor)
Dr. Sudesh Rathod
Dr. Roshan D'Souza
Dr. Aamod Thakkar
Mr. V. B. Dandwate
Dr. Rana Ansaria
Dr. Janhavi Bhagwat
Mr. Vishal Nangare
Dr. Udayan Apte
Mr. Rohit Nagalgaon
Ms. Neha Vajandar
Ms. Uma Bandekar
Ms. Shagufa Shaikh
Ms. Reena Patil
Ms. Nausheen Shaikh
Ms. Kranti Patil

CONTENTS

1. Preface

2. Preamble

3. Pedagogy

4. Tables of Courses, Topics, Credits and Workload

5. Theory Syllabus for Semester V (Course codes: USZO501-USZO504)

6. Practical Syllabus for Semester V (Course code: USZOP05)

7. References and Additional Reading (Course codes: USZO501-USZO504)

8. Learners' Space (Course codes: USZO501-USZO504)

9. Theory Syllabus for Semester VI (Course codes: USZO601-USZO604)

10. Practical Syllabus for Semester VI (Course code: USZOP06)

11. References and Additional Reading (Course codes: USZO601-USZO604)

12. Learners' Space (Course codes: USZO601-USZO604)

13. Marking Scheme of Examination (Theory and Practical)

14. Skeleton Practical Exam Papers: Semester V and Semester VI

15. Add-on Project (Course codes: USZOR01 and USZOR02)

PREFACE

Revision of Syllabus, an integral part of educational institutions and one of the important functions of Board of Studies of any University, is an opportunity to revisit what is being taught and what ought to be taught to learners in the landscape of changing times.

A great initiative in the form of, prior to and during the process of curriculum design, involving various stakeholders has been a hallmark of the syllabus committee for Zoology in general and the committee for T. Y. B. Sc. Zoology, SEM V and SEM VI in particular. It is after a lot of hard work in a true team spirit that this syllabus has been prepared and presented for coming into force from the Academic Year 2018-2019.

Human beings are an intricate and unique entity of the 'Kingdom Animalia.' It is no wonder that students of yore and the present day are drawn to the subject of Zoology in all aspects of life and living, like iron to magnet. This poses a challenge while designing a curriculum since the young minds attracted to the subject, thought passionate about the subject may possess differential abilities to grasp the subject and may do so at their own pace.

The curriculum has thus to be designed not only to engage interest, to stimulate and inspire the learner but also to kindle the spirit of inquiry. The syllabus presented herewith for implementation with effect from the academic year 2018-19, in the subject of Zoology also is an instrument to inculcate in the learner the culture of critical thinking.

The scope of the curriculum therefore has to be wider incorporating elements of traditional as well as contemporary and even futuristic dimensions of the particular area of study. This aspect of curriculum design has been exemplarily met with by this syllabus in Zoology for SEM V and SEM VI at T. Y. B. Sc.

Another important consideration for the syllabus committee is to incorporate in the architectural design of the curriculum, the scope for teachers to use classical as well as contemporary technological tools of pedagogy with an aim to connect and cater to all types of learners including slow learners as well as the advanced ones. This syllabus with clearly stated objectives and outcomes, unit-wise, is one of the best examples of being an instrument of mixed pedagogy available to the teachers.

In spite of constraints in the form of having to teach curricula without including any dissection in the course of study, the syllabus committee has designed the syllabus keeping the classical flavour of the subject intact.

A unique feature of this syllabus is its unique blend of standardization and customization creating a vibrant ecosystem of teaching-learning for the teacher to function as a facilitator and mentor and for the student to take a few steps towards being a motivated student and an autonomous learner.

I place on record, appreciation for all members of the syllabus committee as well as the dynamic and visionary leader in the form of convenor of the syllabus committee, and congratulate them all, on behalf of faculty members and students of Zoology, for having designed this progressive syllabus for T. Y. B. Sc. (SEM V and SEM VI) in Zoology, to be implemented from the academic year 2018-19.

Dr. (Mrs.) V. I. Katchi
Convenor,
Interim BOS in Zoology.

PREAMBLE

Zoology has emerged as a progressive subject in the last decade with innovations in curricular designing and unique initiatives which attracted students, both from urban as well as rural colleges, in large numbers towards this subject. Experiments such as Need Based Flexi Syllabus, Open Unit to include latest topics any time before revision of syllabus, Pyramid Committee for continuity from Semester I to Semester VI, Workshop with Indian Merchants' Chamber for industry - academia interface, Workshop with the meritorious past students and current students for their inputs, uploading Draft Syllabus on the University website for Public Criticism, one month prior to BoS, etc., fetched rich dividends. The fundamental challenge however, was to design curricula without dissections, the backbone of the subject. We Zoologists though are firmly against cruelty to animals and practice conservation, had to take it with a pinch of salt that the dead table fish from the market and pests were also banned for dissection.

In keeping with the traditions this time the learners' space has been incorporated in the syllabus for the advanced learners and Research Based Pedagogical Tools (RBPT) are recommended for a unit after three days workshop organised by IISER and British Council Library, attended by good number of Zoology teachers from the rural area. Application of RBPT is optional. RBPT will be explained again in the post amendment workshop.

After conducting workshops for teachers and students, both in urban and rural areas, it was felt that the research project may be incorporated for additional credits only for the students who wish to pursue higher specialised studies and who may opt for a career in research oriented fields. Apart from a project in the Applied Component such students may present a research project under the guidance of a teacher from their college or any other college or from the industry or may do so on their own which shall be evaluated by the examiners at the time of the practical examinations and that the performance shall be considered separately as additional optional credits, based on the free choice of student and if permitted by the authorities then the same could be transferred to the other / higher programs if desired. It's a modest attempt of bringing choice based credit system with an option of transfer in the main stream academics of the University on the lines of the pioneering effort successfully launched in the subject of NCC, when introduced as an elective in academics.

Care has also been taken to include a unit on muscles which was much neglected so far in anatomy. Possibility cannot be ruled out that it may give further impetus to Zoology students to enter the career of Gym and Fitness. This niche of students shall have upper hand over other personnel in the fitness industry in passing international exams since they already have knowledge of physiology to a desired extent.

I am happy to present this syllabus for consideration of the authorities and I sincerely thank all the members who represented teachers, students, rank holders, people from the industry and interdisciplinary background, scientists from India and abroad, and a journalist from Sawantwadi who is an activist in biodiversity conservation. The draft was on University website for 2 months which gave ample opportunity to the society in general and teachers in particular to criticise. I thank all those who contributed suggestions. Lastly, on behalf of all the Zoologists, I thank the staff of Academic Authorities Unit who has blended so well with teachers that the product is innovations experimented successfully.

- Vinayak Dalvie
Convenor,
T. Y. B. Sc. Syllabus Committee in Zoology

PEDAGOGY

The syllabus framed by taking views of all the stakeholders, both from urban and rural areas into consideration and providing scope to the advanced learners without posing challenges before the average and above average students, certainly needs dynamic pedagogy with range of variations to deliver the objectives with desired outcome.

Course codes USZO501 and USZO601 attempt to make the learners understand the principles of taxonomy, levels of organisations, modern classification up to class and the evolutionary significance of various levels of organization like symmetry, coelom, segmentation, etc. It is desirable to take students in the field, rather than the classroom, and practice experiential learning making taxonomy live and interesting. It won't be an exaggeration if one feels that even protozoans could be observed from natural sample in the field by carrying a microscope. Ideally students should draw diagram of an organism / animal as they perceive through observation rather than copying a diagram from a book into the journal. Various schools of classification make it debatable. Care has been taken to adopt the latest approach and through appropriate pedagogical tools students should be able to attribute characters of a specimen up to specific class.

Course USZO502 introduces various aspects of human blood, clinical disorders and their diagnosis. The significance of the diagnostic tools must be stressed upon as they are relevant to human health. Teachers are expected to elucidate the scope of haematology and immunology as career options in the field of pathology. IISER, Pune in collaboration with British Council is advocating Research Based Pedagogical Tools through workshops sponsored by MHRD government of India. It is suggested that Unit II - Applied Haematology, of this course can also be taught, alternatively, using RBPT. The subtopics are in context to the real life and have a scope of research-based learning through actual laboratory work under the observation of their teachers. The knowledge base of blood and its components that the learners already have can be further enhanced through various activities that learners can undertake in order to relate the theory with the practicals and understand the clinical significance of various diagnostic tests. Course USZO602 includes enzymology, homeostasis and animal tissue culture. Documentaries based on nature and wild life can be effectively used to create interest in the learners about adaptive responses of animals to environment for their survival. Industrial visits, invited talks from industry persons will help in generating awareness about industrial significance of enzymes. Theory supplemented with hands-on practical on sterilization and culture techniques will help the learner to appreciate the importance of animal tissue culture. Visits to departments of microbiology and biotechnology in the institution may be encouraged to interact with teachers & students so as to create more interest. Student led seminars are a self-learning interactive method that may be encouraged.

The topics covered under course USZO503 includes Mammalian Histology, Basic Toxicology, General Pathology and Biostatistics. Microtomy, reintroduced, could be effectively used not only as a histo-pathological tool for clinical pathology but also to emphasize its applications in research. The toxicology studies can be made interesting by emphasizing its importance in pharmaceuticals and additionally the insights into regulatory aspect can be given to understand the practical difficulties and the norms associated with toxicity testing. Study visit to the pathological laboratory planned for unit II could also cover these aspects. Application of biostatistics in interpretation and validation of experimental data should be highlighted. The learners could be introduced to statistical software which have their applications in biostatistics. Course USZO603 includes Molecular Biology, Genetic Engineering, Human Genetics and Bioinformatics. Molecular biology and genetic engineering could be taught using ICT and videos available online. It is recommended to have an

industrial interface. Teachers are expected to explain the scope of gene manipulation techniques in medical science as well as industry. Through ICT, various concepts of bioinformatics such as protein sequencing, construction of evolutionary trees etc. can be taught. Use of available software in public domain to study human diseases could be focused on. The practical utilization of bioinformatics in preparing probes using database could be stressed.

A synergistic pedagogical approach between the theory and practical course of USZO504 could help in better understanding of the various subtopics such as integumentary system, osteology and the developmental stages of chick embryo. There is a scope for using ICT related teaching tools that would help in understanding the structural and the functional aspects of epidermal and dermal derivatives, various fore limb and hind limb muscles and their arrangement etc. Syllabus of the USZO604 deals with the various environmental issues and their management. Guest lectures could be arranged of the experts from such fields who can provide additional insights to these aspects. Informative documentaries based on wildlife conservation as well as human-animal conflict could make the topics relevant and interesting. Apart from formal teaching group discussion and experience sharing could be practiced for bioprospecting and zoopharmacognosy. Case studies could be supplemented with to understand the patterns of distribution of different animal species throughout the globe.

The learners' space provided in the syllabus is an effort to shift the pedagogy from being teacher-centric to learner-centric. It will be supportive to enthusiastic learners in gaining extra knowledge through various suggested activities to make their concepts impeccable and gain additional subject knowledge. Research project (USZOR01 and USZOR02), which is optional having additional credits could be mentored by the teachers encouraging more and more students to opt with a view to inculcate research culture.

- Co-Convenors

Syllabus for T. Y. B. Sc. Course: ZOOLOGY
Credit Based Semester and Grading System
- with a Choice for Additional Credits
(To be implemented from the Academic Year 2018-2019)

SEMESTER - V					
THEORY					
COURSE NO.	**COURSE CODE**	**UNIT**	**TOPICS**	**CREDITS**	**LECTURES/ WEEK**
11	USZO501	I	Principles of Taxonomy	2.5	1
		II	Kingdom: Animalia I		1
		III	Kingdom: Animalia II		1
		IV	Type study: *Sepia*		1
12	USZO502	I	Basic Haematology	2.5	1
		II	Applied Haematology		1
		III	Basic Immunology		1
		IV	Applied Immunology		1
13	USZO503	I	Mammalian Histology	2.5	1
		II	Toxicology		1
		III	General Pathology		1
		IV	Biostatistics		1
14	USZO504	I	Integumentary system and derivatives	2.5	1
		II	Human Osteology		1
		III	Muscles of long bones of Human limbs		1
		IV	Developmental biology of Chick		1
				10	**16**
PRACTICAL					
USZOP05	Practicals based on all four courses			**06**	**16**
Total Number of Credits and Workload				**16**	**32**
Research Project					
USZOR01	Additional Credits (Choice Based / Optional)			**1**	**No Workload for Teachers**

Syllabus for T. Y. B. Sc. Course: ZOOLOGY
Credit Based Semester and Grading System
- with a Choice for Additional Credits
(To be implemented from the Academic Year 2018-2019)

SEMESTER - VI					
THEORY					
COURSE NO.	**COURSE CODE**	**UNIT**	**TOPICS**	**CREDITS**	**LECTURES/ WEEK**
15	USZO601	I	Phylum Chordata: Group Protochordata and Group Euchordata I	2.5	1
		II	Group Euchordata II		1
		III	Group Euchordata III		1
		IV	Type study: Shark		1
16	USZO602	I	Enzymology	2.5	1
		II	Homeostasis		1
		III	Endocrinology		1
		IV	Animal Tissue Culture		1
17	USZO603	I	Molecular Biology	2.5	1
		II	Genetic Engineering		1
		III	Human Genetics		1
		IV	Bioinformatics		1
18	USZO604	I	Environment management	2.5	1
		II	Wildlife management		1
		III	Bioprospecting and Zoopharmacognosy		1
		IV	Zoogeography		1
				10	**16**
PRACTICAL					
USZOP06	Practicals based on all four courses			**06**	**16**
Total Number of Credits and Workload				**16**	**32**
Research Project					
USZOR02	Additional Credits (Choice Based / Optional)			**1**	**No Workload for Teachers**

T. Y. B. Sc. Zoology: Semester V (Theory)
Course Code: USZO501:
Taxonomy - Invertebrates and Type Study
Course 11

Unit I: Principles of Taxonomy (15L)

Objective:

- *To introduce the principles of taxonomy and modern system of classification in animal kingdom with evolution point of view.*

Desired outcome:

- *Learners will apprehend the basis of classification and modern classification up to class of the lower invertebrate animals.*

1.1: Levels of Organization:

1.1.1: Unicellularity, colonization of cells, multicellularity

1.1.2: Levels of Organization: Acellular, Cellular, Tissue level, Organ level and 'Organ-system' level

1.2: Symmetry

1.2.1: Basic concept and definition

1.2.2: Types:

a. Asymmetry: e.g. *Amoeba*
b. Radial symmetry: e.g. Starfish
c. Bi-lateral symmetry: e.g. Invertebrate - Planaria
Vertebrate - Man

1.2.3: Evolutionary significance of symmetry

1.3: Coelom

1.3.1: Basic concept and definition

1.3.2: Formation of coelom

1.3.3: Types:

a. Acoelomate: Platyhelminthes e.g. Liverfluke
b. Pseudocoelomate: Nematoda e.g. Roundworm
c. Coelomate: e.g. Frog

