

**Shiksha Mandal's**  
**BAJAJ COLLEGE OF SCIENCE, WARDHA**  
 (An Autonomous college - Affiliated to RTM Nagpur University)

**DIRECTION RELATING TO THE EXAMINATION LEADING TO THE DEGREE OF  
 MASTER OF SCIENCE, SEMESTER PATTERN (CBCS-CHOICE BASED CREDIT SYSTEM)  
 FOR SESSION: 2021-22 2022-23 and onwards**

- The duration of the M. Sc. course shall be of two academic years consisting of four semesters with the University examinations at the end of each semester namely:
  - M. Sc. Semester I Exam
  - M. Sc. Semester II Exam
  - M. Sc. Semester III Exam
  - M. Sc. Semester IV Exam
- The theory examination of Semester-I, II, III, IV shall be held as per the schedule given in Table below:

Sr. No.	Name of the examination	Main Examination	Supplementary Examination
1	Semester I, Semester III	Winter	Summer
2	Semester II, Semester IV	Summer	Winter

**ELIGIBILITY TO THE COURSE:**

- The following applicant candidates shall be eligible for the admission to Master of Science and examinations

A	For M.Sc. (Chemistry) Semester-I	For admission to the M. Sc. Semester I in Chemistry, a candidate shall have offered Chemistry / Industrial Chemistry as one of the subjects at the qualifying B.Sc. Examination.
B	For M.Sc. (Botany) Semester-I	For admission to the M. Sc. Semester I in Botany, a candidate shall have offered Botany as one of the subjects at the qualifying B.Sc. Examination / B.Sc. (Agriculture) with Botany is one of the subject.
C	For M.Sc. (Zoology) Semester-I	For admission to the M. Sc. Semester I in Zoology, a candidate shall have offered Zoology as one of the subjects at the qualifying B.Sc. Examination.
D	For M.Sc. (Microbiology) Semester-I	For admission to the M. Sc. Semester I in Microbiology, a candidate shall have offered Microbiology / Biotechnology as a subject of study and examination at B.Sc. degree.
E	For M.Sc. (Biotechnology) Semester-I	For admission to the M. Sc. Semester I in Biotechnology, a candidate shall have offered Chemistry and Biotechnology as subjects of study and examination at B.Sc. degree.

Candidates shall have passed any one of the above examinations from Rashtrasant Tukadoji Maharaj Nagpur University or any other statutory University of India or abroad, recognized by the UGC or any other concerned apex regulatory authority / body of India.

**4. Semester Examinations**

A	M. Sc. Semester I Examination	Students who have fulfilled the eligibility criteria as mentioned in Section 3 and have been admitted to this course in Semester I.
B	M. Sc. Semester II Examination	Students who have been admitted to this course in semester II.
C	M. Sc. Semester III Examination	Students who have been admitted to this course in semester III.
D	M. Sc. Semester IV	Students who have been admitted to this course in semester IV.  Every student shall submit two copies of the project report (typed and properly bound) for the Fourth Semester to the Concerned.

	Department at least one month prior to the commencement of the final practical examination through the Head of the Department. Along with the certificate signed by the supervisor and declaration by the candidate towards original work which is not submitted to any university or organization for award of the degree. The scheme/guidelines for the students and supervisors regarding Project Work Report are given in Appendix 04
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Note: Subject to the Rules of ATKT as mentioned in para 5 of this direction)

5. The ATKT rules for admission for the M. Sc. Course (Theory, Practical and Seminar as separate passing head) shall be as given in the following table

Admission to Semester	Candidate should have passed in all the subjects of the following examination of J.B. College of Science.	Candidate should have passed at least two third of the passing heads of the following examinations
Semester I	As provided in the para 3 of the direction	-----
Semester II	-----	-----
Semester III	-----	Semester I and II taken together
Semester IV	-----	-----

6. The medium of instruction and examination shall be English.
7. The number of papers and maximum marks assigned to each paper and minimum marks / grade, an examinee must obtain in order to pass the examination shall be as prescribed in appendices appended with this direction.
8. The examinee at each of the examination shall have option of not being declared successful at the examination in case he / she does not secure a minimum of grade equivalent to 55% marks at the examination. This option will have to be exercised every time the application is submitted to any of the examinations. Once this option is exercised, the option shall be binding on the examinee and it shall not be evoked in under any circumstances.
9. The classification of the examinee successful at the semester and examinations and at the end of final semester examination shall be as per the rules and regulations of Choice Based Credit System as prescribed in appendices, appended with this direction.
10. Successful examinees at the end of M. Sc. Sem-IV Examination who obtained CGPA above 7.51 shall be placed in First Division with distinction, those obtaining CGPA from 6.00 to 7.50 shall be placed in First Division, those obtaining CGPA from 4.50 to 5.99 shall be placed in Second Division and those obtaining CGPA from 4.00 to 4.49 shall be placed in Third Division.
11. No candidate shall be admitted to an examination under this direction, if he / she have already passed the same examination of this college or of any other university.

**Semester I for M.Sc.-Zoology Program**

Code	Theory/ <b>Practical</b>	Teaching scheme (Hours/ Week)			Credits	Examination Scheme					
		Theory/Lecture	<b>Practical</b>	<b>Total</b>		Duration in hrs	Max. Marks		Total Marks	Minimum Passing Marks	
							External Marks	Internal Asse.		Theory	<b>Practical</b>
Core 1	Paper-I, Structure and function of Invertebrates	4	--	4	4	3	80	20	100	40	--
Core 2	Paper-II, Biochemistry - I *	4	--	4	4	3	80	20	100	40	--
Core 3	Paper-III, Cell Biology and Genetics	4	--	4	4	3	80	20	100	40	--
Core 4	Paper-IV, Developmental Biology, Principle and Application *	4	--	4	4	3	80	20	100	40	--
Pract. Core 1 and 2	Practical-I - Structure and Function of Invertebrates and Biochemistry – I*	--	8	8	4	3-8*	100**	--	100	--	40
Pract. Core 3 and 4	Practical-II - Cell Biology, Genetics and Developmental Biology ( Principles & Applications)*	--	8	8	4	3-8*	100**	--	100	--	40
Seminar 1	Seminar 1	2	--	2	1	--	--	25	25	10	--
	<b>Total</b>	<b>18</b>	<b>16</b>	<b>34</b>	<b>25</b>	<b>--</b>	<b>520</b>	<b>105</b>	<b>625</b>	<b>170</b>	<b>80</b>

Semester II for M.Sc.-Zoology Program												
Code	Theory /Practical	Teaching scheme (Hours/ Week)			Credits	Examination Scheme						
		Theory	Practical	Total		Duration in hrs	Max. Marks		Total Marks	Minimum Passing Marks		
							External Marks	Internal Asse.		Theory	Practical	
Core 5	Paper- V - Structure and Function of Vertebrates	4	--	4	4	3	80	20	100	40	--	
Core 6	Paper-VI - Comparative Endocrinology	4	--	4	4	3	80	20	100	40	--	
Core 7	- Paper-VII - Molecular Biology and Biotechnology	4	--	4	4	3	80	20	100	40	--	
Core 8	Paper-VIII - Biochemistry – II*	4	--	4	4	3	80	20	100	40	--	
Pract. Core 5 and 6	Practical-III - Structure and Function of Vertebrates and Comparative Endocrinology	--	8	8	4	3-8*	100**	--	100	--	40	
Pract. Core 7 and 8	Practical –IV - Molecular Biology, Biotechnology and Biochemistry – II*	--	8	8	4	3-8*	100**	--	100	--	40	
Seminar 2	Seminar 2	2	--	2	1	--	--	25	25	10	--	
	<b>Total</b>	<b>18</b>	<b>16</b>	<b>34</b>	<b>25</b>	<b>--</b>	<b>520</b>	<b>105</b>	<b>625</b>	<b>170</b>	<b>80</b>	

Semester III for M.Sc.-Zoology Program												
Code	Theory/Practical	Teaching scheme (Hours/ Week)			Credits	Examination Scheme						
		Theory	Practical	Total		Duration in hrs	Max. Marks		Total Marks	Minimum Passing Marks		
							External Marks	Internal Asse.		Theory	Practical	
Core 9	Paper- IX, Parasitology and Immunology	4	--	4	4	3	80	20	100	40	--	
Core 10	Paper-X, Special Group-Animal Physiology-I Physiology of Digestion and Excretion	4	--	4	4	3	80	20	100	40	--	
Core Elective 1	Paper-XI, Special Group-Animal Physiology-II Physiology of Circulation	4	--	4	4	3	80	20	100	40	--	
Foundation Course 1/Core (Subject Centric) 1	Paper- XII – Biotechnology – I * (for Zoology students) Human Physiology - I (For other PG students )	4	--	4	4	3	80	20	100	40	--	
Pract. Core 9 and 10	Practical-V, Parasitology and Immunology	--	8	8	4	3-8*	100**	--	100	--	40	
Pract. Core Elective 1	Practical-VI, Special Group- Animal Physiology	--	8	8	4	3-8*	100**	--	100	--	40	
Seminar 3	Seminar 3	2	--	2	1	--	--	25	25	10	--	
	<b>Total</b>	<b>18</b>	<b>16</b>	<b>34</b>	<b>25</b>	<b>--</b>	<b>520</b>	<b>105</b>	<b>625</b>	<b>170</b>	<b>80</b>	

Semester IV for M.Sc.-Zoology Program												
Code	Theory /Practical	Teaching scheme (Hours/ Week)			Credits	Examination Scheme						
		Theory	Practical	Total		Duration in hrs	Max. Marks		Total Marks	Minimum Passing Marks		
							External Marks	Internal Asse.		Theory	Practical	
Core 11	Paper-XIII - Biotechniques, Biostatistics, Ethology, Toxicology and  Bioinformatics	4	--	4	4	3	80	20	100	40	--	
Core 12	Paper- XIV, Special Group-Animal Physiology-III  Physiology of Brain, Nerve and Muscle	4	--	4	4	3	80	20	100	40	--	
Core Elective 2	Paper XV, Special Group- Animal Physiology-IV  Physiology of Respiration and Reproduction	4	--	4	4	3	80	20	100	40	--	
Foundation Course 2/Core (Subject Centric) 2	Paper- XVI – Biotechnology – II * (for Zoology students) Human Physiology - II (For other PG students )	4	--	4	4	3	80	20	100	40	--	
Pract. Core 11, 12 & Elective 2	Practical-VII, Special Group- Animal Physiology	--	8	8	4	3-8*	100**	--	100	--	40	
Project	Project	--	8	8	4	--	100**	--	100	--	40	
Seminar 4	Seminar 4	2	--	2	1	--	--	25	25	10	--	
	<b>Total</b>	<b>18</b>	<b>16</b>	<b>34</b>	<b>25</b>	<b>--</b>	<b>520</b>	<b>105</b>	<b>625</b>	<b>170</b>	<b>80</b>	

Note: \* = If required, for two days; \*\* = The Practical and Project shall be evaluated by both the External and Internal Examiner in the respective Department as per guidelines appended with this direction.

