Academic Council Meeting No. and Date : July 06, 2023

Agenda Number : 2 Resolution Number : 30,31 / 4.5 & 4.10

Vidya Prasarak Mandal's
B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme : Bachelor of Science
Specific Programme : Zoology

[T.Y.B.Sc. (Zoology)]

Revised under Autonomy

From academic year 2023 - 2024

Eligibility:

Passed 12th standard (HSC) of Maharashtra State Board / CBSE / ICSE board with Biology as one of the subject.

Implemented From: A.Y. 2023-24

Duration: 3 years (Six Semesters)

Mode of Conduct :

Offline lectures / Online lectures /Laboratory practical / Expeditions/ Projects

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Program Outcome

Students will get the basic knowledge of the subject zoology. The updated k-now- how shall be instilled through concepts, techniques, methodology, discoveries, awareness etc. students shall get substantial background of the subject to support his/her career/ start-up/ further studies/ competitive exams/research etc.

Program Specific Outcome

To nurture interest in the students for the subject of Zoology with basic and modern concepts.

To enhance the importance of Zoology in the present scenario in terms of its history, animal world their biodiversity, conservation, modern technology, ecology, biological social zoology, animal introduction and basic nutritional and health aspects of human life.

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CONTENTS

PREAMBLE

Zoology has emerged as a progressive subject over the past decade, with innovations in curriculum design and unique initiatives that are attracting students from both urban and rural colleges to the subject in large numbers. Experiments such as a need-based flexible curriculum, an open unit that can incorporate the latest topics at any time before revising the curriculum, a pyramid committee for continuity between the first and second semesters VI, a workshop with the Indian Chamber of Commerce for industry-academia interface, a workshop with meritorious past and present students to get their inputs, uploading the draft curriculum on the university website for public criticism a month before the BoS, etc. have proved to be very successful. However, the fundamental challenge has been to design curricula without sections, the backbone of the discipline. We zoologists are strictly against animal cruelty and practice animal welfare, but we had to accept that even the dead edible fish from the market and pests for dissection were banned.

Curriculum revision, an integral part of educational institutions and one of the most important responsibilities of the Board of Studies of any university, is an opportunity to review what is being taught and what should be taught to learners in changing times. The Zoology Curriculum Committee in general and the T. Y. B. Sc. Zoology Committee, SEM V and SEM VI in particular are characterized by a great initiative to involve various stakeholders before and during the process of curriculum design. After hard work and in true team spirit, this curriculum was created and put into effect for the 2023-2024 Academic Year.

The task of the curriculum committee, in the architectural design of the curriculum, is to allow teachers to use both the classical and the modern technological tools of pedagogy to address and accommodate all types of learners, including the slow and the advanced. This curriculum, with clearly stated goals and outcomes for each unit, is one of the best examples of a mixed pedagogy tool available to teachers. Care has also been taken to include a unit on muscles, which has been much neglected in anatomy. It cannot be ruled out that this will give zoology students a further impetus to enter the field of fitness and gymnastics. This niche of students will have the upper hand in international exams over other personnel in the fitness industry, as they already have knowledge of physiology to a desired degree.

Thus, the curriculum must not only arouse interest, stimulate and inspire the learner, but also ignite the spirit of inquiry. The curriculum presented herewith, to be implemented in Zoology from

the academic year 2023-24, is also a tool to inculcate the culture of critical thinking in the learners. What makes this curriculum special is its unique blend of standardization and customization, which creates a vibrant ecosystem of teaching and learning in which the teacher acts as facilitator and mentor and the student can take some steps toward becoming a motivated student and an autonomous learner.

The scope of the curriculum must therefore be broader and include traditional as well as contemporary and even futuristic dimensions of the subject in question. This aspect of curriculum design was exemplified by the zoology curriculum for SEM V and SEM VI at T. Y. B. Sc.

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PEDAGOGY

The curriculum, created taking into account the views of all stakeholders, both urban and rural, and offering leeway to advanced learners without challenging the average and above average students, certainly requires a dynamic pedagogy with a number of variations to achieve the objectives with the desired result.

Course codes BNBUSZO5T1 and BNBUSZO6T1 attempt to introduce learners to the principles of taxonomy, levels of organization, modern classification up to classes, and the evolutionary significance ofthe various levels of organizationsuch as symmetry, coelom, segmentation, and so on. It is desirable to have students learn in the field rather than in the classroom andto make taxonomylively and interesting. It is not an exaggeration to suggest that even protozoa can be observed with a microscope in nature. Ideally, students should draw a diagram of an organism/animal as they perceive it through observation rather than copying a diagram from a book into the notebook. The different classification schools make the topic debatable. Care has been taken to adopt the most recent approach, and with the help of appropriate educational tools, students should be able to assign the characteristics of a specimen up to a specific class.

The BNBUSZO5T2 course introduces various aspects of human blood, clinical disorders and their diagnosis. The importance of diagnostic tools must be emphasised as they are relevant to human health. Faculty are expected to demonstrate the possibilities 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 Government of India MHRD. It is suggested that the unit II - Applied Haematology- of this course can be alternatively taught using RBPT. The subtopics are related to real life and provide scope for inquiry based learning through actual laboratory work under faculty observation. The knowledge of blood and its components that learners already have can be deepened through various activities that learners can perform to link theory to hands-on activities and understand the clinical significance of various diagnostic tests.The BNBUSZO6T2 course covers enzymology, homeostasis, and animal tissue culture. Documentaries about nature and life in the wild can be used effectively to stimulate learners' interest in the adaptive responses of animals tothe environment that ensure their survival. Visits to industry and invited lectures by industry representatives will help raise awareness of the industrial importance of enzymes. Theory, supplemented by practical exercises in sterilisation and culture techniques, will help learners understand the importance of animal tissue culture. Visits to microbiology and biotechnology departments in the institution can be encouraged to interact with faculty and students to generate more interest. Student-led seminars are an interactive method for independent study that can be encouraged.

Topics coveredin BNBUSZO5T3 course include mammalian histology, basic

Toxicology, General Pathology, and Biostatistics. The reintroduced microtomy could not only be used as a histo-pathological tool for clinical pathology, but also highlight its applications in research. Toxicological studies can be made interesting by highlighting their importance in pharmacy, and in addition, insight into the regulatory aspect can be provided to understand the practical difficulties and standards associated with toxicity testing. A study visit to the pathology laboratory planned for the unit II could also cover these aspects. The use of biostatistics in the interpretation and validation of experimental data should be emphasized. Learners could be introduced to statistical software used in biostatistics. The course BNBUSZO6T3 covers molecular biology, genetics

Engineering, Human Genetics, and Bioinformatics. Molecular biology and genetic engineering could be taught using ICT and videos available online. It is recommended that a

6 industrial interface. Teachers are expected to explain the scope of genetic manipulation

techniques in medical science and industry. ICT can be used to teach various bioinformatics concepts such as protein sequencing, evolutionary tree construction, etc. The use of publicly available software to study human diseases could become the focus of
become. The practical application of bioinformatics in the preparation of probes using databases could be emphasized.

A synergistic pedagogical approach between the theoretical and practical courses of USZO504 could contribute to a better understanding of the different subtopics, such as the integumentary system, osteology, and the developmental stages of the chick embryo. There is an opportunity to use ICT-related teaching tools that would contribute to the understanding of the structural and functional aspects of epidermis and dermis derivatives, various muscles of the anterior and posterior extremities and their arrangement, etc. The BNBUSZO6T4 curriculum addresses the various environmental issues and their management. Guest lectures by experts in these fields could be organized to provide additional insight into these aspects. Informative documentaries on wildlife conservation and human-wildlife conflict could make the topics relevant and interesting.

In addition to formal classes, group discussions and sharing of experiences could be practiced for bioprospecting and zoopharmacognosy. Case studies could be added to understand the distribution patterns of different animal species across the globe.

The learner space provided in the curriculum is an attempt to move pedagogy from teacher-centered to learner-centered. It will help the enthusiastic learners to acquire additional knowledge through various proposed activities to perfect their concepts and acquire additional expertise. Research projects (BNBUSZOR1 and BNBUSZOR2), which are optional and earn extra credit, could be supervised by teachers to encourage more and more students to opt for it, thus creating a research culture.