1.3.4: Evolutionary significance of coelom

1.4: Metamerism

1.4.1: Basic concept and definition

1.4.2: Types:

a. Pseudometamerism: e.g. Tapeworm

b. True metamerism:
   i. Homonomous - Annelida e.g. *Nereis*
   ii. Heteronomous - Cephalization - Insecta e.g. Dragonfly
   Cephalothorax - Crustacean e.g. Lobster

1.4.3: Evolutionary significance of metamerism

1.5: Taxonomy

1.5.1: Basic concept, definition and objectives

1.5.2: Linnaean Hierarchy, Binomial Nomenclature

1.5.3: Six Kingdom classification:

General characters of each Kingdom with examples:

- Kingdom Archaebacteria
- Kingdom Eubacteria
- Kingdom Protista
- Kingdom Fungi
- Kingdom Plantae
- Kingdom Animalia

1.6: Kingdom Protista: Animal like Protists: Protozoa

1.6.1: General characters of Protozoa

1.6.2: Classification of Protozoa with distinguishing features and suitable examples:

- Phylum Sarcomastigophora
  - Class Sarcodina e.g. *Amoeba*
  - Class Mastigophora e.g. *Trypanosoma*
- Phylum Ciliophora
  - Class Ciliata e.g. *Opalina*
  - Class Phyllopharyngea e.g. *Dysteria*
- Phylum Sporozoa
  - Class Aconoidasida e.g. *Plasmodium*
  - Class Conoidasida e.g. *Toxoplasma*

Unit II: Kingdom Animalia I **(15L)**

Objective:

- *To comprehend the general characters and classification of Kingdom Animalia from Porifera to Nematoda and specific characters of organisms belonging to these phyla.*

Desired outcome:

- *The learners will be familiarized with classification up to phylum Nematoda along with their examples.*

2.1: Phylum Porifera

a. General characters
b. Classification up to class with distinguishing features and suitable examples:
   - Class Calcarea e.g. *Leucosolenia (Branched sponge)*

- Class Hexactinellida e.g. *Hyalonema* (Glass-rope sponge)
- Class Demospongia e.g. *Euspongia* (Bath sponge)

2.2: Phylum Cnidaria

a. General characters
b. Classification up to class with distinguishing features and examples
   - Class Hydrozoa e.g. *Hydra*
   - Class Scyphozoa e.g. *Aurelia* (Jelly fish)
   - Class Anthozoa e.g. *Meandrina* (Maze Coral)

2.3: Phylum Platyhelminthes

a. General characters
b. Classification up to class with distinguishing features and examples
   - Class Turbellaria e.g. *Dugesia* (Planaria)
   - Class Trematoda e.g. *Schistosoma* (Blood-fluke)
   - Class Cestoda e.g. *Taenia* (Tapeworm)
c. Morphology, life cycle and pathogenicity of *Fasciola hepatica*

2.4: Phylum Nematoda

a. General characters
b. Classification up to class with distinguishing features and examples
   - Class: Aphasmida (Adenophorea) e.g. *Trichinella* (Trichina worm)
   - Class: Phasmida (Secernentea) e.g. *Ascaris* (Roundworm)

Unit III: Kingdom Animalia II **(15L)**

Objective:

- *To introduce basic concepts of classification up to class in animal kingdom from phylum Annelida to Hemichordata and to familiarize with their characters.*

Desired outcome:

- *Learners will get an idea of higher groups of invertebrate animal life, their classification and their peculiar aspects.*

3.1: Phylum Annelida

3.1.1: General characters

3.1.2: Classification up to class with distinguishing features and examples
   - Class Polychaeta e.g. *Neries* (Clamworm)
   - Class Oligochaeta e.g. *Pheretima* (Earthworm)
   - Class Hirudinea e.g. *Hirudinaria* (Leech)

3.2: Phylum Arthropoda

3.2.1: General characters
3.2.2: Classification up to class with distinguishing features and examples
   - Subphylum Chelicerata
     - Class Arachnida e.g. *Hottentotta* (Scorpion)
     - Class Merostomata e.g. *Limulus* (Horse-shoe crab)
     - Class Pycnogonida e.g. *Nymphon* (Sea spider)

- Subphylum Crustacea
  - Class Malacostraca e.g. *Scylla* (Crab)
  - Class Maxillipoda e.g. *Balanus* (Barnacle)
- Subphylum Uniramia
  - Class Chilopoda e.g. *Scolopendra* (Centipede)
  - Class Diplopoda e.g. *Xenobolus* (Millipede) ·

  Class Insecta e.g. *Attacus* (Moth)

3.3: Phylum Mollusca

3.3.1: General characters of the Phylum

3.3.2: Classification up to class with distinguishing features and examples

- Class Aplacophora e.g. *Chaetoderma* (Glisten worm solenogaster)
- Class Polyplycophora e.g. *Chiton* (Coat-of-mail shell)
- Class Monoplacophora e.g. *Neopilina*
- Class Gastropoda e.g. *Nerita* (Nerit)
- Class Pelecypoda e.g. *Solen* (Razor clam)
- Class Scaphopoda e.g. *Dentalium* (Tusk shell)
- Class Cephalopoda e.g. *Nautilus* (Pearly nautilus)

3.4: Phylum Echinodermata

3.4.1 General characters

3.4.2 Classification up to class with distinguishing features and examples

- Class Asteroidea e.g. *Protoreaster* (Starfish)
- Class Ophiuroidea e.g. *Ophiothrix* (Brittle star)
- Class Echinoidea e.g. *Clypeaster* (Sand dollar)
- Class Holothuroidea e.g. *Cucumaria* (Sea cucumber)
- Class Crinoidea e.g. *Antedon* (Sea lily)

3.5 Minor phyla

3.5.1: General characters along with examples of

- Phylum Acanthocephala e.g. *Moniliformis*
- Phylum Onychophora e.g. *Peripatus* (Velvet worm)
- Phylum Chaetognatha e.g. *Sagitta* (Arrow worm)

3.5.2: *Peripatus*, a connecting link - Affinities with Phylum Annelida, Arthropoda and Mollusca.

3.6 Phylum Hemichordata

3.6.1: General characters, classification with distinguishing features and examples

- Class Enteropneusta e.g. *Balanoglossus* (Acorn worm)
- Class Pterobranchia e.g. *Rhabdopleura*
- Class Planctosphaeroidea e.g. *Planctosphera*

3.7 Basic concepts of phylogeny: Phylogenetic tree of invertebrates

Unit IV: Type study: *Sepia* **(15L)**

Objective

- *To acquaint learners with the details of Sepia as a representative of invertebrate animals.*

***Desired* outcome**

- *Learners will get an idea of general characteristics and details of invertebrate animal systems.*

4.1: General characters and classification, Habit and habitat, External characters, mantle cavity, locomotion, economic importance

4.2: Digestive system, Respiratory system, Circulatory system, Excretory system, Nervous system and Sense organs, Reproductive system

Course Code: USZO502:
Haematology and Immunology
Course 12

Unit I: Basic Haematology (15L)

Objectives:

- *To introduce to the learner the composition of blood, haemorrhage and haematopoiesis.*
- *To acquaint the learner with the physiology of blood clotting and clinical aspects of haematology.*

Desired outcome:

- *The learner shall comprehend basic haematology.*
- *The learner will be able to identify various components of haemostatic systems.*

1.1: Composition of plasma: Water, respiratory gases, dissolved salts, plasma proteins, nutrients, enzymes, hormones, nitrogenous waste products

1.2: Haematopoiesis: Erythropoiesis, leucopoiesis and thrombopoiesis

1.3: Erythrocytes: Structure and functions, abnormalities in structure, total count, variation in number; ESR; types of anaemia

1.4: Haemoglobin: Structure, formation and degradation; variants of haemoglobin (foetal, adult), abnormalities in haemoglobin (sickle cell and thalassemia)

1.5: Leucocytes: Types and functions, total count and variation in number; leukaemia and its types

1.6: Thrombocytes: Structure, factors and mechanism of clotting, failure of clotting mechanism

1.7: Blood volume: Total quantity and regulation; haemorrhage

Unit II: Applied Haematology (15L)

Objective:

- *To introduce to the learner the basics of applied haematology and to impart knowledge of diagnostic techniques used in pathology.*

Desired outcome:

- *The learner will be familiar with the terminology used and diagnostic tests performed in a pathological laboratory.*
- *The learner shall be acquainted with diagnostic approaches in haematological disorders.*
- *The learner will be better equipped for further pathological course or working in a diagnostic laboratory.*

2.1: Introduction and scope of Applied Haematology: Clinical, microbiological, oncological and forensic haematology

2.2: Clinical significance of Diagnostic Techniques

2.2.1: Microscopic examination of blood:

- Blood cancer (lymphoma, myeloma),
- Infectious diseases (malaria, leishmaniasis),
- Haemoglobinopathies (sickle cell anaemia, thalassemia)

2.2.2**:** Coagulopathies: Haemophilia and purpura

2.2.3**:** Biochemical examination of blood:

- Liver function tests: AST, ALT, LDH, Alkaline phosphatase , Total and direct bilirubin
- Kidney function test**:** Serum creatinine, Blood Urea Nitrogen (BUN)
- Carbohydrate metabolism tests: Blood sugar, Glucose tolerance test, Glycosylated haemoglobin test
- Other biochemical tests: Blood hormones - TSH, FSH, LH.

Unit III: Basic Immunology (15L)

Objective:

- *To introduce the topic of immunology by emphasizing the basic concepts to build a strong foundation and to give an overview of the immune system that plays an important role in disease resistance.*

Desired outcome:

- *The learner shall comprehend the types of immunity and the components of immune system.*
- *The learner will realize the significant role of immune system in giving resistance against diseases.*

3.1: Overview of Immunology

3.1.1: Concept of immunity

3.1.2: Innate immunity - Definition, factors affecting innate immunity, Mechanisms of innate immunity - First line of defence - physical and chemical barriers; Second line of defence - phagocytosis, inflammatory responses and fever

3.1.3: Adaptive or Acquired immunity, Antibody mediated and cell mediated immunity; Active Acquired immunity - Natural and Artificial; Passive Acquired immunity - Natural and Artificial

3.2: Cells and Organs of immune system

3.2.1: Cells of immune system - B cells, T cells and null cells, macrophages, dendritic cells and mast cells

3.2.2: Organs of immune system

- Primary: Thymus and bone marrow
- Secondary: Lymph nodes and spleen

3.3: Antigens: Definition and properties; haptens

3.4: Antibodies: Definition, basic structure, classes of antibodies - IgG, IgA, IgM, IgD and IgE

3.5: Antigen processing and presentation

3.5.1: Endogenous antigens - cytosolic pathways

3.5.2: Exogenous antigens - endocytic pathways

Unit IV: Applied Immunology (15L)

Objectives:

- *To introduce immunopathology to the learner*
- *To introduce the concept of vaccines and vaccination.*
- *To familiarise the learner to immunological perspectives of organ transplantation.*

Desired outcome:

- *The learner shall understand immunopathology and the principles and applications of vaccines.*
- *The learner will develop basic understanding of immunology of organ transplantation.*

4.1: Antigen-Antibody interaction

4.1.1**:** General features of antigen-antibody interaction

4.1.2**:** Precipitation reaction - Definition, characteristics and mechanism.

- Precipitation in gels (slide test)
- Radial immunodiffusion (Mancini method)
- Double immunodiffusion (Ouchterlony method)

4.1.3**:** Immunoelectrophoresis - Counter-current and Laurel's Rocket electrophoresis

4.1.4**:** Agglutination reaction definition, characteristics and mechanism.

- Haemagglutination (slide and micro-tray agglutination)
- Passive agglutination
- Coomb's test

4.1.5**:** Immunoassay - ELISA

4.2: Vaccines and Vaccination

4.2.1**:** Principles of vaccines - active and passive immunization, Routes of vaccine administration

4.2.2**:** Classification of vaccines:

- Live attenuated
- Whole-Killed or inactivated
- Sub-unit vaccines: Toxoids, Protein vaccines, Viral-like particles, DNA vaccines

4.2.3**:** Adjuvants used for human vaccines:

- Virosomes and Liposomes
- Saponins

- Water-in-oil emulsions

4.2.4**:** Vaccines against human pathogens:

- Polio
- Hepatitis A and B
- Tuberculosis (BCG)

4.3: Transplantation Immunology: Introduction to transplantation; Types of grafts; Immunologic basis of graft rejection: MHC compatibility in organ transplantation, Lymphocyte and Antibody mediated graft rejection; Precautionary measures against graft rejection

Course Code: USZO503:
Histology, Toxicology, Pathology and Biostatistics
Course 13

Unit I: Mammalian Histology (15L)

Objectives:

- *To familiarize the learner with the cellular architecture of the various organs in the body.*
- *To make the learner understand the need and importance of different types of tissues in the vital organs and their functions.*

Desired outcome:

- *Learner would appreciate the well planned organization of tissues and cells in the organ systems.*

1.1: Vertical section (V.S.) of skin: Layers and cells of epidermis; papillary and reticular layers of dermis; sweat glands, sebaceous glands and skin receptors

1.2: Digestive System

1.2.1: Vertical section (V.S.) of tooth; hard tissue - dentine and enamel; soft tissue - dentinal pulp and periodontal ligaments

1.2.2: Transverse section (T.S.) of tongue - mucosal papillae and taste buds

1.2.3: Alimentary canal - Transverse section (T.S.) of stomach, small intestine, large intestine of mammal.

1.2.4: Glands associated with digestive system - Transverse section (T.S.) of salivary glands, liver.