**Details of course code and names of Theory paper for M.Sc.-Zoology Program**

<b>Semester</b>	<b>Code</b>	<b>Paper</b>	<b>Name of Paper</b>
<b>Semester-I</b>	Core 1	Paper 1	Structure and Function of Invertebrates
	Core 2	Paper 2	Biochemistry – I*
	Core 3	Paper 3	Cell Biology and Genetics
	Core 4	Paper 4	Developmental Biology (Principle and Application)*
<b>Semester-II</b>	Core 5	Paper 5	Structure and Function of Vertebrates
	Core 6	Paper 6	Comparative Endocrinology
	Core 7	Paper 7	Molecular Biology and Biotechnology
	Core 8	Paper 8	Biochemistry – II*
<b>Semester-III</b>	Core 9	Paper 9	Parasitology and Immunology
	Core 10	Paper 10	Animal Physiology / Cell Biology
	Core Elective I	Paper 11	Animal Physiology / Cell Biology
	Core (Subject Centric) I	Paper 12	Biotechnology – I* (For Zoology students) Human Physiology I (for other PG students)
<b>Semester-IV</b>	Core 11	Paper 13	Biotechnology, Biostatics, Ethology, Toxicology and Bioinformatics
	Core 12	Paper 14	Animal Physiology / Cell Biology
	Core Elective II	Paper 15	Animal Physiology / Cell Biology
	Core (Subject Centric) II	Paper 16	Biotechnology – II* (For Zoology students) Human Physiology II (for other PG students)

For details on,

1. Project: Refer Appendix 2
2. Seminar: Refer Appendix 3
3. Internal Assessment Marks: Refer Appendix 4
4. Practical Examination: Refer Appendix 5
5. Core Elective Papers: Refer Appendix 6
6. Foundation Course/Core (Subject Centric): Refer Appendix 7
7. Rules and Regulation regarding pattern of question paper, absorption scheme and CBCS pattern: Refer Appendix 8

## Appendix-2

### **Project Work Scheme:**

#### **Guidelines for the Students, Supervisors and Examiners**

Every student is required to carry out a project work in semester IV. The student will have to carry out the project work (based on guidelines given in this direction) in lieu of practical in the fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national /regional/private research institute/organization. The project can be of following types. A) Experimental Project Work; OR B) Field Based Project Work; OR C) Review writing based Project Work.

#### ***Experimental Project Work and Field Based Project Work***

Student can carry out Experimental / Field Based Project Work on a related research topic of the subject /course. It must be an original work and must indicate some degree of experimental work / Field work. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical / lab Examination of Semester IV or VI as applicable. The project report shall comprise of Introduction, Material and Methods, Results, Discussion, Summary, Conclusion and, References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator.

#### ***Review writing based Project Work***

Student can carry out review writing Based Project Work on a related topic of the subject / course. It must be a review of topic based on research publications. Student shall refer peer reviewed original research publications and based on findings, write a summary of the same. The pattern of review writing shall be based on reputed reviews published in a standard, peer reviewed journals. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical / lab Examination of Semester IV as applicable. The project report shall comprise of Abstract, Introduction, detailed review, Discussion, Summary, Conclusion and, References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator

- The supervisors for the Project Work shall be from the following.  
A person shall be an approved faculty member in the relevant subject OR  
Scientists of National Laboratories/Regional Research Laboratories/Nagpur University/Other Universities recognized by UGC.
- The Project Work will carry total 100 marks and will be evaluated by both external and internal examiner in the respective Department.
- The examiners will evaluate the Experimental Project Work taking into account the Coverage of subject matter, Arrangement and presentation, References etc.

For written Project work	: 40 Marks – Evaluated jointly by External & Internal
Presentation	: 20 Marks – Evaluated jointly by External & Internal
For Viva-Voce	: 20 Marks – Evaluated by External examiner
Internal Assessment	: 20 Marks – Evaluated by Internal examiner
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Total	: 100 Marks

### Appendix-3

#### **Seminar:**

#### **Guidelines for Students, Supervisors and Examiners**

1. In each semester, the student will have to deliver a seminar on any topic relevant to the syllabus / subject encompassing the recent trends and development in that field / subject. The topic of the seminar will be decided at the beginning of each semester in consultation with the supervising teachers. The student has to deliver the seminar which will be followed by discussion. The seminar will be open to all the teachers of the department, invitees, and students.
2. The students should submit the seminar report typed and properly bound in two copies to the head of the department. The said shall be evaluated by the concerned supervisor / head of the department. The record of the seminar should be preserved till the declaration of the final result.

### Appendix-4

#### **Internal Assessment:**

For the purpose of internal assessment the College shall conduct one to three assignments described below. Best two scores of a student in these tests shall be considered to obtain the internal assessment score of that student.

General guidelines for Internal Assessment are:

- a) The internal assessment marks assigned to each theory paper as mentioned in Appendix-1 shall be awarded on the basis of assignments like class test, attendance, home assignments, study tour, expedition, visit to educational institutions and research organizations, field work, group discussions or any other innovative practice/activity.
- b) There shall be one to three assignments (as described above) per theory paper.
- c) There shall be no separate/extra allotment of work load to the teacher concerned. He/she shall conduct the internal assessment activity during the regular teaching days/periods as a part of regular teaching activity.
- d) The concerned teacher/department /college shall have to keep the record of all the above activities.
- e) At the beginning of each semester, every teacher/department /college shall inform his/her students unambiguously the method he/she propose to adopt and the scheme of marking for internal assessment.
- f) Teacher shall announce the schedule of activity for internal assessment in advance in consultation with HOD/Principal.

### Appendix-5

#### **Practical Examination:**

1. Each practical carries 100 marks. For the examination, the distribution of the marks shall be as follows:
  - a. Record / Journal / Internal assessment : 20 marks – Evaluated by Internal
  - b. Practical Performance : 60 marks – Evaluated jointly by External & Internal
  - c. Viva-voce : 20 marks - Evaluated by External

NOTE: Practical performance shall be jointly evaluated by the External and Internal Examiner. In case of discrepancy, the External Examiner's decision shall be final.

2. Practical exam shall be of 3 to 8 hours duration for one or two days, depending on subject and number of students.
3. The Practical Record of every student shall carry a certificate as shown below, duly signed by the teacher-in-charge and the Head of the Department.
4. If the student fails to submit his/her certified Practical Record duly signed by the Teacher-In-Charge and the Head of the Department, he/she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.
5. The certificate template shall be as follows:

## CERTIFICATE

Name of the college / institution \_\_\_\_\_

Name of the Department: \_\_\_\_\_

This is to certify that this Practical Record contains the bonafide record of the Practical work of Shri / Shrimati / Kumari \_\_\_\_\_ of M. Sc. \_\_\_\_\_ Semester \_\_\_\_\_ during the academic year \_\_\_\_\_. The candidate has satisfactorily completed the experiments prescribed by BAJAJ COLLEGE OF SCIENCE, WARDHA (An Autonomous college - Affiliated to RTM Nagpur University) for the subject \_\_\_\_\_

Dated \_\_\_/\_\_\_/\_\_\_\_\_

Signature of the teacher who taught the examinee

1. \_\_\_\_\_
2. \_\_\_\_\_

Head of the Department

### Appendix-6

#### Subject wise Core Elective Papers:

M. Sc. Subject	Core elective paper to be opted in Semester III	Core elective paper to be opted in Semester IV
M. Sc. (Chemistry)	Environmental Chemistry I	Environmental Chemistry II
	Instrumental Techniques in Chemistry I	Instrumental Techniques in Chemistry II
M. Sc. (Botany)	Molecular Biology and Plant Biotechnology I	Molecular Biology and Plant Biotechnology II
	Reproductive Biology of Angiosperms I	Reproductive Biology of Angiosperms II
	Advanced Phycology and Hydrobiology I	Advanced Phycology and Hydrobiology II
	Mycology and Plant Pathology I	Mycology and Plant Pathology II
	Palaeobotany I	Palaeobotany II
	Palynology I	Palynology II
	Plant Physiology I	Plant Physiology II
M. Sc. (Zoology)	Animal Physiology II	Animal Physiology IV
	Cell Biology II	Cell Biology IV
M. Sc. (Microbiology)	Microbial Diversity, Evolution and Ecology (MDEE) I	Microbial Diversity, Evolution and Ecology (MDEE) II
	Bioinformatics (BIF) I	Bioinformatics (BIF) II
M. Sc. (Biotechnology)	Industrial Biotechnology I	Industrial Biotechnology II
	Environmental Biotechnology I	Environmental Biotechnology II

Note: Student can choose Core Elective Paper from the above list at the beginning of Semester III. Once the choice between Core Elective Paper is made by the candidate at the beginning of Semester III, it cannot be changed in Semester IV.

### Appendix-7

#### **Foundation Course/Core (Subject Centric) Paper:**

Student can choose either Foundation course paper or Core (Subject Centric) paper at the beginning of Semester III. Once the choice between Foundation Course/Core (Subject Centric) is made by the candidate at the beginning of Semester III, it cannot be changed in Semester IV.

#### Part A:

**Foundation Course:** Candidate can opt for any one foundation course paper as shown below in the semester III and IV. However, Student shall opt for this paper from any other subject other than his/her main subject for post-graduation (e.g. A candidate pursuing M. Sc. Chemistry can opt for foundation course papers mentioned in other M. Sc. subjects except papers mentioned under M. Sc. Chemistry). If the candidate decides to opt for foundation course papers then he/she shall not be eligible to opt for Core (Subject Centric) papers in their respective subjects.

List of foundation courses available:

<b>M. Sc. Subject</b>	<b>Foundation Course I in semester III</b>	<b>Foundation Course II in Semester IV</b>
M. Sc. (Chemistry)	Medicinal Chemistry I	Medicinal Chemistry II
M. Sc. (Botany)	General Botany	Applied Botany
M.Sc. (Zoology)	Human Physiology for other PG students (other than Zoology) Biotechnology – I for PG Zoology students *	Applied Human Physiology for other PG students (other than Zoology) Biotechnology – II for PG Zoology students *
M. Sc. (Microbiology)	General Microbiology	Advanced Microbiology
M. Sc. (Biotechnology)	Introductory Biotechnology	Molecular Biotechnology

#### Part B:

**Core (Subject Centric):** Candidate can opt for this paper as shown below in the semester III and IV in their main subject of postgraduation only (e.g. A candidate pursuing M. Sc. Zoology can opt for Core (Subject Centric) papers from M. Sc. Zoology ONLY). If the candidate decides to opt for Core (Subject Centric) papers in their main subject of postgraduation then he/she shall not be eligible to opt for foundation course papers neither in their own subject nor in any other subject.

List of Core (Subject Centric) course available in the respective subject:

<b>M. Sc. Subject</b>	<b>Core (Subject Centric) I in semester III</b>	<b>Core (Subject Centric) II in semester IV</b>
M. Sc. (Chemistry)	Spectroscopy I	Spectroscopy II
M. Sc. (Botany)	Aesthetic Botany	Plant Resources
M. Sc. (Zoology)	Biotechnology – I*	Biotechnology – II*
M. Sc. (Microbiology)	Drugs & Disease Management (DDM)	Vaccines & Delivery Systems
M. Sc. (Biotechnology)	Diagnostic Medical Biotechnology	Therapeutic Medical Biotechnology

## Appendix-8

### **General Rules and Regulations regarding pattern of question paper, absorption scheme and choice based credit system:**

#### **A) Pattern of Question Paper**

1. There will be four units in each paper.
2. Maximum marks of each theory paper will be 80
3. Question paper will consist of five questions, each of 16 marks.
4. Four questions will be on four units with internal choice (One question on each unit).
5. Fifth question will be compulsory with questions from each of the four units having equal weightage and there will be no internal choice.

#### **B) Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA)**

M. Sc. Program shall consist of four semesters, wherein the student has to complete 100 credits. Each subject (or course) has fixed number of credits. The types of subject subheads are: Core, Core Practical, Core (Subject Centric), Core Elective, Core Elective Practical, Foundation Course, Seminar and Project/Review writing.

#### **Explanatory terms:**

1. **Core:** Major theory papers in the concerned subject.
2. **Core Elective:** These papers will be specialization in the concerned subject. Ex. Zoology – MRP, AP, Fisheries, Entomology etc.
3. **Foundation Course/Core (Subject Centric):** For details, refer Appendix 7.
4. **Project/Review writing:** Project / Review writing is in semester IV.
5. **Seminar:** The seminar in each semester shall be presented by the candidate in his/her parent department only.

#### **Credits:**

It is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture) or two hours of practical work / field work or two hours of seminar per week.

For example a subject with 4-8 (L- P) means it has 4 Lectures, 8 Practical in a week. This subject will have eight credits ( $4 \times 1 + 8 \times \frac{1}{2} = 8$ ). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on the marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Letter Grade	O	A+	A	B+	B	C	P	F	Ab
Grade Point	10	09	08	07	06	05	04	0	0

A student obtaining Grade F shall be considered failed and will be required to reappear for the examination.

