



RISE WITH EDUCATION

NAAC REACCREDITED - 'A' GRADE

(Affiliated to University of Mumbai)

Faculty: Science

Program: T.Y.B.Sc

Subject: ZOOLOGY

Academic Year: 2020 – 2021

**Revised Syllabus in Zoology
under Choice Based Credit System (CBCS)
Approved by the Board of Studies in Zoology
Effective from academic year 2020 – 2021**

T. Y. B. Sc. Zoology Syllabus (Autonomous)
Semester V and Semester VI
(Choice Based Credit System, with effect from academic year 2020-21)

Preamble

“Educating the mind without educating the heart is no education at all.”– Aristotle

Academic Autonomy entitles the institution with certain privileges, one of them being freedom to prescribe our own course and curriculum, and refine it to make it locally relevant. This academic freedom is a milestone for academic excellence.

Considering the aspiration levels of students that are changing under the overarching influences of technological revolution and globalization, educationists need to understand that students have to be provided with opportunities to share, discover and participate actively in the learning process. Thus, in this context, a well-designed syllabus can be an essential tool for effectively managing a course that will enable teachers pursue efforts to keep students abreast with advancements in their areas of specialization.

Some of the key features of this revised syllabus are –

- ✓ Comparative anatomy – to appreciate it as an important tool which helps to determine the evolutionary relationships between organisms, to understand the similarities and differences in anatomy of different species besides its relevance in evolutionary biology and phylogeny.*
- ✓ Haematology, Immunology and General Pathology – that relate to the role played by science in daily life, society and the environment.*
- ✓ Toxicology – involving relevance of toxicity studies and regulatory guidelines, ethics in animal studies, alternatives to animal models.*
- ✓ Tissue culture – involving understanding of culture media and animal tissue cultures facilities, relevance of biosafety guidelines while working on mammalian cells under in vitro conditions.*
- ✓ Field Biology – involving understanding about ecology, the diversity and evolution of various organisms, besides creating interest in field techniques and provide skills with respect to field related studies.*
- ✓ Epidemiology – creating awareness through scientific, systematic and data-driven study of frequency and pattern of distribution and causes with risk factors of health-related diseases, states and events in specified populations.*

Striving efforts of the professors of Zoology at SIES College, Sion (West) and other board members from outside the institution have helped to bring this syllabus to its fruition and logical conclusion. This syllabus is a holistic approach towards the science of Zoology that will prepare students to use scientific knowledge, skills and training to pursue further education and employment in biology related fields. We hope this syllabus will be a sanctioned arena for exploration for the students and thereby expect implementation of this syllabus to enhance the competencies of students.

Dr. Satish Sarfare
Chairman,
Board of Studies in the subject of Zoology

Members of the Board of Studies in the subject of Zoology

- ✓ *Professor (Dr.) Chhaya Panse – Principal and Head, Department of Zoology, MD College, Mumbai (Vice Chancellor's Nominee)*
- ✓ *Professor (Dr.) Manoj Mahimkar – Principal Investigator, Cancer Research Institute, ACTREC, Kharghar, Navi Mumbai; (Subject expert from outside the Parent University to be nominated by the Academic Council)*
- ✓ *Dr. Sasikumar Menon – Director, Institute for Advanced Training & Research in Interdisciplinary Sciences (IATRIS), (Therapeutic Drug Monitoring Lab), Sion, Mumbai; Faculty, Pharma Analytical Sciences, Ruia College, Mumbai (Subject Expert from outside college/Industry expert)*
- ✓ *Mr. Kedar Gore – Director, The Corbett Foundation (Non-profit Organization), Mumbai, (Subject expert from outside college / Representative from Corporate sector / Allied area)*
- ✓ *Ms. Uma Bandekar – Clinical Team Manager with ICON plc (Postgraduate Meritorious Alumnus)*
- ✓ *Dr. Satish Sarfare – Head and Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Mr. Pushparaj Shetty – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Dr. Rupali Vaity – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Mr. Madhavan Gopalan – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Dr. Aditya Akerkar – Faculty, Department of Zoology, SIES College, Mumbai*

Syllabus Committee

- ✓ *Dr. Satish Sarfare – Head and Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Mr. Pushparaj Shetty – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Dr. Rupali Vaity – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Mr. Madhavan Gopalan – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Dr. Aditya Akerkar – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Ms. Krishita Sanil – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Mr. Avadhesh Ram – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Ms. Neha Prasad – Faculty, Department of Zoology, SIES College, Mumbai*
- ✓ *Ms. Deepali Bhadvankar – Faculty, Department of Zoology, SIES College, Mumbai*

T. Y. B. Sc. Zoology Syllabus (Autonomous)
(Choice Based Credit System, with effect from academic year 2020-21)

Grid of Syllabus Semester -V

Theory				
Course Code	Unit	Topic	Credits	L / Week
SIUSZO51	I	Genetics	2.5	1
	II	Comparative Chordate Anatomy - I		1
	III	Developmental Biology – I		1
	IV	Histology and Endocrinology-I		1
SIUSZO52	I	Haematology - I	2.5	1
	II	Physiology		1
	III	Immunology - I		1
	IV	General pathology		1
SIUSZO53	I	Molecular Biology-I	2.5	1
	II	Genetic engineering-I		1
	III	Toxicology-I		1
	IV	Animal tissue culture		1
SIUSZO54	I	Wildlife conservation and management	2.5	1
	II	Field biology		1
	III	Epidemiology-I		1
	IV	Zoogeography		1
			10	16
Practicals				
SIUSZOP51		Practicals of Course SIUSZO51	3	8
SIUSZOP52		Practicals of Course SIUSZO52		
SIUSZOP53		Practicals of Course SIUSZO53	3	8
SIUSZOP54		Practicals of Course SIUSZO54		
			06	16
Total			16	32

Grid of Syllabus Semester -VI

Theory				
Course Code	Unit	Topic	Credits	L / Week
SIUSZO61	I	Evolution and Paleontology	2.5	1
	II	Comparative Chordate Anatomy - II		1
	III	Developmental Biology – II		1
	IV	Histology and Endocrinology-II		1
SIUSZO62	I	Haematology – II	2.5	1
	II	Enzymology		1
	III	Immunology –II		1
	IV	Homeostasis and regulation		1
SIUSZO63	I	Molecular Biology-II	2.5	1
	II	Gene engineering-II		1
	III	Toxicology-II		1
	IV	Bioinformatics		1
SIUSZO64	I	Biodiversity and conservation	2.5	1
	II	Behavioural biology		1
	III	Epidemiology-II		1
	IV	Bioprospecting, Bioethics & Zoopharmacognosy		1
			10	16
Practicals				
SIUSZOP61 SIUSZOP62		Practicals of Course SIUSZO61 Practicals of Course SIUSZO62	3	8
SIUSZOP63 + SIUSZOP64		Practicals of Course SIUSZO63 Practicals of Course SIUSZO64	3	8
			6	16
Total			16	32

Programme: Bachelor of Science, B.Sc. – Zoology

“I cannot teach anybody anything, I can only make them think” - Socrates

The characteristic graduate attributes comprising of Programme Outcomes, Programme Specific Outcomes and Course Outcomes for a science graduate in the subject of Zoology are as follows:

Note the list of abbreviations:

*PO: Programme Outcome, PSO: Programme Specific Outcome, CO: Course Outcome
Cognitive Levels:- R: Remember, U: Understand, Ap: Apply, An: Analyze, E: Evaluate, C: Create*

Serial Number	Details of Programme Outcomes (POs)
PO1 (Skill Level)	Problem Solving Ability (<i>U, Ap</i>) <ul style="list-style-type: none">• Apply the knowledge of various courses learned under a program to break down complex problems into simple components.• Adopt and assimilate problem-based learning models and apply one’s learning to solve real life problem situations.
PO2 (Skill Level)	Critical Thinking (<i>U, An, E</i>) <ul style="list-style-type: none">• Develop critical thinking based on a rationale to identify assumptions, verifying the accuracy and validity of assumptions and making informed decisions.• Inculcate the ability of logical reasoning to question the rationale behind concepts, ideas, and perspectives.
PO3 (Skill Level)	Effective Communication Skills (<i>Ap, C</i>) <ul style="list-style-type: none">• Improve written and oral communication skills so as to express thoughts and ideas effectively.• Demonstrate the ability to listen carefully and imbibe soft skills to convey and receive instructions clearly.• Develop presentation skills to present complex information in a clear, lucid and concise manner.
PO4 (Skill Level)	Proficiency with Information and Communication Technology (<i>U, An, E</i>) <ul style="list-style-type: none">• Demonstrate ability to access, evaluate and use a variety of relevant information resources inclusive of internet and electronic media for the purpose of collating and analysing data.• Understand the scope and limitations of tools or software’s used in Information and Communication Technology.
PO5 (Skill Level)	Leadership Skills and Teamwork (<i>U, Ap, An, C</i>) <ul style="list-style-type: none">• Demonstrate leadership skills formulating an inspiring vision, thereby building a team, motivating and inspiring team members to engage and achieve that vision.• Develop management skills to guide people in taking tasks to their logical conclusion.• Inculcate the ability to facilitate coordinated effort as a group or team in the interests of common cause and recognise the contribution of team members.
PO6 (Attitude Level)	Self-directed and Lifelong Learning (<i>U, Ap, An</i>) <ul style="list-style-type: none">• Demonstrate the ability to work independently and take responsibility for one’s actions.• Acquire the ability to explore and evolve by becoming self-sufficient and self-reliant.• Adapt lifelong learning approaches to broaden one’s horizons for personal growth

	and development.
PO7 (Attitude Level)	Ethical Values and Environmental Concerns (<i>U, Ap, E</i>) <ul style="list-style-type: none"> • Embrace moral or ethical values in conducting one's life and implement ethical practices in all aspects of life. • Create awareness and concern for environmental and sustainability issues. • Understand and realize the significance and relevance of co-habitation and co-evolution in attaining the needs of sustainable development.
PO8 (Attitude Level)	Gender Sensitization and Community Service (<i>U, Ap, An</i>) <ul style="list-style-type: none"> • Respect gender sensitivity, gender equity and gender justice. • Encourage mutual understanding and express empathetic social concern towards different value systems and different strata of society. • Engage in community service through Institutional Social Responsibility.

