SYLLABUS

MS Programme in Zoology

under the One Year Grading System
Sessions 2023-2024, 2024-2025 and 2025-2026

Department of Zoology
University of Dhaka

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SYLLABUS

MS Programme in Zoology

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Rules and Guidelines for MS Programme in Zoology
for the session 2023-2024, 2024-2025 and 2025-2026

1. Introduction to the Department of Zoology

The Department of Zoology, University of Dhaka is one of the oldest departments of the university and the pioneer institute to introduce teaching and research in animal sciences in the country, and therefore, played a commendable role in promoting zoological study in Bangladesh. Since its inception in 1954, the department has been the best learning seat for zoology in the country and producing graduates of global competence, successfully serving the nation in various capacities. As a research hub, the department undertakes enormous researches to generate knowledge for the improvement of zoological sciences, food security, biodiversity conservation and management, biotechnology, epidemiology, pest control, etc. The department also provides advisory and community services to government and private sectors, related to biodiversity conservation and environmental protection.

The department is housed in a large three-storied beautifully designed building located at a scenic place within the Curzon Hall Campus and has required infrastructural facilities for delivery of lectures, practical demonstrations and undertaking research activities. The department has adequate number of lecture rooms, equipped with modern logistics, for each individual cohort of students. The department has also adequate number of undergraduate practical laboratories.

Faculty members and non-academic staffs: The Department of Zoology has 29 faculty members (December, 2024). Almost all of the faculty members are highly qualified with brilliant results in the undergraduate and graduate levels. Most of the members achieved PhD degrees from countries like Australia, Canada, Turkey, Japan, UK and USA. At the moment, two female and two male faculty members are on 'study leave' to pursue MS and PhD (from the Australia, Turkey, Japan, UK and USA). The department has 12 Professors (six female and six male), 06 Associate Professors (three female and two male), 07 Assistant Professors (three female and five male) and 04 Lecturers (three female one male). The department has supernumerary (2 posts) and honorary professors. Few retired professors are also involved with the department. The department have 18 non-academic staff (two female and sixteen male).

Research Facilities: Research is also a major focus of the department and carried out in all disciplines of zoology, particularly in specialized branches of the department, viz. Fisheries, Entomology, Wildlife & Conservation Biology, Parasitology and Genetics & Molecular Biology with focus on demand led areas. The department has moderately equipped specialized research laboratories, representing all specialized branches. The departmental faculties and students publish a good number of research articles every year. Collaborative researches are carried out with different research institutions home and abroad.

Collaborative research opportunity: A pond of 0.99 hectare, located within Curzon Hall Campus is available for aquatic research. The University of Dhaka has been developing marine research facilities at Cox's Bazaar and would be available for zoology students for carrying research on marine ecosystem and biodiversity.

Apart from these, the Department undertakes research in collaboration with other research institutions of the country such as, Bangladesh Atomic Energy Commission, Bangladesh Council for Scientific and Industrial Research, National Institute of Biotechnology, Bangladesh Jute Research Institute, Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute, National Institute for Preventive and Social Medicine, Space Research and Remote Sensing Organization, Fisheries Research Institute, ICDDR,B, BIRDEM, BSMMU, etc. Funds are sought from a number of national and international organizations. The national institutions include University Grants Commission, Ministry of Science and

Technology and ICT, Bangladesh Agricultural Research Council, Ministry of Environment and Forests, Ministry of Fisheries and Livestock, Ministry of Agriculture, Ministry of Education, etc.

Departmental library: Department of Zoology has a seminar library: Professor Yousuf Zai Seminar Library, named after the first Head of the Department. The library contains more than seven thousand books and a huge number of reading materials, including journals, thesis papers, project reports, etc.

Departmental museum: The department harbours a museum which is the largest of its kind in the country and holds a large number of animal specimens (representing all major phyla), embryological and histological preparations, animal skeletons, models, etc. and is used for practical demonstration classes.

Animal Garden: The department maintains an animal garden which is located in between Shahidullah Hall and Geology Department, University of Dhaka. The garden is rectangular in shape and approximately 12000 square feet (200 feet in length & 60 feet in width). Since the start of the department the animal garden is regularly utilized in animal research of different kinds. The garden is divided into five zones pertaining to the five branches of the departments, viz. fisheries, entomology, wildlife & conservation biology, parasitology & public health, and genetics & molecular biology, where each branch maintains a small research laboratory mainly for animal rearing and some testing.

Stipends and awards available at the department: The department offers a few stipends and awards to the outstanding students. The department announces such stipends/awards on a yearly basis and invites applications from those who fulfill the criteria set for the stipends/awards.

Mission and Vision of the Department: Zoology is the aspect of science that deals with the study of the animals' morphology, physiology, habitat, behavior, evolution and genetics. Zoology department has 25-Year Academic Plan (2011-2035) where vision and mission are clearly mentioned and are given below:

Mission: To develop human resources and knowledge base through teaching and research to contribute to national development.

Vision: An ecologically / environmentally sound Bangladesh.

Academic Programme of the department
The department offers four academic degree programmes. These are:

i. Bachelor of Science (Honours) in Zoology- BS (Honours) is a four year integrated degree programme comprising of theory and practical works.
ii. Master of Science (MS) in Zoology- a one year programme based either on course work and practicals (Group A: Non-thesis Group) or research and course works (Group B: Thesis Group). MS degree courses are offered in 5 specialized branches of zoology, *viz.* Entomology, Fisheries, Wildlife & Conservation Biology, Parasitology & Public Health and Genetics & Molecular Biology. An MS student may choose any one of these branches for her/his study.
iii. MPhil in Zoology- is a two year degree, based on course work and research. Courses are offered in the above mentioned specialized branches. Registered students need to successfully complete 8-credit course to be promoted from 1st year to 2nd year of the programme.
iv. PhD in Zoology- is normally a four year degree based on research, however, need to take 8-credit course to be promoted from 1st year to 2nd year of the programme, except for the students completed their 4 years BS and 1 year MS in Dhaka University.

2. Introduction to the MS Programme

Programme name: Master of Science in Zoology MS in Zoology.

2.1 General Objectives of the Programme

The MS in Zoology is a comprehensive programme and intended to produce professionals of global competence capable of contributing to national development in each of the five different branches of zoology, viz. Fisheries, Entomology, Wildlife & Conservation Biology, Parasitology & Public Health and Genetics & Molecular Biology. The MS program in Zoology is aligned to meet the expectations of country's policy for tertiary education.

2.2 Eligibility for Admission to the MS in Zoology Programme

(a) For Internal Students

All the successful students of the BS (Hons) programme of the department are eligible to get admission into the MS Program of the Department without having any screening or admission test. A student may seek admission to the immediate next batch of MS Programme following publication of BS (Hons) results. However, in a special circumstance, a student may seek admission within two years of the publication of his/her BS (Hons) results upon approval of the departmental Academic Committee and the Vice Chancellor of the University. A student having four year BS Honours in Zoology from any recognized university is eligible to apply for admission into MS course with the approval of the Academic Committee.

(b) For external students

Admissions for the one-year Master's program in the Department of Zoology will be conducted for available seats in accordance with established policies by the department. There will be no restrictions on the age or academic session of applicants. To be eligible for admission to the regular Master's (Thesis) program, candidates must have completed a four-year Bachelor's (Honors) degree in Zoology, Fisheries, Oceanography, Marine Sciences, Public Health, Environmental Science, Biochemistry, Microbiology, Genetic Engineering and Biotechnology, Botany, Natural Sciences, or hold an MBBS degree from a public university or a university recognized by the University Grants Commission of Bangladesh. Applicants must meet the minimum academic qualifications for secondary and higher secondary levels required for undergraduate admission, as specified by the Faculty of Biological Sciences and the Faculty of Sciences at the University of Dhaka. Furthermore, a minimum CGPA of 3.25 (on a scale of 4) in the Bachelor's (Honors) program is required. The admission process includes both written and oral examinations, with evaluation and final results conducted in alignment with departmental policies.

2.3 Options in MS in Zoology Programme

(a) Choice for specialization

The MS degree in Zoology is offered in the following five specialized areas of Zoology:

(i)Zoology in Fisheries; (ii) Zoology in Entomology; (iii) Zoology in Wildlife and Conservation Biology; (iv) Zoology in Parasitology and Public Health; and (v) Zoology in Genetics and Molecular Biology.

A student may take up only one of these specialized programmes. After admission in to the MS course, the students will be asked to apply for his/her choice for a specialized branch with priority preferences. The department will then allocate the specialized branch of MS study to the students on a merit basis.

(b) Options for Thesis and Practical Groups

The department offers the MS degree by course and practical work (Non-thesis Group) or by course and thesis work (Thesis Group). Students having a CGPA 3.25 and above in BS level may opt for thesis work as a partial fulfilment of his/her MS degree. However, the department may refix the CGPA points time to time. A thesis student requires to perform his/ her research work under the supervision of a teacher of

her/his specialized branch of study. The student needs to contact the teacher under whom he/she is willing do thesis work and once the teacher agrees to supervise the work, only then the student may embark on his/her thesis work. The students are also required to fill out a proforma mentioning the thesis title and the name of the supervisor.

3. Duration of the Programme

The MS Programme will be of 1 (one) academic year duration as distributed below:

Classes	28 weeks
Preparation time for course final examination	4 weeks
Course final examination (theory)	4 weeks
Time for submission of review and seminar/projects/practical report after completion of last theoretical examination	2 weeks
Time for submission of thesis after completion of last theoretical examination	12 weeks
Results	4 weeks
Total	52 weeks

Results would be published within 4 weeks from the date of last final examination (theory/ practical/viva-voce/thesis presentation, whichever is the latest).

4. Assignment of credits

The entire Master's programme in Zoology will be covered by a set of theoretical classes, thesis work, practical (laboratory/field) and seminar courses.

(a) **A total of 30 credits,** either under 5 or 10 individual courses is assigned for the MS course without having any provision for options for courses.

(b) The distribution of credits is as follows:

Theory	Practical (including a short assignment project)/Thesis	Review and Seminar other than thesis work	Viva-voce	**Total credit**
20	6	2	2	**30**

(c) **Theoretical courses:** A minimum of 15 class-hours will constitute 1 (one) credit and there will be 30 lecture-hours for a 2-credit course and 60 lecture-hours for a 4-credit course.

(d) **Practical courses:** Practical courses are only for the students of non-thesis group. There will be 30 practical classes under 6 credit courses, an assignment project work for 1 credit course and a number of field/laboratory visits will be organized as decided by each of specialized branches of the MS Programme.

(e) **Thesis:** The student will embark on his/her thesis research from the beginning of MS study and must submit thesis within 12 weeks after completion of the theoretical examination. Of the allocated 6 credits for thesis, 60 marks (40%) will be dedicated to thesis presentation/defence on the research work.

(f) Review and Seminar: Each given student (from thesis and non-thesis groups) of each

specialized branch requires to give a seminar on a specific published topic, assigned by the respective specialized branch. Seminar will be organized after the completion of the theoretical examinations and will carry 2 credits. Students are required to prepare a paper on his/her topic and make a power-point presentation for evaluation.

5. Evaluation of students' performance

The total performance of a student in a given course will be evaluated on the basis of a scheme of continuous assessment, in-course and final examinations.

(a) In-courses assessment (theory courses) will be made through a set of in-course examinations and class participation. In-course examination of one hour duration shall be conducted and evaluated by the course teacher. There will be a minimum of 2 (two) written examinations for 3 or 4 credit courses and a minimum of 1 (one) written examinations for 2 credit courses. Questions for in-course examination should preferably be of objective type. Additional assessment examinations may be made by the course teacher. In such cases the marks of all the examinations will be used to calculate average marks for the course. The course teacher will show the assessed in-course scripts to the students.