#### **Valuation pattern:**

Every credit is for 25 marks and valuation and grade points will be given as per following pattern.

Marks obtained In Theory/Practical (Out of 100 marks)	Marks obtained In Theory/Practical (Out of 50 marks)	Marks obtained In Theory/Practical (Out of 25 marks)	Letter Grade	Grade point
91-100	46-50	23-25	O	10
81-90	41-45	20-22	A+	09
71-80	36-40	18-19	A	08
61-70	31-35	15-17	B+	07
51-60	26-30	13-14	B	06
41-50	21-25	11-12	C	05
= 40	=20	=10	P	04
<40	<20	<10	F	0
Ab	Ab	Ab	Ab	0

### Computation of SGPA and CGPA:

Following shall be the procedure to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

1. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e

$$\text{SGPA (Si)} = \frac{\sum(C_i \times G_i)}{\sum C_i}$$

where  $C_i$  is the number of credits of the  $i^{\text{th}}$  course and  $G_i$  is the grade point scored by the student in the  $i^{\text{th}}$  course.

### Illustration for SGPA:

e.g. If student obtained following marks in Semester-I, then his/her SGPA shall be obtained as illustrated in below table

Code	Theory / Practical	Credits	Marks Obtained	Out of	Grade Point	Grade Letter	Credit Point (Credit x Grade Point)
Core 1	Paper 1	4	91	100	10	O	4x10=40
Core 2	Paper 2	4	89	100	9	A+	4x9=36
Core 3	Paper 3	4	50	100	5	C	4x5=20
Core 4	Paper 4	4	78	100	8	A	4x8=32
Pract. Core 1 & 2	Practical 1	4	89	100	9	A+	4x9=36
Pract. Core 3 & 4	Practical 2	4	85	100	9	A+	4x9=36
Seminar 1	Seminar 1	1	23	25	10	O	1x10=10
	<b>Total</b>	<b>25</b>					<b>210</b>

Thus,  $\text{SGPA} = \frac{210}{25} = 8.4$

2. The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a program, i.e.

$$\text{CGPA} = \frac{\sum(C_i \times S_i)}{\sum C_i}$$

where  $S_i$  is the SGPA of the  $i^{\text{th}}$  semester and  $C_i$  is the total number of credits in that semester.

### Illustration for CGPA

e.g. If student scored following SGPA in each semester, then his/her CGPA shall be obtained as illustrated in below table

Semester 1	Semester 2	Semester 3	Semester 4
Credit : 25 SGPA: 8.46	Credit : 25 SGPA: 7.83	Credit : 25 SGPA: 5.69	Credit : 25 SGPA: 6.31

Thus,

$$\text{CGPA} = \frac{25 \times 8.46 + 25 \times 7.83 + 25 \times 5.69 + 25 \times 6.31}{100}$$
$$= \frac{211.5 + 195.75 + 142.45 + 157.75}{100} = \frac{707.25}{100} = 7.0725 \quad \text{i.e. } 7.07$$

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

e. g. 7.0765 = 7.08 or 7.0755 = 7.07 or 6.5168 = 6.52 etc.

Transcript (Format): Based on the above recommendations on Letter grades, grade points and SGPA and CGPA, the institute may issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.

**Bajaj College of Science, Wardha**  
(An Autonomous College)  
**Department of Zoology**  
**Syllabus for M.Sc. Zoology (Semester Pattern)**  
**Semester – I**  
**Choice Based Credit System**  
**With effect from Academic Year 2021-22**  
\*(As per BOS 09-04-2021)

## **Semester-I**

### **Paper-I, Structure and function of Invertebrates**

PG- ZOO (07)- S1-T1

#### **Unit-I**

- 1.1 Classical and molecular taxonomic parameters, species concept, systematic gradation of animals, nomenclature, modern scheme of animal classification into sub-kingdom, division, section, phyla and minor phyla.
- 1.2 Ultrastructure of protozoan locomotary organs (pseudopodia-cytoplasmic organelles, flagella, cilia and pellicular myonemes) and mechanism of various modes of locomotion.
- 1.3 Dermal cells and skeletal organization in calcareous sponges, Hexactinilida and Demospongiae (Porifera).
- 1.4 Polymorphism and metagenesis in coelenterate. Types of polyps, medusa and metamorphosis.

#### **Unit-II**

- 2.1 Origin of metazoan-colonial, syncytial and molecular theories.
- 2.2 Reproductive system-structure and mechanism of reproduction in *Dugesia*, *Fasciola*, *Taenia* and *Ascaris*.
- 2.3 Formation, Evolution and significance of coelom, metamerism and symmetry in classification of animals, particularly coelomata.
- 2.4 Evolution of nephridia and mechanism of excretion (nitrogenous excretory products, transport of water and salts) in Polychaeta, Oligochaeta and Hirudinea of Annelida.

#### **Unit-III**

- 3.1 *Peripatus* (Onychophora) structure, affinities and taxonomic position.
- 3.2 Respiratory organs in Arthropoda. Mechanism of gaseous exchange in tracheal respiration in Insecta and gill respiration in Crustacea.
- 3.3 *Neopilina* ( Monoplacophora): structure, affinities and taxonomic position.
- 3.4 Neuroanatomy in Gastropoda, Bivalvia and Cephalopoda.

#### **Unit-IV**

- 4.1 Water vascular system in Echinodermata: structure and functions.
- 4.2 Larval forms in Echinodermata: Metamorphosis and phylogenetic significance.
- 4.3 General account and affinities of Ctenophora and Rotifera.
- 4.4 General account and affinities of Entoprocta and Ectoprocta.

# Biochemistry-I\*

## Semester I :

### Paper II - Biochemistry-I

PG- ZOO (07)- S1-T2

#### Unit I: Biomolecules I: Carbohydrates and Lipids

- 1.1 Properties of Water: With interactions in aqueous systems. Ionization of water, weak acids and weak base.
- 1.2 The pH scale, measurement of pH, acid base titration curves. Buffers, biological buffer systems.
- 1.3 Carbohydrates: Classification, basic chemical structure, monosaccharides, aldoses, and ketoses, cyclic structure of monosaccharides, stereoisomerism, anomers and epimers. Biological significance.
- 1.4 Lipids: Classification, structure and function of major lipid subclasses-acylglycerols, circulating lipids, chylomicrons, LDL, HDL, and VLDL.

#### Unit II: Biomolecules II: Proteins and Nucleic acids

- 2.1 Amino acids: Classification, Properties, rare amino acids.
- 2.2 Protein Structure: alpha-helix beta- structure,  $\beta$ -helix, super secondary structure. Tertiary Structure, Quaternary structure – hemoglobin.
- 2.3 Peptide bond, Vander Walls, electrostatic, Hydrogen bonding, and hydrophobic interactions.
- 2.4 Nucleic acids: Structure of Pyrimidines and purines. DNA and RNA types and properties.

#### UNIT III: Enzymology-I

- 3.1 Enzymes and Catalysts, Classification and nomenclature of enzymes. Chemical nature and properties of enzymes.
- 3.2 Factors affecting enzyme activity: Concentration of enzymes, Concentration of substrate, effect of temperature, effect of pH.
- 3.3 Effect of product concentration, effect of activators, effect of time, effect of light and radiation.
- 3.4 Active site and salient features of active site. Specificity of enzyme action (Lock & key model & Induced fit model).

#### UNIT IV: Enzymology-II

- 4.1 Enzyme Inhibition: Competitive inhibition, Non-competitive inhibition, Uncompetitive inhibition, Irreversible inhibition, Suicide inhibition, Allosteric inhibition.
- 4.2 Mechanism of Enzyme action.
- 4.3 Regulation of enzyme activity in the living system: Allosteric regulation, Activation of latent enzyme,
- 4.4 Control of enzyme synthesis, Enzyme degradation, Isoenzymes.

## **Semester-I**

### **Paper-III, Cell Biology and Genetics**

PG- ZOO (07)- S1-T3

#### **Unit-I**

- 1.1 Membrane structure and function - structure of model membrane, lipid bilayer, membrane protein diffusion, osmosis, active transport, uniport, multiport, symport, antiport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
- 1.2 Structural organization and functions of cell organelles- nucleus, mitochondria, endoplasmic reticulum, Golgi complex, lysosomes and peroxisomes.
- 1.3 Structure and Functions of microfilaments, microtubules and their role.
- 1.4 Cell division and cell cycle - phases of cell cycle, checkpoints of cell cycle, regulation of cell cycle, mitosis, meiosis.

#### **Unit-II**

- 2.1 Cell signaling - hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, Receptor protein- tyrosin kinase and ion channel receptors.
- 2.2 Signal transduction pathways, primary and secondary messenger systems, regulation of signaling pathways.
- 2.3 Cellular communication - general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix and integrins.
- 2.4 Cancer - genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis.

#### **Unit-III**

- 3.1 Mendelian, non-Mendelian inheritance - mono / dihybrid inheritance, types of dominance, multiple allelism, probability, exercises for solving genetics problems.
- 3.2 Extensions of Mendelian principles - codominance, incomplete dominance, gene interactions, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
- 3.3 Quantitative Genetics - polygenic traits and mode of inheritance, analysis of variation, genetic and environmental factors, heritability, inbreeding and consequences, coefficient of inbreeding and consanguinity.
- 3.4 Mutation - types, causes and detection, mutant types- lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants.

#### **Unit-IV**

- 4.1 Structural and numerical alterations of chromosomes - deletion, duplication, inversion, transversion, translocation, ploidy and their genetic implications.
- 4.2 Extra chromosomal inheritance - cytoplasmic inheritance, inheritance of mitochondrial genes, maternal inheritance.
- 4.3 Microbial genetics - recombination in bacteria and gene mapping, transformation, conjugation, transduction (generalized and specialized), fine structure mapping of genes.
- 4.4 Human genetics- pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

## **Semester-I**

### **Paper-IV - Developmental Biology (Principles and applications)\***

PG- ZOO (07)- S1-T4

#### **Unit 1**

##### **Gametes, fertilization and early development**

- 1.1 Ultra-structures of human spermatozoa and egg.
- 1.2 Cytological and molecular events of fertilization (sea urchin).
- 1.3 Types of cleavage, blastula, fate map and gastrulation (frog).
- 1.4 Implantation (human) and germ layer formation.

#### **Unit 2**

##### **Basic concepts of development**

- 2.1 Concept of organizer and mesoderm induction.
- 2.2 Potency of cells: stem cells-types and properties , concept of differentiation, commitment, specification.
- 2.3 Genomic imprinting : DNA methylation and Histone modification in epigenetics
- 2.4 Sex determination (mammals, *Drosophila*) and Dosage compensation in mammals.

#### **Unit 3**

##### **Axis specification, Regeneration and Ageing**

- 3.1 Morphogen gradients: Gradient formation and cell specification.
- 3.2 Basics of axis formation in *Drosophila*
- 3.3 Concept of regeneration: Types and mechanism of regeneration.
- 3.4 Ageing: The Biology of Senescence, Causes of ageing (Oxidative damage, General wear and tear, Mitochondrial genome damage, Telomere shortening)

#### **Unit 4**

##### **Techniques in developmental biology:**

- 4.1 Amniocentesis and chorionic villi sampling.
- 4.2 Assisted reproductive techniques (IVF, ICSI, GIFT, ZIFT).
- 4.3 In-situ Hybridization and CRISPR-Cas 9
- 4.4 Transgenic animals: Production of Transgenic animals (DNA microinjection, Retrovirus mediated gene transfer, Embryonic stem cell mediated gene transfer)

## M.Sc. Semester I

### Practical-I - Structure and Function of Invertebrates and Biochemistry – I\*

PG- ZOO (07)- S1-P1

#### Section-A

#### 1. Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.

Classification upto order and comments on the specimens representing all phyla.

#### 2. Anatomical Observations

Anatomical observations, demonstration and detailed explanation of

- a) **Digestive system** of Earthworm, Leech, Cockroach, Silkworm and Honey bee
- b) **Nervous system** of Prawn, Cockroach, Silkworm and Honey bee and
- c) **Reproductive system** of Earthworm, Leech, Cockroach and Honey bee with the help of ICT tools/ Models/ Charts/ Photographs etc.

