

University of Rajasthan, Jaipur
M.Sc. Zoology Syllabus
Semester Scheme 2012-14 (I, II, III and IV Sem)

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1. NEW ORDINANCES RELATED TO M.Sc. ZOOLOGY (Semester Scheme)

O.199F1: The examination of Regular students of Master degree (Post-graduate) courses of the University admitted in the academic session 2011-12 and after shall be based on (a) Semester Examinations, (b) Continuous Assessment, (c) Choice Based Credit System, and (d) Semester Grade Point Average and Cumulative Grade Point Average system as provided in O.199F1 to O.199F5. The ordinances which were in force prior to academic session 2011-12, will be applicable for Non-collegiate students (wherever permissible) and students admitted prior to academic session 2011-12 only. The ordinances O.199F1 to O.199F5 will have overriding effect over other ordinances for the Regular courses leading to Masters' degree.

O.199F2: Fifteen (15) hours of theory teaching will lead to one credit (which means one hour per week theory teaching in a semester of 90 teaching days) and in case of practical 45 hours of laboratory work will lead to two credit (which means 3 hours practical class per week in a semester of 90 teaching days). Each semester of Master's course shall offer 36 credits or more. Number of Semester Examinations and Minimum Credit required to be earned for award of Master degree in various Post-Graduate courses is specified in table given below.

S. No.	Faculty	Degree	Subject	Number of Semesters	Minimum Credit Required
1	Arts	M.A. (Master of Arts)	1. English	4	120
2			2. European Studies	4	120
3			3. French	4	120
4			4. Hindi	4	120
5			5. Philosophy	4	120
6			6. Sanskrit	4	120
7			7. Urdu	4	120
8	Social Science	M.A. (Master of Arts)	1. Anthropology	4	120
9			2. Economics	4	120
10			3. Garment Production and Export	4	120

			Management		
11			4. Geography	4	120
12			5. History	4	120
13			6. Mathematics	4	120
14			7. Political Science	4	120
15			8. Psychology	4	120
16			9. Public Administration	4	120
17			10. Sociology	4	120
18			11. Statistics	4	120
19			M.S.W. (Master of Social Work)	4	120
20			M.J.M.C.(Master of Journalism and Mass Communications)	4	120
21	Fine Arts	M.A. (Master of Arts)	Dramatics	4	120
22			Drawing and Painting	4	120
23			Music	4	120
24		M.V.A. (Master of Visual Arts)	4	120	
25		M. Mus. (Master of Music)	4	120	
26	Commerce	M.Com. (Master of Commerce)	Accountancy and Business Statistics	4	120
27			Business Administration	4	120
28			Economic Administration and Financial Management and Cooperation	4	120
29		M.C.C.A. (Master of Cost Control and Accounts)	4	120	
30		M.H.R.M. (Master of Human Resource Management)	4	120	
31		M.I.B. (Master of International Business)	4	120	
32		M.F.C. (Master of Finance and Control)	4	120	
33	Management	M.B.A. (Master of Business Administration)	4	120	
34		M.B.A. (Executive) (Master of Business Administration (Executive))	4	120	
35		M.B.A. (CAM) (Master of Business Administration-Computer Aided Management)	4	120	
36		M.B.A. (E-Com) (Master of Business Administration-E-Commerce)	4	120	
37	Education	M.Ed. (Master of Education)	2	60	
38		M.P.Ed. (Master of Physics Education)	4	120	
39		M.Lib. & Inf. Sc.(Master of Library and Information Science)	2	60	
40	Law	LL.M. (Master of Law)	4	120	
41		LL.M. (H.R.&V.E.) (Master of Law –Human Rights and Value Education)	4	120	
42	Science	Master of Science	1. Anthropology*	4	120
43			2. Biochemistry	4	120

44			3. Biotechnology	4	120
45			4. Botany	4	120
46			5. Chemistry	4	120
47			6. Environmental Science	4	120
48			7. Garment Production and Export Management*	4	120
49			8. Geography*	4	120
50			9. Geology	4	120
51			10. Home Science	4	120
52			11. Information Technology	4	120
53			12. Mathematics*	4	120
54			13. Microbiology	4	120
55			14. Pharmaceutical Chemistry	4	120
56			15. Physics	4	120
57			16. Psychology*	4	120
58			17. Statistics*	4	120
59			18. Zoology	4	120
60			M.C.A. (Master of Computer Applications)	6	180
61			B.Sc.-M.Sc. Integrated Biotechnology	10	300
62			B.Sc.-M.Sc. Integrated Information Technology	10	300
63			M.Tech. (Engineering Physics)	4	120
64	Engineering and Technology	Dual degree B.Tech. M.Tech. in Converging Technologies	1. Nanomaterials and Nanotechnology	10	300
65			2. Bioinformatics and Biotechnology	10	300
66			3. Information and Communication Technologies	10	300
67			4. Cognitive and Neuroscience	10	300

*Candidate who have been admitted to Master's degree in Anthropology/ Garment Production and Export Management / Geography/ Mathematics/ Psychology/ Statistics based on the Bachelor degree in Arts shall be awarded the M.A. degree in the concerned subject and candidates who have been admitted to Master's degree in Garment Production and Export Management based on the Bachelor degree in Commerce shall be awarded the M.Com. degree in the subject.

The number of papers, course type and credits and detailed syllabus for each course shall be shown in the syllabus for the course concerned. A candidate will be required to earn minimum credits prescribed above for award of the Master degree.

O.199F3:

- a) The Department in context of this ordinance means the Department/Centre of concerned PG subject at University of Rajasthan or that of an affiliated institution or college, as the case may be. Teacher of parent Department means a duly appointed Teacher as per UGC prescribed qualifications in the Department where student is enrolled for the course.
- b) A Credit Monitoring Committee (CMC) of the Department will consist of the Head and THREE Senior Most Teachers on roll of the Department with Head of the Department as Chairperson. Under special circumstance, when the number of teachers on roll is less than four, the Vice-Chancellor may constitute the Credit Monitoring Committee. Registration of candidates in the First and subsequent Semesters after the prescribed last date shall not be permitted. For subsequent semesters no minimum credit earning criterion will be applicable. Credit registration atleast once in all Compulsory Credit Course shall be binding, however, earning all CCC Credits for accumulation of the prescribed minimum credits shall not be required.
- c) The candidate will be required to finalize the number of credits at the time of registration in a semester and no change will be permitted after seven days of start of the semester. The CMC of the Department shall forward the credit registration details of all students enrolled in the semester, latest by the tenth day of commencement of the semester. The prior approval of Credit Monitoring Committee will be essential and decision of Credit Monitoring Committee shall be final and binding.
- d) The Credit Courses have been classified as
 - i. Compulsory Core Courses(CCC)
 - ii. Elective Core Courses(ECC),
 - iii. Seminar (SEM), Project Work (PRJ), Field Study (FST), Self Study Courses(SSC), and other Supportive Courses (OSC), Research Publications [RPJ] can also be taken in support of Core or Elective course wherever so prescribed.
- e) The aim of the seminar is to give students an exposure to recent developments and advance topics of research interest. The Seminar preparations can be undertaken only on prior approval of Credit Monitoring Committee of the Department. The CMC will allot Seminar Credits on Merit Basis out of desiring students. Seminar preparations are to be undertaken under guidance of a Teacher of parent Department. No teacher shall be permitted to guide more than three students in a semester for Seminar supervision. The guiding teacher will make continuous internal assessment of the Seminar. At the End of Semester Examination (EoSE) the Seminar will be conducted and credits will be awarded by a Board of Three Examiners consisting of the Head of the Department, guide and one faculty member other than guide.
- f) The aim of Project Work or Field Study is to introduce students to research methodology in the subject and prepare them for pursuing research in theoretical or experimental or computational areas of the subject. The project work or Field Study is to be undertaken under guidance of a Teacher of the Department or a Scientist or any other suitable person with proven research excellence in the concerned field of study. The Project Work or Field Study can also be taken up in an outside institution of repute on approval by Credit Monitoring Committee of the Department. The Project

Work or Field Study can be undertaken only on prior approval of Credit Monitoring Committee of the Department. The CMC will allot Project Work or Field Study Credits on Merit Basis out of desirous students. The guiding teacher will make continuous internal assessment of the Project Work/ Field Study. No teacher shall be permitted to guide more than three students in a semester for Project Work/Field Study under his/her supervision. EoSE for Project Work/ Field Study will be held at the unit where project work has been undertaken by a board of three examiners consisting of HoD, guide and one senior faculty.

- g) Each department is required to arrange delivery of all compulsory core courses and special number of elective core courses so that the students enrolled for the course can complete prescribed minimum number of credits. It is not binding on the Department to make provision for all elective core courses.
- h) A course is identified by a course code designated by a string of six alphanumeric characters and a course title. In a course code the first three characters of the string indicate the Department offering the course and the later three alphanumeric characters designate a particular course. In the case of compulsory core course the fourth character identifies the semester numeric digit and in case of the elective core courses the fourth character indicates the cluster of specialization. For compulsory theory core courses the fifth character is '0', for laboratory core courses it is '1' and for Project Work/ Seminar/Field Study it is '2' and for Research Publications in journals it is '3'.
- i) There will be no supplementary/due paper/special examination. Students with grade 'F' or 'E' will have to get themselves re-registered in the course if they so desire with option either as a Self Study Course or as a regular course depending on the feasibility at the Department. The credit will be considered and counted only if registered and approved by the Credit Monitoring Committee at the time of semester registration.
- j) The candidate shall not be permitted to appear in EoSE of a particular credit if (i) he/she does not fulfil the minimum 75% attendance requirement, or (ii) he/she fails to secure a Semester Grade Point Average (SGPA) of 1.5 in the continuous assessment. The concerned department will have to communicate the eligibility of candidate for EoSE to the University Fifteen days before commencement of Examination.

O.199F4: In Continuous Assessment (Department/ College/Institution wise) and End of Semester Examination (EoSE) examination (University as a whole) separate Grades will be awarded as specified under this ordinance. The continuous assessment will consist of two components, namely, (i) Internal Assessment and (ii) Sessional Test(s) in ratio 30:70. The internal assessment component will comprise of assessment of students performance on the basis of factors like Attendance, Classroom Participation, Quiz, Home Assignment etc. The sessional test shall be conducted on coverage of 50% of course content specified in the syllabus. The Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) for Continuous Assessment will be calculated on the Department/College level and for EoSE at the University level. The name of College/Department will be mentioned with SGPA and CGPA of Continuous Assessment.

O.199F5:

- a) Grades in a particular examination with less than 10 students registered in the course (cumulative at Department level for continuous assessment and cumulative at university level for EoSE) will be awarded on the basis of percentage of marks obtained as per table given below.

Percentage Range	Grade	Grade Point	Grade Definition
75-100	O	6	Outstanding
65-74	A	5	Very Good
55-64	B	4	Good
45-54	C	3	Average
33-44	D	2	Below Average
25-33	E	1	Poor
0-24	F	0	FAIL

- b) Grades in a particular examination with more than 10 students registered in the course (cumulative at Department level for continuous assessment and cumulative at university level for EoSE) will be calculated on the basis of relative merit of marks obtained, that is, Grade O (Point 6) to top 10% students, Grade A (Point 5) to next 25 % students in merit order, Grade B (Point 4) to further next 30% students in the merit order and Grade C (Point 3) to further next 25% in the merit order and Grade D (Point 2) to remaining last 10% students with exceptions permitted (i) to the extent to award students with same mark and the same grade, (ii) to award Grade E (Point 1) to those students securing less than 33% but more than 25% marks in the examination, and (iii) to award Grade F (Point 0) to those students securing less than 25% marks in the examination. The grade point assignment is also given below in tabular form.

Standing in Merit of the Course or Marks Obtained in the course	Grade	Grade Point	Grade Definition
Top 10 % in Merit	O	6	Outstanding
Among Top 35% in Merit but not in Top 10%	A	5	Very Good
Among Top 65% in Merit but not in Top 35%	B	4	Good
Among Top 90% in Merit but not in Top 65%	C	3	Average
Among Last 10% in Merit	D	2	Below Average
25% <=Marks<33%	E	1	Poor
Marks<25%	F	0	FAIL

- c) Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) will be calculated on the credit weighted average of the grade points obtained as given below.

$$SGPA = \frac{\sum_{i=1}^n C_i P_i}{\sum_{i=1}^n C_i}$$

Where

C_i : Number of credits earned in the i^{th} course of Semester for which SGPA is to be calculated.

P_i : Grade Point Earned in i^{th} course

i : 1, 2, ..., n represents the number of courses in which a student is registered in the concerned semester.

$$CGPA = \frac{\sum_{i=1}^n C_i P_i}{\sum_{i=1}^n C_i}$$

Where

C_i : Number of credits earned in the i^{th} course of Course till date for which CGPA is to be calculated.

P_i : Grade Point Earned in i^{th} course

i : 1, 2, ..., n represents the number of courses in which a student is registered in the concerned semester.

- d) The SGPA, CGPA grades will be assigned as per table given below.

SGPA or CGPA	Grade	Definition
5.50 to 6.00	O	Outstanding
4.50 to 5.49	A	Very Good
3.50 to 4.49	B	Good
2.50 to 3.49	C	Average
1.50 to 2.49	D	Below Average
0.50 to 1.49	E	Poor
0.00 to 0.49	F	FAIL

- e) The University will issue a complete transcript of credits, grade obtained, SGPA and CGPA on declaration of each semester result and a consolidated one on the accumulation of minimum credits required for the award of Master degree.
- f) The maximum period for accumulation of the credit for Award of Master degree is 5 years (8 years for Ten Semester courses). Failing which the credits earned will stand withdrawn and null and void.
- g) The details of conversion of seven point scale into percentage as per UGC notification is given below

SGPA or CGPA	Grade	Definition	Percentage
5.50 to 6.00	O	Outstanding	75-100
4.50 to 5.49	A	Very Good	65-74
3.50 to 4.49	B	Good	55-64
2.50 to 3.49	C	Average	45-54
1.50 to 2.49	D	Below Average	33-44
0.50 to 1.49	E	Poor	25-33

0.00 to 0.49	F	FAIL	0-24
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Thus the percentage will be obtained by using this table

CGPA	%	CGPA	%	CGPA	%
6	100	4	60	2	39
5.9	95	3.9	59	1.9	37.8
5.8	90	3.8	58	1.8	36.6
5.7	85	3.7	57	1.7	35.4
5.6	80	3.6	56	1.6	34.2
5.5	75	3.5	55	1.5	33
5.4	74	3.4	54	1.4	32.2
5.3	73	3.3	53	1.3	31.4
5.2	72	3.2	52	1.2	30.6
5.1	71	3.1	51	1.1	29.8
5	70	3	50	1	29
4.9	69	2.9	49	0.9	28.2
4.8	68	2.8	48	0.8	27.4
4.7	67	2.7	47	0.7	26.6
4.6	66	2.6	46	0.6	25.8
4.5	65	2.5	45	0.5	25
4.4	64	2.4	43.8	0.4	20
4.3	63	2.3	42.6	0.3	15
4.2	62	2.2	41.4	0.2	10
4.1	61	2.1	40.2	0.1	5

The enhancement of CGPA by 0.01 will enhance percentage as given below:

Grade	SGPA or CGPA	Percentage enhancement on 0.01 CGPA enhancement
O	5.50 to 6.00	0.5
A	4.50 to 5.49	0.1
B	3.50 to 4.49	0.1
C	2.50 to 3.49	0.1
D	1.50 to 2.49	0.12
E	0.50 to 1.49	0.08
F	0.00 to 0.49	0.5

For example (i) CGPA of 5.73 is equivalent to 86.5%, (ii) CGPA of 5.12 is equivalent to 71.2%, (iii) CGPA of 4.34 is equivalent to 63.4%, (iv) CGPA of 3.26 is equivalent to 52.6%, (v) CGPA of 2.17 is equivalent to 41.04%, and (vi) CGPA of 1.11 is equivalent to 29.88%.

2. Eligibility:

As per the University Website

3. Scheme of Examination:

- (1) Each theory paper EoSE shall carry 100 marks The EoSE will be of 3 hours duration. Part 'A' of theory paper shall contain 10 Short Answer Questions of 20 marks, based

on knowledge, understanding and applications of the topics/texts covered in the syllabus. Each question will carry two marks for correct answer.

- (2) Part “B” of paper will consist of four questions with internal choice (except in cases where a different scheme is specifically specified in the syllabus) of 20 mark each. The limit of answer will be five pages.
- (3) Each Laboratory EoSE will be of four/six hour durations and involve laboratory experiments/exercises, and viva-voce examination with weightage in ratio of 75:25.

4. Course Structure:

The details of the courses with code, title and the credits assigned are as given below.

Abbreviations Used

Course Category

CCC: Compulsory Core Course

ECC: Elective Core Course

OEC: Open Elective Course

SC: Supportive Course

SSC: Self Study Core Course

SEM: Seminar

PRJ: Project Work

RP: Research Publication

Contact Hours

L: Lecture

T: Tutorial

P: Practical or Other

S: Self Study

Relative Weights

IA: Internal Assessment (Attendance/Classroom Participation/Quiz/Home Assignment etc.)

