UGC
MODEL CURRICULUM

ZOOOLOGY

UNIVERSITY GRANTS COMMISSION
NEW DELHI
2001
UGC MODEL CURRICULUM

ZOOLEGY

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FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as few years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convener as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.
Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly response to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon'ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with options either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/ addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon'ble Vice Chancellor and the Hon'ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon'ble Registrars to confirm that this time bound exercise has been done and send a copy of the university's updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.

December 2001

HARI GAUTAM
MS (SURGERY) FRCS (EDIN) FRCS (ENG)
FAMS FACS FICS FIACS DSc (HON CAUSA)
CHAIRMAN, UGC
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2.0 Course Structure and Scheme of Examinations for M.Sc. (Zoology)</td>
<td>8</td>
</tr>
<tr>
<td>3.0 Course Structure and Scheme of Examination for Undergraduate Studies</td>
<td>13</td>
</tr>
<tr>
<td>4.0 Manpower, Infrastructure and Financial Implications</td>
<td>70</td>
</tr>
<tr>
<td>5.0 Representative Syllabi for M.Sc.</td>
<td>72</td>
</tr>
</tbody>
</table>
CURRICULUM DEVELOPMENT COMMITTEE FOR ZOOLOGY

1. **Prof. K. Muralidhar**
   Ph.D., FASc., FNASC, FNA
   Department of Zoology
   University of Delhi, Delhi
   Nodal Person

2. **Prof. H.A. Ranganath**
   Ph.D., FASc.
   Department of Zoology
   University of Mysore, Mysore
   Member

3. **Dr. (Ms) Aparna Dixit, Ph.D.**
   Centre for Biotechnology
   Jawaharlal Nehru University, New Delhi
   Member

4. **Prof. T. Ramakrishna Rao, Ph.D.**
   Department of Zoology
   University of Delhi, Delhi
   Member

5. **Prof. U.C. Goswami, Ph.D.**
   Department of Zoology
   University of Guwahati, Guwahati
   Member

6. **Prof. Ravi Prakash, Ph.D.**
   Department of Biosciences
   M.D. University, Rohtak
   Member

7. **Dr. A. Sehgal, Ph.D.**
   Department of Zoology
   Zakir Hussain College
   University of Delhi, Delhi
   Member

8. **Dr. R.S. Bedwal, Ph.D.**
   Department of Zoology
   University of Rajasthan, Jaipur
   Member

9. **Prof. S.K. Saidapur**
   Ph.D., FASc, FNA
   Department of Zoology
   Karnataka University, Dharwad
   Member

10. **Prof. Durairaj, Ph.D.**
    Former Head, Department of Zoology
    University of Madras, Chennai
    Member
11. Prof. C.M. Chaturvedi, Ph.D.  
   Department of Zoology  
   Banaras Hindu University  
   Varanasi  

12. Dr. P. Prakash, Ph.D.  
   Dy. Secretary  
   University Grants Commission
INTRODUCTION

University

Every civilized society has a knowledge base in terms of intellectuals, scholars, scientists, professionals and institutions. In very olden days, this base was not visible but the results were visible in the battle strategies and architectural splendors. However, in the post-renaissance era, this base became not only visible but also got translated in terms of economic and biological health of nations in addition to military strengths.

It is also true that in not so distant past, this knowledge base in India was confined to the university sector. In the last two decades, however, it is shifting, in India, to CSIR, DST, DBT, ICMR, DOE, DRDO, ISRO, DAE patronized institutions away from UGC recognized conventional universities. As the economic strength and biological health are linked to science (modern science i.e. post-renaissance European science), science education assumes tremendous importance. We have to ensure quality and spread in this science base. Universities should therefore redefine their undergraduate and post-graduate curricular studies, in the present social context, in order to re-establish themselves as true knowledge bases.

Science, Scientists and Society

Science represents the total organized information about all natural materials and phenomena. Nature includes both the biotic and abiotic components. Science is built on experimental results. Science is pursued by men and women who are motivated enough to seek answers to questions about nature and bright enough to put interesting and new questions. Incompetence and lack of conviction in the philosophy of science characterize mediocrity. Experimental methods of science are universal and verifiable. They are characterized by logic, reproducibility, varying degrees of ruggedness and purposefulness. Communication of results and methods is an inseparable part of scientific career. Scientific results are subject to interpretations. The interpretation is open to questioning as it gives rise to more testable ideas. The philosophy of science in its purest sense includes the possibility of being falsifiable. Karl Popper goes to the extent of saying that non-falsifiable knowledge is not science. Pursuit of science is only one among the many activities that the human mind can carry out. However, scientific temper which is the basis of science and also the result of scientific activity is supposed to influence other spheres of human activity.

Scientists are also human beings. They have minds and personalities similar to that of other human beings. It is their professional pursuit that gives them a rational mind. Scientists who point to the conflict between the rationality underlying scientific activity and irrationality
often seen in other spheres of human activity should know better. It is wishful thinking to expect all human activities to be scientific and rational. Rationality in non-scientific activities is a matter of opinion and hence not absolute, unlike in a scientific discipline.

Excellence in science is supposed to be supported and respected. Unlike in business and trade, there is no market force operating in science that ensures excellence. The quality of science carried out by a society is limited by the quality of men managing it. No value survives unless it is in the selfish interest of the majority. Like the quality in values of human life, quality of science and ethics in science is limited by the quality of scientists and non-scientists who operate it.

Science as we know today is essentially of post-renaissance European origin. Western science is another phrase for it. Scientific knowledge is limited by the constraints inherent in the existing scientific methods. Science in that sense does not claim to answer all questions especially those that are not amenable to modern scientific methods. Hence intellectual confusion arising out of analysis of the sociology of science and scientists is man made. Similarly, the conflict between religion and science is only apparent and unreal as the two seek different goals. The philosophy of life that includes religion of some sort is at best an opinion and at worst a faith. Science does not indulge in either conformity or conflict with any non-scientific activity of human mind. Science in a broader sense is akin to philosophy. Philosophy seeks truth and goes to great extent in knowing the root and causality of this universe and human existence. Analytical thinking is its strong method. Science, technology and scientific temper if made the basis of national development and international relations essentially results in philosophy for human life as an individual and a part of a political system.

The values of science are preserved and respected for the sake of science per se, when science is pursued by individual scientist without hoping for reward or social recognition. When scientific activities are institutionalized and pursuit of science becomes a career and not personal obsession, organisation, management and sustenance of scientific institutions becomes a major activity. As this activity is manned by men and women who are far from the experimental laboratory, ambience and personal knowledge, non-scientific forces and interests creep in and influence decisions.

**Education in Science**

The sole purpose of education is to develop consciousness. Nurturing body, mind and spirit results in developing physical, mental and spiritual consciousness. Education should hasten the transformation of men and women into responsible and conscious human beings. Formal education in an institutional framework can hasten this process. Pursuit of science requires training. Science education should achieve this purpose i.e. developing skills to carry out research in a given area of science and understanding of fundamental concepts to be able to solve a specific problem. A combination of good training plus individual talent and motivation
can only result in creating research scientists of high calibre-research scientists who enrich society as well as teachers with true understanding and high motivation to teach science.

Organizing Post-Graduate Science Education in Biology

Relatively speaking, physical and chemical sciences have become highly conceptualized and hence relatively easier to formulate and impart training in. However, biological sciences are more information based. The theory of evolution by natural selection and reductionistic approach are the only major concepts in biology. However, training in theory and practice is still based on a vast mass of information. Even a cursory glance reveals a dozen departments with names like genetics, biochemistry, biophysics, biotechnology, pharmacology, physiology, sericulture, microbiology, entomology etc. distributed in conventional, agricultural, medical and veterinary universities. All of these curricular contents overlap with that of departments of Botany and Zoology. Obviously all those departments are teaching some aspects of biology compelled by various constraints as well as individual aims. Departments of Zoology are as diverse in curricular content as the number of biology related disciplines and institutions. Everybody is trying to teach everything under different names. These diverse trends are guided by opinions on controversies like:

- How much of basic science versus applied science?
- How much of classical versus modern aspects?
- How much of courses with strength versus popular (fundable at research level) courses?

In essence, it is 'identity crisis'. No body seems to be clear as what constitutes biology (Zoology or Botany).

An additional base for the debate has been 'integrated life sciences versus botany or zoology'. The concept of life sciences is valid only when a single thread runs through the information provided under various disciplines. As of today one such thread is biochemistry and another thread is cell biology. However this reductionist approach has limitations. This is because physics and chemistry have penetrated, to varying degrees, the different areas of biology. While in physiology it is hundred percent, it has not even scratched areas like behavioural ecology.

Yet another factor in deciding the curricular content is the NET (National Eligibility Test for research fellowship). A look at the NET syllabus and biology syllabus in various universities reflects extremes. On one hand certain departments have simply adopted NET syllabus and have become coaching centers and there are others whose syllabus has no relevance to NET syllabus. Biology is much larger than NET syllabus. An important question to answer is whether we train students for larger biology or for NET qualification or for neither? This also implies that NET syllabus is skewed for valid reasons. I personally believe that departments of Zoology should attempt training students for a larger canvas of biology but which also permits students to clear NET. Reforming NET examination is another matter, of course.
A number of ‘model structures’ can be visualised for post-graduate education in Zoology. These would be:

i) Department of Biosciences or School of Life Sciences offering a single M.Sc. in Life Sciences/Biology/Biosciences and which is uniform in product profile throughout the country.

ii) Department of Biology/Zoology offering a single M.Sc. in Biology with each University having a different flavour in terms of specialization or strength (Physiology or Entomology or Fish biology, etc.). One can look at syllabi of Madras University, Delhi University, Gujarat University etc. to realize this.

iii) Department of Zoology offering a single M.Sc. programme balancing pure and applied, classical and modern aspects, theory and practicals, market demands and knowledge demands.

iv) Institutes of Zoological sciences offering multiple M.Sc. programmes not in Zoology but in Cell biology, Physiology, Immunology, etc.

v) Department of Zoology offering a set of courses leading to two streams of students. One, leading to organismic biology which deals with such studies at the level of whole organisms or populations and communities and two, leading to Reductionist Biology which deals with such studies at the molecular and cellular level of organization. This, in another sense is Biochemistry, Cell and Molecular biology and Biophysics.

We believe that model (v) is the most appropriate for a vast majority of Universities. Examples of courses under the first stream of organismic biology could be environmental biology, taxonomy and systematics, evolutionary biology, population and community ecology, genetics, comparative physiology etc. Examples for courses of the second stream could be enzymology and regulation of metabolism, comparative biochemistry, cellular and molecular parasitology, molecular biology of prokaryotes, neurophysiology, neurochemistry and neuropharmacology, molecular endocrinology, reproduction and development etc.

At the M.Sc. and M.Phil. level, course titles should be specialised areas/topics and not discipline/subdiscipline based. A percentage of students at the end of M.Sc./M.Phil. can terminate their higher education and enter undergraduate teaching jobs. Entry to Ph.D. should be highly restricted to truely motivated and talented students who will pursue research/teaching at P.G. level as a career. We believe that the plan suggested in the following pages would remove the present conflict between M.Sc. in integrated life sciences and M.Sc. in Botany/Zoology. Integrated biology/Life sciences can only be taught at undergraduate level. Post-graduate education should be in specialised areas of zoology and botany.

**Coordinated Changes in Undergraduate and Post-Graduate Studies**

Undergraduate and post-graduate science education serve slightly different purposes as much as the social background of students who get into and get out of these levels differ.
Undergraduate training in biological sciences must be more broad based and with interfaces with other sciences like physical, chemical, mathematical etc. Undergraduate education should be catering to a much larger, and necessarily diverse, size of student population. It should be much more sensitive to social realities, market demands and learning methodologies. Suffice it to say that it should be in biology. The diversification into plant, animal and microbial sciences should only be at the post-graduate level. Throughout school and undergraduate courses, unity in diversity should be emphasized while at the post-graduate and research courses, diversity from unity should be explained and pursued.

**Undergraduate Level Training in Biology**

At the undergraduate level, it was strongly felt that universities should start 3 year B.Sc. degree course in Biology (Integrated?) replacing the present B.Sc. (Hons.) Courses in Botany, Zoology, Microbiology, Biochemistry, Genetics, Biotechnology, etc. as well as the 3 year B.Sc. course where three equal subjects are taught (e.g. Botany, Zoology and Chemistry, Physics, Chemistry & Zoology etc.). An integrated Biology Course is characterised by:

i. No subsidiaries are envisaged. All courses are equal.

ii. Non-biology sciences like Physics, Chemistry etc. are integrated with biology.

iii. Botany and Zoology courses are taught as integrated courses with each other.

A comparison of the courses suggested in the following pages for such a B.Sc. in Biology with courses presently offered in B.Sc. (Hons.) courses in Botany or Zoology as well as with Botany and Zoology curricular content in non-Honors B.Sc. degree courses revealed that the suggested B.Sc. (Biology) course content includes all that is presently being taught and also more in the form of modern aspects and applied aspects. In term of teaching load, this is more than equal to the combined load of Botany and Zoology in 3-yr. B.Sc. degree courses offering BZC or PCZ as 3 equal subjects.

The existing 8 papers of B.Sc. (Hons.) in Botany or Zoology of University of Delhi are as follows:

<table>
<thead>
<tr>
<th>B.Sc. (Hons.) Botany</th>
<th>B.Sc. (Hons.) Zoology</th>
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<tbody>
<tr>
<td>1. Cell Biology &amp; Biochemistry</td>
<td>1. Physiology and Physiological Chemistry</td>
</tr>
<tr>
<td>2. Thallophytes</td>
<td>2. Non-chordates</td>
</tr>
<tr>
<td>5. Angiosperm Anatomy &amp; Embryology</td>
<td>5. Developmental Biology &amp; Histology</td>
</tr>
<tr>
<td>6. Angiosperm Taxonomy &amp; Gymnosperms</td>
<td>6. Evolution and Genetics</td>
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</table>

All these courses except the course on Pteridophytes, Bryophytes and Gymnosperms figure in the suggested B.Sc. (Biology) curriculum. The applied biology course can be suitably designed to take care of economic botany and applied zoology. In addition, the B.Sc. (Biology) course has well designed courses in Molecular Biology, Microbiology, Cytology, Environmental Science and Biophysics not to speak of courses in non-biology sciences and languages. As the
latter are not subsidiaries, but are integrated with the biology courses, teaching and learning should be more serious than at present. **However to suit many small educational centres where changes are difficult to implement, models of B.Sc. (Zoology) have also been suggested in the following pages.**

The designing of the present Course in B.Sc. (Biology) also took into account job market and the demands of the present day scientific educational and research enterprises. We believe that at the end of this 3 year course in Biology, three streams of students would emerge. Students of the first stream would terminate their formal science education and look for employment. A **number of one year long post-graduate diploma courses in biology but stressing applied aspects** (e.g. Sericulture, Biotechnology, Aquaculture, Clinical Biochemistry, Diagnostics, Education, Mass-Media, etc.) can be designed and offered by Colleges, Polytechniques, University departments, etc. as add on courses by taking which, this stream of students would be gainfully employed. The market would be schools, colleges, newspapers, radio and television, funding agencies, diagnostic laboratories, departments, etc.

Students of the second stream would hopefully go for higher education leading to masters and research degrees. They would be however having aptitude and strength for, broadly speaking ‘Organismic Biology’. They would be interested in evolutionary biology, biodiversity and conservation etc.

Students of the third stream are those that have aptitude for physico-chemical sciences. Hence these students would go for higher education leading to masters and research degrees. But they would take such courses in Biology/Botany/Zoology which emphasize mechanistic biology or molecular/cellular biology. We believe that molecular scientists without a biological perspective are as useless to biology as biologists who indulge in molecular work without understanding molecular techniques. If 21st century molecular biology in India has to make real contribution we have to train biologists in molecular sciences and not the other way round which is what we have been doing so far.

The post-graduate courses for students of 3rd stream should be strong in laboratory experimental biology just like those for students of 2nd stream being strong in field/observational biology.

The B.Sc. laboratory work shall include (i) conventional laboratory exercises; (ii) field work/trips and (iii) computer laboratory/Information technology based group work. The conventional laboratory exercises shall impart skills (e.g. instrumentation skills including basic electronics, surgical skills, computing and modelling skills, skills in sterile techniques, microscopic skills, etc.) There shall be only 3 laboratories each of 2500 sq.ft. area. One of these shall be exclusively a computer laboratory. The second one shall be an analytical instrument laboratory and for surgeries and the third one for microscopy and sterile techniques. All the laboratory exercises shall be conducted as a single continuous laboratory course and not linked
to each of the theory papers as is the custom now. There shall be 18 hours of laboratory/field work per week. The IT based group work shall involve analysis of real data, presentation of results, use of virtual laboratory, PC based self-learning exercises etc. This component should make the modern student of biology completely computer literate. The field work shall be done extensively to get familiarity with flora and fauna of local territory.

At the post-graduate level also, the entire laboratory work can be integrated and not linked to each theory paper. In other words making time-table should be made easier. A series of exercises/field trips should train the students in experimental skills/tools rather than trying to reflect a theory paper. The post-graduate students at the end of the first year should be made familiar with tools, techniques and methods of biology and should become competent to design experiments for the 2nd year practicals and further in research. Familiarity with material, tools and techniques is what should be aimed as post-graduate laboratory course. Experimental methods of research or theory paper related laboratory in the 2nd year of M.Sc. are based, after all, on tools and techniques only.