#### 3. Mounting

Whole mount preparation of plankton and/or study of permanent preparation of the following with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

- a. Earthworm – Nerve ring, ovary, spermatheca, nephridia.
- b. Leech – jaws, ciliated organ.
- c. Cockroach – Mouth parts, Salivary glands, trachea.
- d. Prawn – Appendages, Statocyst.
- e. Protozoans- rhizopods , flagellates , ciliates (fresh water forms).
- f. Porifera – Spicules and gemmules of fresh water sponges.
- g. Crustaceans and rotifers - Planktonic copepodes, cladoceran, ostracoderm and rotifers.
- h. Larval forms of the free living invertebrates.
- i. Larval forms of parasitic invertebrates.

#### 4. Study of permanent Invertebrate slides

- a. Porifera – T.S. and L.S. of *Sycon*, gemmules, spongian fibres, spicules
- b. ctenophora – T.S. of *Hydra* , T.S. of Sea anemone, Ephyra larva
- c. Helminths – T.S. of *Planaria*, T.S. of *Taenia* , scolex W.M., Mature , gravid proglotids , T.S. of male and female *Ascaris*, W.M of *Ankylostoma* , *Enterobius*, *Dracunculus*, *Wuchereria*
- d. Annelida -T.S. of *Nereis*, T.S. of Earthworm passing through various organs, T. S. of Leech.
- e. Arthropod larvae – Nauplius, Zoea, Metazoea, Megalopa, Mysis.
- f. Mollusca – T.S. of foot, Veliger and Glochidium larva.

- g. Echinodermata- Pedicellariae, T.S. of arm of star fish, Bipinnaria, Oricularia larva.
- h. Hemichordata – T.S. through collar, proboscis, trunk and branchio-genital regions.  
Tornaria larva.

**Section-B\***

1. Preparation of standard buffers and determination of a pH of a solution.
2. Determination of pKa of weak acid by pH meter.
3. Determination of isoelectric pH of casein, egg albumin & BSA.
4. Titration of mixture of strong acid and weak acid.
5. Titration curves of amino acid/weak acids and determination of pK value.
6. Qualitative analysis of Carbohydrates, Proteins, Urea, Creatinine, Cholesterol.
7. Colorimetric estimation of proteins by biuret method.
8. Extraction of total lipids by Folch Method.
9. Determination saponification value of fats.
10. Determination of Acid value of fats.
11. Preparation of starch from potato and its hydrolysis by salivary amylase.
12. Effect of pH on activity of enzyme
13. Isolation of Urease and demonstration of its activity

**Distribution of Marks: Marks**

1. Anatomical observations	10
2. Stained permanent preparation:	10
3. Identification and comment on the spots (1-10)	30
4. Biochemistry Experiments (Major)	15
5. Biochemistry Experiments (Minor)	10
6. Submission of stained permanent slides	05
7. Class Record	10
8. Viva-voce	10

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**Total marks 100**

## M.Sc. Semester – I

### Practical-II - Cell Biology, Genetics and Developmental Biology\*

PG- ZOO (07)- S1-P2

#### Section-A

1. Study of mitotic metaphasic chromosomes in plant material.
2. Preparation of human karyotypes by using photographs/pictures.
3. Demonstration of Barr body in human female leucocytes.
4. Demonstration of polytene chromosome in dipteran larvae with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
5. Problems on genetics based on monohybrid/dihybrid ratios, sex linked inheritance and blood groups.
6. Study of various human genetic traits.

#### Section-B \*

- 1 Histology of male and female reproductive organs and accessory reproductive glands with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
- 2 Study of different types of eggs on the basis of their yolk content.
- 3 Study of developmental stages of live eggs of *Lymnea* or any gastropod with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 4 Study of developmental stages of insects/ fishes with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 5 Study of developmental stages of frog with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 6 Chick embryo mounting by window method.
- 7 Study of developmental stages of chick through slides and whole mounts.
- 8 Morphological study of different types of placenta with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
9. Study of Sperm vitality, motility, viability and HOS.

#### Distribution of Marks

1. Cytological preparation	20
2. Problems on genetics (any two)	20
3. Study of developmental stages	15
4. Study of eggs / Chick embryo mounting / Sperm vitality / Sperm count / hypo-osmotic test for fertility	10
5. Identification and comment on spots (1-5)	15
6. Class record	10
7. Viva-voce	10

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**Total marks 100**

## **List of Books for reference M.Sc. Zoology Semester – I**

### **Paper I :- Structure and function of Invertebrates**

1. Hyman L.H. -The Invertebrate Vol. I, Protozoa through Ctenophora. McGraw-Hill Co., New York.
2. Barrington E.J.W.- Invertebrate structure and function. Thomas Nelson and sons Ltd., London.
3. Jagerstein G. -Evolution of Metazoan life cycle . Academic press, New York and London.
4. Hyman L.H. -The invertebrate McGraw-Hill Co., New York.
5. Barnes R.D. -Invertebrate Zoology W.B. Saunders and Co., Philadelphia
6. Hyman L.H. -The Invertebrates, smaller coelomate groups. Vol. 5 McGraw-Hill Co. New York.
7. Marshall A.J. and Williams W.D. -(1972) J. B. Zoology of Invertebrates , ElBs and McMillan,London.
8. Backlemiccher W.N. -Principles of comparative anatomy of Invertebrates Oliver and Boyed Edinberg.
9. Hadisi J. -The Evolution of Metazoa. Pergamon Press, Oxford.
10. Dales R.P.- Annelids, Hutchinson, London.
11. Green J. -Biology of Crustacea, Wither by, London.
12. Morton J. E. -Mollusca, Hutchinson, London.
13. Nichols D. -Echinodermata, Hutchincon, London.

### **Paper II : Biochemistry-I\***

1. Lehninger-Principles of biochemistry.
2. Donald Voet and Judith Voet- Biochemistry.
3. Harper -Biochemistry.
4. Jeremy M. Berg, John L. Tymovzko , Lubert Stryer- Biochemistry.
5. U. Satyanarayana, U. Chakrapani -Biochemistry.

### **Paper III : Cell Biology and Genetics**

1. De Robertis- E. D. P., - Cell and Molecular Biology , I. S. E. publication.
2. Turner P. C. and Mc Lennan - Molecular Biology ; Viva Books Pvt. Ltd.
3. Benjamin Lewis - Gene VIII , Oxford press.
4. Watson J. D. - Molecular biology of Gene ., Benjamin publication.
5. Darnell J. - Molecular cell Biology ; Scientific American Books USA.
6. Alberts B., Bray D. Lewis J.- Molecular Biology of the Cell , garland publishing Inc.
7. Laodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., - Molecular Cell Biology W. H. Freeman and Co.
8. Cooper G. M. - The Cell: Molecular Approach

#### **Paper IV: Developmental Biology\***

1. S.F. Gilbert. 4th Edn. - Developmental Biology, Sinauer Associates Inc. Publishers.
2. Lewis Wolpert et al. 1998. - Principles of development: Oxford University Press.
3. Balinsky (1981) 5th Ed. - An Introduction to Embryology: (CBS College Publishing).
4. Austin and Short - Embryonic and foetal development. Cambridge University Press 1982, 1994 2nd Ed.
5. Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 &2. Lamming 1984, 2000. Developmental Biology. 2nd Edition. Leon W. Browner Saunders College publishing.
6. Current Topics in Developmental Biology eds. R. A. Pedersen and G. P. Schatten.
7. Principles of animal developmental biology: S. C. Goel, Himalaya Publishing House.
8. Developmental Biology, S.F. Gilbert. 4th Edn. Sinauer Associates Inc. Publishers.
9. An Introduction to Developmental Biology: D. A. Ede.
10. Principles of developmental: Paul Weiss edited by Hafner publishing company New York.
11. Cells into organs. 2nd Edition. The forces that shape the Embryo. John Philip Trinkaus ed. Tom Aloisi.
12. Principles of development: Lewis Wolpert et al. 1998. Oxford University Press.
13. Foundations of Embryology. B. M. Patten & B. M. Carlson. Tata McGraw Hill Publishing Company
14. Ltd., New Delhi. 24
15. An Introduction to Embryology: Balinsky (1981) 5th Ed. (CBS College Publishing).
16. Embryonic and foetal development. Cambridge University Press by Austin and Short, 1982, 1994 .2nd Ed.

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\*(As per BOS 09-04-2021)

**Semester-II**

**Core 5 - Paper- V - Structure and Function of Vertebrates**

PG- ZOO (07)- S2-T1

**Unit-I**

- 1.1 Origin and ancestry of Chordata.
- 1.2 General organization and affinities of Cephalochordata.
- 1.3 Structure, development and metamorphosis of Amoecoetus.
- 1.4 General characters and affinities of Dipnoi.

**Unit-II**

- 2.1 Organs and mechanism of respiration in Pisces and Amphibia.
- 2.2 Vertebrate integument and its derivatives.
- 2.3 Appendicular skeleton (Limbs and girdles) in Amphibia, Reptilia, Aves and Mammals.
- 2.4 General body organization and classification in Chelonia.

**Unit-III**

- 3.1 Evolution of urinogenital organs in vertebrates.
- 3.2 Origin of Birds.
- 3.3 Cetacea: general characters and adaptations.
- 3.4 Comparative anatomy of the brain in vertebrates (teleost, frog, lizard, fowl and rat).

**Unit- IV**

- 4.1 Autonomous nervous system in vertebrates: structure and functions.
- 4.2 Evolution of heart in vertebrates.
- 4.3 Sense organs in vertebrates.
- 4.4 Evolution of Man.

## **Semester-II**

### **Core 6 - Paper-VI - Comparative Endocrinology**

PG- ZOO (07)- S2-T2

#### **Unit-I**

- 1.1 Hormones and functions in Coelenterata and Helminths.
- 1.2 Neurosecretory system in Annelida: structure, hormones and functions.
- 1.3 Neuroendocrine system in Mollusca: structure, hormones and functions.
- 1.4 Hormones and functions in Echinodermata.

#### **Unit-II**

- 2.1 Neuroendocrine system in crustacean; structure and hormones.
- 2.2 Endocrine control of metamorphosis, reproduction and colour change mechanisms in crustacea.
- 2.3 Cephalic neuroendocrine system in insects: structure and hormones.
- 2.4 Endocrine control of metamorphosis and reproduction in insects.

#### **Unit-III**

- 3.1 Pineal organ: structure, hormones and functions.
- 3.2 Hypothalamo hypophysial system: structure, hypothalamic nuclei, hormones and function.
- 3.3 Pituitary: cell types, hormones and functions.
- 3.4 Thyroid: Structure, hormones and function.

#### **Unit-IV**

- 4.1 Parathyroid ultimobranchial glands: Structure, hormones and regulatory mechanisms.
- 4.2 Gastro-entero-pancreatic endocrine system: endocrine pancreas and gastro intestinal tract: endocrine cells, hormones and functions.
- 4.3 Adrenal gland: structure, hormones and functions in vertebrates.
- 4.4 Gonadal hormones in vertebrates and their hormonal actions, feedback mechanisms.

## **Semester-II**

### **Core 7 - Paper-VII - Molecular Biology and Biotechnology**

PG- ZOO (07)- S2-T3

#### **Unit-I**

- 1.1 Cot  $\frac{1}{2}$  and Rot  $\frac{1}{2}$  values, organelle genome, DNA structure, forms of DNA.
- 1.2 DNA replication – molecular mechanisms of prokaryotic and eukaryotic DNA replication, regulation of replication.
- 1.3 DNA damage and repair – types of DNA damages, excision repair system.
- 1.4 Mismatch repair, recombination repair, double strand break repair, and transcription coupled repair.