Serial Number	Details of Programme Specific Outcomes (PSOs)
PSO1	Conceptual Understanding and Emerging Applications (<i>R, U, Ap, An</i>) <ul style="list-style-type: none"> • Inculcate conceptual and coherent understanding of zoology, and demonstrate a broad understanding of animal diversity, including fundamental and systematic knowledge of the scientific classification, taxonomy and evolutionary relationships of major groups of animals. • Understand the nature and basic concepts of cell biology, biochemistry, animal physiology, molecular biology, ecology among other topics, so as to recognize the relationships between structure and functions at different levels of biological organization for the major groups of animals. • Demonstrate interest in different areas of zoology so as to analyse the scope of emerging applications of biological sciences in medicine, genetics, wildlife, etc. and apply appropriate methodologies with cutting edge tools/techniques in biological sciences to seek solutions to emerging problems faced by mankind. • Demonstrate the relevance of the procedural subject knowledge that creates different types of professionals related to the disciplinary/subject area of zoology, including professionals engaged in research and development, teaching and government/public service.
PSO2	Analytical reasoning and Scientific Inquiry (<i>U, An, E</i>) <ul style="list-style-type: none"> • Inculcate a sense of inquiry and capability for asking relevant or appropriate questions, articulating problems or concepts or questions. • Encourage the ability to analyse, interpret and draw conclusions from qualitative/quantitative data and critically evaluate ideas, experiences, theories and concepts by following scientific approach to knowledge development from an open minded and reasoned perspective. • Develop analytical skills involving paying attention to detail and imbibe the ability to construct logical arguments using correct technical language related to the relevant subject. • Analyse and interpret data/information collected or related to experiments or investigations, using appropriate methods involving Biostatistics, Bioinformatics among others and report accurately the findings of the experiment/investigations while relating the conclusions/ findings to relevant theories of zoology.
PSO3	Laboratory Skills and Fieldwork (<i>R, U, E, C</i>) <ul style="list-style-type: none"> • Understand and apply standard operating procedures as per Good Laboratory Practices so as to develop laboratory skills and qualities required for successful career in teaching, research, industry, etc. • Demonstrate awareness regarding animal ethics, human ethics, conservation of flora and fauna, so as to promote safe environment and ecosystem, in the pursuit of disciplinary knowledge.

	<ul style="list-style-type: none"> • Develop instrumentation handling skills and laboratory techniques relevant to academia and industry, integrate knowledge, skills with technical competency, so as to create solutions for issues and problems related to biological sciences. • Demonstrate leadership qualities, command trust and respect, thereby, motivating and inspiring team members to work effectively in diverse teams during excursions or study tours. Realise the relevance of participation in field studies in the context of teamwork as well as life on the outdoors.
PSO4	<p>Research Aptitude and Interdisciplinary Approach (<i>Ap, An, E, C</i>)</p> <ul style="list-style-type: none"> • Inculcate and adapt to research aptitude and culture, integrate research-based knowledge in an interdisciplinary framework, and realise the relevance of choosing research as an alternative career option. • Demonstrate the awareness regarding compliance with research ethics, awareness about conflicts of interests and Intellectual Property Rights, and avoiding unethical behaviour such as fabricating, falsifying or misrepresenting data or to committing plagiarism. • Inculcate the ability to recognise cause and effect relationships, formulate hypothesis, reporting the results of an experiment or investigation, and application of research tools for analysis and interpretation of data. • Inculcate an interdisciplinary approach, to understand and consolidate fundamental concepts through inquiry based curriculum, develop critical thinking and problem solving ability required to solve different types of biology related problems with well-defined solutions, and tackle open-ended problems that may cross disciplinary-area boundaries.

Course Outcomes for TYBSc

At the root of all (science) education (Core Learning Outcome):

“The imaginative and original mind need not be overawed by the imposing body of present knowledge or by the complex and costly paraphernalia which today surround much of scientific activity. The great shortage in science now is not opportunity, manpower, money, or laboratory space. What is really needed is more of that healthy scepticism which generates the key idea – the liberating concept.”

– P.H. Abelson

Purity of mind leads to clarity in thought and action for creation of an original archaic work.

As well, to consciously attempt the basic pursuit of understanding human existence.

Semester V – Theory

Course Code: SIUSZO51

Course Name: Genetics, Comparative Chordate Anatomy, Developmental Biology, Histology and Endocrinology

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Genetics	CO1: Students will articulate various aspects of chromosome. They will be able to prepare karyotypes and could reiterate the anomalies caused by changes in chromosome structure.	R, U, An	PO1, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit II: Comparative Chordate Anatomy - I	CO2: Differentiate various types integumentary structures and derivatives in vertebrates and also acquaint with the special derivatives of epidermis.	R, U, An	PO2 PSO1, PSO2

Unit III: Developmental Biology - I	CO3: Understand the processes involved in embryonic development with reference to chick as a model and to know about the genetic basis of development in animals.	R, U, An	PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Histology and Endocrinology - I	CO4: Gain an insight of the mammalian exocrine system and its function in homeostasis and to integrate it with other body systems.	R, U	PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZO52

Course Name: Haematology, Physiology, Immunology and General pathology

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Haematology - I	CO1: Introduction to Haematology, a branch of medicine concerned with the study, diagnosis, treatment, and prevention of diseases related to the blood, and to know about the diagnostic techniques used in Haematology.	R, U, Ap, An	PO2, PO6, PO8 PSO1, PSO2, PSO3, PSO4
Unit II: Physiology-I	CO2: Gain insight into functioning and regulation of organ systems (circulatory and nervous).	R, U, An	PO1, PO2, PO6, PO8 PSO1, PSO2, PSO3
Unit III: Immunology-I	CO3: Acquaint with the body's defense system (immune system) and its combat against intruders, the invading pathogens, and to apply this knowledge in medical science in vaccination, organ transplant and tumour treatment.	R, U, Ap, An	PO1, PO2, PO6, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: General Pathology	CO4: Comprehend the causes and various type of pathogenesis.	R, U, Ap	PO1, PO2, PO6, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZO53

Course Name: Molecular Biology, Genetic engineering, Toxicology and Animal tissue culture

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Molecular Biology-I	CO1: Understand the molecular mechanisms for gene functioning and control systems.	R, U, An	PO2, PO8 PSO1, PSO2, PSO4
Unit II: Genetic Engineering-I	CO2: Acquaint with the vast array of techniques used to engineer genes which can be applied in numerous	R, U, Ap	PO2, PO7, PO8 PSO1, PSO2,

	fields like medicine, research, etc. for human benefit.		PSO3, PSO4
Unit III: Toxicology-I	CO3: Introduce to the field of toxicology; become aware about various regulatory bodies and regulations related to toxicology. Also, an acquaintance with toxicokinetics.	R, U, Ap, An	PO1, PO2, PO6, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Animal tissue culture	CO4: Understand significance of cell culture as a tool in specialized areas of research and its applications in industries like biotechnology, in fields such as <i>in vitro</i> fertilization and replacement of animals in medical and toxicology experiments.	R, U, Ap, An, C	PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZO54

Course Name: Wildlife conservation and management, Field biology Techniques, Epidemiology and Zoogeography

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Wildlife conservation & management	CO1: Acquaint with various laws and management strategies to conserve wildlife.	R, U, Ap, An	PO1, PO2, PO6, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit II: Field biology techniques	CO2: To get equipped with numerous techniques to study animals in the field.	R, U, Ap, An, E	PO1, PO2, PO4, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit III: Epidemiology-I	CO3: Acquire knowledge of disease transmission, prevention and dynamics wrt to population.	R, U, Ap, An	PO1, PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Zoogeography-I	CO4: Acquaint to a branch of science dealing with the geographic distribution of animals and to know how and why different animal species are distributed around the globe.	R, U, An	PO1, PO2 PSO1, PSO2

Semester VI – Theory

Course Code: SIUSZO61

Course Name: Evolution, Comparative Chordate Anatomy, Developmental Biology, Histology and Endocrinology

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Evolution & Paleontology	CO1: Articulate various concepts of paleontology with respect to Indian scenario. Also, to recollect aspects of molecular evolution.	R, U, Ap, An	PO1, PO2, PO7 PSO1, PSO2, PSO3, PSO4
Unit II:	CO2:	R, U, An	PO2

Comparative Chordate Anatomy-II	Differentiate various types integumentary structures and derivatives in vertebrates and also acquaint with the special derivatives of epidermis.		PSO1, PSO2
Unit III: Developmental biology-II	CO3: Acquire the knowledge of the process called morphogenesis; learn about the developmental abnormalities, and gain an understanding of cancer biology.	R, U, Ap, An	PO2, PO8 PSO1, PSO2, PSO4
Unit IV: Histology and Endocrinology-II	CO4: Gain an insight of the mammalian endocrine system and its function in homeostasis. Classify various chemical messengers in human system.	R, U	PO2, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZO62

Course Name: Hematology, Enzymology, Immunology and Homeostasis and regulation

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Hematology-II	CO1: Introduce to applied aspects of Haematology, to understand diagnosis, treatment, and prevention of diseases related to the blood.	R, U, Ap, An	PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit II: Enzymology	CO2: Insight into nomenclature, types and working of enzymes.	R, U, Ap, An	PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit III: Immunology-II	CO3: Acquaint with the body's defense system (immune system) and its combat against intruders, the invading pathogens, and to understand the application of this knowledge in medical science in vaccination, organ transplant and tumour treatment.	R, U, Ap, An	PO1, PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Homeostasis and regulation	CO4: Comprehend the causes and response shown by animals on subjecting to stress like changes in factors such as temperature and water.	R, U, An	PO2, PO8 PSO1, PSO2

Course Code: SIUSZO63

Course Name: Molecular biology, Genetic engineering, Toxicology & Bioinformatics

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Molecular Biology-II	CO1: Understand the magnitude of damage due to alterations in DNA molecule and to appreciate the importance of DNA repair mechanisms helping to maintain cellular homeostasis.	R, U, An	PO2, PO8 PSO1, PSO2, PSO4
Unit II: Genetic Engineering-II	CO2: Acquaint with the vast array of techniques used to tamper genes which can be applied in numerous fields like medicine, research, etc. for human benefit.	R, U, Ap, An	PO2, PO8 PSO1, PSO2, PSO3, PSO4

Unit III: Toxicology-II	CO3: Become aware about various sources, properties and transformations of toxins.	R, U, Ap, An, E	PO1, PO2, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Bioinformatics	CO4: Analyse the features of information stored in macromolecules using computers and to demonstrate various software used for the same.	R, U, Ap, An, C	PO1, PO2, PO4, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZO64

Course Name: Biodiversity and Conservation, Behavioral Biology, Epidemiology, Bioprospecting & Bioethics