(b) Continuous assessment of practical (laboratory/field) courses will be made through observations of the students at work, and also through viva-voce, homework assignments, evaluation of practical reports, in-course practical examinations and project report as preferred by the department.

(c) The scheme and pattern of continuous assessment will be announced by the course teacher on the first day of classes.

(d) Distribution of marks for a theory course:

Class attendance	5%
In-course assessment	35%
Course final examination	60%

(e) Distribution of marks for a practical course (6 credit):

i) In-course	40% (60 marks)
Class attendance for practical (7.5 marks)	5%
In-course assessment & project (In-course assessment 27.5 marks + Assignment Project 25 marks)	35%
ii) Course final examination	60% (90 marks)

(f) The distribution of marks for thesis (6 credit):

Thesis presentation/defense	40% (60 marks)
Thesis evaluation by external examiners	60% (90 marks)

(g) The distribution of marks for seminar (2 credit)

Presentation	50%
Review paper	50%

(h) Basis for awarding marks for class attendance:

Attendance (%)	**Marks (%)**
95 and above	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1
Less than 75	0

(i) Make-up examination (theory courses):

A student failing to appear in an in-course examination will not be allowed to sit for any make-up examination. Absence in any in-course examination will be counted as zero for calculating the average in in-course examination for that course. However, a student can apply to the chairman of the department for make-up test provided he/she satisfies certain conditions. The Chairman will only place the application before the academic committee if the particular student had met an accident or his/her parent(s) had expired or he/she had gone through a surgical procedure one/two days before assessment examination date or any other such situation which the Academic Committee feels can be considered. The make-up examination must be held before the start date of the final examination.

(j) The course final examination (theory courses):

i. The course final examination will be conducted centrally by the Controller of Examinations as per existing system.

ii. Pattern of theory questions will be decided by the academic committee of the department. However, there will be no objective questions/part in the course final examination. There would be combination of broad and short questions.

iii. The course final examinations will be of three (3) hours duration for 4-credit courses, 2½ hours for 3-credit courses, and two (2) hours for 2-credit courses.

iv. For the evaluation of course final examination there will be two examiners: the first examiner- course teacher and the second examiner- anyone other than the course teacher, preferably form the department.

v. Under double-examiner system if the difference of first and second examiners marks of a course is more than 20% of total marks, there will be a 3rd examiner. Marks of the nearest two examiners will be averaged out as final marks.

(k) Assessment of seminar: Seminar (other than thesis) will be evaluated by internal members of the examination committee. Fifty percent marks will be allocated for the presentation, and the rest 50% marks for the report.

(l) Assessment of final laboratory work for non-thesis students: The final examination on practical work will be evaluated by the course teacher along with the external examiner.

(m) Assessment of project: For the students of non-thesis group a short project be assigned for the individual students by the concerned class teachers. The project will be evaluated by the class teachers.

(n) Assessment of thesis: Oral presentation/thesis defence will be evaluated by all members of the committee and the concerned supervisor. Thesis will be evaluated by two external examiners from outside of the department. If difference of marks of the internal and external examiners is

more than 20%, there will be a third examiner to examine the thesis. Marks of the nearest two examiners will be used to get average marks as final marks.

(o) Viva-voce/oral examination: Viva-voce/oral examination will be conducted by the Examination Committee.

(p) The Grading System: Marks obtained for each course will be converted to grades. A basic four point (4.00) grading scale will be followed. The following letter grades and corresponding grade-points will be used to determine the grade point average (GPA):

Marks obtained	Corresponding Letter Grade	Grade Point
80% or above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00

6. Grading description

The explanations of letter grades are described as follows:

A: Exceptional performance; all course objectives achieved; objectives met in a consistently outstanding manner.

B: Very good performance; significantly more than the majority (at least two-thirds) of the course objectives achieved; objectives met in a consistently thorough manner.

C: Satisfactory performance; at least majority of the course objectives achieved; objectives met satisfactorily.

D: Minimally acceptable performance; less than the majority but more than the minimum required course objectives achieved.

F: Unacceptable performance; minimum required course objectives not met; objectives not met at a minimally acceptable level; no credit earned.

7. Earned credits

A course in which a student has obtained ‘D’ or a higher grade will be counted as credits earned by him/her. Any course in which a student has obtained ‘F’ grade will not be counted towards his earned credits.

8. Calculation of GPA

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses passed/completed by a student. The Grade Point Average (GPA) is computed in the following manner:

$$GPA = \frac{\sum (\text{Gradepoints x Credits})}{\text{Sum of Credits Attempted}}$$

The Grade Point Average (GPA) is computed by dividing the total accumulated grade points earned during the MS programme by total credit points attempted. For successful completion of MS programme a student must earn 30 credits or more if approved with no F grade in any course. However, this minimum requirement may be raised by any department as per their programme and final GPA will be calculated using all the credits attempted.

9. Eligibility for sitting at the course final examination

(a) A student must attend **at least 75%** of the total classes held in an academic year to be eligible for appearing in the final examination of that year without paying any penalty.

(b) A student attending **at least 60%** classes but less than 75% classes will be allowed to appear for the examination after paying non-collegiate fees fixed by the university.

(c) A student attending **less than 60%** classes will not be allowed to appear for final examination for that year.

10. Publication of results

The results will be published within six weeks of completion of practical examination (for practical group) and after six weeks of submission of thesis paper (thesis group). Results will be published separately for non-thesis (practical group) and thesis group students.

11. Retake Examination

A student can appear in retake examination once only in one course to clear F grade within six weeks after announcement of the results and definitely before registration for convocation. His/her in-course assessment marks will be retained.

12. Readmission

(a) A student failing to earn the degree may seek readmission once with the next batch. For readmission, a student will have to apply within one month after announcement of the result of the concerned year. Readmission will be allowed only after the approval of the departmental academic committee.

(b) On readmission, a student may be allowed by the departmental Academic Committee to retain his/her in-course marks, earned earlier as chosen by him/her. The academic committee of the department will determine whether the re-admitted student can undertake any thesis work.

(c) If a student succeeds after taking readmission his/her transcript will bear “R” after GPA, with a foot note of mentioning “R means readmission”

13. Requirements for successful completion

A student must earn GPA of 2.50 on a 4.00 scale for obtaining MS degree.

14. Time limit for completion of Master's degree

A student must fulfill all the requirements for a master's degree within a maximum period of two academic years, starting from the year of enrolment, in case he/she appears and fails in the examination. In case the student is unable to participate he/she needs to inform the Chairman of the department. However, in case of continuing with the program for the second year he/she requires readmission upon approval of the department. In that case, his/her obtained marks obtained in the previous year will be discarded.

15. Other general regulations

(b) At the beginning of the session, a course teacher shall provide the students a course outline including the obvious, main topics, teaching approaches (e.g., labs, case studies, field work, etc.), schedule of exams, text books and other required materials.

(c) The course teacher shall announce the results of the in-course tests within two weeks of the date of holding the exams and submit the marks to the chairman of the examination committee for the respective batch and also a copy to the Controller of Examinations at least two weeks before the start of the annual examination. He/she should also submit a statement showing the total number of classes held and the number of classes attended by each student in his/her course to the chairman of the examination committee for the respective batch.

(d) Tabulation work will start only after all the marks of the course final examinations for the year are received by the Chairman of Examination Committee. Marks received by the Chairman of the Examination Committee shall remain in the sealed envelopes as sent by the Examiner/Examiners until tabulation work is started. In case of thesis group tabulation starts only after thesis presentation.

(e) The present system of conducting course final examination and publication of results by the office of the Controller of Examinations shall continue.

(f) For any matter not covered in these rules, the existing rule of the University of Dhaka will be applicable.

16. Relevancy of Syllabus of the Department of Zoology, University of Dhaka to the SDGs (Sustainable Development Goals) in Bangladesh

SDGs	**Relevancy of Syllabus to the SDGs**
Goal 1: No poverty 	ZF 604; ZF 608; ZF 610; ZW 628; ZG 648: ZG 649.
Goal 2: Zero hunger 	ZF 604; ZF 606; ZF 607; ZF 608; ZE 616; ZE 617 ZP 638; ZG 648; ZG 649.
Goal 3: Good health and well-being for people 	ZE 618; ZE 620; ZP 639; ZP 640; ZP 643; ZP 644; ZG 645; ZG 646; ZG 647; ZG 648.

Goal 4: Quality education 	The department has adopted Outcome Based Education. The curriculum has been updated. The program will be regularly evaluated as per OBE principles and revised, as necessary, to ensure quality education.
Goal 5: Gender equality 	
Goal 6: Clean water and sanitation 	ZP 640; ZG 649.
Goal 9: Industry, Innovation, and Infrastructure 	ZF 04; ZF 605; ZF 608; ZG 646; ZG 647; ZG 648.
Goal 10: Reducing inequalities 	
Goal 12: Responsible consumption and production 	ZF 604; ZF 605; ZF 608; ZE 619; ZG 648; ZG 649.
Goal 13: Climate action 	ZE 615; ZG 646; ZG 647 ZG 648; ZG 649.

Goal 14: Life below water 	ZF 601-ZF 610; ZP. 636.; ZP 637; ZW 626; ZW 627; ZW 628; ZW 629; ZG 645; ZG 646; ZG 647.
Goal 15: Life on land 	ZP 635; ZW 625; ZW 626; ZW 628; ZW 629; ZE 614; ZE 615; ZE 619; ZG 645; ZG 646; ZG 647; ZG 648; ZG 649.
Goal 16: Peace, justice and strong institutions 	ZF 610; ZW 626; ZG 649.
Goal 17: Partnerships for the goals 	The department has collaboration and partnership with a number foreign and national universities, research organizations and NGOs to achieve its goal.