Unit II: Toxicology (15 L)

Objectives:

- *To introduce the learner to the principles of toxicology with particular emphasis on toxic responses to chemical exposures, nature and effect of toxicity and toxicity testing.*
- *It also intends to develop amongst students an introductory understanding of regulatory affairs in toxicology.*

Desired outcome:

- *The course will prepare learner to develop broad understanding of the different areas of toxicology.*
- *It will also develop critical thinking and assist students in preparation for employment in pharmaceutical industry and related areas.*

2.1: Basic toxicology

2.1.1: Introduction to toxicology - brief history, different areas of toxicology, principles and scope of toxicology

2.1.2: Toxins and Toxicants - Phytotoxins (caffeine, nicotine), Mycotoxins (aflatoxins),

Zootoxins (cnidarian toxin, bee venom, scorpion venom, snake venom)

2.1.3: Characteristics of Exposure - Duration of exposure, Frequency of exposure, Site of exposure and Routes of exposure

2.1.4: Types of Toxicity - Acute toxicity, Sub-acute toxicity, Sub-chronic toxicity and Chronic toxicity

2.1.5: Concept of LD_{50}, $^{LC}_{50}$, $^{ED}_{50}$

2.1.6: Dose Response relationship - Individual / Graded dose response, Quantal dose response, shape of dose response curves, Therapeutic index, Margin of safety

2.1.7: Dose translation from animals to human - Concept of extrapolation of dose, NOAEL (No Observed Adverse Effect Level), Safety factor, ADI (Acceptable Daily Intake)

2.1.8: Target organ toxicity:
Hepatotoxicity: susceptibility of the liver, types of liver injury, examples of hepatotoxicants;
Neurotoxicity: vulnerability of nervous system, examples of neurotoxicants;
Nephrotoxicity: susceptibility of kidney, examples of nephrotoxicants

2.2: Regulatory toxicology

2.2.1: OECD guidelines for testing of chemicals (an overview)

2.2.2: CPCSEA guidelines for animal testing centre, ethical issues in animal studies

2.2.3: Animal models used in regulatory toxicology studies

2.2.4: Alternative methods in toxicology (*in vitro* tests)

Unit III: General Pathology (15L)

Objectives:

- *To introduce the learner to basics of general pathology.*
- *To impart knowledge of retrogressive, necrotic, pathological conditions in the body.*
- *To explain repair mechanism of the body.*

Desired outcome:

- *Learner will be familiar with various medical terminology pertaining to pathological condition of the body caused due to diseases.*

3.1: General Pathology: Introduction and scope

3.2: Cell injury: Mechanisms of cell injury: ischemic, hypoxic, free radical mediated and chemical

3.3: Retrogressive changes: Definition, cloudy swelling, degeneration: fatty, mucoid and amyloid (causes and effects)

3.4: Disorders of pigmentation: Endogenous: Brief ideas about normal process of pigmentation, melanosis, jaundice (causes and effects)

3.5: Necrosis: Definition and causes; nuclear and cytoplasmic changes; types: coagulative, liquefactive, caseous, fat and fibroid

3.6: Gangrene: Definition and types - dry, moist and gas gangrene

Unit IV: Biostatistics (15L)

Objective:

- *To make learner familiar with biostatistics as an important tool of analysis and its applications.*

Desired outcome:

- *The learner will be able to collect, organize and analyse data using parametric and non-parametric tests.*
- *They will also be able to set up a hypothesis and verify the same using limits of significance.*

4.1: Probability Distributions: Normal, Binomial, Poisson distribution, Z-transformation, p-value, Probability - Addition and multiplication rules and their applications

4.2: Measures of Variation: Variance, standard deviation, standard error

4.3: Testing of Hypothesis: Basic concepts, types of hypothesis: Null hypothesis and Alternate hypothesis, Levels of significance and testing of hypothesis

4.4: Parametric and non-parametric test: Parametric tests: two-tailed Z-test and t-test Non-parametric test: Chi-square test and its applications

4.5: Correlation: Correlation coefficient and its significance

Course Code: USZO504:
Anatomy and Developmental Biology
Course 14

Unit I: Integumentary system and derivatives (15L)

Objective:

- *To introduce the learner to understand different integumentary structures and derivatives in the vertebrates and to acquaint learners with special derivatives of integument.*

Desired outcome:

- *Learner will be able to understand the importance of various types of epidermal and dermal derivatives along with their functions.*

1.1: Basic structure of integument: Epidermis and dermis

1.2: Epidermal derivatives of Vertebrates

1.2.1: Hair, hoof, horn, claw, teeth, beak and epidermal scales (small scales, large scales, modified scales - spine)

1.2.2: Glands - types (mucous, serous, ceruminous, poison, uropygial and salt gland) and functions

1.2.3: Type of feathers

1.3: Dermal derivatives of Vertebrates: Scales in fish; scutes in reptiles and birds; dermal scales in mammals - Armadillo, Antler - Caribou

1.4: Special derivatives of integument: Wart in toad, rattle in snake, whale bone in baleen whale, kneepads in camel.

Unit II: Human Osteology (15L)

Objective:

- *To introduce the learner to different bones of human skeleton and their functional importance.*

Desired outcome:

- *Learner will be able to understand the structure, types and functions of human skeleton.*

2.1: Introduction: Bone structure (Histology), physical properties, chemical composition and general functions of bones.
Cartilage: General structure, functions

2.2: Axial skeleton

2.2.1: Skull: General characteristics of skull bones - Cranial and facial bones

2.2.2: Vertebral column: General characteristics of a vertebra, structure of different types of vertebrae (cervical, thoracic, lumbar, sacrum and coccyx)

2.2.3: Ribs and sternum: General skeleton of ribs and sternum

2.2.4: Hyoid bone: Structure and function.

2.3: Appendicular skeleton
2.3.1: Pectoral girdle and bones of forelimbs

2.3.2: Pelvic girdle and bones of hind limbs

Unit III: Muscles of long bones of Human limbs (15L)

Objectives:
- *To study long limb muscles involved in body movements.*
- *To identify various arrangements of the long limb muscles and to relate the arrangement with contraction and motion.*
- *To study muscle injuries and syndromes.*

Desired outcome:
- *Learner will be able to understand the types of long limb muscles, its arrangement and their role in body movements.*

3.1: Introduction and types of long limb muscles
3.1.1: Flexors, Extensor, Rotator, Abductors, Adductors

3.2: Muscles of forelimbs
3.2.1: Muscles that move the arm (Humerus) - *Triceps brachii, Biceps brachii, brachialis* and *brachioradialis*

3.2.2: Muscles that move the forearm (Radius-ulna) - *Flexor carpi radialis, Flexor carpi ulnaris* and *Extensor carpi ulnaris*

3.2.3: Muscles that move the wrist, hand and fingers - *Flexor digitorium superficialis, Extensor carpi radialis* and *Extensor digitorum*

3.3: Muscles of hindlimbs
3.3.1: Muscles that move the thigh (Femur) - Sartorius, Adductor group, Quadriceps group (*Rectus femoris, Vastus lateralis, Vastus medialis*), Hamstring group (*Biceps femoris, Semimembranosus, Semitendinosus*)

3.3.2: Muscles that move the lower leg (tibia-fibula) - *Fibularis longus, Gastrocnemius, Tibialis anterior, Soleus, Extensor digitorum longus* and *Fibularis tertius*

3.3.3: Muscles that move the ankle, foot and toes - *Tibialis anterior, Extensor digitorum, Longus* and *Fibularis* muscles

Unit IV: Developmental biology of Chick (15L)

Objective:

- *To introduce the learner to the basics of developmental biology with reference to chick as a model and also familiarize with experiments related to it.*

Desired outcome:

- *Learner will be able to understand the processes involved in embryonic development and practical applications of studying the chick embryology.*

4.1: Introduction to Developmental Biology: Basic concept and principles of developmental biology - morphogenesis, organogenesis, fate maps, cell adhesion, cell affinity and cell differentiation.

4.2: Development of Chick embryo

4.2.1: Structure of Hen's egg, physico-chemical nature and forms of yolk - granular, platelets and spheres; fertilization, cleavage, blastulation, gastrulation

4.2.2: Structure of chick embryo - 18hours, 24 hours, 33 hours, 48 hours and 72 hours

4.2.3: Extra embryonic membranes

4.2.4: Organizer: Introduction, Spemann Mangold experiment, Hensen's node as an organizer

Practical Syllabus for Semester V
Course code: USZOP05; Course 11

1. Classification of phyla up to class and study of the general characters up to class.
   Kingdom Protista - Animal-like Protists: Protozoa

   A. Phylum: Sarcomastigophora
      - Class Sarcodina e.g. *Amoeba*
      - Class Mastigophora e.g. *Euglena*

   B. Phylum: Ciliophora
      - Class Ciliata e.g. *Paramoecium*
      - Class Phyllopharyngea e.g. *Dysteria*

   C. Phylum: Sporozoa,
      - Class Aconoidasida e.g. *Eimeria*
      - Class Conoidasida e.g. *Sarcocystis*

   Kingdom Animalia

   D. Phylum: Porifera
      - Class Calcarea e.g. *Scypha* (Little vase sponge)
      - Class Hexactinellida e.g. *Hyalonemma* (Glass-rope sponge)
      - Class Demospongia e.g. *Spongilla* (Freshwater sponge)

   E. Phylum Cnidaria
      - Class Hydrozoa e.g. *Vellela* (By-the-wind sailor)
      - Class Scyphozoa e.g. *Rhizostoma* (Barrel jellyfish)
      - Class Anthozoa e.g. *Corallium* (Coral)

   F. Phylum Platyhelminthes
      - Class Turbellaria e.g. *Dugesia* (Planaria)
      - Class Trematoda e.g. *Fasciola* (Liverfluke)
      - Class Cestoda e.g. *Taenia* (Tapeworm)

   G. Phylum Nematoda
      - Class Aphasmida (Adenophorea) e.g. *Trichinella* (Trichina worm)
      - Class Phasmida (Secernentea) e.g. *Ascaris* (Roundworm)

   H. Phylum Annelida
      - Class Polychaeta e.g. *Arenicola* (Lugworm)
      - Class Oligochaeta e.g. *Tubifex* (Sludge worm)
      - Class Hirudinea e.g. *Pontobdella* (Marine leech)

   I. Phylum Arthropoda
   Subphylum Chelicerata
      - Class Arachnida e.g. *Hotentotta* (Scorpion)
      - Class Merostomata e.g. *Limulus* (Horseshoe crab)
      - Class Pycnogonida e.g. *Nymphon* (Sea spider)

Subphylum Crustacea

- Class Malacostraca e.g. *Panulirus* (Lobster)
- Class Maxillipoda e.g. Cyclops (Copepods)

Subphylum Uniramia

- Class Chilopoda e.g. *Scolopendra* (Centipedes)
- Class Diplopoda e.g. *Xenobolus* (Millipedes)

Class Insecta e.g. *Attacus* (Moth)

J. Phylum Mollusca

- Class Aplacophora e.g. *Chaetoderma* (Glisten worm solenogaster)
- Class Polyplacophora e.g. *Tonicella* (Lined Chiton)
- Class Monoplacophora e.g. *Neopilina*
- Class Gastropoda e.g. *Turbo* (Turban shell)
- Class Pelycypoda e.g. *Donax* (Wedge shell)
- Class Scaphopoda e.g. *Dentalium* (Tusk shell)
- Class Cephalopoda e.g. *Octopus*

K. Phylum Echinodermata

- Class Asteroidea e.g. *Asterias* (Starfish)
- Class Ophiuroidea e.g. *Ophiothrix* (Brittle star)
- Class Echinoidea e.g. *Echinus* (Sea urchin)
- Class Holothuroidea e.g. *Cucumaria* (Sea cucumber)
- Class Crinoidea e.g. *Crinoid* (Sea lily)

L. Phylum Hemichordata

- Class Enteropneusta e.g. *Saccoglossus*
- Class Pterobranchia e.g. *Rhabdopleura*
- Class Planctosphaeroidea e.g. *Planctosphaera*

2. Minor Phyla

Acoelomate

M. Phylum Acanthocephala e.g. *Echinorhynchus*

Coelomate

N. Phylum Chaetognatha e.g. *Sagitta*

O. Phylum Onychophora e.g. *Peripatus* (Velvet worm)

3. Study of *Sepia* with the help of diagram / Photograph / Simulation whichever possible. No animal shall be dissected.
   a) Digestive system,
   b) Reproductive system
   c) Nervous system
   d) Jaws
   e) Radula
   f) Chromatophores
   g) Spermatophores
   h) Statocyst

4. Study tour - Visit to fish market / Aquarium / Local Gardens / Local available niche / National Parks / Sanctuaries / and such other places to observe invertebrates with special emphasis on Western Ghats and coast of Maharashtra and submit a report. College may conduct more than one field visit for wide exposure, if feasible. However, at least one field visit should be such that it is affordable to every student.

Course code: USZOP05; Course 12

1. Enumeration of Erythrocytes - Total Count.
2. Enumeration of Leucocytes - Total Count.
3. Differential count of Leucocytes.
4. Erythrocyte Sedimentation Rate by suitable method - Westergren or Wintrobe method.
5. Estimation of haemoglobin by Sahli's acid haematin method.
6. Determination of serum LDH by using colorimeter / spectrophotometer.
7. Estimation of total serum/ plasma proteins by Folin's method.
8. Estimation of serum/ plasma total triglycerides by Phosphovanillin method.
9. Latex agglutination test - Rheumatoid Arthritis.
10. Determination of bleeding and clotting time.

Course code: USZOP05; Course 13

1. Study of mammalian tissues: V.S. of Tooth, T.S. of Stomach, T.S. of small intestine**,** T.S. of Liver.
2. Microtomy: Tissue preservation and fixation, dehydration, infiltration, paraffin embedding and block preparation, sectioning, staining.
3. Identification of diseases or conditions (from slides or pictures): Vitiligo, Psoriasis, Bed sores, Necrosis, Oedema
4. To study the effect of CCl_4 on the level of enzyme activity in liver on aspartate and alanine amino transferase, alkaline phosphatase (*in vitro* approach).
5. Study and interpretation of abnormal pathological reports: Blood (CBC), Urine (Routine) and Stool (Routine).
6. Following biostatistics practicals will be done using data analysis tool of Microsoft Excel (DEMONSTRATION in regular practicals) and manually:
   a. Problems based on Z-test
   b. Problems based on t-test
   c. Problems based on Chi-square test
   d. Correlation, regression analysis - demonstration only.
   e. Problems based on ANOVA - demonstration only.

(Learner is expected to identify appropriate test for the given problem)

Course code: USZOP05; Course 14

1. Study of integumentary systems - V. S. of Skin of Shark, Frog, *Calotes*, Pigeon and Human
2. Study of Human Axial Skeleton - Skull (whole) and Vertebral column (axis, atlas, typical cervical, typical thoracic, typical lumbar, sacrum, coccyx)
3. Study of Human Appendicular Skeleton - Pectoral and pelvic girdle with limb bones
4. Study of muscles of forelimbs - *Biceps brachii, Brachialis, Brachio radialis, Triceps brachii, Flexor carpi radialis, Flexor carpi ulnaris* and *Extensor carpi ulnaris*
5. Study of muscles of hind limbs - Sartorius, Adductor group, Quadriceps group *Rectus femoris, Vastus lateralis, Vastus medialis, Hamstring* group (*Biceps femoris, Semimembranosus, Semitendinosus*), *Fibularis longus, Gastrocnemius Tibialis anterior, Soleus, Extensor digitorum longus, Fibularis tertius*
6. Study of ontogeny of chick embryo using permanent slides - 18 hours, 24 hours, 33 hours, 48 hours and 72 hours.
7. Preparation of temporary mounting of chick embryo up to 48 hours of incubation.