Examinations

We believe that examination by external examiner should be dispensed with at the undergraduate level as well as for the 1st year of post-graduate degree course. However, undergraduate colleges/centres can be made transparent by putting their course material, project work, reports on the Web-site for network (local area/state/country level). Continuous internal assessments of every day's laboratory work should be preferred to end of the semester/year external examination based assessment. We believe that the former is more rational from the student point of view than the latter. Regular attendance will automatically become a necessity.
COURSE STRUCTURE AND SCHEME OF EXAMINATIONS FOR M.SC. (ZOOLOGY)

- The degree shall be called M.Sc. (Zoology).
- The course shall be based on semester system. The recommended duration is 4 semesters.
- A student shall have to take 100 credits of course work and clear it to be eligible for the award of M.Sc. degree.
- Each paper shall carry 3 credits which translates as 3 hours of contact period between teacher and taught per every week for 12 weeks. This amounts to 36-43 lectures varying from university to university as lecture duration can be 45-60 mins.
- Admission shall be based on an entrance examination.
- Out of the 100 credits, 48 credits should be acquired through theory papers and 48 credits through laboratory work and 4 credits through seminar course/term paper. It is suggested that those 48 credits of work be solely assessed continuously by internal means.
- There shall be a list of courses/papers that are offered by a department. Students can choose from among these such of those courses/papers which would lead them to acquire expertise in one of the two streams possible. The stream A can be called ‘Organismic Biology’ and stream B can be called as ‘Molecular Cell Biology’. The following are the recommended courses/papers for the two streams of students. Credits are also indicated.
M.Sc. (Zoology)
Course Structure

Semesters
I & II

Stream-A
4 Core courses
1 Laboratory course
1 Seminar course

Stream-A
4 Elective courses
out of 10 courses
1 Laboratory course
1 Seminar course

8 Common courses
2 Laboratory courses
2 Seminar courses

Stream-B
4 Core courses
1 Laboratory course
1 Seminar course

Stream-B
4 Elective courses
out of 10 courses
1 Laboratory course
1 Seminar course

Semester III

Semester IV
# M.Sc. (Zoology)

## List of Suggested Course Titles

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course No.</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>I</td>
<td>ZOO-401</td>
<td>Biosystematics and Taxonomy</td>
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<tr>
<td></td>
<td>ZOO-402</td>
<td>Quantitative Biology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-403</td>
<td>General and Comparative Endocrinology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-404</td>
<td>Molecular Cell Biology</td>
<td>3</td>
</tr>
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<td></td>
<td>ZOO-405</td>
<td>Laboratory Course</td>
<td>12</td>
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<tr>
<td></td>
<td>ZOO-SC-1</td>
<td>Seminar</td>
<td>1</td>
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<tr>
<td>II</td>
<td>ZOO-406</td>
<td>Population Genetics &amp; Evolution</td>
<td>3</td>
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<tr>
<td></td>
<td>ZOO-407</td>
<td>Gamete Biology</td>
<td>3</td>
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<td>ZOO-408</td>
<td>Techniques &amp; Tools for Biology</td>
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<td>ZOO-409</td>
<td>Environmental Physiology</td>
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<td>ZOO-SC-2</td>
<td>Seminar</td>
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<td>III</td>
<td>ZOO-501A</td>
<td>Structure &amp; Function of Invertebrates</td>
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<td>Comparative Anatomy of Vertebrates</td>
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<td>Animal Behaviour</td>
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<td>ZOO-SC-3</td>
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<td>ZOO-501B</td>
<td>Biology of Vertebrate Immune System</td>
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<td>Genes and Differentiation</td>
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<td>ZOO-503B</td>
<td>Molecular Cytogenetics</td>
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<tr>
<td>IV</td>
<td>ZOO-506A</td>
<td>Reproductive Physiology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-507A</td>
<td>Biology of Parasitism</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-508A</td>
<td>Wildlife &amp; Conservation Biology</td>
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<tr>
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<td>ZOO-509A</td>
<td>Ecotoxicology</td>
<td>3</td>
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<tr>
<td></td>
<td>ZOO-510A</td>
<td>Limnology</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-511A</td>
<td>Microbial Ecology</td>
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</tr>
<tr>
<td></td>
<td>ZOO-512A</td>
<td>Biological Oceanography</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-513A</td>
<td>Desert Ecology</td>
<td>3</td>
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<tr>
<td></td>
<td>ZOO-514A</td>
<td>Insect Physiology</td>
<td>3</td>
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<tr>
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<td>ZOO-515A</td>
<td>Ichthyology</td>
<td>3</td>
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<tr>
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<td>ZOO-516A</td>
<td>Aquaculture &amp; Fisheries</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-517A</td>
<td>Laboratory Course</td>
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<td></td>
<td>ZOO-SC-4</td>
<td>Seminar</td>
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<td></td>
<td>ZOO-506B</td>
<td>Neurophysiology</td>
<td>3</td>
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<tr>
<td></td>
<td>ZOO-507B</td>
<td>Metabolic Regulation &amp; Cell Function</td>
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<td>ZOO-508B</td>
<td>Biology of Single Cell Eukaryotes</td>
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<td>ZOO-509B</td>
<td>Molecular Parasitology</td>
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<td>Molecular Endocrinology</td>
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<tr>
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<td>ZOO-511B</td>
<td>Genomes &amp; Genomics</td>
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<td>ZOO-512B</td>
<td>Biomolecules &amp; Structural Biology</td>
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<td>ZOO-513B</td>
<td>Tumor Immunology</td>
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<tr>
<td></td>
<td>ZOO-514B</td>
<td>Cancer Biology</td>
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</tr>
<tr>
<td></td>
<td>ZOO-515B</td>
<td>Reproductive Technologies</td>
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<tr>
<td></td>
<td>ZOO-516B</td>
<td>Proteins &amp; Nucleic Acids</td>
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<td>ZOO-517B</td>
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<tr>
<td></td>
<td>ZOO-SC-4</td>
<td>Seminar</td>
<td>1</td>
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It is advisable that, in a semester system the examinations for theory and practicals are conducted only by the department which is teaching the course. As per the theory courses, students will be separately examined in each of these courses by a written examination at the end of the semester. Each university can decide the internal mechanisms of paper setting, moderation, printing, evaluation and announcement of results. Regarding practicals, it is
suggested that the 1st year M.Sc. practical examination be altogether abolished. Even for 2nd year, where practicals are linked to each of the theory papers, a separate paper wise examination may be thought of. Even here it is upto the university to develop and decide on the modalities especially with regard to external examinership.
COURSE STRUCTURE AND SCHEME OF EXAMINATION FOR UNDERGRADUATE STUDIES

B.Sc.(Biology)

The degree shall be called B.Sc. (Biology).

- It is preferable to have semester system. However it can also be run in an yearly system.
- It shall be of 6 semesters/3 years.
- A student admitted should accumulate 90 credits by way of theory courses and 108 credits by way of laboratory courses.
- Out of 90 credits, 10% (9 credits) shall be for language proficiency (English, Sanskrit/Regional language, Science and Society), 30% for non-biology sciences (Physics, Biophysics, Mathematics, Biostatistics, Chemistry, Biochemistry and Computer applications, etc.) and 60% for biology courses.
- All courses shall be sub-discipline based and not a topic based.
- The recommended courses are as follows:
# B.Sc. (Biology)
## List of Suggested Course Titles

<table>
<thead>
<tr>
<th>Year/ Semester</th>
<th>Course No.</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>ZOO-101</td>
<td>Mathematics for Biologists</td>
<td>3</td>
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<tr>
<td></td>
<td>ZOO-102</td>
<td>Biodiversity-1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-103</td>
<td>Biodiversity-2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-104</td>
<td>English for Scientists</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-105</td>
<td>Cytology</td>
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<tr>
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<td>ZOO-100L-I</td>
<td>Laboratory Course</td>
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<tr>
<td>1/2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>ZOO-106</td>
<td>Chemistry for Biologists</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ZOO-107</td>
<td>Regional Language/Sanskrit</td>
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<tr>
<td></td>
<td>ZOO-108</td>
<td>Environmental Science</td>
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</tr>
<tr>
<td></td>
<td>ZOO-109</td>
<td>Genetics</td>
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<tr>
<td></td>
<td>ZOO-110</td>
<td>Plant Anatomy</td>
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<tr>
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<td>ZOO-100L-I</td>
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<tr>
<td>2/3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>ZOO-201</td>
<td>Physics for Biologists</td>
<td>3</td>
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<tr>
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<td>ZOO-202</td>
<td>Biodiversity-3</td>
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<tr>
<td></td>
<td>ZOO-203</td>
<td>Microbiology</td>
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<td>ZOO-204</td>
<td>Biostatistics</td>
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<tr>
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<td>ZOO-205</td>
<td>Ecology</td>
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<td>ZOO-200L-II</td>
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<td>Physics for Biologists</td>
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<td>ZOO-207</td>
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<td>ZOO-208</td>
<td>Plant Physiology</td>
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<td>ZOO-209</td>
<td>Biodiversity-4</td>
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<td>ZOO-210</td>
<td>Plant Development</td>
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<td>18</td>
</tr>
<tr>
<td>Year/Semester</td>
<td>Course No.</td>
<td>Course Title</td>
<td>Credits</td>
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<td>ZOO-301</td>
<td>Biophysics</td>
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<td></td>
<td>ZOO-302</td>
<td>Animal Physiology</td>
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<td>ZOO-303</td>
<td>Animal Development</td>
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</tr>
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<td>ZOO-304</td>
<td>Computer Applications</td>
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<td></td>
<td>ZOO-305</td>
<td>Evolution</td>
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<td></td>
<td>ZOO-300L-III</td>
<td>Laboratory Course</td>
<td>18</td>
</tr>
<tr>
<td>3/6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>ZOO-306</td>
<td>Biochemistry</td>
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<tr>
<td></td>
<td>ZOO-307</td>
<td>Science &amp; Society</td>
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<tr>
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<td>ZOO-308</td>
<td>Molecular Biology</td>
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<td></td>
<td>ZOO-309</td>
<td>Applied Biology</td>
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<td></td>
<td>ZOO-310</td>
<td>Cell Biology</td>
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<tr>
<td></td>
<td>ZOO-300L-III</td>
<td>Laboratory Course</td>
<td>18</td>
</tr>
</tbody>
</table>

**B.Sc. (Zoology)**

Although CDC for Zoology recommends that it is desirable to have B.Sc. (Biology) as an integrated course as this truly reflects, the spirit of undergraduate science education and the nature of this subject, it was also felt that in many parts of the country replacement of Zoology and Botany by Biology may not be immediately possible. Hence in the following pages, the model syllabus for Zoology at B.Sc. level is given. It should be noted that Zoology is being taught in Indian Universities at the B.Sc. level in various forms. There is a Zoology given as honours level subject, Zoology as part of three equal subject combination (e.g. Botany, Zoology and Chemistry) as in many south Indian Universities and Zoology taught as subsidiary subject. To avoid confusion, the syllabus for all these three forms is separately given below as three models.

The diversity of fauna and flora prohibits uniform detailed syllabus for the whole country. Locally available study material in terms of fauna should be used to teach the same principles. Even in theory papers, emphasis on different sub areas could be different in different parts of our country. For example in applied Zoology papers, each College or area may have strength in certain aspects but may be weak in other aspects. Hence syllabus could accordingly change according to local strengths. What is emphasized in Madras University with rich marine biodiversity need not be same in an interior University like Bhopal or Delhi. The main problem would be teaching modern areas of Zoology like developmental biology, molecular and cytogenetics or molecular biology or computer skill dependent areas like genomics. Most of the
non-metropolitan city based Colleges and Universities are not equipped both in manpower and instrumentation to deal with this problem. It is here that UGC has to step in with some mechanism of funding linked to recruitment policy and accreditation so that justice could be done to undergraduate training in Zoological sciences with respect to both coverage of modern areas and integration towards holistic conceptual biology without division into plant, animal and microbial sciences.

**Explanation of Teaching Load vis-à-vis the Three Models**

As per UGC norms one should have 180 working days. At 5 hours of instruction per day, this would amount to 2700 hours of teaching in three years of B.Sc. study. It is envisaged that in Model I, seventy per cent (70%) of this time will be spent on Zoology with other subjects (Botany, Chemistry and Humanities) sharing the rest. In Model II, 50% of teaching time is allotted to Zoology and in Model III, 30% of the teaching time each is given for Zoology, Botany and Chemistry. A credit hour for theory classes is defined as one contact hour per week over 12 weeks between the teacher and the taught. For the laboratory work, two hours of practical work will be considered as one credit hour.

**MODEL I**

At 900 hours of teaching per year, 5 hours of teaching per day is possible. Hence, three theory classes of one hour each and one laboratory class of two hours can be held every day throughout the year at five working days/week. Hence on a credit basis, 45 credits of theory work and 15 credits of practical work are possible in every year. There will be a total of 1890 hours of instruction in three years in Zoology alone (i.e. 70% of the total of 2700 hours/three years). Hence under Model I, out of 135 credits of theory for three years, 90 credits goes to Zoology and out of 45 credits of laboratory work, 30 credits of laboratory work would be allotted to Zoology. Hence this will make possible teaching of Zoology distributed over three years as follows. In the first and second years, 459 hours and 540 hours of teaching can be done while in the third year, all the 900 hours can be devoted to Zoology.

A total of 12 theory papers (6 of 9 credits load, 6 of 6 credits load) are possible. The distribution of credits can be altered depending the strengths of individual departments. Each course can be run on an annual basis or when split, on a semester basis.

**MODEL II**

This Model permits 1350 hours of Zoology teaching over three years. It is possible to have 90 credits of Zoology teaching. This will include 69 credits of theory (12,12 and 45 credits for the 1st, 2nd and 3rd years respectively) and 21 credits of practical over three years. In the first year two theory papers of six credits each (four lecturers per week) and one laboratory credit per week (2 and 1/4 hours) is possible. In the second year a similar load is possible. In the third year, all the 900 hours can be given to Zoology at 45 credits of theory and 15 credits of
laboratory work (i.e. three lecturers of one hour each and one practical of two hours each for every working day of the year). A total of 9 papers in theory (5 of 9 credits worth, 4 of 6 credits worth) is possible.

MODEL III

Zoology teaching comprises 30% of the total teaching. Every year, it is possible to save one hour of theory per working day and two & a half hours of laboratory work every week amounting to 45 credits of theory (15 credits each per year) and 9 credits of laboratory work (3 each for every year). This would permit 6 papers (3 of 9 credits worth and 3 of 6 credits worth). As usual credits allotted can depend upon the strength of each department.

The teaching load distribution and the suggested course titles for the three models are given in tabular form (Tables following this page).

Suggested teaching load regarding Zoology Undergraduate Courses

<table>
<thead>
<tr>
<th>Year</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Credits</td>
<td>Number of theory papers</td>
<td>Teaching (hrs/week)</td>
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<tr>
<td>1st</td>
<td>15 + 7.5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2nd</td>
<td>30 + 7.5</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>3rd</td>
<td>45 + 15</td>
<td>6</td>
<td>15</td>
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</tbody>
</table>

T + Theory; P + Practicals

Suggested List of Course Titles

<table>
<thead>
<tr>
<th>Year</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z-102B: Cell Biology</td>
<td>Z-102A: Cell Biology &amp; Biochemistry</td>
<td>Z-102: Cell and Developmental Biology</td>
</tr>
<tr>
<td>2nd</td>
<td>Z-201B: Animal Diversity-2</td>
<td>Z-201A: Physiology, Endocrinology and Embryology</td>
<td>Z-201: Genetics</td>
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<tr>
<td></td>
<td>Z-203B: Endocrinology and Reproductive Biology</td>
<td>Z-203A: Genetics and Evolution</td>
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<td>Z-204B: Evolution and Behaviour</td>
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<tr>
<td></td>
<td>Z-303B: Environmental Biology and Toxicology</td>
<td>Z-303A: Environmental Physiology</td>
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<tr>
<td></td>
<td>Z-304B: Biochemistry and Biotechnology</td>
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<td></td>
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<tr>
<td></td>
<td>Z-305B: Developmental Biology</td>
<td>Z-304A: Reproduction and Development</td>
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<tr>
<td></td>
<td>Z-306A: Biotechniques</td>
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</tbody>
</table>
Syllabi for Suggested List of Courses under B.Sc. (Zoology)
MODEL I

Z-101B: Animal Diversity-I

   2. Protozoa - Type study and study of locomotion, osmoregulation, nutrition and reproduction in protozoa.
   4. Porifera and coelenterata - Type study, corals and coral reefs, polymorphism in hydrozoa.
   5. Ctenophora - affinities. Type study.
   6. Platyhelminthes and Nemathelminthes - Type study, reproduction and parasitic adaptations.
   7. Annelida - Coelome and excretory system. Type study.
   8. Mollusca - Type study, torsion & detorsion in gastropoda.
   9. Onychopora - Type study and affinities.
   10. Arthropoda - Crustacean larval forms, vision in Arthropodes, metamorphosis in insects, Type study, social life in insects, Trilobites.