17. Branch-Wise Distribution of Courses and Credits

17.1 MS in Zoology (Fisheries)

ZF 601	Fish Biology and Advanced Physiology	2 credits
ZF 602	Fish Population Dynamics and Fisheries Modelling	2 credits
ZF 603	Aquatic Resources, Biodiversity, Fisheries Management and Conservation	2 credits
ZF 604	Advanced Aquaculture, Fish Nutrition and Fish feed technology	2 credits
ZF 605	Fish Genetics, Biotechnology and Bioinformatics	2 credits
ZF 606	Fish Disease, Immunology, and Aquatic Health Management	2 credits
ZF 607	Aquatic Environment, Ecology and Limnology	2 credits
ZF 608	Marine Biology and Oceanography	2 credits
ZF 609	Post-harvest Technology and Quality Assurance	2 credits
ZF 610	Fisheries Extension, Marketing and Socio-economics	2 credits
ZF 651	Practical Fisheries (Gr-A)	6 credits
ZF 656	Thesis (Gr-B)	6 credits
ZF 657	Review and Seminar	2 credits
ZF 658	Viva voce	2 credits
	Total:	**30 credits**

17.2 MS in Zoology (Entomology)

ZE 611	Insect Systematics and Nomenclature	2 credits
ZE 612	Insect Organ System and Functional Adaptations	2 credits
ZE 613	Insect Developmental Biology, Endocrinology and Molecular Biology	2 credits
ZE 614	Insect Behavioural Adaptations and Insect-Plant interactions	2 credits
ZE 615	Insect Ecology and Biodiversity Management	2 credits
ZE 616	Insect Pest and Pest Management	2 credits
ZE 617	Toxicology and Impacts on Ecosystem	2 credits
ZE 618	Medical and Veterinary Entomology	2 credits
ZE 619	Insect Bioresources, Management and Conservation	2 credits
ZE 620	Insect Epizootiology and Disease Dynamics	2 credits
ZE 652	Practical Entomology (Gr-A)	6 credits
ZE 656	Thesis (Gr-B)	6 credits
ZE 657	Review and Seminar	2 credits
ZE 658	Viva voce	2 credits
	Total:	**30 credits**

17.3 MS in Zoology (Wildlife and Conservation Biology)

ZW 625	Wildlife Ecology and Biogeography	4 credits
ZW 626	Conservation Biology	4 credits
ZW 627	Behavioural Ecology and Anthrozoology	4 credits
ZW 628	Wildlife Resource Management	4 credits
ZW 629	Conservation Outside Protected Areas and Bioinstrumentation	4 credits
ZW 653	Practical Wildlife and Conservation Biology (Gr-A)	6 credits
ZW 656	Thesis (Gr-B)	6 credits
ZW 657	Review and Seminar	2 credits
ZW 658	Viva voce	2 credits
	Total:	**30 credits**

17.4 MS in Zoology (Parasitology and Public Health)

ZP 635	Parasite Systematics and Biology	2 credits
ZP 636	Parasite Physiology and Biochemistry	2 credits
ZP 637	Molecular Biology of Parasites	2 credits
ZP 638	Immunology	2 credits
ZP 639	Pathology and Medical Microbiology	2 credits
ZP 640	Parasite-Host Ecology and Behaviour	2 credits
ZP 641	Parasite Biodiversity and Population Dynamics	2 credits
ZP 642	Epidemiology and Disease Control	2 credits
ZP 643	Public Health Parasitology	2 credits
ZP 644	Veterinary Parasitology	2 credits
ZP 654	Practical Parasitology and Public Health (Gr-A)	6 credits
ZP 656	Thesis (Gr-B)	6 credits
ZP 657	Review and Seminar	2 credits
ZP 658	Viva voce	2 credits
	Total:	**30 credits**

17.5 MS in Zoology (Genetics and Molecular Biology)

ZG 645	Molecular Biology	4 credits
ZG 646	Advanced Molecular Genetics	4 credits
ZG 647	Functional Genomics, Proteomics and Bioinformatics	4 credits
ZG 648	Recombinant DNA Technology	4 credits
ZG 649	Molecular Ecology and Conservation Genetics	4 credits
ZG 655	Practical Genetics and Molecular Biology (Gr-A)	6 credits
ZG 656	Thesis (Gr-B)	6 credits
ZG 657	Review and Seminar	2 credits
ZG 658	Viva voce	2 credits
	Total:	**30 credits**

MS in Zoology (Fisheries)

Course No.	Course Title	No. of Credits	Credit Hours
ZF 601	**Fish Biology and Advanced Physiology**	**2**	**30**

Fish Biology

Introduction to Fish Biology: Definition and scope of fish biology - History of ichthyology - Overview of fish diversity and global distribution: Fish phylogeny and evolutionary history

Anatomy and Morphology: External morphology and its functional significance - Skeletal system; Musculature and locomotion adaptations; Sensory organs and communication.

Physiology and Adaptations of Circulatory and respiratory systems: Osmoregulation and ion regulation - Thermoregulation in fishes - Bioluminescence and other unique adaptations.

Reproductive Biology and Development: Reproductive strategies: oviparity, viviparity, ovoviviparity;

Life history and development of selected fishes: Maturation and spawning, Spawning behaviors and parental care - Larval development and recruitment dynamics.

Fish Behavior and Migration: Schooling and social interactions - Migration types and mechanisms (e.g., diadromy, catadromy)

Advanced Physiology

Digestion: Physiology of digestion of fish;

Reproduction: Nutritional and environmental factors influencing the reproduction of fish.

Osmoregulation: Osmoregulation of freshwater and marine fishes.

Endocrinology: Endocrinology in fish and its application in breeding.

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Course No.	Course Title	No. of Credits	Credit Hours
ZF 602	**Fish Population Dynamics and Fisheries Modelling**	**2**	**30**

Fish Population Dynamics

Concept of population and stock, unit stock, distribution and abundance, relative and absolute abundance, cohort and population structure.

Fish age and growth estimation: The von Bertalanffy growth equation; seasonal and non-seasonal growth equation. Growth parameters, K, L_∞, C, etc.

Estimation of mortality rates: Methods for estimation of total mortality (Z), fishing (F) and natural mortality (M); estimating survival and mortality rates.

Stock-Assessment: General aspects of fish stock assessment; stock-recruitment relationship; over-fishing and under fishing concept; by-catches and discards estimation of stock.

Fishery data collection for assessment and management: Issues and objectives of data collection, biological data, collection of length frequency data; catch assessment and fishing effort survey; estimation of CPUE and fish productivity and participatory data collection; species composition; distribution and abundance data; availability and gear selectivity; exploitation ratio; analysis of data; presentation of data for fishery management and decision making.

Fisheries Modelling

Prediction models: Surplus production model, Biomass model, Yield per Recruitment (Y/R); Biomass per Recruitment (B/R); Catch curve; Maximum Sustainable Yield (MSY), and Virtual Population Analysis (VPA).

Microcomputer programme packages: Graphical and computer based analysis of growth - stock assessment based on length frequency analysis. LFDA (Length-Frequency Distribution Analysis), FISAT (FAO-ICLARM Stock Assessment Tools), ELEFAN I & II.

References

Bagenal, T. 1978. *Methods for Assessment of Fish Production in Freshwaters.* IBP Handbook, No. 3. Blackwell Science, London.

Hart, P.J.B. and Reynolds, J.D. 2002. *Handbook of Fish Biology and Fisheries,* Vol. 1 and 2. Blackwell Publishing, London.

Jennings, S., Kaiser, J.M. and Reynolds J.D. 2001. *Marine Fisheries Ecology.* Blackwell Science, London.

King, M. 1995. *Fisheries Biology: Assessment and Management.* Fishing News Books, Oxford, UK.

Royce, W.F. 1984. *Introduction to the Practice of Fishery Science.* Academic Press, USA.

Sparre, P. and Yenema, S.C. 1992. *Introduction to Tropical Fish Stock Assessment.* FAO *Fisheries Technical Paper No. 306*. FAO, Rome.

Welcomme, R.L. 2001. *Inland Fisheries Ecology and Management.* FAO Fishing News Books, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 603	**Aquatic Resources, Biodiversity, Fisheries Management and Conservation**	**2**	**30**

Aquatic Resources

Fish habitats:Types, extent and status.

Fish diversity: Freshwater and marine finfishes and shellfishes with major commercial group; Abundance of different groups of fish; Other aquatic invertebrates and sea weeds; Endangered and rare fish.

Fisheries Institutions/Organizations: Government and non-government organizations; Professional bodies; Research and academic institutions; Fisheries cooperatives.

Fisheries infrastructures: Landing centres, fish harbours, processing plants, fish hatcheries, gear manufacturing facilities.

Resources and its statistics: Fisheries resources survey and monitoring system in Bangladesh;

Contribution of fisheries to the economy, nutrition and employment in Bangladesh; Fish production statistics of Bangladesh; Aquatic resources of the Sundarbans and Haors.

Aquatic Biodiversity: Definition, origin, importance and factors of aquatic biodiversity; types, use and values of aquatic biodiversity. Conservation of aquatic biodiversity. Conservation strategies and action plan for the biodiversity of Bangladesh. Legislations and concerned organizations. CBD, Ramsar Convention and CITES.

Fisheries Management

Concept and principles of fisheries management: Tragedy of the Commons in fisheries context; Issues and threats to fisheries resources; Case study: In-depth analysis on the collapse of Cod/Sole/Anchovy fisheries.

Methods and tools in fisheries management: Regulatory methods, restrictions and control (Biological: MSY, mortality, effort, breeding season and life-history information; Ecological & physical: habitat, spatial and temporal; social & legal context); Criteria to evaluate fishery management tools/interventions; Case study: In-depth analysis of Hilsa Fisheries Management Action Plan (HFMAP)

Approaches in fisheries management: Ecosystems, habitat and landscape approaches; Community based management; Rights-based approach.

Legal instruments in Bangladesh: Fish Conservation Act and Rules;National Fisheries Policy 1998 and 2010; Community Based Fisheries Management Policy; Marine Fisheries Ordinance 1983.

Open water fisheries enhancement: Different steps of developing a fisheries management plan; Case study: Hilsa Fisheries Management Action Plan (HFMAP).

References

Ali, M.Y. 1997. Fish, Water and People. The University Press Limited, Dhaka, Bangladesh.

Farooque, M. 1997. Regulatory Regime in Inland Fisheries in Bangladesh: Issues and Remedies. Bangladesh Environmental Lawyers Association (BELA), Dhaka.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hasan, M.A., Khondker, M. and Rahman, M.M. (ed.). Encyclopedia of Flora and Fauna of Bangladesh. Vol.23. Freshwater Fishes. Asiatic Society of Bangladesh, Dhaka.

Siddiqui, K.U., Islam, M.A., Kabir, S.M.H., Ahmad, M., Ahmed, A.T.A., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hasan, M.A., Khondker, M. and Rahman, M.M. (ed.). Encyclopedia of Flora and Fauna of Bangladesh. Vol. 24. Marine Fishes. Asiatic Society of Bangladesh, Dhaka.

Sissenwine, M. P., & Kirkley, J. E. 1980. Fishery management techniques, a review. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Center.

Tsai, C. and Ali, M.Y. 1997. Openwater Fisheries of Bangladesh. The University Press Limited, Dhaka, Bangladesh.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 604	Advanced Aquaculture, Fish Nutrition and Fish feed technology	**2**	**30**

Introduction to aquaculture and its importance: History, definition, types, scope and significance of aquaculture, comparison of aquaculture with agriculture and commercial fisheries. Aquaculture - Global and Bangladesh Scenario.

GAP-Good Aquaculture Practices: Concept, applications and challenges. Role of exotic fishes in aquaculture production in Bangladesh.

Inland Aquaculture: Basis of inland aquaculture; Present practices of fish and shellfish culture in Bangladesh; Inland aquaculture with references to prawn, barbs, carps, tilapia, catfish (pungus) culture methods. Ornamental fish culture techniques. Hatchery and fish farm design: commercial fish seed production.

Coastal and marine aquaculture: Basis of coastal aquaculture; Coastal aquatic zonation and environmental process. Culture techniques and management of seaweed and *Spirulina*, mussels, scallops, mullets, milkfish and sea bass; Cage and pen culture techniques. Marine pearl and oyster culture. Intertidal farming and open water sea ranching. *Artemia* culture in salt pens.

Aquaculture Nutrition

Nutritional requirements: Qualitative and quantitative requirements of protein, fat and energy for fishes.

Feed preparation: Formulations, millings and bulk storage.

Farm made aquafeeds: On-farm feed preparation and feeding strategies for carps and shrimp. Fish meal, Fish silage.

Non-Conventional Feed Resources (NCFR): Definition, characteristics, availability, nutritive value and constraints to utilization.

Feeding of cultured fish: Appetite and satiation; factors influencing feeding behavior; feed types; handling and storage of feed; feeding methods. Fish feed Act and Rules.

Selected Nutrient terms and analytical techniques: Proximate analysis (moisture, ash, crude protein, total lipids); apparent digestibility; Total Digestible Nutrients (TDN); Digestible Dry Matter (DDM); Net energy (NE); Relative feed value (RFV); Non-protein nitrogen (NPN); Nonfiber carbohydrates (NFC); energy utilization, bioavailability.