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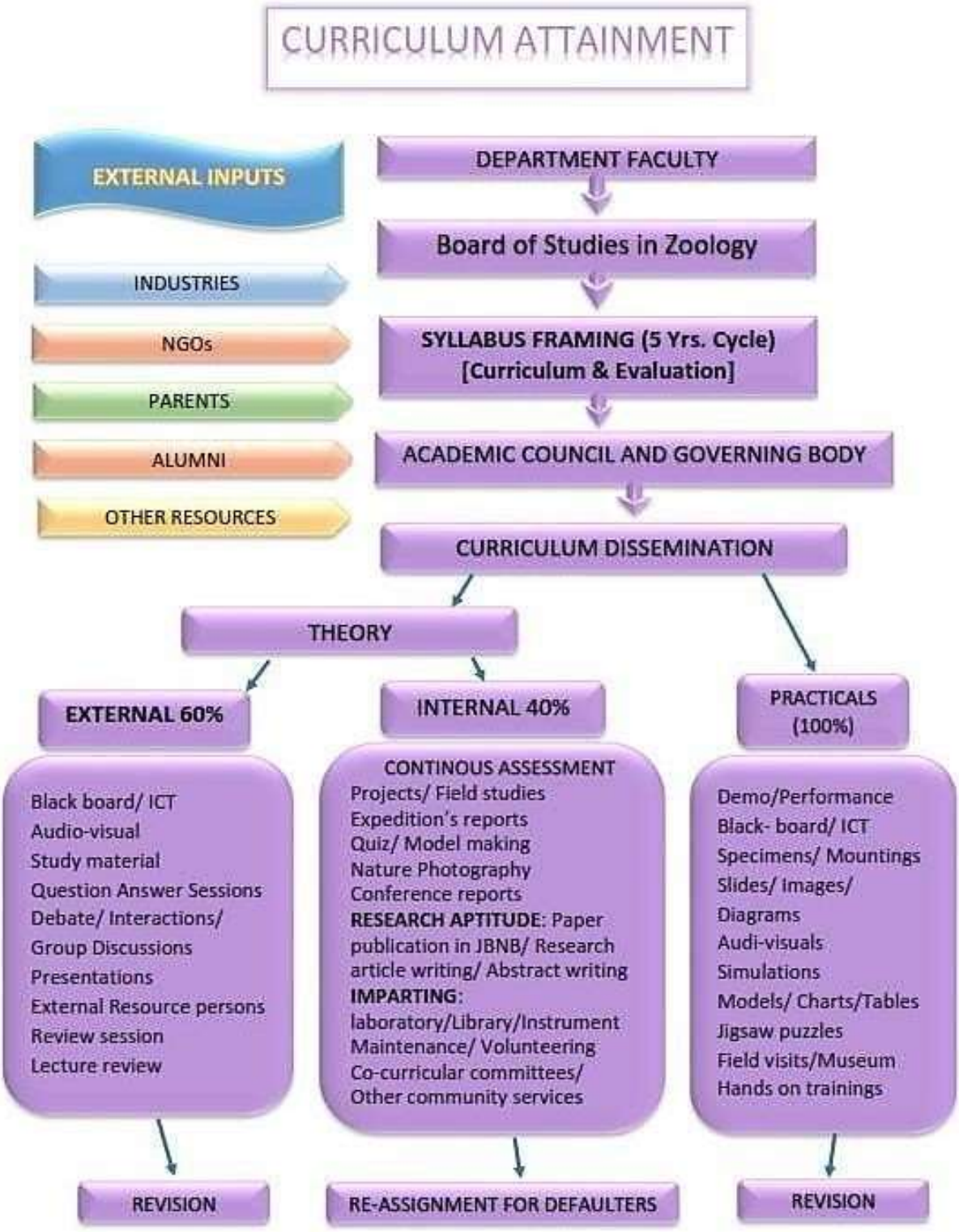
CURRICULUM ATTAINMENT
EXTERNAL INPUTS
INDUSTRIES
NGOs
PARENTS
ALUMNI
OTHER RESOURCES
DEPARTMENT FACULTY
Board of Studies in Zoology
SYLLABUS FRAMING (5 Yrs. Cycle) [Curriculum & Evaluation]
ACADEMIC COUNCIL AND GOVERNING BODY
CURRICULUM DISSEMINATION
THEORY
EXTERNAL 60%
INTERNAL 40%
PRACTICALS (100%)
Black board/ ICT
Audio-visual
Study material
Question Answer Sessions
Debate/ Interactions/
Group Discussions
Presentations
External Resource persons
Review session
Lecture review
CONTINOUS ASSESSMENT
Projects/ Field studies
Expedition's reports
Quiz/ Model making
Nature Photography
Conference reports
RESEARCH APTITUDE: Paper publication in JBNB/ Research article writing/ Abstract writing
IMPARTING:
laboratory/Library/Instrument Maintenance/ Volunteering
Co-curricular committees/
Other community services
Demo/Performance
Black- board/ ICT
Specimens/ Mountings
Slides/ images/
Diagrams
Audi-visuals
Simulations
Models/ Charts/Tables
Jigsaw puzzles
Field visits/Museum
Hands on trainings
REVISION
RE-ASSIGNMENT FOR DEFAULTERS
REVISION

SEMESTER - V

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 2023-2024)

SEMESTER - V					
THEORY					
COURSENO.	**COURSE CODE**	**UNIT**	**TOPICS**	**CREDITS**	**LECTURES/WEEK**
1	BNBUSZO5T1	I	Principles of Taxonomy	2.5	1
		II	Kingdom: Animalia I		1
		III	Kingdom: Animalia II		1
		IV	Type study: *Sepia*		1
2	BNBUSZO5T2	I	Basic Haematology	2.5	1
		II	Applied Haematology		1
		III	Basic Immunology		1
		IV	Applied Immunology		1
3	BNBUSZO5T3	I	Mammalian Histology	2.5	1
		II	Toxicology		1
		III	General Pathology		1
		IV	Biostatistics		1
4	BNBUSZO5T4	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
	BNBUSZO5T5		Oceanography, Crafts and Gear Farming of Major Carps, Introduction to other Commercial Aquaculture Practices in Fresh WaterCulture of Shell fishes and Fin-Fish Quality Control and Packaging Marketing and Finance, Case Study and Simulation	2	4

T. Y. B. Sc. Zoology: Semester V (Theory)

Course Code: BNBUSZO5T1

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 animalkingdom with evolution point of view.

Desired Outcome:

Learners will apprehend the basis of classification and modern classification up to classof 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*
	e.g. Vertebrate - Man

1.2.3 : Evolutionary significance of symmetry

1.3 : Coelom

1.3.1 : Basic concept and

definition1.3.2: 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

Nomenclature1.5.3: 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: Phylum - 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 fromPorifera 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 withtheir 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 phylumAnnelida to Hemichordata and to familiarize with their characters.

Desired Outcome:

Learners will get an idea of higher groups of invertebrate animal life, their classificationand 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 andMollusca.

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 : Study of the Following

- Digestive system,
- Respiratory system,
- Circulatory system,
- Excretory system,
- Nervous system and Sense organs,
- Reproductive system

Course Code: BNBUSZO5T2
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, variationin 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 andits 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 ofdiagnostic techniques used in pathology.

Desired outcome:

The learner will be familiar with the terminology used and diagnostic tests performed in apathological 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

purpura2.2.3**:** 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 importantrole 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 againstdiseases.

3.1 : Overview of Immunology

3.1.1 : Concept of immunity

3.1.2 : Innate immunity - Definition, factors affecting innate immunity, Mechanisms of innateimmunity - 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; ActiveAcquired 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 ofvaccines.
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
- **Nasal Vaccine –**
- **Covid vaccine dosage-**
- **Cervical cancer vaccine**
- Virsomes 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: BNBUSZO5T3

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 organsystems.

1.1 : Vertical section (V.S.) of skin: Layers and cells of epidermis; papillary and reticularlayers 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 intestineof 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 toxicresponses to chemical exposures, nature and effect of toxicity and toxicity testing.
It also intends to develop amongst students an introductory understanding of regulatoryaffairs in toxicology.

Desired outcome:

The course will prepare learner to develop broad understanding of the different areas oftoxicology.
It will also develop critical thinking and assist students in preparation for employment inpharmaceutical 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 doseresponse, 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 pathologicalcondition 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 itsapplications.

Desired outcome:

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

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 andAlternate hypothesis, Levels of significance and testing of hypothesis

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

4.5 : Correlation: Correlation coefficient and its significance

Course Code: BNBUSZO5T4
Anatomy and Developmental Biology
Course 14

Unit I: Integumentary system and derivatives **(15L)**

Objective:

- *To introduce the learner to understand different integumentary structures and derivativesin 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 **wing feathers-flight feather-primary, secondary and tertiary**

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. **Ischial callosity in monkey (sitting pads), brood pouch in Kangaroo.**

Unit II: Human Osteology **(15L)**

Objective:

To introduce the learner to different bones of human skeleton and their functionalimportance.

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 sternum2.2.4: Hyoid bone: Structure and function.

2.3 : Appendicular skeleton

2.3.1 : Pectoral girdle and bones of forelimbs2.3.2: 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 arrangementwith 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 andtheir 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 carpiulnaris* 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 asa model and also familiarize with experiments related to it.

Desired outcome:

Learner will be able to understand the processes involved in embryonic development andpractical 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 anorganizer

Practical Syllabus for Semester V

Course code: BNBUSZO5P1

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. Animal may 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.

Practical Syllabus for Semester V
Course code: BNBUSZO5P1
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.

Practical Syllabus for Semester V
Course code: BNBUSZO5P2
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)

Practical Syllabus for Semester V

Course code: BNBUSZO5P2

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, Tricepsbrachii, Flexor carpi radialis, Flexor carpi ulnaris* and *Extensor carpi ulnaris*
5. Study of muscles of hind limbs - Sartorius, Adductor group, Quadriceps group *Rectusfemoris, 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

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14. 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
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Course 14

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3. Comparative Anatomy of Vertebrates by Robert Wiedersheim.
4. Illustrations of Comparative Anatomy, Vertebrate and Invertebrate - For The Use of Students In The Museum Of Zoology And Comparative Anatomy.
5. 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.
6. The Anatomy and Biology of the Human Skeleton by D. Gentry Steele. Atlas of Chick Development - By Ruth Bellairs and Mark Osmond.
7. 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.\Autoimmune diseases are on the rise. Explore the reasons, types as well as its mechanisms.
7. Distinguish different types of hypersensitivity.
8. Make a detailed report on bone marrow transplantation.
9. Explain the application of radiation technology in vaccine development.
10. Attempt to understand immune mechanisms in invertebrates.
11. 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 bodyof vertebrates
1.	Ectoderm		
2.	Endoderm		
3.	Mesoderm		
4.	Dual origin		

3. From internet, survey types of stains used in temporary and permanent preparation ofslides.
4. Find the ways to prevent post mortem changes in histological preparation of experimentalanimals.
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 toxicityevaluation.
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 testsused 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 injectionsespecially used in babies.
12. Distinguish between the effect of exercises on muscles of a marathon runner and a weightlifter.
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

SEMESTER - VI

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 2023-2024)

SEMESTER - VI					
THEORY					
COURSE NO.	**COURSE CODE**	**UNIT**	**TOPICS**	**CREDITS**	**LECTURES/ WEEK**
15	BNBUSZO6T1	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	BNBUSZO6T2	I	Enzymology	2.5	1
		II	Homeostasis		1
		III	Endocrinology		1
		IV	Animal Tissue Culture		1
17	BNBUSZO6T3	I	Molecular Biology	2.5	1
		II	Genetic Engineering		1
		III	Human Genetics		1
		IV	Bioinformatics		1
18	BNBUSZO6T4	I	Environment management	2.5	1
		II	Wildlife management		1
		III	Bioprospecting and Zoopharmacognosy		1
		IV	Zoogeography		1
				10	**16**
PRACTICAL					
BNBUSZO6P1 & BNBUSZO6P2	Practicals based on all four courses			**06**	**16**
Research Project					
BNBUSZO6R1	Additional Credits (Choice Based / Optional)			**1**	**No Workload for Teachers**

T. Y. B. Sc. Zoology: Semester VI (Theory)

Course Code: BNBUSZO6T1

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 viewand 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 referenceto 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 charactersClass 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 andMammalia 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 charactersExamples
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 CharactersExamples
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 charactersExamples
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: BNBUSZO6T2

Physiology and Tissue Culture

Course 16

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

Objective:

To introduce to the learner the fundamental concepts of enzyme biochemistry and toenable 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 therapeuticapplications 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 andLineweaver-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 environmentalchanges 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 theirfunctions.