ST: Sessional Test

EoSE: End of Semester Examination

FIRST SEMESTER

No.	SUBJECT CODE	Course title	Course Category	Credit	Contact hours per week			EoSE Duration (hrs)	
					L	T	P	Thy	P
1	ZOL 101	BIOSYSTEMATICS AND TAXONOMY	CCC	6	6	0	0	3	0
2	ZOL 102	STRUCTURE AND FUNCTIONS OF INVERTEBRATES	CCC	6	6	0	0	3	0

3	ZOL 103	BIOCHEMISTRY	CCC	6	6	0	0	3	0
4	ZOL 104	BIostatISTICS AND BIOINFORMATICS	CCC	6	6	0	0	3	0
5	ZOL 111	PRACTICAL – I	CCC	6	0	0	9	0	4
6	ZOL 112	PRACTICAL – II	CCC	6	0	0	9	0	4

Second Semester

S. No.	SUBJECT CODE	Course title	Course Category	Credit	Contact hours per week			EoSE Duration (hrs)	
					L	T	P	Thy	P
1	ZOL 201	EVOLUTION AND POPULATION GENETICS	CCC	6	6	0	0	3	0
2	ZOL 202	PHYSIOLOGY	CCC	6	6	0	0	3	0
3	ZOL 203	MOLECULAR BIOLOGY & BIOTECHNOLOGY	CCC	6	6	0	0	3	0
4	ZOL 204	ECONOMIC ZOOLOGY	CCC	6	6	0	0	3	0
5	ZOL 211	PRACTICAL – III	CCC	6	0	0	9	0	4
6	ZOL 212	PRACTICAL – IV	CCC	6	0	0	9	0	4

THIRD SEMESTER

S. No.	SUBJECT CODE	Course title	Course Category	Credit	Contact hours per week			Exam duration (Hrs.)	
					L	T	P	Thy	P
1	OL 301	BIOLOGY OF CHORDATES	CCC	6	6	0	0	3	0
2	ZOL 302	GENE DIFFERENTIATION	CCC	6	6	0	0	3	0
3		CORE ELECTIVE-1	ECC	6	6	0	0	3	0
4		CORE ELECTIVE-2	ECC	6	6	0	0	3	0
5	ZOL 311	PRACTICAL -V	CCC	6	0	0	9	0	4
6		CORE ELECTIVE - PRACTICAL	ECC	6	0	0	9	0	4

FOURTH SEMESTER

S. No.	SUBJECT CODE	Course title	Course Category	Credit	Contact hours per week			Exam duration (Hrs.)	
					L	T	P	Theory	P
1	ZOL 401	ENVIRONMENTAL BIOLOGY AND ETHOLOGY	CCC	6	6	0	0	3	0
2	ZOL 402	TOOLS AND TECHNIQUE	CCC	6	6	0	0	3	0
3		CORE ELECTIVE-3	ECC	6	6	0	0	3	0
4		CORE ELECTIVE -4	ECC	6	6	0	0	3	0
5	ZOL 411	PRACTICAL -VI	CCC	6	0	0	9	0	4
6		CORE ELECTIVE- PRACTICAL	ECC	6	0	0	9	0	4

COURSE NAME - PG ZOOLOGY SEMESTER SYSTEMSPECIALIZATION CLUSTERS

A. CANCER AND RADIATION BIOLOGY

B. CELL & MOLECULAR BIOLOGY

C. ENTOMOLOGY

D. ENVIRONMENTAL BIOLOGY

E. REPRODUCTIVE BIOLOGY

F. FISH & FISHERIES

Elective course code	specialization	Paper title	prerequisite	semester
ZOL A01	Cancer Biology	Cancer and radiation biology Paper I		III
ZOL A02	Cancer Biology	Cancer and radiation biology Paper II		III
ZOL A03	Cancer Biology	Cancer and radiation biology Paper III	Must clear ZOL-A01 & ZOL-A02	IV
ZOL A04	Cancer Biology	Cancer and radiation biology Paper IV	Must clear ZOL-A01 and ZOL-A02	IV
ZOL B01	Molecular biology	Cell & molecular biology Paper I		III
ZOL B02	Molecular biology	Cell & molecular biology Paper II		III
ZOL B03	Molecular biology	Cell & molecular biology Paper III	Must clear ZOL-B01 AND ZOL -B02	IV
ZOL B04	Molecular biology	Cell & molecular biology Paper IV	Must clear ZOL-B01 AND ZOL -B02	IV
ZOL C01	Entomology	Entomology paper I		III
ZOL C02	Entomology	Entomology Paper II		III
ZOL C03	Entomology	Entomology Paper III	Must clear ZOL-C01 AND ZOL -C02	IV
ZOL C04	Entomology	Entomology Paper IV	Must clear ZOL-C01 AND ZOL -C02	IV

ZOL D01	Envir. Biol	Environmental biology Paper I		III
ZOL D02	Envir. Biol	Environmental biology Paper II		III
ZOL D03	Envir. Biol	Environmental biology Paper III	Must clear ZOL-D01 AND ZOL - D02	IV
ZOL D04	Envir. Biol	Environmental biology Paper IV	Must clear ZOL-D01 AND ZOL - D02	IV
ZOL E01	Repro Biol	Reproductive biology Paper I		III
ZOL E02	Repro Biol	Reproductive biology Paper II		III
ZOL E03	Repro Biol	Reproductive biology Paper III	Must clear ZOL-E01 AND ZOL -E02	IV
ZOL E04	Repro Biol	Reproductive biology Paper IV	Must clear ZOL-E01 AND ZOL -E02	IV
ZOL F01	Fisheries	Fish & fisheries Paper I		III
ZOL F02	Fisheries	Fish & fisheries Paper II		III
ZOL F03	Fisheries	Fish & fisheries Paper III	Must clear ZOL-F01 AND ZOL -F02	IV
ZOL F04	Fisheries	Fish & fisheries Paper IV	Must clear ZOL-F01 AND ZOL -F02	IV

ZOL 101 - BIOSYSTEMATICS AND TAXONOMY

UNIT - I

1. Definition and basic concepts of biosystematics and taxonomy. History of taxonomy.
2. Importance and applications of biosystematics in biology.
3. Definition and understanding of various taxonomic categories.
4. Species concepts and species categories –subspecies and infra species.

UNIT – II

Modern trends in taxonomy-

5. Chemotaxonomy
6. Cytotaxonomy
7. Molecular taxonomy
8. Neotaxonomy
9. Determination of phylogenetic relationships using computer programs.

UNIT - III

- 10 Taxonomic procedures; collection, preservation, curation and process of identification.
- 11 Taxonomic characters of different kinds. Quantitative and Qualitative analysis of variation.
- 12 Process of typification, different zoological types and their significance.
- 13 Theories of biological classification.

UNIT - IV

- 14 Different kinds of systematic Publications.
- 15 Taxonomic Keys: their kinds, merits and demerits. Use of taxonomic keys.1
- 16 International Code of Zoological Nomenclature (ICZN)
- 17 Interpretation and application of important rules and formation of scientific names of different taxa.

PRACTICALS

- Identification, Classification and study of the animals from major invertebrate groups (Protozoa to Hemichordate including minor phyla) using museum specimens, slides, models or charts.
- Specimens :
 - PROTOZOA -Gregarines, Monocytes, Ciliates, Euplates, Dominion, Noctiluca, Radiolarian, Stenior, Opelika PEREIRA- Sectional view of sycon (T.S., L.S.), Grantia (T.S.).
 - CNIDARIA-Slides of Obelia polyp and medusa, Pennaria, Aurelia Tentaculocytes Museum specimens of Virgularia, spongodus, Zoanthus, Favia.
 - HELMINTHES- Slides of Temnocephala Museum Specimens of Ascaris lumbricoides, Taenia Solium, Planaria
 - ANNELIDA- Slides of Ozonbranches, Glossophonia. Museum Specimens of Eunice, chloehava. Polynoe, Terebella. Eurythoe.
 - ARTHROPODA- Slides of Cytops, Daphnia, Chelifer, section of Peripatus. Museum Specimens of Balanus Lepas, Palinurus, Uca, Pycna, Hippa, Gongylus, Belostoma. Limulus, Squilla, Eupagurus.
 - MOLLUSCA-Museum Specimens of Dolabella, Pteria, Nerita, Sanguinolaria, Chicoreus, Ficus, Lambis, Tridacna, Onchidium, Oliva, Murex, Turritella, Bulla, Cardium, Arca.
 - ECHINODERMATA-Museum Specimen of Linkia, echinodiscus, Holotharia, Antedon.
 - MINOR PHYLA-slides of Bugula, Plumatalla, Cristatella, Pectinella, Museum Specimen of Phoronis, Dendrostoma.
 - LARVAE- Planula, Redia, Cercaria, metacercaria, Trochopore, Nauplius, Zoea, Mysis, Phyllosoma, Trilobite larvae of limulus, Antilon, Veliger, Bipinnaria, Ophio and Echinopluteus, Auricularia, tornaria

- Composition assessment of taxonomic diversity in a habitat. (grassland, arid land, wet land etc.)
- Use of taxonomic keys to identify t least 6-10 orders of insects (upto order level only).
- Visit river/pond/ sea

SUGGESTED BOOKS

- Biodiversity, E.O. Wilson, academic Press; Washington.
- Principle of Animal Taxonomy; G.G. Simpson. Oxford IBH Publishing Company.
- Elements of Taxonomy. E. Mayer.
- The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.
- Theory and Practice of Animal Taxonomy. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.
- Advancement in Invertebrate Taxonomy and Biodiversity. Rajeev Gupta. Agrobios International.

ZOL102 -STRUCTURE & FUNCTION OF INVERTEBRATES

UNIT I

1. Body organization :

- 1.1 Origin of life, Uni and multi cellular organisms
- 1.2 Body cavity : Acoelome, Pseudocoelome , Coelome (schizo and enterocoelous)
- 1.2 Fate of Blastopore : Protostome, Deuterostome
- 1.3 Fate of Blastomeres : Determinate and Indeterminate blastomeres
- 1.4 Type of cleavage : Spiral and Radial
- 1.5 Type of symmetry : Body planes, Asymmetry, Radial, biradial, bilateral symmetry
- 1.6 Segmentation : Pseudo, superficial and metameric

2. Locomotion :

- 2.1 Flagella and ciliary movement in Protozoa.
- 2.2 Hydrostatic movement in Coelenterata, Annelida and Echinodermata.

UNIT II

3. Nutrition and Digestion:

- 3.1 Strategies of feeding in invertebrates and digestion in lower Metazoa.
- 3.2 Feeding in Polycheata, Mollusca and Echinodermata.

4. Respiration:

- 4.1 Organs of respiration in invertebrates - Gills, book lungs and trachea.
- 4.2 Mechanism of respiration

5. Excretion:

5.1 Organs of excretion in invertebrates specially Coelomoducts, Nephridia and Malphigian tubules, organ of bojanus, green gland

5.2 Mechanisms of excretion.

UNIT III

6. Nervous System :

6.1 Primitive nervous system Coelenterata and Echinodermata.

6.2 Advanced Nervous system Annelida, Arthropoda (Crustacea and insecta) and Mollusca (Cephalopoda)

7. Reproduction :

7.1 Regeneration, Asexual (paramecium, obelia) and sexual reproduction (annelida,arthropoda and mollusca)

UNIT IV

8. Important systems:

8.1 Canal system in sponges

8.2 Parasitic helminths

8.3 Proto,meso and meta nephridia

8.4 Respiration in unio and pila

8.4 Water vascular system in star fish

9. Minor Phyla : Organization and general characters

9.1 Tardigrada , Entoprocta , Ctenophora , Rhyncoela, Spincula, Rotifera,Gastrotricha

PRACTICALS

1. virtual dissection of invertebrates using computer software

OR

Dissection: Nervovs System, Leech, crab of Scorpion, Mytillus, Sepia, Aplyisa, Sea Urchin, Holothuria, Star Fish.

- Mounting: Hydra, Obelia, Sertulria, companvlaria, tubvlaria, Miracidivm larvae, cercaria, Radia Rarvae, Cyclops, Daphnia, Zoea, Megalopa Muis planktons

SUGGESTED BOOKS

- Invertebrate Zoology: A Functional Evolutionary Approach Edward E.(Edward E. Ruppert) Ruppert , Richard S. Fox
- Invertebrate Zoology Author: R. S. K. Barnes³.The invertebrates. Vol.1. Protozoa through Ctenophora, Hyman, L.H. McGraw Hill Co., New York.,
- The Invertebrates. Vol.2. Hyman, L.H. McGraw Hill Co., New York
- The Invertebrates smaller coelomate groups, Vol.5. Hyman, L.H. McGraw Hill Co., New York.
- The Invertebrates. Vol.8. Hyman, L.H. McGraw Hill Co., New York. and London

- Invertebrate structure and function. Barrington, E.J.W. Thomas Nelson and Sons Ltd. London
- Invertebrates Richard C. Brusca , Gary J. Brusca and Nancy J. Haver
- A Biology of higher invertebrates, Russel-Hunter, WD. McMillan Co. Ltd., London
- Student Text Book of Zoology. Vol.I.II and III. Sedgwick.A. Central Book Depot, Allahabad.
- Text book of Zoology. Parker, T.J., Haswell. W.A.Macmillan Co., London.
- Biology of the Invertebrates by Jan A. Pechenik
- Invertebrate Zoology Lab Manual Robert L. Wallace , Walter K. Taylor
- The Invertebrates: A Synthesis - R. S. K. Barnes Peter P. Calow P. J. W. Olive D. W. Golding J. I. Spicer

ZOL 103 - BIOCHEMISTRY

UNIT I

1 The scope of biochemistry

1.1 Bio molecules

- 1.2 Chemical bonds,
- 1.3 pH
- 1.4 Acid, Base ,Buffer 1.
- 1.5 Concept of free energy.

2. Proteins:

Covalent properties of Proteins

- 2.1 Structure and chemistry of amino acids
- 2.2 Isolation and purification of protein
- 2.3 Protein sequencing
- 2.4 Peptide synthesis
- 2.5 Covalent modifications
- 2.6 Protein splicing
- Protein secondary and tertiary structure
- 2.7 Peptides and peptide bonds
- 2.8 Ramchandaran plots and amino acid propensities
- 2.9 Common secondary structures
- 2.10 Protein tertiary structure and, folding patterns
- 2.11 Common tertiary structural motifs.
- 2.12 Role of packing constraints in tertiary structure patterns.
- 2.13 Divergent vs. convergent evolution of similar structure.
- Globular and fibrous proteins.

- 2.14 Water and the hydrophobic effect
- 2.15 Tertiary and quaternary effect.
- 2.16 Motifs in globular proteins
- 2.17 Properties of protein interiors and surfaces.
- 2.18 Fibrous proteins (keratin, fibroin, collagen and elastin) Protein folding and thermodynamics
- 2.19 Protein folding and dynamics
- 2.20 Folding Overview: the Levinthal paradox
- 2.21 Condensation and molten globules
- 2.22 Chaperon-assisted protein folding
- 2.23 Amino acid sequence variation and protein misfolding diseases Allostery (Hemoglobin), Myoglobin structure and oxygen binding
- 2.24 Hemoglobin subunits cooperatively, the Hill coefficient.
- 2.25 Quaternary structure changes and Sickle cell and other molecular diseases

UNIT II

3. Carbohydrates: Structure and biological importance of -

- 3.1 Monosaccharide,
- 3.2 Oligosaccharides
- 3.3 Polysaccharides(Storage and structural polysaccharides, glycosaminoglycans
- 3.4 Glycoconjugates(glycoprotein and preteoglycans)

4. Lipids

- 4.1 Fatty acids: structure, nomenclature, acyl glycerols, wax, phospholipids, sphingolipids, glycolipids, lipoproteins
- 4.2 Terpenoids and sterols: structure, properties and function
- 4.3 Function of lipids
- 4.4 Signal transducing molecules

5 . Nucleic acid structure

- 5.1 Nucleotides
- 5.2 Primary structure of nucleic acid.
- 5.2 Secondary and tertiary structures of nucleic acids; Triple helices and H- DNA; unusual secondary structure of DNA
- 5.3 Duplex stability
- 5.4 Hybridization
- 5.5 DNA and RNA sequencing.

UNIT III

6. Vitamins

- 6.1 Classification, structure, occurrence and functions of fat soluble vitamins
- 6.2 Classification, structure, occurrence and biological functions water soluble vitamins
- 6.3 Phenolics and alkaloids: structure, biological properties and functions

7. Enzymes:

- 7.1 Enzyme as biocatalyst
- 7.2 The kinetics of enzyme catalysis
- 7.3 Principles of enzyme catalysis
- 7.4 Proteases, polymerases, other examples
- 7.5 Coenzymes and Cofactor
- 7.6 Isozymes
- 7.7 Enzyme inhibition
- 7.8 Allosteric enzyme
- 7.9 RNA catalysis
- 7.10 Chemistry and structure of ribozymes
- 7.11 Evolutionary implications
- 7.12 Immobilized enzymes and their applications
- 7.13 Enzymes as biosensor

UNIT IV

8. Metabolism

- 8.1 Catabolism, anabolism, Metabolic pathway, regulation, concept of free energy
- 8.2 Carbohydrate metabolism: Enzymatic reaction, regulation and importance of Glycolysis, Citric acid cycle, Pentose phosphate pathway, glycogenolysis, glycogenesis, gluconeogenesis.
- 8.3 Lipid metabolism : fatty acid oxidation, fatty acid biosynthesis, biosynthesis of triglycerides, Cholesterol
- 8.4 Amino acid metabolism: Catabolism of amino acid, transamination, deamination, biosynthesis of nonessential amino acid, fate of carbon skeleton
- 8.5 Nucleotide metabolism: Degradation of purine and pyrimidines nucleotides, biosynthesis (De novo, salvage pathways) of purine and pyrimidine nucleotides
- 8.6 Oxidative phosphorylation and mechanism of ATP biosynthesis.

9. Inborn error of metabolism: (Important diseases of

- 9.1 carbohydrate
- 9.2 protein

9.3 lipid

9.4 nucleotide metabolism

PRACTICALS

- Identification of protein, carbohydrate and lipid in various tissues/food material
- Identification of different kinds of mono-di and polysaccharides in biological /food materials.
- Verification of Beer-Lambert's Law using Any colour solution
- Determination of absorption maxima of a coloured solution
- Plotting of standard curve
- Quantative estimation of the following in various tissues
 - Carbohydrates: Glycogen, glucose and ascorbic acid.
 - Proteins :Total proteins
 - Lipids: Total lipid, Phospholipids and cholesterol.
 - Nucleic acid: DNA and RNA
 - Enzymes: Acid and alkaline phosphates
- Paper chromatography: unidimensional chromatography, using amino acids from purified samples and biological materials.
- Paper /PAGE electrophoresis, determination of serum protein through paper /PAGE electrophoresis
- Determination of pH of different solutions

SUGGESTED BOOKS

- Biochemistry by Albert's R.H. Frey P.A. and Jencks W.P. Jones, & Bartlett Publisher, Boston/London. 1992
- Lehninger Principles of biochemistry by Nelson D.L. and Cox M.M. Macmillan/Worth Publishers. 2000
- Stryker L. Biochemistry. W.H.Freeman and Co. New York, 2001
- Fundamentals of Biochemistry by Voet D. Voet J.G. and Pratt C.W.. Johan Wiley and sons Inc. New York, 1999
- Principles and Techniques of Practical Biochemistry by Wilson K. and Walker J. Cambridge University Press, Cambridge, 1994
- Principles of Biochemistry by Zubay G.L.Parson W.W and Vence D.E. Wm.C.Brown Publishers, Oxford, England, 1995
- Harper's biochemistry by Murray, Granner, Mays Rodwell, McGraw Hill Publication, 2000

- Biochemistry by Mathew,C.K., Van Holde,K.E.,Ahren,K.G. Pearson education Pvt.Ltd.,Delhi,India,2003
- Principles of Biochemistry by Horton,H.R., Morsan, L.A., Scrimgeour,K.G.,Perry,M.D,Rawn,J.D., Pearson Educations,International,2006.
- Biochemistry (The Molecular basis of Life)by McKee,T.,McKee,J.R. Mc Grew Hill Companying.
- Biochemistry and molecular Biology by Elliott,W.H. ,Elliott,D.C.Oxford University Press,Oxford,2003.
- Lippincott's Illustrated Review by Champe,P.C.,Harvey,R.A. Lippincott Williams & Wilkins,Philadelphia

ZOL 104-BIOSTATISTICS AND BIOINFORMATICS

UNIT I

1. Introduction to Biostatistics
 - 1.1 Definitions of biostatistics
 - 1.2 Statistical symbols
 - 1.3 Scope & Applications of biostatistics
 - 1.4 Collection, organization and representation of data
2. Measures of Variability
 - 2.1 Mean deviation
 - 2.2 Standard deviation
 - 2.3 Variance and coefficient of variation
3. Correlation and Regression
 - 3.1 Types of correlation
 - 3.2 Methods of studying correlation
 - 3.3 Regression analysis
 - 3.4 Uses of regression analysis

UNIT II

4. Tests of Significance
 - 4.1 Significance of difference in means
 - 4.2 Standard error of mean
 - 4.3 Student's t-test
 - 4.4 F-test
5. Chi-square test
 - 5.1 Testing goodness of Fit
 - 5.2 Chi-square distribution and characteristics
 - 5.3 Applications of Chi-square test
 - 5.4 Yate's correction

6. Analysis of Variance
 - 6.1 One-way classification
 - 6.2 Two-way classification
- UNIT III**
7. Introduction to Bioinformatics
 - 7.1 Definitions of bioinformatics
 - 7.2 Applications of bioinformatics
 - 7.3 Scope of bioinformatics
 - 7.4 Bioinformatics in India
- UNIT IV**
8. Biological Databases
 - 8.1 Primary, secondary and composite databases
 - 8.2 Nucleotide sequence databases
 - 8.3 Protein sequence databases
 - 8.4 Structural databases
9. Sequence Analysis
 - 9.1 Types of sequence alignment
 - 9.2 Methods of sequence alignment
 - 9.3 Scoring schemes
 - 9.4 Gaps and gap penalties
10. Genomics and proteomics
 - 10.1 Structural genomics
 - 10.2 Functional genomics
 - 10.3 Comparative genomics
 - 10.4 Classification of proteomics
 - 10.5 Data mining in proteomics
 - 10.6 Significance of proteomics

PRACTICALS

- Preparation of frequency tables, histograms, frequency curves, ogives and pie diagrams.
- Calculation of standard deviation and coefficient of variation.
- Estimation of significance between samples using Student's t-test, F-test and Chi-square test.
- Plotting of regression lines, calculation of correlation and regression analysis .
- Analysis of variance (One-way & Two –way classification).
- Study of the tools used in bioinformatics.
- Retrieve the sequence for the database.
- Genome sequencing techniques.