Nutritional bioassay: Hematological and histological parameters of a healthy herbivore (*Labeorohita*) and a carnivore (*Clarias batrachus*) fish.

Nutrient and Environment: Environmental issues on fish feed used for aquatic systems, Environmental issues related to high density fish culture in cages.

Fish feed Acts and rules: Salient features of Fish Feed and Animal Feed Acts 2010; Fish Feed Rules 2011

References

FAO. 2011. Cultured Aquatic Species Information Programme. Cyprinus carpio (Linnaeus, 1758). Fisheries and Aquaculture Department. (available at: www.fao.org /fishery/ culturedspecies/ Cyprinus carpio/en).

Huet, M. 1994. *Textbook of Fish Culture- Breeding and Cultivation of Fish.* 2nd edition. Fishing News Books, Oxford, UK.

Imai, T. 1977. *Aquaculture in Shallow Seas Progress in Shallow Sea Culture.* Amerind Publishing Co., Delhi, India.

Iversen, E.S. 1977. *Farming the Edge of the Sea.* 2nd edition. Fishing News Books Ltd., Oxford, UK.

Jhingran, V.G. 1975. *Fish and Fisheries of India*. Hindustan Publ. Corp., Delhi, India.

Milne, P.H. 1972. *Fish and Shellfish Farming in Coastal Waters.* West Byfleet. Fishing News Books, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 605	**Fish Genetics, Biotechnology and Bioinformatics**	**2**	**30**

Fish Genetics and breeding

Principles of fish genetics and breeding: natural and artificial breeding, inbreeding and outbreeding; Consequence of inbreeding depression; Genetic selection and breeding of fish; Hybridization of fish: Principles, types techniques and applications

Sex determination and sex reversal in fishes.
Genes, genetic codes, genome and genetic markers: Introduction to gene, genetic codes and genomes of fish; Types of molecular markers (allozymes, segments of particular gene, microsatellite and SNPs etc.); Uses of RELP, RAPD, AFLP in aquaculture.

Biotechnology
Biotechnology in fisheries: Introduction, biotechnological techniques, role of biotechnology in improving aquaculture production and in fisheries resources conservation.
Chromosomal engineering: Induction of ploidy (polyploidy), gynogenesis, androgenesis.
DNA Processing: DNA extraction, PCR amplification (principle, types, techniques and applications), Electrophoresis (general principles, classification and application) and DNA sequencing.
Transgenesis and GMOs: General concepts, methods for the production of transgenic fish, application; merits and demerits.
DNA fingerprinting and barcoding: Concepts and principles, techniques and applications.
Cryopreservation: General principles, preservation techniques of gametes and embryos and its application
Bioinformatics
Introduction to Bioinformatics: Concept and application.
Bioinformatics tools: Types, and applications in fisheries.
Sequence Analysis: Introduction to raw sequence formats; handling of various sequence formats, sequence conversion and alignments; measuring genetic distance; Phylogenetic tree construction.
Sequence Analysis Tools: BLAST (Basic Local Alignment Search Tool), sequence alignment (ClustalW, Muscles), T-Coffee, MEGA, Phylogenetic tree building software; sequence submission in database.
Introduction to Biological databases: Primary and secondary databases and its importance;
Primary databases: GenBank; EMBL (European Molecular Biology Laboratory); DDBJ (DNA Data Bank of Japan), BOLD etc.;
References
Colin, E.P. 1993. *Genetics and Fish Breeding.* Chapman and Hall, UK.
Das, P. and Jhingran, A.G. 1976. *Fish Genetics in India*. Today and Tomorrow Publishers, New Delhi.
Douglas, T. 2001. *Genetics for Fish Hatchery Managers.* 2nd edition. Kluwer Academic Publishers, Baton Rouge, USA.
Fingerman, M., Nagabhushanam, R. and Thompson, M.F. 1999. *Recent Advances in Marine Biotechnology* (Vol. 1-3). Oxford and IBH Publishing Co. Ltd., New Delhi.
Lakra, W.S. 2000. *Fish Genetics and Biotechnology*, CIFE, Mumbai, India.
Sinnot, E.W., Dunn, L.C. and Dobzhansky, T. 1989. *Principles of Genetics.* McGraw Hill Publishing Company Ltd., New Delhi.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 606	**Fish Disease, Immunology, and Aquatic Health Management**	**2**	**30**

Fish diseases
Concept of fish disease, terminologies related to diseases, environmental change and disease occurrence; causes and types of diseases.
Parasitic diseases of fish: Causes, aetiology, pathogenicity, and control measures of common protozoan, crustacean, helminth, acanthocephalan diseases of carps, catfishes and shrimps.
Microbial diseases of fish: Causes, symptoms, pathology, etiology and control measures for common bacterial, viral and fungal diseases of fishes and shrimps.
Non-pathogenic diseases: Causes, symptoms, control measures of environmental. nutritional, genetic diseases and diseases of unknown aetiology of fish diseases. Toxicity of pesticides, fertilizers, heavy metals, antibiotics, and microa & nanoplastics in fish: Sources, extent and their impacts on fish

health (Growth, behabiour, dysbiosis, enzymatic, haematological, histopathological and genotxic changes). Prevention and control strategies.

Disease diagnosis in fish: Conventional laboratory techniques for viral, bactrial and fugal identification; Molecular techniques for pathogen identifications. Clinical and pathological signs of diseased fish; histopathological techniques; Imunodiagnostic techniques: ELISA, PCR, Western blot etc.

Immunology

General concepts and types of immunity in fish; immune systems in fish;

Stress responses in fish: Concepts, definitions, types of stressors-physical, biological and chemicals; Stress and immune response, physiological outcomes of stress.

Innate immune response: Nonspecific cellular and humoral immunity in fish.

Adaptive immune response: Specific Cell mediated and humoral immunity.

Antigen and antibody: General concepts of antigens and antibody; type and structure of antibody; antibody production and functions.

Fish vaccination: Concepts, types and vaccination methods of fish.

Aquatic Health Management

Management of fish diseases: Basis for fish disease management; Role of husbandry in controlling diseases in fish farms; Principles, concepts and different prophylactic and metaphylactic measures (therapeutic treatments, administration of vaccines and immunostimulants). Fish disease and public health issues; fish quarantine and certification.

References

Chemg, T.C. 1967. *The biology of animal parasites*. Saunders, London.

Dogiel, V.A., , Petrusheveski, G.K. Polyanski, Y.I. 1961. *Parasitology of fishes*. Oliver, London.

Roberts, R.J. (ed.). 2001. Fish pathology, 3rd edition. Saunders. London, New York.

Schaperclaus, W. Kulow, H. and Schrecknbachy, K. 1991. *Fish diseases*, Vo. I & II. Oxonian Press (Pvt.) Ltd.

Shuzo, E. (1999). *Infectious diseses of fish*. Oxonian Press (Pvt.) Ltd.

Sinderman, C.J. 1970. Principal diseases of marine fish and shellfishes. Academic Press, London, New Yoerk.

Van Duijn,C, 1966. Diseases of fishes, Iliffe Books, London.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 607	**Aquatic Environment, Ecology and Limnology**	**2**	**30**

Aquatic Environment

Classification of wetlands; characteristics, ecological and productivity functions, and importance of wetlands.

Water cycles and hydrodynamic patterns in Bangladesh; flood pulse and formation of fish production systems in aquatic environment and its relevance with life cycles of fish; adaptation strategies of fish with highly oscillating hydrodynamics and flood cycles.

Degradation to aquatic environment: natural causes; FCD/I; wetland conversion and reclamation, habitat fragmentation and its impacts on aquatic biodiversity; water pollution-pollutant types, sources and impacts on different life stages.

Water quality and its ranges, spatial and temporal fluctuations; and interrelationships between the major environmental factors affecting fish community. Limiting/biotic factors and biological cycle in ponds.

Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP); strategy for protection of aquatic resources.

Fish Ecology:

Aquatic organisms and global ecology: Ecology of freshwater column, coastal ecosystems, deep-water

marine zones. The role of the oceans in global warming. Role of gases in sea level rise. Effects of climate change in world ocean and freshwaters.

Aquatic communities and Fish assemblages: Competition, predation and disturbances, coexistence and succession; effects of predation in communities, disturbances and patchy dynamic concepts. General patterns of species richness; species diversity and diversity indices.

Life-history strategy: Cost of reproduction and the consequences. Bioenergetics of life history patterns.

Impacts of man's activities on ecosystem: Harvesting natural product, ocean dumping and disposal, accidental discharge, ballast discharge and its ecological significance. Eutrophication: causes, process, impact and mitigation. Harmful algal blooms and bioactive marine products. Invasive alien fish and its impact on ecosystem.

Freshwater, estuarine, marine fisheries ecosystems in Bangladesh.

Limnology

Water as a substance: Lentic and lotic water system. Hydrological cycle, global water balance.

Abiotic limnology: Physico-chemical parameters of freshwater system and their interrelationships.

Biotic limnology: Plankton: Phytoplankton, zooplankton and benthos and their types.

Water quality criteria: Limnological basis for fish culture; limnological effects of fertilization and liming.

Water budgeting: Concepts. Water budgets for pond and polders; estimation methods of carrying capacity of water bodies; models and its interpretation.

Eutrophication: Process and types, problems and remedial measures.

References

Barnes, R.S.K. and Mann, K.H. 1991. *Fundamentals of Aquatic Ecology.* Blackwell Scientific Publication, UK.

Charles, R.G., Michio, K. and Richard, D.R. 2012.*Climatic Change and Global Warming of Inland Waters*: *Impacts and Mitigation for Ecosystems and Societies.* Wiley-Blackwell, USA.

Payne, A.I. 1986. *The ecology of tropical lakes and rivers*. John Wiley & Sons., USA.

Ruttner, F.1984. *Fundamentals of Limnology.* University of Toronto Press, Canada.

Thurman, V.H. and Trujillo, A.P. 2004. Introductory Oceanography. 10th edit. Pearson Prentice Hall, NJ, USA.

Wetzel, R. 2001. *Limnology, Lake and River Ecosystem.* Academic Press, USA.

Wootton, R.J. 1999. *Ecology of Teleost Fishes.* Blackwell Scientific Publication, UK.

References

FAO. 1988. *Non-Conventional Feed Resources in Asia and Pacific*.3rd edition. Fisheries Technical Paper, FAO, APHCA Branch, Bangkok.

Goddard, S. 1996. *Feed management in Intensive Aquaculture.* Chapman and Hall, USA.

Halver, I.E. and Hardy, R.W. 2002. *Fish Nutrition*. 3rd edition. Academic Press, New York.

Hoar, W.S., Randall, D.J. and Donaldson, E.M. 1983. *Fish Physiology.* Academic Press, Orlando, USA.

Lagler, K.F., Bardach, J.E., Miller, R.R. and May, P.D.R. 1977. *Ichthyology*. John Wiley and Sons, New York.

New, M.B., Tacon, A.G.J. and Csavas¸ I. 1995. *Farm Made Aquafeeds.* FAO *Press,* Washington DC, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 608	Marine Biology and Oceanography	2	30

Marine Biology

Introduction to Marine Biology: Overview of Marine Ecosystems- Oceans, seas, and their classification; History of Marine Biology- Key figures and milestones in marine science; Marine Environment and Habitat Types- Coastal zones, open ocean, deep-sea, estuaries, and coral reefs.