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 ParathyroidPancreas Adrenal

Unit IV: Animal Tissue Culture (15L)

Objective*:*

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

Desired outcome*:*

The learner shall understand the significance of tissue culture as a tool in specializedareas 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 media4.2.2: 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 culture4.5.2**:** Cover slip, Flask and Tube culture 4.5.3: Primary and established cell lines 4.5.4: Hybridoma technology

Course Code: BNBUSZO6T3:
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 genecontrol is necessary for cell survival.

Desired outcome:

Learner shall get an insight into the intricacies of chemical and molecular processes thataffect genetic material.

The course shall prepare learner to recognize the significance of molecular biology as abasis for the study of other areas of biology and biochemistry.

Learner shall also understand related areas in relatively new fields of genetic engineeringand 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 B1)

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 produceimproved 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 onhuman 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 fibrosis3.2.3**:** 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 structureand 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: BNBUSZO6T4:

Environmental Biology and Zoopharmacognosy

Course 18

Unit I: Environment management **(15L)**

Objective:

Learner should understand different factors affecting the environment and variousmethods to improve environmental stewardship.

Desired outcome:

Learner will understand the different factors affecting environment, its impact andenvironment 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 : **Amendments and Rules (added)**

Deleted:- 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 - 19891.5.3: 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 wildlifeconservation 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, **Ecotourism (Added)**

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 animalsapparently self-medicate themselves.

Desired outcome:

Learner will understand the paradigms of discovery and commercialization of biologicalresources 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 mammals3.2.5: Contribution to human medicines

Unit IV: Zoogeography **(15L)**

Objectives:

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 aredistributed 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: BNBUSZO6P1:
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 (Rabbitfish)	e.g. *Rhinobatos* (Guitar fish), *Chimaera*
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. Animal can 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: BNBUSZO6P1:
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: BNBUSZO6P2:
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 tipor 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 subjectof interest with the use of operators.

Course code: BNBUSZO6P2:
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

1. Modern text book of Zoology - Vertebrates; Professor R.L. Kotpal; Rastogipublication; Third Edition 2012.
2. 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.
3. Chordate Zoology Volume II, Prof. N. Arumogam. Saras Publication. Chordate Anatomy Mohan *P.* Arora, Himalaya Publishing House, First edition.
4. 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.
5. Introduction to Zoology - Vol II: K. K. Chaki, G. Kundu and S. Sarkar, New Crystal Book Agency.
6. Chordate Zoology by E. L. Jordan and P. S. Verma, edition,2009, Chand publications. Chordate Zoology by P. S. Verma, edition,2009, Chand publications.
7. Modern Textbook of Zoology Vertebrates by R.L. Kotpal, edition Jan 2015, Rastogi publications.
8. Practical Zoology: Vertebrate, by S. S. Lal, 2015.
9. A Textbook of Invertebrate Zoology & Cell Biology, by V. S. Kanwate, A. N. Kulkarni et al. ed. Alka Prakashan.
10. 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
11. Davidson, Sept. 2015, Publisher: Forgotten Book.

ADDITIONAL READING

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-

https://www.shapeoflife.org/phylum-chordata-advanced

Course 16

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

ADDITIONAL READING:

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

Course 17

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1. Genetics - The continuity of life; Daniel Fairbanks and Ralph Andersen; Brooks/ Cole Publishing Company; 1999.
2. Introduction to Molecular Biology; Peter Paolella; Tata McGraw Hill; 2010.
3. Molecular Biology; David Freifelder; Narosa Publishing House; 2008.
4. Genetics; Robert Weaver and Philip Hedrick; McGraw Hill; 2001.
5. Genetics - A Molecular Approach; Third Edition; Peter J. Russell; Pearson Education, Inc. (Benjamin Cummings), San Francisco; 2010.
6. Molecular Biology - Academic Cell Update; Update Edition; David Clark; Elsevier, Inc.; 2010.
7. Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978.
8. Principles of Genetics; Eighth Edition; Gardner, Simmons and Snustad; John Wiley and Sons (Asia) Pte. Ltd., Singapore; 2002.
9. The Science of Genetics - An Introduction to Heredity; Fourth Edition; George W. Burns;
10. Macmillan Publishing Co., Inc., New York; 1980.
11. Molecular Biology - Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates, Phil Turner & Mike White; Garland Science; 2013
12. 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.
13. Introduction to Proteomics; Daniel C. Liebler; Humana Press; 2002.
14. Molecular cloning; Joseph Sambrook, David William Russell; Third Edition; CSHL Press;2001.
15. 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.
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17. Methods In Enzymology, Vol 152; Berger Sl, Kimmer AR; Academic Press; 1987. Genomes 3; Third Edition; T.A.Brown; Garland Science Publishing; 2007.
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19. and Pasternak, J. J.; ASM press, Washington; 2010.
20. 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
21. Publishing; 1999.
22. Proteins; Second Edition; Creighton T.E.; W.H. Freeman; 1993.
23. Proteomics - Protein Sequence to Function; Pennington, S.R and M.J. Dunn; Viva Books;2002.
24. Genetic engineering - Principles and Practice; Sandhya Mitra; Macmillan India Ltd., New Delhi.
25. Biotechnology - Fundamentals and Applications; Third Enlarged Edition; S.S. Purohit; Student Edition, Jodhpur; 2005.
26. Biotechnology - Expanding Horizons; B.D.Singh; Kalyani Publishers, Ludhiana. A textbook of Biotechnology; R.C.Dubey; S.Chand and Company Ltd., New Delhi.
27. Cell and Molecular Biology; Eighth Edition; E.D.P. De Robertis, E.M.F. De Robertis Jr.;

Info-Med Ltd.; 1988.
28. Genetics (Bios Instant Notes); Third Edition; G.I. Hickey, H.L. Fletcher and P. Winter; Taylor and Francis Group, New York; 2007.
29. Genetics - A Conceptual Approach; Third Edition; Benjamin A. Pierce; W.H. Freeman and Company, New York; 2008.
30. New Clinical Genetics; Second Edition; Andrew Read and Dian Donnai; Scion Publishing Ltd., UK; 2011.
31. Genetics; Third Edition; Robert F. Weaver and Philip W. Hedrick; Wm. C. Brown Publishers (The McGraw-Hill Companies, Inc.); 1997.
32. Human Molecular Genetics; Fourth Edition; Tom Strachan and Andrew Read; Garland Science, USA; 2011.
33. Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978.
Human Genetics - An Overview; Alice Marcus; Narosa Publishing House; 2010.
34. 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/
35. Bioinformatics - Concepts, Skills, and Applications; S.C. Rastogi & others; CBS Publishing; 2003.
36. Bioinformatics - A practical guide to analysis of Genes & Proteins; Andreas D Baxevanis& B F Francis; John Wiley; 2000.
37. Introduction to Bioinformatics; 1st Edition; T K Attwood, D J parry-Smith; PearsonEducation, 11th Reprint; 2005.
38. 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.
39. Basic Bioinformatics; S. Ignacimuthu, S.J.; Narosa Publishing House; 1995.
40. An Introduction to Bioinformatics Algorithms; Neil C. Jones and Pavel A. Pevzner; MITPress, First Indian Reprint; 2005.
41. Bioinformatics - Managing Scientific Data; Zoe Lacroix, Terence Critchlow; Morgan Kaufmann Publishers (Elsevier Science); 2003 (for the V unit).
42. Phylogenetics: Theory and Practice of Phylogenetic Systematics; Second edition; Bruce
43. S. Lieberman; Wiley-Blackwell; 2011.
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49. Systems Metabolic Engineering; Dr. Christoph Wittmann, Sang Yup. Lee; Springer; 2012
Bioinformatics (Bios Instant Notes); Second Edition (Special Indian Edition); T. Charlie
50. Hodgman, Andrew French and David R. Westhead; Garland Science (Taylor and Francis Group); 2010.
51. Understanding Bioinformatics; Marketa Zvelebil and Jeremy O. Baum; Garland Science(Taylor and Francis Group); 2008.

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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.