#### **Unit-II**

- 2.1 Transcription- prokaryotic and eukaryotic transcription, RNA polymerases, transcriptional unit, initiation, elongation, termination, transcriptional factors.
- 2.2 Regulation of transcription – Operon, positive and negative control, attenuation phage strategies, anti-termination, response elements and inducible elements.
- 2.3 Translation - prokaryotic and eukaryotic translation, genetic code, altered code in elongation, termination factors, fidelity of translation, post translational modifications.
- 2.4 Mobile DNA elements – transposable elements, IS elements, P elements, retroviruses, retrotansposons.

#### **Unit-III**

- 3.1 Antisense and ribozyme technology – initiation of splicing, polyadenylation, molecular mechanisms of antisense molecules, miRNA, siRNA, gene silencing.
- 3.2 Isolation and sequencing of DNA, gene amplification, PCR, RAPD, RFLP, Maxam-Gilbert, Sanger's dideoxy methods.
- 3.3 Splicing and Cloning – Cloning vectors for recombinant DNA technology- plasmids, cosmids, phagemids, YACS, gene replacement, restriction enzymes.
- 3.4 Hybridization techniques – Southern- Northern hybridization, microarray.

#### **Unit-IV**

- 4.1 Medical biotechnology- Application of restriction fragment length polymorphism (RFLP) in forensic science, disease prognosis and genetic counseling.
- 4.2 Agricultural biotechnology- biofertilizers, bioinsecticides, biogas.
- 4.3 Immunobiotechnology-Hybridoma technology and monoclonal antibodies.
- 4.4 Industrial and Environmental biotechnology-microbial production of fermentation products, enzymes, antibiotics, single Cell proteins and biosensors.

## **Biochemistry-II\***

**Semester – II :-**

### **Paper VIII - Biochemistry-II**

PG- ZOO (07)- S2-T4

#### **UNIT I: Bioenergetics and Metabolism-I**

- 1.1 Cell bioenergetics: First and second law of thermodynamic, internal energy, enthalpy, entropy.
- 1.2 Glycolysis: Anaerobic pathway of glucose metabolism, two phases of glycolysis, Gluconeogenesis.
- 1.3 Citric acid cycle: Aerobic pathway of glucose metabolism.
- 1.4 Alternate pathways of carbohydrate metabolism: Pentose phosphate pathway, glyoxylate cycle.

#### **UNIT II: Bioenergetics and Metabolism-II**

- 2.1 Lipid metabolism: Beta oxidation of saturated and unsaturated fatty acids.
- 2.2 Oxidation of fatty acids with odd number of carbon atoms, formation of ketone bodies.
- 2.3 Electron transport chain: Mitochondrial organization, Components and reactions of electron transport chain.
- 2.4 Oxidative phosphorylation. Inhibitors of oxidative phosphorylation.

#### **UNIT-III: Bioenergetics and Metabolism III**

- 3.1 Metabolism of amino acids: Transamination, Deamination
- 3.2 Biosynthesis of Purine and pyrimidine nucleotides.
- 3.3 Urea cycle, regulation of urea cycle.
- 3.4 Integration between urea cycle and TCA cycle. Metabolic disorders of urea cycle.

#### **UNIT-IV: Hormones and Metabolic disorders**

- 4.1 Classes of Hormones: Peptide. Amine and Steroid
- 4.2 Peptide (Insulin and Glucagon) and Steroid hormone (Testosterone): Mode of Action
- 4.3 Vitamins: Types and Significance
- 4.4 Neurohormones (Nitric oxide, Dopamine): Mode of action

## M.Sc. Semester-II

### Practical-III - Structure and Function of Vertebrates and Comparative Endocrinology

PG- ZOO (07)- S2-P1

#### Section-A

##### 1. Study of museum specimens using already available specimens in the museum/ charts/ models/ photographs/ digital alternatives etc.

Classification of vertebrates up to order and comments on the specimens representing all phyla.

##### 2. Anatomical Observations

Anatomical observations, demonstration and detailed explanation of the following with the help of ICT tools/ models/ charts/ photographs etc.

- a) Brain and cranial nerves- Fish/ Rat.
- b) Arterial and venous systems- Fish/Rat
- c) Urinogenital system- Fish/Rat.
- d) Reproductive systems- Fish/Rat.
- e) Internal ear in fish, Weberian ossicles in fish, accessory respiratory organs in fish.

##### 3. Mounting:

Study of Stained Permanent preparation of scales, ampullae of Lorenzini, otolith, striated muscles and cartilage of fish using animal wastes from local recognized fish markets or with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.

##### 4. Microtomy, Histology and Skeleton

- a. Fixation, embedding, sectioning and staining of the internal organs of vertebrates (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry farms/ fish markets etc.)
- b. Study of slides of internal organs of vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- c. Axial and appendicular skeleton of fowl and rabbit using already available skeleton/ ICT tools/ models/ charts/ photographs etc.

#### Section-B

1. **Microtomy** - Fixation, embedding, sectioning and staining of the endocrine gland (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry farms/ fish markets etc.)
2. **Histological study** – a) Histological slide of endocrine glands and gonadal endocrine components, EM structure of endocrine gland. b) Identification of pituitary cell type. c) Identification of  $\alpha$ ,  $\beta$ ,  $\gamma$ , cells of Islets of Langerhans with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.
3. **Anatomical Observations-** Anatomical observations, demonstration and detailed explanation of the endocrine glands in a) Cockroach and b) Endocrine glands- pituitary, thyroid parathyroid, adrenal in fish/rat with the help of ICT tools/ models/ charts/ photographs etc.

### **Distribution of Marks**

1. Anatomical observations of fish/rat	15
2. Stained permanent preparation:	10
3. Identification and comment on the spots (1-10)	30
4. Submission of stained permanent slides	05
5. Anatomical observations of Endocrine glands	10
6. Histological staining of endocrine gland	10
7. Class Record	10
8. Viva-voce	10

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**Total marks 100**

### **M.Sc. - Semester-II**

#### **Practical –IV - Molecular Biology, Biotechnology and Biochemistry – II\***

PG- ZOO (07)- S2-P2

#### **Section-A**

1. Demonstration of glycogen/ carbohydrate- PAS reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
2. Demonstration of DNA: Feulgen's reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
3. Demonstration of DNA: RNA: Methyl Green- Pyronin reaction (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
4. Demonstration of Lipid: Sudan Black B staining (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
5. Demonstration of Protein: HgBP staining (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
6. Histochemical analysis of alkaline phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
7. Histochemical analysis of acid phosphatase (Source of tissue: Animal wastes from local recognized slaughter houses/ poultry forms/ fish markets etc.)
8. Biochemical estimation of sugar: O-toluidine method (Source of blood: Local recognized pathology laboratory)
9. Biochemical estimation of protein: Lowrey's method (Source of blood: Local recognized pathology laboratory)
10. Biochemical estimation of DNA: Diphenylamine method (Source of blood: Local recognized pathology laboratory)
11. Biochemical estimation of RNA: Orcinol method (Source of blood: Local recognized pathology laboratory)
12. To perform tests for qualitative analysis of saliva.
13. To perform tests for qualitative analysis of bile.

### Section-B\*

14. Separation of amino acids by two-dimensional TLC.
15. Separation of amino acids by descending\ascending paper chromatography.
16. Estimation of glycine by Sorenson's formol titration.
17. Paper electrophoresis of serum proteins
18. Gel electrophoresis of serum proteins
19. Separation of proteins by SDS-PAGE and Native PAGE
20. Demonstration of Western Blot
21. Isolation of DNA and RNA from various samples.
22. Extraction and estimation of DNA from coconut endosperm
23. Separation of DNA by Agarose Gel Electrophoresis.
24. Estimation of vitamin-C in lemon and oranges.
25. Estimation of Urease

### M.Sc. - Semester-II

#### Practical -IV - Molecular Biology, Biotechnology and Biochemistry II\*

#### Distribution of Marks Marks

1. Histochemical demonstration of DNA/RNA protein / carbohydrate/lipids/enzymes	15
2. Estimation of sugar/protein/DNA/RNA/ qualitative analysis of saliva/bile	20
3. Biochemistry experiment I	20
4. Biochemistry experiment II	20
5. Submission of stained permanent slides	05
6. Class record	10
7. Viva voce	10
<b>Total marks</b>	<b>100</b>

## **List of Books for reference**

### **M.Sc. - Semester-II**

#### **Paper V: Structure and function of Vertebrates**

1. Alexander R.N., The Chordata, Cambridge University Press London.
2. Barrington EJW, The Biology of Hemichordates and Protochordates, Oliver and Boyd Edinberg.
3. Bourne G.H., The structure and function of nervous tissue Academic press New York.
4. Kingslay J.S, Outlines of Comparative anatomy of vertebrates, Central Book Depot, Allahabad.
5. Honyelli A.R. The Chordates Cambridge University Press, London
6. Smith H.S. Evolution of Chordate structure, Hold Rinehart and Winton Inc. New York
7. Walter H.A. and Sayles L.D. Biology of Vertebrates Macmillan and co. New York
8. Romer A.S. Vertebrate body W.P. Sanders co., Philadelphia.
9. Young J.Z. Life of Vertebrates Oxford University Press, London.
10. Young J.Z. Life of Mammals Oxford University Press, London.
11. Colbert E.H. Evolution of Vertebrates John Wiley and sons Inc. New York.
12. Kent C.J. Comparative anatomy of Vertebrates.
13. Waterman A.J. Chordate Structure and Functions Macmillan Co. New York.
14. Montagna W. Comparative anatomy clarendon press, Oxford
15. Weichert C.K. Preach W. Elements of Chordates anatomy McGraw-Hill book co., New York.
16. Lovettrup S. The phylogeny of Vertebrates John Wiley and sons Inc., London.
17. Joysey K.A. and Kemp T.S. Vertebrate Evolution Oliver and Boyd, Edinberg.
18. Romer A.S. Vertebrate Paleontology University of Chicago Press, Chicago.
19. Newman Phylum Chordata.
20. Goodrich E.S. Structure and development of vertebrates. Dover publications Inc., New York
21. Hardisty M.W. and Potter I.C. Biology of Lampreys Academic Press New York
22. T.B. of Zoology Parker and Haswell W.A. Macmillan co. Ltd. London
23. The Biology of Amphibia Noble G.K. Dover Publication Inc New York

#### **Paper VI: Comparative Endocrinology**

1. General & Comparative Endocrinology: E.J.W., Barrington, Oxford, Clarendon Press.
2. Text Book of Endocrinology: R.H. Williams, W.B. Saunders.
3. Endocrine Physiology: C.R. Martin, Oxford University Press.
4. Comparative Endocrinology: A Gorbman et al, John Wiley & Sons.
5. Medical Physiology: W.F. Ganong (1981): 10th Edn. Lange Medical Publications.
6. Principles of Anatomy and Physiology: Tortora Grabowski, 9th Edn., John Willey & Sons.
7. Reproductive Physiology of Vertebrates: Van Tienhoven, A. (1983): 2nd Edn. Cornell Univ. Press, New York.
8. The Pituitary Gland: Imura, H. (1994), 2nd Edn., Comprehensive Endocrinology Revised Series Raven, New York.