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit I: Biodiversity and Conservation	CO1: Acquaint with various aspects of strategies to conserve wildlife.	R, U, Ap, An	PO1, PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit II: Behavioral Biology	CO2: Expand the knowledge of different facets of behavioral biology.	R, U, An	PO2 PSO1, PSO2, PSO4
Unit III: Epidemiology-II	CO3: Acquire knowledge of disease transmission, prevention and dynamics w.r.t. to population.	R, U, Ap, An	PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4
Unit IV: Bioethics, Bioprospecting and Zoopharmacognosy	CO4: Acquaint to patent protection and knowledge of self-medication response shown by animals.	R, U, Ap, An	PO1, PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Semester V – Practical

Course Code: SIUSZOP51

Course Name: Practical I based on SIUSZO51

Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none"> Experimentally demonstrate culturing of model organism like drosophila widely used to study genetics. Recognize anatomical structure in animals. Differentiate between various types of digestive, nervous, excretory and integumentary systems in animals. Knowledge of concepts of genetics applied to prepare a detailed report on survey of biometrics of human body. 	R, U, Ap, An	PO1, PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP52

Course Name: Practical II based on SIUSZO52

Course Outcome (CO)	Cognitive	Affinity with
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	Level	PO/ PSO
<ul style="list-style-type: none"> • Demonstrate experimentally various parameters of haematology. • Recognize and differentiate between various human tissues and diagnostic symptoms of pathogenesis. 	R, U, Ap, An, E	PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP53

Course Name: Practical III based on SIUSZO53

Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none"> • Acquire problem solving skills in genetics and molecular biology. • Understand the principles of toxicology and genetic engineering experimentally. • Demonstrate experiments useful in animal tissue culture. 	R, U, Ap, An, E	PO1, PO2, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP54

Course Name: Practical IV based on SIUSZO54

Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none"> • Articulate knowledge of geography and zoology to map various animals. • Learn about aspects of biology experimentally (water analysis, biodiversity indices, etc.) that are handy to carry out field studies. 	R, U, Ap, An, E, C	PO1, PO2, PO4, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Semester VI – Practical

Course Code: SIUSZOP61

Course Name: Practical I based on SIUSZO61

Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none"> • Experimentally demonstrate laws of natural selection. • Recognize anatomical structure in animals. • Differentiate between various types of digestive, nervous, excretory and integumentary systems in animals. • Successfully prepare a detailed report on evolution of atleast one organ in an animal indicating enhanced knowledge. 	R, U, Ap, An, E, C	PO1, PO2, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP62

Course Name: Practical II based on SIUSZO62

Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none"> • Demonstrate experimentally various factors governing enzyme functions by varying parameters. • Interpret various diagnostic reports (blood, urine). • Recognize and differentiate between various human tissues and diagnostic symptoms of pathogenesis. 	R, U, Ap, An, E	PO1, PO2, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP63

Course Name: Practical III based on SIUSZO63

Course Outcome(CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none">• Acquire problem solving skills in genetics and molecular biology.• Understand the principles of toxicology and genetic engineering experimentally.• Demonstrate virtually software used in analyzing biological data.	R, U, Ap, An, E, C	PO1, PO2, PO3, PO4, PO7, PO8 PSO1, PSO2, PSO3, PSO4

Course Code: SIUSZOP64

Course Name: Practical IV based on SIUSZO64

Course Outcome(CO)	Cognitive Level	Affinity with PO/ PSO
<ul style="list-style-type: none">• Understand classical behaviour of animals experimentally.• Develop problem solving ability to resolve biostatistics related queries using softwares.• Learn aspects biology that are easy to carry out field studies.	R, U, Ap, An, E, C	PO1, PO2, PO3, PO5, PO7, PO8 PSO1, PSO2, PSO3, PSO4

T. Y. B. Sc. Zoology Syllabus (Autonomous)
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Semester V – Theory

Paper Code: SIUSZO51

Paper title: Genetics, Comparative Chordate Anatomy, Developmental Biology, Histology and Endocrinology

Learning Objectives

To know about the different integumentary structures and derivatives in vertebrates and to get acquainted with the special derivatives of epidermis.

To gain an insight of the mammalian endocrine system and its function in homeostasis. To understand the processes involved in embryonic development with reference to chick as a model and to know about the genetic basis of development in animals.

Unit I: Genetics

15 Lectures

Normal human karyotype: Karyotype preparation & banding techniques (FISH), band numbering scheme.

Chromosome non-disjunction & chromosomal anomalies: Deletions & duplications with examples; micro-deletion & micro-duplication with examples, translocation, Down's syndrome & other translocation; other abnormalities: Inversions, ring chromosomes, polyploidy and its types.

Inborn errors of metabolism: The concept of inherited metabolic diseases, genetics of human metabolic diseases: Phenylketonuria, alkaptonuria & albinism, maternal PKU, G6PD deficiency and variants of G6PD; complex traits in families: Diabetes mellitus.

Unit II: Comparative Chordate Anatomy-I

15 Lectures

Structure of integument and its derivative:

General structure of integument.

Comparative study of skin in different classes

Study of derivatives of skin: Epidermal glands, Scales, Feathers, Hair, Beaks, Digital tips, Horns and antlers

Special derivatives of skin: whale bone, Rattle in snakes, Liliac callosities in Langur/ Macaque and kneepads in Camel

Digestive system:

Evolution of digestive tube; Primary divisions of the tube.

Tooth structure & position, teeth in lower vertebrates, mammalian dentition.

Morphology of gut wall

Comparative study of Esophagus, Stomach and Intestine in chordates

Circulatory System:

Evolution of heart, Heart of gill breathing fishes, Heart of lung fishes and amphibians, Hearts of amniotes.

Arterial channels and its modification: Aortic arches in fishes, Aortic arches in tetrapods

Venous channels and its modification: Venous system in shark (Basic pattern) other fishes and tetrapods

Lymphatic system in vertebrates.

Unit III: Developmental biology-I

15 Lectures

Chick Embryology:

Development stages Hamilton Hamburger Stages- 5; 7; 12; 16; 19. Extra-embryonic membranes

Types of placentae:

Extra embryonic membranes in mammal, classification of placentae on the basis of external

morphology and histology.

Developmental Strategies: Sexual reproduction and metamorphosis, Apoptosis and its role in development.

Unit IV: Histology and Endocrinology-I

15 Lectures

General organization: Mammalian endocrine system

Hormones: Classification, properties, mechanism of hormone action, hormone secretion and transport

Histology, functions and disorders of the following endocrine glands:

Pituitary, Thyroid, Parathyroid, Pancreas, Adrenal.

Paper Code: SIUSZO52

Paper title: Haematology, Physiology, Immunology and General pathology

Learning Objectives

To introduce Haematology, a branch of medicine concerned with the study, diagnosis, treatment, and prevention of diseases related to the blood, and to know about the diagnostic techniques used in Haematology.

To acquaint with the body's defense system (immune system) and its combat against intruders, the invading pathogens, and to apply this knowledge in medical science in vaccination, organ transplant and tumour treatment.

Unit I: Haematology-I

15 Lectures

Composition of blood

Plasma and formed elements

Blood volume

Total quantity and regulation; haemorrhage

Plasma proteins

Inorganic constituents, respiratory gases, organic constituents other than proteins (including internal secretions, antibodies and enzymes)

RBCs

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

Hemoglobin

Structure, formation and degradation, role in transport of oxygen and carbon dioxide (Chloride shift and Bohr's effect); types of hemoglobin (foetal, adult and sickle)

WBCs

Types of leukocytes and function, total count and variation in number; leucopoiesis; leukemia and its types

Blood clotting

Thrombocytes; factors and mechanism of coagulation; anticoagulants; formation of blood platelets (thrombopoiesis); clotting mechanism; bleeding and clotting time; failure of clotting mechanism; Haemophilia and Purpura

Unit II: Physiology-I

15 Lectures

Regulation of blood circulation: Vascular pumps: Suction pump in open circulation and pressure pump in closed circulation, Heart size (Heart mass-Hm) in vertebrates, heart rate frequency in vertebrates and invertebrates, Cardiac output, Pace maker, neurogenic and Myogenic hearts;

Electrical activity in heart muscles: Electrocardiogram; chemical and nervous regulation of heart.

Chemical Messengers: Introduction, concept and classification; Neurotransmitters and Neurosecretory substance, Acetyl catecholamine, Gama-amino butyric acid (GABA), Aspartic acid, Purine ATP, Mode of working of transmitters; Neurosecretory substances and a brief account of Neurosecretory

system.

Unit III: Immunology-I

15 Lectures

Introduction to Immunology and historical perspective Components of Immune system

Innate immunity – Factors affecting innate immunity

Mechanisms of innate immunity – Physical barriers, chemical barriers and cellular barriers Adaptive or Acquired immunity – Active Acquired immunity – Natural and Artificial; Passive Acquired immunity – Natural and Artificial

Cells and Organs of Immune system

Cells of immune system – Lymphoid cells: B lymphocytes (Humoral immunity), T lymphocytes (Cell-mediated immunity) and Natural killer cells; Mononuclear phagocytes; Dendritic cells and Mast cells

Organs of immune system – Primary – Thymus and bone marrow Secondary – Lymph node and spleen

Antigens

Immunogenicity versus Antigenicity, factors that influence immunogenicity, Epitopes, Haptens

Antibodies

Basic structure and function, Antibody classes and biological activities, Antigenic determinants on immunoglobulins

Antigen-Antibody interaction

General features of antigen-antibody interaction; Precipitation reactions: Radial immunodiffusion (Mancini method), Double immunodiffusion (Ouchterlony method), Immunoelectrophoresis; Agglutination reactions: Haemagglutination, Agglutination inhibition; RIA, ELISA

Unit IV: General Pathology

15 Lectures

Infectious diseases: Aetiology; infectious agents: viruses – hepatitis, fungi – skin diseases

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

Disorders of pigmentation: Endogenous: Normal process of pigmentation, melanosis, jaundice (causes and effects)

Necrosis: Definition and causes; nuclear and cytoplasmic changes; Types: Coagulative, Liquefactive, Caseous, Fat and Fibroid

Gangrene: Definition and types – Dry, moist and gas gangrene

Circulatory disturbances: Causes and effects of Hyperaemia, Ischaemia, Thrombosis, Embolism, Oedema and Infarction

Inflammation: Definition and causes (pathogenic and immune); cardinals of inflammation; acute and chronic inflammation

Applied pathology: Anatomical, clinical and molecular; investigating methods: biopsy and surgery (for pathological examination of tissue)

Forensic pathology: Autopsy; Post-mortem changes – Algor mortis: body cooling, Rigor mortis – stiffening of limbs, state of decomposition – Autolysis (process of self-digestion) and putrefaction

Paper Code: SIUSZO53

Paper title: Molecular Biology, Genetic engineering Toxicology and Animal tissue culture

Learning Objectives

To understand the magnitude of damage due to alterations in DNA molecule and to appreciate the importance of DNA repair mechanisms helping to maintain cellular homeostasis.