References and Additional Reading for Semester V

Course 11:

REFERENCES

- A manual of Zoology - Part I, Invertebrata; Ayyar, M. Ekambaranath
- Invertebrate Zoology - Volumes of different Phyla; Hyman L.H.
- Instant Notes in Animal Biology by Richard D. Jurd.
- Introduction to Zoology - Vol I: K. K. Chaki, G. Kundu and S. Sarkar, New Crystal Book Agency.
- Modern text book of Zoology - Invertebrates; Eleventh; Edition Professor R.L. Kotpal; Rastogi publication
- Invertebrate Zoology by E. L. Jordan & P. S. Verma Rev. edition,2009, Chand publications
- Invertebrate Zoology by P. S. Verma, edition, 2009, Chand publications
- Zoology for degree students, Non chordates by V.K. Agarwal 2011, S. Chand Publication
- Zoology for Degree Students, B.Sc. First Year, by V. K. Agarwal, Pub. S. Chand Coy.
- B. Sc. Zoology, Invertebrate Zoology by V.K. Aggarwal2017, S. Chand publications
- Invertebrate Zoology by Fatik Baran 2012, PHI Learning
- A Textbook of Invertebrates by N.C. Nair et al. 2010 Saras publications
- Practical Zoology: Invertebrate, by S. S. Lal, 2016
- Invertebrate Zoology by Ruppert, Fox, Barnes, 7thedition,2003 publications Cengage Learning
- Invertebrate Zoology by D.T. Anderson 2nd edition 2002, publications Oxford
- Invertebrates by Richard C. Brusca et. al, 3rdedition2016, publications Oxford
- Biology of the invertebrates by Jan A. Pechenik, 7th edition,2014 publications McGraw Hill
- An introduction to the invertebrates by Janet Moore, 2ndedition2006, publications Cambridge
- Protozoology, by S. V. Nikam & S. T. Tanveer ed. 2011, Pub. Oxford Book Company(N.B.: This book includes Phylum Sarcomastigophora)

ADDITIONAL READING

- https://www.earthlife.net/inverts/an-phyla.html
- http://www.biologydiscussion.com/invertebrate-zoology/invertebrates-phyla/study-notes-on-invertebrates-phyla/28077
- http://www.asfa.k12.al.us/ourpages/auto/2014/4/23/64232119/invertebrate-animal-phyla-notes.pdf
- http://www.biology-pages.info/I/Invertebrates.html
- https://portals.iucn.org/library/sites/library/files/documents/2012-064.pdf
- http://instruction2.mtsac.edu/mcooper/Biology%202/Labs/Protistalab1.pdf
- http://www.faculty.ucr.edu/~legneref/invertebrate/inverteb.htm
- http://www.cbv.ns.ca/mchs/diversity/ProtozoansPage1.html
- http://bioweb.uwlax.edu/bio203/s2009/maiers_andr/Classification.htm
- https://www.earthlife.net/inverts/annelida.html
- https://manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/worms-phyla-platyhelmintes-nematoda-and-annelida
- http://www.fossilmuseum.net/Tree_of_Life/PhylumAnnelida.htm
- http://www.austincc.edu/sziser/Biol%201413/LectureNotes/lnexamIII/Phylum%20Annelida.pdf
- http://animaldiversity.org/accounts/Annelida/classification/

- http://faculty.college-prep.org/~bernie/sciproject/project/Kingdoms/Animal%20Kingdom%20-%205/Local%20copy/classification/arthropoda.html
- http://bio.rutgers.edu/~gb102/lab_2/309am-arthro.html
- http://www.auburn.edu/academic/classes/biol/1030/boyd/lect10-14outline.htm
- http://www.fossilmuseum.net/Tree_of_Life/PhylumArthropoda.htm
- http://www.geo.arizona.edu/geo3xx/geo308/FoldersOnServer/2003/3Mollusca.htm
- http://www.fossilmuseum.net/Tree_of_Life/PhylumMollusca.htm
- http://www.geo.arizona.edu/geo3xx/geo308/FoldersOnServer/2003/Lab7EchinoArthro.htm
- https://www.earthlife.net/inverts/echinodermata.htmla
- http://www.uky.edu/OtherOrgs/KPS/paleoclass/pages/wimbergechinodermata.htm
- http://www.fossilmuseum.net/Tree_of_Life/Phylum-Echinodermata.htm

Course 12
REFERENCES

- Human Physiology - Volume 1; C.C. Chatterjee.
- Essentials of Haematology; Shirish M. Kawthalkar; Jaypee Brothers.
- Williams Hematology; Kenneth Kaushansky, Marshall A. Lichtman, E. Beutler, Thomas J. Kipps, Josef Prchal, Uri Seligsohn.
- Essential Haematology; Victor Hoffbrand, Paul Moss, John Pettit.
- Rapid Review of Hematology; Ramadas Nayak; Jaypee Brothers.
- Precise Haematology; Usha Rusia, Meera Sikka, Renu Saxena; Wiley India.
- Short Textbook of Haematology; Shah B.S.; C.B.S. Publisher and Distributor.
- Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd., Kolkata; 1999.
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978.
- A Text book of Practical Physiology; First Edition; V.G. Ranade; A.V.G. Prakashan, Pune; 1968.
- Principles of Anatomy & Physiology; Thirteenth Edition; Gerard J. Tortora & Bryan Derrickson; Biological Science Textbooks, Inc.; 2012.
- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013.
- Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006.
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014.
- Harrison's Hematology and Oncology; 3rd Edition (Harrison's Specialty);Dan Longo; McGraw-Hill.
- Essentials of Haematology; Second Edition; Kawthalkar Shirish M.; Jaypee; 2013.
- Medical Biochemistry by C. Jaypee; 2012.
- Essentials in Hematology and Clinical Pathology; Nayak, Ramadas.
- Clinical Pathology and Hematology; Maheshwari, Nanda; Jaypee.
- Practical Hematology; Dacie J V; Churchill Livingstone; 2006.
- Lecture Notes: Haematology; Hatton, Chris S. R. Hughes-Jones, Nevin C. Hay, Deborah; Wiley-Blackwell.
- ABC series: ABC of Clinical Haematology; Provan; Drew Publisher: BMJBooks.
- Principles of Anatomy & Physiology; Thirteenth Edition; Gerard J. Tortora & Bryan Derrickson; Biological Science Textbooks, Inc.; 2012.
- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013.
- Immunology - Introductory Textbook; Shetty N.; New Age International; 2005.
- Immunology - Essential and Fundamental; Pathak S., & Palan U.; Science Publishers; 2005.
- Immunology: A textbook; Rao C. V.; Alpha Science Int'l Ltd.; 2005.
- Ananthanarayan and Paniker's textbook of Microbiology; C. J. Paniker (Ed.); Ananthanarayan R.; Orient Blackswan; 2005.
- Textbook of Immunology; Haleem Khan, Rajendra Sagar, Sadguna.
- Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014.
- Immunology; Third Edition; Janis Kuby; W.H. Freeman; 1997.
- Kuby Immunology; Sixth Edition; Thomas J. Kindt, Richard A. Goldsby, Barbara Osborne & Janis Kuby; W.H. Freeman; 2007.
- Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006.

- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014.
- Cellular and Molecular immunology; Abbas A. K., Lichtman A. H. &Pillai S.; Elsevier Health Sciences; 2014.
- Roitt's Essential Immunology - Vol. 20; Delves P. J., Martin S. J., Burton D. R., & Roitt I. M.; John Wiley & Sons; 2011.
- The Elements of Immunology; Khan F.H.; Pearson Education, India; 2009.
- Kuby Immunology; Sixth Edition; Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne & Janis Kuby; W.H. Freeman; 2007.
- Janeway's Immunobiology; Murphy K. & Weaver C.; Garland Science; 2016.
- Fundamental Immunology; Paul W. E.; Philadelphia: Lippincott-Raven; 1999.
- Immunology - Introductory Textbook; Shetty N.; New Age International; 2005.
- Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014.
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014.
- Lehninger's Principles of Biochemistry; David Lee Nelson, A. L. Lehninger, Michael M Cox; W.H. Freeman, New York; 2008.
- Biochemistry; 5th ed.; J M Berg, J L Tymoczko and Lubert Stryer; W.H. Freeman, New York; 2002.
- Biochemistry; 2nd edition; Donald Voet and Judith G Voet; J. Wiley and Sons, New York; 1995.

ADDITIONAL READING:

- Biology - A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015.
- Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005.
- Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007.
- Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw-Hill Education; 2012.
- Biology - Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005.
- The Emperor of All Maladies: A biography of Cancer; Siddhartha Mukherjee; Scribner, New York; 2010.
- Molecular Cell Biology; Fifth edition; Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, S. Lawrence Zipursky & James Darnell; W.H. Freeman & Company, New York; 2004.
- 'India facing shortage of life-saving albumin serum'; written by Abantika Ghosh, New Delhi; The Indian Express, October 16, 2014, 2:25 am.
- Articles on "Blood groups"; (1) The Indian Express, August 15, 2012/ Times of India, August 16, 2012; (2)Times of India, September 11, 2014.
- 'Nanoparticle vaccine shows potential as immunotherapy to fight multiple cancer types'; UT Southwestern Medical Center; Science Daily, April 24 2017; https://www.sciencedaily.com/.
- Textbook of Biochemistry with clinical correlations; Fourth Edition: Edited by Thomas M.Devlin; Wiley-Liss Publication.
- Biochemistry; Third Edition: Pamela C. Champe, Richard A. Harvey, Denise R. Ferrier; Indian Edition by JP Publication.

Course 13
REFERENCES

- A Textbook of Histology; Deshmukh Shivaji; Dominant Pub.
- Colour Textbook of Histology; Gartner, Leslie P.; Saunders.
- A Textbook of Histology; Mathur Ramesh; Anmol Pub.
- A Textbook of Histology and A Practical Guide; Gunasegaran J.P.; Elsevier
- A Textbook of Histology; Khanna D.R.; Sonali Pub.
- Practical Zoology; Second Edition; Dr. K.C. Ghose&Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999.
- Casarett and Doulls Toxicology - The basic science of poisons; Edited by Curtis Klaassen; McGraw-Hill; 2001.
- Toxicological testing handbook - Principles, applications and data interpretation; David Jacobson-Kram and Kit Keller; CRC Press; 2006.
- Principles and methods of toxicology; A. Wallace Hayes; CRC Press; 2007.
- Toxicology - principles and methods; M.A. Subramanian; MJP Publishers, Chennai; 2004.
- Fundamentals of Toxicology; Kamleshwar Pandey and JP Shukla; New Central book agency Ltd., Kolkata; 2011.
- Elements of Toxicology; Kamleshwar Pandey and JP Shukla; Wisdom Press, New Delhi; 2010.
- Principles and Applications of Toxicology; Lahir Y.K.; Seekay Publications; 2013.
- Essentials of Clinical Toxicology; Lall S.; Narosa Publishing House; 1998.
- A Textbook of Veterinary and General Pathology; Second edition; J. L. Vagad; IBDC Publishers.
- Clinical Pathology; Guru G.; NCERT; 1988.
- Clinical Pathology; Batra Neelam; Vikas Publishing House Pvt. Ltd.; Nov. 1982.
- Essentials of General Pathology; Dr. Sudha Shivraj, Dr. Satish Kumar Amarnath, Dr. Sheela Devi; Exclusively distributed by CBS Publishers & Distributors.
- Textbook of Pathology; Harsh Mohan; Jaypee Publishers.
- Biostatistics - The Bare Essentials; Third Edition; Geoffrey R. Norman, David L. Streiner; B.C. Decker, Inc., Hamilton; 2008.
- Fundamentals of Biostatistics; Second Edition; Veer Bala Rastogi; Ane Books Pvt. Ltd., New Delhi; 2009 (Reprint 2010).
- Fundamentals of Biostatistics; Second Revised Edition; Irfan Ali Khan and Atiya Khanum; Ukaaz Publications, Hyderabad; 2004.
- Instant Medical Biostatistics; Dr. Ranjan Das and Dr.Papri N. Das; Ane Books Pvt. Ltd., New Delhi; 2009.
- Primer of Biostatistics; Fifth Edition; Stanton A. Glantz; McGraw-Hill Companies, Inc.; 2002.
- Basic Biostatistics - Statistics for Public Health Practice; Second Edition; B. Burt Gerstman; Jones and Bartlett Learning Burlington; 2015.
- Biostatistics - A Guide to Design, Analysis, and Discovery; Second Edition; Ronald N. Forthofer, Eun Sul Lee and Mike Hernandez; Elsevier, Inc., (Academic Press), USA; 2007.
- Statistics in Biology and Psychology; Sixth Edition; Debajyoti Das and Arati Das; Academic Publishers, Kolkata.

ADDITIONAL READING:

- Biology - A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015.
- Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005.
- Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007
- Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw-Hill Education; 2012.
- Biology - Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005.
- Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014.
- Disease & Medicine in India - A Historical Overview; Deepak Kumar; Tulika Books, India; 2012.

Course 14

REFERENCES

- Comparative Anatomy of the Vertebrates; Ninth Edition; Kent, G.C. and Carr R.K.; The McGraw-Hill Companies; 2000.
- Text book of Chordates; Saras publication.
- Modern text book of Zoology; Prof. R.L. Kotpal.
- Integumentary system and its derivatives; Samuel D. Hodge.
- Atlas of Human Anatomy - Vol I; R.D. Sinelnikov; Mr. Publishers Moscow.
- A Guide of Osteology (for medical students); Prakash Kendra, Lucknow.
- Text Book of Comparative Anatomy and Physiology; Tortora.
- Human Osteology - Tim D White.
- Text Book of Human Osteology - Singh Inderbir.
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978.
- Human Anatomy - John W. Hole, Jr., Karen A. Koos, Publisher: W. C. Brown Publisher, USA.
- Principles of Anatomy and Physiology - Gerard T. Tortora and Sandra Reynolds Grabowski. Publisher: Harpers Collins College Publishers (7th Edition).
- Developmental biology - Gilbert.
- Development of Chick - Patten.
- Developmental Biology - Wolpert.
- Text book of Embryology - N. Arumugam.
- Chicken Development - Embryology; W.H. Freeman & B. Bracegirdle.
- Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999.

ADDITIONAL READING

- Comparative Anatomy of Vertebrates by Sumitra Saxena and R. K. Saxena. ·

Comparative Anatomy of Vertebrates by S. K. Kulshrestha.

- Vertebrates: Comparative Anatomy, Function, Evolution by Kenneth Kardong. ·

Comparative Anatomy of the Vertebrates by George C Kent and Robert K. Carr. ·

Comparative Anatomy of Vertebrates by Robert Wiedersheim.

- Illustrations of Comparative Anatomy, Vertebrate and Invertebrate - For The Use of Students In The Museum Of Zoology And Comparative Anatomy.
- Human Osteology, 3rd Edition by Tim D. White, Michael T. Black and Pieter A. Folkens.
- Hand Book of Osteology, 13th Edition by S. Poddar and Ajay Bhagat.
- The Anatomy and Biology of the Human Skeleton by D. Gentry Steele.
- Atlas of Chick Development - By Ruth Bellairs and Mark Osmond.
- Laboratory embryology of the chick by Lloyd Eugene Downs.
- Vertebrate Embryology: A Laboratory Manual - Richard M. Eakin.
- Molecular Embryology: Methods and Protocols by Paul T. Sharpe, Ivor.
- Dictionary of Developmental Biology and Embryology by Frank J. Dye.

LEARNERS' SPACE

Course 11

1. Learners can visit different websites to get information about the invertebrates discovered recently in Maharashtra as well as in the world.
2. Learners can play games to identify kingdom, phylum or class based on the characters of animals.
3. Investigate the process of formation of first life/cell on earth
4. List the names of places in India where corals are found.
5. Study the corals as an indicator of healthy ecosystem.
6. Enlist medicinal uses of leech.
7. State the differences between *Loligo* and *Sepia*.
8. Collect information on differences between minor phyla and major phyla.
9. Study the economic importance of molluscs.
10. Collect the information on torsion-detorsion in gastropods.