9. Comparative Vertebrate Endocrinology: Bentley, P.J. (1976) Cambridge University Press, Cambridge.
10. General & Comparative Endocrinology: E.J.W., Barrington, Oxford, Clarendon Press.
11. Text Book of Endocrinology: R.H. Williams, W.B. Saunders.
12. Comparative Vertebrate Endocrinological: Bentley, P.J. (1976) Cambridge University Press, Cambridge.
13. Invertebrate endocrinology: D. B. Tembhare, Himalaya publishing House (2012) 23

### **Paper VII: Molecular Biology and Biotechnology**

1. Harper's Review of Biochemistry, Prentice Hall.
2. Principles of Biochemistry by Lehninger and Nelson, CBS publications and Distributors.
3. The Biochemistry "Students companion" by Allen J. Scism, Prentice Hall.
4. Fundamentals of Biochemistry by Jain J. L., S. Chand Publication.
5. Principles of Biochemistry by Zubay J. L., W.M. C. Brown Publishers.
6. Principles of Biochemistry by Horton, Prentice Hall.
7. Concept of Biochemistry by Boyer R., Coel publication co.
8. Harper's Biochemistry eds. Murray, R. K. P. and Granner, D. K. Prentice Hall.
9. Biochemistry by Mathews C. K. and Van Holde K. E., Benjamin C. publishing Co.
10. Biochemistry by Garrett R. H. and Grisham C. M., Saunders College publication.
11. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication.
12. Molecular Biology by Turner P. C. and Mc Lennan, Viva Books Pvt. Ltd.
13. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd.
14. Molecular Biology by Freifelder D., narosa publication House.
15. Gene VI by Benjamin Lewis, Oxford press.
16. Gene VIII by Benjamin Lewis, Oxford press.
17. Molecular biology of Gene by Watson J. D. et. al., Benjamin publication.
18. Molecular cell Biology by Darnell J. Scientific American Books USA.
19. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., garland publishing Inc.
20. Genetics Vol. I and II by Pawar C. B., Himalaya publication.
21. Essentials of Molecular Biology by Freifelder D., narosa publication House.
22. Molecular Cell Biology by Lodish H., Berk A., Zipursky S. L., Matsudaira P., Baltimore D. and Darnell J., W. H. Freeman and Co.
23. The Cell: Molecular Approach by Cooper G. M.
24. Molecular Biology by Upadhyay A and Upadhyay K. Himalaya publication.

### **Paper VIII: Biochemistry-II\***

1. Lehninger-Principles of biochemistry.
2. Donald Voet and Judith Voet- Biochemistry.
3. Harper -Biochemistry.
4. Jeremy M. Berg, John L. Tymovzko, Lubert Stryer- Biochemistry.
5. U. Satyanarayana, U. Chakrapani -Biochemistry.

**Bajaj College of Science, Wardha**  
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(With effect from academic session 2022-23 As per BOS dated 12-04-2022)

**Semester- III**

**Paper- IX, Parasitology and Immunology**

PG- ZOO (07)- S3-T1

**Unit I :**

- 1.1 *Vibrio cholera and Clostridium titani*- Life cycle, mode of transmission, infection and treatment
- 1.2 *Yersinia pestis*- Life cycle, mode of transmission, infection and treatment
- 1.3 Influenza and H1 N1 viruses- Life cycle, mode of transmission, infection and treatment.
- 1.4 Dengue and Hepatitis- Life cycle, mode of transmission, infection and treatment

**Unit II:**

- 2.1 *Trypanosoma and Entamoeba* - Life cycle, mode of transmission, infection and treatment
- 2.2 *Leishmania and Malaria*- Life cycle, mode of transmission, infection and treatment
- 2.3 *Wuchereria and Trichinella* - Life cycle, mode of transmission, infection and treatment
- 2.4 Toxins and antitoxins

**Unit III:**

- 3.1 Immune system- innate and adaptive immunity; Antigens and antibodies and its interaction
- 3.2 Cells and organs of immune system; T cells and B cells - maturation, activation and differentiation, T cell receptors
- 3.3 Major Histocompatibility Complex (MHC)- general organization and inheritance of the MHC, MHC molecules and genes
- 3.4 Complement system- classical, alternative and lectin pathways, regulation of complement system, biological consequences of complement activation

**Unit IV:**

- 4.1 Cytokine receptors- properties of cytokines, cytokine receptors, cytokine secretion by TH1 and TH2 subsets; Cell mediated cytotoxic responses- effector mechanisms, leukocyte activation and migration.
- 4.2 Hypersensitivity reactions- types, mechanisms of type I to IV hypersensitivity reactions; Autoimmunity- Organ specific autoimmune disease and treatment
- 4.3 Transplantation immunology- blood antigens, transplantation rejection, graft rejection, familial grafting, tissue typing, cross matching, immunosuppression.
- 4.4 Tumor immunology- Types and roles of tumor antigens, immune response to tumor; Immunotechniques- RIA and ELISA

## **Semester -III**

### **Paper-X, Special Group-Animal Physiology-I**

PG- ZOO (07)- S3-T2-SP1

## **Physiology of Digestion and Excretion**

### **Unit-I**

- 1.1 Histology of salivary glands, Mechanism of salivary secretion, composition and functions of saliva.
- 1.2 Histology of stomach, mechanism of secretion of gastric juice, composition and functions of gastric juice.
- 1.3 Histology of pancreas, mechanism of pancreatic secretion, composition and functions of pancreatic juice.
- 1.4 Histology of liver, bile secretion, its composition and functions.

### **Unit-II**

- 2.1 Histology of small and large intestine, intestinal glands, its secretion and control, intestinal bacteria.
- 2.2 Neural and endocrine regulation of gastro intestinal movements and secretions.
- 2.3 Gastrointestinal hormones - Synthesis, chemical structure and functions.
- 2.4 Digestion and absorption of proteins, carbohydrates and fats in the gastrointestinal tract.

### **Unit-III**

- 3.1 Functional anatomy of kidney.
- 3.2 Mechanism of formation of urine.
- 3.3 Normal and abnormal constituents of urine.
- 3.4 Mechanism of concentration and dilution of urine – The Counter current system.

### **Unit-IV**

- 4.1.1 Regulation of urine and body fluid concentration and volume, hormonal mechanism of Antidiuratic hormone, Aldosterone and Renin – Angiotensin system in renal physiology.
- 4.2 Regulation of water, electrolytes and acid base, renal clearance.
- 4.3 Physiology of nitrogen excretion
- 4.4 Renal failure.

## **Semester –III**

### **Paper-XI, Special Group- Animal Physiology-II**

PG- ZOO (07)- S3-T3-EL1

#### **Physiology of Circulation**

##### **Unit-I**

- 1.1 Types of heart (Myogenic and Neurogenic ).
- 1.2 Anatomy, histology and nerve innervation of the heart, heart valves.
- 1.3 Pace maker and specialized conducting fibers.
- 1.4 Blood pressure and factors affecting blood pressure.

##### **Unit-II**

- 2.1 Cardiac cycle, Electrocardiogram (ECG).
- 2.2 Cardiac output, heart sound.
- 2.3 Haemodynamics.
- 2.4 Cardiac Failure.

##### **Unit-III**

- 3.1 Cellular composition and functions of blood.
- 3.2 Blood groups and Blood transfusion.
- 3.3 Blood sugars – Causes and control of hypoglycemia and hyperglycemia
- 3.4 Blood lipids- Causes and control of hypolipidimia and hyperlipidimia

##### **Unit-IV**

- 4.1 Plasma proteins- Albumins, globulins.
- 4.2 Haemostasis, Cascade of biochemical reactions involved in coagulation of blood.
- 4.3 Transport of O<sub>2</sub> & CO<sub>2</sub> by blood.
- 4.4 Lymph – composition, formation and functions.

## **Semester III**

### **Core (Subject Centric)- I**

#### **Paper- XII - BIOTECHNIQUES – I\* (for by PG Zoology students)**

PG- ZOO (07)- S3-T4-FC1

(With effect from academic session 2022-23 As per BOS dated 12-04-2022)

#### **Unit I : MICROSCOPY**

- 1.1 Properties of light: Nature of light, wavelength, reflection, refraction, polarization
- 1.2 Microscopes: Principles and application
- 1.3 Light Microscopy, Phase Contrast Microscopy, Fluorescence microscopy
- 1.4. Scanning and transmission electron microscopy and Atomic Force microscopy

#### **Unit II: SPECTROSCOPY**

- 2.1 Spectroscopy: Basic Principles and applications
- 2.2 Types of Spectroscopy : UV visible, IR absorption spectroscopy, Raman Spectroscopy
- 2.3 Principle and Biological application of Mass Spectroscopy
- 2.4 X-ray diffraction (XRD) and NMR

#### **Unit III: Separation techniques in Biology**

- 3.1 Chromatography : Principle and types
- 3.2 Adsorption and partition chromatography
- 3.3 Size exclusion and ion exchange chromatography
- 3.4 Molecular separation by affinity chromatography,

#### **Unit IV: Microbiological Techniques**

- 4.1 Media preparation and sterilization.
- 4.2 Inoculation and growth monitoring.
- 4.3 Use of fermenters.
- 4.4. Microbial assays



## Semester-III Practical-VI, Special Group- Animal Physiology

PG- ZOO (07)- S3-P2

### I. Physiology Experiments

- 1 Effect of pH, temperature and incubation on human salivary amylase activity.
- 2 Determination of :-
  - a) Clotting time, bleeding time.
  - b) Erythrocyte sedimentation rate and c) Hemoglobin concentration.
- 3 Study of structure of RBCs in vertebrates with the help of already available permanent slides/ ICT tools/ models/ charts/ photographs etc.
- 4 Total leukocyte count and differential leukocyte count.
- 5 Total erythrocyte count.

### II. Quantitative Analysis

- 1 \*Estimation of blood Glucose by oxidase enzymatic technique (Source of blood: Local recognized pathology laboratory)
- 2 \*Estimation of blood proteins by Bradford's technique (Source of blood: Local recognized pathology laboratory)
- 3 Estimation of blood triglycerides (Source of blood: Local recognized pathology laboratory)
- 4 Estimation of blood cholesterol (Source of blood: Local recognized pathology laboratory)
- 5 Estimation of blood Sodium, potassium, Calcium (Source of blood: Local recognized pathology laboratory)
- 6 Estimation of blood alkaline & acid phosphatase (Source of blood: Local recognized pathology laboratory).
- 7 \*Separation of biomolecules by Gel filtration chromatography (Source of blood: Local recognized pathology laboratory).

### III. Qualitative Analysis

- 1 Normal & abnormal constituents of human urine.
- 2 Blood group detection by antisera.
- 3 Preparation and study of Urine crystals.
- 4 Estimation of serum urea by diacetyl monoxime method (Source of blood: Local recognized pathology laboratory)
- 5 Preparation and study of haemin crystals.

**IV. Histological Study of Stomach, Liver, Small intestine, Large intestine, Pancreas, Kidney, Thyroid, Pituitary, Blood smear, Heart, T.S. Vein, T.S. Artery with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.**

#### Distribution of Marks:

#### Marks - 100

1. Physiology Experiment	20
2. Major quantitative analysis	20
3. Minor quantitative analysis	10
4. Qualitative analysis	15
5. Identification and comment on spots(1-5)	15
6. Practical Record	10
7. Viva-voce	10

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Total marks 100

## **Suggested Readings**

### **Parasitology**

1. Brock Biology of Microorganisms (Ed. IX) M. T. Madigan J. M. Martinko and J.Parker. Prentice Hall International Publication.
2. The Nematode Parasite in Vertebrate, W. Youle and Maplestone.
3. General Parasitology, V. A. Dogiel.
4. Helminthology, E. C. Faury.
5. Platyhelminthes and Parasitism, D.R.Birt.
6. Animal Parasite- O.W. Aisen
7. Parasitic Protozoa, J.P. Kreier and J.R. Baker. Allen and Unwin Press.
8. Medical and Veterinary Protozoology M. G. Kathering , A. James paul and V. Zaman. Churchill Livingstone

1. Immunology – R. C. Kuby et al.
2. Immunology - Tizzard.
3. Immunology -. Roitt, Brostoff and D. Male.
4. Microbiology- M. T. Pelzer. Jr. E. C. S. Chan and N. R. Krieg. Tata McGraw – Hill Immunology - Abbas

### **Physiology**

1. Bell, G.E. & Davidson, J.N. & Emslie D. Smith- Text Book of Physiology & Biochemistry.
2. Medical Physiology: A Wiley Medical Publication, John Wiley & Sons, New York.
3. Comar, C.L. & Felix Bronner (1961) - Mineral Metabolism, Acad Press, New York & London.
4. Dayson (1964)- A Text Book of General Physiology: Little Brown & Co. Boston.
5. R. Eckert & D. Randall (1983) - Animal Physiology: W.H. Rexeman & Co.
6. M.A. Edwards & K.A. Hassall (1980) - Biochemistry & Physiology of the Cell: (2nd Edn.), Mc. Graw Hill Co.
7. Cuthe F. (1968)- The Physiology of Cells: The Macmillan Co.
8. Guyton, A.G. (1968)- Textbook of Medical Physiology: 7th Edn. Saunders Pub.
9. C.L. Prosser - Comparative Animal Physiology ,W.B. Saunders & Company.
10. R. Eckert - Animal Physiology: Mechanism & Application, W.H. Freeman & Company.
11. W.S. Hoar- General & Comparative Animal Physiology.
12. W.F. Ganong (1981) -Medical Physiology 10th Edn. Lange Medical Publications.