B. List of Recommended Books
   3. Barnes, R.D: Invertebrate Zoology (W.B. Saunders Co.).

C. List of Suggested Practicals
   1. Examination of paramecium, amoeba, Euglena and vorticella slides.
   2. Study of sycon, Hylonema and spongilla from slides & specimens.
   4. Life history of Fasciola and Taenia.
   5. Specimens and slides of Oxyuris, Ascaris.
   7. Transverse sections of tissues of leach and earthworm.
   8. Nereis - Transverse sections and mount of parapodium.
   11. Spiders, ticks, mites - specimens.
   15. Minor phyla - specimen study.
MODEL I

Z-102B: Cell Biology

A. 1. Diversity of cell size and shape
    2. Cell theory
    3. Structure of prokaryotic and eukaryotic cells
    4. Isolation and growth of cells
    5. Microscopic techniques for study of cells
    6. Cellular organelles-separation and characterization
    7. Cellular energy transactions - role of mitochondria and chloroplasts
    8. Membrane transport of small molecules and the ionic basis of membrane excitability
    9. Intracellular compartments and protein sorting
   10. Vesicular traffic in the secretory and endocytic pathways
   11. Cell signalling
   12. Cytoskeleton
   13. Cell-division cycle
   14. The mechanics of cell division
   15. Cell junctions, cell adhesion, and the extracellular matrix
   16. Cell differentiation
   17. Cell in development
   18. Differentiated cells and the maintenance of tissues

B. List of Recommended Books

   1. Lodish et al.: Molecular Cell Biology (Scientific American Books)
   2. De Robertis and DeRobertis: Cell and Molecular Biology (Saunders College)
   3. A C Giese: Cell Physiology
   5. Wilson, EB: Cell in Development and Inheritance (MacMillan)

C. List of Suggested Practicals

   1. Cell structure: prokaryotic and eukaryotic cell types with the operation of light microscope, phase contrast and polarising microscopes: Care and maintenance of the microscopes.
   2. Phase contrast microscopy-setting, measurements of refractive index, measurement of nuclear and cytoplasmic volume.
   3. Separation and isolation of cells by sedimentation velocity in unit gravity.
7. Permeability tests using erythrocytes.
8. Analysis of erythrocyte membrane lipids by thinlayer chromatography.
9. Isolation and estimation of DNA from rat liver hepatocytes.
10. Agarose gel electrophoresis, staining and identification of nucleic acids.
12. Aggregation of sponge cells and demonstration of features of cell adhesion.
13. Cytochemical demonstration of phenolase/phosphatases in tissue sections.
MODEL I

Z-201B: Animal Diversity-II

A.  1. Origin and general characters of chordates.
    2. Protochordates - Classification upto orders, Interrelationships, structural organisation of hemichordates, urochordates, post embryonic development of amphioxus.
    3. Agnatha - Classification upto orders.
    4. Fishes - Classification upto orders, parental care, respiratory organs, migration.
    6. Reptiles - Classification upto orders, extinct reptiles, poisonous snakes of India.
    7. Bird migration, principles of bird flight, origin of birds.
   10. Comparative anatomy of systems (e.g. kidney, heart, sense organs etc.)

B. List of Recommended Books


C. List of Suggested Practicals

1. Specimen study of Balanoglossus, Botrylus.
2. Slides from representative types.
3. Fishes - Dissections.
5. Amphibia - Dissections and museum specimens.
7. Aves - Dissections, mounts and museum specimen study.
8. Mammals - Dissections, museum specimen studies.
MODEL I

Z-202B: Physiology

A. 1. Aim and Scope of Physiology - Cell Physiology, mammalian physiology, comparative physiology and applied physiology.
   4. Blood - Composition and function of blood and lymph; Blood groups; Blood coagulation; Structure and function of haemoglobin.
   5. Heart - Structure; origin, conduction and regulation of heart beat; Cardiac cycle and ECG.
   6. Peripheral circulation - blood pressure, capillary pressure, regulation.
   7. Respiration - Mechanism and control of breathing.
   8. Digestion and absorption of dietary components.
   10. Structure and function of kidney - physiology of urine formation.
   11. Physiology of mechanical and osmotic work - skeletal and smooth muscle function.
   12. Physiology of neuronal function.
   13. Endocrine glands and hormones.
   15. Integration of tissue functions - neuronal & endocrine aspects.
   16. Metabolism - concept, selected examples, pathways and regulatory features.

B. List of Recommended Books

2. Ganong: Review of Medical Physiology (Lange)

C. List of Suggested Practicals

1. Experiments to show diffusion
2. Erythrocytes - ionic effects
3. Haemoglobin estimation
4. Blood cell count - haemocytometer
5. Blood coagulation experiments
6. Qualitative tests for sugars, proteins, lipids
7. Study of reflex action
8. Salivary amylase action
9. Perfusion of heart and recording of heart beat
10. Dissection of endocrine glands
11. Histology of tissues.
MODEL I

Z-203B: Vertebrate Endocrinology and Reproductive Biology

A. 1. Integrative physiology - basic concepts of neural and endocrine regulation of physiological processes.
   2. Endocrine glands and hormones - Classification of hormones, Brief account of structural features, histology of endocrine glands, Hormonal effects.
   3. Hormonal regulation of physiological processes - basic concepts and methods.
   5. Hormones and human health - production of hormones as pharmaceuticals.
   6. Reproductive strategies in vertebrates.
   7. Reproductive cycles in vertebrates.
   8. Hormonal regulation of gametogenesis in males and females.
  10. Accessory sex organs and their dependence as steroid hormones. Sex determination and sex differentiation.
  11. Endocrine disorders - brief description.

B. List of Recommended Books

C. List of Suggested Practicals
   1. Study of endocrine glands of rat.
   3. Surgical techniques like Ovariectomy, Orchidectomy, adrenalectomy.
   4. Cryothidism in rats.
   5. Effect of castration on accessory sex organs of rats.
   6. Histology of pituitary, ovary, testes, adrenal, uterus, seminal vesicles.
MODEL I

Z-204B: Evolution & Behaviour

A. 1. Concept of Evolution
    2. Origin of Life on Earth
    3. Origin of prokaryotic and eukaryotic cells.
    5. Concept of species and speciation.
    6. Molecular phylogeny; Phylogeny of horse.
    7. Mimicry
    8. Polymorphism; Population genetics, Genetic drift, Hardy-Weinberg Law.
    9. Macro and microevolution; Evolution of Man.
   10. Introduction to Ethology - animal sense organs.
   11. Patterns of behaviour, approaches to the study of behaviour.
   13. Reproductive behavioural patterns.
   14. Social organization in animals, social interactions among individuals.
   15. Comparative aspects of learning.
   17. Hormones, Drugs and behaviour.

B. List of Recommended Books

C. List of Suggested Practicals
   1. Adaptive modifications in feet of birds.
   3. Embryological evidence for evolution.
   4. Analogy and homology.
   5. Serial homology.
MODEL I

Z-301B: Ecology

   2. Organisms - Principles of adaptation to external factors (eg: temperature etc.).
   3. Precipitation patterns, vegetation, soil types-causes and consequences.
   7. Commonsalism & mutualism.
   8. Communities and Ecosystems - concepts, ecosystem energetics.
  10. Community development - ecological succession, major biomes.
  11. Wildlife management, conservation of renewable resources.
  13. Zoogeography - principles concepts of parallelism, endemism etc. Factors influencing animal distribution.

B. List of Recommended Books

C. List of Suggested Practicals
   1. Field work to understand basic ecological concepts.
   2. Laboratory experiments wherever possible.
MODEL I

Z-302B: Genetics and Immunology

A. 1. Mendelian inheritance patterns and laws of heredity
    2. Co-and incomplete dominance
    3. Linkage & linkage maps
    4. Varieties of gene expressions - multiple alleles, lethal genes, pleiotropic genes, gene
       interactions, epistasis
    5. Sex-chromosome systems and sex-linkage
    6. Non-chromosomal inheritance
    7. Mutations and chromosomal alterations, meiotic consequences.
    8. Human genetics - Chromosomal and single gene disorders; genetic counselling,
       somatic cell genetics.
    9. Gene mapping and genome analysis
   10. Immunity - innate and adaptive, cells, tissues and molecules of immune system.
   12. Humoral Immune Response - basic details
   13. MHC genes and gene products
   14. Complement and its action
   15. Immunotolerance, automimunity and hypersensitivity-concepts

B. List of Recommended Books

   1. Strickberger: Genetics (MacMillan)
   2. Farnsworth: Genetics (Harper & Row)
   3. Roitt I: Essential Immunology (ELBS)
   4. Kuby: Immunology (W.H. Freeman)

C. List of suggested Practicals

   1. Construction of a familial pedigree
   2. Probability exercises
   3. Chromosomal aberrations - slides
   4. Observation of Drosophila - wild and mutants
   5. Demonstration of antigen-antibody interaction in gels
   6. Separation of gamma globulins by salt precipatation
MODEL I

Z-303B: Environmental Biology and Toxicology

    2. Energy flow in ecosystem-trophic levels
    3. Food chains
    4. Characteristics of populations
    5. Environmental pollution - air, water and soil. Green house effect.
    6. Biotic community
    7. Conservation of Natural Resources
    8. Introduction to toxicology - definition of toxicity, classification of toxicants.
    9. Xenobiotics
   10. Toxic agents & mode of action - pesticides, metals, solvents, radiation, carcinogens, poisons.
    11. Environmental toxicology - food additives, air, water and soil pollutants.
    12. Principles of systemic toxicology
    13. Genotoxicology
    15. Applications of toxicology
    17. Environmental policy
    18. Environmental Impact Assessment
    19. Regulatory toxicology, Residue analysis
    20. Human toxicology and medical ethics.

B. List of Recommended Books

    1. Odum: Ecology (Amerind)

C. List of Suggested Practicals

    1. Determination of carbonate and nitrate in samples of soil.
    2. Determination of free Co₂ and salinity in ponds.
    3. Estimation of productivity of a pond ecosystem.
    4. Estimation of population density.
    5. Analysis of producers & consumers in grasslands.
    6. Field expeditions & project reports.
MODEL I

Z–304B: Biochemistry and Molecular Biology

A. 1. Aminoacids and Peptides - Properties & structure
2. Carbohydrates and lipids - classification, structures and clinical significance
3. Vitamins - Discovery, structures and functions
4. Proteins - Classification, structural properties
5. Nucleic acid and nucleotides - structural properties and functions
6. Analytical and separation techniques in biochemistry and biophysics
7. Nature of enzymes - Classification, purification and kinetic assays, Immunobilized enzymes & their uses.
8. Design and regulation of metabolism - selected examples from carbohydrate, lipid, nucleotide and amino acid metabolism.
9. Genes and chromosomes - nature of genetic material-central dogma
10. Organization of DNA - Viral, bacterial and eukaryotic, palindromes, split genes, transposons
11. DNA replication - general principles, enzymes and inhibitors
12. DNA repair
13. Transcription - basic details
14. Protein biosynthesis - basic details
15. Co-and post-translation modifications, inhibitors
16. Regulation of gene expression - general principles

B. List of Recommended Books

1. Stryer, L: Biochemistry (Freeman)
2. Conn et al: Outlines of Biochemistry (Wiley)

C. List of Suggested Practicals

1. Criteria of reliability of quantitative experiments
2. Principles of Colorimetry
3. Determination of pK, pl
4. Chromatography - Paper, gel etc.
5. Kinetic analysis of any enzyme
6. Base composition of DNA
7. Sub-cellular fractionation
8. Demonstration of restriction enzyme action.
MODEL I

Z-305B: Developmental Biology

A. 1. Gametogenesis - spermatogenesis and oogenesis, vitellogenesis, egg membranes
    2. Fertilization - sperm-egg interactions - biochemical events, post fertilization events
    3. Parthenogenesis
    4. Types of animal eggs; patterns of cleavage; germ layers, gastrulation, fate maps and cell lineage
    5. Extra embryonic membranes, types and physiology of placenta
    6. Organizer - concept, induction process
    7. Organogenesis of heart, kidney nervous system & sense organs
    8. Post-embryonic developments - insects & amphibians
    9. Regeneration in invertebrates and vertebrates, development of immune system in vertebrates
    10. Ageing - concepts and models.

B. List of Suggested Books

1. Balinsky: Introduction to Embryology (CBS College Publishers)
3. Davenport: An outline of animal development (Addison-Werley)
4. Grant: Biology of Developmental System
5. Subramanyan, T: Developmental Biology (Narosa Publishing House)

C. List of Suggested Practicals

1. Organization of gonads in crab and mouse
2. Live gametes under microscope
3. Observations on development of fertilized frog eggs
4. Living chick embryos - observations
5. Whole mounts of chick embryo stages
6. Regeneration in amphibians
7. Sea urchin - parthenogenesis
MODEL I

Z-306B: Applied Zoology

Any of the following suggested applied topics should be taken.

A. 1. Bioinformatics
    2. Reproductive Technologies
    3. Aquaculture
    4. Medical Zoology
    5. Biotechnology

1. Bioinformatics

   Historical perspective on computers and their applications to biology
   Operating systems DOS, WINDOWS, UNIX
   Introduction to Programming
   The Internet and the Biologist
   Data bases and information retrieval
   Sequence analyses - basic concepts and operational aspects
   Phylogenetic analyses
   Predictive methods based on sequence data
   Genome information
   Programming using C
   C data types
   C assignments statements
   One dimensional arrays
   Strings & C string library
   Structures & unions.

2. Reproductive Technologies

   1. Gamete technology - gametogenesis in economically important invertebrates &
      vertebrates. Collection and Cryopreservation of gametes and embryos.
   2. Sperm function tests and semen analyses. In vitro fertilization and embryotransfer.
   3. Immunocoontraception, vaccines.
   4. Hormone assays - bioassays & immunoassays, RIA and ELISA, Immunodiagnostics
      for pregnancy, cancer and reproductive tract infections.
   5. Embryo sexing - methods & principles.
   6. Animal house-design, breeding & maintenance of animals - production of transgenic
      animals.
   7. Embryocloning and cloning of animals by nuclear transfer.
3. **Aquaculture**

1. World aquaculture-role, importance, status, production trend, important species, current concepts of culturable Fin fishes and shell fishes.
2. Micronutrients.
4. Marine Fisheries of India, Pelagic and Demersal. Fishery resources, their exploitation, area, seasons, production, efforts, utilization, demand and potential resources.
5. Estuarine and brackish water fishes of India - Characteristic species and their exploitation.
6. Fresh water fishes of India. River system, reservoir, pond, tank fisheries, captive and cultured fishereis, cold water fisheries.
7. Fishing craft and gear.
8. Finfishes, Crustaceans, Molluscs their culture.
9. Sea weed culture: Species selection for culture, specific feed and seeds, seed selection, genetics.
10. Seed production: Natural seed resources-its assessment, collection. Hatchery production.
11. Nutrition: Sources of food (Natural, Artificial), feed compositions (Calorie, Chemical ingredients) Energetics of food conversion, feeding schedule, methods of feed formulation, storage and quality control.
12. Field Culture: Ponds-running water, recycled water, cage culture, pen culture, sea ranching and artificial recruitment, culture site, its requirement, nursery and grow out pond: Preparation, management, fertilization, stocking, feeding, monitoring and management. Poly culture-Farm construction.

4. **Medical Zoology**

- Introduction to Parasitology (pertaining to various terminologies used).
- Brief introduction to pathogenic microbes: Viruses, Rickettsiae, Spirochaetes and Bacteria.
- Brief accounts of life history, mode of infection and pathogenicity of the following pathogens with reference to man prophylaxis and treatment:
  (a) *Pathogenic protozoans*: Entamoeba, Trypanosoma, Leishmania, Giardia, Trichomonas, Plasmodium.
(b) **Pathogenic helminths**: Fasciolopsis, Schistosoma, Echinococcus, Ancylostoma, Trichinella, Wuchereria, Dracunculus, Oxyuris.

Brief account of arthropods as direct agents of disease or discomfort; accidental injury to sense organs; blood loss; entomophobia; dormatosis; mylasis; allergy and venoms.

Arthropods as vectors of human diseases; Malaria (Anopheles stephensi A. culicifacies); yellow fever and Dengue haemorrhagic (Aedes aegypti, Ae albopictus); Filarisis (culex pipions fatigans Mansonia sp.); Japanese B. Encephalitis (C. tritaenorrhynchus) Plague (Ctenocophilides cheopie) and Epidemic typhus (Pediculus).

Distribution biology and control of the above mentioned vectors. Histopathological changes in organs in relation to diseases such as liver cirrhosis, nephrosis; tumours, cancers.

Epidemic diseases, such as typhoid, cholera, small pox; their occurrence and eradication programmes.

Brief introduction to human defense mechanisms. Antigens and antibodies.

General account of drug therapy and drug resistance.

**B. List of Recommended Books**


**C. List of Suggested Practicals**

Preparation of blood film: examination of blood parasites: Trypanosoma and Plasmodium.

Preparation of permanent stained mounts of rectal ciliates of frog.

Study of permanent slides and specimens of parasitic protozoans, helminths and arthropods mentioned in the theory syllabus.

Anopheles: dissection of female adult mosquitoes for sporozites and oocysts.

Collection of helminth parasites from vertebrates; their preservation and staining.

Staining bacteria.

Study of slides showing histopathological changes in liver and kidney in respect of cirrhosis and nephrosis respectively.

Analysis of blood Groups: A,B,O and AB.

Pathological examination of sputum, blood, urine and stool.

Blood: Erythrocyte sedimentation rate (ESR); Haematocrit; bleeding time; coagulation time; prothrombin time.


Colorimetric estimation haemoglobin.

R.B.C., W.B.C. counts.

Medicolegal tests for blood: Benzidine test, precipitin test and complement fixation test.
5. **Biotechnology**

1. Basic concepts in genetic engineering.
2. Enzymology of genetic engineering: Restriction enzymes, DNA ligase, Polymerase etc.
3. Cloning Vehicles: Plasmids, Cosmids, Lambda phage, Charon phage, Shuttle vectors, 2 μDNA plasmids, yeast plasmids.
4. Introduction of cloned genes into the host cells: Transformation, transduction, Particle gun, electroporation, liposome mediated, cultivation etc.
6. Gene libraries - Construction and analysis of cDNA, mRNA, isolation, cDNA synthesis, cloning and amplification of gene libraries, Genomic DNA libraries, YACs, BACs, Measuring activity of fused genes, Identifying the products of cDNA clones.
7. Changing genes: Site - directed mutagenesis.
8. Transferring genes into animal oocytes, eggs, embryos and specific animal tissues.
9. Application and Impact of rDNA technology.
10. Ethical issues and biosafety regulations.