To get acquainted with the vast array of techniques used to tamper genes which can be applied in numerous fields like medicine, research, etc. for human benefit.

To understand significance of cell culture as a tool in specialized areas of research and its applications in industries like biotechnology, in fields such as in vitro fertilization and replacement of animals in medical and toxicology experiments.

UNIT- I: Molecular Biology-I

15 Lectures

The nature & properties of the genetic material

DNA as genetic material: Griffith's transformation experiment., Avery MacCleod & McCarty experiments, Hershey-Chase experiment

RNA as genetic material: Singer & Conrat expt. on TMV.

DNA Replication: Semiconservative nature of DNA replication, Meselson & Stahl experiment, prokaryotic & eukaryotic replication, semi-discontinuous replication preming, bidirectional & unidirectional replication, θ mode of replication in bacteriophages, enzymes involved in DNA replication.

Gene regulation: Control of gene expression in prokaryotes; Lac Operon, Trp Operon. Control of gene expression in eukaryotes; heterochromatin, euchromatin, transcriptional level control (transcription factors other than those involved in formation of initial complex; DNA binding domains, Helix turn helix, Zinc fingers, Leucine zipper, HLH (Helix – Loop – Helix) motif), Role of DNA methylation.

UNIT –II: GENETIC ENGINEERING –I

15 Lectures

Enzymes involved in Genetic Engineering: Introduction, nomenclature and types with examples, working mechanism.

Ligases – E.coli DNA ligase, T4 DNA ligase, polynucleotide kinase, phosphatases, DNA and RNA polymerases, reverse transcriptase, terminal transferase

Vectors for gene cloning: General properties, advantages and disadvantages of cloning vectors – Plasmid vectors, phage vectors, cosmid vectors, phasmid vectors, YAC vectors

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

Transfection techniques: Liposome mediated gene transfer, calcium phosphate precipitation method, electroporation, Biolistics (gene gun), somatic cell hybridization.

UNIT-III: Toxicology-I

15 Lectures

Introduction to toxicology – History and scope of toxicology

Principles of toxicology – Different areas of toxicology, Classification of toxic agents Characteristics of Exposure – Duration of exposure, frequency of exposure, site of exposure and routes of exposure Dose Response relationship – Individual/ Graded dose response relationships, Quantal dose response relationships, shape of dose response curves, Concept of LD50, LC50, ED50, Therapeutic index, Margin of safety and exposure

Variation in toxic responses – Selective toxicity, Species differences

Descriptive animal toxicity tests – Acute toxicity testing, Skin and Eye irritations, Sensitization, Subacute (Repeat-Dose Study), Subchronic, Chronic, Developmental and Reproductive toxicity

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

OECD guidelines for testing of chemicals (an overview)

CPCSEA guidelines for animal testing centre, ethical issues in animal studies (an overview) Animal models used in regulatory toxicology studies (an overview)

Alternative methods in toxicology (*in vitro* tests) (an overview)

UNIT- IV: Animal tissue culture

15 Lectures

Definition, principle and significance of tissue culture.

Animal tissue culture. Maintenance of sterility and use of antibiotics, Mycoplasma and viral contaminants. Various systems of tissue culture - their distinguishing features advantages and

limitations.

Culture medium: Logic of formulation (natural media, synthetic media, and sera).

Methodology: i. Primary culture: Behaviour of cells, properties, utility. ii. Explant culture. iii. Suspension culture.

Characteristics of cells in culture. Contact inhibition, anchorage in/dependence, cell-cell communication, cell senescence.

Growth studies: Cell proliferation, cell cycle, mitosis in growing cells.

Organ culture: Methods, behaviour of organ explant, and utility of organ culture. Organ transplants.

Freeze storing of cells and transport of cultures.

Applications of Tissue Culture

and diagnostic tests. Development and preparation of vaccines against infecting organisms, mammalian cloning.

Workings of a commercial laboratory (Design, aseptic techniques and control of contamination, quarantine, pathological indexing, packaging, cost analysis, marketing).

Paper Code: SIUSZO54

Paper title: Wildlife conservation and management, Field biology Techniques, Epidemiology and Zoogeography

Learning Objectives

To introduce a branch of science dealing with the geographic distribution of animals and to know how and why different animal species are distributed around the globe and techniques to study animals in field.

Unit-I: Wildlife conservation & management

15 lectures

Acts and regulations:

Wildlife protection Act of India, CITES, TRAFFIC, RED Data Book.

Measures to control poaching & wildlife trade. Dealing with Human –Wildlife conflicts.

Compensating losses.

EIA studies; role of pollution control boards- central and Maharashtra

Threats to Wildlife: Diseases (zoonosis and reverse zoonosis), competition, hunting, poaching, encroachment, deforestation, tourism, overgrazing, human animal conflict and climate change.

Community Conservancies: Snow Leopard Conservancy in India

Community-based Nature Conservancy (CNC) in Tadoba.

Unit-II: - Field biology techniques

15 Lectures

Field note book and its records Qualitative & Quantitative data Field kit and its usage

Cameras, binoculars, field scopes, camera traps etc. Different methods of recording field observations

Use of rings / tags, Color codes, Colour marking on animals Studying & analyzing Animal Tracks & signs

Scat analysis and evaluation of food, feeding and health

Unit-III: Epidemiology-I

15 lectures

Understanding Epidemiology with respect to disease frequency, distribution and determinants.

Epidemiological approach and aims of epidemiology. Basic measurements in epidemiology, Tools of measurement.

Epidemiologic methods: Observational studies and Experimental studies. Uses of epidemiology

Infectious disease epidemiology

Dynamics of disease transmission Disease prevention and control

Distribution of animals: In space – Horizontal or superficial, In time – Geological or durational

Patterns of animal distribution: Continuous, discontinuous, isolation and bipolarity

Theories of animal distribution

Barriers of distribution of animals: Topographic, climatic, vegetative, large water masses, land mass, lack of salinity and special characteristic habits, homing instinct

Means of dispersal – Land bridges, natural rafts and drift wood, favouring gales, migration by host, accidental transportation and by human agencies

Zoogeographical Realms

Palaearctic, Ethiopian, Oriental, Australian, Neotropical, Nearctic and Antarctic

SEMESTER V PRACTICAL

Practical Paper Code: SIUSZOP51

Based on SIUSZO51

- 1) Study of various model organisms used in genetic studies.
- 2) Preparation of media for fruit fly culture aseptically.
- 3) Preparation and comparison of different types of media for fruit fly culture.
- 4) Identification of sexes in fruitflies & Crossing of fruit fly.
- 5) Identification of contrasting characters in fruit fly w.r.t. genetics.
- 6) Study of development of Chick Embryo - up to 48 hrs of incubation.
- 7) Study of dentition in animals and its type. (Using Dental formula).
- 8) Study of neurogenic heart, myogenic heart and types of circulatory fluid.
- 9) Observation and analysis of types of feathers in birds.
- 10) Observation of Mammalian tissues: pituitary, adrenal, thyroid and pancreas
- 11) Observation of chick embryo at various stages.
- 12) Calculation and analysis of cephalic index, arm span to body ratio, leg-to-body ratio and intra-limb ratio in a random population (different age groups) and make a report.

Practical Paper Code: SIUSZOP52

Based on SIUSZO52

- 1) Enumeration of erythrocytes – Total count.
- 2) Determination of Erythrocyte Sedimentation Rate by suitable method – Westergren or Wintrobe method.
- 3) Estimation of haemoglobin by Sahli's acid haematin method. Enumeration of leucocytes – Total Count.
- 4) Differential count of WBC. Determination of serum LDH.
- 5) Estimation of total plasma proteins by Folin's method.
- 6) Estimation of serum/ plasma total triglycerides by Phosphovanillin method.
- 7) Latex agglutination test – Rheumatoid Arthritis; Slide test for pregnancy.
- 8) Study of T.S. of lymphoid organs: Thymus, spleen and lymph nodes, and leukemic cells from permanent slides.

Practical Paper Code: SIUSZOP53

Based on SIUSZO53

- 1) Estimation of RNA by the Orcinol method.
- 2) Estimation of DNA by the Diphenylamine method.
- 3) Isolation of genomic DNA and checking its purity by horizontal electrophoresis.
- 4) Study of the effect of food additive/ drug/ naphthalene balls on the chromosomes of onion root tips and calculation of the mitotic index.
- 5) Problems based on molecular biology and genetic engineering.

- 6) Estimation of the concentration of cell suspension by serial dilution of stock cell suspension and checking its viability.
- 7) Isolation of cells from the given tissue by trypsinization and checking its viability.

Practical Paper Code: SIUSZOP54
Based on SIUSZO54

- 1) Use of GPS in designing a working area for field study/ report making.
- 2) Analysis of Qualitative and Quantitative data with respect to field biology.
- 3) Analysis of community by working out ecological indices (frequency/importance probability, rarity, fidelity, constancy, species diversity and Shannon-Wiener Indices) Using transect method and quadrat method.
- 4) Study of chemical properties of water: BOD, COD, Nitrate-Nitrogen and Nitrite Nitrogen, Phosphate phosphorus, Acidity and Alkalinity of water sample.
- 5) Identification of field equipment.
- 6) Identification of rings, tags, colour codes and colour markings on animals.
- 7) Identification and analysis of animal signs and tracks.
- 8) Analysis of scat with the help of key.
- 9) Study of tracing of pug marks of wildlife.
- 10) Identification of various Zoogeographical regions on a map and animals in zoogeographical realms.

Semester VI - Theory

Paper Code: SIUSZO61

Paper title: Evolution, Comparative Chordate Anatomy, Developmental Biology, Histology and Endocrinology

Learning Objectives

To know about the different integumentary structures and derivatives in vertebrates and to get acquainted with the special derivatives of epidermis.

To gain an insight of the mammalian endocrine system and its function in homeostasis. To understand the processes involved in embryonic development with reference to chick as a model and to know about the genetic basis of development in animals.

Unit I: Evolution & Paleontology:

15 Lectures

Geological Timescale

Invertebrate Palaeontology:

Ichnofossils – modes of preservation, Classifications and Ichnofacies. Evolutionary trend and geological history of Ammonoidea and Trilobita.