Course 12

1. Study the latest medical applications of haemopoietic cells.
2. Prepare a report on thrombosis, its causes, risk factors, symptoms and prevention.
3. Other than haemophilia, there are many more coagulation factor disorders. Explore this area.
4. Investigate the traditional and recent methods of grouping and cross matching of blood.
5. Compile information on Bombay blood group.
6. Study the recent advancements in organ transplantation.
7. Autoimmune diseases are on the rise. Explore the reasons, types as well as its mechanisms.
8. Distinguish different types of hypersensitivity.
9. Make a detailed report on bone marrow transplantation.
10. Explain the application of radiation technology in vaccine development.
11. Attempt to understand immune mechanisms in invertebrates.
12. Attempt to understand immune mechanisms in pets.

Course 13

1. Define- Histopathology. Name the cytological techniques used to stain DNA in the tissues.
2. Prepare a chart as follows

Sr. No.	Type of Embryonic origin	Tissues/Organ/Gland	Position in the body of vertebrates
1.	Ectoderm		
2.	Endoderm		
3.	Mesoderm		
4.	Dual origin		

3. From internet, survey types of stains used in temporary and permanent preparation of slides.
4. Find the ways to prevent post mortem changes in histological preparation of experimental animals.
5. Enumerate sub-lethal dose or sub-lethal concentration of a toxicant.
6. Give the significance of probit analysis and comment on Finney method of toxicity evaluation.

7. Find the differences between bioaccumulation, biotransformation and bio-magnification in the trophic levels. Do search for bioremediation against pollutants.
8. Discuss the various routes of intoxication in vertebrate animals.
9. Enlist the common inflammatory diseases.
10. Define - Metastasis and Neoplasia
11. Explain the procedure of biopsy. Give its significance.
12. Prepare a chart as follows:

Sr. No.	Samples	Types of pathological test conducted.	Confirmation of diseases
1.	Blood		
2.	Urine		
3.	Sputum		
4.	Semen		
5.	Root hair somatic cell		
6.	Bone marrow		
7.	Stool		

13. Give the use of standard error in biological research.
14. Explain various types of correlations possibilities in biological events.
15. Differentiate between primary and secondary data.
16. Study computer spreadsheet programme. Find software programmes for statistical tests used in biological research.

Course 14

1. Distinguish between holocrine, merocrine and apocrine glands.
2. Explain the difference between plastic and cosmetic surgery.
3. Comment on skin cancer and its preventive measures.
4. Find the ABCD rule for recognizing melanoma
5. Elaborate the term cyanosis.
6. Find the correlation between biological clock/rhythm melanin secretion and sleep.
7. List various applications of forensic osteology and human osteoarchaeology.
8. Role of osteology in understanding human evolution and taxonomy.
9. Give the correlation between age, nutrition and growth of bones.
10. Find out the following:
    a) Correlation between muscles and body building
    b) Smallest muscle, strongest muscle and the muscle that is never tired in our body.
    c) Number of muscles required for taking one step
11. Name three muscles or muscle groups used as sites for intramuscular injections especially used in babies.
12. Distinguish between the effect of exercises on muscles of a marathon runner and a weight lifter.
13. Describe different theories of experimental embryology.
14. Collect the brief information regarding the human embryogenesis.
15. Explain recapitulation theory.
16. Use of French flag model to understand developmental biology.
17. Complete the following table:

Drosophila body Patterning		
Category of genes	**Name of genes**	**Role of genes**
Egg-polarity genes	----------	Establish the Antero-posterior axis
Gap genes	----------	Establish 3 broad segments of the embryo
Pair-rule genes	----------	Establishes odd and even segments
Segment-polarity genes	----------	Establishes anterior posterior polarity of each segment
Homeotic genes	----------	Establishes segmental identity

T. Y. B. Sc. Zoology: Semester VI (Theory)
Course Code: USZO601:
Taxonomy - Chordates and Type Study
Course 15

Unit I: Phylum Chordata: Group Protochordata and Group Euchordata I (**15L**)

Objective:

- *To introduce basic concepts of modern Chordate classification with evolution point of view and to understand the concept of taxonomy in higher animal kingdom.*

Desired outcome:

- *Learners will get an idea of origin of Chordates, its taxonomy up to class with reference to phylogeny and their special features.*

1.1: General characters, Difference between non-chordates and chordates

Origin of chordates: Annelids as ancestors, Arachnids as ancestors and affinities with Echinodermata

1.2: **Protochordata**

1.2.1: General characters of Group Protochordata

1.2.2: Distinguishing characters of Subphylum Urochordata and Cephalochordata

1.2.3: Subphylum Urochordata

- Class Ascidiacea e.g. *Herdmania*
- Class Thaliacea e.g. *Salpa*
- Class Larvacea e.g. *Oikopleura*

1.2.4: Subphylum Cephalochordata

- Class Leptocardii e.g. *Branchiostoma* (*Amphioxus*)

1.3: Group Euchordata I

Group Euchordata: General characters

- Subphylum Vertebrata: General characters
- Division Agnatha and Gnathostomata: Distinguishing characters.

General characters with examples of:

- Class Ostracodermii e.g. *Cephalaspis*
- Class Cyclostomata e.g. *Petromyzon* (Lamprey)

Unit II: Group Euchordata II **(15L)**

2.2.1: Division: Gnathostomata

- Superclass: Pisces and Tetrapoda
- Superclass - Pisces: Distinguishing characters
  - Class Placodermi e.g. *Climatius*
  - Class Chondrichthyes e.g. *Rhinobatos* (Guitar fish)
  - Class Osteichthyes e.g. *Exocetus* (Flying fish)

2.2.2: Dipnoi (Lung fish): Distribution, habit and habitat, external and internal characters, affinities with super class Pisces, affinities and differences with class Amphibia

2.3: Superclass Tetrapoda

- Class Amphibia: General characters

  Examples:

  a. Limbless amphibian e.g. *Ichthyophis* (Caecilian)
  b. Tailed amphibian e.g. *Amphiuma*
  c. Tailless amphibian e.g. *Hyla* (Tree frog)

Unit III: Group Euchordata III **(15L)**

Objective:

- *To introduce the learners to the distinguishing characters of classes Reptilia, Aves and Mammalia and their adaptive features with reference to their habitat.*

Desired outcome:

- *Learners will understand the characteristic features and examples of class of Reptilia, Aves and Mammalia.*

3.1: Class Reptilia: General characters

Examples

a. Extinct reptile e.g. *Ichthyosaurus*
b. Living fossil e.g. *Sphenodon* (Tuatara)
c. Aquatic reptile e.g. *Chelonia* (*Sea turtle*)
d. Arboreal reptile e.g. *Chamaeleo* (Chamaeleon)

3.2: Class Aves: General Characters

Examples

a. Arboreal bird e.g. *Melanerpes* (Wood pecker)
b. Terrestrial bird e.g. *Gallus* (Fowl)
c. Swimming bird e.g. *Phalacrocorax* (Cormorant)
d. Wading bird e.gs. *Ardeola* (Heron)
e. Birds of prey e.g. *Tyto* (Owl)
f. Flightless birds e.g. *Dromaius* (Emu)

3.3: Class Mammalia: General characters

Examples

a. Egg-laying mammals e.g. *Ornithorhyncus* (Duck-billed platypus)
b. Pouched mammals e.g. *Macropus* (Kangaroo)
c. Insect eating mammals e.g. *Sorex* (Common shrew)
d. Toothless mammals e.g. *Bradypus* (Sloth)
e. Gnawing mammals e.g. *Funambulus* (Squirrel)
f. Primates e.g. *Macaca* (Monkey)

Unit IV: Type study: Shark (15L)

Objective:

- *To study in depth one vertebrate animal type i. e. general characteristics and salient features of animal type - shark.*

Desired outcome:

- *Learners will get an idea of vertebrate animal life after studying one representative animal - shark.*

4.1: Habit & habitat, distribution, external characters, classification and economic importance.

4.2: Skin, exoskeleton, endoskeleton and systems

a) Digestive system
b) Respiratory system
c) Blood vascular system
d) Nervous system and receptor organs
e) Urinogenital system, copulation, fertilization and development

Course Code: USZO602:
Physiology and Tissue Culture
Course 16

Unit I: Enzymology **(15L)**

Objective:

- *To introduce to the learner the fundamental concepts of enzyme biochemistry and to enable the learner realize applications of enzymes in basic and applied sciences.*

Desired outcome:

- *The learner shall understand fundamentals of enzyme structure, action and kinetics.*
- *The learner shall appreciate the enzyme assay procedures and the therapeutic applications of enzymes.*

1.1: Introduction and Nomenclature: Definition; concept of activation energy; nomenclature and classification (based on IUB - Enzyme Commission) of enzymes; chemical nature of enzyme, co-factors and co-enzymes

1.2: Enzyme Action and Kinetics: Mechanism; Factors affecting enzyme activity - substrate, pH and temperature. Derivation of Michaelis-Menten equation and Lineweaver-Burk plot; Concept and significance of K_m, V_{max} and K_{cat}

1.3: Enzyme Inhibition: Competitive and non-competitive inhibitors and their kinetics; therapeutic applications of enzyme inhibitors

1.4: Regulation of Enzyme Activity: Allosteric regulation and regulation by covalent modification of enzymes; Isozymes (LDH)

1.5: **Industrial applications of enzymes**: Food and detergents

Unit II: Homeostasis **(15L)**

Objective:

- *To introduce to the learner the concept of homeostasis-thermoregulation and osmoregulation*

Desired outcome:

- *The learner shall comprehend the adaptive responses of animals to environmental changes for their survival.*

2.1: Homeostasis

2.1.1: External and internal environment; Acclimation and acclimatization

2.1.2: Body clock - Circadian & Diurnal rhythm

2.2: Thermoregulation

2.2.1: Endothermy and ectothermy

2.2.2: Temperature balance: Heat production - shivering and non-shivering thermogenesis; brown fat, mechanisms of heat loss

2.2.3: Adaptive response to temperature - daily torpor, hibernation, aestivation

2.3: Osmotic and Ionic Regulation

2.3.1: Living in hypo-osmotic, hyper-osmotic and terrestrial environment - Water absorption, salt water ingestion and salt excretion, salt glands, metabolic water

2.3.2: Role of kidney in ionic regulation

Unit III: Endocrinology (15L)

Objective:

- *To introduce to the learner the details of endocrine glands and its disorders.*

Desired outcome:

- *The learner shall understand the types and secretions of endocrine glands and their functions.*

3.1: General organization of mammalian endocrine system

3.2: Hormones: Classification, properties, mechanism of hormone action

3.3: Histology, functions and disorders of the following endocrine glands:

- Pituitary
- Thyroid
- Parathyroid
- Pancreas
- Adrenal

Unit IV: Animal Tissue Culture (15L)

Objective*:*

- To *introduce to the learner the fundamental concepts of tissue culture and guide them progressively to certain areas of animal tissue culture.*

Desired outcome*:*

- *The learner shall understand the significance of tissue culture as a tool in specialized areas of research.*
- *The learner will appreciate its applications in various industries.*

4.1: Aseptic techniques

4.1.1**:** Sterilization - basic principles of sterilization, importance of sterility in cell culture

4.1.2**:** Sterile handling - swabbing, capping, flaming, handling bottles and flasks, pipetting, pouring

4.2: Culture media

4.2.1: Types of media - Natural and Artificial media

4.2.2: Balanced Salt Solutions

4.2.3: Complete Media - amino acids, vitamins, salts, glucose, oxygen supplements, hormones and growth factors, antibiotics

4.2.4: Factors influencing cell culture - surface tension and foaming, viscosity, temperature, osmolality, pH, CO_2, bicarbonate and O_2

4.3: Advantages of tissue culture - control of the environment, *in vitro* modelling of *in vivo* conditions

4.4: Limitations of tissue culture

4.5: Culture techniques

4.5.1: Preparation of cells / organs for culture

4.5.2**:** Cover slip, Flask and Tube culture

4.5.3: Primary and established cell lines

4.5.4: Hybridoma technology

Course Code: USZO603:
Genetics and Bioinformatics
Course 17

Unit I: Molecular Biology **(15 L)**

Objectives:

- *To introduce learner to chemical and molecular processes that affect genetic material.*
- *To make learner understand the concept of DNA damage and repair, and how gene control is necessary for cell survival.*

Desired outcome:

- *Learner shall get an insight into the intricacies of chemical and molecular processes that affect genetic material.*
- *The course shall prepare learner to recognize the significance of molecular biology as a basis for the study of other areas of biology and biochemistry.*
- *Learner shall also understand related areas in relatively new fields of genetic engineering and biotechnology.*

1.1: Types of mutation

1.1.1**:** Point mutations - substitution, deletion and insertion mutations

Substitution mutations - silent, missense and nonsense mutations, transition and transversion

Deletion and Insertion mutations - frameshift mutations

1.1.2**:** Trinucleotide repeat expansions - fragile X syndrome, Huntington disease

1.1.3**:** Spontaneous mutation - tautomeric shifts, spontaneous lesions

1.2: Induced mutations

1.2.1**:** Physical agents:

- Ionizing radiation (X-rays, α, β and γ rays)
- Non-ionizing radiation (UV light)

1.2.2**:** Chemical agents:

- Base analogs (5-bromouracil)
- Intercalating agents (ethidium bromide)
- Deaminating agents (nitrous acid)
- Hydroxylating agents (hydroxylamine)
- Alkylating agents (mustard gas)
- Aflatoxin (aflatoxin B_1)

1.3: Preventative and repair mechanisms for DNA damage

1.3.1: Mechanisms that prevent DNA damage - superoxide dismutase and catalase

1.3.2: Mechanisms that repair damaged DNA - direct DNA repair (alkyl transferases, photoreactivation, excision repair)

1.3.3: Postreplication repair - recombination repair, mismatch repair, SOS repair

1.4: Eukaryotic gene expression

1.4.1: Regulatory protein domains - zinc fingers, helix-turn-helix domain and leucine zipper

1.4.2**:** DNA methylation

Unit II: Genetic Engineering (15 L)

Objective:

- *To introduce learner to a set of techniques to modify an organism's genome to produce improved or novel genes and organisms.*

Desired outcome:

- *The learner shall get acquainted with the vast array of techniques used to manipulate genes which can be applied in numerous fields like medicine, research, etc. for human benefit.*

2.1: Tools in Genetic Engineering

2.1.1: Enzymes involved in Genetic Engineering: Introduction, nomenclature and types of restriction enzymes with examples, Ligases - *E. coli* DNA ligase, T4 DNA ligase, polynucleotide kinase, phosphatases, DNA polymerases, reverse transcriptase, terminal transferase

2.1.2: Vectors for gene cloning: General properties, advantages and disadvantages of cloning vectors - plasmid vectors (pBR322), phage vectors (λ Phage), cosmid vectors (c2XB)