## **Biotechniques – I \***

1. Robert Broun, McGraw Hill International Edition -Introduction to instrumental analysis.
2. K. Wilson and K.H. Goulding ELBS Edition.54 - A Biologist Guide to Principle and Techniques of Practical Biochemistry
3. Alcamo -DNA Techniques.
4. Ed. M. F. A. Goosen, A.J. Daugulis and P.Faulkner -Insect Cell Culturing Engineering.
5. B. D. Singh -Biotechnology.
6. Pranav kumar edition II -Fundamentals and techniques of biophysics and molecular biology,

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**Semester – IV**  
**Choice Based Credit System**

(With effect from academic session 2022-23 As per BOS dated 12-04-2022)

**Core XI - Paper-XIII - Biotechniques, Biostatistics, Ethology, Toxicology and Bioinformatics - PG- ZOO (07)- S4-T1**

**Unit- I**

- 1.1 Sterilization techniques, media for microbial culture, inoculation methods
- 1.2 Animal cell & tissue culture- primary culture, cell lines, cell quantification, growth kinetics of cells in culture, cryopreservation of cells
- 1.3 Basic principle of sedimentation and centrifugation; Radioactive isotopes.
- 1.4 Chromatographic separation- Thin layer and gas chromatography; Electrophoretic separation techniques

**Unit- II**

- 2.1 Central tendency and dispersion- mean, mode and median with examples; Dispersion and variance.
- 2.2 Probability and probability distribution -Basic theory and type of probability and probability distribution with example (binomial, poisson and normal distribution).
- 2.3 Sampling – types, standard error (SE), standard deviation (SD), significance tests - t- test, z- test, Chi square test- assumption, importance and example
- 2.4 Neuronal control, genetic and environmental components in development of animal behavior; Animal ethics- Introduction, concept, organizations and their functions

**Unit- III**

- 3.1 Introduction and scope of toxicology
- 3.2 Environmental toxicology- Classification of environmental toxicants; Pesticides, Fertilizers, Heavy and trace metals, radioactive substances, food additives, automobile emission.
- 3.3 Translocation of toxicants- absorption, distribution, biotransformation and excretion of toxicants
- 3.4 Toxicity tests- Types (Acute and Chronic), calculation of LC50 and LD 50; Antidotal therapy - Antidotes, type of antidotes and antidotal procedure.

**Unit- IV**

- 4.1 Introduction and scope of bioinformatics - history, scope of bioinformatics in research, business and employment opportunities; Bioinformatics in India.

- 4.2 Sequence alignment- Pair wise sequence alignment and multiple sequence alignment.
- 4.3 Biological databases- Basic local alignment search tool (BLAST), and FASTA, Variants of BLAST, PSI-BLAST.
- 4.4 Phylogenetic analysis- Tree style, tree building methods

## **Semester -IV**

### **Core XII - Elective III**

#### **Paper- XIV, Special Group-Animal Physiology-III**

#### **Physiology of Brain, Nerve and Muscle**

PG- ZOO (07)- S4-T2-SP2

#### **Unit-I**

- 1.1 Morphological differentiation of mammalian brain
- 1.2 Brain stem
- 1.3 Cerebellum
- 1.4 Physiology of learning, memory and sleep

#### **Unit-II**

- 2.1 Types and functional properties of neurons
- 2.2 Ultrastructure of neuron
- 2.3 Ultrastructure of synapse and molecular mechanism of synaptic transmission
- 2.4 Bioelectrical properties of neurons- neuronal excitability, resting membrane potential-Nernst equation, sodium and potassium pump, propagation of nerve impulses, generation of action potential.

#### **Unit III**

- 3.1 Biosynthesis, storage and release of neurotransmitters: Acetylcholine , GABA, Epinephrine, Nor-epinephrine , Serotonin.
- 3.2 Neuropeptides- oxytocin, vasopressin, thyrotropin releasing hormone, cholecystokinin
- 3.3 Receptor physiology - Mechanoreception, photoreception, phonoreception, chemoreception
- 3.4 Disorders of nervous system: Alzheimer's disease, Parkinson's disease.

#### **Unit-IV**

- 4.1 Ultrastructure of skeletal muscle
- 4.2 Molecular mechanism of muscle contraction- muscle proteins, Calcium receptors, Calmodulin, Calcium pump, sliding filament theory, chemistry and role of ATP in muscle contraction.
- 4.3 Properties of muscle (twitch, tetanus, summation, tonus, all or none principle fatigue), muscular disorders.
- 4.4 Ultrastructure of Neuromuscular Junction.

## **Semester -IV**

### **Core XIII – Elective IV**

#### **Paper XV, Special Group-Animal Physiology-IV**

#### **Physiology of Respiration and Reproduction**

PG- ZOO (07)- S4-T3-EL2

##### **Unit I**

- 1.1 Physiological anatomy of respiratory system.
- 1.2 Mechanism of respiration – Mechanism of breathing and the exchange of respiratory gases at pulmonary surface.
- 1.3 Transport of respiratory gases by blood.
- 1.4 Lung volumes and capacities, partial pressure of gases.

##### **Unit II**

- 2.1 Oxygen dissociation curve, Carbon -dioxide dissociation curve.
- 2.2 Carbonic anhydrate, chloride shift.
- 2.3 Neural and chemical regulation of respiration
- 2.4 Hypoxia, Cyanosis.

##### **Unit III**

- 3.1 Endocrine control of spermatogenesis and oogenesis
- 3.2 Leydig cells, sertoli cells and their hormones
- 3.3 Follicular cells and luteal cells and their hormones
- 3.4 Corpus luteum- formation, structure, hormones and functions

##### **Unit IV**

- 4.1 Placenta - structure, hormones and functions
- 4.2 Physiology of lactation
- 4.3 Role of hormones and pheromones in reproduction
- 4.4 Causes of infertility in male and female; In vitro fertilization (IVF) and Test Tube Baby

## **Semester -IV**

### **Core (Subject Centric)- II**

#### **Paper- XVI - BIOTECHNIQUES – II\* (for by PG Zoology students)**

PG- ZOO (07)- S4-T4-FC2

(With effect from academic session 2022-23 As per BOS dated 12-04-2022)

#### **Unit I: Molecular Biology Techniques**

- 1.1 Phage display and yeast two hybrid assay
- 1.2 Transcript analysis
- 1.3 Foot printin-g assay and site directed mutagenesis
- 1.4 Biosensors: Principle, types and uses

#### **Unit II: *Drosophila* Culture Techniques**

- 2.1 Design and functioning of *Drosophila* culture laboratory.
- 2.2 Types of *Drosophila* culture media.
- 2.3 Cell proliferation assay.
- 2.4 Cell viability assay, MTT assay

#### **Unit III: Histochemical and Immunochemical Techniques**

- 3.1 Tissue fixation and processing : Types of fixatives, Principles and methods of fixation
- 3.2 Sectioning and Staining of tissue sections: Instruments used in sectioning, Principle, types and staining methods of tissues
- 3.3 Immunohistochemistry Principles, method of application of Immunohistochemistry and immunofluorescence techniques for localization of proteins in tissues.
- 3.4 In situ hybridization of nucleic acids

#### **Unit IV: Radioisotope and mass isotope techniques in biology**

- 4.1 Radioactive isotopes and half life of isotopes
- 4.2 Metabolic labeling.
- 4.3 Sample preparation for radioactive counting.
- 4.4 Safety guidelines Autoradiography.

## **Semester-IV, Practical-VII, Special Group- Animal Physiology**

PG- ZOO (07)- S4-P1

### **I. Physiology Experiments**

- 1 Study of Electrocardiograph (ECG) under different physiological conditions with the help of ICT tools/ charts/ models / photographs etc.
- 2 Body size and oxygen consumption in aquatic animals.
- 3 Effect of pH, temperature on oxygen and carbon dioxide concentration in pond water.
- 4 Biochemical estimation of tissue cholesterol by Salkowski method (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 5 Measuring of heart beat under different physiological condition.
- 6 Study of nerve cells and neurosecretory cells of cockroach with the help of already available permanent slides/ ICT tools/ charts/ models/ photographs etc.
- 7 Estimation of SGOT/SGPT from blood sample (Source of blood: Local recognized pathology laboratory)

### **II. \*Quantitative Analysis**

- 1 Muscle / Liver glycogen by Montgomery method (Source of muscle/ liver: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 2 Determination of fructose in seminal vesicle/ semen (Source of semen: Government artificial insemination centre)
- 3 Determination of semen constituents (Source of semen: Government artificial insemination centre)
- 4 Estimation of percentage quantity of lactose in milk in vertebrates.

### **III. \*Qualitative Analysis**

- 1 Estimation of lactate dehydrogenase (Source of blood: Local recognized pathology laboratory).
- 2 Histochemical localization of a dehydrogenase (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 3 \*Estimation of glycogen / carbohydrate by Iodine test (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 4 \*Estimation of lipid by Acrolein test (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 5 \*Estimation of protein by Ninhydrin reaction (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)
- 6 \*Histochemical localization of NADPH Diaphorase (Source of tissue: Local recognized fish markets/ slaughter houses/ poultry farms etc.)

**IV. Histological Study of Brain, Testis, Ovary, Thyroid, Adrenal, Corpus luteum in ovary, Leydig cells in testis, T. S. Muscle fiber, T. S. Spinal cord, Cerebellum & cerebrum, Nerve fiber, Lung with the help of already available permanent slides/ ICT tools/ charts/ photographs etc.**

<b>Distribution of Marks:</b>		<b>Total Marks</b>
1.	Physiology Experiment	20
2.	Major quantitative analysis	20
3.	Minor quantitative analysis	15
4.	Qualitative analysis	10
5.	Identification and comment on spots(1-5)	15
6.	Practical Record	10
7.	Viva-voce	10
<b>Total marks</b>		----- 100

**Semester-IV, Project**

PG- ZOO (07)- S4-PJ

100

(80 marks project evaluation including viva + 20 marks Internal assessment)

## **Suggested Readings**

### **Tissue culture and Biotechniques**

1. Animal cell culture – A practical approach, (III Edition) Ed. John R. W. Masters. IRL Press.
2. *In vitro*-cultivation of animal cell, biotechnology by open learning (BIOTOL), Butterworth Heinemann Ltd. Linaere house, Jordan Hill Oxford.
3. Introduction to instrumental analysis, Robert Broun, McGraw Hill International Edition.
4. A Biologist Guide to Principle and Techniques of Practical Biochemistry K. Wilson and K.H. Goulding ELBS Edition.
5. Molecular Cell Biology, J. Darnel, H. Lodish and D. Baltimore. W. H. Freeman and Company New York.
6. DNA Techniques by Alcamo.
7. Insect Cell Culturing Engineering, Ed. M. F. A. Goosen, A.J. Daugulis and P.Faulkner.
8. Biotechnology - B. D. Sings.
9. Biophysical Chemistry – Upadhyay, Upadhyay and Nath.