General account of Gondwana vertebrates, Siwalik Mammals and possible cause of their extinction. Dinosaurs and their extinction.

Evolutionary trends in Equidae, Proboscidae and Hominidae.

Molecular evolution: Molecular evolutionary clock, Heterochrony in evolutionary lineage.

Unit II: Comparative Chordate Anatomy: II

15 Lectures

2.1: Respiratory system:

Gills: Agnathans, Cartilageous fishes, Bony fishes, Larval gills Air breathing bony fishes, Nares and nasal canals in chordates. Swim bladder and origin of lungs

Amphibian lungs, Reptilian lungs, Lungs and their ducts in birds, Mammalian lungs.

2.2: Nervous system:

Development and differentiation of primary brain vesicles and their cavities, flexures of brain, Evolution of cerebral hemispheres, cerebellum

Cranial nerves & autonomic nervous system with reference to shark, frog, lizard, pigeon & rabbit.

2.3 Urinogenital System:

Archinephros, pronephros, mesonephros, metanephros, Structure of nephron

Urinogenital ducts, urinary bladder.

Testes and male genital duct, Intromittent organs.

Ovaries and female genital ducts. Types of uteri in chordates.

Unit III: Developmental Biology II:

15 Lectures

Morphogenesis: Fate maps, cell differentiation, embryonic stem cells, differential cell affinity, cell adhesion, morphogenetic movements. Induction and competence, epithelial-mesenchymal interaction

Developmental abnormalities: Congenital abnormalities: Fetal Alcohol syndrome and Spinal bifida (Man/ animal model)

Cancer: Hallmarks of cancer, Types of Cancer, Causes of Cancer, Oncogenes, Tumour suppressor genes, cell signaling in cancer. Precision medicine

Unit IV: Histology and Endocrinology II:

15 Lectures

Histology: Histological structures and functions of the following mammalian organs: stomach, intestine, liver, kidney, testis, ovary.

Paper Code: SIUSZO62

Paper title: Hematology, Enzymology, Immunology and Homeostasis and regulation

Learning Objectives

To familiarize with the concept of haematology, homeostasis and to comprehend the adaptive responses of animals for thermoregulation and maintaining water and ionic balance.

To study Histology to comprehend the architecture of various organs in the body.

To introduce the basics of General pathology to know about the retrogressive, necrotic, circulatory, neoplastic pathological conditions in the body.

Unit-I: Hematology-II

15 Lectures

Introduction to Applied Hematology

Definition, scope and brief introduction of basic branches: clinical, microbiological, oncological and forensic hematology

Diagnostic techniques used in Hematology

Microscopic examination of blood: For detection of blood cancers (lymphoma, myeloma), infectious diseases (Malaria, Leishmaniasis), hemoglobinopathies (Sickle cell anaemia, Thalassemia)

Coagulopathies: Diagnostic methods (Hemophilia and Purpura)

Microbiological examination: Blood culture: Method and application in diagnosis of infectious diseases (Typhoid and TB)

Biochemical examination of blood:

Liver function tests: AST, ALT, Total bilirubin, Prothrombin time/ International normalized ratio (PT/ INR), LDH and Alkaline phosphatase

Kidney function tests: Serum creatinine, blood urea nitrogen (BUN)

Carbohydrate metabolism tests: Blood sugar, Glucose tolerance test, Glycosylated hemoglobin test

Other biochemical tests: Blood hormones (Thyroid, FSH, LH), Cancer Antigen test (CA124 or CA125)

Blood Bank: Collection, storage and preservation of blood components Blood transfusion:

Cross matching, Transfusion of blood

Unit II: Enzymology

15 lectures

Definition, nomenclature and classification (based on Enzyme Commission) of enzymes; cofactors and coenzymes; the concept and properties of active site

Factors affecting enzyme activity – pH and temperature; concept of activation energy; Enzyme structure (lysozyme and serine protease)

Enzyme kinetics, concept of steady state, derivation of Michaelis-Menten equation and Lineweaver-Burk plot, enzyme assay, concept and significance of k_m , V_{max} and k_{cat} ; modulation of enzyme activity with reference to GDH

Enzyme inhibitors – Competitive and non-competitive inhibitors and their kinetics, therapeutic applications of enzyme inhibitors

Regulation of enzyme activity; Hill equation; allosteric regulation and regulation by covalent modification of enzymes; zymogens (pepsinogen and proelastase); isozymes (LDH)

Clinical significance and industrial application of enzymes

Unit III: Immunology-II

15 Lectures

3.1: Hypersensitivity, Autoimmunity and Immunodeficiency

Definition of Hypersensitivity; Classification of hypersensitivity reactions: Type-I, Type-II, Type-III and Type-IV (one example of each type)

Introduction to hypersensitivity, brief account of types of hypersensitivity Introduction to autoimmunity, brief account of autoimmune diseases

Introduction to immunodeficiency, brief account of primary immunodeficiency, e.g. SCID; brief account of secondary immunodeficiency, e.g. AIDS

3.2: Transplantation Immunology

Introduction to transplantation; Immunological basis of graft rejection; Clinical manifestations of graft rejection; General immunosuppressive therapy

3.3: Cancer and Immune system

Oncogenes and cancer induction; Tumour antigens; Brief account of cancer immunotherapy

3.4: Vaccines and Vaccination

Introduction to vaccines, Vaccination: Development and challenges; Brief account of designing vaccines for active immunization: Whole organism vaccines, Purified macromolecules as vaccines, Recombinant vector vaccines, DNA vaccines, Subunit vaccines

UNIT IV: Homeostasis and regulation

15 Lectures

Homeostasis: External and internal environment; Acclimation and acclimatization

Control systems in biology: Feedback mechanisms – Negative feedback and positive feedback mechanisms and examples of each

Thermoregulation: Endothermy, ectothermy (relation between temperature and biological activities); temperature balance; heat production – shivering and nonshivering thermogenesis; brown fat – special thermogenic tissue in mammals; mechanisms of heat loss; adaptive response to temperature – daily torpor, hibernation, aestivation

Osmotic and Ionic regulation: Maintaining water and electrolyte balance; ionic regulation in iso-osmotic environment; living in hypo-osmotic and hyper-osmotic environment; problems of living in terrestrial environment; water absorption, salt water ingestion and salt excretion, salt glands, role of kidney in ionic regulation, metabolic water

Paper Code: SIUSZO63

Paper title: Molecular biology, Genetic engineering, Toxicology & Bioinformatics

Learning objectives:

To introduce the principles of Toxicology with particular emphasis on toxic responses to chemical exposures, nature and effect of toxicity and toxicity testing; to develop an introductory understanding of regulatory affairs in toxicology and also to develop critical thinking and assist students in preparation for employment in pharmaceutical industry and related areas.

To familiarize with genetic engineering.

To introduce Bioinformatics – a computational approach to learning the structure and organization of genomes, phylogeny, metabolism and immunology.

UNIT- I: Molecular biology-II

15 Lectures

Types of mutation

Point mutations – Substitution, deletion and insertion mutations

Substitution mutations – Silent (same-sense), missense and nonsense mutations, transition and transversion

Deletion and Insertion mutations – frameshift mutations

Trinucleotide repeat expansions – Fragile X syndrome, Huntington's disease Spontaneous mutation – tautomeric shifts, spontaneous lesions

Induced mutations/ mutagens/ mutagenic agents

Physical agents – Ionizing radiation (X-rays, α , β and γ rays), non-ionizing radiation (UV light)

Chemical agents – Base analogs (5-bromouracil, 2-aminopurine), intercalating agents (acridine dyes, ethidium bromide and ICR compounds), deaminating agents (bisulfite compounds and nitrous acid), hydroxylating agents (hydroxylamine), alkylating agents (ethylmethane sulphonate, ethylethane sulphonate, mustard gas, polycyclic aromatic hydrocarbons), aflatoxin (aflatoxin B₁)

Prevention of DNA damage and Repair mechanisms

Mechanisms that prevent DNA damage – Superoxide dismutase and catalase Mechanisms that repair damaged DNA – Direct DNA repair (alkyl transferases, photoreactivation, excision repair)

Post replication repair – Recombination repair, mismatch repair, SOS repair, transcription-repair coupling

UNIT- II: Genetic Engineering-II

15 Lectures

PCR: Principle of Polymerase chain reaction (PCR); Applications of PCR

Sequencing techniques: DNA sequencing: Sanger's method – Manual and automated methods. Protein sequencing: Sanger's method, Edman's method; Applications of sequencing techniques

Separation and detection techniques: Blotting techniques: Southern blotting, Northern blotting and Western blotting; Applications of blotting techniques. Capillary electrophoresis.

Microarray techniques: ESTs, DNA microarray and applications

UNIT-III: Toxicology-II

15 Lectures

Absorption, Distribution and Excretion of toxicants – Overview of absorption of toxicants by gastrointestinal tract, lungs, skin; overview of volume of distribution of toxicants, storage of toxicants in tissues, blood brain barrier, passage of toxicants through placenta; overview of urinary excretion, fecal excretion, other routes of elimination of toxicants.

Biotransformation of xenobiotics – Overview of general principles, xenobiotic biotransformation by Phase I enzymes and Phase II reactions (examples of carbon tetra chloride and acetaminophen).

Target organ toxicity – overview of toxic responses of liver and kidney.

Toxic effects of pesticides – Overview of toxic effects of insecticides and rodenticides Toxic effects of metals – Factors impacting metal toxicity, Biomarkers of metal exposure, overview of toxic effects of major toxic metals (Arsenic, Chromium, Lead, Mercury) Properties and Toxicities of animal venoms: Properties of animal toxins, toxin from arachnids (scorpion/spider), toxin from ants (bees/wasps), toxin from reptiles (lizards/snakes), Antivenom and potential clinical applications of venoms

UNIT-IV: Bioinformatics

15 Lectures

DNA databases and protein databases, primary & secondary data bases, FASTA & BLAST (Basic Local Allignment Search Tool), Uniprot, Clustal omega, Literature data base: PubMed (Public Medline);

Construction and analysis of a phylogenetic trees. Applications of bioinformatics. Immunoinformatics, OMIM, metabolomics

Paper Code: SIUSZO64

Paper title: Biodiversity and Conservation, Behavioral Biology, Epidemiology, Bioprospecting & Bioethics

Unit-I: Biodiversity and Conservation

15 lectures

Concept of Biodiversity.