- Methods of sequence alignment.
- Nucleotide and protein Sequence databases.
- Gene bank flat file format.
- Data mining in proteomics.

- Class Record.
- Viva-voce

RECOMMENDED BOOKS

- Sokal, R. R. and Rolf F. J. Biometry : Freeman, San Francisco, US
- Snedecor, H. W. and Cochran, W. G. Statistical Methods. Affiliated East-West Press, New Delhi.
- Green R.H.Sampling Design and Statistical methods for Environmental Biologist, John Wiley & Sons, New York
- Attwood, T.K. and Parry Smith, D. J. (2006) Introduction to Bioinformatics. P 240, Pearson Education, Singapore
- Bourne, P. E and Weissig, H. (Eds.) (2003) Structural Bioinformatics. P.649, Wiley –Liss, New Jersey, USA.
- Lesk, A. M. (2005) Introduction to Bioinformatics. 2nd ed., Oxford Press.
- Krane, D. E and Raymer, M. L. (2006)
- Fundamental concepts of Bioinformatics. P.314,Pearson Education, Singapore
- Mount, D. W. (2001)Bioinformatics: Sequence and Genome Analysis, P. 564, Cold Spring Harbor Laboratory Press, New York, USA.
- Tisdall, J. D. (2001)Beginning Perl for Bioinformatics. p. 368, O'relly, California, USA.
- David W. Mount, Bioinformatics: Sequence and Genome Analysis, Second Edition.
- Jae K. LeeStatistical Bioinformatics: A Guide for Life and Biomedical Science Researchers.
- Allan Bluman **Elementary Statistics: A Brief Version** (5th Edition)

ZOL 111- PRACTICAL –I

(BASED ON ZOL 101, ZOL 102)

ZOL 112- PRACTICAL- II

(BASED ON ZOL 103, ZOL 104)

ZOL 201-EVOLUTION AND POPULATION GENETICS

UNIT I

1. Concepts of evolution and theories of organic evolution (Lamarckism, Darwinism, Mendelism) Evolution in our hands, major transitions in Evolution.
2. Neo- Darwinism, Darwinian medicine
 - 2.1 Hardy-Weinberg law of genetic equilibrium

2.2 Detailed account of destabilizing forces- Natural selection, Mutation, Genetic drift, Migration, Meiotic drive

2.3 Genetic structure of natural populations

2.4 Phenotypic variations

2.5 Models explaining changes in genetic structure of population

UNIT II

3 Genetics of speciation

3.1 Phylogenetic and biological and other concepts of species

3.2 Patterns and mechanisms of reproductive isolation

3.3 Models of speciation (Allopatric, sympatric, parapatric, peripatric)

3.4 Co-evolution and sexual selection, altruism, punctuated equilibrium, phyletic gradualism

4. Molecular population genetics

4.1 Gene duplication and divergence

4.2 Patterns of change in nucleotide and amino acid sequences

4.3 Ecological significance of molecular variations

UNIT III

5. Genetics of Quantitative traits in populations

5.1 Analysis of quantitative traits

5.2 Quantitative traits and natural selection

5.3 Estimation of heritability

5.4 Genotype-environment interactions

5.5 Molecular analysis of quantitative traits

5.6 Phenotypic plasticity

6. Molecular Evolution

6.1 Gene Evolution

6.2 Evolution of gene families

6.3 Molecular drive

UNIT IV

7. Molecular Phylogenetics

7.1 How to construct phylogenetic trees

7.2 Phylogenetic inference-Distance methods, parsimony methods, maximum likelihood Method

7.3 Immunological techniques

7.4 Amino acid sequence and phylogeny

7.5 Nucleic acid phylogeny- DNA- DNA hybridizations, Restriction Enzyme sites, Nucleotide sequence comparisons and homologies.

7.6 Molecular Clocks.

PRACTICALS

Numerical based on theory

SUGGESTED BOOKS

- Genetics and Origin of Species. Dohnzhansky, Th., F.J.Alaya, G.L.Stebbins and J.M. Valentine, Surjeet Publication, Delhi
- Evolutionary Biology, Futuyamma, D.J.Suinuaner Associates, INC Publishers, Sunderland.
- A Primer of Population Genetics. Hart, D.L. Suinuaer Associate, Inc, Massachusetts.
- Genes and Evolution. Jha A.P. John Publication, New Delhi
- Species Evolution- The role of chromosomal change. King, M. Cambridge University Press, Cambridge.
- Evolution and Genetics Merral, D.J.Holt, Rinchart and Winston, Inc.
- Evolutionary Genetics. Smith,J.M. Oxford University Press, New York.
- Evolution. Strickberger, M.W.Jones and Barlett Publishers, Boston London
- Evolution and population genetics, Rashmi Sisodia, Paragon, International Publishers.
- Encyclopedia of Evolution Vol I and Vol II- By Mark Pagel, Oxford University Press.

ZOL 202 - PHYSIOLOGY**UNIT-I**

1. Digestive system:

1.1 Nature of food-stuff

1.2 Various types of digestive enzymes and their action in alimentary canal,

1.3 Absorption and assimilation of food

1.4 Nervous and hormonal control of digestion

1.5 Energy balance

2. Circulatory system:

2.1 Composition and function of blood,

2.2 Haemopoiesis, blood clotting,

2.3 Blood volume, blood volume regulation,

2.4 Immunity, homeostasis,

2.5 Comparative anatomy of heart structure,

2.6 Myogenic heart, ECG – its principle and significance, cardiac cycle,

2.7 Heartbeat, blood pressure and blood groups.

3. Respiratory system:

3.1 Respiratory organs (gills, trachea and lungs), respiratory pigments

3.2 Mechanism of breathing,

3.3 Physiology of respiration, control of breathing,

3.4 Aerodynamics and BMR.

UNIT-II

4. Excretory system:

4.1 Comparative physiology of excretion,

4.2 Functional architecture of kidney and nephron,

4.3 Nitrogenous end products, formation of urine and its hormonal control,

4.4 Role of kidney in osmoregulation, urine concentration,

4.5 Waste elimination, micturition

4.6 Electrolyte balance, acid-base balance.

5. Muscular system:

5.1 Types and properties of muscles,

5.2 Functional architecture of skeletal muscles,

5.3 Biophysical and biochemical events during muscular activity.

6. Nervous system:

6.1 Functional architecture of neurons,

6.2 Origin and propagation of nerve impulse through axon,

6.3 Action potential, synaptic transmission,

6.4 Reflex arc and reflex action,

6.5 Gross neuroanatomy of the brain and spinal cord,

6.6 Central and peripheral nervous system,

6.7 Neural control of muscle tone and posture.

UNIT-III

7. Sense organs:

7.1 Structural architecture and functioning of eyes and ears,

7.2 Tactile response.

8. Thermoregulation and cold tolerance:

8.1 Heat balance and exchange, endotherms Vs ectotherms,

8.2 Counter-current heat exchanger,

8.3 Torpor, hibernation and aestivation,

8.4 Adaptations to extreme climate,

8.5 Comfort zone, body temperature- physical, chemical and neural regulation.

9. Stress:

9.1 Basic concepts of environmental stress and strain,

9.2 Homeostasis, physiological response to body exercise,

9.3 Meditation, yoga and their effects.

UNIT-IV

10. Endocrinology:

10.1 Endocrine glands in vertebrates, hormones and related diseases.

11. Reproduction:

11.1 Reproductive cycle,

11.2 Reproductive processes (implantation, parturition and lactation), neuroendocrine regulators in insects and mammals, pheromones.

PRACTICALS

- Demonstration of the use and operation of oscilloscope for recording neuroelectric activity and electrocardiogram.
- Kymographic recording of muscle twitch, summation of twitches, chronic contractions, tetanus, fatigue and stair-case phenomenon from the sciatic nerve gastronemius muscle preparation of frog.*
- Demonstration of Kymographic recording of the frog heart beat and the study of the effect of electrical stimulation, hot and cold, drugs, etc*
- Study of spinal and convulsive reflexes in frog*
*In case, frogs become available students may be asked to perform the various exercises. Otherwise following CAL exercise may be included (please see E-pharm programme)
 - The effect of K^+ , Ca^{++} , ACh and Epinephrine on the isolated heart of frog and conclude your data with the graphic representation
 - The effect of various doses of ACh and Nor-epinephrine on Blood pressure, Heart Rate and Respiratory Rate of the dog.
 - The effects of Atropine, Epinephrine, Ephedrine and Eserine on Rabbit's eyes and other such exercise can be framed from the E-Pharm software.
- Photometric determination of haemoglobin in blood sample.
- Determination of MCV, MCH, MCHC and colour Index of the given sample of blood.
- Demonstration of the blood clotting time, erythrocyte sedimentation rate, haemolysis and crenation.
- Determination of the urea in urine
- Determination of the glucose in urine.
- Radiation uptake in various tissues: elementary idea of using radioactivity detection instruments.
- Study of digestive enzymes in different parts of the alimentary canal.

SUGGESTED BOOKS

- Eckert Animal Physiology Mechanisms and Adaptation. R. Eckert (ed), 5th edition, W.H. Freeman and Company, New York.
- Biochemical Adaptation. P.W. Hochachka and G.N. Somero (eds), Princeton Univ. Press, Princeton, New Jersey.
- General and Comparative Animal Physiology, W.S. Hoar (ed), Prentice Hall of Indian.
- Animal Physiology: Adaptation and Environment, K.S. Schiemdt Neilsen (ed), University Press, Cambridge, UK.
- A regulatory Systems Approach. Strand, F.L. Physiology: Macmillan Publishing Co., New York.
- Practical Biochemistry, L. Lummer (ed), Tata McGraw Hill
- Environmental and Metabolic Animal Physiology, C.L. Prosser (ed), Wiley-Liss Inc., New York.
- Environmental Physiology, P. Willmer, G. Stone, and I. Johnson (eds), Blackwell Publishing, Oxford, UK.
- Adaptation to Environment: Essays on the Physiology of Marine Animals. R.C. Newell (ed), 1976. Butterworths, London, UK.
- Physiological Ecology: An evolutionally approach to resource use. Townsend, C.R. and P. Cawlow. Blackwell Sci. Inc. Pub., Oxford, UK.
- Optima for Animals. R.M. Alexander (ed), Princeton Univ. Press. Princeton, New Jersey.
- Comparative Physiology: Life in water or land. P. Dejours, L. Bolis, C.R. Taylor and E.R. Weibel (eds), Liviana Press, Padova, Italy.
- Animals and Temperature: Phenotypic and Evolutionary Adaptation. I.A. Johnson & A.F. Bennett (eds), Cambridge Univ. Press, Cambridge, UK.
- Physiological Animal Ecology. G.N. Louw, Longman Publishing Group, Harloss, UK.
- An Introduction to General and Comparative Endocrinology, E.J.W. Barrington (ed), Clarendon Press, Oxford.
- Comparative Vertebrate Endocrinology. P.J. Bentley (ed), Cambridge University Press.
- Text Book of Endocrinology, R.H. Williams (ed), W.B. Saunders, Company, Philadelphia.
- Endocrine Physiology. C.R. Martin (ed), Oxford Univ. Press, New York.
- Comparative Endocrinology, A. Gorbman et al., John Wiley & Sons.

ZOL 203 - MOLECULAR BIOLOGY & BIOTECHNOLOGY**UNIT I**

1. DNA replication

- 1.1 Prokaryotic and eukaryotic DNA replication.
- 1.2 Mechanics of DNA replication.
- 1.3 Enzymes and accessory proteins involved in DNA replication.

2. Recombination and repair

- 2.1 Holiday junction.
- 2.2 FLP/FRT and Cre-Lox recombination.
- 2.3 Rec A and other recombinases.
- 2.4 DNA repair mechanisms.

UNIT II

3 Transcription

- 3.1 Prokaryotic transcription.
- 3.2 Eukaryotic transcription.
- 3.3 Regulatory elements and mechanisms of transcription regulation.
- 3.4 Transcription termination – attenuation and antitermination.
- 3.5 Gene silencing.

4 Post-transcriptional modifications in RNA

- 4.1 5'- Cap formation.
- 4.2 End processing and polyadenylation.
- 4.3 Splicing and editing.
- 4.4 Nuclear export of mRNA.
- 4.5 RNA stability.

UNIT III

5 Translation

- 5.1 Genetic code
- 5.2 Prokaryotic and eukaryotic translation
- 5.3 Regulation of translation
- 5.4 Co-and post-translation modifications of proteins.

6 Protein sorting Organelle biogenesis and protein synthesis.

- 6.1 Synthesis and targeting of mitochondrial and chloroplast proteins
- 6.2 Synthesis and targeting of peroxisomal proteins
- 6.3 Secretory pathways

- 6.4 Translocation of secretory proteins across the ER membrane
- 6.5 Insertion of membrane proteins in the ER membrane
- 6.6 Post-translation modifications in rER.
- 6.7 Protein glycosylation in ER and Golgi complex
- 6.8 Golgi and post-Golgi protein sorting and proteolytic processing
- 6.9 Receptors-mediated endocytosis and sorting of internalized proteins
- 6.10 Molecular mechanisms of vesicular traffic.

UNIT IV

7 Molecular mapping of genome

- 7.1 Genetic and physical maps
- 7.2 Southern hybridization, fluorescence in *situ* hybridization(FISH) for genome analysis.
- 7.3 Molecular markers in genome analysis(RFLP, RAPD and AFLP)
- 7.4 Application of RFLP in forensic, disease prognosis, genetic counseling and pedigree analysis.

8 Transgenic animals and knock-outs

- 8.1 Production
- 8.2 Applications
- 8.3 Embryonic stem cells
- 8.4 Bioethics

9 Assisted reproduction technologies

- 9.1 Embryo sexing and cloning.
- 9.2 Screening for genetic disorders.
- 9.3 ICSI, GIFT etc.
- 9.4 Cloning of animals by nuclear transfer.

PRACTICALS

- Squash and smear preparations of testis of cockroach / grasshopper aceto-orcein and Fuelgen staining of these preparations.
- Study of mitosis in onion root tip and meiosis in testes of insect or mammal.
- Study of giant chromosomes in the salivary gland of *Chironomus* larva or *Drosophila*
- Vital and supravital staining (with Neutral red and Janus green (B) of cells of the testis of an insects or mammal to study the mitochondria.
- Preparation of multipolar nerve cell from the spinal cord of a mammal.

- Study of prepared microscope slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.

SUGGESTED BOOKS

- Molecular Biology of the Gene. I.D Watson, N.H. Hopkins, J.W. Roberts, J.A. Steiz and AM Weiner The Benjamin/Cummings Pub. Co., Inc., California.
- Molecular Cell Biology, J. Darnell H.Lodish and D. Baltimore Scientific American Books, Inc., USA.
- Molecular Biology of the cell. B.Alberts, D.D.Bray, J.Lewis, M.Rafif, K. Roberts and J.D.Watson. Garland Publishing inc., New York.
- Gene IV, Benjamin Lewin. Oxford University Press, UK.
- Molecular Biology and Biotechnology. A comprehensive desk reference, R.A.Meyers (Ed.), VCH Publishers, Inc., New York.
- Molecular Cloning: A Laboratory Manual, J.Sambrook, E.F.Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York.
- Introduction to Practical Molecular Biology, P.D.Dabre, John Wiley& Sons Ltd. New York.
- Molecular Biology Lab Fax, T.A.Brown (Ed.), Bios Scientific Publishers Ltd., Oxford

ZOL 204- ECONOMIC ZOOLOGY

UNIT-I

1. Economic importance of Protozoa: Beneficial and Harmful Protozoa.
2. Economic importance of Helminthes: Beneficial and Harmful Helminthes.
3. Economic importance of Arthropods: Beneficial and Harmful mites and ticks, crustaceans, spiders, insects.
4. Insects as pollinators, ornamental insects, as food.
5. Lac insect, Honey bees, Silk worm and industries related to them.
6. Harmful insects: - Insect pests: crop pests, storage pests, pests of fruits and vegetables, Pests of medical and veterinary importance and their management.

UNIT-II

7. Pisciculture and products of fishing industry
 - 7.1 Common Freshwater and Marine Food Fishes of India.
 - 7.2 Freshwater Aquarium, Common Freshwater aquarium Fishes.
 - 7.3 Exotic Food and Game Fishes.

8. Prawn fisheries.

9. Economic importance of mollusca: Pearl culture.

UNIT-III

10. Poultry keeping and Duck poultry.

11. Dairy farming and Piggery.

12. Leather industry, wool industry, (Fur and Fur Industry).

UNIT-VI

13. Pharmaceuticals from animals (Snake venom).

14. Wild life in India and its conservation and Significance.

15. Economic Importance of Mammals (Rodents and their management).

PRACTICALS

- General introduction to stains, preservations and fixatives.
- Museum specimens
 - Protozoa- Selected species of economic importance
 - Plathelminthes- Selected species of economic impotence
 - Arthropoda- Mites, Ticks, Spiders, Insects
- Permanent preparations- Whole mounts, various body parts/Appendages
- Visit to fish industry/Poultry farm/ Dairy/ Leather industry etc.
- Viva voce
- Record

RECOMMENDED BOOKS:

- Economic Zoology by G.S Shukla & V.B. Upadhyay, 1991-92 Rastogi Publications, Meerut, India.
- Fish& Fisheries by Kamaleshwar Pandey & J.P Shukla 2007. Rastogi Publications, Meerut, India.
- Fish & Fisheries of India by V.G. Jhingran 1982, Hindustan Pub, Corp. India.
- A hand book on Economic Zoology by Jawid Ahsan and Subhas Prasad Sinha, S. Chand & company Ltd. Ramnagar.

ZOL 211- PRACTICAL-III

(BASED ON ZOL 201, ZOL 202)

ZOL 212- PRACTICAL – IV

(BASED ON ZOL 203, ZOL 204)

ZOL 301- BIOLOGY OF CHORDATES**UNIT I**

1. Origin and outline classification of the chordates.
2. Salient features and Interrelationships of Hemichordate, Urochordata and Cephalochordata.
3. Origin, evolution and adaptive radiation of chordates.
4. Origin, evolution and general characters of Agnatha: Ostrachoderms and Cyclostomes.
5. The early Gnathostomes (Placoderms).