Marine Ecology and Biodiversity: Marine Food Webs; Species Interactions; Biodiversity Hotspots; Marine Invasions

Marine Organisms and Adaptations: Plankton- Phytoplankton, zooplankton, and their ecological roles; Fish and Marine Vertebrates-Adaptations in marine mammals, reptiles, and birds; Marine Invertebrates- Mollusks, arthropods, echinoderms, and cnidarians; Adaptations to the Marine Environment- Osmoregulation, thermoregulation, and buoyancy control.

Coral Reefs and Coastal Ecosystems: Coral Reef Ecology; Threats to Coral Reefs, Mangroves, Salt Marshes, and Seagrasses- Role in coastal protection, carbon sequestration, and biodiversity support.

Current Issues and Emerging Topics: Ocean Acidification- Causes, impacts on marine organisms, and mitigation strategies; Climate Change and the Marine Environment- Impact on biodiversity, distribution of species, and ecosystem services; Marine Renewable Energy- Tidal, wave, and offshore wind energy and their effects on marine life.

Oceanography

Introduction to Oceanography and related sciences: Overview of ocean science disciplines (physical, chemical, biological, and geological oceanography). Key historical features and importance of ocean exploration.

Physical Oceanography: Ocean circulation. Waves and tides.

Chemical Oceanography: Composition and chemistry of seawater. Properties of seawater and its relation to temperature, salinity, density. Ocean acidification and its ecological impacts.

Geological Oceanography: Plate tectonics and the ocean basins. Marine sediments (classification, sources, and distribution).

Biological Oceanography: Marine plankton, nekton and benthos. Ecological zonation of the ocean floor. Adaptations of marine organisms to the pelagic and benthic environments. Deep sea fishes and their adaptations.

Coastal Oceanography: Estuaries, deltas, and lagoons. Mixing process in the coastal and marine water.

Human-Ocean Interactions: Introduction to blue economy. Sustainable ocean resource management (fisheries, minerals, renewable energy). Marine pollution (plastic, oil spills, heavy metals).

Climate changes and ocean: Role of the ocean in the global climate system (El Niño/La Niña, heat transport). Impacts of climate change on oceans (sea level rise, coral bleaching)**.**

Course No.	Course Title	No. of Credits	Credit Hours
ZF 609	Post-harvest Technology and Quality Assurance	2	30

Post-harvest Technologies

Fish harvesting: Methods of harvesting freshwater and marine fishes; grading, packaging, storage, transportation of fish for consumers.

Post-harvest technologies: Principles and methods of freezing and chilling, changes during freezing fish;

quality control during freezing and chilling.

Principles and techniques of fish drying, smoke and salt curing; fermentation, marinating and pickling of fish.

Introduction to fish canning, principles of thermal processing, changes during canning, problems related to fish canning.

Fishery products: Utilization of fishery products and by products - fish meal, fish body and liver oils, fish silage, fish hydrolysates and miscellaneous by products - fish maws and isinglass, pearl essence and chitin processing from shrimp and crab shell.

Quality Control

Quality determination and standard: Methods for determining quality of raw materials and fishery products. Factors affecting the quality of raw materials and finished products. Estimation of total viable bacteria in fish and fishery products. Determination of coliform and faecal coliforms in fish or fishery products.

Quality assurance: Introduction to HACCP, its principles and applications. Stages for developing a HACCP Plan. Best Manufacturing Practices (BMP). Quality Certifications.

Fisheries products laws and rules: Salient features of Fish and Fish Products (Inspection and Quality control) Ordinance, 1983 and its updates (1997, 2008).

References

Alam, A.K.M.N. 2014. Post harvest Fishery Losses and Mitigation Measures. Department of Fish Technology, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Balachandran, K.K. 2001. Post harvest technology of fish and fish products. Daya Publishing House, New Delhi.

Clucas, I.J. and Ward, A.R. 1996. Post Harvest Fisheries Development: A Guide to Handling. Preservation, Processing and Quality. Natural Resources Institute, Overseas Development Administration, UK.

Connell, J.J. 1980/1990. Control of Fish Quality. 2nd Edition. Fishing News Books Ltd., Farnham, Surrey, England.

Cutting, C.L. 1999. Fish Processing and Preservation. Agro-botanical Publishers, India.

Govindan, T. K. 1985. Fish Processing Technology. Oxford & IBH Publ. Co. Pvt. Ltd., New Delhi.

Regenstein, J.M. and Regenstein, C.E. 1997. Introduction to fish Technology. 1st edition, CBS Publishers and Distributors. India.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 610	**Fisheries Extension, Marketing and Socio-economics**	**2**	**30**

Extension Services

Concept of Extension services: for whom, how and why?
Sustainable livelihood Approach (SLA): Concept and approach; Framework, livelihood assets and strategies in SLA; Livelihood security and vulnerability context in SLA.

Fish Marketing

Market channels: Introduction and approach to assess fish marketing and its channels; Market channels for fish and fisheries products in Bangladesh; Case study: Shrimp/Hilsa/mud crab.

Market-led approaches for sustainable fisheries: Eco-label certification schemes for seafood; Criteria to achieve certification for eco-label; Case study: Marine steward Council/Sea Choice/Ocean Wise

Fisheries Economics

Economics and decision making: Basic concept of scarcity and economics; Decision making (at individual, societal and national level) in Economics; Case study: Decision making in the context of hilsa fisheries and its management in Bangladesh.
Demand and supply of fish:-Concept of supply and demand; Elasticity of demand and supply; Implications of supply and demand in markets and fisheries sector.
Production: Purpose of production and its function; Short-run and long-run production inputs factors, profit maximization; Government's role in aquaculture in Bangladesh; Growth of aquaculture and its role in the economic development of Bangladesh.

References

Cambell, J. and Salagrama, V. 2000. New Approaches to Participation in Fisheries Research: A Discussion Document. FAO and SIFAR.

CRS. 2002. RRA and PRA manual. Catholic Relief Support, USA.

IIRR. 2003. Participatory Methods in Community-based Coastal Resource Management. IIRR, The Philippines.

Kleih, U., Greenhalgh, P., & Oudwater, N. 2003. A guide to the analysis of fish marketing systems using a combination of sub-sector analysis and the sustainable livelihoods approach.

Mankiw, N. G. (2014). Principles of macroeconomics. Cengage Learning.

Phillip, T. 1996. Rapid Rural Appraisal and Participatory Rural Appraisal and Aquaculture. FAO Tech Paper 358. FAO, Rome.

Sen, A. 1986. Poverty and Famines, an essay on entitlement and deprivation. ELBS, Oxford University Press, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZF 651	**Practical Fisheries (Gr-A)**	**6**	**90**

Taxonomic study of fishes (fin fish & shell fish)
Brief study on biology and morphology of finfishes and shellfishes;
Study the morphometry of finfishes and shellfishes
Identification of common finfishes and shellfishes of Bangladesh;
Reproductive stages, fecundity and GSI
Different reproductive stages;
Brief study on fecundity and GSI – application.
Study of plankton and benthos
Study of plankton and benthos community and their types;
Collection and identification of planktons and benthos from an aquatic ecosystems; Analysis of planktonic and benthic composition.
Induced breeding technique
Dissection and display of reproductive system (male and female) of fish;
Dissection and display of pituitary gland and preparation of pituitary gland extracts and its application in fish breeding.

Water Quality Analysis

Equipment used in water analysis;
Water sampling and water quality parameters;
Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids;
Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; chlorophyll a;
Application of fertilizers and pond liming.

Estimation of fish population parameters using LFDA and FiSAT

Fish population estimation parameters and estimation methods (using LFDA and FiSAT);
Benefits of Fish population monitoring.

Determination of age with scale, otolith and vertebrae methods

Brief discussion on fish biology and importance of age determination;
Different techniques of age with scale, otolith and vertebrae methods.

Length-weight relationship and condition factors

Feeding habits of fish and preparation of fish feeds

Different food and feeding habits of fishes;
Practical Formulation and preparation of a balanced fish feed;
Proximate analysis- moisture, crude protein, crude lipid, ash, acid insoluble ash content of feed;
Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed;
Estimation of protein and lipid quality;
Determination of gross energy content of feed and feed ingredients;
Determination of the digestibility of feed using markers;
Estimation of FCR from feeding trials and preparation of feeding table;
Estimation of growth parameters from feeding trials;
Analysis of gut content analysis to study artificial and natural food intake.

General procedure for inspection of fish health

General procedures for disease diagnosis;
Taxonomy and identification of fish parasites;
Techniques for disease diagnosis;
Challenge tests; Purification of virus;
Stress related study of fish and shellfish;
Disease treatments.

Exposure visit and Demonstration:

Molecular taxonomy and DNA barcoding of fish;
Fertilization, liming and feeding trails in a hatchery/fish farm;
Fish processing industry; and
Catch assessment survey and monitoring (open water).

Assignment Project:

References

Ahmed, A.T.A., Kabir, S.M.H., Ahmed, M., Rahman, A.K.A., Haque, E.U., Ahmed, Z.U., Begum, Z.N.T., Hassan, M.A., and Khondker, M. (ed.). 2008. *Encyclopedia of Flora and Fauna of Bangladesh, Vol. 18. Part 11. Arthropoda: Crustacea*. Asiatic Society of Bangladesh, Dhaka.

Jhingran, V.G. 1983. *Fish and Fisheries of India*. Hindustan Publishing Corporation, Delhi, India

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Nikerson, J.T. and Sinskey, A.J. 1977. *Microbiology of Foods and Food Processing*. 3rd edition. Elsevier, New York, Oxford, Amsterdam.

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Shafi, M. and Quddus, M.M.A. 1982. *Bangladesher Matsya Sampad* (in Bangla). Bangla Academy, Dhaka.

Welch, P.S. 1952. *Limnology*. McGraw-Hill Book Co., New York.

Wetzel, R.G. 1983. *Limnology*. CBS College Publishing. The Dryden Press, California.

ZF 656	**Thesis (Gr-B)**	**6 credits**
ZF 657	**Review and Seminar**	**2 credits**
ZF 658	**Viva voce**	**2 credits**

MS in Zoology (Entomology)

Course No.	Course Title	No. of Credits	Credit Hours
ZE 611	**Insect Systematics and Nomenclature**	**2**	**30**

Insect systematics

Introduction to insect systematics: Introduction, definition of some terms used in insect systematics.

Fossil insects: Paleozoic and Mesozoic insects; localities of these fossil insects; phylogenetic development of insects (orders); evolution of insects.

An overview of the orders of insects: Diagnostic characters of all insect orders; important families of insect orders.

Insect collection, preservation, morphological and molecular identification, cataloguing, description, and publications; reference works in insect taxonomy.

Insect nomenclature:
Interpretation of the rules of nomenclature in terms of the following aspects: Stability, priority, name changing, name given to hybrids, synonymy, date of publication, validity, formation of names, infra-specific names, authorship, homonymy, genus group names, the type methods, and ICZN.

References

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects*. 7th edition. Belmont, CA: Thomson Brooks/Cole, Australia.

Gullan, P.J. and Cranston, P.S. 2010. *The insects: An outline of entomology.* 4th edition. Blackwell Publishing, Ltd., Malden, MA, USA.

ICZN. 1999. *International Code of Zoological Nomenclature*. Published by International Trust for Zoological Nomenclature in association with British Museum (Natural History), London, New York.

Kapoor, V.C. 2017. *Theory and Practice of Animal Taxonomy and Biodiversity*. 8th edition. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Mayr, E. 1991.*Principles of Systematic Zoology*. 2nd edition. McGraw-Hill Co., New York.