General concepts of Private forests, Reserve forests, Sanctuaries (Eagle nest wildlife sanctuary, Hoolongpar sanctuary, Bhimashankar wildlife sanctuary, Gahirmatha marine wildlife sanctuary, Point calimere wildlife sanctuary, Pangolakha wildlife sanctuary), National Parks (Sanjay Gandhi national park, Kaziranga national park, Marine/ Corbett/ Tadoba/ Sunderbans/ Silent valley/ Keoladeo Ghana/ Gir),

Wildlife reserves, Coastal Regulation Zone.

In situ and *ex-situ* conservation.

Germ plasm, Gene banks, Seed banks, frozen zoo, Ecotourism.

Unit-II: Behavioral Biology

15 lectures

Animal Behaviour: Habitat selection; Food selection; dispersal, homing, ritualization, courtship, territoriality, aggression.

Social Behaviour: Schooling in fish, herding in mammals; Group selection. Kin selection, Altruism, Reciprocal Altruism, Inclusive Fitness; Social organization in insects and Primates. Parental care in animals, Hamilton's rule in behavior biology.

Unit-III: Epidemiology-II

15 lectures

Prevention and control of communicable diseases: Notification, isolation, quarantine, disinfection; concurrent, terminal, precurent/ prophylactic methods of disinfection: natural, physical, chemical, immunization; general measures, health education in India.

Epidemiology of communicable diseases: Diagnosis, transmission, prevention, control measures and treatment of-

- Diseases of viral origin- SARs, Dengue
- Diseases of bacterial origin- TB, national TB control programme.
- Diseases of protozoan origin- Malaria, national malaria control programme.

Epidemiology of non communicable diseases: Diabetes and cancer

International Health organizations: WHO, UNICEF, UNDP,FAO,ILO, World Bank Non Governmental and other agencies: Rockfellar foundation, Ford foundation, CARE, International Red Cross, Indian Red Cross.

Bioethics

Intellectual property rights and patenting; forms of protection – Patents, copyrights, trade secrets, trademarks; patenting biological materials – Live forms, genes and DNA sequences

Bioprospecting

Traditional prospecting, Modern bioprospecting, Chemical prospecting, Genetic prospecting, Bionic prospecting, Economic value and benefit sharing, Bioprospecting and conservation, pros and cons of bioprospecting

Zoopharmacognosy

Definition, history and types, Self-medication and its mechanism, Methods of self-medication through – Ingestion: ants and mammals, Geophagy invertebrates and birds, Absorption and adsorption, Topical application – Birds and mammals, Applications of Zoopharmacognosy – Social and transgenerational zoopharmacognosy Value to humans.

SEMESTER VI –PRACTICAL

**Practical Paper Code: SIUSZOP61
Based on SIUSZO61**

1. Study of natural selection.
2. Study of convergent and divergent evolution with appropriate tools.
3. Construction of phylogenetic trees w.r.t. evolution.
4. Study of types of fossils.
5. Study of cartilage and bone structure.
6. Study of Placoid, cycloid and ctenoid scales of fish.
7. Study of types of nerve cells.
8. Observation of Permanent slides of Mammalian Tissues: liver, kidney, testis, ovary, stomach and intestine.
9. Comparison of digestive tubes of fishes, aves and mammals
10. Comparative analysis of urine of herbivore and omnivore.
11. Compare and analyze the evolution of any one organ in human (or any animal) body and make a report.

**Practical Paper Code: SIUSZOP62
Based on SIUSZO62**

1. Effect of 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 (drug as an enzyme inhibitor) on activity of enzyme Acid Phosphatase.
5. Study of separation of LDH isozymes by agarose gel electrophoresis/PAGE.
6. To study the effect of enzymes (and/ drugs) in detergents.
7. Study of mammalian tissues:
 - i. V.S. of Skin
 - ii. V.S. of Tooth

- iii. T.S. of Stomach
- iv. T.S. of Ileum
- v. T.S. of Liver
- vi. T.S. of Pancreas
- vii. T.S. of Lung
- 8. Identification of following diseases or conditions (from slides or pictures):
Melesma, Vitiligo, Psoriasis, Bed sores, Necrosis, Oedema, Malaria, Filariasis, Leishmaniasis
- 9. Vidal's Test
- 10. Study and interpretation of pathological reports: Blood, urine and stool (faeces).

Practical Paper Code: SIUSZOP63
Based on SIUSZO63

- 1. Problems based on molecular biology.
- 2. Problems based on genetic engineering.
- 3. Demonstration of Western Blotting technique using teaching kit.
- 4. Extraction of DNA from Human blood and checking its purity using teaching kit.
- 5. Effect of CCl₄ on the level of enzyme activity in serum acid and alkaline phosphatase, aspartate and alanine aminotransferase.
- 6. Effect of salt of a heavy metal/ nicotine/ alcohol on the heartbeat of Daphnia.
- 7. Determination of LC₅₀ for a suitable pollutant (anyone salt of a heavy metal dissolved in water) on Daphnia by Probit analysis.
- 8. Problem-solving in bioinformatics.
- 9. Report preparation in bioinformatics.
- 10. To design a nucleotide primer for PCR.

Practical Paper Code: SIUSZOP64
Based on SIUSZO64

- 1. Identification of sanctuaries, national parks, and wildlife reserves on map.
- 2. Study of behavioural patterns of *Betta splendens*.
- 3. Study of bird acoustics.
- 4. Identification of calls of wildlife.
- 5. Identification of various wildlife adaptation.
- 6. Study of venomous/ poisonous animals /plants.
- 7. Identification and mounting of mouthparts of the mosquito.
- 8. Problems based on biostatistics.
- 9. Study of the density of animals population by Capture-recapture methods.
- 10. Rapid field test to estimate nitrates, base deficiency and sulphates in soil samples.
- 11. Estimation of carbonates, organic content, moisture content ,texture analysis and pH of soil.
- 12. Excursion Report submission based on -Tourism based conservation activity, ecological adaptation, ill effects of tourism.
- 13. Report submission on behavioural biology.

T T. Y. B. Sc. Zoology Syllabus (Autonomous)
(Choice Based Credit System, with effect from academic year 2020-21)

Scheme of Examination

The performance of learners will be evaluated in two parts for the Theory component of the Course:

1. Internal Assessment with 40% marks
 2. Semester End Examination (written) with 60% marks
- The Practical component of the Course will be evaluated by conducting Semester End Practical Examination of 50 marks.

Internal Assessment Theory (40%)

It is the assessment of learners on the basis of continuous evaluation as envisaged in the Credit Based System by way of participation of learners in various academic and correlated activities (poster presentations, debates, discussions, skits, seminars, etc.) in the given semester of the program.

Marks: 40

1. Class test (Centralized Examination): **20 Marks**
2. At the departmental level evaluation will be conducted on the basis of review submitted by the student of any research paper/ article relevant to each paper: **20 Marks**

Semester End Assessment Theory (60%)

Marks: 60

Duration: 2 hours

Theory question paper pattern:

- There shall be five questions of 12 marks each. On each unit there will be one question and the 5th question will be based on the entire syllabus.

OR

There shall be four questions of 15 marks each, each question based on one unit.

- All questions are compulsory with internal choice within the questions.
- Questions may be subdivided and the allocation of marks depends on the weightage of the topic.

Semester End Assessment Practical

Marks: 50

Duration: 5 hours

REFERENCES:

Comparative anatomy:

- Modern text book of Zoology – Invertebrates; Eleventh Edition; Professor R.L. Kotpal; Rastogi publication
- Invertebrate Zoology; E.L. Jordan and P.S. Verma
- A manual of Zoology - Part I, Invertebrata; Ayyar, M. Ekambaranath
- Invertebrate Zoology – Volumes of different Phyla; Hyman L.H.
- Invertebrate Zoology for Degree students; V. K. Agarwal; S.Chand Publication; 2012
- Invertebrate Zoology - Vol 1; Parker and Haswell
- Biology of Invertebrates; Fourth Edition; J.A. Pechnik; Tata McGraw Hill
- A textbook of Zoology; T.J. Parker & W.A. Haswell; MacMillan
- Invertebrate Zoology; Bares; Saunders
- Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999
- Text book of Invertebrates; N.C.Nair, S. Leelavathy, N. Soundara Pandian, T. Murugan, N. Arumugam; Saras Publication
- Invertebrate Zoology – A functional evolutionary approach; Seventh Edition; Edward E. Ruppert, Richard S. Fox & Robert D. Barnes; Cengage Learning India Pvt. Ltd.; 2004

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*

Basic Hematology

- Human Physiology - Volume 1; C.C. Chatterjee
- Essentials of Haematology; Shirish M. Kawthalkar; Jaypee Brothers
- Williams Hematology; Kenneth Kaushansky, Marshall A. Lichtman, E. Beutler, Thomas J. Kipps, Josef Prchal, Uri Seligsohn
- Essential Haematology; Victor Hoffbrand, Paul Moss, John Pettit
- Rapid Review of Hematology; Ramadas Nayak; Jaypee Brothers
- Precise Haematology; Usha Rusia, Meera Sikka, Renu Saxena; Wiley India
- Short Textbook of Haematology; Shah B.S.; C.B.S. Publisher and Distributor
- Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd., Kolkata; 1999
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978
- A Text book of Practical Physiology; First Edition; V.G. Ranade; A.V.G. Prakashan, Pune; 1968
- Principles of Anatomy & Physiology; Thirteenth Edition; Gerard J. Tortora & Bryan Derrickson; Biological Science Textbooks, Inc.; 2012
- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013
- Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014
- Harrison's Hematology and Oncology; 3rd Edition (Harrison's Specialty); Dan Longo; McGraw-Hill

- Essentials of Haematology; Second Edition; Kawthalkar Shirish M.; Jaypee; 2013
- Medical Biochemistry by M.N. Chatterjee and Rana Shinde; Jaypee; 2012
- Essentials in Hematology and Clinical Pathology; Nayak, Ramadas
- Clinical Pathology and Hematology; Maheshwari, Nanda; Jaypee
- Practical Hematology; Dacie J V; Churchill Livingstone; 2006
- Lecture Notes: Haematology; Hatton, Chris S. R. Hughes-Jones, Nevin C. Hay, Deborah; Wiley-Blackwell
- ABC series : ABC of Clinical Haematology; Provan; Drew Publisher: BMJ Books
- Principles of Anatomy & Physiology; Thirteenth Edition; Gerard J. Tortora & Bryan Derrickson; Biological Science Textbooks, Inc.; 2012
- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013