UNIT II

6. A general account of the Elasmobranchii, Holocephali, Dipnoi and Crosspterygii.
7. Adaptive radiation in bony fishes.
8. Origin, evolution and adaptive radiation of Amphibia.
9. Parental care in Amphibia
10. Neotany in Amphibia

UNIT III

11. Origin and evolution of Reptiles: Seymouria and Cotylosauria.
12. Skull of Reptiles.
13. Venom in Ophidians.
14. Dinosaurs.
15. Living reptiles: a brief account of Rhynchocephalia. Chelonia, Crocodilia and Squamata.

UNIT IV

16. Origin and evolution of birds.
17. Origin of flight: Flight adaptations.
18. Flightless Birds.
19. Modifications of Beak, Feet and Palate in Birds.
20. Origins of mammals: Primitive mammals (Prototheria and Metatheria).
21. General account on adaptive radiations in Eutherian mammals.
22. Evolution of man.

PRACTICALS

1. Virtual dissections using computer software

Dissections:-

- Cranial Nerves of *Wallago attu* or any other locally abundant fish
- Neural Complex of *Herdmania*
- Accessory respiratory organs of *Heteropneustes fossilis*
- Labyrinthine organs of *Anabas testudinus*

2. Museum specimens:

Lower Chordates: *Salpa* Asexual and Sexual stage, *Dolliolum* oozoid, *Botrylus*, *Herdmania*, and *Amphioxus*.

Pisces: *Petromyzon*, *Myxine*, *Rhinobatus*, *Pristis*, *Trygon*, *Chimaera*, *Polydon*, *Acipenser*, *Amia*, *Lepidosteus*, *Protopterus*, *Lepidosiren*, *Neoceratodus*, *Notopterus*, *Exocoetis*, *Echeneis*, *Pleuronectes*, *Mastacembelus*, *Diodon*, *Tetradon*, *Ostracion*, *Lophis*, *Syngnathus*, *Hippocampus*, *Anguilla*, *Labeo*, *Ophicephalus*.

Amphibia: *Ichthyophis*, *Necturus*, *Proteus*, *Ambystoma*, *Axolotl*, *Salamander*, *Siren*, *Alytes*, *Pipa*, *Bufo*, *Hyla*, *Rhacophorus*, *Rana*.

Reptilia: *Testudo*, *Chelonea*, *Sphenodon*, *Calotes*, *Hemidactylus*, *Phrynosoma*, *Draco*, *Varanus*, *Chameleon*, *Cobra*, *Hydrophis*, *Rattle Snake*, *Viper*, *Pit Viper*, *Krait*, *Eryx*, *Gravialis*.

Aves: *Taylor Byrd*, *Indiana Hoel*, *Jungle fol*, *Pavois*, *Columbia*, *Psittacidé*, *Wood paquer*, *Bubo* (Horned Owl), *Archéoptéryx*, *Flamingant*.

Mammals: *Ornithorhynchus*, *Echidna*, *Macropus*, *Hedgehog*, *Manis*, *Loris*, *Bat*, *Mongoose*, *Hystrix*, *Otter*.

3. Microscopic Slides:

Lower Chordates: *Herdmania* spicules, *Herdmania* tadpole larva, *Amphioxus* T. S. passing through oral hood, pharynx, testes, ovary, intestine and caudal regions, *Ammocoete* larva whole mount.

Pisces: Placoid scale, Cycloid scale, Ctenoid scale.

Amphibia: V S skin of Frog, T S passing through stomach, duodenum, intestine, liver, pancreas, lung, kidney, testes, ovary, spinal cord, bone.

Reptilia: V S skin of lizard.

Aves: V S skin of bird, contour feather, down feather.

Mammals: V S skin of mammals, T S passing through stomach, intestine, liver, pancreas, kidney, testes, ovary, thyroid gland, adrenal gland, pituitary gland, lung, bone, spinal cord, Blood smear, Simple cuboidal epithelium, Simple columnar epithelium, Simple squamous epithelium, Adipose tissue, Reticular tissue.

4. Comparative Osteology:

Comparative account of Axial and Appendicular skeletons of Frog, Varanus, Fowl and Rabbit (both articulated and disarticulated).

Skull of Reptiles (Anapsida and Diapsida).

Palate in Birds.

Skull and lower jaw of Carnivore mammal & herbivore mammal.

SUGGESTED BOOKS

- The chordata, Alexander, R.M. Cambridge University Press, London.
- The Biology of Hemichordata and Protochordata. Barrington, E.J.W. Olter and Boyd. Edinhourgh.
- Structure and Habit in vertebrate evolution - carter, G.S. Sedgwick and Jackson. London
- Comparative anatomy of vertebrates. Kent. C.G.
- Chordate morphology. Malcom Jollie. East-West Press Pvt.Ltd., New Delhi.
- Analysis of vertebrate structure. Milton Hilderhrand. John Wiley and Sons., Inc, New York
- Text Book of Zoology, Sedgwick, A.A. Students Vol.II.
- Vertebrate Body. Romer A.S. W.B. Saunders Co., Philadelphia.
- Life of vertebrate, Young. J.Z. The Oxford University Press. London.
- Life of mammals, Young. J.Z. The Oxford University Press. London.
- Evolution of the vertebrates, Colbert. E.H. John Wiley and Sons Inc., New York.
- Vertebrate Paleontology. Romer. A.S. University of Chicago Press, Chicago.
- Chordata structure and function. Waterman. A.J. Macmillan Co. New York.
- Vertebrate evolution. Joysey. K.A. and T.S. Kemp. Oliver and Boyd. Edinburgh.
- The Phylogeny of vertebrate. Lovtrup. S. John Wiley and Sons. London
- The biology of the Amphibia. Kingsley Noble G. Dover Publications. New York
- Avian Biology (in several volumes), Farner, D. S. and King, J. R., Academic Press, New York, 1971.
- Analysis of Vertebrate Structure, Hildebrand, M. 4th edition, John Wiley & Sons, Inc., New York, 1995.
- Biology and Comparative Physiology of Birds, Marshall, A. J., Volume I & II, 1960.
- Vertebrate Life, McFarland, W. N., Pough, F. H., Cade, T. J. and Heiser, J. B., Macmillan Publishing Co., Inc., New York, 1979.
- Text Book of Zoology, Parker, T. S. and Haswell, W. A., ELBS, 1978.

ZOL 302-GENES AND DIFFERENTIATION

UNIT I

1. Introduction to animal development

- 1.1 Problems of development biology
- 1.2 Develop patterns in metazoans
- 1.3 Development in unicellular eukaryotes
- 2. Creating multicellularity
 - 2.1 Cleavage types
 - 2.2 Comparative account of gastrulation
- 3. Early vertebrate development
 - 3.1 Neurulation and ectoderm
 - 3.2 Mesoderm and endoderm
- 4. Cytoplasmic determinants and autonomous cell specification
 - 4.1 Cell commitment and differentiation
 - 4.2 Cell specification in nematodes
 - 4.3 Germ cell determinants
 - 4.4 Germ Cell Migration.
 - 4.5 Progressive cell- Cell interaction and cell specification fate

UNIT II

- 5. Body Axes
 - 5.1 Establishment of body axes in mammals and birds
 - 5.2 Proximate tissue interactions
 - 5.3 Genetics of axis specifications in Drosophila
- 6. Homeobox concept in different phylogenetic groups
- 7. Tetrapod limb development
- 8. Hormones as mediators of development
 - 8.1 Amphibian metamorphosis
 - 8.2 Insect metamorphosis
 - 8.3 Ovarian Iuteinization and mammary gland differentiation.

UNIT III

- 9. Environmental evolution and animal development.
 - 9.1 Environmental cues and effects
 - 9.2 Malformations and disruptions.
 - 9.3 Changing evolution through development modularity
 - 9.4 Developmental constraints
 - 9.5 Creating new cell types-basic evolutionary mystery.
- 10. Biology of sex determination
 - 10.1 Chromosomal sex determination - Mammals and Drosophila
 - 10.2 Testis determination genes
 - 10.3 Ovarin development
 - 10.4 Secondary sex determination in mammals.
 - 10.5 Environmental sex determination

UNIT IV

- 11. Cell diversification in early embryo

- 11.1 Xenopus blastomeres
- 11.2 Morphogen gradients
- 11.3 Totipotency & Pluripotency
- 11.4 Embryonic stem cells.
- 11.5 Renewal by stem cells-epiderms
- 11.6 Skeletal muscle regeneration
- 11.7 Connective tissue cell family

12. Hemopoietic stem cells

- 12.1 Stem cell disorders.
- 12.2 Blood cell formation
- 12.3 Bone marrow transplants
- 12.4 Gene therapy

PRACTICALS

- Identification of male and female Drosophila.
- Identification of wild and mutant forms of Drosophila
- Monohybrid and dihybrid inheritance in Drosophila
- Simple problems based on mendalism to be done by the students.
- Identifications of blood groups in man.
- Demonstration of sex chromatin.
- Embryology of Frog
- Embryology of Chick

SUGGESTED BOOKS

- Development Biology S.F.Gilbert, Sinauer Associates Inc., Massachusetts
- Morphogenesis of vertabrate. Torrey,T.W. John Wiley and Sons Inc., New York and London.
- An Introduction to embryology, Balinsky, B.I.: W.B. Saunders Comp., ?
- Davidson, E.H.: Gene activity in early development. Academic Press, New York.,
- Modern embryology, Bodemer, C.W.: Holt Chart and Winston, Inc. New York; Chicago
- Principle of Animal Developmental Biology. Geol, S.C. Himalaya Publishers 1984.
- Metamorphosis, Etkin, W.L.I. Gilbert.: North-Holland Co., Amsterdam.
- Developmental Biology. R.M Twyman. Viva Books Private Limited. New Delhi.
- From egg to Embryo. Slack J.M.W. Cambride University Press, Cambridge UK.
- Principles of Development. Wolpert, L. Oxford University Press, Oxford, UK.

ZOL 311 - PRACTICAL-V

BASED ON ZOL 301 & 302

ZOL 401 - ENVIRONMENTAL BIOLOGY AND ETHOLOGY**UNIT I**

1. Ecological law of minimum and law of tolerance
2. Ecological niches , overlapping of niches , ecotone
3. Energy flow, food chain, food web and trophic levels, ecological pyramids
4. Nutrient cycles in nature -carbon, nitrogen, phosphorus and water.
5. Ecozones of India -habitat and fauna
- 6 Population ecology:
 - 6.1 Characteristics of a population
 - 6.2 Population growth curves, population regulation
 - 6.3 Life history strategies (r and K selection)
- 7 Environmental Pollution - air, water, noise and radiation (electromagnetic and ionizing) ; carbon foot print

UNIT II

8. Biodiversity :
 - 8.1 Species diversity, ecosystem diversity , genetic diversity and molecular Diversity.
 - 8.2 Alpha, Beta and Gamma Diversity
 - 8.3 Biodiversity indices. Measuring -species richness, species evenness Simpson's diversity Index and Shannon's diversity index
 - 8.4 Biodiversity act of India and Biodiversity hot spots in India (with special reference to Western Ghats and North east), UNESCO heritage sites (Kaziranga National Park)
- 9 Ecological communities : (succession, zonation, environment, biota and adaptations)
 - 9.1 Terrestrial
 - 9.2 Fresh water
 - 9.3 Marine and estuarine
10. Climatic Changes -El Nino and La Nina, Earth quacks and Tunami
- 11 . Elementary knowledge of : Wildlife acts and schedules, CITIES, TRAFFIC, WWF, Ramser convention, IUCN,ZSI,ZAI,ENVIS,IGCMC, Project Tiger, Biosphere reserves, world heritage sites and hot spots.

UNIT - III

12. Scientists and their works : Konrad Lorenz, Niko Tinbergen, Karl Von Frisch, Skinner B F and Harlow Harry, Richard Dawkins, EO Wilson, Desmond Morris

13. Concepts of Ethology (SS,FAP,ASE,IRM) , Flush Toilet model ; Genes and behaviour; Evolution of behaviour, Development of behavior

14. Neuroethology :

14.1 Methods of studying brain and behaviour: neuroanatomical, neurophysiological and neurochemical

14.2 Basic knowledge of EEG, LASER, PET,CAT , MRI and nuclear medicine imaging

14.3 Mammalian Brain and Behaviour, Limbic system and hypothalamus

14.4 Sleep - arousal and reticular formation

15. Definition of Social behaviour

15.1 Properties and advantages of social grouping, social group of monkeys

15.2 Sociobiology-Darwinian fitness, individual fitness, kin selection, group selection, cooperation, reciprocation, altruism , reciprocal altruism, Proximate and Ultimate causations

15.3 Home range, territory, core area and aggression

15.4 Human behaviour

UNIT IV

16. Feeding and sexual strategies in animals

17. Parental care in animals

18. Communication in animals - vocal, tactile, visual and chemical

19. Learning:

19.1 Introduction and definition

19.2 Types - Habituation, trial and error ,conditioning , cognition and imprinting

19.3 Short and long term memory, neural mechanism of learning

PRACTICALS

- Estimation of alkalinity, acidity, dissolved oxygen, chloride Ph in water, nitrogen, phosphorous

- Microbial analysis in soil
- Limnological study of a local water body submission of written report
- Learning by trail and error in animals using maze and jumping box
- Study of movement of fish in aquarium
- Study of courtship in birds
- Food preference in tribolium
- Pheromones in earthworms
- Study of imprinting in chicks

SUGGESTED BOOKS

- Ecology, Individuals. Populations and Communities. Begon. M., J.I., Harper and C.R. Townsend, Blackwell Science. Oxford U,
- Ecological concepts. Cherrett, J.M. Blackwell Sci. Publi. Oxford U.K.
- Population biology. Elseth. B.D. and K.M.Baumgartner. Van Nostrand Co., New York
- Fundamentals of ecological modeling. Jorgenson. SE. Elsevier. New "
- Animal behaviour: A synthesis of ethology and comparative psychology. Hinde. R.A. McGraw-Hill. New York.
- Behavioural ecology. Krebs J.R. and N.B. Davis: Blackwell. Oxford. U.K.
- Sociology: The new synthesis. Wilson. E.O. Harbard Univ. Press. Cambridge. Mass.USA
- A New Ecology - Systems Perspective
Sven Erik Jørgensen, Brian Fath, Simone Bastianoni, Joao Marques, Felix Muller, S. Nors Nielsen, Bernard Patten, Enzo Tiezzi and Robert Ulanowicz
Elsevier May 2007
- Ecological Census Techniques - A Handbook (2nd edition)
Edited by William J. Sutherland
CUP August 2006
- The Life of Mammals (Life of Mammals)
by David Attenborough
- Alcock, John . Animal behaviour—an evolutionary approach. (Sinauer Associates). 547 pages.
- Barnard, C.J. . Animal behaviour. (Croom Helm, London). 340 pages.
- Barnett, S.A. . Modern Ethology.
- Chauvin, Remy . Ethology: The biological study of Animal Behavior. (International Univ. Press). 245 pages.
- Colgan, Patric W. . Quantitative Ethology. (John. Wiley & Sons). 364 pages.
- Immelman, C. Introduction to Ethology.
- Manning, Aubrey . An Introduction to animal behaviour. (Edward Arnold Publ., London). 208 pages.
- 18.Manning, Aubrey . An introduction to animal behaviour. (Addison-Wesley Publ.Co.). 294 pages.
- 19.McFarland, David. Animal behaviour: Psychology, Ethology & Evolution. (ELBS Publ.).
- 20.Slater, P.J.B. . Essentials of animal behaviour. (Cambridge Univ. Press). 233 pages.
- 21. Wallace, Robert A. . The ecology and evolution of animal behavior. (Goodyear Publ. Co. Inc.). 284 pages.
- Fundamentals of Ecology by Eugene Odum, Gary W. Barrett, Hardcover: 624 pages, Brooks Cole

- The Science of Ecology by Richard Brewer, Hardcover: 816 pages, Publisher: Brooks Cole
- Applied Ecology and Environmental Management (2ND 00)
Edward I. Newman (Paperback | ISBN10: 0632042656; ISBN13: 9780632042654)
- Applied Ecology and Natural Resource Management (03)
Guy R. McPherson and Stephen DeStefano | ISBN10: 051105811X; ISBN13: 9780511058110)
- Essentials of Ecology C Townsend, M Begon, J L Harper

ZOL 402-TOOLS & TECHNIQUES

UNIT I

1. Principle, construction and application of
 - 1.1 Light Microscopy
 - 1.2 Phase contrast Microscopy
 - 1.3 Interference Microscopy
 - 1.4 Polarized Microscopy
 - 1.5 Fluorescence Microscopy
 - 1.6 Electron Microscopy (TEM+SEM)
 - 1.7 Confocal and Atomic Force Microscopy

UNIT II

2. Electrophoresis; Principle, construction, application and equipment used
 - 2.1 Various types such as ; paper, agarose, PAGE, submerged DNA , Pulse chase
 - 2.2 Isoelectric focusing points and capillary electrophoresis
 - 2.3 Various media for Electrophoresis
3. Chromatography; Principle, construction, application and equipment used
 - 3.1 Various types such as; paper, TLC, GLC, HPLC, Ion-Exchange and affinity chromatography.

UNIT III

4. Colorimetry and Spectrophotometry; Principle, construction, application and equipment used
 - 4.1 Various types such as; fluorescence, UV, IR, Atomic Absorption
 - 4.2 Lambert-Beer's Law
5. Principle and application of radiations in biology
 - 5.1 Radiation Dosimetry and equipment used for it
 - 5.2 Radioisotopes, types, characteristics and uses of
 - 5.3 Tracer techniques in biology
 - 5.4 Scintillation techniques

UNIT IV

6 Principle of cytological and cytochemical techniques

6.1 Fixation, chemical basis of fixation by formaldehyde, gluteraldehyde, chromium salts, mercury salts, osmium salts, alcohol and acetone.

6.2 Chemical basis of Staining of carbohydrates, proteins, lipids and nucleic acids.

7 Cell and Tissue Culture techniques

7.1 Design and functioning of tissue culture laboratory

7.2 Cell proliferation measurements

7.3 Cell viability testing

7.4 Culture media preparation and harvesting techniques.

PRACTICALS

- Demonstration of different types of Microscopes
- Demonstration of different types of Spectrophotometers
- Demonstration of Chromatographic equipment
- Demonstration of Electrophoresis equipment.
- Visit to tissue culture lab
- Some exercises based on the syllabi may be devised according to the availability of equipments.