**B. List of Suggested Books**

2. R.A. Meyers (Ed.): Molecular Biology and Biotechnology, (VCH Publishers)

**C. List of Suggested Practicals**

1. Simple exercises to teach principles. As it is a costly laboratory, local improvisations and innovations can be done.
MODEL II

Z-101A: General Zoology

A. 1. Principles of classification
    2. Classification of animals, Non-chordates: Salient Features and classification up to classes.
    3. Hemi-chordates & Chordates: Salient features and classification up to sub-classes with examples for adaptive features.
    4. Higher Chordates: Salient Features and Classification of extent groups up to orders with examples for adaptive features.
    5. Diversity in animal form and function, like:
       i. Support and Movement
       ii. Nutrition
       iii. Gas exchange & transport
       iv. Excretory organs
       v. Sensory system
       vi. Reproductive patterns.

B. List of Recommended Books

1. Boolotian and Stiles: College Zoology (Macmillan)
2. Campbell: Biology (Benjamin)
4. Wolfe: Biology the Foundations (Wadsworth)
5. Parker & Haswell: Text Book of Zoology Vol.II (Macmillan)

C. List of Suggested Practicals

1. Study of transverse sections of *Sycon, Hydra, Fasciola, Ascaris, Hirudinaria* and Frog.
2. Salient features and classification up to class of *Amoeba, Englenta, Paramecium, Masmodium, Physalia, Sea-anemone, Ascaris, Octopus, Peripatus, Limulus, Nereis, Chiton, Antedon* etc.
3. Salient features and classification up to class of *Balanoglossus, Herdmania, Amphioxus Lamprey, Trygon, Chimaera, Lung fish, Snake, Ambystona, Uraeypilus, Alytes, Hyla, Chamdeon, Tortoise, poisonous and non-poisonous snake, Duck, Platypus, Kiwi* etc.
4. Study of exoskeletons.
5. Demonstration of ciliary moments.
6. Appendages of Palaemon.
7. Locomotion of Snail.
8. Dissections and mounts for nutrition, respiratory and circulatory systems, sense organs and nervous systems, urinogenital systems and Reproduction.
MODEL II

Z-102A: Cell Biology and Biochemistry

A. 1. The Cell
    2. Methods in Cell Biology
    3. Organization of Cell - extranuclear and nuclear
    4. Cell Reproduction
    5. An elementary idea of cell transformation and cancer
    6. An elementary idea of cellular basis of immunity
    7. Chemistry of living system
    8. Properties of water as a biological solvent
    9. Biomolecular organization
   10. Chemical bonds and bond energy
   11. Aminoacids, peptides and proteins
   12. Enzymes
   13. Biomolecules - lipids, carbohydrates, nucleic acids

B. List of Recommended Books
   1. Alberts et al: Molecular Biology of the Cell (Garland)
   2. Lodish et al: Molecular Cell Biology (Freeman)

C. List of Suggested Practicals
   1. Light microscope - use
   2. Diversity of eukaryotic cell-stained cells
   3. Subcellular organelle staining
   4. Mitosis in onion root tip
   5. Meosis in grasshopper testis
   6. Polytene chromosomes
   7. Erythrocyte plasma membrane permeability
   8. Cell separations by low speed centrifugation
   9. Atomic models of peptides, aminoacid, fatty acid, nuceotide
  10. Demonstration of enzyme activity
  11. Qualitative tests for sugars, aminoacids
  12. Lipid analysis
  13. Paper Chromatography of aminoacids.
MODEL II

Z-201A: Physiology, Endocrinology & Developmental Biology

A. 1. Respiration - types, pigments, $O_2$-dissociation curves
2. Circulation - Blood composition, coagulation, haemoporesis, heart types
3. Nutrition, digestion and Absorption
4. Excretion - Nitrogenous wastes
5. Coordination - Neural mechanisms
6. Thermoregulation and osmoregulation
7. General characters of hormones
8. Mammalian endocrine glands
9. Insect endocrine glands
10. Aim and scope of Developmental Biology
11. Gametogenesis - spermatogenesis and oogenesis
12. Fertilization - morphology and biochemistry
13. Types and patterns of cleavage
14. Blastulation and fate map construction in frog & chick
15. Gastrulation
16. Primary organizer and extra embryonic membranes
17. Competence, determination, differentiation and regeneration.

B. List of Recommended Books
1. Hoar: General and Comparative Physiology (Prentice Hall)
3. Prosser: Comparative animal Physiology (Satish Book Enterprise)
4. Hadley: Endocrinology (Prentice Hall)
5. Balinsky: An introduction to Embryology (CBS College Publishers)

C. List of Suggested Practicals
1. Determination of pulse rate at rest and after exercise
2. Determination of oxygen consumption of cockroach
3. Capillary circulation in web of frog
4. Estimation of hemoglobin content in blood of rat
5. Preparation of hemin crystals from blood of rat
6. To demonstrate activity of salivary amylase and effect of acid and heat
7. Semi quantitative test for detection of glucose (Benedict’s method)
8. To determine the presence of protein in a sample
9. To demonstrate knee-jerk reflex, existence of blind spot of eye and to determine the near point of vision
10. Handling, sexing numbering and maintenance of albino rat
11. General survey of endocrine glands of rat
12. Study of vaginal smear of rat
13. Demonstration of the following surgical operations in rat: (a) castration (b) adrenalectomy
14. Study of histological slides of the following endocrine glands in rat: testis, ovary, thyroid, adrenal, pituitary, islets of Langerhans
15. Demonstration of endocrine glands in cockroach (Periplaneta)
16. Study of eggs and tadpoles of frog from collected/preserved material
17. Study of frog development through prepared slides and models
18. Preparation of permanent mounts of different stages of frog development
19. Effects of thyroid hormone and an antithyroid drug on frog metamorphosis
20. Study of structure of egg of hen and vital staining of the embryo
21. Window preparation in egg of hen
22. Study of whole mount preparations of chick embryos from 16-18 hrs., 24-28 hrs., 33-36 hrs. and 42-48 hrs. of development
23. Study of different types of eggs
24. Study of different types of sperm by smear preparation (grasshopper, frog and rat).
MODEL II

Z-202A: Genetics, Evolution and Applied Zoology

A.  1. Elements of heredity and variation
    2. The varieties of gene expression
    3. Gene linkage
    4. Sex-chromosome systems
    5. Chromosome alterations and meiotic consequences
    6. Human genetics
    7. Applications of genetic engineering
    8. Concept and evidences of organic evolution
    9. Theories of organic evolution
   10. Evolution of man
   11. Molecular evolutionary ideas
   12. Basic concepts and operational aspects of sericulture, pisciculture, apiculture, medical entomology, aquaculture, Assisted Reproduction Technologies, Diagnostic cytogenetics. (A choice of any two can be made).

B. List of Recommended Books

   1. DeRobertis and DeRobertis: Cell and Molecular Biology
   2. Strickberger: Genetics (Macmillan)
   3. Farnaworth: Genetics (Harper & Row)
   4. Moody: Introduction to Evolution
   5. Savage: Evolution (Holt, Reinhart and Winston)
   7. Srivastava: Text Book of Applied Entomology (Kalyani Publishers)
   8. Venkitaraman: Economic Zoology (Sudarsana Publishers)

C. List of Suggested Practicals

   1. Application of law of probability
   2. Frequency of genetic traits in humans
   3. Pedigree charts
   4. *Drosophila* cultures 0 Wild and mutants
   5. Pevtrance using *Drosophila* mutants
   6. Sex-linked inheritance
   7. Lethal gene markers
   8. Multiple allelism
   9. Chromosomal aberrations
MODEL II

Z-301A: Functional Anatomy of Non-Chordata

A. 1. Introduction to non-chordata - General characters and comparison with Chordata
    2. Protozoa:
       Salient features and outline classification upto classes
       Study of *Amoeba, Euglena, Paramecium* and *Monocystis* with reference to
       locomotion, nutrition and reproduction
       Parasitic protozoans of man with reference to diagnostic characters, mode of
       infection and diseases caused (*Entamoeba, Giardia, Trypanosoma, Leishmania*)
       Origin of Metazoa.
    3. Porifera:
       Salient features and outline classification upto classes
       Study of Leucosolenia and Sycon with reference to structure, reproduction and
       development.
    4. Cnidaria:
       Salient features and outline classification upto classes
       Study of Obelia and Aurelia with reference to structure and reproduction
       A brief account of corals and coral reefs.
    5. Ctenophora:
       Salient features of a ctenophore and comparison with Cnidarians
    6. Platyhelminthes:
       Salient features and outline classification upto classes
       Study of *Fasciola* and *Taenia* with reference to structure reproduction, life-cycle and
       parasitic adaptations.
    7. Nemathelminthes:
       Salient features and outline classification upto classes
       Study of *Ascaris* with reference to structure, reproduction and life-cycle
       Parasitic nematodes of man with reference to diagnostic characters, mode of
       infection and diseases caused (*Ancylostoma, Enertrobius* and *Wuchereria*).
    8. Annelida:
       Salient features and outline classification upto classes
       Types and significance of coelom
       Metamerism and its significance
       Study of *Nereis* with reference to structure and reproduction; parasitic adaptations of
       *Hirudinaria*
       Trochphore larva and its significance.
9. **Arthropoda:**
   Salient features and outline classification up to classes
   Study of *Palaemon* and *Palamnaeus* with reference to structure and reproduction
   Zoological importance of *Peripatus* and *Limulus*.

10. **Mollusca:**
    Salient features and outline classification up to classes
    Study of *Unio* and *Pila* with reference to structure and reproduction
    Torsion in Gastropoda.

11. **Echinodermata:**
    Salient features and outline classification up to classes
    Study of starfish (*Asterias*) with reference to structure, locomotion, mode of feeding
    and reproduction
    Echinoderm larvae and their significance with emphasis on Dipleurula.

**B. List of Recommended Books**

1. Barnes: Invertebrate Zoology (Hall-Saunders International)
2. Barrington: Invertebrate Structure and Function (Nelson)
3. Boolootin & Stiles: College Zoology (Macmillan)
8. Nigam, Biology of Non-chordates (S. Nagin Chand)
9. Purves & Orians: Life-the Science of Biology (Sinauer)

**C. List of Suggested Practicals**

1. Survey of pond water for study of free living protozoans
2. Preparation of cultures of *Paramecium* and *Euglena*
3. Study of canal systems (asconoid, syconoid, leuconoid) by prepared slides and models
4. Mounting of spicules
5. Study of the following museum specimens: *Leucosolenia, Sycon, Euplectella, Hyalonema, Spongilla, Cliona, Euspongia*.
6. Survey of pond water for study of *Hydra*
7. Study of the following through prepared slides: T.S. of *Hydra* through ovary and testis, *Scyphistoma, Ephyra*. 
8. Study of the following museum specimens: *Physalia*, *Porptia*, *Velella*, *Aurelia*, *Tubipora*, *Corallium*, *Gorgonia*, *Pennatula*, *Metridium*, *Fungia*, *Millepora*.
9. Study of the following museum specimens: *Hormiphora/Pleurobranchia*, *Beroe*.
10. Study of the following by slides/museum specimens: *Dugesia*, *Polystoimum*, *Schistosoma*, *Echinococcus*, *Fasciola*, *Taenia*, miracidium, sporocyst, redia, cercaria, metacercaria, hexacanth, bladder worm.
11. Study of the following by slides/museum specimens: *Ascaris* (male and female), T.S. of *Ascaris*, *Wuchereria*, *Ancylostoma*, *Enterobius*.
12. Leech: External features, Dissections and permanent preparations of jaws and salivary glands.
13. *Nereis*: Permanent stained preparation of parapodium
14. Study of the following museum specimens/slides: *Nereis*, *Aphrodite*, *Arenicola*, *Sabella*, *Acanthobdella*, *Branchellion*, *Bonellia*.
15. Trochophore larva, T.S. of leech.
18. Study of the following larval forms with the help of slides: Nauplius, Zoea, Megalopa.
20. Study of the following museum specimens: *Chiton*, *Cyprea*, *Patella*, *Aplysia*, *Doris*, *Vaginula*, *Acutina*, *Dentalium*, *Mylitus*, *Pecten*, *Teredo*, *Solen*, *Sepia*, *Loligo*, *Octopus*.
21. Study of the following museum specimens: Star-fish, brittle-star, sea urchin, sea cucumber, sea lily.
22. Study of the following larval forms: *Bipinnaria*, *Brachiolaria*, *Auricularia*, *Ophiopluteus*, *Echinopluteus*.
MODEL II

Z-302A: Comparative Anatomy of Chordates

A. 1. Outline classification and evolution of chordates
    2. *Integument and its derivatives:*
       Structure of scales, feathers, hair, beaks, claws, nails, hoofs, horns, antlers, glands.
    3. *Endoskeleton:*
       General considerations, Axial skeleton, Appendicular skeleton.
    4. *Digestive system:*
       Digestive tube and its evolution, Primary divisions of the tube, Types of teeth and dental formula in mammals.
    5. *Respiratory system:*
       Cutaneous respiration, Gills and lung, Air-sacs in birds.
    6. *Circulatory system:*
       Evolution of heart and aortic arches, Portal systems, Lymphatic system.
    7. *Nervous system:*
       General plan of brain and spinal cord, Evolution of cerebral hemispheres and cerebellum, Sense organs, Chemoreceptors, Neuromast organs of lower vertebrates, Eye and ear.
    8. *Urinary system:*
       Excretory unit, Reproductive unit.

B. List of Recommended Books

1. Hildebrand: Analysis of Vertebrate Structure (Wiley)
2. Kingsley: Outlines of Comparative Anatomy (Central Book Depot)
3. Romer & Parsons: The vertebrate Body (Saunders)

C. List of Suggested Practicals

1. *Protochordates:*
   *Amphioxus* - External features and mounting of oral hood, velum and pharyngeal wall.
2. Study of the following slides of *Amphioxus:* T.S. through oral hood, midgut diverticulum, Pharyngeal region and gonads, post oral region, intestine and L.S. of whole body.
3. Study of the following museum specimens: *Botryllus, Pyrosoma, Salpa, doliolo.*
4. Study of vertical sections of the skin of the following: Bony fish (scaly and scaleless), frog, reptile, bird and mammal.
5. Mounting of placoid, cycloid and ctenoid scales.
7. Study of different types of feather: Contour, filoplume and down feathers.
8. Comparative study of skeletal system of Mystus, Rana, Varanus, Gallus, rabbit.
9. General anatomy Mystus/Cirrhus, Calotes, Columba, Funambulus and comparative study of the following systems:
   Digestive system: types of teeth, alimentary canal and associated glands
   Vascular system
   Heart and afferent and efferent bronchial vessels of a bony fish (Mystus/Cirrhus)
   Arterial and venous systems of Calotes, Columba and Funambulus
   Respiratory system
   Accessory respiratory organs of Clarias, Heteropeustes and Ophioccephalus
   Air sacs in Columba (demonstration only)
   Urinogenital system, Brain
   Cranial nerves (V, VII, IX, X) of bony fish (Mystus/Cirrhus), Sense organs: Pecten of Columba, Columella of Columba, internal ear of a bony fish, Weberian ossicles of Mystus/Cirrhus.
10. Histology: Study of permanent slides of the following tissues and organs of mammals; Tooth, Tongue, Oesophagus, Stomach, Intestine, Pancreas, Liver, Spleen, Kidney, Cartilage, Bone.
11. Classification and distinctive features of the following:
   Cyclostomata: Petromyzon, Myxine
   Chondrichthyes: Scoliodon, Sphyra, Torpedo, Pristis
   Osteichthyes: Protopterus, Lophius, Exocetus, Hippocampus, Syngnathus, Tetradon, Diodon, Amia, Catla, Labeo, Wallago, Anguilla
   Amphibia: Ichthyophis, Axolotl larva, Amphiuma, Pipa, Xenopus, Rhacophorus
   Reptilia: Chameleons, Draco, Heloderma, Uromastix, Alligator, Crocodylus, Natrix, Naja, Vipera, Crotalus
   Aves: Apterys, Struthio, Aptenodytes, Francolinus, Tytoalba, Dinopiu, Milvus, Corvus, Pavo, Eudynamys, Passer, Psittacula, Anas, Grus
   Mammalia: Ornithorhynchus, Tachyglossus, Macropus, Manis, Erinaceus, Pteropus, Lemur, Loris, Bradypus, Phoca, Lutra, Equus cabalus, Camelus, Capra, Bos.
12. Visit to a zoological park.
MODEL II

Z-303A: Environmental Physiology

A.  1. Adaptation:
   Levels of adaptation
   Mechanisms of adaptation
   Significance of body size

   2. Physiological adaptations to different environments:
   Marine, Shores and Estuaries, Freshwater, Extreme aquatic environments,
   Terrestrial Life, Extreme terrestrial environments, Parasitic habitats.

   3. Stress physiology:
   Basic concept of environmental stress and strain; concept of elastic and plastic
   strain; stress resistance, stress avoidance and stress tolerance.
   Adaptation, acclimation and acclimatization.
   Concept of homeostasis.
   Endothermy and physiological mechanism of regulation of body temperature.
   Physiological adaptation to osmotic and ionic stress; mechanism of cell volume
   regulation.
   Osmoregulation in aqueous and terrestrial environments.
   Physiological response to oxygen deficient stress.
   Physiological response to body exercise.
   Meditation, Yoga and their effects.

B. List of Recommended Books

   1. Eckert, R. Animal Physiology: Mechanisms and Adaptation, W.H. Freeman and
      Company, New York.

   2. Hochachka, P.W. and Somero, G.N. Biochemical Adaptation, Prince
toin, New
      Jersey.


      New York.


      York.