Basic Immunology

- Immunology - Introductory Textbook; Shetty N.; New Age International; 2005
- Immunology - Essential and Fundamental; Pathak S., & Palan U.; Science Publishers 2005
- Immunology: A textbook; Rao C. V.; Alpha Science Int'l Ltd.; 2005
- Ananthanarayan and Paniker's textbook of Microbiology; C. J. Paniker (Ed.); Ananthanarayan R.; Orient Blackswan; 2005
- Textbook of Immunology; Haleem Khan, Rajendra Sagar, Sadguna
- Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014
- Immunology; Third Edition; Janis Kuby; W.H. Freeman; 1997
- Kuby Immunology; Sixth Edition; Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne & Janis Kuby; W.H. Freeman; 2007
- Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014

Immunology

- Cellular and Molecular immunology; Abbas A. K., Lichtman A. H. & Pillai S.; Elsevier Health Sciences; 2014
- Roitt's Essential Immunology – Vol. 20; Delves P. J., Martin S. J., Burton D. R., & Roitt I. M.; John Wiley & Sons; 2011
- The Elements of Immunology; Khan F.H.; Pearson Education, India; 2009

Molecular Biology

- Genetics – The continuity of life; Daniel Fairbanks and Ralph Andersen; Brooks/ Cole Publishing Company; 1999
- Introduction to Molecular Biology; Peter Paoletta; Tata McGraw Hill; 2010
- Molecular Biology; David Freifelder; Narosa Publishing House; 2008
- Genetics; Robert Weaver and Philip Hedrick; McGraw Hill; 2001
- iGenetics – A Molecular Approach; Third Edition; Peter J. Russell; Pearson Education, Inc. (Benjamin Cummings), San Francisco; 2010
- Molecular Biology – Academic Cell Update; Update Edition; David Clark; Elsevier, Inc.; 2010
- Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978
- Principles of Genetics; Eighth Edition; Gardner, Simmons and Snustad; John Wiley and Sons (Asia) Pte. Ltd., Singapore; 2002
- The Science of Genetics – An Introduction to Heredity; Fourth Edition; George W. Burns; Macmillan Publishing Co., Inc., New York; 1980
- Molecular Biology – Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates,

Phil Turner & Mike White; Garland Science; 2013

- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013
- Biochemistry; Fifth Edition; Reginald H. Garrett & Charles M. Grisham; Brooks/ Cole (Cengage Learning); 2013
- <https://www.ncbi.nlm.nih.gov/books/>

Genetic Engineering

- Current Protocols in Molecular Biology; Frederick M. Ausubel, Roger Brent, Robert E. Kingston
- Introduction to Proteomics; Daniel C. Liebler; Humana Press; 2002
- Molecular cloning; Third Edition; Joseph Sambrook & David William Russell; CSHL Press; 2001
- Gene Cloning – An Introduction; Fourth Edition; Brown T.A.; Wiley-Blackwell; 2011
- Recombinant DNA – Genes and Genomes : A short course; Third Edition; Watson J.D., Myers R.M., Caudy A., Witkowski J.K.; Freeman and Co., NY; 2007
- Principles Of Gene Manipulation & Genomics; S.B. Primrose & R.M. Twyman; Blackwell Science Publications; 2006
- Methods In Enzymology, Vol 152; Berger SI, Kimmer AR; Academic Press; 1987
- Genomes 3; Third Edition; T.A.Brown; Garland Science Publishing; 2007
- Molecular Biotechnology - Principles and applications of recombinant DNA; Glick B.R. and Pasternak J. J.; ASM press, Washington; 2010
- Microbiology; Fifth Edition; Pelczar M.J. et al; Tata McGraw-Hill Co., New Delhi; 2001
- Introduction to Protein Structure; Second Edition; Branden C. and Tooze J.; Garland Publishing; 1999
- Proteins; Second Edition; Creighton T.E.; W.H. Freeman; 1993
- Proteomics - Protein Sequence to Function; Pennington, S.R and M.J. Dunn; Viva Books; 2002
- Genetic engineering – Principles and Practice; Sandhya Mitra; Macmillan India Ltd., New Delhi
- Biotechnology – Fundamentals and Applications; Third Enlarged Edition; S.S. Purohit; Student Edition, Jodhpur; 2005
- Biotechnology – Expanding Horizons; B.D.Singh; Kalyani Publishers, Ludhiana
- A textbook of Biotechnology; R.C.Dubey; S.Chand and Company Ltd., New Delhi
- Molecular Biology – Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates, Phil Turner & Mike White; Garland Science; 2013
- Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006
- Molecular Biotechnology – Principles & Applications of Recombinant DNA; Fourth Edition; Bernard R. Glick, Jack J. Pasternak & Cheryl L. Patten; American Society for Microbiology, Washington DC; 2010
- DNA & Biotechnology; Third Edition; Molly Fitzgerald-Hayes & Frieda Reichsman; Academic Press; 2009
- Biochemistry; Fifth Edition; Reginald H. Garrett & Charles M. Grisham; Brooks/ Cole (Cengage Learning); 2013

Genetics

- iGenetics – A Molecular Approach; Third Edition; Peter J. Russell; Pearson Education, Inc. (Benjamin Cummings), San Francisco; 2010
- Cell and Molecular Biology; Eighth Edition; E.D.P. De Robertis, E.M.F. De Robertis Jr.; Info-Med Ltd.; 1988

- Genetics – Bios Instant Notes; Third Edition; G.I. Hickey, H.L. Fletcher and P. Winter; Taylor and Francis Group, New York; 2007
- Genetics – A Conceptual Approach; Third Edition; Benjamin A. Pierce; W.H. Freeman and Company, New York; 2008
- New Clinical Genetics; Second Edition; Andrew Read and Dian Donnai; Scion Publishing Ltd., UK; 2011
- Genetics; Third Edition; Robert F. Weaver and Philip W. Hedrick; Wm. C. Brown Publishers (The McGraw-Hill Companies, Inc.); 1997
- Human Molecular Genetics; Fourth Edition; Tom Strachan and Andrew Read; Garland Science, USA; 2011
- Genetics; M.W. Farnsworth; Harper and Row Publishers, Inc., USA; 1978
- Human Genetics – An Overview; Alice Marcus; Narosa Publishing House; 2010
- The Science of Genetics – An Introduction to Heredity; Fourth Edition; George W. Burns; Macmillan Publishing Co., Inc., New York; 1980
- Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013
- DNA & Biotechnology; Third Edition; Molly Fitzgerald-Hayes & Frieda Reichsman; Academic Press; 2009
- Biochemistry; Fifth Edition; Reginald H. Garrett & Charles M. Grisham; Brooks/ Cole (Cengage Learning); 2013
- An Introduction to Human Molecular Genetics – Mechanisms of Inherited Diseases; Second Edition; Jack J. Pasternak; John Wiley & Sons, Inc., New Jersey; 2005
- ABC of Clinical Genetics; Helen Kingston; BMJ Books; 2002
- Ian C. Gray, et al.; Single nucleotide polymorphisms as tools in human genetics; Human Molecular Genetics, 2000, Vol. 9, No. 16, Review 2403-2408
- <https://www.ncbi.nlm.nih.gov/books/>
- <https://ghr.nlm.nih.gov/>
- <https://ghr.nlm.nih.gov/primer/howge/network/genelocation>
- <http://www.stockton-press.co.uk/ejhg>

Animal Tissue Culture

- Culture of animal cells – A manual of basic technique; R. Ian Freshney; John Wiley and Sons Publications; 2005
- Basic cell culture – A practical approach; J. M. Davis; Oxford University Press; Indian edition; 2005
- Animal cell culture – Biotechnology Series: Vol.1; Bina Mishra, B.P.Mishra, Pran Bhat, P.N. Bhat; Studium Press (India) Pvt. Ltd; 2011
- Animal cell culture – Concept and Applications; Shweta Sharma; Oxford Book Company; 2012
- Biotechnology of Animal Tissues; Dr. P.R.Yadav and Dr. Rajiv Tyagi; Discovery Publishing House, New Delhi; 2006
- DNA & Biotechnology; Third Edition; Molly Fitzgerald-Hayes & Frieda Reichsman; Academic Press; 2009

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw- Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- *The 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*

Immunology:

- Kuby Immunology; Sixth Edition; Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne & Janis Kuby; W.H. Freeman; 2007
- Janeway's Immunobiology; Murphy K. & Weaver C.; Garland Science; 2016
- Fundamental Immunology; Paul W. E.; Philadelphia: Lippincott-Raven; 1999
- Immunology - Introductory Textbook; Shetty N.; New Age International; 2005
- Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw- Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- *The Emperor of All Maladies: A biography of Cancer; Siddhartha Mukherjee; Scribner, New York; 2010*
- *Molecular Cell Biology; Fifth edition; Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, S. Lawrence Zipursky & James Darnell; W.H. Freeman & Company, New York; 2004*

Articles on Haematology -

- *“India facing shortage of life-saving albumin serum”; written by Abantika Ghosh, New Delhi; The Indian Express, October 16, 2014, 2:25 am*
- *Articles on “Blood groups”; (1) The Indian Express, August 15, 2012/ Times of India, August 16, 2012; (2) Times of India, September 11, 2014*

Article on Immunology –

- *“Nanoparticle vaccine shows potential as immunotherapy to fight multiple cancer types”; UT Southwestern Medical Center; ScienceDaily, April 24 2017; <https://www.sciencedaily.com/>*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw- Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- *World Encyclopedia of Animals; English language edition; Elena Marcon & Manuel Mongini; Orbis Publishing Limited; 1984*

Bioethics, Bioprospecting and Zoopharmacognosy

- *Molecular biotechnology – Principles and Practices; Channarayappa Biotechnology; P.K. Gupta*
- *Biotechnology; B.D. Singh*
- *Biotechnology Fundamentals & Applications; S.S. Purohit*
- *Pharmacognosy and Pharmacobiotechnology; Ashutosh Kar Trease and Evans Pharmacognosy; Evans W.C.*
- *Pharmacognosy; Kokate, C.K.A and Purohit A.P.*
- *Practical Pharmacognosy; Gokhale S.B and Kokate C.K. Text book of Pharmacognosy; T.E. Wallis*

Integumentary System and derivatives

- *Comparative Anatomy of the Vertebrates; Ninth Edition; Kent G.C. and Carr R.K.; The McGraw-Hill Companies; 2000*
- *Text book of Chordates; Saras publication Modern text of Zoology; Prof. R.L. Kotpal*
- *Integumentary system and its derivatives; Samuel D. Hodge*

Endocrinology

- Text book of endocrinology; Williams
- Textbook Of Endocrinology Hardcover; Dharmalingam; 2010 Endocrinology; Sixth Edition; Mac Hadley, Jon E. Levine Bailey's textbook of histology Hardcover; Frederick R Bailey
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978
- A Textbook of Comparative Endocrinology; First U.S. Edition; Aubrey Gorbman & Howard A. Bern; Wiley Eastern Private Ltd., New Delhi; 1962
- Samson Wright's Applied Physiology; Thirteenth Edition; Cyril A. Keele, Eric Neil & Norman Joels; Oxford University Press; 1982