SUGGESTED BOOKS

- Principle and Techniques of Practical Biochemistry ; Wilson & Keith
Cambridge Publications
- Biotechniques; Theory and Practice ; SVS Rana.Rastogi Publications, Meerut
- Clinical Biochemistry; Techniques and Instrumentation, JS Varcoe, World
Scientific Publication Company,ISBN ; 978-981-02-4556-6

ZOL 411- PRACTICAL-VI

BASED ON ZOL 401 & 402

ZOL A01 - CANCER & RADIATION BIOLOGY**Basics of Radiation Biology****UNIT I**

1. Types of Radiation and Radioactivity

- 1.1 Nuclear radiations
- 1.2 X-rays
- 1.3 Natural radioactivity
- 1.4 Artificial radioactivity
- 1.5 Half life of radioisotopes
- 1.6 Background radiation
- 1.7 Units of radiations

UNIT II

2. Detection and Measurement of Radiation

- 2.1 G. M. counter
- 2.2 Scintillation counter
- 2.3 Proportional counter
- 2.4 Gamma ray spectrophotometer
- 2.5 Radioautoradiography
- 2.6 Radioimmunoassay

UNIT III

3. Radiation Chemistry

- 3.1 Radiolysis of water
- 3.2 Formation of oxygen reactive species
- 3.3 Oxygen effect
- 3.4 Direct and indirect effects

4. Radiation Monitors

- 4.1 Film badge
- 4.2 Pocket dosimeter
- 4.3 Thermo luminescence dosimeter
- 4.4. Area monitoring

UNIT IV

5. Radioactive contamination and decontamination

- 5.1 Sources of contamination

- 5.2 Control of contamination
- 5.3 Contamination monitoring
- 5.4 Decontamination
- 6. Radioactive waste management
 - 6.1 Nuclear fallout
 - 6.2 Types of radioactive waste
 - 6.3 Discharge of radioactive waste
 - 6.4 Management of nuclear waste

ZOL A02 - CANCER AND RADIATION BIOLOGY
Radiation Effects & Safety

UNIT I

- 1. Cellular Radiobiology
 - 1.1 Survival curves
 - 1.2 Concept of LD50
 - 1.3 Radiosensitivity of cell cycle phases
 - 1.4 Classification of mammalian radiosensitivity
 - 1.5 Factors influencing radiosensitivity
 - 1.6 Effect of radiation on macromolecules
 - 1.7 Apoptosis

UNIT II

- 2. Acute Radiation Effects
 - 2.1 Skin reactions
 - 2.2 Gastro-intestinal syndrome
 - 2.3 Hematopoietic syndrome
 - 2.4 Central nervous system syndrome
- 3. Delayed Radiation Effects
 - 3.1 Stochastic and deterministic effects
 - 3.2 Life shortening
 - 3.3 Radiation hormesis
 - 3.4 Radiologic aging
 - 3.5 Radiation carcinogenesis

UNIT III

- 4. Cytogenetic Effects of Radiation
 - 4.1 Chromosomal aberrations

- 4.2 Micronuclei induction
- 4.3 Radiation mutations
- 5. Radiation Hazards and Control
 - 5.1 Radiation accidents
 - 5.2 Control of radiation hazards

UNIT IV

- 6. Radiation Safety and Regulatory Aspects
 - 6.1 Maximum permissible dose
 - 6.2 Source storage facilities
 - 6.3 Radiographic installations
 - 6.4 Personnel management
 - 6.5 Safe work practice
 - 6.6 Recommendations of National/International statutory bodies

PRACTICALS

- Knowledge and use of the various instruments. Geiger-Muller counter, Scintillation counters, Survey meter, Single-channel gamma spectrometer, Cobalt camera.
- Finding out the operating voltage of the G-M tube.
- Calculation of Inverse Square Law
- Determination of the resolving time of the G-M tube.
- Absorption of beta and gamma rays
- Determination of Backscattering factors
- Histopathological, histochemical and biochemical studies of various tissues after external irradiation.
- Paper radiochromatography: use of solvents, use of reagents, interpretation of chromatogram, scanning procedure.
- Personnel monitoring: use of survey meter, film badge, and room contamination monitor
- Decontamination of contaminated material.
- Visits to the Radiotherapy Department, S.M.S. Medical College, Jaipur: Rajasthan Atomic Power Project. Kota and Bhabha Atomic Research Centre, Mumbai.
- Class Record.
- Viva-voce

RECOMMENDED BOOKS

- Andrews, H.L.: Radiation Biophysics. Prentice-Hall Engel-Wood Cliffs. New Jersey. 1974 or Later Edition.
- Avena, V : Ionizing Radiation and Life.. Mosby, S1. Lonis. 1971 or Later Edition.

- Baverstock, K. of Staltar, J. Low Dose Radiation Biological Bases of Risk Assessment. Taylor of Francis, 1989.
- Broil. AB Low level Radiation Effects. A fact Book : Society of Nuclear Medicine, USA, 1982.
- Bulokav EB. ,V Naiitel and J.B. Reitan.: Radiobiological Consequences of Nuclear Accidents- Contamination Radioecology, Radiobiology and Health.
- Chase, GD. and Robinowitz, J.L. Radioisotope Methodology. Burgess Publishing Co. Minneapolis, Minn, USA. 3rd Edition, 1967 or Later.
- Coggle. J.E. : Biological Effects of Radiation. Taylor and francis Ltd., London, 1988 or Later Edition.
- Dalrymple, G.V, Ganldev, M.E., Kollmorgen, G.M. and Vogel, H.J.. Medical Radiation Biology. Saunders. Philadelphia, 1973 or Later Edition.
- Duncan, R.C., Knapp., R.G., and Miller III, M.C., : Introductory Biostatistics for the Health Sciences. John Wiley and Sons. Inc., New York, 1977 or Later Editon.
- Fobrikant. J.I. : Radiobiology. Year book med., Chicago, 1972 or Later Edition.
- G.B. gendes, H. Metives and J. Stathes. : Biological Assessment of occupational Exposure to Actinides. Nuclear Tech. Pub. Kent, 1989.
- Gesben, G. , C.M. Menaene and H. Smilts.: Environment and Human Risks of Tritium. Nuclear Tech. Pub. Kent, 1986.
- Granien, R., Applied Radiobiology of Radiation Protection. Prentice Hall, 1990.
- Grosel, D.S. and Hop Zwood, L.E. Biological Effects of Radiations. Academic Press, New York, 2nd Edition, 1979 or Later Edition.
- Hall. E.1. Radiobiology for the Radiologist. 3d Edition, Harper and Row, 1990 or Later edition.
- Hall. E.1.: Radiation and Life. Pergamon Press, Oxford, U.K. 2nd Edition, 1987.
- Hendec. w.R.: Health Effects of Low Level Radiation. Prentice Hall. 1984.
- Huilgol. N.G. et al.: Low level Radiation and Living State. Naraza Publishing House, Community Center Panchsheel Park, New Delhi, 1993.
- Kiefer J. Biological Radiation effects. Springer-Venlag, Berlin, 1989.
- Kriegel, H. ef of. Developmental Effects of Prenatal Irradiation. VCH, . 1982.
- Lawrence c.w. Cellular Radiobiology. Arnold, London, 1971 or Later Edition.
- Pant, G.S. and Basu, AK. Biological Aspects of Human Irradiation Eds. Himalaya Publishing House, Delhi, 1992.
- Pizzarello D. J. and Witcofsli Lea R.L. and Febiger: Basic Radiation Biology. Philadelphia, 1970 or Later.
- Prasad, K.N., Human Radiation Biology. CRC Press, inc. Cleveland, Ohio, USA, 1984.

- Rajan O. Advanced Medical Radiation Dosimetry. Prentice-Hall of India Pvt. Ltd., New Delhi, 1992.
- Riklin, E. ed. Frontiers of Radiation Biology. VCH, 1990.
- Scheres, E. ,c. Streffer, K.R. Trott.: Radiation Exposure and Occupational Risks Eds. Berlin, 1990.
- Seiwan J. Elements of Radiobiology, Thomas, C.C. 1983.
- Steve Forshie: Essentials of Radiation Biology and Protection, Publisher: Delmar Cengage Learning.
- Upton, A.C. Radiation Carcinogenesis. Ehseviees, 1986.

ZOL -A03-CANCER AND RADIATION BIOLOGY

Nature of Cancer

UNIT I

1. Introduction to Cancer
 - 1.1 Definitions of cancer
 - 1.2 Global aspects of cancer
 - 1.3 Cancer problem in India
2. Epidemiology of cancer
 - 2.1 Cancer incidence
 - 2.2 Geographic and environmental factors
 - 2.3 Cancer of different age groups
 - 2.4 Cancer of different sex
 - 2.5 Familial cancers

UNIT II

3. Classification of Tumors
 - 3.1 Benign and malignant tumors
 - 3.2 Carcinoma and sarcoma
 - 3.3 Leukemia and lymphoma
 - 3.4 Epithelial and non-epithelial tumors
 - 3.5 Specialized tumors
4. Cancer Related Genes and Cell Growth
 - 4.1 Growth promoting oncogenes
 - 4.2 Growth suppressing anti-oncogenes
 - 4.3 Viral oncogenes
 - 4.4 Genes regulating apoptosis
 - 4.5 Inherited cancer genes
 - 4.6 Mutator genes and cancer

UNIT III

5 Risk factors for cancer

- 5.1 Tobacco
- 5.2 Alcohol
- 5.3 Physical factors
- 5.4 Occupational exposure
- 5.5 Environmental carcinogens

6 Nutrition and Cancer

- 6.1 Cancer risk from food
- 6.2 Avoidance of cancer by food

UNIT IV

7 Characteristics of tumors

- 7.1 Rate of growth
- 7.2 Clinical and gross features
- 7.3 Microscopic features
- 7.4 Local invasion
- 7.5 Metastasis

8 Biochemistry of cancer

- 8.1 Biochemical characteristics of cancer cells
- 8.2 Biochemical mechanisms for activation of proto-oncogenes to oncogenes
- 8.3 Biochemistry of metastasis
- 8.4 Tumor markers
- 8.5 Clinical usefulness of tumor markers

ZOL A04 - CANCER AND RADIATION BIOLOGY Caustion, Diagnosis, Prevention & Treatment of Cancer

UNIT I

1. Common types of cancer

- 1.1 Oral cancer
- 1.2 Stomach cancer
- 1.3 Liver cancer

- 1.4 Lung cancer
- 1.5 Prostate cancer
- 1.6 Skin cancer
- 1.7 Breast cancer
- 1.8 Gynecological cancers

UNIT II

- 2 Causation of Cancer
 - 2.1 Chemical carcinogenesis
 - 2.2 Radiation carcinogenesis
 - 2.3 Viral carcinogenesis
 - 2.4 Hormones and cancer
 - 2.5 Hereditary and cancer

UNIT III

- 3 Diagnosis of cancer
 - 3.1 Histological methods
 - 3.2 Cytological methods
 - 3.3 Histochemistry and cytochemistry
 - 3.4 Immunohistochemistry
 - 3.5 Electron microscopy
 - 3.6 Biochemical assays
 - 3.7 Modern aids in tumor diagnosis
- 4 Prevention of Cancer
 - 4.1 Primary prevention: Education, motivation and legislation
 - 4.2 Secondary prevention: Detection of precancerous or early cancerous lesions; chemoprevention

UNIT IV

- 5 Treatment of Cancer
 - 5.1 Surgery
 - 5.2 Radiation therapy
 - 5.3 Chemotherapy
 - 5.4 Hormone therapy
 - 5.5 Immune therapy
 - 5.6 Hyperthermia

PRACTICALS

- Tumor Pathology :
- Pre-cancerous lesions
- Sarcomas, Carcinomas, Leukemias, teratocarcinomas

- Tumors of different tissues and organs in animals and humans.
- Tumor induction :
- Skin carcinogenesis in mice- Initiators and promoters
- Cervical carcinogenesis in mice
- Oral carcinogenesis in hamsters
- Mammary carcinogenesis in rats
- Short term carcinogenicity tests:
- Chromosomal aberrations
- Micronucleus test
- Sister chromatid exchanges
- Radiation therapy of transplantable tumors
- Tumor transplantation
- Tumor growth pattern
- Radioresponse of tumors
- Chemoprevention of chemical carcinogenesis
- Morphological, histopathological, and biochemical studies of various cancerous tissues.
- Study of Pre-cancerous and cancerous lesions of oral cancer , Breast cancer, Cervix cancer, prostate cancer etc.
- Visit to Radiotherapy Department, S. M. S. Medical College, Jaipur, Sri Bhagwan Mahaveer Cancer Hospital, Jaipur and Tata Memorial Cancer Hospital, Mumbai.
- Class Record
- Viva-voce

RECOMMENDED BOOKS

- A. Ramesha Rao. Who runs the risk of cancer. Shipra publication.
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- P.S. Lotran, V. Kumar, T.Collins. Pathology of Diseases Robbins.
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- Vinay Kumar, Ramzi, S. Cotran and Stranley L. Robbins. Basic pathology. Thomson press Ltd., NOIDA, 1999.
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- Lewis J. Kleinsmith , Principles of Cancer Biology. Publisher: Benjamin Cummings
- Robert A. Weinberg, The Biology of Cancer, Publisher: Garland Science
- Lauren Pecorino, Molecular Biology of Cancer, Publisher: Oxford University Press, USA.
- Lauren Pecorino, Cellular and Molecular Biology of Cancer, Publisher: Oxford University Press, USA .
- Randall W. Phillis, Biology of Cancer, Publisher: Benjamin Cummings.
- Randall W. Phillis, Cancer of Systems Biology, Publisher: CRC Press
- Arthur B. Pardee, The Biology and Treatment of Cancer, Publisher: Wiley-Blackwell.

- Craig A. Almeida , Targeted Therapies in Cancer, Publisher: Springer .
- Craig A. Almeida, Cancer, Publisher: Oxford University Press, USA.

ZOL -B01 CELL AND MOLECULAR BIOLOGY

UNIT I

1. Biomembranes

1. Universality of biomembranes

- 1.1 Difference in phospholipid composition in two membrane leaflets.
- 1.2 Intrinsic and extrinsic proteins.
- 1.3 Integral and glycolipids.
- 1.4 Mobility of lipids and integral proteins in biomembrane.
- 1.5 Fluidity of biomembranes.
- 1.6 Cell junctions (Gap, tight and desmosomes etc.).

2. Transport across cell membrane

- 2.1 Mechanism of diffusion, Facilitated diffusion.
- 2.2 Osmosis and water channels/ movement, Flick's law, Donnan equilibrium.
- 2.3 Uniporter-catalyzed transport. Difference between uniport-catalyzed transport and passive diffusion, GLUT- 1 transport & its kinetic.
- 2.4 Intracellular ion environment and membrane electric potential.
- 2.5 Active transport - P-class ion pumps, F-class and V-class ion pumps and ABC superfamily. Plasma Membrane $\text{Ca}^{++}\text{ATPase}$ pump Muscle $\text{Ca}^{++}\text{ATPase}$ pump and $\text{Na}^{+}/\text{K}^{+}$ ATPase pump.
- 2.6 Cotransport by symporters and antiporters.
- 2.7 Transport across epithelia, Receptor mediated endocytosis.

UNIT II

3. Cytoskeleton

3.1 Microfilaments

- 3.2 Actin cytoskeleton G-actin and F-actin and structural and functional polarity. Cortical actin network, erythrocyte and platelet cytoskeleton.

3.3 Actin bundle support projecting fingers of membrane.

3.4 Dynamics of actin assembly Actin polymerization. Toxins effect on actin monomer - polymer equilibrium stabilization of actin filaments by actin capping protein. Movement actin polymerization

(a) Intracellular bacterial and viral movements.

(b) Actin polymerization at the leading edge of moving cells.

3.5 Myosin

(a) Structure and mechanism of movement with actin.

(b) Conformational changes in myosin during movement.

3.6 Microtubules: Microtubules structure and microtubule assembly from organizing centers, Microtubule dynamics, Microtubule associated proteins (MAP's) and cross-linking of microtubules, Microtubules and mitosis

(a) Centrosome duplication.

(b) Kinetochore and force for poleward chromosome movement.

(c) Organization of spindle pole and orientation of assembly.

(d) Formation of poles and capture of chromosomes.

(e) Kinetochore and force of poleward chromosome movement.

(f) Astral microtubule and cytokinesis.

(g) Microtubules and plant cell formation.

3.7 Kinesin and Dynein.

3.8 Cell movements

(a) Intracellular transport: Role of kinesin and dynein, microtubule tracks and intracellular membrane vesicles.

(b) Amoeboid movements.

(c) Second messengers and signal transduction pathways for coordination of migration of cells.

4 Cilia and Flagella

4.1 Structure and movements

(a) Sliding of outer doublet.

(b) Dynein sliding forces in axonemes.

(c) Dynein and axonemal bending.

(e) Dynein regulatory complex.

UNIT III

5 Cell-Cell adhesion and communication

5.1 Cadherin mediated Ca^{++} -- dependent homophilic cell-cell adhesion.

5.2 N-CAM's mediate Ca^{++} -- independent homophilic cell-cell adhesion.

5.3 Cadherin containing junctions.

5.4 Gap junctions and connexins.

6 Cell matrix adhesion

6.1 Integrin-in cell matrix and cell-cell interaction.

6.2 Integrin and cell to substratum attachment.

6.3 Collagen-Basic structure and assembly.

6.4 Non-collagen components of extracellular matrix (Laminin, fibronectin and cell surface proteoglycans).

- 6.5 Plant cell wall.
- 6.6 Auxin and cell expansion.
- 6.7 Cellulose fibril synthesis and orientation.
- 6.8 Plasmodesmata.

UNIT IV

7 Cell-Cell Signaling

- 7.1 Endocrine, paracrine and autocrine signaling.
- 7.2 Receptor Proteins- Cell Surface receptors and intracellular receptors.
- 7.3 Cell Surface receptors-G-protein coupled receptors, ion channel receptors, tyrosine kinase-linked receptors and receptors with intrinsic enzymatic Activity.
- 7.4 Second messenger System - cAMP and IP₃, DAG
- 7.5 MAP kinase cascade, JAK/STAT and TGF- β / Smad signaling, NF-kB signaling.
- 7.6 Signaling from plasma membrane to nucleus (a) CREB links cAMP signals to transcription (b) MAP kinase.

8 Signal - Mediated transport through Nuclear Pore

- 8.1 Nuclear pore complex
- 8.2 Nuclear exports signals and transport of cargo proteins from nucleus to cytosol.
- 8.3 Nuclear localization signal and transport of cargo proteins from cytoplasm to nucleus.

ZOL B02 - CELL AND MOLECULAR BIOLOGY

UNIT I

1. Cell Cycle

- 1.1 Bacterial cell cycle (Helmstetier - Cooper or I+C+D model).
- 1.2 Partition and cytokinesis.
- 1.3 Eukaryotic cell cycle – G₁, S, G₂ and M phases.
- 1.4 Cell cycle and check points.
- 1.5 Molecular basis of cell cycle regulation
 - (a) Cyclins and cyclin - dependent kinases.
 - (b) Regulation of CDK cyclin activity.

2. Cell Death

- 2.1 Apoptosis and necrosis.
- 2.2 Apoptosis-its characteristics.
- 2.3 Genes involved in apoptosis.

UNIT II**3 Aging: The biology of senescence**

3.1 Maximum life span and life expectancy.

3.2 Causes of aging:

(a) General wear and tear and genetic instability.

(b) Free radicals, oxidative damage and antioxidants.

(c) Telomerases and aging.

4 Cancer

4.1 Tumor cells and onset of cancer.

4.2 Proto-oncogenesis and tumor suppressor genes.

4.3 Mutation causing loss of cell cycle.

4.4 Mutations affecting genuine stability.

UNIT III**5 Molecular structure of genes and chromosomes**

5.1 Molecular definition of gene.

5.2 Chromosomal organization of genes and non-coding DNA.

5.3 Mobile DNA.

5.4 Functional re-arrangements in chromosomal DNA.

5.5 Organizing cellular DNA into chromosomes.

5.6 Morphological and functional elements of eukaryotic chromosomes.

6 Genetic analysis in Cell Biology

6.1 Mutation: type and causes.

6.2 Isolation and analysis of mutants.

6.3 Genetic mapping of mutations.

6.4 Molecular cloning of genes defined by mutations.

UNIT IV**7 Regulation of Gene expression**

7.1 Operon concept.

7.2 Positive and Negative regulation.

7.3 Inducers and corepressors.

7.4 Regulation by attenuation: his and trp operons.

8 DNA binding proteins and gene regulation

- 8.1 DNA binding domains.
- 8.2 Homeodomain proteins.
- 8.3 Zinc finger proteins.
- 8.4 Winged-helix (Forked head) proteins.
- 8.5 Leucine-Zipper proteins.
- 8.6 Helix Loop helix proteins.