Richards, O.W. and Davies, R.G. (revised by Imm's, A.D.). 1997. *A General Text Book of Entomology.* The English Language Book Society and Mathuen & Co. Ltd., UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 612	**Insect Organ System and Functional Adaptations**	**2**	**30**

Insect structure

Integument derivatives: Apodeme and apophysis, seta, tentorium.

Thorax: Areas and suture of tergum, sternum and pleuron; pterothorax. Wing: Wing structure and modifications, wing coupling apparatus and mechanism of flight. Leg: Leg structure and modifications.

Abdomen: Segmentation and appendages; Genitalia and their modifications; Insect sense organs (mechano-, photo- and chemoreceptors).

Chitin: Structure, formula, function.

Sound producing organs, light producing organs and colour production process.

Functional system

Digestive system: Morphology and histology of the alimentary canal; modifications of the digestive tract. Filter chamber- structure, types and functions.

Respiratory system: Structure and function; spiracles - structure and types.

Circulatory system: Morphology, function and haemocytes.

Excretory system: Morphology and types of Malpighian tubules; cryptonephridia.

Reproductive system: Morphology, male and female reproductive organs; types of ovarioles.

Nervous system: Morphology, central, peripheral and sympathetic nervous system.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function.* 5th edition. Cambridge University Press, New York.

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects.* 7th edition. Belmont, CA: Thomson Brooks/Cole, Australia.

Gullan, P.J. and Cranston, P.S. 2010. *The insects: An outline of entomology.* 4th edition. Blackwell Publishing, Ltd., Malden, MA, USA.

Richards, O.W. and Davies, R.G. (revised by Imm's, A.D.). 1997. *A General Text Book of Entomology.* The English Language Book Society and Mathuen & Co. Ltd., UK.

Ross, H.H. 1964. *A text book of entomology.* John Wiley and Sons, New York.

Snodgrass, R.E. 2004. *Principles of Insect Morphology.* Tata McGraw Hill Publ. Co. Ltd., New Delhi, India.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 613	**Insect Developmental Biology, Endocrinology and Molecular Biology**	**2**	**30**

Insect developmental biology

General concept and branches of developmental biology

Development in Insects:

Embryonic Development: Vitellogenesis and oogenesis; insect egg and their types, fertilization, zygote formation, cleavage, formation of blastoderm and germ band; gastrulation; germ band elongation and blastokinesis; organogenesis and hatching. Genetic control of embryogenesis.

Post Embryonic Development: Metamorphosis of insect**;** Types, larva and pupa; Histological changes in the metamorphic stages of insect.

Irregular development: parthenogenesis, paedogenesis, neoteny, hermaphroditism (mode of reproduction), viviparity.

Insect endocrinology

Introduction to endocrinology: General concepts and branches of endocrinology; types and function of hormone; types and function of pheromone.

Endocrine system: Neurohaemal organ in insect; endocrine control of insect reproduction, development.

Role of hormone in insect development and metamorphosis.

Insect Molecular Biology

Chromosomal and Extrachromosomal organisation of DNA in Insects.

Insect Genes and Genome organisation

Some basic tools of Molecular Biology: How to cut, copy, paste, measure and visualize DNA, Polymerase Chain Reaction, cDNA Cloning, DNA sequencing and analyzing the sequence data.

Application of Molecular Biology in Entomological Problems: Application in sex determination, Insect behavior, Insects systematics and Evolution, and for Pest Management Programs.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function.* 5th edition. Cambridge University Press, New York.

Hoy, M. A. 1994. *Insect Molecular Genetics: An Introduction to Principles and Applications*. Academic Press.

Kapoor, V.C. 1990. *Origin and evolution of insects*. Kalyani Publishers, New Delhi.

Klowden.M.J.2007. *Physiological systems in insects*. 2nd edition. Academic Press.

Nation, J.L. 2002. *Insect Biochemistry and Physiology.* 2nd edition. CRC Press, Florida, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 614	**Insect Behavioural Adaptations and Insect-Plant interactions**	**2**	**30**

Phylum Arthropoda

Basic responses and patterns of behaviour: Habituation; behavioural periodicity and clocks.

Functional aspects of behaviour: Displacement; orientation, navigation and homing.

Communications: Chemical, audio, visual, tactile and inter-specific communications.

Host selection and feeding: Phytophagous, blood feeding and entomophagous insects.

Defence: Behavioural, structural, chemical defences; colourational defenses

(e.g. cryptic colouration, flash patterns, warning colouration, mimicry) and group

defenses; Parental care and presocial behaviour.

Eusocial behaviour: Social wasps, bees, ants and termites.

Insect-plant Dynamics

Plant-insect herbivore relationships; mutualistic associations; pollination and insects.

Life histories and reproductive strategies.

References

Atkins, M.D.1980. *Introduction to insect behavior.* Macmillan Publishing Co. Inc., New York.

Matthews, R.W. and Matthews, J.R. 2009. *Insect behavior.* 2nd edition. Springer, New York.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 615	**Insect ecology and Biodiversity Management**	**2**	**30**

Introduction

Trophic relationship: Trophic structure of community; coevolution of plants and herbivores; coevolution of prey and predator; energy flow.

Impact of climate change on the life of insects; Theories on population regulation.

Ecological genetics: Polymorphism, balanced and transient polymorphism, industrial melanism and insect under pesticide stress.

Insect interactions: Competition, predation and parasitoidism, and the models proposed on these.

Insect dispersal; Insect migration; Photoperiodism.

Life budget: Concepts; life table on insects - construction and analysis.

Systems ecology: Concept; system measurement; system modelling.

Phase variations in insects, with particular emphasis on locust.

Insects of soil, litter, carrion and dung.

Diversity and stability at community level: Relative abundance (commonness and rarity of species), species diversity (species richness, species evenness, measures of diversity).

References

Begon, M. and Mortimer, M. 1981. *Population ecology - a unified study of animals and plants.* 3rd edition. Blackwell Science, Oxford, UK.

Krebs, C.J. 2009. Ecology - *The experimental analysis of distribution and abundance.* 6th edition. Pearson Benjamin Cummings, San Francisco.

Odum, E.P. 2004. *Fundamentals of Ecology.* 5th edition. Cengage Learning, Boston, MA, USA.

Price, P. W., Denno, R. F., Eubanks, M. D., Finke, D. L. and Kaplin, I. 2011. *Insect Ecology.* Cambridge University Press.

Riklefs, R.E. 1979. *Ecology*. Thomas Nelson and Sons Ltd., USA.

Varley, G.C., Gradwell, G.R. and Hassell, M.P. 1980. *Insect population ecology- an analytical approach.* Blackwell Scientific Publications, Oxford, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 616	Insect Pest and Pest Management	2	30

Status of pests and nature of damage.

Pest control methods: Physical, cultural, biological, and legal control.

Integrated Pest Management (IPM): Components and advantages; Cost-benefit analysis; How to design, develop and implement a practical IPM system. A successful case study of IPM. Methods of pesticide application.

Insect pest sampling techniques; Bioassay techniques.

Development of pest management programmes for certain pests and crops: Jute hairy caterpillar on jute plant, rice hispa on rice crops and sugarcane stem borer on sugarcane.

Biology, life history, nature of damage and control measures of the following pests:

Jute pests- jute semilooper and jute mites; Sugarcane pests- sugarcane stem borer; Rice pests- rice ear-cutting caterpillar and rice hispa; Vegetable pests- potato tuber worm, epilachna beetle and mustard aphid; Fruit tree pests and fruit pests- mango stem and shoot borer, citrus leaf miner and palm beetle; Tea pests- flush pests and root pests.

Biology, nature of injury and control measures of major and minor insect pests: Forest trees and vegetation; Stored grains- red flour beetle, rice meal moth and saw- toothed grain beetle.

References

Kabir, A.K.M.F. 1975. *Jute pests of Bangladesh.* Bangladesh Jute Research Institute, Dhaka, Bangladesh.

Metcalf, C.L., Flint, W.P. and Metcalf, R.L. 1962. *Destructive and useful insects*. McGraw Hill Book company, New York.

Pedigo, L.P. 2002. *Entomology and Pest Management.* 4th edition. Prentice-Hall of India Pvt. Ltd., New Delhi, India.

Proceedings of the SAAR. *Workshop on Rice Hispa 28-29 December, 1986.* Organized jointly by BRRI & BARC, Bangladesh Rice Research Institute, Dhaka.

Sana, R.I. 1989. *Tea Science.* Ashrafia Boi Ghar, Bangla Bazar, Dhaka.

Van Driesche, R.G. and Bellows, T.S. 1996. *Biological Control.* Chapman and Hall, New York.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 617	Toxicology and Impacts on Ecosystem	2	30

Definition, classification of toxic compounds: The WHO recommended classification of pesticides by hazards. Brief outlines of insecticides, acaricides, nematocides, rodenticides, fungicides, and herbicides Systemic insecticides for plants and animals.

Inorganic insecticides and Synthetic organic insecticides: Arsenic, fluorine, lead and sulphur compounds preparation – Residual period, doses, method of use and mode of action of these compounds. Phenolic compounds, chlorinated hydrocarbons, organophosphates, carbamates, cyclodiene compound and naphthalene derivatives. Residual period, doses, method of use and mode of action of these compounds.

Organic insecticides of plant origin: Pyrethrines, nicotine, rotenone. Sources, use, doses, types and mode of action of these compounds

Fumigants: Methyl bromide, HCN, carbon bisulphides, sulphur dioxide, chloropicrin, carbon tetrachloride, ethyl dibromide, nicotin and phostoxin. Use, mode of action and general precautions to be followed in fumigation.

Miscellaneous

Attractants, repellents, antifeedants, chemosterilants, insect growth regulators and synergistic compounds. Insecticide resistance including detoxification mechanisms. Formulation of insecticides. Appliances for dissemination of insecticides. Dose determination.

References

FAO and WHO. 2002. *Manual on development and use of FAO and WHO specifications for pesticides.* FAO and WHO joint meeting on pesticide specifications. 255pp.

Metcalf, C.L. and Flint, W.P. 1962. (revised by R.I. Metcalf). *Destructive and Useful Insects- their habits and control.* Tata McGraw Hill Pub. Co. Ltd., New Delhi.

Pedigo, L.P. 2002. *Entomology and Pest Management.* 4th edition. Prentice-Hall of India Pvt. Ltd., New Delhi.

International programme on chemical safety, a cooperative agreement among FAO, ILO, UNEP, UNIDO, UNITAR, WHO and OECD. 2009. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification. 78pp.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 618	**Medical and Veterinary Entomology**	**2**	**30**

Medical entomology

General introduction; Biology, life-history, host-parasite relationship and control measures of the following: General introduction; Biology, life-history, host-parasite relationship and control measures of the following: (a) mosquitoes; (b) sandflies; (c) fleas; and (d) ticks and mites.

Brief outline of the following insects and the diseases they carry: (a) house flies; (b) horseflies and deerflies; (c) black flies; (d) tsetse flies; (e) bed bugs; (f) triatomine bugs; and (g) lice. Myiasis: definition and types;

Epidemiology: Including infection, dispersion, life cycle of pathogen and control measures of the following diseases: (a) malaria; (b) leishmaniasis; (c) filariasis; (d) arbovirus diseases (dengue and yellow fever). Maggot therapy.

Forensic entomology: Concept; Insect in crime detection and significance.

Veterinary entomology

General introduction; ectoparasites of cattle sheep, goats and birds: ticks, mites, flies, fleas and lice (Clinical features, diagnosis and treatment).