C. List of Suggested Practicals

1. Direct field data collection on adaptive features vis-à-vis a given environment.
2. *In vitro* experiments on environmental parameters and cellular biochemical responses measurements.
MODEL II

Z-304A: Reproduction and Development

A. 1. Structure and function of the adult mammalian ovary
    2. Corpus luteum and its control
    3. Gamete and Zygote transport
    4. Biology of decidualization
    5. Placentation and its regulation,- Types of placentation, - Placental hormones and their regulation
    6. Foetoplacental unit as an endocrine entity
    7. Parturition and its regulation
    8. Structure of mammary gland
    10. Structure, function and regulation of male accessory reproductive organs.
    11. Structure of sperm, biochemistry of semen, capacitation of spermatozoa.
    13. Principles of bio-assay and application,- Techniques of RIA, EIS and radio receptor assay,- In-vitro fertilization, embryo transfer technique, collection and preservation of gametes,- Use of polyclonal and monoclonal antibodies in the study of reproduction.
    15. Reproductive cycles in vertebrates; In vitro oocyte maturation and fertilization.
    16. Comparison of cleavage, gastrulation and fate maps in sea urchin, Amphioxus, frog and chick upto the formation of three germ layers.
    17. Determination and differentiation - Primary organizer and induction, analysis of the nature of inducer and its mechanism of action, Morphogenetic gradients in egg cytoplasm of sea urchin.

B. List of Recommended Books

1. Balinsky: Introduction to Embryology (CBS College Publishers)
2. Hadley: Endocrinology (Prentice Hall)

C. List of suggested Practicals

1. Handling, sexing numbering and maintenance of albino rat
2. General survey of endocrine glands of rat
3. Study of vaginal smear of rat
4. Demonstration of the following surgical operations in rat: (a) castration  
   (b) adrenalectomy  
5. Study of histological slides of the following endocrine glands in rat: testis, ovary,  
   thyroid, adrenal, pituitary, islets of Langerhans.  
6. Demonstration of endocrine glands in cockroach (*Periplaneta*)  
7. Study of eggs and tadpoles of frog from collected/preserved material  
8. Study of frog development through prepared slides and models  
9. Preparation of permanent mounts of different stages of frog development.  
10. Effects of thyroid hormone and an antithyroid drug on frog metamorphosis.  
11. Study of structure of egg of hen and vital staining of the embryo.  
12. Window preparation in hen egg  
13. Whole mount preparations of chick embryos.  
14. Types of eggs-study.  
15. Types of sperms-smear preparations.
MODEL II

Z-305A: Animal Behaviour and Applied Zoology

A.  
1. Introduction of Ethology.
2. The sensory world of animals:
   Behavioural Equipment (Senses, Organs).
3. Patterns of Behaviour:
   a) Individual behavioural pattern
   b) Homing behaviour
4. Genetics of Behaviour:
   a) Genetic basis of behaviour
   b) Learning behaviour
5. Evolutionary approach to behaviour; Levels of natural selection.
6. Reproductive behavioural patterns:
   a) Courship and ritual behaviour
   b) Mating
   c) Parental investment
   d) Stickle back behaviour
7. Social organization:
   a) Dominance Hierarchies
   b) Social competition
   c) Territoriality
8. Individual social interactions:
   a) Animal Communications
   b) Dance Language of the honey bees
   c) Aggregation
   d) Social facilitation.
9. Comparative aspects of learning:
   a) Definition and forms of learning behaviour; Development of learning
   b) Mechanisms of learning
   c) Imprinting
11. Elementary knowledge of sericulture, apiculture, Lac culture, fish culture, poultry keeping, Dairy industry.
12. Elements of pest control.
B. List of Recommended Books

2. Grier: Biology of Animal Behaviour (Mosby College)
3. Immelmann: Introduction to Ethology (Plenum Press)
4. Lorenz: The Foundation of Ethology (Springer-Verlag)
5. Manning: An Introduction to Animal Behaviour (Addison - Wesley)
7. Price & Stoker: Animal behaviour in laboratory and field (Freeman)
8. Wood-Gush: Elements of Ethology (Chapman and Hall)
9. Freeland: Problems in practical advanced level biology (Hoddes and Stoughten)
10. Shukla and Upadhyaya: Economic Zoology (Rastogi Publishers)

C. List of suggested Practicals

1. Habituation in earthworms/mosquito larvae.
2. Feeding behaviour in housefly.
3. An investigation into the locomotory behaviour of maggots of the housefly.
4. Study of behaviour in troop of monkeys (Sankat Mochan Complex): Study of individual patterns of behaviour, Study of social patterns of behaviour
5. Interspecific association - cattle and egrets/behaviour of stray dogs in a natural setting/Flocking behaviour in pigeons.
6. Film shows on animal behaviour.
7. Visit to study the management of the following: fish farm, dairy farm, poultry farm, sericulture and apiculture, Submission of report on anyone of the above visits.
8. Life cycles of lac insect and honeybee (chart/model/material).
9. Study of the structural organization of the bee hive.
MODEL II

Z-306A: Biotechniques

A. 1. Assay
2. Definition and criteria of reliability
   Chemical assays
   Biological assays - in vivo and in vitro assays.
3. Principles and uses of analytical instruments - Balances, pH meter, calorimeter, spectrophotometer, ultracentrifuge, densitometric scanner, spectrofluorometer, chemiluminometers, radioactivity counters, differential scanning calorimeter, ESR and NMR spectrometres.
5. Microbiological techniques:
   Media preparation and sterilization
   Inoculation and growth monitoring
   Use of fermentors
   Biochemical mutants and their use
   Microbial assays.
6. Cell culture techniques:
   Design and functioning of tissue culture laboratory
   Cell proliferation measurements
   Cell viability testing
   Culture media preparation and cell harvesting methods.
7. Cryotechniques
   Cryopreservation for cells, tissues, organisms
   Cryotechniques for microscopy
   Freeze-drying for physiologically active substances.
8. Separation techniques in biology:
   Molecular separations by chromatography, electrophoresis, precipitation etc.
   Organelle separation by centrifugation etc.
   Cell separation by flow cytometry, density gradient centrifugation, unit gravity centrifugation, affinity adsorption, anchorage based techniques etc.
9. Computer aided techniques for data presentation, data analyses, statistical techniques, special softwares for specific tasks.
10. Radioisotope and mass isotope techniques in biology:
    Sample preparation for radioactive counting
Autoradiography
Metabolic labelling
Magnetic Resonance Imaging.

11. Immunological techniques based on antigen-antibody interactions.

12. Surgical techniques:
   Organ ablutions (eg: ovariectomy, adrenolectomy etc.)
   Perfusion techniques
   Indwelling catheters
   Stereotaxy
   Parabiosis.


B. List of Recommended Books: (All latest editions)


C. List of Suggested Practicals

   As listed above. Representative exercises should be done.
MODEL III

Z-101: Life and Diversity of Animals

Functional morphology of the types included with special emphasis on the adaptations to their modes of life and environment. General characters and classification of all phyla upto orders with examples emphasizing their biodiversity, economic importance and conservation measures where required.

A. 1. Introduction to animal Kingdom
    2. Protozoa – Type study-plasmodium, parasitic protozoans
    3. Porifera - Type study-sycon
    4. Coelenterata - Type study-sea anemone, Corals and coral reefs
    5. Helminthes - Type study-Liverfluke, Helminthparasites
    6. Annelida - Type study-Nereis, Metamerism, Trochophora larva
    7. Arthropoda - Type study-Prawn and grasshopper
    8. Mollusca - Type study-sepia
    9. Echinodermata - Type study-Seastar, Echinoderm larvae
   10. Hemichordata - Type study-Balanoglossus
   11. Chordates - Origin
   12. Prochordates - Type study-Amphioxus, Cephalochordata and Urochordata
   13. Agnatha - Type study-Petromyzon
   14. Pisces - Type study-Mullet, Scales & fins. Migration. Parental Care
   15. Amphibia - Origin, Type study-frog, Parental Care
   16. Reptilia - Type study-calotes, Origin, Extinct reptiles, Poisonous and non-poisonous snakes, Poison apparatus.
   17. Aves - Type study-Pigeon, Flight adaptation, Bird migration.

B. List of Recommended Books (All latest editions)


C. List of Suggested Practicals

1. Study of Museum specimens and slides relevent to the types studied in theory.
2. Dissection of digestive, reproductive and nervous systems of cockroach.
3. Dissection of digestive, arterial, venous and urinogenital systems of Frog.
4. Mounting of
   a) Body setae of Earthworm
   b) Mouthparts of any 4 insects (Mosquito, Housefly, Bedbug, Plant bug, Cockroach and Honeybee)
   c) Salivary glands of cockroach
   d) Appendages of prawn
   e) Hyoid apparatus of Frog
   f) Brain of Frog
5. Identification of prepared skeletal structures of shark, frog, calotes, pigeon and rat; palates of birds, skulls of dog and rabbit.
6. Demonstration of dissections of arterial, venous and urinogenital systems of rat. Feathers, flight muscles and viscera of bird.
7. Field study report.
MODEL III

Z-102: Cell and Developmental Biology

A. 1. The Cell
    2. Methods in Cell Biology
    3. Organization of Cell - extranuclear and nuclear
    4. Cell Reproduction
    5. An elementary idea of cell transformation and cancer
    6. An elementary idea of cellular basis of immunity
    7. Historical perspective, aim and scope of developmental biology
    8. Gametogenesis
    9. Fertilization
    10. Types of patterns of cleavage
    11. Process of blastulation and fate map construction in frog and chick
    12. Gastrulation in frog and chick upto the formation of three germinal layers
    13. Elementary knowledge of primary organizer
    14. Elementary knowledge of extra embryonic membranes
    15. Concepts of competence, determination and differentiation
    16. Concept of regeneration

B. List of Recommended Books

1. Alberts, Bray, Lewis, Raff, Roberts & Watson, Molecular Biology of The Cell (Garland)
2. Balinsky, An Introduction to Embryology (CBS College Publishers)
3. Grant : Biology of Developing systems (Holt, Reihart and Winston)
4. Gilbert : Developmental Biology (Sinauer)
5. Alberts, B., et al., Molecular Biology of the Cell (Garland)

C. List of Suggested Practicals

1. Observation of live sperm in physiological saline using phase contrast optics.
2. Demonstration of use of fluorescence microscope (DNA, RNA fluorescence) and familiarity with Cytophotometry.
3. Familiarity with scanning and transmission electron microscope
4. Familiarity to tissue culture (Visit to plant and animal tissue culture labs).
5. Exposure to gel electrophoresis through photographs or in research laboratory.
6. Preparation of polytene chromosomes in Drosophila larva
7. Use of colchicine in arresting anaphase movement (onion root tips).
8. Metaphase chromosome preparations from cornea of mouse.
10. Study of permanent slides to understand the following:
    10.1 Constitutive heterochromatin (C-bands)
    10.2 Semiconservative DNA replication (BrdU-labeling)
    10.3 Estimation of S phase cells in a random population (Autoradiography)
    10.4 Transcription in polytene chromosome puffs (Autoradiography).
11. Frog embryology:
    11.1 Collection of spawn
    11.2 Identification of stages and preservation
    11.3 Preparation of permanent/temporary slide of representative developmental stages.
12. Demonstration of early developmental stages of a freshwater snail (*Limnaea*).
13. Permanent preparation of whole mounts of chick embryo of
    13 to 18 hrs
    24 to 33 hrs
    36 to 48 hrs
    48 to 72 hrs
15. Study of development of frog and chick embryos from permanent slides.
    5.1. Slides of cleavage and tadpole larva of frog
    5.2. Slides of sections of chick embryo through
        5.2.1. Pharynx
        5.2.2. Heart
        5.2.3. Trunk
MODEL III

Z-201 : Genetics

A. 1. Elements of heredity and variation
2. The varieties of gene expression
3. Gene linkage
4. Sex-chromosome systems
5. Structural and numerical alterations of chromosome and meiotic consequences.
6. Human genetics
7. Introduction to application of genetic engineering techniques.
8. Cytoplasmic inheritance - Maternal effect on Limnaea (shell coiling), Male sterility (Rhode's experiment), Carbon-dioxide sensitivity in Drosophila, Kappa particles in Paramecium, Milk factor in mice.
10. Mutation - molecular basis of mutation
11. Applied Genetics

B. List of Recommended Books

5. Gardner, Principles of Genetics, Wiley Eastern Pvt. Ltd.
6. Winchester, Genetics, Oxford IBH Publications.
7. Stickberger, Genetics, MacMillan Publications.

C. List of Suggested Practicals

1. Study of the biology of Drosophila and medium preparation
2. Observation of common mutants of Drosophila
3. Preparation of mounts of the salivary gland chromosomes of Drosophila or Chironomous larva
4. Human blood grouping.
MODEL III

Z-202: Animal Physiology

A.  1. Nutrition, Metabolism and enzymes
    2. Respiration: Organs of respiration - properties and functions of respiratory pigments.
    3. Regulatory mechanisms
    4. Neuromuscular coordination
    5. Endocrine and Reproductive system

B. List of Recommended Books


C. List of Suggested Practicals

    1. Survey of digestive enzymes in cockroach
    2. Study of human salivary activity in relation to pH
    3. Estimation of oxygen consumption in fishes with reference to body weight
    4. Study of ciliary activity in freshwater mussel in relation to temperature
    5. Detection of nitrogenous waste products, in fish tank water, frog tank water, bird excreta and mammalian kidney
    6. Use of Kymograph Unit, Respirometer.
MODEL III

Z-301: Applied Zoology

Principles and practice of any two of the following:

A. 1. Aquaculture
    2. Sericulture
    3. Apiculture
    4. Pest Management
    5. Medical Laboratory Techniques
    6. Poultry Keeping
    7. Computer applications for Biologists
    8. Aquarium Fish Keeping
    9. Endocrinology
   10. Toxicology
   11. Pisciculture
    12. Microbiology
    13. Bioethics
    14. Economic Entomology

B. List of Recommended Books


C. List of Suggested Practicals

1. Aquaculture
   i. Identification of cultivable:
      a. Prawns, crabs and lobsters
      b. clams, mussels and oysters
      c. food fishes
      d. ornamental and exotic fishes
   ii. Analysis of gut contents of fishes to study their feeding habits.

2. Sericulture
   i. Different stages of silkworm from egg to adult stage (egg sheet, different ages of the larva, pupa and adult).
   ii. Dissection of the silk worm to study the internal anatomy and mounting of silk glands.
   iii. Study of disease-causing pests of larva, pupa and adult.
   iv. Equipment needed in silkworm rearing centre.
   v. Mulberry leaves and utilisation.

3. Apiculture
   i. Identification of members of bee colony
   ii. Study of a bee hive
   iii. Study of different types of bees
   iv. Mounting of mouthparts and sting apparatus of honey bee
   v. Identification of different types of hives and equipments used in apiculture

4. Pest Management
   i. Identification of major crop pests given in theory syllabus
   ii. Identification of the common pest of stored products
   iii. Identification of the common household pests
   iv. Study of common plant protection appliances such as foliar spray, sprayers and dusters
   v. Report of a visit to an agricultural institute or fields or factories.

5. Medical Laboratory Techniques
   i. Study of laboratory equipment such as: Autoclave, hot air oven incubator, water bath, centrifuge, refrigerator, colorimeter, pH meter, haemoglobinometer,
microtomes and balances.

ii. Preparation of various reagents and fixatives

iii. Histological techniques; Preparation of biological materials fixing, embedding, sectioning, staining and mounting.

iv. Study of blood pressure apparatus, stethoscope and such other medical apparatus.

v. Blood tests

vi. Urine analysis

NOTE: Care to be taken to provide sterile needles to each student.

6. Poultry Keeping

i. Identification of common breeds of Fowl: Rhode Island Red, Minorca, White Leghorn

ii. Grading, handling and candling of eggs

iii. Sexing of chicks

iv. Dissection of Fowl to understand the anatomy and identification of animal

v. Equipments used in Poultry

vi. Report of field trip to a model poultry farm.

7. Computer Application for Biologists

Demonstration of the use of the following devices- Visual Display Units, keyboards, mouse, lightpens, joysticks, spaceballs, printers, plotters, disks, CDROM and multimedia.

Using DOS and Windows - manipulating files - editing files - BASIC language - writing simple programs in BASIC (e.g. to find the sum of 10 given numbers) - introduction to the use of dBASE, LOTUS 1-2-3, wordprocessors.

Demonstration of the internet and its use.

8. Aquarium Fish Keeping

i. Identification of common aquarium fishes

ii. Identification of different live feed organisms

iii. Study of different types of formulated feeds

iv. Preparation of a formulated feed

v. Study of slides of parasites and diseases

vi. Different equipment used in aquarium maintenance.

vii. Setting up of aquarium.

9. Endocrinology

i. Histological observation of endocrine glands - thyroid, adrenal gland, testis and ovary (mammal)

ii. Dissection and localization of selected endocrine glands - thyroid, pituitary, pancreas, adrenal, testis and ovary (frog and rat).
10. Toxicology
   i. Determination of LC50/LD50
   ii. Dermal toxicity
   iii. Haematological parameters - differential count etc.
   iv. Pesticide residues in vegetables
   v. Behavioural studies
   vi. Identification of histopathological slides
   vii. Biochemical examination - Estimation of AST, ALT, ACP, AIP & Ache

11. Pisciculture
   i. Morphometric measurements of fish
   ii. Measurement of fish age using scales
   iii. Examination of stomach contents of two (carnivorous and herbivorous) types of fishes in order to understand their feeding habits.
   iv. Identification of marine and fresh water fishes, based on museum specimens.