PRATICALS:

1. Operation of various microscopes

- 1.1 Use of phase contrast
- 1.2 Use of fluorescence microscope and demonstration of nucleic acid by acridine orange or ethidium bromide
- 1.3 Use of transmission electron microscope
- 1.4 Use of oculometer-standardization and measurements of cell height, nuclear diameters and tabular diameters
- 1.5 Use of ocular grid- standardization and counting of cells or nuclei in cross section or epithelium

2. Preparation of biological tissues and sectioning for

- Paraffin wax histology by microtome
- Fresh- frozen by cryostat
- Ultra-thin sectioning by ultratome

3. Cytochemistry

- 3.1 Carbohydrate (a) PAS method (b) Alcian blue method
- 3.2 Proteins (a) Mercury bromophenol blue method (b) Ninhydrin method
- 3.3 Lipids (a) Phosphomolybic acid method (b) Copper phthalocynin n method
- 3.4 Nucleic acid (a) Feulgen method (b) Methyle green- Pyronin method.

4. Biochemical methods

- 4.1 Determination of pK value of buffer
- 4.2 Determination of absorption maximum of a solution
- 4.3 Determination of relationship between absorption and various concentration of a solution using a colorimeter, spectrophotometer/spectrophotometer.
- 4.4 Preparation of standard curve for proteins, lipids and carbohydrates
- 4.5 Quantitation of enzymes
 - 4.4.1 by end point techniques as exemplified by alkaline and acid phosphatase
 - 4.4.2 by substrate - left over technique as exemplified by LDH

5. Immunization techniques

5.1 Emulsification with Freund's reagents

5.1.1 Preparation of emulsions with syringe method

5.1.2 Preparation of emulsion with hubbed needle method

5.2 Testing type of emulsion

5.3 Absorption of soluble proteins on insoluble colloidal carrier

5.3.1 Alum precipitates

5.3.2 Alum hydroxide adjuvants

6. Immunization route

6.1 Intradermal

6.2 subcutaneous

6.3 Intramuscular

6.4 Intraperitoneal

6.5 Intravenous

6.6 Foot pad

7. Bleeding schedules and collection of blood

7.1 Bleeding from ear

7.2 Retro-orbital

7.3 Cardiac Puncture

7.4 Branchial vein

7.5 From external jugular vein

8. Separation and Preservation of serum

8.1 Liquid storage

8.1.1 Using preservative

8.1.2 Sterilization

8.2 By freezing

8.3 By lyophilization

9. Permanent slides: Types of cells (squamous, cuboidal, columnar epithelial cells, blood cells, nerve cells, muscle cells), connective tissues of various types. adipose tissue, mitotic & meiotic chromosomes and their different phases .

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ZOL B03 - CELL AND MOLECULAR BIOLOGY

UNIT I

1. Molecular Immunology

- 1.1 Components of immunity
- 1.2 Innate (nonspecific) immunity
 - 1.2.1 Anatomic barriers
 - 1.2.2 Chemical barriers
 - 1.2.3 Phagocytic barriers
 - 1.2.4 Inflammatory barriers
- 1.3 Adaptive (specific) immunity

1.3.1 Humoral and cell-mediated immune responses (CMI)

- (a) Recognition of antigen by B- and T-lymphocytes and antigen presenting cell.
- (b) Clonal selection of lymphocytes

1.3.2 Cellular interactions required for generation of immune responses

- (a) Activation and proliferation of B and T cells.
- (b) Generation of humoral immune responses.
- (c) Generation of CMI.

2. Cells and organs of immune system

2.1 Hematopoiesis

- 2.1.1 B-Lymphocytes, T-lymphocytes and Null cells.

- 2.1.2 Mononuclear cells (antimicrobial and cytotoxic activities, secretion of factors).
- 2.1.3 Granulocytic cells (Neutrophils, Eosinophils and Basophils).
- 2.1.4 Mast cells.
- 2.1.5 Dendritic cells and Langerhans cells.

2.2 Organs of immune system

- 2.2.1 Primary lymphoid organs (Thymus and bone marrow)
- 2.2.2 Secondary lymphoid organs (Lymph nodes, spleen, mucosal associated lymphoid tissue and cutaneous associated lymphoid tissue, tonsils and Peyer's patches).
- 2.2.3 Lymphatic system.

UNIT II

3 Antigens

- 3.1 Immunogenicity versus antigenicity
- 3.2 Factors that influence immunogenicity
 - 3.2.1 Contribution of the immunogens (foreignness, molecular size, chemical composition and heterogeneity, susceptibility to antigen processing and presentation).
 - 3.2.2 Haptens and epitopes.
 - 3.2.3 Immunogen dosage and route of administration and adjuvants.

4 Immunoglobulins structure and function

- 4.1 Molecular structure of Ig
- 4.2 Immunoglobulin classes (IgG, IgM, IgE and IgD and their biological activities).
- 4.3 Immunoglobulin - mediated effector functions (Opsonization, activation of complement, antibody dependent cell- mediated cytotoxicity , neutralization).
- 4.4 Antigenic determinants on immunoglobulin (isotype, allotype and idiotype)
- 4.5 Monoclonal antibodies
 - 4.5.1 Formation and selection of hybrid cells
 - 4.5.2 Production of monoclonal antibodies
 - 4.5.3 Clinical uses of monoclonal antibodies
 - 4.5.4 Catalytic monoclonal antibodies (abzymes).

UNIT III**5 Organization and expression of Ig genes**

5.1 Genetic model compatible with Ig structure.

5.1.1 Germ line and somatic variation models.

5.1.2 Two gene model of Dryer and Bennett

5.1.3 Verification of Dryer and Bennett hypothesis

5.2 Multigene organization of Ig genes

5.2.1 I-chain multigene family

5.2.2 k-chain multigene family

5.2.3 Heavy chain multigene family

5.3 Variable region gene rearrangement

5.3.1 V-J rearrangements in light chain DNA

5.3.2 V-D-J rearrangements in heavy chain DNA

5.4 Mechanism of variable region DNA rearrangement

5.4.1 Recombination signal sequences

5.4.2 Enzymatic joining of gene segments

5.4.3 Identification of Raf-1 and Raf-2 genes

5.4.4 Defects in Ig gene rearrangements

5.4.5 Productive and nonproductive rearrangement

5.4.6 Allelic exclusions

5.5 Generation and antibody diversity

5.5.1 Multiple germ line V,D and J gene segments

5.5.2 Combinatorial V-J and V-D-J joining

5.5.3 Junctional flexibility

5.5.4 P-addition and N-addition

5.5.5 Association of heavy and light chain

5.6 Class switching among constant region genes

5.6.1 Expression of Ig genes

(a) Differential RNA processing of heavy chain primary transcripts.

(b) Expression of membrane of secreted Ig.

(c) Simultaneous, assembly and secretion of IgM and IgD.

(d) Synthesis, assembly and secretion of Ig.

5.6.2 Regulation of Ig gene transcription

- (a) Effect of DNA rearrangement of transcription.
- (b) Inhibition of Ig-gene expression in T- cells.

5.6.3 Antibody genes and antibody engineering

- (a) Chimeric and hybrid monoclonal antibodies.
- (b) Monoclonal antibodies constituted from Ig gene libraries.

6 Antigen - Antibody Interaction.

- 6.1 Antibody affinity and activity.
- 6.2 Cross reactivity.
- 6.3 Agglutination reactions.
- 6.4 Precipitation reaction.
- 6.5 Complement and complement fixation test.

UNIT IV

7 Major Histocompatibility complex.

- 7.1 General organization and inheritance of MHC.
 - 7.1.1 Location and function of MHC.
 - 7.1.2 MHC haplotypes.
- 7.2 MHC molecules and genes
 - 7.2.1 Structure of class I molecules.
 - 7.2.2 Structure of class II molecules
 - 7.2.3 Organization of class I and II genes.
 - 7.2.4 Peptide binding by MHC molecules.
 - 7.2.5 Class III molecules
- 7.3 Genomic maps, of MHC genes
 - 7.3.1 Maps of class I MHC
 - 7.3.2 Maps of class II MHC
 - 7.3.3 Maps of class III MHC
- 7.4 Regulation of MHC expression.
- 7.5 MHC and immune responsiveness.
- 7.6 MHC and diseases susceptibility.

8 Antigen processing and presentation

- 8.1 Role of antigen presenting cell

8.1.1 Early evidence for the necessity of antigen processing.

8.1.2 Cells that function in antigen presentation.

8.2 Evidence for two processing and presentation pathways.

8.2.1 Endogenous antigens. The cytosolic pathways

(a) Peptide generation by proteosomes.

(b) Peptide transport from the cytosol to rER.

(c) Assembly of peptide with class I MHC molecules

8.2.2 Exogenous antigens. The endocytic pathway.

(a) Peptide generation in endocytic vesicles

(b) Transport of class II MHC molecules to endocytic vesicles.

(c) Assembly of peptide with class II MHC molecules.

ZOL B04 -CELL AND MOLECULAR BIOLOGY

UNIT I

1. Cytokines

1.1 Properties of cytokines

1.2 General structure of cytokines

1.3 Function of cytokines

1.4 Cytokines related diseases.

1.4.1 Bacterial septic shock

1.4.2 Bacterial toxic shock and similar diseases

1.4.3 Lymphoid and myeloid cancers

1.4.4 Chagas disease

2. Immune system in health and disease

2.1 Immune response to infectious disease

2.1.1 Viral infections

(a) Viral neutralization by humoral antibody.

(b) Cell - mediated antiviral mechanism.

(c) Viral evasion of host defense mechanisms.

2.1.2 Bacterial infections

(a) Immune responses to extra cellular and intracellular bacteria.

(b) Bacterial evasion of host defense mechanism.

2.1.3 Protozoa and diseases.

2.1.4 Diseases caused by helminthes.

UNIT II

3 Vaccine

3.1 Active and passive immunization.

3.2 Designing vaccines for active immunization.

3.3 Whole organism vaccine

3.3.1 Attenuated viral or bacterial vaccines.

3.3.2 Inactivated viral or bacterial vaccines.

3.4 Polysaccharide vaccines.

3.5 Recombinant vector vaccines.

3.6 DNA vaccines.

3.7 Synthetic peptide vaccines.

3.8 Multivalent peptide vaccines.

4 AIDS

4.1 Structure and types, genome organization, replication, opportunistic agents and therapeutic agents

4.2 Immunodeficiencies – Lymphoid and myeloid lineage.

UNIT III

5. Hypersensitivity

5.1 Type I, II, III and IV

5.2 *In vivo* and *in vitro*

6. Autoimmunity

6.1 Organ specific autoimmune disease

6.2 Systemic autoimmune disease.

UNIT IV

7. Tumor immunology

7.1 Tumor antigen

7.2 Tumor evasion.

7.3 Immune system against tumors.

7.4 Therapies.

8. Transplantation immunology

8.1 Acute ,hyperacute and chronic rejection .

8.2 Tissue matching(HLA typing)

8.3 Graft Vs host (GVH) reaction

8.4 Xenotrasplantation

8.5 Immunosuppressive drugs, role of monoclonal antibodies in transplantation.

PRACTICALS: IV SEMESTER

1. Fractionation

- 1.1 Tissue homogenization and fractionation by differential centrifugation for isolation of mitochondria, nuclei and cytosol and use of marker enzymes for assessment of purity of the components
- 1.2 Fractionation of protein, RNA and DNA and their Quantification

2. Separation techniques

- 2.1 Separation of proteins and DNA by agarose electrophoresis
- 2.2 Separation of proteins and isoenzymes on SDS-PAGE and PAGE
- 2.3 Electroeluting of proteins,DNA/RNA from electrophoretic gels
- 2.4 Separation of amino acids by paper chromatography
- 2.5 Separation of phospholipids by TLC
- 2.6 Separation of haemoglobin by column chromatography

3. Chromosomal Techniques

- 3.1 Preparation of salivary gland chromosomes from Drosophila / Chironomous larva and stain with acetocarmine/aceto-orcein/ fuelgen
 - 3.2 Preparation of mammalian chromosomes from bone marrow or testis and stain with Giemsa stain.
-

4. Isolation of T and B cells from sensitized animals

4.1 From spleen

4.2 From lymph nodes

4.3 From human blood-rosette formation

5. Purification of antibodies and antigens

5.1 Insolubilization of antibodies and antigenic proteins using glutaraldehydes

5.2 Immuno-adsorption

5.3 Dissociation of absorbed material from immuno-adsorbents

6. Quantitation of antibodies

6.1 Precipitation techniques

6.2 Immunodiffusion method

6.3 Immunoelectrophoresis method

7. Immunoassays RIA, ELISA

8. Permanent slides: Thymus, lymph nodes, spleen, bone marrow and cancer cells of various types.

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ZOL C01 - ENTOMOLOGY

Insect systematic and taxonomy and insect ecology

UNIT-I

1. Historical review of insect classification .basis of insect classification.

Phylogeny of Arthropoda and Hexopoda .Introduction to primitive insects.

2. Detailed classification of important and selected super families and families of the following orders- Orthoptera, Isoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera.

UNIT-II

3. Social life in Isoptera and Hymenoptera. Life cycle of locusts and aphids.

4. Origin and evolution of insects with special reference to fossil insects. Causes of success of insects.

UNIT-III

5. Ecology of insects-

(a) Effect of physical factors.

(b) Intra and inter specific relations. (Biotic factors)

(c) Insect plant interaction.

UNIT-IV

6. Population ecology:Population dynamics, size, fluctuation, biogeography, community ecology, species interaction, community structure, diversity.

7. Biochemical adaptations to environmental stress (metamorphosis, diapause, polymorphisms, swarms, out breaks and migration).

ZOL C02 - ENTOMOLOGY

Insect morphology, physiology, embryology and development

UNIT-I

1. General organization of insect body,

1.1 Integument

1.2 Head: sutures and area of cranium, tentorium, Gnathal appendages.

1.3 Thorax: Legs and their modifications, wings and wing coupling.

UNIT-II

2. (a) Digestive system

2.1 Alimentary canal and its modifications

2.2 Physiology of digestion.

3. Physiology of circulatory system

4. Excretory system and its modifications

5. Respiratory system and its modifications, adaptations for aquatic respiration.

UNIT-III

6. Nervous system and its modifications.

7. Morphology and physiology of neuroendocrine system.

8. Sense organs: Mechanoreceptors, Chemoreceptor.

9. Auditory organs, light producing organ, sound producing organ, visual organ (Compound eye and ocelli).

10. Muscular system and distribution of muscles.

UNIT-IV

11. Reproductive system. Morphology and physiology of male and female, reproductive system, its associated ducts and glands and external genitalia.

12. Embryology: - Structure of egg, embryonic and post embryonic development,

13. Types of larvae, pupae and metamorphosis.

ZOL C03 - - ENTOMOLOGY

Economic Entomology

UNIT-I

1. Concept of pest .How and why insects have become pests?

2. Bionomics, distribution; mode of damage caused and management of major pests

UNIT-II

3. Cash crops: sugar cane, tobacco and mustered, cotton .
4. Cereal crops: wheat, paddy, millet, maize, sorghum, pulses.

UNIT-III

5. Pests of vegetables, fruits and oil seed crops.
6. Pests of medical and veterinary importance and role of WHO and UNICEF.
7. Storage pests (stored grains and milled products).

UNIT-IV

8. Forensic entomology with special reference to man and wild life.
9. Beneficial insects (silk worm, honey bee, lac insect and industries related to them).

ZOL C04 - ELECTIVE/SPECIAL PAPER- ENTOMOLOGY

Insect toxicology and pest control

UNIT-I

1. Definition and history of various methods of insect pest control
 - 1.1 Physical
 - 1.2 Mechanical
 - 1.3 Chemical
 - 1.4 Cultural
 - 1.5 Quarantine regulations.

UNIT-II

2. Nomenclature and classification of insecticides. Concept of
 - 2.1 Ist , IInd and IIIrd generation pesticides
 - 2.2 Pesticides act of India.
 - 2.3 Selection of insecticides, their formulation and mode of action.
3. Preventive measures and antidotes.
4. Fumigants and appliances used for application of insecticides.

5. Mechanism of insecticides resistance in insects. Insecticide synergists and antagonist.

UNIT-III

6. Biological control :

6.1 Definition, biological control agents

7. Parasites :

7.1 Parasitoids

7.2 Predators

7.3 Microbial pesticides

7.4 Mass production and distribution

7.5 Advantages and disadvantages of biological control.

UNIT-IV

8. Integrated pest management (IPM)

8.1 Definition, importance,

8.2 Tools, basic principles

8.3 Evolutionary trends.

(b) Dynamics of environmental pollution.

9 . Pesticides:

9.1 Their impact on wild life

9.2 Their impact on human health (bio accumulation, bio magnification, biodegradation)

PRACTICALS: SEMESTER III & IV

1. Dissection

- a. Cockroach – Endocrine complex, Nervous System, Alimentary Canal
- b. Gryllus - Nervous System, Alimentary Canal
- c. Poecilocerous pictus - Nervous System, Alimentary Canal
- d. Honey bee - Nervous System
- e. Butter fly - Nervous System
- f. White grub - Nervous System
- g. House fly - Nervous System

2. Permanent preparation

- a. Sting apparatus (Honey bee)

- b. Pollen basket (Honey bee)
 - c. Mouth parts
 - 1. Piercing & sucking – (Mosquito)
 - 2. Siphoning – (Butterfly)
 - 3. Chewing & lapping – (Honey bee)
 - 4. Sponging – (Housefly)
 - 5. Biting & Chewing – (Cockroach)
 - d. Tympanum (Grasshopper)
 - e. Spiracle (Grasshopper)
 - f. Antennae (Mosquito, house fly, honey bee, butterfly, beetle, grasshopper, bug, cockroach)
 - g. Legs (All insects as given above)
 - h. Wings (Mosquito, house fly, honey bee, grasshopper, bug, cockroach)
 - i. Whole mounts of insects (Lice, ants, aphids, termite, bedbug, thrips, mosquito etc.)
3. Appliances for application of insecticides
 - (i) Knap sack sprayer
 - (ii) Knap sac duster
 - (iii) Hand sprayer
 4. Insect rearing
 - (i) Tribolium
 - (ii) Rhizopertha
 - (iii) Heliothis armigera
 - (iv) Corcyra
 - (v) Callosobruchus sps
 - (vi) Lesioderma serricornae
 5. Testing of insecticide – Bioassay method
 6. Study of prepared slides.
 - (i) Whole mount of insects
 - (ii) Legs
 - (iii) Mouth Parts
 - (iv) Wings
 - (v) Histology
 - (vi) Antennae
 7. Museum Study
 8. Microtomy
 9. Field trips for insects collection
 10. collection and preservation of insects
 11. Bioassay

Spots

1. Insects of economic importance
2. Morphological adaptation
3. Whole mount insects slide

4. Histology slide
5. Specialized organ (Antennae/leg/mouth parts)
6. Insects identification and rearing
7. Appliance for application of insecticide

ZOL D01 - Environmental Biology

Atmosphere, ecosystems, resources and conservation

UNIT I

1. Environment

- 1.1 Earth (core, mantle, tectonic plates) ; atmosphere- Troposphere, Stratosphere, Mesosphere, Thermosphere, Exosphere
- 1.2 Climate , koppen scale
- 1.3 Cloud types and winds easterly, westerly, Beaufort wind force scale, Fujita Scale
- 1.4 Mountain building and evolution of continents.