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1. Essentials of Environmental Science; N. Vasudevan; Narosa Publishing House Pvt. Ltd. New Delhi 110002.
2. Environmental Biology; P.S Verma, V.K Agarwal; S. Chand & company Ltd. New Delhi 110055.
3. A textbook of Environmental Science; Arvind Kumar; A P H Publishing Corporation, NewDelhi 110002.
4. Environmental Biotechnology - Basic Concepts and Application; Indu Shekhar Thakur; I.
5. K. International Pvt. Ltd. New Delhi 110016.
6. Text book of environmental science; S. C. Santra.Wild life management; Rajesh Gopal.
7. Wildlife Management and Conservation - Contemporary Principles and Practices**;** Paul R.Krausman and James W. Cain III.
8. Wildlife Ecology, Conservation, and Management; John M. Fryxell, Anthony R. E. Sinclair, Graeme Caughley.
9. Molecular Biotechnology - Principles and Practices; Channarayappa.Biotechnology - P. K. Gupta.
10. Biotechnology - B. D. Singh.
11. 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.
12. Practical Pharmacognosy- Gokhale, S. B. and Kokate, C. K.Text book of Pharmacognosy; T. E. Wallis.
13. Zoogeography - The Geographical Distribution of Animals; Philip J. Darlington JR;
14. Academic Publishers, Kolkata Animal Geography - ewbegin. Vertebrate Paleontology Romer.
15. Ecological animal geography- Allee, Park and Schmidt.
16. 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, DigantaBhusan 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 Choiceto 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 wildlife 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.

EvALUATION SCHEME

Scheme of Examination (Theory, Internal Assessment and Practical Examinations)

a) External assessment of SIXTY (60) marks per course per semester should be conducted as per the following skeleton question paper pattern.

b) Internal Assessment of FORTY (40) marks per course per semester should be conducted

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

Marks Distribution and Passing Criterion for Each Semester

SEMESTER -V							
Theory				**Practical**			
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSZO5T1	40	16	60	24	BNBUSZO5P1	100	40
BNBUSZO5T2	40	16	60	24			
BNBUSZO5T3	40	16	60	24	BNBUSZO5P2	100	40
BNBUSZO5T4	40	16	60	24			
SEMESTER -V**I**							
Theory				**Practical**			
BNBUSZO6T1	40	16	60	24	BNBUSZO6P1	100	40
BNBUSZO6T2	40	16	60	24			
BNBUSZO6T3	40	16	60	24	BNBUSZO6P2	100	40
BNBUSZO6T4	40	16	60	24			

I. EXTERNAL EVALUATION (THEORY)
SKELETON- EXAMINATION PATTERN (THEORY)

Time: 2 hours **Total marks: 60**

Q1	Based on Unit 1	12 marks
Q.2.	Based on Unit 2	12 marks
Q.3.	Based on Unit 3	12 marks
Q.4.	Based on Unit 4	12 marks
Q.5.	Based on all four Units	12 marks

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

Theory Examination Skeleton Question Paper

All Questions are compulsory

Figures to the right indicate full marks

Time: 2 hours			**Total marks 60**
Q.1.	**UNIT 1**	Answer any two out of three (6 marks each) OR Answer any three out of five (4 marks each)	12 marks
Q.2.	**UNIT 2**	Answer any two out of three (6 marks each) OR Answer any three out of five (4 marks each)	12 marks
Q.3.	**UNIT 3**	Answer any two out of three (6 marks each) OR Answer any three out of five (4 marks each)	12 marks
Q.4.	**UNIT 4**	Answer any two out of three (6 marks each) OR Answer any three out of five (4 marks each)	12 marks
***Q.5.**	**All Units**	**A.** Objective type questions: (eight Que.)… **8 marks** **B.** Answer in one sentence / Give one word OR Define the term (four Que.) ..... **4 marks** **OR** All **12 objective** questions (mixed from unit1 to unit4) **(all questions, will carry 1 mark each)**	12 marks

***For Question 5 it is recommended to have objective questions such as –**

(a)	Match the column	(b)	MCQ
(c)	Give one word for	(d)	True and False
(e)	Define the term	(f)	Answer in one sentence etc.
(g)	Fill in the blanks	(h)	Define/ give one word

II. INTERNALS EVALUATION

Part I: Curriculum	Part II: Extra- curriculum	Part III : Community services	Part IV: Attendance and/or Leadership qualities
Assignments/Projects/ Field studies/ Special Expedition's reports/ Quiz/ Model making PPT Presentation/ Book review/ Zoological documentary movie review/ Debate/ Tutorials/ Test (optional)	Nature Photography with descriptions/ Conference reports /Writing and publishing news article/ Research Aptitude: Paper publication in JBNB/ Research article presentation in conferences/ Article writing /Abstract writing/ certification from Swayam or MOOC or equivalent /	Laboratory/ Library/ Instrument Maintenance/ General Volunteering Co-curricular committees/ Other community services/ excursion management or volunteering/ any extraordinary help to the institute	Attendance 90% or above will secure full marks OR Leadership in conference organization of the department/ Cultural/ NSS/ Gymkhana/ NCC/ Magazine Committee
20 Marks	**10 Marks**	**05 Marks**	**05 Marks**

N.B.

1. Continuous evaluation shall be assured through the semester.
2. In-charge teachers should avoid conducting test in the curriculum as far as possible.
3. A diary shall be maintained by the student which will be submitted to the In-charge Teacher periodically for the assessment.
4. Students must report and obtain signature of the In-charge teacher after every valid activity for the consideration of the credit of marks duly certified by the concerned authority.
5. In-charge teacher should have the freedom to change criterion or introduce new criterion in all the parts (part I to Part IV) for internal evaluation.

Internal Examination on Curriculum: (Class Test Pattern) (Optional)

Instructions:

All Questions are compulsory

Figures to the right indicate full marks

Duration : 30 Minutes **Total Marks : 20**

	All Questions shall be mixed type based on Unit 1 to Unit 4	
Q. 1	Objective type:- **MCQs** / True or False / Match the following	04
Q. 2	Answer in one word/ sentence / Definitions (**any six** out of total **eight** que.)	06
Q. 3	Answer in brief (**any two** out of total **four** que.)	10

T. Y. B. Sc. Zoology: Semester V (Practical)
Course Code: BNBUSZO5P1:
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: BNBUSZO5P1:
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: BNBUSZO5P2:
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: BNBUSZO5P2:
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 30

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

Q.3 Viva-voce 05

Q.4 Journal 05

T. Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: BNBUSZO6P1:
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 givendiagram 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: BNBUSZO6P1:

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 glandse) 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: BNBUSZO6P2:

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.	15
	OR	
Q.1	Isolation & Estimation of DNA by Diphenylamine method.	
Q.2	Separation of Genomic DNA by Agarose gel electrophoresis.	09
	OR	
Q.2	Colorimetric estimation of proteins from given sample by Folin's method.	
Q.3	Problems based on Restriction endonucleases (any two).	08
	OR	
Q.3	Calculation of mitotic index from the photograph or stained preparation of onion root tip or cancer cells.	
	OR	
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:	08
	BLAST for nucleotide sequence comparison.	
	OR	
	Databases at NCBI for querying a nucleotide / protein sequence with the helpof suitable operator.	
	OR	
	PubMed for downloading a research paper of interest with the help of suitable operator.	
Q.5	Viva voce	05
Q.6	Journal	05

T.Y. B. Sc. Zoology: Semester VI (Practical)
Course Code: BNBUSZO6P2:
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 financialconstraints.	10
Q.7	Journal	05
Q.6	Viva voce	05

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

There will be a "Research Project" component that is optional and meets the needs of advanced learners and those seeking higher studies and/or careers in research. Because the Research Project is optional, its credits are in addition to those otherwise assigned to the B.Sc. programme in Zoology. Therefore, the credits of the research project are considered as additional credits whose performance will be evaluated separately. Needless to mention that the marks / GPA / grade obtained by the learner in the research project in both the semesters i.e. V. and VI, will have to appear separately on the mark sheet or be certified separately by the University of Mumbai. These grades will not be added to the total of the programme and will not be considered for the class / grade / GPA / merit / rank for this programme of the University of Mumbai. The evaluation of the research project is carried out by assigning tasks to the examiners in one or more centres in each district, where the learners who have completed the projects are invited for evaluation on a day set for this purpose by the chairman of the practical examinations, who plans, coordinates and officially announces this through the University. The remuneration for the evaluation of the research project is determined by the University from time to time.

Learners may seek guidance for the research project from a mentor, who may be a teacher from his/her college or another college or from industry; however, it is not mandatory to have a mentor, as the researchproject may be conducted independently. The evaluation will be based on the spiral-bound proposal submitted in Semester V and the dissertation submitted in Semester VI, together with the viva voce conducted by the examiner, the details of which are as follows

In the V semester, learners submit a sketch/scheme/project proposal that is evaluated by an external examiner. The evaluation will be based on the following guidelines such as literature review / survey, objectives, work plan, materials and methods, rationale, hypothesis, expected outcome, relevance and bibliography, etc., as presented in the spiral-bound research proposal, which will be awarded 25 points, in Semester V. The viva conducted by the concerned external examiner on this proposal will be awarded 25points. If desired, the learner may prepare a PowerPoint presentation on the research proposal. A total of 50 marks will be awarded for the research proposal in Semester V, credited as (01).

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 withdissertation shall carry 50 marks having credit of (01) in semester VI.

A list of candidates offering the project and the titles of their respective projects should be provided by the College along with the application for examination 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.