Human Osteology

- Atlas of Human Anatomy – Vol I; R.D. Sinelnikov; Mr. Publishers Moscow
- A Guide Of Osteology (for medical students); Prakash kendra, Lucknow
- Text Book Of Comparative Anatomy And Physiology; Tortora
- Human Osteology; Tim D.White
- Text Book of Human osteology; Singh Inderbir
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978

Experimental and Chick embryology

- Developmental biology; Gilbert Developmental biology; Patten Developmental biology; Wolpert
- Text book of embryology; N. Arumugam
- Chicken Development – Embryology; W.H. Freeman & B. Bracegirdle Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw- Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- *Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014*
- *Comprehensive Endocrinology Series – Endocrine Control of Sexual Behaviour; Carlos Beyer; Raven Press, New York; 1979*

Comparative vertebrate anatomy:

- Modern text book of Zoology – Vertebrates; Third Edition; Professor R.L. Kotpal; Rastogi publication
- Vertebrate Zoology; E.L. Jordan and P.S. Verma
- A manual of Zoology – Vol. II, Vertebrata; Ayyar, M. Ekambaranath
- Vertebrate Zoology – Volumes of different Phyla; Hyman L.H.
- Vertebrate Zoology for Degree students; V. K. Agarwal; S.Chand Publication; 2012
- Vertebrate Zoology – Vol.II; Parker and Haswell
- Minor phyla – General information; Fifth Edition; Professor R.L. Kotpal; Rastogi Publication
- Vertebrate Comparative Anatomy, Function, Evolution; Fourth Edition; K.V.Kardong; Tata McGraw Hill
- The life of Vertebrates; J.Z. Young; ELBS - Oxford University Press
- Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw-Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- *World Encyclopedia of Animals; English language edition; Elena Marcon & Manuel Mongini; Orbis Publishing Limited; 1984*

Homeostasis

- *Comparative Animal Physiology; Knut Schmidt Nielson; Cambridge Press*
- *Comparative Animal Physiology; Prosser and Brown*
- *Comparative Animal Physiology; William S Hoar*
- *Text book of Comparative Physiology; R Nagabhusanam, Ms Kodarkar, Sarojini R; India Book House Pvt. Ltd.*
- *Animal Physiology; N. Arumugam, A. Mariakuttikan; Saras Publication*

Enzymology

- *Lehninger's Principles of Biochemistry; David Lee Nelson, A.L. Lehninger, Michael M Cox; W.H. Freeman, New York; 2008*
- *Biochemistry; Fifth Edition; J. M. Berg, J. L. Tymoczko and Lubert Stryer; W.H. Freeman, New York; 2002*
- *Biochemistry; Second Edition; Donald Voet and Judith G. Voet; J.Wiley and Sons, New York; 1995*
- *Biochemistry; Fourth Edition; U. Satyanarayana & U. Chakrapani; Elsevier; 2013*
- *Concepts in Biochemistry; Third Edition; Rodney Boyer; John Wiley & Sons, Inc.; 2006*
- *Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014*
- *Biochemistry; Fifth Edition; Reginald H. Garrett & Charles M. Grisham; Brooks/ Cole (Cengage Learning); 2013*

Histology

- *A Textbook of Histology; Deshmukh Shivaji; Dominant Pub.*
- *Colour Textbook of Histology; Gartner, Leslie P.; Saunders*
- *A Textbook of Histology; Mathur Ramesh; Anmol Pub.*
- *A Textbook of Histology and A Practical Guide; Gunasegaran J.P.; Elsevier*
- *A Textbook of Histology; Khanna D.R.; Sonali Pub.*
- *Practical Zoology; Second Edition; Dr. K.C. Ghose & Dr. B. Manna; New Central Book Agency Pvt. Ltd. , Kolkata; 1999*

General pathology

- *A Textbook of Veterinary and General Pathology; Second edition; J. L. Vagad; IBDC Publishers*
- *Clinical Pathology; Guru G.; NCERT; 1988*
- *Clinical Pathology; Batra Neelam; Vikas Publishing House Pvt. Ltd.; Nov. 1982*
- *Essentials of General Pathology; Dr. Sudha Shivraj, Dr. Satish Kumar Amarnath, Dr. Sheela Devi; Exclusively distributed by CBS Publishers & Distributors*
- *Textbook of Pathology; Harsh Mohan; Jaypee Publishers*

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain,*

Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015

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

Zoogeography

- Zoogeography – The Geographical Distribution of Animals; Philip J. Darlington JR; Academic Publishers, Kolkata Animal Geography; Newbegin
- Vertebrate Paleontology; Romer
- Ecological Animal Geography; Allee, Park and Schmidt Zoogeography of India and South East Asia; Dr. S.K.Tiwari; CBS Publishers and Distributors, Delhi; 1985

Toxicology

- Casarett and Doulls Toxicology – The basic science of poisons; Edited by Curtis Klaassen; McGraw-Hill; 2001
- Toxicological testing handbook – Principles, applications and data interpretation; David Jacobson-Kram and Kit Keller; CRC Press; 2006
- Principles and Methods of toxicology; A. Wallace Hayes; CRC Press; 2007
- Toxicology – Principles and Methods; M.A. Subramanian; MJP Publishers, Chennai; 2004
- Fundamentals of Toxicology; Kamleshwar Pandey and J.P. Shukla; New Central book agency Ltd., Kolkata; 2011
- Elements of Toxicology; Kamleshwar Pandey and J.P. Shukla; Wisdom Press, New Delhi; 2010
- Principles and Applications of Toxicology; Lahir Y.K.; Seekay Publications; 2013
- Essentials of Clinical Toxicology; Lall S.; Narosa Publishing House; 1998

Bioinformatics

- Bioinformatics - Concepts, Skills, and Applications; S.C. Rastogi & others; CBS Publishing; 2003
- Bioinformatics - A practical guide to analysis of Genes & Proteins; Andreas D Baxevanis & B. F. Francis; John Wiley; 2000
- Introduction to Bioinformatics; First Edition; T.K. Attwood, D.J. Parry-Smith; Pearson Education, Eleventh Reprint; 2005
- Bioinformatics; First Edition; C.S.V. Murthy; Himalaya Publishing House; 2003
- Bioinformatics - Sequence and Genome analysis; David W. Mount; Cold spring harbor laboratory press; 2004
- Basic Bioinformatics; S. Ignacimuthu, s.j.; Narosa Publishing House; 1995
- An Introduction to Bioinformatics Algorithms; Neil C. Jones and Pavel Pevzner; MIT Press, First Indian Reprint; 2005
- Bioinformatics - Managing Scientific Data; Zoe Lacroix, Terence Critchlow; Morgan Kaufmann Publishers (Elsevier Science); 2003
- Phylogenetics: Theory and Practice of Phylogenetic Systematics; Second edition; Bruce S. Lieberman; Wiley-Blackwell; 2011
- Molecular Evolution: A Phylogenetic Approach; Roderick D.M. Page, Edward C. Holmes; Well Publishing; 1998
- Essential Bioinformatics; Jin Xiong; Cambridge University Press; 2006
- Proteomics - From Protein Sequence to Function; First Edition; S.R. Pennington, M.J. Dunn; Springer publications; 2001

- Proteomics; Timothy Palzkill; Springer; 2002
- Metabolomics - A Powerful Tool in Systems Biology; Jens, Nielsen, Michael C., Jewett; Springer; 2007
- Systems Metabolic Engineering; Dr. Christoph Wittmann & Sang Yup Lee; Springer; 2012
- Bioinformatics (Bios Instant Notes); Second Edition (Special Indian Edition); T. Charlie Hodgman, Andrew French & David R. Westhead; Garland Science (Taylor and Francis Group); 2010
- Understanding Bioinformatics; Marketa Zvelebil & Jeremy O. Baum; Garland Science (Taylor and Francis Group); 2008
- Bioinformatics Computing – The complete practical guide to bioinformatics for Life scientists; Bryan Bergeron; Eastern Economy Edition; Prentice-Hall of India Pvt. Ltd., New Delhi; 2003
- Bioinformatics; Prakash S. Lohar; MJP Publishers, Chennai; 2009
- Introduction to Bioinformatics; First Edition; S. Sundara Rajan & R. Balaji; Himalaya Publishing House, Mumbai; 2002
- Molecular Biology – Bios Instant Notes; Fourth Edition; Alexander McLennan, Andy Bates, Phil Turner & Mike White; Garland Science; 2013
- DNA & Biotechnology; Third Edition; Molly Fitzgerald-Hayes & Frieda Reichsman; Academic Press; 2009
- Medical Biochemistry; Fourth Edition; John Baynes & Marek Dominiczak; Saunders (Elsevier); 2014

ADDITIONAL READING:

- *Biology – A Global Approach; Tenth Edition (Global Edition); Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson; Pearson Education Ltd., England; 2015*
- *Biology; Seventh Edition; Neil A. Campbell & Jane B. Reece; Pearson Education, Inc.; 2005*
- *Biology; Student Edition; Kenneth R. Miller & Joseph S. Levine; Prentice Hall; 2007*
- *Biology: Eleventh Revised Edition; Sylvia S. Mader & Michael Windelspecht; McGraw- Hill Education; 2012*
- *Biology – Concepts & Applications; Sixth Edition; Cecie Starr; Brooks/ Cole; 2005*
- World Encyclopedia of Animals; English language edition; Elena Marcon & Manuel Mongini; Orbis Publishing Limited; 1984

Environment Management

- Essentials of Environmental Science; N. Vasudevan; Narosa Publishing House Pvt . Ltd. New Delhi 110002
- Environmental Biology; P.S Verma, V.K Agarwal; S. Chand & company Ltd., New Delhi 110055
- A textbook of Environmental Science; Arvind Kumar; A P H Publishing Corporation, New Delhi 110002
- Environmental Biotechnology - Basic Concepts and Application; Indu Shekhar Thakur; I.K.International Pvt.Ltd., New Delhi 110016
- Text book of environmental science; S.C. Santra

Wildlife Management

- Wild life management; Rajesh Gopal
- [Wildlife Management & Conservation - Contemporary Principles & Practices; Paul R. Krausman & James W. Cain III](#)
- Wildlife Ecology, Conservation & Management; [John M. Fryxell](#), [Anthony R. E. Sinclair](#), [Graeme Caughley](#)