12. Microbiology
   i. Preparation of media and cultivation of microorganisms:
      A. Broth
      B. Agar
         a. slants
         b. stabs
         c. plating
   ii. Observation of various microbial colonies on plates
   iii. Observations of cell shape and arrangement under light microscope
   iv. Staining the microbes
      A. Gram’s stain
      B. Simple stain
      C. Negative stain
      D. Acid fast stain
      E. Spore stain
      F. Capsule stain
   v. Observation of bacteriophage plaques
   vi. Bacterial motility under microscope.
   vii. Measurement of bacterial cell size
   viii. Pure culture techniques
      A. spreading
      B. streaking
      C. serial dilution
   ix. Microbial population enumeration
      A. Cell counting
a. spread plate
b. pour plate
c. turbidimetry

x. Routine biochemical tests for identification of bacteria
   A. sugars - acid and gas production
   B. IMVic tests - Indole, Methyl red, citrate utilisation, Voges, Proskauer test
   C. Nitrate reduction
   D. $\text{H}_2\text{S}$ production

13. Bioethics
   i. Spotters of microorganisms used in environmental degradation
   ii. Identification of plants susceptible to pests
   iii. Chromosome types & Structure
   iv. Whole mount of giant chromosomes
   v. Preparation of charts of genetic diseases and their cure
   vi. Visit to a Molecular Biology lab
   vii. Visit to AIDS awareness centre
   viii. Preparation of reports on Human Genome Project and issues in population control.

14. Economic Entomology
   i. Methods of collection and preservation of insects.
   ii. Identification of insects in general and major pests
   iii. Study of life cycle of hemimetabolous, holometabolous and ametabolous insects (at least one example in each).
   iv. Rearing of insects
   v. Study of parasitic and predatory insects (one in each) in relation to their adaptations
   vi. Insecticide and plant protection appliances
   vii. Record.
MODEL III

Z-302: Ecology and Evolution

A. 1. Brief introduction to the major ecosystems of the world
    2. Biotic community
    3. Conservation of natural resources
    4. Ecology in relation to climate in India
    5. Morphological, physiological and behavioural adaptations to external factors such as temperature, moisture, salinity and light.
    6. Thermoregulatory mechanisms
    7. Populations - growth & regulation
    8. Competition, Predation, Parasitism, Commensalism and Mutualism
    9. Communities and Ecosystems.
   10. Environmental pollution
   11. Concept and evidences of organic evolution
   12. Theories of organic evolution
   13. Origin of life
   14. Concept of micro, macro- and mega-evolution
   15. Concept of species
   16. Fossils and evolutionary rate
   17. Phylogeny of horse
   18. Evolution of man

B. List of Recommended Books

1. Odum : Ecology (Amerind)
2. Odum : Fundamentals of Ecology (W.B. Saunders)
4. Turk and Turk : Environmental Science (W.B. Saunders)
5. Dobzhansky, Ayala, Stebbins & Valentine : Evolution (WH Freeman)
7. Major : Population, Species & Evolution

C. List of Suggested Practicals

1. Adaptive modifications in the feet of birds.
3. Embryological evidence of evolution
4. Analogy and Homology
5. Serial homology.
MANPOWER, INFRASTRUCTURE AND FINANCIAL IMPLICATIONS

Science has to be learnt and imbibed by practical experience and not from didactic lectures alone. The Royal Society lecture tradition set by Humphrey Davy and Michael Faraday is ideal for all teachers to know. If taken in spirit, this would mean that the student first gets ‘hands-on’ experience and then the theory is built around it. This would simply imply that our laboratories and field work should be strengthened. Of course recruitment of quality teachers is no less important.

In order to strengthen the laboratory part of the instruction, funds are required. A certain amount innovation is also required in designing cheaper practical exercises using local material. Teachers who understand the subject can always innovate. Teachers who are teaching from books and who have no understanding the science course turn out to be uncrispiring. Biology, more than any other science has to be made exciting by proper teaching.

The biology laboratories set up in 1930s and 40's in most of the universities served well for more than half a century. They are inadequate for today’s undergraduate and post-graduate biology courses. Instrumentation has increased enormously in biology curricula. Most of these instruments do not come cheap. Hence substantial investment has to be made.

It is our belief that the proposed B.Sc. (Biology) cannot be implemented without adequate human, financial and material resources.

For handling a batch of one hundred students, in addition to field work, three laboratories of 2500 sq.ft. are required. The type of exercises suggested for the laboratory component of the course requires an initial investment of Rs.40-50 lakhs to start a B.Sc. (Biology) course de novo. A similar investment would be required for starting an M.Sc. (Zoology) course as recommended here. The cost is mainly due to the instrument purchase.

For example, modern science laboratory work requires clean water and constant voltage uninterrupted electricity. So water purifiers and voltage stabilizers are a must for a modern laboratory. Analytical instruments for measurement of biologicals are also costly. Some of them are required in multiple units (eg: binocular microscopes, colorimeters, pH meters etc.). Others which are required in single copies are spectrophotometer, centrifuge, chromatography units, autoclaves, etc. Many computers have to be bought in order to conduct virtual practical exercises as well as for data processing and presentation. A major aim of the suggested B.Sc. (Biology) Course is integration of IT education into Biology for theory and much more, for laboratory instruction and practice. Teacher workshops should be organised to train, update and enthruse teachers at regular intervals. Teacher manuals giving insights into theory portion as well as protocols for laboratory exercises should be prepared by experienced teachers. These
activities should be initiated under the aegis of UGC to ensure that standards are maintained in all P.G. Colleges and Universities.
REPRESENTATIVE SYLLABI FOR M.SC.

The course titles have been carefully chosen to represent Core courses and Elective courses solely based on two criteria. One, to do justice to the subject and two, to reflect Indian strengths and advantages.

The diversity of subject matter in Zoology equals the diversity of animal life forms. Accordingly, faculty strengths and specialisations differ from university to university not to speak of P.G. Colleges. This has two implications. One, except for Core courses, no uniformity in all course titles can be envisaged for the whole country. Two, even the model syllabus cannot be written in extreme detail as was originally desired. That would leave no room for individual departmental strengths and weaknesses to play a role. Hence what is given in the following passes is one, syllabus for only Core papers and few Elective papers. Two, the syllabus is indicative of broad topics. Details and depth of treatment is left to individual departments. So much for the P.G. level courses. As far as the U.G. level courses even suggestive syllabi have not been given as each of the course contents has to be designed and tailor made for each university and college departments. The course structure, it is believed is best suited for our country while the Course content can vary from department to department especially with regard to non-biology science courses and language courses. As this is for the first time that integrated biology is being proposed at the B.Sc.level, a teacher workshop should be first conducted to evolve by consensus a model syllabus representing the spirit of the course.
Zoo-401: Biosystematics & Taxonomy

1.0 Definition and basic concepts of biosystematics and taxonomy
   1.1 Historical resume of systematics
   1.2 Importance and applications of biosystematics in biology
   1.3 Material basis of biosystematics - different attributes

2.0 Trends in biosystematics - concepts of different conventional and newer aspects
   2.1 Chemotaxonomy
   2.2 Cytotaxonomy
   2.3 Molecular taxonomy

3.0 Molecular perspective on the conservation of diversity
   3.1 Diversity and ecosystem process: theory, achievements and future directions.

4.0 Dimensions of speciation and taxonomic characters
   4.1 Dimensions of speciation - types of lineage changes, production of additional lineage.
   4.2 Mechanisms of speciation in panmictic and apomictic species.
   4.3 Species concepts - species category, different species concepts; sub-species and other infra-specific categories.
   4.4 Theories of biological classification, hierarchy of categories.
   4.5 Taxonomic characters - different kinds, origin of reproductive isolation - biological mechanism of genetic incompatibility.

5.0 Procedure keys in taxonomy
   5.1 Taxonomic procedures-taxonomic collections, preservation, curetting process of identification.
   5.2 Taxonomic keys-different kinds of taxonomic keys, their merits and demerits.
   5.3 Systematic publications - different kinds of publications.
   5.4 Process of typification and different Zoological types.
   5.5 International code of Zoological Nomenclature (ICZN) - its operative principles, interpretation and application of important rules, Zoological nomenclature; formation of scientific names of various taxa.

6.0 Evaluation of biodiversity indices
   6.1 Shannon-Weinner index, dominance index
   6.2 Similarity and dissimilarity index
   6.3 Association index

Suggested Reading Material (All latest editions)

2. J.C. Avise. Molecular Markers, Natural History and Evolution, Chapman & Hall, New York.
5. E. Mayer. Elements of Taxonomy.
Zoo-402: Quantitative Biology

1.0 Basic Mathematics for Biologists
   1.1 Matrices and vectors
   1.2 Exponential functions
   1.3 Periodic functions
   1.4 Differential equations, Integration

2.0 Biostatistics
   2.1 Probability distributions and their properties
   2.2 Hypothesis testing
   2.3 Analysis of frequencies
   2.4 Experimental design and sampling theory
   2.5 Analysis of variance
   2.6 Correlation
   2.7 Regression
   2.8 Non-parametric tests
   2.9 Probability theory

3.0 Mathematical Modeling
   3.1 Types of models-statistical; empirical; mechanistic; stochastic; simulation, etc.
   3.2 Properties of models-generality, precision, realism
   3.3 Building a model-planning (conceptualisation), implementation, evaluation, sensitivity analysis
   3.4 Detailed treatment of selected specific models from different areas of Biology (examples)
      i. Cycling of nutrients in an ecosystem/eutrophication model
      ii. Optimal clutch size in birds
      iii. Morphogenesis
      iv. Genetic drift

Suggested Reading Material

Zoo-403: General and Comparative Endocrinology

1.0 Aims and scope of endocrinology
   1.1 Hormones as messengers
   1.2 Hormones and eukaryotic metabolic regulation
   1.3 Classification of hormones
   1.4 Discovery of hormones
   1.5 Experimental methods of hormone research
   1.6 Validity of comparative study of hormones

2.0 Phylogeny of endocrine glands (Pituitary, pancreas, adrenals, thyroid, etc.)

3.0 Ontogeny of endocrine glands.

4.0 Neuroendocrine system and neurosecretion

5.0 General principles of hormone action
   5.1 Nature of hormone action
   5.2 Hormone receptors-physico-chemical preparation.
   5.3 Hormone receptors-signal transaction mechanisms.
   5.4 Hormones and homeostasis.
   5.5 Hormonal regulation of carbohydrate, nitrogen and lipid metabolism.
   5.6 Hormones and behavior.
   5.7 Termination of hormone action

6.0 Hormone structure and evolution
   6.1 Chemical nature and gross features of hormones
   6.2 Evolution of protein hormones and their receptors

7.0 Biosynthesis and secretion of hormones
   7.1 Hormone lends in circulation and other body fluids.
   7.2 Biosynthesis of steroid hormones de novo.
   7.3 Biosynthesis and aminoacid derived small size hormones (eg: T_4, Epinephrine, etc.).
   7.4 Biosynthesis and simple peptide hormones-Pre and Prohormones.
   7.5 Co-translational and post-translational modifications of hormone structure.

8.0 Metabolism of hormones

9.0 Hormones and Behaviour

10.0 Hormones, Growth and Development

11.0 Hormones and Reproduction
   11.1 Seasonal breeders
   11.2 Continuous breeders

Suggested Reading Material

3. R.H. Williams. Text Book of Endocrinology, W.B. Saunders
Zoo-4.4: Molecular Cell Biology

1.0 Introduction-experimental systems in Cell Biology
2.0 Biomembranes
   2.1 Molecular composition and arrangement functional consequences.
   2.2 Transport across cell membrane-Diffusion, active transport and pumps, uniports, symports and antiports.
   2.3 Membrane potential
   2.4 Co-transport by symporters or antiporters
   2.5 Transport across epithelia
3.0 Cytoskeleton
   3.1 Microfilaments and microtubulus-structure and dynamics
   3.2 Microtubulus and mitosis
   3.3 Cell movements-intracellular transport, role and kinesin and dynein, signal transduction mechanisms
4.0 Cilia and Flagella
5.0 Cell-Cell signalling
   5.1 Cell surface receptors
   5.2 Second messenger system
   5.3 MDP kinase pathways
   5.4 Signalling from plasma membrane to nucleus
6.0 Cell-Cell adhesion and communication
   6.1 Ca++ dependent homophilic cell-cell adhesion
   6.2 Ca++ independent homophilic cell-cell adhesion
   6.3 Gap junctions and connexins
7.0 Cell matrix adhesion
   7.1 Integrins
   7.2 Collagen
   7.3 Non-collagen components
   7.4 Auxin & Cell expansion
   7.5 Cellulose fibril synthesis and orientation
8.0 Cell cycle
   8.1 Cyclines and cyclin dependent kinases
   8.2 Regulation of CDK-cycline activity.
9.0 Genome organization
   9.1 Hierarchy in organization
   9.2 Chromosomal organization of genes and non-coding DNA
   9.3 Mobile DNA
   9.4 Morphological and functional elements of eukaryotic chromosomes
10.0 Genetic analysis in Cell Biology

11.0 Intracellular protein traffic
   11.1 Protein synthesis on free and bound polysomes
   11.2 Uptake into ER
   11.3 Membrane proteins, Golgi sorting, post-translational modifications
   11.4 Biogenesis of mitochondria, and nuclei
   11.5 Trafficking mechanisms

12.0 Biology of cancer

13.0 Biology of aging

14.0 Apoptosis-definition, mechanism and significance

Suggested Reading Material


Zoo-406: Population Genetics and Evolution

1.0 Concepts of evolution and theories of organic evolution with an emphasis on Darwinism

2.0 Neo-Darwinism
   2.1 Hardy-Weinberg law of genetic equilibrium
   2.2 A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration (v) Meiotic drive

3.0 Quantifying genetic variability
   3.1 Genetic structure of natural populations
   3.2 Phenotypic variation
   3.3 Models explaining changes in genetic structure of populations
   3.4 Factors affecting human disease frequency

4.0 Molecular population genetics
   4.1 Patterns of change in nucleotide and amino acid sequences
   4.2 Ecological significance of molecular variations
   4.3 Emergence of Non-Darwinism-Neutral Hypothesis

5.0 Genetics of quantitative traits in populations
   5.1 Analysis of quantitative traits
   5.2 Quantitative traits and natural selection
   5.3 Estimation or heritability
   5.4 Genotype-environment interactions
   5.5 Inbreeding depression and heterosis
   5.6 Molecular analysis of quantitative traits
   5.7 Phenotypic plasticity

6.0 Genetics of speciation
   6.1 Phylogenetic and biological concept of species
   6.2 Patterns and mechanisms of reproductive isolation
   6.3 Models of speciation (Allopatric, sympatric, parapatric)

7.0 Molecular Evolution
   7.1 Gene Evolution
   7.2 Evolution of gene families, Molecular drive
   7.3 Assessment of molecular variation

8.0 Origin of higher categories
   8.1 Phylogenetic gradualism and punctuated equilibrium
   8.2 Major trends in the origin of higher categories
   8.3 Micro-and Macro-evolution

9.0 Molecular phylogenetics
   9.1 How to construct phylogenetic trees?
9.2 Phylogenetic inference—Distance methods, parsimony methods, maximum likelihood method
9.3 Immunological techniques
9.4 Amino acid sequences and phylogeny
9.5 Nucleic acid phylogeny—DNA-DNA hybridizations, Restriction Enzyme sites, Nucleotide sequence comparisons and homologies
9.6 Molecular clocks

10.0 Origin and evolution of economically important microbes and animals
11.0 Population genetics and ecology
   11.1 Metapopulations
   11.2 Monitoring natural populations
   11.3 Why small populations become extinct?
   11.4 Loss of genetic variations
   11.5 Conservation of genetic resources in diverse taxa

Suggested Reading Material

Zoo-407: Gamete Biology

1.0 Heterogamy in eukaryotes
2.0 Comparative account of differentiation of gonads in a mammal and an invertebrate
3.0 Leydig cells
   3.1 Morphology
   3.2 Differentiation
   3.3 Function and its regulation
4.0 Spermatogenesis
   4.1 Morphological basis in Rodents
   4.2 Morphological basis in any Invertebrate
   4.3 Gamete specific gene expression and genomics
5.0 Biochemistry of Semen
   5.1 Semen composition and formation
   5.2 Assessment of sperm functions
   5.3 Y-specific probes
6.0 Fertilization
   6.1 Pre-fertilization events
   6.2 Biochemistry of fertilization
   6.3 Post-fertilization events
7.0 Collection and cryopreservation of gametes and embryos
8.0 Ovarian follicular growth and differentiation
   8.1 Morphology
   8.2 Endocrinology
   8.3 Molecular Biology
   8.4 Oogenesis and vitellogenesis
   8.5 Ovulation and ovum transport in mammals
9.0 Biology of sex-determination and sex-differentiation a comparative account
10.0 Multiple ovulation and embryo transfer technology (MOET)
   10.1 In vitro oocyte maturation
   10.2 Superovulation
   10.3 In vitro fertilization
11.0 Transgenic animals and knock-outs
   11.1 Production
   11.2 Applications
   11.3 Embryonic stem cells
12.0 Care and breeding of experimental animals including bioethics
13.0 Assisted reproduction technologies
   13.1 Embryo sexing and cloning
13.2 Screening for genetic disorders
13.3 ICSI, GIFT etc.
13.4 Cloning of animals by nuclear transfer

14.0 Teratological effects of Xenobiotics

15.0 Immunocontraception
  15.1 Gamete specific antigens
  15.2 Antibody mediated fertilization block and termination of gestation.
  15.3 Other contraceptive technologies
  15.1 Surgical methods
  15.2 Hormonal methods
  15.3 Physical barriers
  15.4 IUCD

Suggested Reading Material

ZOO-408: TOOLS AND TECHNIQUES FOR BIOLOGY

1.0 Assay
1.1 Definition and criteria of reliability
1.2 Chemical assays
1.3 Biological assays- in vivo and in vitro assays

2.0 Principles and uses of analytical instruments-Balances, pH meter, colorimeter, spectrophotometer, ultracentrifuge, densitometric scanner, spectrofluorometer, chemiluminometers, radioactivity counters, differential scanning calorimeter, ESR and NMR spectrometres

3.0 Microscopy- Principle of light transmission, electron, phase-contrast, fluorescence, electron cryo, confocal, scanning electron microscopes. Microphotography. Image analysers

4.0 Microbiological techniques
4.1 Media preparation and sterilization
4.2 Inoculation and growth monitoring
4.3 Use of fermentors
4.4 Biochemical mutants and their use
4.5 Microbial assays

5.0 Cell culture techniques
5.1 Design and functioning of tissue culture laboratory
5.2 Cell proliferation measurements
5.3 Cell viability testing
5.4 Culture media preparation and cell harvesting methods

6.0 Cryotechniques
6.1 Cryopreservation for cells, tissue, organisms
6.2 Cryotechniques for microscopy
6.3 Freeze-drying for physiologically active substances

7.0 Separation techniques in biology
7.1 Molecular separations by chromatography, electrophoresis, precipitation etc.
7.2 Organelle separation by centrifugation etc.
7.3 Cell separation by flowcytometry, density gradient centrifugation, unit gravity centrifugation, affinity adsorption, anchorage based techniques etc.