Syllabus for
T.Y.B.Sc. Fishery Biology, Semester V
Course BNBUSFBIO5T1, and BNBUSFBIO5P1
To be implemented from Academic Year 2023-24
(Any 4 Units to be Opted)

	SEMESTER-V (THEORY)		
Sr. No.	**BNBUSZO5T5**	**No. of lectures**	**Learning pleasure**
	Oceanography, Aquaculture Practices, Marketing and Finance		
	Unit 1: Oceanography	**15L**	**25hrs**
	Objectives: • *To study different instruments and equipments in navigation and oceanography.* • *To introduce physical, chemical and biological oceanography*		
	Desired outcome: • *Learner shall understand and learn about the use of sea safety, navigational equipment and oceanographic instruments* • *Learner shall understand basic physical, chemical and biological oceanography*		
1.1	**Navigational and sea safety equipments** 1. Life saving devices 2. Global Positioning System (GPS) 3. Rudder 4. Signaling devices	**03L**	**05hrs**
1.2	**Oceanographic Instruments** 1. Niskin water sampler 2. Peterson's grab 3. Dredges 4. Fish finding instruments / Methods 5. Remote sensing	**06L**	**11hrs**
1.3	**Introduction to basic physical, chemical and biological oceanography**	**06L**	**09hrs**

	Unit: 2: Crafts and Gear	15L	26hrs
	Objectives: • *To study the process of boat building, materials used and various types of dieselengines* • *To study various types of nets used in fishery*		
	Desired outcome: • *Learner shall comprehend boat building techniques and design of engines usedin mechanized boats* • *Learner shall understand the operations of various types of nets and fishingmethod*		
2.1	**Basic boat building** 1. (parts, design, material used), 2. methods of protection from foulers and borers	**04L**	**07hrs**
2.2	**Basic studies of marine engines** 1. Outboard and Inboard Engines 2. Sectional View of 2-stroke and 4-stroke Diesel engines 3. Winch and Deck Side Equipment	**05L**	**09hrs**
2.3	**Operations** 1. Gill, Trawl, Purse seine Nets 2. Hooks and Lines 3. Non-conventional Fishing Methods such as • Light Fishing • Hose Pipe Fishing • Electric Fishing	**06L**	**10hrs**
	Unit: 3 Farming of major carps	**15L**	**30hrs**
	Objectives: • *To study and develop skills in breeding techniques, hatchery, nursery andmanagement of various carps.* • *To study and explore various techniques used in fishery and poly culturepractices*		

	Desired outcome: • *Learner will understand breeding techniques and skills for culture of major carps.* • *Learner will comprehend hatchery and nursery management of major carps.*		
3.1	**Breeding techniques of major carps and common carp**	**06L**	**13hrs**
3.2	**Hatchery and nursery management of:** 1. Major Carps-IMCs: *Labeo rohita* (Rohu), *Catla catla* (Catla), *Cirrhinus mrigala* (Mrigal) 2. Exotic carps: *Hypophthalmichthys molitrix* (Silver carp), *Ctenopharyngodon idella* (Grass carp) *Cyprinus carpio* (Common carp)	**05L**	**08hrs**
3.3	**Mono-culture and polyculture practices:** 1. Extensive 2. Semi-intensive 3. Intensive	**04L**	**07hrs**
	Unit 4: Introduction to other commercial aquaculture practices in fresh water	**15L**	**25hrs**
	Objectives: • *To develop skills and understanding of breeding and rearing of sewage-fedfishery, Basa cat fish and Tilapia by novel ways*		
	Desired Outcome: • *Learner will be equipped to carry out entrepreneurial operations or gainconfidence to work in freshwater prawn unit* • *Learner will gain knowledge about how to breed and rear ornamental fishes andcommercially viable fish species*		
	Macrobrachium rosenbergii **(Freshwater prawn)** 1. Breeding, life cycle, hatchery management *2.* Monoculture of *Macrobrachium rosenbergii* *3.* Composite culture of major carps and *Macrobrachium rosenbergii*	**05L**	**09hrs**

	Ornamental fishes – breeding and rearing: 1. Egg layers: • *Danio spp.* (Danio) • *Pterophyllum spp.* (Angel) • *Symphysodon spp.* (Discus) • *Paracheirodon innesi* (Neon tetra) • Flower horn (Hybrid variety) • *Betta splendens* (Siamese fighter)	**03L**	**05hrs**
	2. Live bearers: • *Poecilia reticulate* (Guppy) • *Xiphophorus hellerii* (Swordtail) • *Poecilia velifera* (Tangerine) • *Poecilia sphenops* (Molly) • *Xiphophorus maculatus* (Platy)	**03L**	**05hrs**
4.3	**Breeding and rearing of:** *3.* Sewage-fed fishery of air breathing fish: *Pangasianodon hypophthalmus* (Stripedcatfish), *Clarius spp.*, *Heteropneustes spp.* and *Anabas spp.* *4.* *Pangasius bocourti* (Basa Catfish) *5.* All meal (Less bones) *Tilapia* – GIFT (Genetically Improved Farmed *Tilapia)*	**04L**	**06hrs**
	Unit: 5 Culture of shell fishes and fin-fish	**15L**	**23hrs**
	Objectives: • *To study breeding techniques, hatchery and management of fin-fish and shellfishes* • *To study rearing practices of fin-fish and shell fishes.* • *To study culture of brackish water shrimp*		
	Desired Outcome: • *Learner shall understand breeding techniques, hatchery and management of fin-fish and shellfishes.* • *Learner shall understand the rearing techniques*		

5.1	**Breeding, hatchery, nursery management and rearing (extensive, semi-intensive,intensive)** 5 Fin-fish – *Lates calcarifer* (Sea bass) 6 *Litopenaeus vannamei* (Brackish water prawn or Pacific white shrimp) 7 *Scylla serrata* (Giant mud Crab) 8 *Pinctada vulgaris* (Pearl)	**15L**	**23hrs**
	Unit 6: Quality control and packaging	**15L**	**27hrs**
	Objectives: *To comprehend various aspects of quality control and packaging involved in fishprocessing and marketing*		
	Desired Outcome: • *Learner will be oriented towards understanding the various stages of quality control* • *Learner will gain knowledge about the postmortem changes, spoilage mechanisms and methods involved in evaluating the freshness and quality of fishes and prawns / shrimps* • *Learner shall comprehend the value of maintaining and taking sanitary precautions during the processing and packaging operations*		
6.1	**Post mortem changes and mechanism of spoilage:** 5 Hyperaemia 6 Rigor mortis 7 Autolysis 8 Rancidity	**04L**	**07hsr**
6.2	Brief methods for evaluating freshness and quality of fish and prawns / shrimps 1. Organoleptic 2. Microbial 3. Chemical	**04L**	**07hsr**
6.3	**Sanitary operations** 1. Maintenance of hygiene of food contact surfaces, storage and equipment 2. Water quality, ice, sewage and waste water disposal and effluent treatment plant	**03L**	**06hsr**

6.4	Various packaging materials used in freezing and canning industry 1. Polyolefin 2. Wax duplex carton 3. Master carton 4. Can 5. Lacquered can 6. Retort 7. Freezing procedures including hygienic washing, dressing	**04L**	**07hsr**
6.5	**Quality Policy and Quality Analysis: ISO 22000/HACCP/ BRC/IFS**		
	Unit: 7 Marketing and finance	**15L**	**27hrs**
	Objectives: • *To acquaint and instill knowledge of the fundamentals of marketing and financerequired for entrepreneurship in fishery related enterprises and co-operatives*		
	Desired outcome: • *Learner shall acquire knowledge about traditional marketing practices and role ofco-operatives in selling fish.* • *Learner shall be exposed to the avenues and procedure for raising funds for fishery related entrepreneurial practices*		
7.1	**Traditional marketing** vis-a-vis role of fishery co-operatives with referenceto operations at Satpati, Sasoon dock and Karanja	**04L**	**06hrs**
7.2	**Global marketing** and Export-Import procedures and role of Marine ProductsExports Development Authority (MPEDA)	**04L**	**06hrs**
7.3	**Fund raising:** 1. Financial institutions 2. Schemes and subsidies 3. Basic accounting 4. Costing and feasibility report i. Role of NABARD (National Bank for Agriculture and Rural Development) for refinancing and NFDB (National Fishery Development Board, Hyderabad) for funding through the State Government	**07L**	**15hrs**

	Unit 8: Case Study and Simulation	15L	25hrs
	Case Study and Simulation is one of the eight units and hence may or may not be optedby the college. If opted, teachers in consultation with the students shall select the case studies for this unit every year, if required, and shall seek endorsement of the Head andthe Principal. Colleges/ Institutes have to select the topics as per their needs and available resources.It is pertinent to note that the case studies and simulations shall be operational and available in the syllabus only till it comes under the scope of internal assessment		
	Objectives: • *To inculcate entrepreneurial abilities and skills so as to make the learner confident and prepare them to raise new projects and venture in the realm offishery biology* • *To understand the concepts and to develop the acumen of the learner in a betterway* • *To assess varying dimensions while taking decisions in fishery biology*		
	Desired outcome: • *Learner will gain technical and financial knowledge in fishery biology businessventures.* • *Learner will develop better acumen so as to take wise and necessary decisionswhile participating in fishery biology related projects*		
8.1	**(Any eight from suggested below or more, developed by teacher)** 1. Sawantwadi New Fish Market developed through NFDB funding 2. Trilok foods, an RTE industry established as PPP through DST funding 3. Sewage-fed fishery; Kolkata model 4. Pancham Aquaculture 5. Naik Oceanic 6. Aquaponics, Hydroponics 7. Mahseer Ranching at Dehu	**15L**	**25hrs**

	SEMESTER III (PRACTICAL
	Practical BNBUSZO5P5 (Course - V)
1	Identification and functioning of oceanographic instruments: 1. Niskin water sampler 2. Peterson's Grab 3. Dredge
2	Layout of fishing vessels and sectional view of 2 stroke and 4 stroke dieselengines, lifesaving equipment, winch and deck side equipment.
3	Identification of various stages of development of carps and study of sexualdimorphism in adults. A. Indian major carps: 1. *Labeo rohita* (Rohu) 2. *Catla catla* (Catla) 3. *Cirrhinus mrigala* (Mrigal) B. Exotic carps: 1. Cyprinus carpio (Common Carp) 2. Hypophthalmichthys molitrix (Silver Carp) 3. Ctenopharyngodon idella (Grass Carp)
4	Identification of 1. *Litopenaeus vannamei* (Pacific white shrimp) and 2. *Macrobrachium rosenbergii* (Freshwater prawn) 3. Study of sexual dimorphism in adults.
5	Identification of fishes: 1. Anabas testudineus (Climbing perch) 2. Clarius batrachus (Walking catfish) 3. Boleophthalmus spp. (Mudskipper) 4. Pangasianodon hypophthalmus (Iridescent shark) 5. Pangasius bocourti (Basa catfish) 6. *Tilapia*(GIFT)