### **Toxicology**

1. Animal Clinical Chemistry: A Primer for Toxicologists. G.O. Evans (Ed.) ISBN: 0748403515, Taylor & Francis, 1996.
2. Animal Models in Toxicology. S.C. Gad & C.P. Chengelis (Eds.), ISBN: 0824784561, Marcel Deker, 1992.
3. Annual Reviews of Pharmacology & Toxicology, ISBN: 0824304373, 1997
4. Basic Toxicology: Fundamentals, Target Organ & Risk Assessment. F.C. Lu, ISBN: 1560323809, Taylor & Francis, 1996.
5. Casarett & Doull's Toxicology: The Basic Science of Poisons. C.D. Klaassen (Ed), ISBN: 0071054766, McGraw-Hill, 1996.
6. Comprehensive Toxicology. I. Sipes, C.A. McQueen & A. Gandolfi (Eds.), ISBN: 0080423019, Elsevier Science, 1997.
7. General & Applied Toxicology. B. Ballantyne, T. Mars & P. Turner (Eds), Vol I & II, ISBN: 0333498011, Macmillon/Stockton Press, 1993.
8. Loomi's Essentials of Toxicology, T.A. Loomis & A.W. Hayes, ISBN: 0124556256, Academic Pess, 1996.
9. Encyclopaedia of Toxicology, Chemical and Concepts, P. Wexler, ISBN: 012227220-X, Academic Press, 1998.
10. Dictionary of Toxicology. E. Hogson, J.E. Chambers & R.B. Mailman, ISBN: 1561592161, Groves ic, 1997.

### **Biostatistics**

1. Biostatistics-Arora and Malhan
2. Biostatistics- Jasraj and Gurudeep Raj
3. Biostatistics- P. Ramkrishan
4. Methods in Biostatistics-Mahajan

## **Bioinformatics**

1. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Edition CBS Pub. New Delhi.
2. Bergman, N. H. Comparative Genomics. Humana Press Inc. Part of Springer Science+BusinessMedia, 2007.
3. Baxevanis, A. D. Ouellette, B. F. F. 2009. Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.
4. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics, 2<sup>nd</sup> Edition. Benjamin Cummings.
5. Des Higgins and Willie Taylor 2000. Bioinformatics: Sequence, structure and databanks. Oxford University Press.
6. Rashidi H. H. and Buehler 2002. Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London.
7. Gibas Cynthia and Jambeck P. 2001. Developing Bioinformatics Computer Skills: Shroff Publishers and Distributors Pvt. Ltd. (O'Reilly), Mumbai.

## **Biotechniques – II \***

1. Robert Broun, McGraw Hill International Edition -Introduction to instrumental analysis.
2. K. Wilson and K.H. Goulding ELBS Edition.54-A Biologist Guide to Principle and Techniques of Practical Biochemistry
3. Alcamo -DNA Techniques.
4. Ed. M. F. A. Goosen, A.J. Daugulis and P.Faulkner -Insect Cell Culturing Engineering.
5. B. D. Singh -Biotechnology.
6. Pranav kumar, edition II – Fundamentals and techniques of biophysics and molecular biology.

## Question paper pattern: Guidelines to paper setters

The theory question papers comprises of **four** questions. All questions are compulsory and carry equal marks.

Q. 1.	One long answer question from OR Two short notes from	Unit-I Unit-I	16 8+8 = 16
Q. 2.	One long answer question from OR Two short notes from	Unit-II Unit-II	16 8+8 = 16
Q. 3.	One long answer question from OR Two short notes from	Unit-III Unit-III	16 8+8 = 16
Q. 4.	One long answer question from OR Two short notes from	Unit-IV Unit-IV	16 8+8 = 16
Q. 5.	Four short notes from	Unit I to IV	4+4+4+4 = 16

**Syllabus for Foundation course in Zoology**  
(to be opted by students perusing P.G. in subjects other than Zoology)

Students pursuing P.G. degree in Zoology can opt subject as follows for Semester III & IV

<b>Foundation course I in Semester III</b>	<b>Foundation Course II in Semester IV</b>
Medicinal Chemistry I	Medicinal Chemistry II
General Botany	Applied Botany
General Microbiology	Advanced Microbiology
Introductory Biotechnology	Molecular Biotechnology

### **Semester -III**

#### **Paper-XII, Foundation I, Human Physiology (for other than Zoology students)**

##### **Unit- I: Digestion**

- 1.1 Digestive tract, digestive glands, its secretion and role in digestion
- 1.2 Gastrointestinal hormones
- 1.3 Digestive disorders- Diarrhea, constipation and peptic ulcer
- 1.4 Antioxidant nutrients, free radicals and physiology of ageing

##### **Unit- II: Respiration**

- 2.1 Respiratory system
- 2.2 Respiratory pigment- Haemoglobin
- 2.3 Transport of respiratory gases (O<sub>2</sub> and CO<sub>2</sub>)
- 2.4 Respiratory disorders- Asthma and Bronchitis

##### **Unit- III: Excretion**

- 3.1 Human kidney (Structure)
- 3.2 Mechanism of urine formation
- 3.3 Adrenal gland and water electrolyte balance
- 3.4 Renal function test; Dialysis

##### **Unit- IV: Endocrine glands**

- 4.1 Pituitary gland and its hormones
- 4.2 Thyroid gland and its hormones
- 4.3 Adrenal gland and its hormones
- 4.4 Endocrine pancreas

## **Semester -IV, Paper-XVI,**

### **Foundation II, Applied Human Physiology**

#### **Unit 1- Circulation**

- 1.1. Structure of Heart and its function
- 1.2. Cardiac cycle, ECG and blood pressure
- 1.3. Blood groups, blood transfusion
- 1.4. Heart failure; Trade milk test (TMT); Angioplasty and Angiography

#### **Unit 2- Brain**

- 2.1 Structure of human brain
- 2.2 Sense organ- Eye
- 2.3 Sense organ- Ear
- 2.4 Disorders of nervous system- Alzheimer's and Parkinson's disease

#### **Unit 3- Reproduction**

- 3.1 Reproductive organs and its function- Ovary and testis
- 3.2 Menstrual cycle, pregnancy, menopause and andropause
- 3.3 Role of placentas
- 3.4 Parturition and lactation

#### **Unit 4- Reproduction**

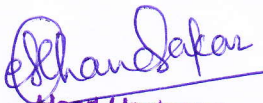
- 4.1 Contraceptive methods in male and female- Barrier methods, natural methods, oral contraceptives and IUCD
- 4.2 Polycystic ovary syndrome; Breast cancer
- 4.3 Prostate cancer; Impotency
- 4.4 IVF; Surrogacy

## Suggested Readings for foundation I and Foundation II

### Human Physiology

- 1 Text Book of Physiology & Biochemistry : Bell, G.E. & Davidson, J.N. & Emslie D. Smith, 1922
- 2 Medical Physiology : A Wiley Medical Publication, John Wiley & Sons, New York.
- 3 Mineral Metabolism : Comar, C.L. & Felix Bronner (1961) Acad Press, New York & London.
- 4 A Text Book of General Physiology : Dayson (1964) : Little Brown & Co. Boston.
- 5 Animal Physiology : R. Eckert & D. Randall (1983) 2nd Edn., W.H. Rexeman & Co.
- 6 Biochemistry & Physiology of the Cell : (2nd Edn.), M.A. Edwards & K.A. Hassall (1980) Mc. Graw Hill Co.
- 7 The Physiology of Cells : Cuthe F. (1968) : The Macmillan Co.
- 8 Textbook of Medical Physiology: Guyton, A.G. (1968). 7th Edn. Saunders Pub.
- 9 Samson Wrights Applied Physiology : Oxford University Press.
- 10 Comparative Animal Physiology C.L. Prosser, W.B. Saunders & Company.
- 11 Animal Physiology : Mechanism & Application, R. Eckert, W.H. Freeman & Company.
- 12 General & Comparative Animal Physiology : W.S. Hoar.
- 14 Medical Physiology : W.F. Ganong (1981) : 10th Edn. Lange Medical Publications.
- 15 Principles of Anatomy and Physiology: Tortora Grabowski, 9th Edn., John Willey & Sons.
- 16 Reproductive Physiology of Vertebrates: Van Tienhoven, A. (1983): 2nd Edn. Cornell Univ. Press, New York
- 17 A textbook of in vitro fertilization and assisted reproduction edited by P.R. Brinsden and P. A. Rainsbur Jaypee brothers 1992.
- 18 Advances in Reproductive Physiology, Vol. 1 to 6: McLaren, (1968). Logos Press Ltd., London.
- 19 Advances in Reproductive Toxicology eds. S. C. Joshi and A. S. Ansari Pointer publishers. Andrology. 2<sup>nd</sup> Edition Male Reproductive health and dysfunction (Eds. E. Nieschlag & H.M. Behre) 2000
- 20 Biochemistry of Mammalian Reproduction: Zanveld, L.J.D. & R.T. Chatterton (1982). John Wiley & sons, New York. The Ovary. Vol. I, II & III: Zuckerman, S, (1962). Academic Press, London.
- 21 Biology of Gestation: Assalye, N.S. (1968). Academic Press, London.
- 22 Biology of ovarian follicles in mammals (1985). S. S. Guraya Springer-Verlag.
- 23 Comparative cellular and molecular biology of testis in vertebrates (Trends in endocrine, paracrine and autocrine regulation of structure of functions) (2001) S.S. Guraya, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta
- 24 Comparative Endocrinology and Reproduction. Eds. K.P. Joy, A. Krishna and C. Haldar, Narosa Publishing House (1998).
- 25 Contraceptive Technology Past, Present and Future: Das. R.P. (1989). N.I.H.F.W. New Delhi.
- 26 Control of ovulation: Crighton, D.B., Haynes, N.B. Foxcroft, G.R. & G.E. Lamming (1978). Butterworths, London
- 27 Encyclopedia of Reproduction Vol. I, II, III, IV eds. Ernst Knobil and J.D. Neill (1998).
- 28 Endocrinology and metabolism. 4<sup>th</sup> edition 2001. Philip Felig & Lawrence A. Frohmon McGraw Hill Inc. Medical Publishing Division.
- 29 Endocrinology. Vol. 1 to 3: L.J. Degroot et al. (1989). W.B. Saunders Co. Philadelphia.
- 30 General Endocrinology: Turner, C.D. & J.T. Bagnara (1990) W.B. Saunders Co., & Toppan Co., Philadelphia, London & Tokyo.
- 31 Hormonal Control of Lactation: Cowie, A.T. Forryth, I.A. and I. Hart (1980). Springer-Verlag, Berlin & New York

32. Mammalian Oviduct: Hafez, E.S., and R.J. Blandu. The University of Chicago Press, Chicago, London.
33. Marshall's Physiology of Reproduction. 4<sup>th</sup> Edition Vol. 3 Pregnancy and Lactation Part I, II, III edited by G.E. Lamming, Champan and Hall.
34. Ovarian Cycle of Mammals: Perry, J.S. Oliver and Boyd, Edinburgh.
34. Patterns of Reproduction: Asdell, S.A. (1964). Constable and Co. London.
35. Physiology of Lactation: Smith, Vearch, Constable & Co., London.
37. Postgraduate Reproductive endocrinology. 4<sup>th</sup> Edition. 1997. R. Rajan Jaypee brothers. Medical Publishers (P) Ltd.
38. Practice of fertility control, Choudhary S. K. Churchill and Livingstone.
39. Progress in Reproductive Biology, Vol. 4. The pineal and reproduction: Reiter, R.J. Series Ed. P.O. Hubinant, Karger, Basel. Paris, London (latest edition).
40. Reproduction in Mammals Series: 1 to 6: Austin, C.R. and R. V. Short (1984 & 1994), Cambridge University Press, Cambridge.
41. Reproductive Endocrinology: Ref. No. 1, Vol. 3 Hormones in Reproduction.
42. Seasonal Patterns of Stress, immune function and disease R.J. Nelson, G.E. Demas, S.L. Klein, L.J. Kriegsfeld. 2002. Cambridge Univ. Press.
43. Shaw's textbook of Gynaecology eds. V. G. Padubidri and S. N. Daftary. 2000.
44. The Biology of Blastocyst: Blandau, R.J. (1971). The University of Chicago Press, Chicago & London.
45. The Prostaglandins Vol. I & II: Ramwell, P.W. (1974). Prenum Press, New York and London.
46. The Testis Vol. 1 to 4: Jhonson, A.D. and W. R., Gomes.
47. Vertebrate Foetal Membrances: Mossman, H.W. (1989). Rutgress Press Ltd.
48. WHO laboratory manual for the examination of human semen and sperm - cervical mucus interaction. 4<sup>th</sup> Edition Cambridge Univ. Press. 2000.

  
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