8.0 Computer aided techniques for data presentation, data analyses, statistical techniques, special softwares for specific tasks.

9.0 Radioisotope and mass isotope techniques in biology
9.1 Sample preparation for radioactive counting
9.2 Autoradiography
9.3 Metabolic labelling
9.4 Magnetic Resonance Imaging
10. Immunological techniques based on antigen-antibody interactions
11. Surgical techniques
   11.1 Organ ablations (eg: ovariectomy, adrenolectomy etc.)
   11.2 Perfusion techniques
   11.3 Indwelling catheters
   11.4 Stereotaxy
   11.5 Parabiosis
12. Biosensors

**Suggested Reading Material (All latest Editions)**

Zoo-409: Environmental Physiology (Physiological Ecology)

1.0 Adaptation
   1.1 Levels of adaptation
   1.2 Mechanisms of adaptation
   1.3 Significance of body size

2.0 Physiological adaptations to different environments
   2.1 Marine
   2.2 Shores and Estuaries
   2.3 Freshwater
   2.4 Extreme aquatic environments
   2.5 Terrestrial Life
   2.6 Extreme terrestrial environments
   2.7 Parasitic habitats

3.0 Stress Physiology
   3.1 Basic concept of environmental stress and strain; concept of elastic and plastic
       strain; stress resistance, stress avoidance and stress tolerance.
   3.2 Adaptation, acclimation and acclimatization
   3.3 Concept of homeostasis
   3.4 Endothermy and physiological mechanism of regulation of body temperature
   3.5 Physiological adaptation to osmotic and ionic stress; mechanism of cell volume
       regulation
   3.6 Osmoregulation in aqueous and terrestrial environments
   3.7 Physiological response to oxygen deficient stress
   3.8 Physiological response to body exercise
   3.9 Meditation, Yoga and their effects.

Suggested Reading Material

Zoo-501: Structure and Function in Invertebrates

1.0 Principles of Animal taxonomy
   1.1 Species concept; International code of zoological nomenclature
   1.2 Taxonomic procedures; New trends in taxonomy
   1.3 Animal collection, handling and preservation

2.0 Organization of coelom
   2.1 Acoelomates
   2.2 Pseudocoelomates
   2.3 Coelomates: Protostomia and Deuterostomia

3.0 Locomotion
   3.1 Flagella and ciliary movement in Protozoa
   3.2 Hydrostatic movement in Coelenterata, Annelida and Echinodermata

4.0 Nutrition and Digestion
   4.1 Patterns of feeding and digestion in lower metazoa
   4.2 Filterfeeding in Polychaeta, Mollusca and Echinodermata

5.0 Respiration
   5.1 Organs of respiration: Gills, lungs and trachea
   5.2 Respiratory pigments
   5.3 Mechanism of respiration

6.0 Excretion
   6.1 Organs of excretion: coelom, coelomoducts, Nephridia and Malphigian tubules
   6.2 Mechanisms of excretion
   6.3 Excretion and osmoregulation

7.0 Nervous system
   7.1 Primitive nervous system: Coelenterata and Echinodermata
   7.2 Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda)
   7.3 Trends in neural evolution

8. Invertebrate larvae
   8.1 Larval forms of free living invertebrates
   8.2 Larval forms of parasites
   8.3 Strategies and Evolutionary significance of larval forms

9.0 Minor Phyla
   9.1 Concept and significance
   9.2 Organization and general characters

List of Practicals

1. Nervous System: Crab; Sepia/Loligo
2. Mounting: Nephridium and Spermatheca in Earthworm
3. Respiratory system: Mounting of Gills, Trachea and Booklungs

PROTOZOA - Gregarines, Monocystis, Ceratium, Euplotes, Didinium, Noctiluca, Radiolaria, Stentor, Opalina.
PORIFERA - Sectional view of Sycon (T.S., L.S.), Grantia (T.S.)
CNIDARIA - Slides of Obelia polyp and Medussa, Pennaria, Aurelia - Tentaculocysts
Museum Specimens of Virgularia, Spongodus, Zoanthus, Favia
HELMINTHES - Slides of Temnocephala
Museum Specimens of Ascaris lumbricoides, Taenia solium, Planaria
ANNELEIDA - Slides of Ozobranchus, Glossiphonia
Museum Specimens of Eunice, Chloea flava, Polynoe, Terebella, Eurythoe
ARHTROPODA - Slides of Cyclops, Daphnia, Chelifera, 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, Olvia, Murex, Turritella, Bulla, Cardium, Arca
ECHINODERMATA -
Museum Specimen of Linckia, Echinodiscus, Holothuria, Antedon
MINOR PHYLA - Slides of Bugula, Plumatella, Cristatella, Pectinella
Museum Specimen of Phoronis, Dendrostoma
FOSSIL SPECIMENS - Aurelia-Planula, Redia, Cercaria, Filiform of Strongyloides, Trochophore, Nauplius, Zoea, Mysis, Phyllosoma, Trilobite larvae of limulus, Antlion, Veliger, Bipinnaria, Ophio and Echinopluteus, Auricularia, Tornaria.

Suggested Reading Material
Zoo-502A: Comparative Anatomy of Vertebrates

1.0 Origin of Chordata
   1.1 Concept of Protochordata

2.0 The nature of Vertebrate morphology
   2.1 Definition, scope and relation to other disciplines
   2.2 Importance of the study of vertebrate morphology

3.0 Origin and classification of vertebrates

4.0 Vertebrate integument and its derivatives
   4.1 Development, general structure and functions of skin and its derivatives
   4.2 Glands, scales, horns, claws, nails, hoofs, feathers and haris

5.0 General plan of circulation in various groups
   5.1 Blood
   5.2 Evolution of heart
   5.3 Evolution of aortic arches, and Portal systems

6.0 Respiratory system
   6.1 Characters of respiratory tissue
   6.2 Internal and External Respiration
   6.3 Comparative account of respiratory organs

7.0 Skeletal system
   7.1 Form, function, body size and skeletal elements of the body
   7.2 Comparative account of jaw suspensorium, Vertebral column
   7.3 Limbs and girdles

8.0 Evolution of Urinogenital system in vertebrate series

9.0 Sense organs
   9.1 Simple receptors
   9.2 Organs of Olfaction and taste
   9.3 Lateralline system
   9.4 Electrorception

10.0 Nervous system
   10.1 Comparative anatomy of the brain in relation to its functions
   10.2 Comparative anatomy of spinal cord
   10.3 Nerves-Cranial, Peripheral and Autonomous nervous systems

List of Practicals

1. Dissections: Rat/mouse/scoliodon - Digestive, Reproductive, Arterial, Venous systems, Neck nerves.
2. Museum specimens and slides
   Protochordates - Salpa-sexual, Salpa-aseual, Botryllus, Herdmania. Fishers
Rhinobatus, Chimaera, Acipenser, Amia, Periophthalmus, Triacanthus, Notopterus notopterus, Scatophagus argus, Trichurus, Mastacembalus armatus, Exocoetus (flying fish), Diodon hystrix, Echeneis neucrates.
Amphibians - Ichthyophis, Geganophis, Rhacophorus, Rana tigrina, Amblystoma.
Reptiles - Sitana, Chameleon, Phynosoma, Chelone mydas.
Birds - Indian Oriole, Indian koel (male), Indian koel (female), Indian tailor bird, Kite, Jungle fowl.
Mammals - Indian Otter, Marmoset, Loris, Bat (Megaderma lyra), Pangolin.
Skull and lower jaw of Chelonia, Crocodile, Bird, Carnivoremammal (dog), Herbivore mammal (horse).
Types of vertebrae of Procoelus, Opisthocoelous, Amphicoelous, Amphiplatian, Heterocoelous, Axis and atlas vertebrae.

Suggested Reading Material

12. Sedgwick, A. A Students Text Book of Zoology, Vol.II.
Zoo-503a: Population Ecology

1.0 Demography
   1.1 Life tables
   1.2 Generation time
   1.3 Net reproductive rate
   1.4 Reproductive value

2.0 Population growth
   2.1 Growth of organisms with non-overlapping generations
   2.2 Exponential growth, Verhulst-Pearl logistic growth model, Case studies (field and laboratory).
   2.3 Stochastic and time lag models of population growth
   2.4 Stable age distribution
   2.5 Population growth projection using Leslie Matrix

3.0 Life history strategies
   3.1 Evolution of life history traits
   3.2 Longevity and theories of ageing
   3.3 Energy apportionment between somatic growth and reproduction
   3.4 Parental investment and offspring
   3.5 Reproductive strategies - ecology and evolution of sex and mating systems, optimal body size' r-and K-selection

4.0 Predation
   4.1 Models of prey-predatory dynamics
   4.2 Optimal foraging theory (patch choice, diet choice, prey selectivity, foraging time)
   4.3 Role of predation in nature

5.0 Competition and Niche theory
   5.1 Intraspecific and interspecific competition
   5.2 History of niche concepts
   5.3 Theory of limiting similarity

6.0 Mutualism
   6.1 Evolution of mutualism
   6.2 Plant-pollinator and animal - animal interactions
   6.3 Basic models

7.0 Population regulation - Extrinsic and intrinsic mechanisms

8.0 Case studies in population dynamics - One or two examples from areas such as Fisheries, Wildlife, and biological control of agricultural pests.

9.0 Ecological modeling - Fundamentals of constructing models and testing them.
Suggested Reading Material

11. Southwood, T.R.E.
Zoo-504A: Animal Behaviour

1.0 Introduction
   1.1 Ethology as a branch of biology
   1.2 Animal psychology - classification of behavioral patterns, analysis of behaviour (ethogram).

2.0 Innate behaviour

3.0 Perception of the environment
   3.1 Mechanical
   3.2 Electrical
   3.3 Chemical
   3.4 Olfactory
   3.5 Auditory
   3.6 Visual

4.0 Neural and hormonal control of behaviour

5.0 Genetic and environmental components in the development of behaviour

6.0 Communication
   6.1 Chemical
   6.2 Visual
   6.3 Light
   6.4 Audio
   6.5 Species specificity of songs
   6.6 Evolution of language (primates)

7.0 Ecological aspects of behaviour
   7.1 Habitat selection, food selection; optimal foraging theory, anti-predator defenses.
   7.2 Aggression, homing; territoriality; dispersal
   7.3 Host-parasite relations

8.0 Social behaviour
   8.1 Aggregations-schooling in fishes, flocking in birds, herding in mammals
   8.2 Group selection, kin selection, altruism, reciprocal altruism, inclusive fitness.
   8.3 Social organization in insects and primates.

9.0 Reproductive behaviour
   9.1 Evolution of sex and reproductive strategies
   9.2 Mating systems
   9.3 Courtship
   9.4 Sperm competition
   9.5 Sexual selection
   9.6 Parental care

10.0 Biological rhythms
10.1 Circadian and circannual rhythms
10.2 Orientation and navigation
10.3 Migrations of fish, turtles and birds

11.0 Learning and memory
11.1 Conditioning
11.2 Habituation
11.3 Insight learning
11.4 Association learning
11.5 Reasoning
11.6 Cognitive skills

Suggested Reading Material

5. Gould, J.L. The mechanisms and evolution of behaviour.
Zoo-501B: Biology of Vertebrate Immune System

1.0 Innate and Acquired Immunity

2.0 Phylogeny and Ontogeny of immune system
   2.1 Organization and structure of lymphoid organs
   2.2 Cells of the immune system and their differentiation
   2.3 Lymphocyte traffic

3.0 Nature of immune response

4.0 Nature of antigens and superantigens
   4.1 Antigenicity and immunogenicity
   4.2 Factors influencing immunogenicity
   4.3 Epitopes and haptens

5.0 Structure and Functions of Antibodies
   5.1 Classes and subclasses
   5.2 Gross and Fine structure
   5.3 Antibody mediated effector functions

6.0 Antigen-Ab interactions in vitro and in vivo.

7.0 Complement System

8.0 Major Histocompatibility Complex in mouse and HLA system in human
   8.1 MHC haplotypes
   8.2 Class I and class II molecules
   8.3 Cellular distribution
   8.4 Peptide binding
   8.5 Expression and diversity
   8.6 Disease susceptibility and MHC/HLA

9.0 Organization and expression of Ig genes
   9.1 Models for Ig gene structure
   9.2 Multigene organization of Ig genes
   9.3 DNA rearrangements and mechanisms
   9.4 Generation of antibody diversity
   9.5 Differential expression of Ig genes.

10.0 T-cell receptors
    10.1 Isolation, molecular components and structure
    10.2 T-cell maturation and thymus
    10.3 T\text{H}-cell activation mechanism
    10.4 T-cell differentiation
    10.5 Cell death and T-cell population

11.0 B-cell generation, activation and differentiation
    11.1 B-cell receptors
11.2 Selection of immature self-reactive B-cells
11.3 B-cell activation and proliferation
11.4 $T_H$-B-Cell interactions
11.5 Humoral immune response-kinetics

12. Cytokines
   12.1 Structures and functions
   12.2 Cytokine receptors
   12.3 Cytokines and Immune response

13. Cell-mediated effector functions
   13.1 Cell adhesion molecules
   13.2 Effector cells and molecules
   13.3 CTL and NK cells-mechanisms of action
   13.4 Delayed type hypersensitivity

14. Immunological tolerance and Anti-immunity

15. Hypersensitivity and immune responses to infection agents especially intracellular parasites.

Suggested List of Practicals

- Antigen-antibody interaction in vitro.
- Radioimmunoassay and ELISA.
- Isolation of B-lymphocytes.
- Phagocytosis in vitro.
- Separation of gamma globulins from serum.
- Blood film preparation and identification of cells.
- Histology of lymphoid organs.
- Immunological diagnosis of pregnancy/infection/cancer.

Suggested Reading Material

1. Kuby. Immunology, W.H. Freeman, USA.
Zoo-502B: Genes and Differentiation

1.0 Introduction to animal development
   1.1 Problems of developmental biology
   1.2 Developmental patterns in metazoans
   1.3 Development in unicellular eukaryotes

2.0 Creating multicellularity
   2.1 Cleavage types
   2.2 Comparative account of gastrulation

3.0 Early vertebrate development
   3.1 Neurulation and ectoderm
   3.2 Mesoderm and endoderm

4.0 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

5.0 Body Axes
   5.1 Establishment of Body axes in mammals and birds
   5.2 Proximate tissue interactions
   5.3 Genetics of axis specification in *Drosophila*

6.0 Homeobox concept in different phylogenetic groups

7.0 Tetrapod limb development

8.0 Hormones as mediators of development
   8.1 Amphibian metamorphosis
   8.2 Insect metamorphosis
   8.3 Ovarian luteinization and mammary gland differentiation.

9.0 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

10.0 Biology of sex determination
   10.1 Chromosomal sex determination - mammals and drosophila
   10.2 Testis determining genes
   10.3 Ovarian development
   10.4 Secondary sex determination in mammals
10.5 Environmental sex determination.

11.0 Cell diversification in early animal embryo
   11.1 Xenopus blastomeres
   11.2 Morphogen gradients
   11.3 Totipotency & Pleuripotency
   11.4 Embryonic stem cells
   11.5 Renewal by stem cells - epidermis
   11.6 Skeletal muscle regeneration
   11.7 Connective tissue cell family

12.0 Hemopoietic stem cells
   12.1 Stem cell disorders
   12.2 Blood cells formation
   12.3 Bone marrow transplants
   13.4 Gene therapy

**Suggested Reading Material**

Zoo-503B: Molecular Cytogenetics

1.0 Biology of Chromosomes:
   1.1 Molecular anatomy of eukaryotic chromosomes
   1.2 Metaphase chromosome: Centromere, Kinetochore, Telomere and its maintenance
   1.3 Heterochromatin and Euchromatin
   1.4 Giant chromosomes: Polytenic and lampbrush chromosomes.

2.0 Sex chromosomes, sex determination and dosage compensation in *C. elegans*, Drosophila and Humans

3.0 Imprinting of genes, chromosomes and genomes

4.0 Somatic cell genetics
   4.1 Cell fusion and hybrids - agents and mechanism of fusion
   4.2 Heterokaryon - Selecting hybrids and chromosome segregation
   4.3 Radiation hybrids, hybrid panels and gene mapping

5.0 Human Cytogenetics
   5.1 Techniques in human chromosome analysis - molecular cytogenetic approach.
   5.2 Human Karyotype - banding - nomenclature
   5.3 Numerical and structural abnormalities of human chromosomes - syndromes.
   5.4 Mendelian and chromosome based heritable diseases in humans.
   5.5 Human genome

6.0 Cytogenetic implications and consequences of structural changes and numerical alterations of chromosomes.

7.0 Microbial Genetics
   7.1 Bacterial transformation, transduction, conjugation, Bacterial chromosome.
   7.2 Bacteriophages: Types, structure and morphology of T4 phage, Morphogenesis.