6	Identification of: A. Ornamental fishes: 1. *Pterophyllum spp.* (Angel) 2. *Xiphophorus hellerii* (Swordtail) 3. *Paracheirodon innesi* (Neon tetra) 4. *Betta splendens* (Siamese fighter) 5. *Danio spp.* (Danio) 6. *Symphysodon spp.* (Discus) 7. Flower Horn (Hybrid variety) B. Aquatic plants: 1. Ludwigia 2. Cabomba *3.* Corkscrew *Vallisneria* 4. Aquarose 5. Amazon Sword plant C. Aquarium accessories: 1. Aerator 2. Under Gravel Filter 3. Internal Filter 4. External / Canister Filter 5. Food dispensers
7	Study of models and functioning of D 81 hatchery, Shirgur's hatcheries and Chinese hatchery.
8	Microbial studies: 1. Dilution of sample 2. Gram staining technique 3. Identification of Bacilli, Cocci, Vibrio bacteria
9	Organoleptic tests for fish and prawn / shrimp
10	Total Plate Count (TPC) of bacteria from fish
11	Identification of packaging materials: 1. Waxed duplex carton 2. Master carton 3. Simple cans 4. Coated [Lacquered] cans 5. Polyolefin 6. Retort

12	Estimation of toxins and moulting retardant 1. H2S (qualitative) 2. Ammonia (qualitative) 3. Ca (quantitative) 4. Mg (quantitative)
13	Photographic documentation of fishery biology related topics. Submission of ~~5~~ hard and soft copies of 5 original photographs taken by the learner (exact details required).
14	Assignment (may be submitted in a group not exceeding three students)

Please refer the Annexure I for the suggested topics for assignment for Course code USACFBIO5P1.

***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:

A. 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).

B. 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:

i. A Committee for the Purpose of Care and Supervision of Experimental Animals (CPCSEA) and

ii. A Dissection Monitoring Committee (DMC) to ensure that no dissections or mountings are done using animals.

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 neighboring colleges.

Semester VI

Syllabus for
T.Y.B.Sc. Fishery Biology, Semester V
Course BNBUSFBIO6T1, and BNBUSFBIO6P1
To be implemented from Academic Year 2023-24
(Any 4 Units to be Opted)

	SEMESTER V (THEORY)		
Sr. No	**BNBUSZO6T5**	**No. of lect.**	**Learning pleas**
	Marine resources, Post-harvest and Farm Engineering		
	Unit 1: Marine Fin-fish of India	**15L**	**30h**
	Objective: • *To study coastal and deep sea fishes* • *To study commercial potential and major landing centres*		
	Desired outcomes: • *Learner shall understand deep sea and coastal fishes.* • *Learner shall understand commercial potential and know about the major landingcentres of the fishes*		
1.1	**Coastal fisheries:** 1. *Stromateus cinereus* (Silver pomfret) 2. *Stromateus niger* (Black pomfret) 3. *Polynemus tetradactylus* (Threadfin) 4. *Pseudosciaena diacanthus* (Two-spined Jewfish or Ghol) 5. *Synagris japonicus* (Blackmouth splitfin) 6. *Scomber microlepidotus* (Mackerel) 7. *Cybium guttatum* (Seerfish or Surmai) 8. *Sardinellal ongiceps* Indian Oil Sardine	**09L**	**18hrs**

1.2	**Deep sea fisheries (more than 45 fathoms) of Indian exclusive economic zone** 1. *Thunnus alalunga* (Longfin tuna) 2. *Sarda orientalis* (Striped bonito)	**04L**	**10hrs**
1.3	**Commercial potential and major landing centres of the above fishes**	**02L**	**04hrs**
	Unit: 2: Marine shell fish of India	**15L**	**30hrs**
	Objective: • *To develop an in-depth understanding of crustacean and molluscan fisheries*		
	Desired outcomes: • *Learner shall understand crustacean and molluscan fisheries* • *Learner shall understand the performance of landing centres of above fisheries*		
2.1	**Crustacean fisheries** 1. *Penaeus monodon* (Giant tiger prawn) 2. *Penaeusn ndicus* (Indian prawn) 3. *Metapenaeus affinis* (Jinga shrimp) 4. *Parapenaeopsis stylifera* (Kiddi shrimp) 5. *Acetes indicus* (Jawala paste shrimp) 6. *Panulirus polyphagus* (Mud spiny lobster) 7. *Scylla serrata* (Giant mud crab)	**08L**	**16hrs**
2.2	**Molluscan fisheries** 1. *Crassostrea spp.* (Oyster) 2. *Sepia pharaonis* (Pharaoh cuttlefish) 3. *Loligo duvaucelii* (Indian squid)	**04L**	**08hrs**
2.3	2.1 Commercial potential and major landing centres of the above shell fishes	**03L**	**06hrs**
	Unit 3: Nutrition	**15L**	**28hrs**
	Objective: • *To study, acquaint and discover the growing market for fish nutrition*		

	Desired outcome: • *Learner will get acquainted with basics of nutritional requirements at various developmental stages of fish and crustaceans*		
3.1	**Nutritional requirements at various stages of development of fish and crustaceans**	**06L**	**08hrs**
3.2	**Culture of natural feed**: 1. *Chaetoceros* 2. *Infusoria* 3. *Artemia* 4. *Brachionus* 5. *Daphnia* / *Moina spp.*		
3.3	3.1 Algology – Identification and culture of commercially important nutritious algae andits products	**03L**	
3.4	Formulated / Pelleted feed – Understanding the composition and use of formulatedfeed for fish and prawns / shrimps at various stages	**03L**	**10hrs**
	Unit 4 :Diseases	**15L**	**27hrs**
	Objective: • *To acquire knowledge of the various aspects of diseases affecting fishes.*		
	Desired outcomes: • *Learner will be oriented towards understanding causes, pathogenicity, prophylaxis and preventive measures of various fish diseases and physiological disorders.*		
4.1	**Viral diseases, prophylaxis and preventive measures.**	**04L**	**07hrs**
4.2	**Bacterial, fungal, protozoan infections and treatment.**	**04L**	**07hrs**
4.3	**Crustacean infections and treatment.**	**04L**	**07hrs**
4.4	**Physiological disorders (Dropsy) / diseases and treatment.**	**03L**	**06hrs**

	Unit 5: Preservation and Processing	**15L**	**30hrs**
	Objective: • *To derive knowledge about various fish preservation and processing methods*		
	Desired outcome: • *Learners will acquire the knowledge and would put in to practice the preservationand processing techniques for commercial ventures*		
5.1	**Traditional methods and their modifications**: 1. Icing 2. Drying 3. Salting	**04L**	**08hrs**
5.2	**Introduction to refrigeration: Types and properties of refrigerants** 1. Types of freezers: a. Brine b. Air blast c. Tunnel d. Contact plate e. Cryo-quick f. IQF: Individual Quick Freezing 2. Freezing Procedures: a. PUD (Peeled and Un-deveined) b. DV (Deveined)	**06L**	**12hrs**
5.3	**Principle and steps involved in can reform and canning of fish and shrimp in variousmedia.**	**03L**	**5hrs**
5.4	**Equipment and utensils used in seafood processing**	**02L**	**05hrs**
	Unit 6: **By-products and Value Added Products**	**15L**	**30hrs**
	Objective: • *To acquire knowledge of fish by-products, value-added products and goodmanufacturing practices.*		

	Desired outcome: • *Learner will gain sound knowledge about the fish by-products and value-addedproducts.* • *Learner will explore good manufacturing practices while manufacturing theseproducts.*		
6.1	**Proximate composition of fish meat and products.**	**04L**	**05hrs**
6.2	**Introduction to by-products:** 1. Fish protein concentrate 2. Fish maws / Isinglass 3. Fish hydrolysates 4. Chitin, Chitosan 5. Glucosamine hydrochloride 6. Gelatin 7. Fish silage 8. Surimi and imitation products 9. Pearl essence	**09L**	**08hrs**
6.3	**Different types of value added products from fish and shell fish:** 1. Fish / Prawn / Shrimp pickle 2. Fish wafers 3. *Acetes indicus* (Prawn) chutney 4. Fish soup powder 5. Fish / Crab steaks 6. RTE (Ready To Eat) 7. Battered and breaded products 8. Marinated tandoori prawns 9. Prawn curry	**05L**	**08hrs**
6.4	**Good manufacturing practices: Health and training of personnel, hygiene.**	**04L**	**05hrs**
	UNIT 7: Farm engineering	**15L**	**23hrs**
	Objective: • *To acquire knowledge about farm engineering and novel fish culture practices.*		

	Desired Outcome: • *Learner will understand the selection process of hatchery sites and various typesof designs and construction of aquaculture farm practices* • *Learners will comprehend the uses of equipment and accessories involved inaquaculture farms*		
7.1	Site selection, designing and construction of hatchery and farms for extensive, semi-intensive and intensive freshwater / brackish-water aquaculture.	**04L**	**06hrs**
7.2	**Types of Confinement culture** 1. Raft culture 2. Rope culture 3. Pen culture 4. Cage culture with special reference to *Rachycentron canadum* (Cobia)	**08L**	**12hrs**
7.3	**Equipment and accessories used in various aqua farms**	**03L**	**05hrs**
	Unit 8: Open Unit	**15L**	**30hrs**
	Open unit is one of the eight units which may or may not be opted by the college. Teachers in consultation with the students shall define syllabus under this unit every year, if required, and shall seek endorsement of the Head and the Principal. Colleges/institutes have to select the topics as per their needs and available resources. It is pertinent to note that the open unit shall be operational and available in the syllabus only till it comes under the scope of internal assessment.		
	Objective: • *To teach any one of the units prescribed in the syllabus with more details and in-depth knowledge leading to specialization in the capsule of units selected.* • *To incorporate the topics of special need of the area that are otherwise not covered in the syllabus.* • *Teachers will have freedom to deal with the latest developments in the subject without wanting for the university to revise the syllabus*		
	Desired Outcome: • *Students will be introduced most recent and advanced knowledge in the field and will carry updated knowledge thereby in securing a better career or the self-employment.* • *Student may help student to develop new concept in aquaculture or imply knowledge in his/her research activities.*		