2 Biomes

- 2.2 Desert
- 2.3 Grassland
- 2.4 Tundra
- 2.5 Tropical and temperate forests
- 2.6 Deciduous and evergreen rain forests
- 2.7 Ecozones of India

UNIT II

3 - Ecosystem

- 3.1 Ecosystem dynamics, concept of ecosystem
- 3.2 Types of ecosystem
- 3.3 Human ecosystem; man made ecosystem on earth- urban rural, agriculture and industrial ecosystem
- 3.4 Impact of growing population
- 3.5 Role of human faith and tradition in ecosystem preservation

4 Aquatic ecosystem (zones and adaptations)

- 4.1 Fresh water(Limnetic)- lakes (lacustrine) and rivers(riverine))
- 4.2 Wetland (Palustrine) : sunderban(Estuarine), kaeoladeo(FW) and sambhar lake(SW)
- 4.3 Estuaries : Chilka ,Kerala Backwaters
- 4.4 Marine zonation ,animals and adaptations
- 4.5 Coral reef : Great barrier reef, Lakshadweep and the Gulf of Mannar

UNIT III

5 Species interactions :

- 5.1 Herbivory, Carnivory ,parasites
- 5.2 Prey -Predator
- 5.3 Commensalisms ,mutualism and Symbiosis

- 6. Non conventional renewable resources
 - 6.1 solar
 - 6.2 wind
 - 6.3 water/Tidal
 - 6.4 geothermal
 - 6.5 solid biomass
 - 6.6 bio fuel, biogas, field crops specially corn
 - 6.7 green data book

UNIT IV

- 7. Conservation :
 - 7.1 Environmental degradation, role of men in changing the environment
 - 7.2 IUCN classification of endangered species, red data book,
 - 7.3 Restoration of wildlife populations by reintroduction (Soft and hard release) and Captive breeding
 - 7.4 in situ and ex situ conservation
- 8. Basic knowledge of National and international organizations:
 - 8.1 MoEF ,ZSI, WII,BNHS
 - 8.2 Zoo Authority of India , Salim Ali Centre for Ornithology & Natural History (SACONH)
 - 8.3 Environmental Information System (ENVIS) , Indira Gandhi Conservation Monitoring Centre (IGCMC)
 - 8.4 The Animal Welfare Board of India, Centre for Environment Education (CEE)
 - 8.5 TRAFFIC, CITIES, WWF, UNEP
 - 8.6 World Heritage and biodiversity Convention,
 - 8.7 Convention on Biological Diversity (CBD)
 - 8.8 Ramsar (Wetlands) Convention and Hot spots

ZOL D02 – Environmental Biology Population ecology, environment awareness and Wildlife

UNIT I

- 1.Factors influencing population
 - 1.1 Natality. Fecundity & fertility
 - 1.2 Mortality and survivorship
 - 1.3 Age structure
 - 1.4 Emigration, Immigration

2. Factors: Influencing population growth
 - 2.1 Density independent factors
 - 2.2 Density dependent factors
3. Methods of population estimations of animal
 - 3.1 Definition -Census and Sampling
 - 3.2 Arial and marine survey
 - 3.3 Belt and quadrate transect
 - 3.4 Line transect
 - 3.5 Population Indices

UNIT II

4. Environment awareness :
 - 4.1 Earth summits
 - 4.2 Carbon footprint and carbon tax
 - 4.3 Global warming, ozone layer depletion
 - 4.4 Important dates and their significance :
 (World Wetlands Day - February 2 ,National Bio diesel Day - March 18,UN World Water Day - March 22,Earth Day - April 22 ,International Day for Biological Diversity (World Biodiversity Day) - May 22,UN World Environment Day - June 5,UN World Day to Combat Desertification and Drought - June 17,UN World Population Day - July 11,International Day for the Preservation of the Ozone Layer - September 16, World Rivers Day - every last Sunday in September, UN World Habitat Day - first Monday in October, International Day for Natural Disaster Reduction - second Wednesday in October, World Soil Day - December 5)
5. Climate disasters : Tsunami, earth quack, cyclone

UNIT III

6. Environmental awareness and education regarding conservation of wildlife
7. Impact of tourism related activities on environment
 - 7.1 Basic principles of ecotourism
 - 7.2 Island ecology and tourism
 - 7.3 Pollution related to tourism- solid and liquid waste from tourist destination

UNIT IV

8. Wildlife
 - 8.1 history
 - 8.2 causes of depletion
 - 8.3 Techniques of studying - Radiometry, photographic identification of animals and remote sensing
 - 8.2 Wildlife of India- Wild life schedules, Ecozones, National parks, sanctuaries, reserves
 - 8.3 Management, special protection programs(Tiger, Rhino, Lion tailed macaque, elephant)

PRACTICALS

- Write characteristics of different biomes and mark their location on world map
- Mark major rivers of world on world map and five riverine system of India on India map- visit a river or pond-submit a write up
- Make a diagram of zones of sea , write characteristics of each-visit any sea-submit a report
- Understand about coral reef, their types, structure and their mark their location in world and India's map
- Mark major Ecozones of India on India's map-visit a desert , grass land or rain forest submit a write up
- Observe behaviour of chital/spotted deer/Axis axis at any reserve /zoo/national park and write details of appearance, distribution, habitat and behaviour
- Mark important sanctuaries and national parks of Rajasthan on map, and write details of any three
- Write principle and method of mark and recapture method(Lincoln index)
- Find out density of monkeys/ cheetal in an area using line transect method
- Write methods of collecting and displaying insects-make a list of insects found in a habitat of your choice

SUGGESTED BOOKS

- Ecology, Individuals. Populations and Communities. Begon. M., J.I., Harper and C.R. Townsend, Blackwell Science. Oxford
 - Ecological concepts. Cherrett, J.M. Blackwell Sci. Publi. Oxford U.K.
 - Population biology. Elseth. B.D. and K.M.Baumgartner. Van Nostrand Co., New York
 - Fundamentals of ecological modeling. Jorgenson. SE. Elsevier. New "
 - A New Ecology - Systems Perspective
Sven Erik Jørgensen, Brian Fath, Simone Bastianoni, Joao Marques, Felix Muller, S. Nors Nielsen, Bernard Patten, Enzo Tiezzi and Robert Ulanowicz
Elsevier
 - Ecological Census Techniques - A Handbook (2nd edition)
Edited by William J. Sutherland
 - Ecological Methods T. R. E. Southwood , Dr Peter A. Henderson
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- Ecology, Individuals. Populations and Communities. Begon. M., J.I., Harper and C.R. Townsend, Blackwell Science. Oxford U,
 - Ecological concepts. Cherrett, J.M. Blackwell Sci. Publi. Oxford U.K.
 - Population biology. Elseth. B.D. and K.M.Baumgartner. Van Nostrand Co., New York
 - Fundamentals of ecological modeling. Jorgenson. SE. Elsevier. New "
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Sven Erik Jørgensen, Brian Fath, Simone Bastianoni, Joao Marques, Felix

Muller, S. Nors Nielsen, Bernard Patten, Enzo Tiezzi and Robert Ulanowicz Elsevier

- Ecological Census Techniques - A Handbook (2nd edition)
Edited by William J. Sutherland
- Ecological Methods T. R. E. Southwood , Dr Peter A. Henderson
- Ecological Methodology Charles J. Krebs

ZOL D03 - Environmental Biology Ecotoxicology and Metagenomics

UNIT I

1. Environmental Health and Toxicology
 - 1.2 Fundamentals of Toxicology
 - 1.2.1 Toxicants of Public Health (Pesticides, metals, solvents, Radiation)
 - 1.2.2 Dose & Toxicity
2. Movement, distribution and fate of toxins
 - 2.1 Bioaccumulation
 - 2.2 Biomagnification
 - 2.3 Translocation of Xenobiotics: Absorption, Biotransformation, Excretion
3. Measuring toxicity (Acute, Sub Chronic and Chronic)
4. Good Laboratory Practices (GLP)
5. Environmental impact assessment (EIA); Process and Methods
6. Risk Assessment
7. Sustainable Development

UNIT II

8. Environmental Management
 - 8.1 Solid Waste Management
 - 8.2 E-Waste & Hazardous Waste
 - 8.3 Legislative approach for Waste management
 - 8.4 Bioterrorism / Biological warfare

UNIT III

9. Microbial Diversity in
 - 9.1 Air
 - 9.2 Water
 - 9.3 Soil
 - 9.4 Extreme environments

UNIT IV

10. Metagenomics (Molecular methods for studying microbial diversity)
 - 10.1 Identifying new genes with metagenomics
 - 10.2 Culture enrichment for environmental samples

- 10.3 Sequence dependent techniques for metagenomics
- 10.4 Function or activity based evaluation of the environment
- 10.5 Ecology and metagenomics
- 10.6 Natural attenuation of pollutants

ZOL D04 - Environmental Biology
Environmental microbiology and biotechnology

UNIT I

- 1. Microbial Interaction with Xenobiotic Inorganic Pollutants
 - 1.1 Persistence and Biomagnification of xenobiotic molecules
 - 1.2 Polychlorinated Biphenyls and Dioxins
 - 1.3 Synthetic Polymers
 - 1.4 Microbial Interaction with some Inorganic pollutants
 - 1.5 Acid mine drainage
 - 1.6 Microbial Conversions of Nitrate
 - 1.7 Microbial Methylations
 - 1.8 Microbial Accumulation of Heavy Metals and Radionuclides

UNIT II

- 2. Biodegradability Testing and Monitoring the Bioremediation of Xenobiotic Pollutants
 - 2.1 Biodegradability and ecological side effect testing
 - 2.2 Biosensor detection of Pollutants
 - 2.3 Bioremediation
 - 2.4 Environmental modification for bioremediation
 - 2.5 Microbial Seeding and Bioengineering Approaches to the Bioremediation of Pollutants
 - 2.6 Bioremediation of Marine Oil pollutants
 - 2.7 Bioremediation of air pollutants

UNIT III

- 3. Microorganisms in Mineral and Energy Recovery, and Fuel and Biomass Production
 - 3.1 Recovery of metals
 - 3.2 Recovery of Petroleum
 - 3.3 Production of Fuels
 - 3.4 Production of Microbial Biomass
 - 3.5 Single-cell protein production

UNIT III

- 4. Microbial Control of Pests
 - 4.1 Microbial control of plant and animal pests
 - 4.2 Microbial control of weeds and cyano Zbacterial blooms
 - 4.3 Genetic engineering in biological control
 - 4.4 Frost protection
 - 4.5 *Bacillus thuringiensis* pesticide
 - 4.6 Other applications

PRACTICALS

1. Bioassay- Determination of LC50 (in fish) and LD50 (in mice) of any toxicant.
2. Estimation (biochemical/ GC/TLC) of any environmental toxicants
3. Testing of water/sewage for physico-chemical parameters-BOD and COD & planktons.
4. Bacterial examination of water – MPN index.
5. Study of microbial diversity (bacteria and fungi) in soil, air and water.
6. Electrophoretic analysis of proteins.
7. Visit to an industry for waste water management.

- Project work based on any unit from paper

SUGGESTED BOOKS

- Environmental Microbiology: R. M. Maier, I. L. Pepper, C. P. Gerba.
- Casarett & Doull's Toxicology: The Basic Science of Poisons. Curtis Klaassen.
- Biotechnology: Applying the Genetic Revolution: D. P. Clark and N. J. Tazdernik.
 - Principle of Environmental Science: W.P. Cunningham & M.A. Cunningham.
 - Microbiology Fundamentals And Applications: S.S. Purohit.
 - Environmental Impact Assessment Methodologies: Y. Anjaneyulu.
-
- Microbial Ecology: Fundamentals and Applications: Ronald M. Atlas, Richard Bartha.
 - Environmental Microbiology: R. M. Maier, I. L. Pepper, C. P. Gerba.
 - Microbial Biopesticides: Opendar Koul, G S Dhaliwal.
 - Bioremediation Technology: Fulekar, M.H. (Ed).
 - Biotransformation: Bioremediation Technology for Health & Environmental Protection: R. D. Stapleton Jr. and V.P. Singh (Ed), Elsevier.

ZOL E01 Reproductive Biology**Endocrine glands and Reproductive organs****UNIT-I****1. Endocrine glands : An overview, Basic concepts of endocrinology****1.1 The female reproductive system:**

1.1.1 Comparative anatomy and physiology of the mammalian and sub mammalian ovary and ductal system.

1.1.2 Follicular growth, kinetics and atresia,

1.1.3 Mechanism of ovulation ,ovarian hormones, two cell theory of estrogen biosynthesis.

1.1.4 Autocrine, Paracrine and endocrine regulation of ovarian functions.

1.2 The male reproductive system:

1.2.1 Comparative anatomy and physiology of the mammalian and sub mammalian testis.

1.2.2 Functional Organization of testis, spermatogenesis cycle.

1.2.3 Testicular androgens, autocrine, paracrine, and endocrine regulation of testicular functions.

Epididymis and the sex accessory glands, Semen and its, biochemistry

UNIT II

2. Regulation of reproduction

2.1 The Hypothalamus and its neurosecretory centres: Structure of neurosecretory cells, the hypothalamic principles: synthesis ,storage, release and chemistry

2.2 The pituitary gland : Functional cytology, adenohipophyseal and Neurohypophysial hormones, their chemistry ,physiology and regulation of secretion.

2.3 The phenomenon of neuroendocrine integration and the hypothalamo hypophyseal gonadal axis

UNIT III

3. Endocrine glands: Study of the major endocrine glands of vertebrate. 20 hours
Structure, secretions and physiology (With the special emphasis on the role in reproduction :

3.1 Thyroid

3.2 Adrenal

3.3 Pineal

3.4 Pancreas

UNIT IV

4. Invertebrates endocrine glands : Anatomy and physiology of the endocrine and neuroendocrine structures of : hours

4.1 Annelids

4.2 Arthropods

4.3 Mollusca

(with special reference to their role in reproduction)

ZOL E02 - Reproductive Biology

Physiology of Reproduction

UNIT I

1. Hormones :

1.1 Characteristics of hormones

1.2 Hormonal regulation

1.3 Feedback mechanism

1.4 Chemical nature of hormones

2. Hormone actions:

2.1 Transportation of hormones

2.2 Receptors and target cells

2.3 Mechanism of actions of hormones

3. Steroid hormones:

3.1 Structure and nomenclature

3.2 Steroidogenesis

4. Prostaglandins: Chemistry, mechanism of action and their role in reproduction

UNIT II

5. Breeding seasons and reproductive cycles:

5.1 Breeding seasons in vertebrate

5.2 Types of reproductive cycle

5.3 Estrous cycle

5.4 Menstrual cycle

5.5 Hormonal regulation of menstrual cycle

6. Hormonal regulation of reproductive behaviour

7. Puberty, adolescence and menopause

7.1 Onset of puberty

7.2 Hormonal control of onset of puberty

- 7.3 Precocious and delayed puberty
- 7.4 Menopause and climacteric
- 8. Biology of spermatozoa and ovum: structure, development and function.

UNIT III

- 9. Fertilization:
 - 9.1 Prefertilization events,
 - 9.2 Biochemistry of fertilization
 - 9.3 Post-fertilization events
 - 9.4 Capacitation
- 10. Implantation:
 - 10.1 Implantation, Decidual changes
 - 10.2 Hormonal regulation,
 - 10.3 Delayed implantation
- 11. Placenta as Endocrine tissue: foeto-placental unit.
- 12. Gestation and its hormonal regulation.
- 13. Parturition
 - 13.1 Onset of Parturition
 - 13.2 Hormonal control of Parturition
- 14. Lactation :
 - 14.1 The mammary gland
 - 14.2 Hormonal control of lactation

UNIT IV

- 15. Biology of Sex-determination and Sex differentiation:
 - 15.1 Development of gonads
 - 15.2 Development of genital ducts and accessory organs
 - 15.3 Development of external genitalia.
 - 15.4 Sex determination in mammals.
- 16. Miscellaneous factors affecting reproduction:
 - 16.1 Nutrition and reproduction
 - 16.2 Effect of light, temperature
 - 16.3 Environmental disruptors
 - 16.4 Change of life style

PRACTICALS

- Location of various endocrine glands in rodents
- Dissection of male and female reproductive systems.
- Microtomy: Histology of male and female genital organs and endocrine glands in normal and pathological conditions
- Study of the permanent histological slides
- Monitoring of vaginal smear.
- Monitoring of sperm function tests.

SUGGESTED BOOKS

- Biology of Gestation by Assali, N. S. (ed.) Vol. I and II Academic Press, New York.
- An Introduction to General and Comparative Endocrinology by Barrington: E. J. W. Clarendon Press, Oxford, 1963
- Delayed Implantation by Enders, N.C. University of Chicago Press, Chicago, 1963.
- A Text Book of comparative Endocrinology by Gorbman, A and Bern, H. A. : John Wiley and Sons Inc., New York, 1962. (Indian reprint, Wiley Eastern Pvt. Ltd., New Delhi, 1974).
- Biology of ovarian follicles in Mammals by Guraya, S. S., Springer Verlag, Berlin.
- Encyclopedia of Reproduction Vol. I to IV by Knobil E. and Neill J.D. Academic Press, New York, 1998.
- Reproductive Physiology by Nalbandov. A. S., W H. Freeman and Co., New York, 1964. (Indian Reprint), D. B. Taraporevala, Sons and Co. 1.td.. Bombay, 1970.
- Andrology Male reproductive Health and dysfunction by Nieschlag F. and Behre H.M Springer-Verlag, Berlin-2001
- Hormones by Norman AW. and Litwack G. Academic Press, New-York, 1997.
- Marshall's Physiology Reproduction Parkes. A. S. Vols. 1; Part I (1956) and 2 (1960) IT(1952) and m (1966) Longmans, Green and Co., London. .
- Biology of Human Reproduction by Pinon, Jr. R. University Science Books California, 2002,
- The Mammary gland and its Secretion Vol. 1 and II by S. K. Kon and A. T. Cowie. academic Press, New York.
- General Endocrinology by Turner, C.D., W B. Saunders and Co., Philadelphia (Tappan International. Edition, Tappan Co. (Singapore) Pvt. Ltd., New Delhi, 1974).
- Williams Textbook of Endocrinology by Shlomo Melmed, Kenneth Polonsky and P. Reed Larsen ed., SAUNDERS, 2007

- Sex, and Internal Secretions Vols. I and II. By Young, W. C.: [Baltimore, Williams & Wilkins](#),1961.
- Knobil and Neill's physiology of reproduction, Vols I and II By Ernst Knobil, Jimmy D. Neill Academic Press ,2006.
- Yen & Jaffe's Reproductive Endocrinology By Jerome Strauss and Robert Barbieri Elsevier 2009.
- Comparative Reproductive Biology Reviewed by Ali Honaramooz, Blackwell Publishing House, Ames, Iowa, USA, 2007.
- Molecular mechanisms in spermatogenesis, Volume 636 By C. Yan Cheng Springer ,USA 2008.
- Essential reproduction By M. H. Johnson, Barry J. Everitt Blackwell publishing ,USA 2007.