Emerging vector borne diseases and global impact

Global climate change, important vector borne diseases of the world, and new dynamics in global veterinary and public health. Medical and Veterinary entomology influencing public policy: Vector-control programs in underdeveloped, developing and developed countries.

References

Herms, W.B. and James, M.T. 1961. *Medical Entomology*. The Macmillan Company, New York.

Kettle, D.S. 1984. *Medical and Veterinary Entomology*. Croom and Helm Publishing, UK.

Lane, R.P. and Crosskey, R.W. 1993. *Medical insects and arachnids*. The Natural History Museum and Chapman & Hall, London.

Service, M.W. 1997. *Medical entomology*. Chapman and Hall, London.

Shearer, R.W. 1997. *Veterinary Entomology*. Chapman and Hall, London.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 619	**Insect Bioresources, Management and Conservation**	**2**	**30**

Bioresources

Introduction to bioresources: Definition, value of bioresources, category of bioresources, bioresource pool, classification of natural resources, insects as bioresource.

Apiculture: Introduction, scope, honey producing bees, bee colony, caste system, development of bee, relationship between the elements of a bee colony, swarming, methods of apiculture, seasonal management of honey bees, organization of work in apiculture, origin and importance of beekeeping, pests and diseases, royal jelly, pollination.

Sericulture: Introduction, scope, silk producing moths, rearing of silk worms, methods of sericulture, seasonal management of silk worms, organization of work in sericulture, pests and diseases.

Lac culture: Introduction, scope, lac producing insects, rearing of lac insects, methods of lac culture, seasonal management of lac insects, organization of work in lac culture, pests and diseases.

Colonization of butterflies: Introduction, scopes, colonizing materials, colonization process and a model of colonization system.

Butterfly farming: Introduction, scopes, brief history, farming process with examples.

Management and conservation

Management and conservation: Definition and concepts; conservation methods and techniques - *ex-situ* and *in-situ*. Conservation of beneficial insects. Prey-predator conservation. Diversity assessment; protected area management through insect conservation. Insect conservation for the twenty first century.

References

Bashar, M. A. 2004. *Instant Basics of Environment.* Positron Publication, Dhaka, Bangladesh.

Bashar, M. A. 2013. *Butterfiles of Bangladesh.* Vols. 1 & 2. Biodiversity Conservation Trust Fund (BCTF) Publications, Dhaka, Bangladesh.

Ganga, G. and Chetty, J. S. 1991. *An Introduction to Sericulture*. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi, India.

Glover, P.M. 1937. *Lac Cultivation in India*. 2nd edition., Indian Lac Research Institute, Ranchi, India.

Jean-Prost, P. 1994. *Apiculture*. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, India.

Jordan, C.F. 1995. *Conservation.* John Wiley & Sons Inc., New York.

Primack, R. B. 2008. *A Primer of Conservation Biology*. 4th edition., Sinauer Associates, Inc., Sunderland, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 620	**Insect Epizootiology and Disease Dynamics**	**2**	**30**

Definition, introduction, objectives and etiology. Causes of disease; Difference between epidemiology and epizootiology. Epizootic and enzootic infections;

Measurements: Basic measurements and observations in Epizootiology; Prevalence and Incidence.

Pathogen transmission in insects: Methods of pathogen transmission; dissemination in insects.

Insect diseases caused by viruses, bacteria, fungi, protozoans and nematodes: pathogenic families; route of entry of pathogen into insect host, dissemination of diseases into insects.

Prevention of insect diseases.

Applied Epizootiology: Microbial control of insects.

References

James, R.F. and Tanada, Y. 1987. *Epizootiology of insect diseases*. John Wiley & Sons, New York.

Pelczar, M.J., Chan, E.C.S. and Krieg, N.R. 2006. *Microbiology.* Tata MacGraw Hill Co., New Delhi, India.

Course No.	Course Title	No. of Credits	Credit Hours
ZE 652	**Practical Entomology (Gr-A)**	**6**	**90**

Comparative external structures of the common insects of following orders: Exopterygote orders - Odonata, Orthoptera, Hemiptera and Homoptera; Endopterygote orders - Coleoptera, Diptera, Lepidoptera and Hymenoptera.

a. Head: Including antennae and types; mouthparts - their types and modification due to feeding habits;

b. Thorax: Including segments; legs and their functional modifications; wings - their articulation and venations;

c. Abdomen: Segmentation; appendages, male and female genitalia, ovipositor, and aedeagus and associated structures.

Mounting of mouth parts, Permanent mounting of wing, leg, and sex organs, mounting of economically important insects.

Study of the functional systems of insects through dissection of common insects of following orders: Orthoptera, Hemiptera, Diptera, Coleoptera and Hymenoptera:

a. Digestive system: Structural variations related to feeding habits;

b. Circulatory and Endocrine system: Different types of haemocytes and neuro-haemal organs of insects.

c. Reproductive system: Male and female systems- testis, ovary and ovariole;

d. Nervous system: Nerve cord, ganglia and connectives;

Study of the flight muscles of insects.

Identification of insects up to family, genus and species (including both exopterygote and endopterygote insects).

Insects, ticks, mites and spiders of medical and veterinary importance.

Economically important insects (beneficial and harmful).

Types of larvae and pupae of insects; Preparation of whole mounts of larvae and pupae of insects; Preparation of histological slides of the larvae, pupae and adults of insect.

Rearing of insects in the laboratory: Mosquitoes, fruit flies, potato tuber moth, and stored grain pests.

Insect sampling: Sampling methods; data collection, procedure of data analysis and concluding remarks.

Bioassay technique (Dose-Response Technique): Test procedure, data recording, data analysis and concluding remarks.

References

Chapman, R.F., Simpson, S.J. and Douglas, A.E. 2013. *The Insects: Structure and Function*. 5th edition. Cambridge University Press, New York.

Johnson, N.F. and Triplehorn, C.A. 2004. *Borror and DeLong's Introduction to the study of Insects*. 7th edition. Belmont, CA: Thomson Brooks/Cole, Australia.

Kettle, D.S. 1984. *Medical and Veterinary Entomology*. Croom and Helm Publishing, UK.

Metcalf, C.L., Flint, W.P. and Metcalf, R.L. 1962. *Destructive and useful insects*. McGraw Hill Book company, New York.

Pedigo, L.P. 2002. *Entomology and Pest Management*. 4th edition. Prentice-Hall of India Private Ltd., New Delhi, India. India Pvt. Ltd., India.

Service, M.W. 1997. *Medical entomology*. Chapman and Hall, London.

Snodgrass, R.E. 2004. *Principles of Insect Morphology*. Tata McGraw Hill Publ. Co. Ltd., New Delhi, India.

ZE 656	**Thesis (Gr-B)**	**6 credits**
ZE 657	**Review and Seminar**	**2 credits**
ZE 658	**Viva voce**	**2 credits**

MS in Zoology (Wildlife and Conservation Biology)

Course No.	Course Title	No. of Credits	Credit Hours
ZW 625	Wildlife Ecology and Biogeography	4	60

Wildlife Ecology

Introduction to wildlife and wildlife ecology

Review of wildlife and wildlife ecology from national and global perspective;
Historical and present status and distribution of ecologically and taxonomically important wildlife of Bangladesh.

Ecosystem and population process

Concept and types of biomes and ecosystems;
Edge, ecotones, and interspersion;
Population dynamics;
Dispersal, dispersion and distribution;
Population regulation and fluctuation;
Competition within and between species;
Predation ecology.

Wildlife and habitat surveys

Census, total counts, estimates, and indices;
Methods and logic of sampled counts;
Indirect estimates of population size;
Point and quadrat sampling of habitats;
Use of mapping in wildlife and habitat survey;
EIA with special focus on baseline and interview survey, critical habitat assessment and impact assessment of wildlife and habitat.

Community ecology

Community structure;
Resource partitioning, niche and competitive exclusion;
Successional changes in wildlife community.

Adaptation

Adaptation, types of adaptation and adaptive radiation;
Examples of adaptations;
Theory of natural selection;
Types and characteristics of abiotic environment.

Biogeography

Introduction to Biogeography

Basic principles and philosophy;
Relationship with other sciences.

Biogeographic patterns

Status and distribution of species at individual and population levels;
Distribution of communities in space and time;
Continental drift.

Biogeographic process

Dispersal and range extension;
Mechanism of movement and nature of barriers;
Dispersal routes.

Geography of diversification

Endemism, cosmopolitanism and disjunction;
Barriers between biographic realms and biotic interchange;
Divergence and convergence of isolated biotas.

Island biogeography

Patterns of species richness in islands;

Island biogeography theory;
Assembly and evolution of insular communities.

References

Bolen, E.G. and Robinson, W.L. 2003. *Wildlife Ecology and Management*, 5th edition. Prentice Hall, Upper Saddle River, New Jersey, USA.

Chapman, J.L. and Reiss, M.J. 1998. *Ecology: Principles and Applications*. Cambridge University Press, Cambridge, UK.

Grimmett, R., Thompson, P. and Inskipp, T. 2021. *Field Guide to the Birds of Bangladesh*. Bloomsbury Publishing.

Hasan, M.K., Khan, M.M.H. and Feeroz, M.M. 2014. *Amphibians and Reptiles of Bangladesh: a field guide*. Arannayk Foundation.

Kabir, S.M.H., Ahmad, M., Ahmad, A.T.A., Rahman, A.K.A. Ahmad, Z.U., Begum, Z.N.T., Hasan, M.A. and Khondker, M. 2009. *Encyclopedia of Flora and Fauna of Bangladesh*. Volume 25-27, Asiatic Society of Bangladesh, Dhaka.

Khan, M.A.R. 2010. *Wildlife of Bangladesh from Amphibia to Mammalia- a Checklist*. Shahitya Prakash, Dhaka, Bangladesh

Khan, M.A.R. 2015. *Wildlife of Bangladesh Checklist and Guide*. Chayabithi, Dhaka, Bangladesh.

Khan, M.M.H. 2018. *Photographic Guide to the Wildlife of Bangladesh*. Arannayk Foundation, Dhaka, Bangladesh.

Lomolino, M.V., Riddle, B.R and Brown, J.H. 2006. *Biogeography*. 3rd edition. Sinauer Associates, Inc. Blackwell Publishing Ltd., UK.

Maurer, B.A. 1994. *Geographical population analysis: Tools for the analysis of biodiversity. Methods in ecology*. Blackwell Scientific, Oxford, U.K.

Sinclair, A.R.E., John, M.F. and Cavghley, G. 2006. *Wildlife Ecology, Conservation and Management*. Sunderland, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 626	**Conservation Biology**	**4**	**60**

Conservation Biology

History, concepts and scopes;

Emergence of conservation biology;

Setting conservation priorities-distinctiveness, endangerment and utility;

Concepts of sustainable development, measures for conservation and sustainable use of wildlife resources;

Invasive species and their management.

Biodiversity conservation and climate change

Global fingerprint of climate change on biodiversity;

Climate change in ecosystems-species loss and system degradation;

Conservation planning and policy initiatives for climate change.

Conservation genetics and genetic management

Genetics in wildlife conservation;

Genetic drift;

Genetic consequences of small population;

Inbreeding and species extinction;

Genetical problem of endangered species in the wild.

Conservation of populations

Effective and small population;

Metapopulations and population fragmentation;

Population viability analysis and minimum viable population;

Management of small population;

Recovery strategies for threatened species.

Conservation of habitat and landscape

Concept and importance of habitat heterogeneity;

Landscape gradients and patch dynamics;

Problem of habitat loss isolation and fragmentation;

Managing habitat connectivity and role of corridors;

Strategies for restoration of degraded habitats and ecosystems;

Management plan for threatened species;

Management plan of protected areas.