2.1.3**:** Cloning techniques: Cloning after restriction digestion - blunt and cohesive end ligation, creation of restriction sites using linkers and adapters, cloning after homopolymer tailing, cDNA synthesis (Reverse transcription), genomic and cDNA libraries

2.2: Techniques in Genetic Engineering

2.2.1**:** PCR techniques: Principle of polymerase chain reaction (PCR), Applications of PCR

2.2.2**:** Sequencing techniques: DNA sequencing: Maxam-Gilbert method, Sanger's method Protein sequencing: Sanger's method, Edman's method Applications of sequencing techniques

2.2.3**:** Detection techniques: Blotting techniques - Southern blotting, Northern blotting and Western blotting Applications of blotting techniques

Unit III: Human Genetics (15L)

Objective:

- *To introduce learner with genetic alterations in human genome and their diagnosis.*

Desired outcome:

- *The learner shall become aware of the impact of changes occurring at gene level on human health and its diagnosis.*

3.1: Non-disjunction during mitosis and meiosis

3.1.1**:** Chromosomal Aberrations: Structural: Deletion: types, effects and disorders;
Translocation: types: Robertsonian and non-Robertsonian disorders;
Inversion: types, effects and significance;
Duplication and their evolutionary significance (multigene families)
Numerical: Aneuploidy and Polyploidy (Autopolyploidy and Allopolyploidy)

3.2: Genetic Disorders

3.2.1**:** Inborn Errors of Metabolism: Phenylketonuria, G-6-PD deficiency, Alkaptonuria, Albinism

3.2.2**:** Single gene mutation: Cystic fibrosis

3.2.3**:** Multifactorial: Breast Cancer

3.2.4**:** Uniparental Disomy: Angelman Syndrome and Prader-Willi Syndrome

3.3: Diagnosis

3.3.1**:** Prenatal Diagnosis: Amniocentesis and Chorionic villus sampling, Banding techniques (G, C, Q), FISH, Protein truncation test (PTT)

3.3.2**:** Genetic counselling

Unit IV: Bioinformatics (15L)

Objective:

- *To introduce learner to bioinformatics - a computational approach to learning the structure and organization of genomes, phylogeny and metabolism.*

Desired outcome:

- *Learner shall become aware of the computational point of view of studying the genomes.*

4.1: Introduction

4.1.1**:** Introduction to Bioinformatics and Bioinformatics web resource (NCBI, EBI, OMIM, PubMed)

4.1.2**:** Applications of Bioinformatics

4.2: Databases - Tools and their uses

4.2.1**:** Biological databases;
Primary sequence databases: Nucleic acid sequence databases **(**GenBank, EMBLEBI, DDBJ) Protein sequence databases (UniProtKB, PIR)
Secondary sequence databases
Derived databases - PROSITE, BLOCKS
Structure databases and bibliographic databases

4.3: Sequence alignment methods

4.3.1**:** BLAST, FASTA

4.3.2: Types of sequence alignment (Pairwise & Multiple sequence alignment)

4.3.3: Significance of sequence alignment

4.4: Predictive applications using DNA and protein sequences
4.4.1: Evolutionary studies: Concept of phylogenetic tree, convergent and parallel evolution

4.4.2**:** Pharmacogenomics: Discovering a drug: Target identification

4.4.3**:** Protein Chips and Functional Proteomics: Different types of protein chip (detecting and quantifying), applications of Proteomics

4.4.4: Metabolomics: Concept and applications

Course Code: USZO604:
Environmental Biology and Zoopharmacognosy
Course 18

Unit I: Environment management (15L)

Objective:

- *Learner should understand different factors affecting the environment and various methods to improve environmental stewardship.*

Desired outcome:

- *Learner will understand the different factors affecting environment, its impact and environment management laws.*

1.1: Natural resources and their Classification

1.1.1: Forest resources, water resources (surface and ground) and mineral resources

1.1.2: Energy resources: renewable (solar, tidal, wind, biofuel) and non-renewable resources (coal, petroleum oil, natural gas)

1.2: Exploitation and Modification of Natural Resources: Impact on climate, flora and fauna

1.3: Waste Management

1.3.1: Technologies in solid waste management:

a) Traditional methods for solid waste management: Composting, Incineration, Landfill Recycling, Windrow composting

b) Modern methods for solid waste management: Anaerobic digestion, ethanol production, biodrying, pyrolysis, Upflow anaerobic sludge blanket (UASB) technology, waste autoclave

1.3.2: e-waste and hazardous waste (biological, chemical, medical and nuclear) management

1.4: Water management

1.4.1: Rainwater harvesting: Definition ways of harvesting, components, model of rain water harvesting: Rural and Urban, Advantages and disadvantages

1.4.2: Watershed management: Definition, need and objectives, classification (mini, micro, mili, sub-watershed, macro-watershed), Watershed management practices: Contour, gully control, stone bunds. Growing greenery and integrated watershed approach (IWA).

1.4.3: Case study: Ice-stupa artificial glaciers by Sonam Wangchuk

1.4.4: Effluent treatment, recycling plants, control and treatment of sewage water.

1.5: Acts and Rules of Environment Management

1.5.1: Environment Protection Act - 1986, Air (Prevention and Control of Pollution) Act - 1981, Water (Prevention and Control of Pollution) Act - 1974

1.5.2: Hazardous Wastes (Management and Handling) Rules - 1989

1.5.3: EIA (Environmental Impact Assessment)

1.5.4: Role of Central and State Government (Pollution Control Board) and NGOs

Unit II: Wildlife Management (15L)

Objectives:

- *To sensitize learner regarding the various threats to the wildlife*
- *To introduce learner various ways that can help in the protection, conservation, management, and enhancement of wildlife populations and habitat.*

Desired outcome:

- *Learner will be able to understand various methods for wildlife conservation.*
- *Learner will be able to apply knowledge to overcome the issues related to wildlife conservation and management.*

2.1: Habit, Habitat, Territory and Niche of Wild Animals: Herbivores, carnivores, solitary, social (flock, pod, community), pack and herd, types of habitats and territories, niche concept

2.2: Threats to Wildlife

2.2.1: Poaching and hunting, deforestation, encroachment, competition (intra-specific and inter-specific), overgrazing and climate change, diseases (zoonosis and reverse zoonosis)

2.2.2: Tourism and human animal conflict

2.3: Wildlife Conservation

2.3.1: Techniques and methods used for wildlife census: Aerial counts, camera trap, line transect census and track surveys, capture mark recapture method, wildlife radio telemetry

2.3.2: Forest management, policies and Acts:
Harvesting Trees, Thinning harvest, Clearcut Harvest, Shelterwood harvest, Seed tree harvest, Group selection harvest, Single-tree selection harvest, Prescribed burning, Reforestation
Forest policy 1894, 1952, 1988;
The Indian Forest Act, 1927; Forest (Conservation) Act, 1980

Unit III: Bioprospecting and Zoopharmacognosy (15L)

Objectives:

- *To introduce the learner to the concepts of bioprospecting and zoopharmacognosy.*
- *Learner will be made aware of the process of discovery and commercialization of new products based on biological resources.*
- *To introduce learner with various ethological aspects by which non-human animals apparently self-medicate themselves.*

Desired outcome:

- *Learner will understand the paradigms of discovery and commercialization of biological resources and knowledge gained from self-medication observed in animals.*

3.1: Bioprospecting

3.1.1: Traditional and modern bioprospecting, economic value of bioprospecting

3.1.2: Bioprospecting and conservation, advantages and disadvantages

3.2: Zoopharmacognosy

3.2.1: Definition and types

3.2.2: Self-medication and its mechanism

3.2.3: Methods of self-medication through:

a) Ingestion - ants and mammals
b) Geophagy - invertebrates and birds
c) Absorption and adsorption

3.2.4: Applications - Social and trans-generational aspects of insects, birds and mammals

3.2.5: Contribution to human medicines

Unit IV: Zoogeography (15L)

O*bjectives:*

- *To introduce learner to the geographic distribution (present and past) of animal species.*
- *To introduce learner to various ways of animal distribution.*

Desired outcome:

- *The learners will become acquainted with how and why different animal species are distributed around the globe.*

4.1: Introduction: Plate tectonics and continental drift theory

4.2: Animal Distribution and Barriers

4.2.1: Isolating Mechanisms

4.2.2: Patterns of animal distribution - continuous, discontinuous and bipolar

4.2.3: Barriers of distribution -Topographic, climatic, vegetative, large water masses, land mass, lack of salinity and special characteristic habit (homing instinct).

4.2.4: Means of dispersal - land bridges, natural rafts and drift wood, favouring gales, migration by host, accidental transportation and by human agencies

4.3: Zoogeographical Realms: Palearctic, Ethiopian, Oriental, Australian, Neotropical, Nearctic and Antarctic

Practical Syllabus for Semester VI
Course code: USZOP06: COURSE 15

1. Group Protochordata

- Subphylum Urochordata
  - Class Larvacea e.g. *Oikopleura* (Sea squirt)
  - Class Ascidiacea e.g. *Ciona* (Transparent Sea squirt)
  - Class Thaliacea e.g. *Salpa* (Common salp)

- Subphylum Cephalochordata
  - Class Leptocardii e.g. *Branchiostoma* (*Amphioxus*)

- Subphylum Vertebrata: Division Agnatha
  - Class Ostracodermi e.g. *Pharyngolepis*
  - Class Cyclostomata e.g. *Petromyzon* (Lamprey)

2. Division Gnathostomata

- Superclass Pisces:
  - Class Placodermi e.g. *Bothriolepis*
  - Class Chondrichthyes e.g. *Rhinobatos* (Guitar fish), *Chimaera* (Rabbitfish)
  - Class Osteichthyes e.g. *Protopterus, Clarius* (Catfish)
- Superclass Tetrapoda:
  - Class Amphibia e.g. *Alytes* (Midwife toad) and *Triton* (Salamander)
  - Class Reptilia e.g. *Varanus* (Monitor lizard) and *Crocodylus* (Crocodile)

3. Class Aves: Examples: *Eudyptes* (Penguin), *Phoenicopterus* (Flamingo) and *Gyps* (Vulture)

4. Class Mammalia: Examples: *Dasyurus* (Quoll), *Petaurista* (Flying squirrel) and *Macaca* (Monkey).

5. Study of Shark with the help of diagram / Photograph / Simulation whichever possible. No animal shall be dissected.

a) Digestive system
b) Heart and Aortic arches
c) Urinogenital System
d) Endoskeleton of shark:
   i. Axial - Skull and vertebral column
   ii. Appendicular - Pelvic and pectoral fins, pelvic and pectoral girdle

6. Visit to fish market / Aquarium / Zoo/ National Park / Local Gardens / Local available niche / Sanctuaries / and such other places in Maharashtra and / or India and / or abroad to observe chordates and prepare a report. College may conduct more than one field visit for wide exposure, if feasible. However, at least one field visit should be such that it is affordable to every student.

Course code: USZOP06: COURSE 16

1. Effect of varying pH on activity of enzyme Acid Phosphatase.
2. Effect of varying enzyme concentration on activity of enzyme Acid Phosphatase.
3. Effect of varying substrate concentration on activity of enzyme Acid Phosphatase.
4. Effect of inhibitor on the activity of enzyme Acid Phosphatase.
5. Separation of LDH isozymes by agarose / polyacrylamide gel electrophoresis.
6. Histology of endocrine glands: T.S. of pituitary, thyroid, parathyroid, pancreas, adrenal.
7. Instruments for tissue culture - Autoclave Millipore filter, CO_2 incubator, Laminar air-flow. (Principle and use).
8. Packaging of glassware for tissue culture.
9. Aseptic transfer techniques.
10. Trypsinization and vital staining using Trypan blue stain.

Course code: USZOP06: COURSE 17

1. Quantitative Estimation of RNA by Orcinol method.
2. Quantitative Estimation of DNA by Diphenylamine method.
3. Separation of Genomic DNA by Agarose gel electrophoresis.
4. Colorimetric estimation of proteins from given sample by Folin-Lowry's method.
5. Problems based on Restriction endonucleases.
6. Karyotype (Idiogram) analysis for the following syndromes with comments on numerical and / or structural variations in chromosomes (no cutting of chromosomes):
    a. Turner's syndrome
    b. Klinefelter's syndrome
    c. Down's syndrome
    d. Cri-du-chat syndrome
    e. D-G translocation
    f. Edward's syndrome
    g. Patau's syndrome

7. Interpretation of genetic formulae: Deletion, duplication, inversion and translocation.
8. Calculation of mitotic index from the photograph or stained preparation of onion root tip or cancer cells.
9. Explore BLAST for nucleotide sequence comparison.
10. Explore the databases (Nucleotide, Protein) at NCBI for querying a nucleotide or protein sequence.
11. Exploring bibliographic database PubMed for downloading a research paper on subject of interest with the use of operators.

Course code: USZOP06: Course 18

1. Estimation of phosphates from sample water.
2. Estimation of BOD from sample water.
3. Estimation of COD from sample water.
4. Estimation of Nitrates from sample water.
5. Estimation of acidity and alkalinity of sample water by methyl orange and phenolphthalein indicator.
6. Comparative study of sound intensity in different places by Decibel meter.
7. Study of bioprospecting:
   a. Tumour suppression compounds e.g. Sponge.
   b. Skin erythema treatment from gel - *Aloe vera, Aloe ferox.*
8. Study of Zoopharmacognosy in ants, cats, elephants and dogs.
9. Indicate the distribution of fauna in the world map with respect to its realm and comment on the pattern of distribution.
   a. Palearctic: Giant Panda and Japanese Macaque
   b. Ethiopian: Common ostrich and African bush elephant
   c. Oriental: Indian one-horned Rhinoceros and Gharial
   d. Australian: Platypus and Red Kangaroo
   e. Neotropical: Guanaco and South American Tapir
   f. Nearctic: Virginia opossum and Sea otter
   g. Antarctic: Emperor Penguin and Antarctic Minke Whale
10. Excursion (Study tour / Visit) to Zoo / Sanctuary / National park / Research institute, etc. and submit a report. College may conduct more than one field visit for wide exposure, if feasible. However, at least one field visit should be such that it is affordable to every student.

References and Additional Reading for Semester VI

Course 15

REFERENCES

- Modern text book of Zoology - Vertebrates; Professor R.L. Kotpal; Rastogipublication; Third Edition 2012.
- Vertebrate Zoology for Degree students; V. K. Agarwal; S. Chand Publication; 2012.
- Fundamentals of Zoology, Dr. K. C. Ghosh and Dr. B. Manna, New Central book Agency (P) Ltd.
- Chordate Zoology Volume II, Prof. N. Arumogam. Saras Publication.
- Chordate Anatomy Mohan P. Arora, Himalaya Publishing House, First edition.
- The life of Vertebrates; J.Z. Young; ELBS - Oxford University Press; Third edition, 2006
- Textbook of chordate Zoology, Vol. II, G.S. Sandhu, H. Bhaskar; Campus Book International, First edition, 2005.
- Introduction to Zoology - Vol II: K. K. Chaki, G. Kundu and S. Sarkar, New Crystal Book Agency.
- URL for search on net: https://www.amazon.com/Protozoology-Susheel-Vilas-Nikam/dp/9350300044.
- Chordate Zoology by E. L. Jordan and P. S. Verma, edition,2009, Chand publications.
- Chordate Zoology by P. S. Verma, edition,2009, Chand publications.
- Modern Textbook of Zoology Vertebrates by R.L. Kotpal, edition Jan 2015, Rastogi publications.
- Practical Zoology: Vertebrate, by S. S. Lal, 2015.
- A Textbook of Invertebrate Zoology & Cell Biology, by V. S. Kanwate, A. N. Kulkarni et al. ed. Alka Prakashan.
- The Animal Kingdom: An Elementary Textbook in Zoology; Specially Classified and Arranged for the Use of Science Classes, Schools and Colleges (Classic Reprint), by Ellis A. Davidson, Sept. 2015, Publisher: Forgotten Book.