ZOL E03 - Reproductive Biology

Contraception and Reproductive Health

UNIT I

1. Fundamental aspects of control of fertility in males:

- 1.1 Mechanical.
- 1.2 Surgical.
- 1.3 Chemical.
- 1.4 Immunological methods.

UNIT II

2. Fundamental aspects of control of fertility in females:

- 2.1 Natural.
- 2.2 Mechanical.
- 2.3 Surgical.
- 2.4 Chemical.
- 2.5 Immunological.
- 2.6 Emergency contraception.

UNIT III

3. Sexually transmitted diseases:Pathophysiology,diagnosis,prevention,treatment of

- 3.1 Bacterial diseases(Syphilis. Gonorrhoea)
- 3.2 Viral (AIDS),
- 3.3 Fungal(Candidiasis),
- 3.4 Protozoan(Trichomoniasis)

4. Hormones and cancer :
 - 4.1 Definition of cancer
 - 4.2 Benign and malignant tumor
 - 4.3 Types of cancer: Prostate ,cervical, breast,testicular and ovarian cancers
 - 4.4 Cancer problem in India
 - 4.5 Hormones and cancer
5. Impact of aging on male and female reproduction:
 - 5.1 Andropause
 - 5.2 Menopause
 - 5.3 Hormone replacement therapy
6. Teratological effects of Xenobiotics

UNIT IV

7. Pheromones :
 - 7.1 Mammalian and insect pheromones
 - 7.2 Applications of pheromones and
 - 7.3 Insect Control of fertility.
 - 7.4 Induced spawning in Fishes and amphibians
8. Demography :
 - 8.1 Population growth rate
 - 8.2 National population policy
 - 8.3 Pearl Index
 - 8.4 Family welfare programme

ZOL E04 - Reproductive Biology

Reproductive Technologies

UNIT I

1. Reproductive dysfunctions in males and females:
 - 1.1 Endocrinological,
 - 1.2 Physiological,
 - 1.3 Anatomical,
 - 1.4 Congenital,

- 1.5 Idiopathic factors.
- 2. Diagnosis of male infertility:
 - 2.1 Semen analysis: Physical examinations, microscopic examinations, biochemical analysis, Immunological tests.
 - 2.2 Sperm function tests: Sperm mitochondrial Hypo-osmotic swelling test, acrosome, reaction. Zona binding assays. Acrosome intactness test. hamster- oocyte penetration test.
 - 2.3 Endocrinological diagnosis.

UNIT II

- 3. Diagnosis of female infertility:
 - 3.1 Monitoring of ovarian and reproductive cycles.
 - 3.2 Endometrial biopsy.
 - 3.3 Ductal blockage.
 - 3.4 Endocrine diagnosis
- 4. Assisted reproductive technology (ART)
 - 4.1 Artificial insemination
 - 4.2 Super ovulation, oocyte collection.
 - 4.3 Collection and preparation of sperm for assisted fertilization.
 - 4.4 In vitro fertilization and related techniques (IVF, GIFT, ZIFT, TET, ICSI etc).
 - 4.5 Ethical issues and regulatory guidelines
- 5. Cryopreservation
 - 5.1 Semen,
 - 5.2 Oocytes
 - 5.3 Embryos

UNIT III

- 6. Animal cloning
- 7. Sperm and Embryo Sexing
- 8. Animal husbandry
 - 8.1 Improvement of breeds of farm animals
 - 8.2 Artificial In semination and embryo transfer technique
 - 8.3 Transgenic animals.
 - 8.4 Induction of early puberty in cattle

UNIT IV

- 9. Pre-natal diagnosis of genetic diseases

10. Hormonal bioassay: Principles, Procedure and applications of hours

10.1 ELISA.

10.2 Radio immunoassay (RIA).

10.3 Radioreceptor binding assay.

10.4 Immuno-cytochemistry

PRACTICALS

- Surgical procedure in reproduction (Castration, Ovariectomy, Adrenalectomy etc.)
- Biochemical investigation of marker parameters
- Induction of superovulation and collection of oocytes
- Hormonal bioassays
- Pregnancy test
- Biochemical investigations of the reproductive glands with special reference to their markers.
- Electrophoresis: Study of protein profile in epididymic fluid.
- Demonstration of in vitro fertilization (GIFT, ZIFT, TET, ICSI, etc.)
- Immunoassays: RIA, ELISA
- A visit to State and National laboratories /Institute

SUGGESTED BOOKS

- Cole, H. H. and Cupps P. T. Reproduction in Domestic animals. Academic Press, New York.
- Clover TD and Barratt c.L.R. Male Fertility and Infertility, Cambridge University Press, Cambridge, 1999.
- Pinon, Jr. R. Biology of Human Reproduction. University Science Books California, 2002.
- The Reproductive Physiology Of Mammals: From Farm To Field And Beyond Keith K. Schillo Cengage Delmar Learning 2008.
- Assisted Reproductive Technology: A Reference Book on A.R.T. by [Philippe Merveil](#) Eska Publishing, 2010.
- Reproductive Endocrinology & Infertility By Daftary & Patki BI Publications Pvt Ltd, 2009.
- Reproductive Endocrinology and Infertility: Integrating Modern Clinical and Laboratory Practice By Douglas T. Carrell Springer ,2010.

- Andrology: Male Reproductive Health and Dysfunction By Eberhard Nieschlag, Hermann M. Behre, Susan Nieschlag Springer, 2010.
- Reproductive Endocrinology: A Molecular Approach By Pedro J. Chedrese springer,USA, 2009.
- Hormonal Contraception: Birth Control, Endocrine System, Steroid Hormone by Frederic P. Miller, Agnes F. Vandome, John McBrewster Alphascript Publishing, 2010.
- Hormonal contraception By Ronald T. Burkman, Steven G. Gabbe Wolter Kluwer ; Lippincott Williams & Wilkins, 2007.
- Text Book on Sexually Transmitted Diseases and AIDS by IASSTD & AIDS by Vinod K Sharma Rishi Bhargava and N.Usman VIVA BOOKS PVT. LTD,Jaipur
- Sexually transmitted diseases: epidemiology, pathology, diagnosis, and treatment By Kenneth A. Borchardt, Michael A. Noble CRC Press, 1997.
- Sexually transmitted diseases By Louise I. Gerdes Greenhaven Press, 2002.
- Reproductive Biotechnology of Farm Animals By Dugwekar Vg Agrotech Publishing Academy, 2006.
- Biotechnology of human reproduction By Alberto Revelli, Ilan Tur-Kaspa, Jan Gunnar Holte Parthenon Pub. Group, 2003.
- "Menopause: Biology and Pathobiology" by Lobo, Rogerio A. Academic Press 2000.
- Dynamics of human reproduction: biology, biometry, demography By James W. Wood Transaction publishers 1994.
- Introduction To Endocrinology By Negi PHI Learning Pvt Limited, New Delhi, 2009.
- The Reproductive System By Kara Rogers (Ed.) Britannica Educational Publishing ,2010.
- WHO. Laboratory manual for the examination of human semen and sperm-cervical mucus interaction. Cambridge: Cambridge University Press; 1999.

ZOL F01- Fish & Fisheries

ICHTHYOLOGY: STRUCTURE AND FUNCTION

UNIT I

1. Classification of fishes with special reference to evolutionary trends and adaptations.
 2. Integument and exoskeleton.
 3. Fins: Types of fins, structure. modifications and functions of fins
 4. Locomotion: Locomotor muscle, the red (slow) and white (fast) muscle fiber types; modes of swimming and hydromechanics of propulsion; role of fins in swimming; significance of swim bladder in swimming; non swimming locomotion.

UNIT II

5. Food, feeding habits and feeding adaptations/behavior; structure of the alimentary canal and physiology of digestion and absorption
6. Blood vascular system: Structure of the heart; principal blood vessels~ and circulation of blood (elasmobranchs, teleost and Dipnoi).
7. Gills and aquatic respiration: Organization of gills in fishes; structure of a typical teleostean gill: physiology of gill respiration gill ventilation. Gill surface area. Blood flow through gills. Water-blood barrier. gas exchange at the gill surface and gas exchange between blood and tissues
8. Air-breathing fishes: causative factors and structural adaptations.

UNIT III

9. Structure and functions of the kidney: nitrogenous end products and pattern of their excretion
10. Water and electrolyte regulation in marine, freshwater and euryhaline fishes
11. Structure and functions of the swim-ladder.

UNIT IV

12. Nervous system: Structure and functions of the central. Peripheral and autonomic nervous systems; anatomy and function of the Mauthner neurons.
13. Structure and functions of the sense organs: Eye; visual pigments and vision, Chemoreceptors: Olfactory and gustatory biological significance of chemoreception. Labyrinth. Mechanoreceptors (lateral line organs).

ZOL F02 Fish & Fisheries**PHYSIOLOGY****UNIT I**

- 1 Structure and physiology of the endocrine organs and tissues:
Pituitary, Thyroid, Gonads, Adrenal, Endocrine pancreas, Ultimobranchial, Caudal neurosecretory cells and urophysis, Pineal.
- 2 Defense mechanism– integument and Immune system, development of immune system, cells and tissues of the fish immune system, modulators of fish immune responses, humoral and cell mediated immune defense, fish antibody molecules and their effector functions.

UNIT II

- 3 Reproduction: Organs of reproduction; modes of reproduction viviparity, hormonal and environmental regulation of reproduction.
- 4 Reproductive strategies, environmental and endocrine factors regulating reproductive cycles, hormonal and molecular mechanisms of oogenesis, spermatogenesis, oocyte

maturation and spermiation, fertilization, mechanism of sex determination, maternal factors in early development.

UNIT III

- 5 Reproductive behaviour: Secondary sexual character. Nest building and parental care.
- 6 Behaviour and cognition -patterns of migration, orientation and homing, schooling, feeding, background adaptations.

UNIT IV

- 7 Adaptations: Coloration, sound production, electric organs, luminescent organs (location, structure, physiology and biological significance).
- 8 Adaptations in deep sea. Hill-stream and cave-dwelling fishes, freezing avoidance in arctic and Antarctic fishes.

PRACTICALS

- Study of the anatomy of teleost represented by the catfish *Wallago attu* External anatomy and gills; viscera, alimentary canal and urinogenital organs; musculature for gill ventilation and feeding; eye muscles and their innervation: endoskeleton (through dried and alizarin preparations) branchial blood vessels; brain and cranial nerves; swimbladder, Weberian ossicles membranous labyrinth connection. Preparation and study of stained permanent mounts of ampullae of Lorenzini (from *Dasyatis*), otoliths, scales (Placoid, cycloid and ctenoid gill filament and olfactory lamella).
- Dissection of air-breathing organs and their blood supply *Anabas testudineus*, *Clarias batrachus*, *Heteropneustes fossilis* and *Channa* sp
- Study of fish anatomy and histology through available slides.
- Preparation of microscopic slides of stained sections of following organs/ tissues/ structures from an adult teleost for their histological study of liver, intestine, kidney, testis, Ovary, gill, pituitary, thyroid tissue, head kidney (for inter-renal and chromaffin tissues).
- Phylogenetic analysis of bony fish: morphological analysis; mtDNA polymorphisms; comparison of protein sequences and construction of phylogenetic tree.
- Display of visceral organs; preparation of fish skeleton; alizarine preparation.
- Collection of body fluids (blood sampling; urine collection; gamete collection).
- Study of various hematological parameters. Fish immune system – isolation of phagocytes and phagocytosis.
- Comparative study of digestive enzymes of herbivore, carnivore and omnivore fishes.
- Estimation of apparent digestibility coefficient of consumed food by fish.
- Oxygen consumption in relation to body size/stress/anesthesia.
- Extraction, isolation and characterization of plasma vitellogenin and egg-yolk proteins.
- Gametogenesis and *in vitro* meiotic oocyte maturation.
- Primary cell and tissue culture; chromosome preparation.

- Surgical procedures (effect of hypophysectomy on osmoregulatory parameters; effect of gonadectomy on fish)
- Chromatophore responses to surgical and chemical procedures.

SUGGESTED BOOKS

- Biology of Fishes, Bone, Q. and Moore, R., Talyor and Francis Group, CRC Press, U.K.
- The Physiology of Fishes, Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK.
- The Senses of Fish Adaptations for the Reception of Natural Stimuli, von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, INDIA.
- Fish physiology by W.S. Hoar and D. 1. Randall (eds.) Vol. 1 to 11. (AP).
- A History of fishes by 1. R Norman.
- The physiology of fishes by ME Brown, Vol I and II
- Ichthyology by K.F. Laglar. 10han Wiley and sons New York.
- Fishes by M. Chandy (NB.T., India)
- Biology of fishes (Saunders, Philadelphia) by B. C. Bond.
- Fish and fisheries of India (Hindustan Pub. Corp.. India) by V. G. Ihingaran.
- The fishes of India (William Dawson and sons, London) by F. Day Vol. I and II.

ZOL F03 - Fish & Fisheries

ICHTHYOLOGY - Aquatic Resources and Their Conservation

UNIT I

- 1 Riverine fisheries- important river systems and their hydrological conditions, flora and fauna with special reference to fisheries, dams and their impact on riverine fisheries, fish ladders, interlinking of rivers and likely impact on fisheries.
- 2 Cold water fisheries - ecology of hill streams, biology of important cold water fishes of India, recreational fishing.
- 3 Lacustrine fisheries - origin of lakes and lake morphology, light, temperature and density relationship in the lacustrine ecosystems, heat energy and water movements, oxygen and other dissolved gases in lakes, pH and redox potential, fisheries profile and potential of major Indian lakes.

UNIT II

- 4 Estuarine fisheries- major estuarine systems of India, hydrography, flora and fauna with special reference to fisheries.
- 5 Marine fisheries – coastal and deep sea fisheries, permanent and seasonal stratification, upwelling, the photic zone, control of primary production by light and nutrients availability, chemical properties of sea water, biology of important fishes (sardine, mackerel, tuna), marine protected areas.

UNIT III

- 6 Integrated resources- coastal wet lands, mangroves, coral reefs, sea grasses and their conservation. Fishing techniques-- technologies for localizing catches- remote sensing, sonar, radar; crafts and gears.
- 7 Stock assessment and management-- Natural markers- morphological analyses, environmental signals, genetic analyses; Applied markers- marking and tagging, Stock identification data analysis - stock composition analysis, age and growth, fecundity estimation, application of statistical methods in fisheries.
- 8 Fish conservation- fishing laws and regulation, permitting. Post harvest technology-- Fish spoilage, rigor mortis, rancidity, enzymatic spoilage, microbial spoilage.

UNIT IV

- 9 Fish preservation and processing- handling of fish at harvest/onboard, principles of fish preservations, methods of preservation, problems associated with fish preservations, quality control.
- 10 Fish products and byproducts: Liver oil, body oil, meal, fish manure, guano. Glue. Isinglass, roe (caviar), tins and leather.
- 11 Aquatic pollution- types and sources, impact of pollution on aquatic organisms, ecosystem analysis- bio-indicators, biomonitoring, environmental factors and fish health, xenobiotics.
- 12 Waste management- national and international standards. Extension services - basic principles and emerging issues of extension, role of information and communication technology in fisheries extension.

ZOL F04 - Fish & Fisheries
ICHTHYOLOGY: Aquaculture

UNIT I

- 1.Culture technology– freshwater (carps, catfishes, murrels, prawns).
- 2.Brackish water (asian sea-bass, milk fish, mullets, crabs, shrimps).
- 3.Mariculture (mussels, oysters, sea weeds), fish food organisms (algae; *Artemia*; zooplankton).

UNIT II

- 4.Water Quality Requirements for Aquaculture- Role of temperature, pH, salinity, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, Biological oxygen demand, Chemical oxygen demand. Integrated farming - fish-cum-live stock farming, paddy-cum-fish farming, aquaculture engineering- aquahouse, hatchery, ponds, race ways, recirculating system, cage, and pen.
- 5.Fish seed technology - natural collection, bundh breeding, induced breeding, cryopreservation of gametes.
- 6.Transport of finfish and shellfish- transport of eggs, fry, fingerlings and adults.

UNIT III

7. Nutrition of aquatic animals - nutritional requirements of commercially important finfish and shellfish, dietary requirements of larvae and brooders, feed types, manufacture and ingredients, anti-nutritional factors in fish feed ingredients and their treatments, use of attractants and growth stimulants in fish feeds, alternative protein sources in aquaculture diets, feeding techniques, role of probiotics in nutrition.

8. Setting up of display aquarium- freshwater and marine aquaria, selection of compatible species, breeding of aquarium fishes.

9. Role of genetics in aquaculture- gynogenesis, androgenesis, triploidy, tetraploidy, hybridization, sex reversal and breeding, production of transgenic fish, impact of GMOs on aquatic biodiversity.

UNIT IV

10. Fish health- infection and diseases in fish, common fish pathogens, routes of pathogen entry in fish, methods of colonization and spread of pathogens, immune - evasion mechanisms of fish pathogens.

11. Environmental impact of aquaculture- aquacultural wastes and future developments in waste minimization, environmental consequences of hypernutrification. Fish vaccines- strategy and use in aquaculture.

PRACTICALS

- Identification of Indian common fish faunal resources from cold water, warm water, brackish water, marine water and ornamental fishes.
- Physico- chemical parameters of freshwater bodies.
- Biological analysis of water and estimation of primary productivity.
- Collection of phytoplankton and zooplankton from natural resources and their identification.
- Study of benthic macroinvertebrates in natural water bodies.
- Study of fishing gears and nets with the help of models.
- Simulated experiments on population enumeration.
- Salinity tolerance in select fishes.
- Determination of age and growth; gonadosomatic index.
- Length-weight relationship and condition factor determination.
- Toxicity testing with zooplankton/fish.
- Estimation of hydrobiological parameters- temperature, pH, conductivity, salinity, dissolved oxygen, primary productivity, ammonia, nitrite, nitrate, phosphate, biological oxygen demand, chemical oxygen demand of nursery, rearing, stocking and breeding ponds.
- Estimation of ovarian egg counts.
- Culture of live food organisms and assay of nutritional quality of live food; estimation of population density of live food organisms.
- Demonstration of breeding pools and hatcheries.

- Induced breeding of Indian major carps and catfishes.
- Identification of eggs, spawn, fry and fingerlings of cultivable fishes of India.
- Collection and identification of aquatic weeds and aquatic insects.
- Study of feeding habits of fishes by gut content analysis.
- Aquarium design and maintenance.
- Formulation and preparation of artificial fish food for Indian major carps and Prawns.
- Visit to freshwater/ marine fish farm and a fish market & identification of dominant finfish and documentation of shellfish.

SUGGESTED BOOKS

- Computers in Fisheries Research, Megrey, B. A. and Moksness, E. (2009), Springer, USA
- Biological Invasions in Marine Ecosystems Ecological, Management and Geographic Perspectives. Rilov, G. and Jeffrey, A. C. (2009), Springer-Verlag, GERMANY
- Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research, ICAR, (2006), DIPA, New Delhi, INDIA.
- Fishponds in Farming Systems, Zijpp, V. D., Verreth, J. A. J., Tri, L. Q., van Mensvoort, M. E. F., Bosma, R. H., and Beveridge, M. C. M., Wageningen Academic Publishers, Netherlands
- Aquaculture Principles and Practices, Pillay, T. V. R., Blackwell Publishing, USA
- Aquaculture and Fisheries Biotechnology Genetic Approaches, Dunham, R. A., CABI Publishing, USA.