8.0 Cytogenetic effects of ionising and non-ionising radiations.

9.0 Molecular cytogenetic techniques
   9.1 FISH, GISH
   9.2 DNA fingerprinting
   9.3 Flow cytometry
   9.4 Automated karyotyping
   9.5 Chromosome painting

10.0 Genome analysis
   10.1 C-value paradox, detailed account of various models of prokaryotic genomes, viral genome, and eukaryotic genomes. organisation of genes in organelle genomes.
   10.2 Molecular analysis of genomic DNA in yeast.
   10.3 Transposable elements in prokaryotes and eukaryotes. Role of transposable elements in genetic regulation.
   10.4 Genome analysis - *Humans, Drosophila, yeast*, microbial genomes.
11.0 Linkage map, cytogenetic mapping
   11.1 Physical maps and molecular maps
   11.2 Strategies of different levels of genome mapping

12.0 Genetics of cell cycle
   12.1 Genetic regulation of cell division in yeast and eukaryotes.
   12.2 Molecular basis of cellular checkpoints
   12.3 Molecular basis of neoplasia.

Suggested Reading Material

Zoo-504b: Molecular Biology

1.0 History and Scope of Molecular Biology

2.0 DNA replication
   2.1 Prokaryotic and eukaryotic DNA replication
   2.2 Mechanics of DNA replication
   2.3 Enzymes and accessory proteins involved in DNA replication

3.0 Transcription
   3.1 Prokaryotic transcription
   3.2 Eukaryotic transcription
   3.3 RNA polymerases
   3.4 General and specific transcription factors
   3.5 Regulatory elements and mechanisms of transcription regulation
   3.6 Transcriptional and post-transcriptional gene silencing.

4.0 Post-transcriptional Modifications in RNA
   4.1 5'-Cap formation
   4.2 Transcription termination
   4.3 3'-end processing and polyadenylation
   4.4 Splicing, Editing
   4.5 Nuclear export of mRNA
   4.6 mRNA stability

5.0 Translation
   5.1 Genetic code
   5.2 Prokaryotic and eukaryotic translation
   5.3 The translational machinery
   5.4 Mechanisms of initiation, elongation and termination
   5.5 Regulation of translation
   5.6 Co- and post-translational modifications of proteins

6.0 Antisense and Ribozyme technology
   6.1 Molecular mechanisms of antisense molecules
   6.2 Inhibition of splicing, polyadenylation and translation
   6.3 Disruption of RNA structure and capping
   6.4 Biochemistry of ribozyme; hammerhead, hairpin and other ribozymes
   6.5 Strategies for designing ribozymes
   6.6 Application of antisense and ribozyme technologies

7.0 Recombination and repair
   7.1 Holiday junction, gene targeting, gene disruption
   7.2 FLP/FRT and Cre/lox recombination
   7.3 RecA and other recombinases
7.4 DNA repair mechanisms

8.0 Molecular mapping of genome

8.1 Genetic and physical maps
8.2 Physical mapping and map-based cloning
8.3 Choice of mapping population; Simple sequence repeat loci
8.4 Southern and flourescence in situ hybridization for genome analysis
8.5 Chromosome microdissection and microcloning
8.6 Molecular markers in genome analysis: RFLP, RAPD and AFLP analysis.
8.7 Molecular markers linked to disease resistance genes
8.8 Application of RFLP in forensic, disease prognosis, genetic counselling, pedigree, varietal, etc. analysis, Animal trafficking and poaching; germplasm maintenance and taxonomy.

Suggested Reading Material


Zoo-506b: Comparative Physiology

1.0 Aims and scope of comparative physiology
   1.1 General physiological functions and principles
   1.2 Validity of comparative approach
   1.3 Organismic and cell physiology

2.0 Respiratory organs and respiratory pigments through different phylogenetic groups.

3.0 Feeding mechanisms and regulation
   3.1 Comparative physiology of digestion

4.0 Patterns of nitrogen excretion among different animal groups

5.0 Osmoregulation in different animal groups

6.0 Thermoregulation
   6.1 Homeothermic animals
   6.2 Poikilotherms
   6.3 Hibernation

7.0 Circulation of body fluids and their regulation

8.0 Receptor physiology - a comparative study
   8.1 Mechanoreception
   8.2 Photoreception
   8.3 Phonoreception
   8.4 Chemoreception
   8.5 Equilibrium reception

9.0 Communication among animals
   9.1 Bio luminescence
   9.2 Pheromones and other semiochemicals
   9.3 Audio signals

10.0 Metabolic pathways and variations in different phylogenetic groups of animals.

11.0 Contractile elements, cells and tissues among different phylogenetic groups
   11.1 Muscle structure and function-correlation
   11.2 Movements - amoeboid, ciliary and flagellar
   11.3 Specialised organs (eg: electric organs and tissues)

12.0 Chromatophores and regulation of their function

Suggested Reading Material

Zoo-507B: Metabolic Regulation and Cell Function

1.0 Thermodynamic principles and steady-state conditions of living organisms
   1.1 Organization of and methods to study metabolism.
2.0 Degradation of glucose, palmitic acid, phenylalanine, tryptophane and nucleotides in animals.
3.0 Energy metabolism and high energy compounds.
   3.1 Redox potentials
   3.2 Mitochondrial electron transport chain
   3.3 Oxidative phosphorylation
4.0 Storage and utilization of biological energy
   4.1 Types of work performed by animals
   4.2 Biosynthesis of urea, proline, aspartic acid, Uridylic acid, adenylc acid, fructose, glucose, glutathione, glycogen, oleic acid and prostaglandins.
5.0 Nature of enzymes
   5.1 Classification and nomenclature of enzymes
   5.2 Kinetic analysis of enzyme catalysed reactions
   5.3 Regulation of enzyme activity by non-genetic mechanisms
   5.4 Half-life of enzymes Intracellular degradation of proteins
6.0 Biosynthesis of proteins and nucleic acids
   6.1 Regulation of metabolic flux by genetic mechanisms
   6.2 Metabolic regulation by extra-cellular signals
   6.3 Metabolic regulation during hypoxia, cellular motility, foetal development, metamorphosis and any differentiation.
7.0 Metabolic profile of adipose, neural, hepatic, steroidogenic and muscle tissues
8.0 Metabolic engineering
9.0 Site-directed mutagenesis and enzyme engineering
10.0 Immobilised enzymes and their applications.

Suggested Reading Material

5. Garett and Grisham, Biochemistry.

List of Suggested Practicals

1. Kinetic analysis of any one enzyme including semi-purification.
2. Clinical biochemistry of any metabolic disorder.
3. Metabolic labelling of any macromolecular cellular constituent (RNA, DNA etc.).
4. Inhibition and activation of any enzyme (allosterim/covalent modification).
5. Induction and suppression of any enzyme/protein *in vivo* and *in vitro*.
6. Sub-cellular fractionation and enzyme markers.
7. Immobilization of any enzyme and a study of the immobilised enzyme.
8. Metabolism in specialised tissues.
Zoo-510b: Molecular Endocrinology

1.0 Definition and scope of molecular endocrinology
   1.1 Discovery of hormones and reductionist biology

2.0 Chemical nature of hormones

3.0 Purification and characterization of hormones

4.0 Production of hormones by biochemical and rDNA technologies

5.0 Structure of hormones
   5.1 Structure-function relationships in hormones-comparative analysis and evolutionary perspectives.

6.0 Nature of hormone action
   6.1 Hormone receptors - identification, quantitation purification and physico-chemical properties.
   6.2 Membrane receptors - structure and signal transduction mechanisms.
   6.3 G-proteins
   6.4 Nuclear receptors - structure and function. Orphan receptors. Metabolic and developmental hormones.
   6.5 Hormonal regulation of carbohydrate, lipid, protein and nucleic and metabolism.
   6.6 Hormonal regulation of growth, reproduction and development through differential gene expression.

7.0 Body fluids and hormones:
   7.1 Reproductive cycles in vertebrates and hormonal concentrations in body fluids.
   7.2 Biosynthesis of hormones-molecular details
   7.3 Transcriptional and post-translational regulation of hormone biosynthetic genes.
   7.4 Hormone and receptor genes in population.

8.0 Genetic analyses of hormonal disorders.

Suggested Reading Material


List of Suggested Practicals

1. Bioassay of any hormone involving target tissue growth/differentiation.
2. Radioreceptor assay for any hormone.
3. RIA and ELISA for any hormone or second messenger.
4. Purification of any protein hormone.
5. Assay of steroid dehydrogenase.
6. Isolation and characterisation of a steroid/prostaglandin.
7. Gel retardation assay for transcription factor like protein (e.g. steroid hormone receptor).
Zoo-512B: Biomolecules and Structural Biology

1.0 Chemical foundations of biology
   1.1 pH, pK, acids, bases, buffers, weak bonds, free energy, resonance, isomerisation, etc.
   1.2 Acid soluble pool of living tissues-aminoacids, monosaccharides, nucleotides, peptides, oligosaccharides and oligonucleotides.

2.0 Proteins-promary, secondary, tertiary and quaternary structures

3.0 Nucleic acids-types and structural organisation. Physico-chemical techniques and macromolecular analysis

4.0 Protein folding and denaturation

5.0 Conjugated proteins-structure and functions

6.0 Protein-ligand, protein-protein, nucleic acid-protein and nucleic acid-ligand interactions

7.0 Macromolecular structural data bases and their analyses

8.0 Assembly of macromolecular complexes-ribosomes, chromatin, plasma membrane and viruses

9.0 Nanoparticles

10.0 Organisation of animal tissues

11.0 Biomaterials

Suggested Books

5. D. Freifelder, Essentials of Molecular Biology.
8. Hawk. Practical Physiological Chemistry.

List of Practicals

1. Colorimetric determination of pK value.
2. Model building using ball and stick/space filling atomic models.
3. Isolation, purity determination and quantitation of cholesterol, DNA and RNA.
4. Quantitation of Protein and Sugar.
5. Spectroscopy-UV, visible fluorescence & IR.
7. Separation of lipids/amino acids by TLC/Paper chromatography.
8. Electrophoresis of DNA-separation of linear, circular and supercoiled forms.
9. Determination of $T_m$ of DNA.
10. Purification of a commercially important bioproduct.
Zoo-516b: Proteins and Nucleic Acids

1.0 Covalent properties of proteins
   1.1 Structure and chemistry of amino acids
   1.2 Protein sequencing
   1.3 Peptide synthesis
   1.4 Covalent modification
   1.5 Protein size and composition
   1.6 Protein splicing

2.0 Protein secondary structure
   2.1 Protein tertiary structure and folding patterns
   2.2 Common tertiary structural motifs
   2.3 Role of packing constraints in tertiary structure patterns
   2.4 Divergent vs. convergent evolution of similar structural motifs

3.0 Globular and Fibrous Proteins
   3.1 Water and the hydrophobic effect
   3.2 Tertiary and quaternary effect
   3.3 Motifs in globular proteins
   3.4 Properties of protein interiors and surfaces
   3.5 Fibrous proteins
   3.6 Structure of bone

4.0 Protein folding and thermodynamics
   4.1 Protein folding and dynamics
   4.2 Folding overview: the Levinthal paradox
   4.3 Condensation and molten globules
   4.4 Ramachandran plots and amino acid propensities
   4.5 Catalysis and assistance
   4.6 Amino acid sequence variation and membrane protein folding
   4.7 Chaperonin-assisted protein folding

5.0 Large macromolecular assemblies
   5.1 Principles of protein-protein interaction
   5.2 Control of assembly
   5.3 Viruses
   5.4 Muscle assemblies

6.0 Use of sequence comparisons of study evolution

7.0 Allostery (Hemoglobin), Myoglobin structure and oxygen binding
   7.1 Hemoglobin subunits cooperativity, the Hill coefficient
   7.2 Quaternary structure changes Sickle cell and other molecular diseases
8.0 Methods to Study Proteins-Protein purification and analysis, Electrophoresis, Dialysis, column chromatography, Ultracentrifugation, Mass spectrometry, Affinity chromatography, Optical spectroscopy, X-ray crystallography, NMR, High resolution electron microscopy. Peptide chemistry-sequencing and synthesis.

9.0 Covalent properties of nucleic acids
   9.1 Modified nucleosides.
   9.2 Properties of polynucleotides.
   9.3 Secondary and tertiary structure

10.0 Chemistry of nucleic acid polymerization. Enzymatic and solid phase methods

11.0 Nucleic acid structure I. Duplex stability, hybridization. RNA structure, hairpin and pseudoknot structures, tRNA.

12.0 Nucleic acid structure II. DNA and RNA helical geometries (A-Z), bending, deformation, triplexes, quadruplexes. Chromatin structure. Structure of the nucleosome core; organization of nucleosomes into solenoids; topological considerations.

13.0 Nucleic acid analysis. DNA and RNA sequencing, determination of modified nucleotides, analysis of nucleic acid secondary structure.

14.0 Interactions of nucleic acids with small molecules.

15.0 Proteins-nucleic acid interactions I.

16.0 Proteins-nucleic acid interactions II.

17.0 Principles of enzyme catalysis.

18.0 RNA catalysis
   18.1 Chemistry and structure of ribozymes
   18.2 Evolutionary implications
   18.3 RNA splicing
   18.4 RNA-and spliceosome-mediated reactions

19.0 Nucleoside analogs. Incorporation of analogs into DNA/RNA and properties of polynucleotides (thionucleotides, fluorophores, biotinylated nucleosides).

20.0 Enzyme mechanisms. Proteases, polymerases, other examples.

21.0 Gene and genome analysis
   21.1 Bioinformatics
   21.2 Genome maps
   21.3 Microarray-bases expression analysis
   21.4 Genomics-based drug discovery

22.0 Extremophiles
   22.1 Life at 105°C or at pH 1 or at 5M KC1
   22.3 Protein stability
   22.3 Protein-nucleic acid interactions
Suggested Reading Material

List of Practical Exercises Suggested for M.Sc.(Zoology) during First Year or First Two Semesters

1. Composition assessment of the taxonomic diversity/biodiversity in a habitat (e.g., grass land, arid land, wet land, etc.).
2. Influence of climatic conditions on taxonomic diversity in a given habitat.
3. Preparation of models showing the status of certain taxa or species in a particular habitat.
4. Demonstration of 'DNA ladder' formation during apoptotic death.
5. Preparation of liposomes.
6. Estimation of gene and genotypic frequencies in light of Hardy-Weinberg Law based on facial traits, ABO blood group data, PTC data dermatoglyphics in a large sample of human population or a class room sample.
7. PC based simulation models for effect of micro-evolutinary forces on allele frequency.
8. Demonstration of chromosomal polymorphism, isozyme polymorphism in some insect population.
9. Morphological variation and its genetic basis in humans, insects, plants or other taxa.
10. Construction of phylogenetic trees based on protein, immunological or molecular data (mt DNA, RFLP data) (PC based simulation).
12. Demonstration of Sewall Wright effect in small samples of Drosophila population
15. Demonstration of density dependent selection in plant or animal populations.
16. Demonstration of reproductive isolation in Drosophila species hybridisation.
17. Demonstration of mating behaviour in wild and mutant strains of Drosophila.
18. PC based simulations of molecular phylogenetics.
19. Estimation of genetic identity (I) and genetic distance from allele frequency data in several populations.
20. Colorimetric estimation of glucose, protein RNA, DNA.
22. Light microscopic examination and preparation of tissue sections.
23. Use of different of microscopes.
24. Sample preparation for SEM and TM.
25. Growth curve for E. coli/Neurospora crassa.
27. Subcellular fractionation of rat liver.
28. Preparation of different cell types—(eg: Hepatic parenchymal cells, adipocytes, macrophages, neuronal cells, etc.).
29. Computer software use for computational tasks, data presentation takes, design task.
30. Separation of proteins on SDS-PAGE.
32. Separation of amino acids by paper chromatography and TLC.
33. Surgical techniques such as adrenalectomy, thyroidectomy, castration, etc. to be done on rats or mice.
34. Isolation of genome DNA.
35. Southern blotting.
36. RFLP analysis.
37. Isolation of RNA.
38. Isolation of poly A+RNA.
40. In vitro translation.
41. In vitro translation.
42. Polymerase chain reaction.
43. Restriction digestion of DNA.
44. Agarose gel electrophoresis of DNA.
45. Isolation of DNA fragments from gels
46. Ligation of DNA fragments.
48. Comparison of RBC and WBC in different groups of vertebrates.
49. Oxygen consumption in aquatic animals under stress.
50. Determination and respiratory quotient in a terrestrial animal effect and temperature.
51. Toxicity text-LC$_{50}$.
52. Pattern of Nitrogen excretion in an amphibian during development.
53. Nervous system of a crab.
55. Gills, Trachea and Booklung-mounting.
56. Experiments on perfused heart of frog using kymograph/oscilloscope.
57. Experiments with Gilson respirometer.
58. To study the effect of temperature on plasma protein: appearance of new protein bands to be studied with gel electrophorsis under temperature stress.
59. Comparison of RBC and WBC number in different groups of vertebrates under different environmental conditions.
60. To study the rate of oxygen consumption by aquatic animals under various environmental stresses.
61. Determination of respiratory quotient of an air-breathing animal at different temperature.
62. To study the changes of blood glucose level under various environmental stages in a vertebrate species.
64. Estimation of daily intake, EC50 and LC50 against mosquito larvae.
65. Study of toxicity of given chemical on analyse activity.
66. Sperm motility tests and analyses.
67. Histology of gonads.
68. Bioassay for Androgens, estrogens and pituitary gonadotrophins
69. Histochemical demonstration of steroid dehydrogenaes.
70. Biochemical analyses of semen
71. In vitro fertilization using zona denuded hamster eggs/mice/fish/frogs.
72. Cytogenetic and molecular methods in sex-determination.