ADDITIONAL READING

- http://faculty.collegeprep.org/~bernie/sciproject/project/Kingdoms/Animal%20Kingdom%20-%205/Local%20copy/classification/chordata.html
- http://www.ucmp.berkeley.edu/chordata/chordata.html
- http://animaldiversity.org/accounts/Chordata/
- https://www.earthlife.net/inverts/chordata.html
- http://www.nhc.ed.ac.uk/index.php?page=493.450
- https://manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-chordata
- http://www.nhptv.org/wild/chordata.asp
- https://www.shapeoflife.org/phylum-chordata-advanced

Course 16

REFERENCES

- Comparative Animal Physiology; Knut Schmidt Nielson; Cambridge Press.
- Comparative Animal Physiology; Prosser and Brown.
- Comparative Animal Physiology; William S Hoar.
- Text book of Comparative Physiology; R Nagabhushanam, Ms Kodarkar, Sarojini R. India Book House Pvt. Ltd.
- Animal Physiology; N. Arumugam, A. Mariakuttikan; Saras Publication.
- Text book of Endocrinology; Williams .
- Textbook of Endocrinology Hardcover; Dharmalingam; 2010.
- Endocrinology; 6th Edition; Mac Hadley , Jon E. Levine.
- Bailey's textbook of histology Hardcover; Frederick R Bailey.
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978.
- Culture of animal cells - A manual of basic technique; R. Ian Freshney; John Wiley and Sons Publications; 2005.
- Basic cell culture - A practical approach; J. M. Davis; Oxford University Press; Indian edition; 2005.
- Animal cell culture - Biotechnology Series: Vol.1; Bina Mishra, B. P. Mishra, Pran P. Bhat, P.N. Bhat; Studium Press (India) Pvt. Ltd; 2011.
- Animal cell culture - Concept and Applications; Shweta Sharma; Oxford book Company; 2012.
- Biotechnology of Animal Tissues; Dr. P. R. Yadav and Dr. Rajiv Tyagi; Discovery Publishing House, New Delhi; 2006.

ADDITIONAL READING:

- A textbook of Enzymes: Shailendra Singh; Campus Book International, New Delhi 2007.
- Biochemical Adaptation: Mechanism and Process in Physiological Evolution: Peter W. Hochachka& George N. Somero, Oxford University Press.
- Comparative Animal Physiology: P. C. Withers, Thomson Publishing Co.
- Mammalian Endocrinology: Ashoke Kumar Boral. New Central Book Agency Ltd.
- Endocrinology-Hormones and Human Health: Prakash S. Lohar, MJP Publishers, Chennai. 2005.
- Biotechnology-an introduction: Second Edition: S. Ignacimuthu, S. J, Narosa Publications.
- Animal Biotechnology: R. Sasidhara, MJP Publishers, Chennai. 2006.

Course 17
REFERENCES

- Genetics - The continuity of life; Daniel Fairbanks and Ralph Andersen; Brooks/ Cole Publishing Company; 1999.
- Introduction to Molecular Biology; Peter Paolella; Tata McGraw Hill; 2010.
- Molecular Biology; David Freifelder; Narosa Publishing House; 2008.
- Genetics; Robert Weaver and Philip Hedrick; McGraw Hill; 2001.
- iGenetics - A Molecular Approach; Third Edition; Peter J. Russell; Pearson Education, Inc. (Benjamin Cummings), San Francisco; 2010.
- Molecular Biology - Academic Cell Update; Update Edition; David Clark; Elsevier, Inc.; 2010.
- Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978.
- Principles of Genetics; Eighth Edition; Gardner, Simmons and Snustad; John Wiley and Sons (Asia) Pte. Ltd., Singapore; 2002.
- The Science of Genetics - An Introduction to Heredity; Fourth Edition; George W. Burns; Macmillan Publishing Co., Inc., New York; 1980.
- Molecular Biology - Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates, Phil Turner & Mike White; Garland Science; 2013.
- https://www.ncbi.nlm.nih.gov/books/
- Current Protocols in Molecular Biology; Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, Seidman J. G., John A. Smith and Kevin Struhl; John Wiley& Son, Inc.; 2003.
- Introduction to Proteomics; Daniel C. Liebler; Humana Press; 2002.
- Molecular cloning; Joseph Sambrook, David William Russell; Third Edition; CSHL Press; 2001.
- Gene Cloning - An Introduction; Brown .T.A; Fourth Edition; Wiley-Blackwell; 2011.
- Recombinant DNA - Genes and Genomes- A short course; 3rd Edition; Watson, J.D., Myers, R.M., Caudy A., Witkowski, J.K.; Freeman and Co. NY; 2007.
- Principles Of Gene Manipulation & Genomics; Primrose SB and R. Twyman; Blackwell Science Publications; 2006.
- Methods In Enzymology, Vol 152; Berger Sl, Kimmer AR; Academic Press; 1987.
- Genomes 3; Third Edition; T.A.Brown; Garland Science Publishing; 2007.
- Molecular Biotechnology - Principles and applications of recombinant DNA; Glick, B.R. and Pasternak, J. J.; ASM press, Washington; 2010.
- Microbiology; Fifth Edition; Pelczar, M.J. et al; Tata McGraw-Hill Co., New Delhi; 2001.
- Introduction to Protein Structure; Second Edition; Branden C. and Tooze J.; Garlan Publishing; 1999.
- Proteins; Second Edition; Creighton T.E.; W.H. Freeman; 1993.
- Proteomics - Protein Sequence to Function; Pennington, S.R and M.J. Dunn; Viva Books; 2002.
- Genetic engineering - Principles and Practice; Sandhya Mitra; Macmillan India Ltd., New Delhi.
- Biotechnology - Fundamentals and Applications; Third Enlarged Edition; S.S. Purohit; Student Edition, Jodhpur; 2005.
- Biotechnology - Expanding Horizons; B.D.Singh; Kalyani Publishers, Ludhiana.
- A textbook of Biotechnology; R.C.Dubey; S.Chand and Company Ltd., New Delhi.
- Cell and Molecular Biology; Eighth Edition; E.D.P. De Robertis, E.M.F. De Robertis Jr.; Info-Med Ltd.; 1988.

- Genetics (Bios Instant Notes); Third Edition; G.I. Hickey, H.L. Fletcher and P. Winter; Taylor and Francis Group, New York; 2007.
- Genetics - A Conceptual Approach; Third Edition; Benjamin A. Pierce; W.H. Freeman and Company, New York; 2008.
- New Clinical Genetics; Second Edition; Andrew Read and Dian Donnai; Scion Publishing Ltd., UK; 2011.
- Genetics; Third Edition; Robert F. Weaver and Philip W. Hedrick; Wm. C. Brown Publishers (The McGraw-Hill Companies, Inc.); 1997.
- Human Molecular Genetics; Fourth Edition; Tom Strachan and Andrew Read; Garland Science, USA; 2011.
- Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978.
- Human Genetics - An Overview; Alice Marcus; Narosa Publishing House; 2010.
- The Science of Genetics - An Introduction to Heredity; Fourth Edition; George W. Burns; Macmillan Publishing Co., Inc., New York; 1980.
- https://www.ncbi.nlm.nih.gov/books/
- https://ghr.nlm.nih.gov/
- Bioinformatics - Concepts, Skills, and Applications; S.C. Rastogi & others; CBS Publishing; 2003.
- Bioinformatics - A practical guide to analysis of Genes & Proteins; Andreas D Baxevanis & B F Francis; John Wiley; 2000.
- Introduction to Bioinformatics; 1st Edition; T K Attwood, D J parry-Smith; Pearson Education, 11th Reprint; 2005.
- Bioinformatics; 1st Edition; C S V Murthy; Himalaya Publishing House; 2003.
- Bioinformatics sequence and genome analysis; David W. Mount; Cold spring Harbor Laboratory Press; 2004.
- Basic Bioinformatics; S. Ignacimuthu, S.J.; Narosa Publishing House; 1995.
- An Introduction to Bioinformatics Algorithms; Neil C. Jones and Pavel A. Pevzner; MIT Press, First Indian Reprint; 2005.
- Bioinformatics - Managing Scientific Data; Zoe Lacroix, Terence Critchlow; Morgan Kaufmann Publishers (Elsevier Science); 2003 (for the V unit).
- Phylogenetics: Theory and Practice of Phylogenetic Systematics; Second edition; Bruce S. Lieberman; Wiley-Blackwell; 2011.
- Molecular Evolution: A Phylogenetic Approach; Roderick D.M. Page, Dr Edward C. Holmes; Well Publishing; 1998.
- Essential Bioinformatics; Jin Xiong; Cambridge University Press; 2006.
- Proteomics - From Protein Sequence to Function; 12 S. R. Pennington, M. J. Dunn; First edition; Springer publications; 2001.
- Proteomics; Timothy Palzkill; Springer; 2002.
- Metabolomics - A Powerful Tool in Systems Biology; Jens Hřiriis Nielsen, Michael C. Jewett; Springer; 2007.
- Systems Metabolic Engineering; Dr. Christoph Wittmann, Sang Yup. Lee; Springer; 2012
- Bioinformatics (Bios Instant Notes); Second Edition (Special Indian Edition); T. Charlie Hodgman, Andrew French and David R. Westhead; Garland Science (Taylor and Francis Group); 2010.
- Understanding Bioinformatics; Marketa Zvelebil and Jeremy O. Baum; Garland Science (Taylor and Francis Group); 2008.

- Bioinformatics Computing - The complete practical guide to bioinformatics for life scientists; Bryan Bergeron; Eastern Economy Edition; Prentice-Hall of India Pvt. Ltd., New Delhi; 2003.
- Bioinformatics; Prakash S. Lohar; MJP Publishers, Chennai; 2009.
- Introduction to Bioinformatics; First Edition; S. Sundara Rajan and R. Balaji; Himalaya Publishing House, Mumbai; 2002.
- Molecular Biology - Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates, Phil Turner & Mike White; Garland Science; 2013.

ADDITIONAL READING

- The Gene: An Intimate History; Siddhartha Mukherjee; Scribner, New York; 2016.
- The Handling of Chromosomes; Sixth Edition; C.D. Darlington & L.F. La Cour; George Allen & Unwin Ltd., London; 1976.
- Molecular Cell Biology; Fifth edition; Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, S. Lawrence Zipursky & James Darnell; W.H. Freeman & Company, New York; 2004.

Course 18

REFERENCES

- Essentials of Environmental Science; N. Vasudevan; Narosa Publishing House Pvt. Ltd. New Delhi 110002.
- Environmental Biology; P.S Verma, V.K Agarwal; S. Chand & company Ltd. New Delhi 110055.
- A textbook of Environmental Science; Arvind Kumar; A P H Publishing Corporation, New Delhi 110002.
- Environmental Biotechnology - Basic Concepts and Application; Indu Shekhar Thakur; I. K. International Pvt. Ltd. New Delhi 110016.
- Text book of environmental science; S. C. Santra.
- Wild life management; Rajesh Gopal.
- Wildlife Management and Conservation - Contemporary Principles and Practices**;** Paul R. Krausman and James W. Cain III.
- Wildlife Ecology, Conservation, and Management; John M. Fryxell, Anthony R. E. Sinclair, Graeme Caughley.
- Molecular Biotechnology - Principles and Practices; Channarayappa.
- Biotechnology - P. K. Gupta.
- Biotechnology - B. D. Singh.
- Biotechnology Fundamentals & Applications - S. S. Purohit.
- Pharmacognosy and Pharmaco biotechnology- Ashutosh Kar.
- Trease and Evans Pharmacognosy - Evans, W.C.
- Pharmacognosy - Kokate, C. K. A. and Purohit, A.P.
- Practical Pharmacognosy- Gokhale, S. B. and Kokate, C. K.
- Text book of Pharmacognosy; T. E. Wallis.
- Zoogeography - The Geographical Distribution of Animals; Philip J. Darlington JR; Academic Publishers, Kolkata
- Animal Geography - Newbegin.
- Vertebrate Paleontology - Romer.
- Ecological animal geography- Allee, Park and Schmidt.
- Zoogeography of India and South East Asia - Dr. S. K. Tiwari; CBS Publishers and Distributors, Delhi; 1985.

ADDITIONAL READING

- Environmental Management: Principles and Practice by Christopher J. Barrow.
- Introduction to Environmental Management by Mary K. Theodore and Louis Theodore.
- Effective Environmental Management: Principles and Case Studies by Rory Sullivan and Hugh Wyndham.
- Solid Waste Management: Principles and Practice by Ramesha Chandrappa, Diganta Bhusan Das.
- Solid Waste Management: An Indian Perspective by M. S. Bhatt and Asheref Illiyan.
- Solid Waste Management by Subhash Anand.
- Watershed Management by Vijay P. Singh and Ram Narayan Yadava.
- Watershed Management by J. V. S. Murty.
- Water Resources, Conservation and Management by S.N. Chatterjee.
- Watershed Management - By Madan Mohan Das, Mimi Das Saikia.
- Concepts in Wildlife Management by B. B. Hosetti.
- Wildlife Management Practices by James Durell.

- Wildlife: management and conservation by M. M. Ranga.
- Ecological Census Techniques: A Handbook by William J. Sutherland - 2006.
- CRC Handbook of Census Methods for Terrestrial Vertebrates by Davis.
- Selecting Wildlife Census by R. F. H. Collinson.
- Forest Measurements: Fifth Edition by Thomas Eugene Avery and Harold E. Burkhart.
- Techniques for wildlife investigations and management by Clait E. Braun, Wildlife Society.
- Zoopharmacognosy by Jesse Russell, Ronald Cohn.
- News Feature: Animals that self-medicate by Joel Shurkin.
- Zoopharmacognosy and Herbal Pharmacology by Thomas H. Ingraham.
- How Animals Heal Themselves: Self-Selection: Self-Selection: Giving Animals the Choice to Select Their Own Natural Medicines: Ingraham Applied Zoopharmacognosy by Caroline Ingraham.
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4267359/.
- Zoopharmacognosy: The Use of Medicinal Plants by Animals by Eloy Rodriguez and Richard Wrangham https://link.springer.com/chapter/10.1007/978-1-4899-1783-6_4
- http://www.calmercreatures.co.uk/zoopharmacognosy-dogs/.
- Zoopharmacognosy, The Self-Medication Behavior Of Animals by Eraldo Medeiros Costa-Neto. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.940.6592&rep=rep1&type=pdf

LEARNERS' SPACE

Course 15

1. Organize a lecture and interaction of an expert working in the field of vertebrate study like wild photography, research project etc.
2. Collect information on phylogeny and geological time scale.
3. Did you notice that the number of frogs or earthworms is decreasing? Find out the probable reasons.
4. Comprehend the benefits of frog to farmer.
5. Study the reasons of extinction of dinosaurs
6. Enlist names of extinct birds.
7. Find out the reasons the *Archaeopteryx* is a connecting link between reptiles and birds.
8. Name the largest terrestrial and aquatic mammal.
9. List the scientific names of sharks found in Indian Ocean.
10. Study how is the age of the fossil decided.