	SEMESTER IV (PRACTICAL)
	Practical BNBUSZO6P5 (Course - XA)
1	**Identification of marine fishes.** 1. *Stromateus cinereus* (Silver pomfret) 2. *Stromateus niger* (Black pomfret) 3. *Polynemus tetradactylus* (Threadfin) 4. *Pseudosciaena diacanthus* (Two-spinned jewfish or Ghol) 5. *Trichiurus haumela* (Ribbon fish) 6. *Synagris japonicus* (Blackmouth splitfin) 7. *Scomber microlepeidotus* (Mackerel) 8. *Cybium guttatum* (Seerfish or Surmai) 9. *Sardinella longiceps* (Indian Oil Sardine) 10. *Thunnus alalunga* (Longfin tuna)
2	**Identification of Crustaceans and Molluscs**. 1. *Penaeus monodon* (Giant Tiger Prawn) 2. *Metapenaeus affinis* (Jinga shrimp) 3. *Parapenaeopsis stylifera* (Kiddi shrimp) 4. *Acetes indicus* (Jawala paste shrimp) 5. *Panulirus polyphagus* (Mud spiny lobster) 6. *Scylla serrata* (Giant mud crab) 7. *Crassostrea spp.* (Oyster) 8. *Sepia pharaonis* (Pharaoh cuttlefish) 9. *Loligo duvaucelii* (Indian squid)
3	Preparation of formulated feed for fish and prawn.
4	**Identification of parasitic infections in aquatic organisms**. 1. Fungal – Dermatomycosis 2. Bacterial – Fin/Tail rot and Dropsy 3. Protozoan – Costiasisand White Spot 4. Crustacean – Argulosis
5	Fish dressing, filleting, prawn peeling – PUD, DV and grading.
6	Fish morphometry – Length weight relationship of a suitable fish.
7	Preparation of Surimi, Fish protein concentrate.

8	Preparations of fish burger, fish fingers, fish/prawn pickle, fish chutney, fish curry.
9	Preparation of Chitin – Chitosan, Pearl essence.
10	**Identification of various farm equipment such as:** 1. Feeding cups / Trays 2. Paddle wheel aerator 3. Fountains 4. Sluice gate models 5. Elbow pipe outlets
11	Study of models of raft, pen, cage culture and materials used in rope culture.
12	Project – Feasibility / Scientific.
13	Field Visit Report.

***Please refer the Annexure II for the suggested field visits and Annexure – III forsuggested topics for projects for Course code BNBUSFBIO6P1*.**

***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 practical mentioned here-inabove.**
 # There shall be at least one excursion / field trip.
For Additional and Latest Information on the topics, various Web Sites can be visited.

N.B:

A. 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).
B. 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:
   a. A Committee for the Purpose of Care and Supervision of Experimental Animals (CPCSEA) and
   b. A Dissection Monitoring Committee (DMC) to ensure that no dissections or mountings are done using animals.

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.

Semester V and IV
Fishery Biology
References and additional reading

BNBUSZO5T5 and BNBUSZO6T5

1) A Text Book of Marine Ecology by Nair M.B. and Thumpy D.H. – Tata MacGraw Hill Pub. – New Delhi.
2) An Introduction to Fishes by Khanna S.S. – Central Book Depot, Allahabad (1993).
3) Aquaculture, Principles and Practices by Pillay T.V.R. – Fishing New Books (1988).
4) Course Manual in Fishing Technology by Latha Shenoy, CIFE, Versova, Mumbai.
5) Crafts and Gear of India by Y. Shrikrishnan and Latha Shenoy – ICAR Pub.
6) Ecological Methods for Field and Laboratory Investigations by P. Michael. TheOceans By Svedrup H.V. – et.al. - Asian Pub. House.
7) Financial management by Prasanna Chandra- Seventh Edition.
8) Financial management by Khan and Jain.
9) Financial management by I. M. Pandey.
10) Fish Biology by C.B.C. Srivastava – Narendra Pub. House.
11) Fish and Fisheries by Chandy – National Book Trust.
12) Fish and Fisheries in India – by Jhingran V.G. – Hindustan Pub. Corporation – NewDelhi.
13) Fisheries Biology, Assessment and Management by Michael King – Fishing News Publishers (1995).
14) Fishery Science by Samtharam R. – Daya Pub. House – 1990.
15) Fisheries Bioeconomics – Theory, Modelling and Management – FAO Fisheries Technical Paper 368 – FAO, 2001.
16) General and Applied Ichthyology by Gupta and Gupta, S Chand Publishers.
17) Handbook of Fish Biology and Fisheries Edited By J.B. Hart and John Reynold.
18) Hand Book of Fresh Water Fishes of India by Beaven C.R. – Narendra Pub. House.
19) Introductory Oceanography by Harold Thurman – Printis Hall Pub. London – 8th Edition.
20) Marine Ecology by Tait R.B. – Oxford Press.
21) Marine Fish and Fisheries by Dr. D. V. Bal and K.V. Rao - Tata MacGraw Hill Pub. – New Delhi.
22) Marketing Management by Philip Kotler.
23) Modern Fishing Gear Technology by N. Shahul Hameed, Boopendranath – DayaPub. House – 2000.

24) Prawn and Prawn Fisheries by Kurian and Sebestian.
25) Project Management by Prasanna Chandra.
26) Refrigeration and air conditioning By C. P. Arora published in 1981.
27) Technology for forming of Pacific White Shrimp *Litopenaeus vannamei* in inland saline soils using ground saline water by Lakra, Reddy and Harikrishna, CIFE and ICAR.
28) Text Book of Fish Biology and Indian Fisheries by Dr. R. P. Parihar, Central Pub. House, Allahabad.
29) The Book of Indian Shells by Deepak Apte – Oxford Uni. Press.
30) Wealth of India – Vol. IV – CSIR Pub.

For Additional and Latest Information on the topics, various Web Sites can be visited.

EVALUATION SCHEME

Marks Distribution and Passing Criterion for Each Semester

SEMESTER -V							
Theory				**Practical**			
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSZO5T5	40	16	60	24	BNBUSZO5P5	100	40
SEMESTER VI							
Theory				Practical			
Course Code	Internal	Min marks for passing	Theory Examination	Min marks for passing	Course Code	Practical Examination	Min marks for passing
BNBUSZO6T5	40	16	60	24	BNBUSZO6P5	100	40

I. INTERNALS EVALUATION

Part I: Curriculum	Part II: Extra- curriculum	Part III : Community services	Part IV: Attendance and/or Leadership qualities
Assignments/Projects/ Field studies/ Special Expedition's reports/ Quiz/ Model making PPT Presentation/ Book review/ Zoological documentary movie review/ Debate/ Tutorials/ Test (optional)	Nature Photography with descriptions/ Conference reports /Writing and publishing news article/ Research Aptitude: Paper publication in JBNB/ Research article presentation in conferences/ Article writing /Abstract writing/ certification from Swayam or MOOC or equivalent /	Laboratory/ Library/ Instrument Maintenance/ General Volunteering Co-curricular committees/ Other community services/ excursion management or volunteering/ any extraordinary help to the institute	Attendance 90% or above will secure full marks OR Leadership in conference organization of the department/ Cultural/ NSS/ Gymkhana/ NCC/ Magazine Committee
20 Marks	10 Marks	05 Marks	05 Marks

N.B.

1. Continuous evaluation shall be assured through the semester.
2. In-charge teachers should avoid conducting test in the curriculum as far as possible.
3. A diary shall be maintained by the student which will be submitted to the In-charge Teacher periodically for the assessment.
4. Students must report and obtain signature of the In-charge teacher after every valid activity for the consideration of the credit of marks duly certified by the concerned authority.
5. In-charge teacher should have the freedom to change criterion or introduce new criterion in all the parts (part I to Part IV) for internal evaluation.

Internal Examination on Curriculum: (Class Test Pattern) (Optional)

Instructions:

All Questions are compulsory

Figures to the right indicate full marks

Duration : 30 Minutes **Total Marks : 20**

	All Questions shall be mixed type based on All units	
Q. 1	Objective type:- A] MCQs OR fill in the blanks OR True or False (10 marks) B] Match the following (05 marks)	15
Q. 2	Answer in one word/ sentence OR Definitions	05

II. EXTERNAL EVALUATION (THEORY)

Theory Examination Skeleton Question Paper

Course Code: BNBUSFBIO5T1 and BNBUSFBIO6T1

All Questions are compulsory

Figures to the right indicate full marks

Time: 2 hours			**Total marks 60**
Q.1.	**UNIT 1**	Answer any two out of three (8 marks each) OR Answer any four out of six (4 marks each)	12 marks
Q.2.	**UNIT 2**	Answer any two out of three (8 marks each) OR Answer any four out of six (4 marks each)	12 marks
Q.3.	**UNIT 3**	Answer any two out of three (8 marks each) OR Answer any four out of six (4 marks each)	12 marks
Q.4.	**UNIT 4**	Answer any two out of three (8 marks each) OR Answer any four out of six (4 marks each)	12 marks
***Q.5.**	**All Units**	A. MCQ/ Fill in the blanks/ True or false (Any six out of eight) B. Match the Column **C.** Answer in one sentence OR Give one word OR Define the term (any three out of four or five) **(all questions, 1 mark each)**	12 marks

***For Question 5 it is recommended to have objective questions such as –**

(a)	Match the column	(b)	MCQ
(c)	Give one word for	(d)	True and False
(e)	Define the term	(f)	Answer in one sentence etc.
(g)	Fill in the blanks	(h)	

Course Code: BNBUSFBIO5P1
Practical Skeleton Paper
Course code: BNBUSZO5P5

Time: 4 hrs. **Total Marks: 100**

Q.1 Identification (spots 'a' to 'e') **20**

a. Identify and describe the oceanographic instrument / 2-stroke / 4-stroke engine.

b. Identify and describe lifesaving equipment / deck side equipment

c. Identify and describe accessory respiratory organ / ornamental fish / aquariumplant.

d. Identify and describe the aquarium accessory.

e. Identify and describe the packaging material.