Course 16

1. Elucidate on the Nobel Prize winning research work in the field of enzymology.
2. Study Eadie-Augustinsson plot and Hanes-Woolf plot of enzyme kinetics.
3. Make a report of isoenzymes (other than LDH) and their role in human body.
4. Kangaroo rats do not need to drink water at all. Explore the reason.
5. Collect information on:
   - Allen's rule
   - Bergman's rule
   - Gloger's rule
   - Jordan's rule
   - Rensch's rule
6. Review the mechanism and role of hormones like ecdysone and juvenile hormone in invertebrates.
7. Pineal gland has received attention as a 'mystery gland'. Find the reasons for it.
8. Prepare a report on therapeutic applications of hormones.
9. Present an account on recent advances in animal tissue culture.
10. 'HeLa' cells make the oldest immortal human cell line. Trace its history and significance.
11. Compare mortal and immortal cell lines.

Course 17

1. Study various types of genetic recombination. Explain any one mechanism.
2. Enlist enzymes involved in the central dogma of molecular biology. Comment on the specific biochemical reaction they catalyze.
3. Collect the information on satellite DNA. Discuss several forms of DNAs.
4. Give significance of telomere.
5. Gain information on chimeric DNA. Give its applications.
6. Comment on gene splicing.
7. Explore DNA microarray applications.
8. Comment on role of transgenic bacteria in pharmaceuticals.
9. Give interesting output of HGP.
10. Give examples of lysosomal storage disorders.
11. Explore information on lethal genes and jumping genes.
12. Enlist the variations in BLAST and FASTA.
13. Find the structure of a protein of your choice using UNIPROT.
14. Give role of bioinformatics in clinical biology.

15. Browse through website OMIA.

Course 18

1. Find out the role of an ISO 14001 environmental management system.
2. Explain environmental audit and carbon footprint.
3. Collect information on life cycle assessment (LCA) as an environmental management tool.
4. Collect the information about institutes those provide environmental management education.
5. Find out the role of industries such as TATA steel in environmental management.
6. Explain the benefits of environmental monitoring for an industry.
7. Comment on ethics of Wildlife Management and Conservation.
8. Role of WTI in wildlife research and management.
9. Comment on Sustainable Wildlife Management (SWM).
10. Convention on Biological Diversity (CBD)
11. Find the following:
    - Bioprospecting and Maya ICBG controversy.
    - Contribution of Babu Kalunde in self-medication.
12. Link the study of human evolution with Zoopharmacognosy.
13. Explain Wallace's Line and Weber's line.
14. Role of zoogeography in speciation.
15. List the animal species which exhibit homing instincts.

***Note - The practicals may be conducted by using specimens authorized by the wild life and such other regulating authorities though it is strongly recommended that the same should be taught by using photographs/audio-visual aids/simulations/ models etc. as recommended by the UGC and as envisaged in the regulation of the relevant monitoring bodies. No new specimens, however, shall be procured for the purpose of conducting practicals mentioned here-in above.**

N.B:

I) It is pertinent to note that we have to adhere strictly to the directions as given in the UGC Circular F14-4/2006 (CPP-II).

II) Apart from the Institutional Animal Ethics Committee (IAEC) and any other Committee appointed by a Competent Authority / Body from time to time, every college should constitute the following Committees:

1) A Committee for the Purpose of Care and Supervision of Experimental Animals (CPCSEA) and
2) A Dissection Monitoring Committee (DMC) to ensure that no dissections are done.

Composition of DMC shall be as follows:

i) Head of the Concerned Department (Convener / Chairperson)
ii) Two Senior Faculty Members of the concerned Department
iii) One Faculty of related department from the same College
iv) One or two members of related department from neighbouring colleges.

Use of animals for any experiment / dissection /mounting is banned. Simulations, authorized permanent specimens / slides, charts, models and other innovative methods are encouraged.

Scheme of Examination (Theory and Practical)

(a) External assessment of one hundred (100) marks per course per semester should be conducted as per the following skeleton question paper pattern.

(c) One practical examination of fifty (50) marks per course each should be conducted at the end of every semester.

SKELETON- EXAMINATION PATTERN (THEORY)

Time: 3 hours **Total marks: 100**

Q1	Based on Unit 1	20 marks
Q.2.	Based on Unit 2	20 marks
Q.3.	Based on Unit 3	20 marks
Q.4.	Based on Unit 4	20 marks
Q.5.	Based on all four Units	20 marks

***Internal option scheme shall be followed from time to time as per university guidelines for T. Y. B. Sc.**

T. Y. B. Sc. Zoology: Semester V (Practical)
Course Code: USZOP05: Course 11

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Sepia: Sketch and label _____ system. (Digestive / Reproductive system / Nervous system) **OR** Identify and Describe: a, b & c (Jaws / Radula / Chromatophores / Spermatophores / Statocyst) **OR** Perform virtual dissection of _____ system.	09
Q.2.	Identify and classify giving reasons: a) Protozoa / Porifera / Cnidaria b) Platyhelminthes / Nematoda c) Annelida / Arthropoda d) Mollusca / Echinodermata	12
Q.3	Identify, classify and describe a) Acanthocephala / Chaetognatha / Onychophora b) Hemichordata c) Observe the animal* (photo/existing preserved specimen) and identify phylum giving reasons. *A suitable animal which is not prescribed in the syllabus	09
Q.4	Field report - Submission and Discussion based on any one field visit which is attended by the student to avoid disparity due to financial constraints.	10
Q.5	Viva voce	05
Q.6	Journal	05

T. Y. B. Sc. Zoology: Semester V (Practical)
Course Code: USZOP05: Course 12

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1 Enumerate erythrocytes in the given sample and comment on clinical condition. 15

OR

Q.1 Enumerate leucocytes in the given sample and comment on clinical condition.

OR

Q.1 Present a report on differential count of leucocytes and comment on clinical condition.

Q.2 Estimate total plasma proteins by Folin's method. 10

OR

Q.2 Estimate serum/plasma total triglycerides by Phosphovanillin method.

Q.3 Estimate haemoglobin by Sahli's acid haematin method. 10

OR

Q.3 Record Erythrocyte Sedimentation Rate by Westergren / Wintrobe method.

OR

Q.3 Determine serum LDH by colorimetric/spectrophotometric method.

Q.4 Perform Latex agglutination test - Rheumatoid Arthritis. 05

OR

Q.4 Record bleeding / clotting time and comment on clinical significance.

Q.5 Viva voce 05

Q.6 Journal 05

T. Y. B. Sc. Zoology: Semester V (Practical)
Course Code: USZOP05: Course 13

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Demonstrate the effect of CCl_4 on the level of enzyme activity of aspartate/ alanine amino transferase / alkaline phosphatase in liver (*in vitro* approach)	10
Q.2	From the infiltrated tissue prepare block, trim and mount it on the block holder.	09
	OR	
Q.2	Mount the ribbon on slide from the given block.	
	OR	
Q.2	Stain the given histological slide and identify the tissue.	
Q.3	Identify and describe a, b, c, d. a) & b) based on study of mammalian tissues c) & d) based on diseases or conditions	08
Q.4	Interpret the pathological report - blood / urine / stool.	05
Q.5	Problems in Biostatistics (Any one)	08
Q.6	Viva voce	05
Q.7	Journal	05

T.Y.B. Sc. Zoology: Semester V (Practical)
Course Code: USZOP05: Course 14

Skeleton Question Paper for Practical Examination

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Make a temporary mounting of chick embryo (up to 48 hours)	10
Q.2	Identify and describe a) and b) Based on integumentary system c) and d) Based on forelimb muscle e) and f) Based on hind limbs muscle g) and h) Based on osteology - human axial skeleton i) Based on osteology - human appendicular skeleton j) Chick embryo up to 72 hours	30
Q.3	Viva-voce	05
Q.4	Journal	05

T. Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: USZOP06: Course 15

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Identify, classify giving reasons a) Urochordata / Cephalochordata / Ostachodermi / Cyclostomata b) Observe the animal* (photo/existing preserved specimen) and state its class giving reasons. * The animal should be other than prescribed in the syllabus	06
Q.2.	Identify, classify and describe a) Pisces b) Amphibia c) Reptilia d) Aves e) Mammalia	15
Q.3	Study of shark with the help of Specimen / Photograph / Simulation (Digestive system / Urinogenital system / Heart and aortic arches)	06
Q.4	Identify, sketch and label / Identify and describe marked portion in given diagram Skull or vertebra of shark / Fin of shark (Pectoral / Pelvic) / Girdle of shark (Pectoral / Pelvic)	03
Q.5	Field report - Submission and Discussion based on any one field visit which is attended by the student to avoid disparity due to financial constraints.	10
Q. 6	Viva Voce	05
Q.7	Journal	05

T. Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: USZOP06: Course 16

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1 Demonstrate the effect of _____ on the activity of acid phosphatase (Substrate concentration / pH variation / Enzyme concentration / Inhibitor concentration) 15

OR

Q.1 Perform trypsinization and show the isolated cells using suitable vital stain.

Q.2 Separate LDH isozymes from the given sample by agarose / polyacrylamide gel electrophoresis 10

OR

Q.2 Demonstrate the packaging of glassware for tissue culture (any 3)

OR

Q.2 Demonstrate the technique of aseptic transfer.

Q.3 Identify and describe a, b, c, d, e 15
a to d: Slides / Photographs of based on histology of endocrine glands
e: Instruments for tissue culture (any one)

Q.4 Viva voce 05

Q.5 Journal 05

T. Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: USZOP06: Course 17

Skeleton of Practical Examination Question Paper

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Isolation & Estimation of RNA by Orcinol method. **OR** Isolation & Estimation of DNA by Diphenylamine method.	15
Q.2	Separation of Genomic DNA by Agarose gel electrophoresis. **OR** Colorimetric estimation of proteins from given sample by Folin's method.	09
Q.3	Problems based on Restriction endonucleases (any two). **OR** Calculation of mitotic index from the photograph or stained preparation of onion root tip or cancer cells. **OR**	08
Q.3a	Analyse the given syndrome and comment on numerical and/or structural variations in chromosomes.	04
Q.3b	Interpretation of a genetic formula.	04
Q.4	Demonstrate the use of bioinformatics tool: BLAST for nucleotide sequence comparison. **OR** Databases at NCBI for querying a nucleotide / protein sequence with the help of suitable operator. **OR** PubMed for downloading a research paper of interest with the help of suitable operator.	08
Q.5	Viva voce	05
Q.6	Journal	05

T.Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: USZOP06: Course 18

Skeleton Question Paper for Practical Examination

Time: 9.30 AM to 2.30 PM **Total Marks: 50**

Q.1	Estimation of BOD / COD / nitrates from the given water sample	10
Q.2	Estimation of phosphates / acidity / alkalinity of sample water.	08
Q.3	Identification a) Based on bioprospecting (*Sponge / Aloe ferox / Aloe vera* - any one) b) Zoopharmacognosy (ants, cats, elephants and dogs - any one)	06
Q.4	Identify the given animals with respect to their realms and comment (any two).	06
Q.5	Study tour Visit Report - Submission and Discussion based on any one field visit which is attended by the student to avoid disparity due to financial constraints.	10
Q.7	Journal	05
Q.6	Viva voce	05

Research Project (Optional with Additional Credits)
Course Code: USZOR01 and USZOR02

There shall be a component of 'Research Project' which will be optional, catering to the needs of the advanced learners and those desirous of pursuing higher studies and / or career in research. Since Research Project is optional, its credits are in addition to the credits otherwise allotted to B.Sc. program in Zoology. The credits of Research Project shall therefore be considered as additional credits, performance of which shall be separately evaluated. Needless to say that the marks / GPA / grade obtained by the learner in the Research Project shall appear separately in the marksheet or shall be certified separately by the University of Mumbai in both the semesters viz. Semester V and Semester VI. These marks shall not be added to the total / grand total of the program and shall not be considered for class / Grade / GPA / merit / rank towards this program of the University of Mumbai. Research Project shall be evaluated by allotting duty to the examiners at a centre / centres in each district where the learners who have completed the projects shall be invited for assessment on a day scheduled for the purpose by the Chairman of Practical Examinations who would plan, coordinate and notify the same officially through the University. The remuneration for assessment of the Research Project shall be as decided by the University from time to time.

The learners may seek guidance for the research work from a mentor who could be a teacher from his/her college or any other college or from the industry; though it is not mandatory to have a mentor since Research Project can also be done independently, However no leniency will be shown during assessment to maintain quality defining the candidate as advanced learner. Assessment will be based on the spiral bound Proposal submitted in Semester V and Dissertation submitted in Semester VI along with *Viva voce* conducted by the examiner, details of which shall be as follows:

In semester V the learners will submit an outline / scheme / project proposal to be evaluated by the external examiner. Evaluation will be based on the following guidelines such as Literature Search / Survey, Objectives, Work plan, Materials and Methods, Rationale, Hypothesis, Expected Outcome, Relevance and Bibliography, etc., as presented in the spiral bound research proposal which shall carry 25 marks, in Semester V. *Viva voce* conducted by the concerned external examiner on the said proposal shall carry 25 marks. Learner may opt for PowerPoint presentation on the said research proposal, if desired. Thus Research Proposal shall carry total 50 marks with a credit of (01), in Semester V.

Actual execution / practical work of this project will be completed before the Semester VI examination. The external examiner will evaluate the 'Printed Dissertation' in Semester VI, carrying 25 marks based generally on guidelines such as Abstract / Synopsis, Materials and methods, Observations, Interpretations of Results, Discussion, Conclusion and Relevance of work, Recommendation, Future scope, etc., incorporated in the Dissertation. *Viva voce* conducted by the external examiner based on the dissertation presented with the PowerPoint presentation or otherwise shall carry 25 marks. Thus Research Project with dissertation shall carry 50 marks having credit of (01) in semester VI.

A list of the candidates offering the project and the titles of their respective project should be forwarded by the College along with the examination application form in SEM-V and SEM-VI.

The total credits (02) of Research Project in Semester V and Semester VI, are additional and may be transferred to the other relevant program and/or for post-graduation program, if desired by the learner, wherever applicable and if permitted by the ordinances of the University of Mumbai, as prescribed therein, if promulgated.