Q.2 Perform organoleptic tests to differentiate fresh and stale fish and prawn. **25**

Q.3 Prepare various dilutions of the given sample of bacteria **15**

OR

Q.3 Quantitative estimation of Calcium / Magnesium from the given water sample **15**

OR

Q.3 Qualitative estimation of NH_3 and H_2S from the given water sample **15**

OR

Q.3 Identify the given bacteria with the help of Gram's Staining technique **15**

Q.4 Submission of following:

a. Five photographs on relevant topics of fishery biology **10**

b. Assignment and viva based on it. **20**

Q.5 Certified journal **10**

Course Code: BNBUSFBIO5P1
Practical Skeleton Paper
Course code: BNBUSZO6P5

Time: 4 hrs. **Total Marks: 100**

Q.1 Identification (spots 'a' to 'e') **20**

- **a.** Identify and describe the given fish w.r.t. fishery.
- **b.** Identify and describe the given crustacean / mollusc w.r.t. fishery.
- **c.** Identify and describe the pathogen and its prevention and treatment of the givenspecimen.
- **d.** Identify and describe farm equipment / model / material.
- **e.** Identify and describe byproducts chitosan / chitin / pearl essence.

Q.2 Prepare the marked by-product / value-added product with suitable method: Surimi/ Fish Protein Concentrate / Fish Burger / Fish or Shrimp Pickle / Chitin / Chitosan. **25**

Q.3 Determine the fish morphometry – Length weight relationship of a suitable fish **15**

OR

Q.3 Demonstrate the technique of fish dressing and filleting **15**

Q.4 Project and viva based on it **20**

Q.5 Field report **10**

Q.6 Certified journal **10**

Annexures Annexure -I

Suggested Topics for Assignment BNBUSFBIO5P1 (Teachers are expected to develop additional innovative topics, varying every year, to be assigned to the students)

1) Market survey for various preserved and processed fish / prawns.
2) Observation on handling of fish on board, at landing centre, in secondary marketand at consumer level.
3) Survey of the local market for the availability of various by-products / value added products and its price.
4) Comparative study of the shelf life of various fishes / fish by-products / value added products in relation to their cost.
5) Study of economics of brackish water pond culture.
6) Study of working of fisheries co-operative societies in your area.
7) Study of cost of construction of fishing vessel and subsidies available for the same.
8) Study of cost of gear manufacturing with different materials and subsidies availablefor the same.
9) Study of cost and profit analysis of any one of the following methods – Trawler / Gill netter / Purse seiner /hooks and lines and Non-mechanized fishing units.
10) Survey of various packaging materials used in fish processing industries.
11) Survey of various feeds used in local aqua farms.
12) Study of economics of pond culture from nearby area.
13) Comparative cost analysis of fingerlings of major carps from your area.
14) Setting up of marine / fresh water aquarium with various accessories and its costing.
15) Survey of costing of aquaria of different sizes and shape.
16) Study of various courses run by Institutes in your area in relation to fisheries.
17) Survey of aquarium shops to compare the costs of various aquarium fishes.
18) Study of economics involved in breeding / rearing of aquarium fishes.
19) Review of different marketing strategy (w.r.t. attracting target clients) used by manufacturers of fish products / byproducts / value added products.
20) Survey of target clients of manufacturers of fish products / byproducts / value added products.
21) Study of working of financial institutions involved in funding fishing industry.

22) Review of export import procedures followed by the fishing industry in your area.

All the topics mentioned above are suggestive in nature and more creative and innovative topics are expected from the students under the able guidance of concerned teachers, to suit the expertise, human resources, infrastructure and local needs as also the interest of thestudents.

The assignment may be submitted in a group not exceeding three students.

Annexure - II

Suggested Field Visits USACFBIO6P1

- There shall be various short and long excursions / study tours / field visits / industrialvisits in every semester, at least one of which shall be financially affordable to every student in the class; and that assessment and marks of field trips shall be solely based upon such where no student was restrained for financial limitations.

- Field visits are to be organized to facilitate students to have firsthand experience and exposure to technology / production / functioning of an organization / unit or witness a relevant activity.

- Each student must make at least 01 (one) such visits to the units/markets/seashores out of 2 to 3 such visits organized by the college.

- **The list is suggestive and not exhaustive**

I) Visit to one of the units with one or multiple activities such as:
- Ornamental / Brackish water / Fresh water fish farm / hatchery

II) Visit to witness one of the activities such as
- Fish angling / trawling / purse seining / gill netting
- Fish finding operations, etc. (Echo Sounder / Sonar / Fish Magnifier)

III) Visit any production units such as
- Food / Fish processing and preservation
- Ornamental articles

IV) Hi-tech and multinational total export oriented units such as
- IQF plant
- Surimi plant
- Fishery plant
- Microbiological units
- Hi–tech fish / prawn / chick hatcheries
- Fish consumer product industries

V) Others –
- Self-Sale Groups
- Co-operative Societies

VI) Govt. Offices such as

- Fishery Department
- MPEDA
- Wild-life Authority

- CITES
- JDEI (Jt. Director-Export and Import)
- Sales Tax
- Income Tax
- Excise Department
- Customs Authority of India
- Local Self Govt. (BMC)
- Clearing Agencies / Agents
- FDA
- ISI
- Agmark, etc.

VII) Visit any ancillary unit such as
- Ice plant
- Can reforming
- Packaging
- Cold storage

VIII) Visit to National Laboratories, National Research Labs and Training Institutes suchas NIO, CIFE, CMFRI, CIFT, FSI, IFP, CIFI, CIFNET, NBFGR, etc.

IX) Following places may be considered for short/long excursions:

MUMBAI DISTRICT:

- Versova Beach/Fish landing centre
- Girgaum Chowpatty
- Sassoon Dock, Colaba
- Ferry Wharf (Bhaucha Dhakka)
- Taraporevala Marine Biological Research Station, Bandra (East)
- Manori beach

THANE DISTRICT:

- Uttan

PALGHAR DISTRICT:

- Arnala Beach and Fishermen co-op. society

- Satpati (also multipurpose fisherman co-operative society)
- Kelwa beach (Datiware / Tembhi)
- Rangaon fish landing centre (Vasai)
- Dahanu (Narpad / Varor fish landing centre)

RAIGAD DISTRICT:

- Alibaug
- Karanja
- Shriwardhan
- Uran creek
- NhavaSheva Port (JNPT) / Jawaharlal Nehru Custom House

RATNAGIRI DISTRICT:

- Ganpatipule beach
- Dapoli (Harnai / Harne Port Fish Auctioning)/ Dabhol / Burondi
- Mirkarwada Harbour (Major fish landing and assembling centre, Ratnagiri)
- Rajiwada (Satellite landing centre, Ratnagiri town)
- Guhagar beach (Use of Solunar Clock for fishing)
- Karla (Ratnagiri) – First Fisherman co-operative society of India (Estd. 1913)
- Marine Biological Research Station, Zadgaon, Ratnagiri (AquariumManagement Training Programme)
- Sangameshwar, Lanja, Rajapur

SINDHUDURG DISTRICT:

- Vengurla
- Malvan
- Deogad
- Anandwadi fish landing centre
- Sawantwadi
- Kankavali
- Sarjekot
- Tarkarli beach

Outside Maharashtra:

- Pirotan Island Marine Park (Jamnagar, Gujarat)
- Lakshwadeep Islands
- Andaman and Nicobar Islands

- The Cochin Fisheries Harbour (Cochin, Kerala)
- Veraval
- Maldives

ANNEXURE III

Suggested Topics for Project USACFBIO6P1 (Teachers are expected to develop additional innovative topics, varying every year, to be assigned to the students)

1) Feasibility report of the maintenance of aquarium fishes in high profile residences.
2) Feasibility report of fresh water / brackish water fish / prawn culture for extensive, semi intensive and intensive.
3) Probability report of maintenance of a culture of *Chaetoptero*sand*Artemia* by the fish farmers.
4) Project report for the establishment of small / medium / large scale ice factory, freezing and canning industry.
5) Feasibility report of various packaging materials in freezing / canning industry.
6) Feasibility report for establishing an aquarium shop.
7) Feasibility report for establishing a fish feed industry.
8) Monitoring various physico-chemical parameters of an aquarium / pond / lake / river / sea.
9) Feasibility report for establishing value added products of fish / shell fish.
10) Project report for culture of commercially important nutritious algae and its products.
11) Project report on survey of fish markets for fluctuation in the availability and price of fishes.

The project may be submitted in a group not exceeding three students.

ANNEXURE IV

Learners' space

When education system today has identified special needs of slow learners we are still silent about needs of high IQ students. Teachers are therefore recommended to identify and encourage such students to undertake research with a view to publish paper/s in peer reviewed International Indexed Journals with high impact factor thus providing 'learners' space'.

Some of the suggestive avenues are listed below which can certainly be not exhaustivesince the said students under the guidance of teachers can identify latest areas of research. Needless to say that 'learners' space" is optional additional activity which may not be undertaken by college if not befitting.

1. Developing statistical model for forecasting fish landing of prominent fishes.
2. Undertaking physicochemical oceanographic research at the established centresin thedeep sea preferably in collaboration with reputed research institutes.
3. Addressing issues of marine oil pollution.