References

Dudley, N. (Editor). 2008. Guidelines for Applying Protected Area Management Categories. Gland, Switzerland: IUCN. x + 86pp. WITH Stolton, S., P. Shadie and N. Dudley (2013). IUCN WCPA Best Practice Guidance on Recognising Protected Areas and Assigning Management Categories and Governance Types, Best Practice Protected Area Guidelines Series No. 21, Gland, Switzerland: IUCN. xxpp.

Dyke, F.V. 2008. *Conservation Biology- Foundations, Concepts and Applications.* Springer Science-Business Media, New York.

Ferriere, R., Dieckmann, U. and Couvet, D. 2004. *Evolutionary Conservation Biology.* Cambridge University Press, Cambridge, UK.

Groombridge, B. 1992. *Global Biodiversity.* World Conservation Monitoring Centre. Global Biodiversity: Status of the Earth's living resources. Chapman & Hall, London.

Macdonald, D.W. and Service, K. 2007. *Key Topics in Conservation Biology.* Blackwell Publishing Ltd., UK.

Miffe, O.K. and Carroll, C.R. 1997. *Principles of Conservation Biology.* Sinauer Associates. Inc. Publ., Sunderland, Massachusetts, USA.

Mills, L.S. 2007. *Conservation of Wildlife Populations: Demography, Genetics and Management*. Blackwell Publishing Ltd., UK.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A. and Kent, J. 2000. *Biodiversity hotspots for conservation priorities.* Nature 403 (6772): 853-858.

Primack, R.B. 2014. *Essentials of Conservation Biology*. 6th Edition. Sinauer Associates, Inc., USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 627	**Behavioural Ecology and Anthrozoology**	**4**	**60**

Behaviour, ecology and evolution

Principals of evolutionary theories;

Questions about behaviour;

Genes and behaviour;

Phenotypic plasticity;

Environmental influences upon behaviour.

Testing hypotheses in behavioural ecology

Breeding behaviour in relation to predation risk;
Social organizations in birds and mammals;
Comparative approach to ecology and behaviour;
Using phylogenies in comparative analysis.

Economic decisions

The economics of carrying capacity and prey choice;
The risk of starvation;
Environmental variability, body reserves and food storing;
The cognitive decisions;
Feeding and danger: a trade-off;
Social learning.

Interspecies interactions

Symbiosis;
Predator versus prey: anti-predatory adaptations;
Evolutionary arms race.

Intraspecies interaction

Group living- benefits and costs;
Optimal group size;
Sexual selection and conflicts;
Parental care and family conflicts;
Mating system and sex allocation;
Kin selection;
Altruism, Selfishness and Spiteful;
Cooperation;
Communications and signals.

Human-wildlife conflicts and coexistence

Conflicts and coexistence;
Threats to human safety;
Anthropogenic factors influencing human-wildlife conflicts;
Human perceptions influencing human-wildlife conflicts;
Human-tiger, human-elephant and human-primate conflicts and coexistence in Bangladesh;
Strategies of conflicts resolution.

Economics of human-wildlife coexistence

Economic and social benefits of human-wildlife coexistence;
Economic and social losses of human-wildlife coexistence;
Compensation policies: global perspective;
Compensation policies for casualties caused by wildlife in Bangladesh.

References

Bateson, M., and P. Martin. 2021. Measuring behaviour: an introductory guide. 4th edition. Cambridge university press.

Conover, M. R., and D. O. Conover. 2022. Human-wildlife interactions: from conflict to coexistence. 2nd edition. CRC Press.

Davies, N., J. R. Krebs, and S. A. West. 2012. An introduction to behavioural ecology. 4th edition. Wiley Blackwell Scientific.

IUCN Resolution WCC. 2020. Res-101 Addressing human-wildlife conflict: fostering a safe and beneficial coexistence of people and wildlife. iucncongress2020.org/motion/117

IUCN. 2023. IUCN SSC guidelines on human-wildlife conflict and co-existance. 1st edition. Gland, Switzerland.
Krebs, J. R. and Davies, N. 1997. Behavioural Ecology: An Evolutionary Approach. 4th Edition. Wiley-Blackwell Scientific.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 628	**Wildlife Resource Management**	**4**	**60**

Human Dimension of wildlife
Values of wildlife to human;
Wildlife resources of Bangladesh with special reference to economically important species prospect and feasibility, scope and methods of farming of frogs, crocodilians, turtles, snakes and deer.

Wildlife resource management strategies
Wildlife control and techniques for managing wildlife population;
Management of wildlife habitats;
Endangered species management;
Managing landscapes and modified habitats (e.g., fragmentation and corridors);
Use of satellite imagery and GIS in assessing modified habitats.

Protected area management
Coverage, spatial distribution and management of protected areas [national parks, sanctuaries, Ramsar sites, World heritage sites, Ecologically Critical Areas (ECA), Important Bird Areas (IBAs) in Bangladesh;
Management of protected areas and case studies from Southeast Asian countries;
Threats management.

Captive breeding and re-introduction
Role of zoological garden and safari park in wildlife conservation;
Developing and maintenance of captive habitat and their management;
Role of captive breeding in re-introduction of endangered species.

Disease management in wildlife
Basic principles;
Disease investigation and management strategies;
Management of over bounded and pest populations.

Wildlife Conservation Laws and Acts
Principles, overview;
Roles of laws, acts, conventions and treaties relating to wildlife conservation;
Wildlife crimes and their impacts;
Wildlife forensics;
Salient features of Wildlife (Conservation and Security) Act, 2012.

References

Bolen, E. G. and Robinson. W. L. 2003. *Wildlife Ecology and Management*, (5th edition). Prentice Hall, Upper Saddle River, New Jersey. 605pp.

Fryxell, J.M., Sinclair, A. R. E., and Cavghley, G. 2006. *Wildlife Ecology, Conservation and Management*. Blackwell Publishing Ltd.

Gilbert, F. F. and Dodds, D. G. 2001. The Philosophy and Practice of Wildlife Management. *Third Edition. Malabar (Florida): Krieger Publishing*. 355 pp.

Giles, R.H. (eds.) 1971. *Wildlife: Management Techniques* (3rd eds.) Hardcover Wildlife Society, Washington.

Hobbs, R. J. (ed.). 2000. *Invasive species in a changing world*. Island Press. Washington DC, USA.

Hosetti, B. B. 2005. *Concepts in Wildlife Management*, 2nd Revised and Enlarge Edition. Daya Publishing House, Delhi.

IUCN. 2008. *Guidelines for Applying Protected Area Management Categories*.

Ranga, M.M. 2005. *Wildlife Management and conservation*. Dr. Updesh Purohit for Agrobios. India.

Saltz, D., White, G.C., 2013. *Wildlife Management*. In: Encyclopedia of Biodiversity (Second Edition), Levin, S.A. (ed.). Academic Press. 403-407 pp.

Wildlife (Conservation and Security) Act. 2012. Government of Bangladesh. Gazette no. 30(25).

Wobeser, G. A. 2007. *Disease in Wild Animals – Investigation and Management*. Springer-Verlag Berlin Heidelberg, Germany. 389 pp.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 629	**Conservation Outside Protected Areas and Bioinstrumentation**	**4**	**60**

Wildlife and Wildlife Conservation Outside Protected Areas

Principles of conservation outside protected areas;

Value of unprotected habitats.

Wildlife in human dominated lands and outside protected areas

(a) city, towns, bazaars, roads, highways, (b) rivers, streams, lakes, haors, baors (c) homestead forests, jungles, bushes, village common forests (d) areas of religious and cultural belief;

Key wildlife populations;

Past and present status and distribution of wildlife;

Threats and their consequences to wildlife population;

Protection/conservation measures of wildlife.

Management of human-dominated landscapes

Human dominated landscapes types and nature.

Community Conserved Areas (CCAs)

Definition, concept, types and nature of CCAs;

Significance of CCAs;

Threats and challenges to CCAs;

Management practices of CCAs in Bangladesh.

Social forestry

Definitions, concepts and components;

Impacts of social forestry on ecosystems and wildlife;

Laws and rules of social forestry.

Conservation strategies

Community-based awareness programmes;

Role of different stakeholder groups including relevant government departments and NGOs;

Ecological restoration techniques for damaged ecosystems and wildlife habitats;

Significance of ecological restoration.

Bioinstrumentation

Camera trap

History and types; basic structure;
Deployment strategies, surveys, monitoring and data recording;
Application in wildlife studies.

Drones

History, basic structure, types;
Surveys and monitoring;
Application in wildlife studies.

Telescope

Types and uses of telescope in wildlife studies.

Tranquillizer gun

History and basic structure;
Chemical bullets and calculation of doses for different animals;
Application of tranquilizer gun.

Radiotelemetry and radio transmitters

History and basic concepts;
Types of radio transmitters and collars for different animals;
Basic operations; data recording and analysis; real-time locating system (RTLS).

Global Positioning System (GPS)

History and basic concept, structure and basic functions;
Calibration and datum setting;
Application of GPS in wildlife studies.

Bird ringing

History and types of rings;
Terminology and techniques of bird ringing;
Wing tags, field readable rings and leg-flags.

Other instruments

Night vision binocular, night vision camera, digital video camera;
Automatic time laps camera, electronic pocket balance;
Electronic digital caliper, led-forehead lamp, sensitive electronic balance.

Other approaches

Acoustic ecology;
Types, sources, and utilization of citizen science data;
Application of Artificial Intelligence (AI) in wildlife research.

References

Abbasi, A. and Chari, K.B. 2005. *Application of GIS and Remote Sensing in Environmental Management.* Discovery, New Delhi, India.

Agarwal, S. and Rana, M.S. 1995. *Application of Telemetry in Wildlife Conservation.* Wildlife Institute if India, Dehra Dun, India.

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Hasan, M.K., Khan, M.M.H., Feeroz, M.M. 2014. *Amphibians and Reptiles of Bangladesh: A Field Guide.* Dhaka, Bangladesh, Arannayk Foundation.

IUCN Bangladesh. 2015a. *Red List of Bangladesh: A Brief on Assessment Result*. Volume 1: IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, pp. 24.
IUCN Bangladesh. 2015b. *Red List of Bangladesh Volume 2: Mammals*. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, pp. xvi+232.
IUCN Bangladesh. 2015c. *Red List of Bangladesh Volume 3: Birds*. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, pp. xvi+676.
IUCN Bangladesh. 2015d. *Red List of Bangladesh Volume 4: Reptiles and Amphibians.* IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, pp. xvi+320.
Khan M.A.R. 1982. *Wildlife of Bangladesh*. The University of Dhaka, Dhaka, 174 pp.
Khan, M.A.R. 2015. *Wildlife of Bangladesh*: *Checklist and Guide*. Dhaka, Chayabithi publication.
Khan, M.H., Aziz, M.A., Uddin, M., Saif, S., Chowdhury, S.U., Chakma, S., Chowdhury, G.W., Jahan, I., Aktar,
R., Myant, M.H., Mohsanin, S. 2012. *Community Conserved Areas in Chittagong Hill Tracts of Bangladesh.* Islam, M.A. (ed.). Wildlife Trust of Bangladesh, Dhaka, Bangladesh.
Primack, R.B. 2014. *Essential of Conservation Biology*. 6th edition. Sinauer Associates, Inc. Publ., Sunderland, Massachusetts, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZW 653	**Practical Wildlife and Conservation Biology (Gr-A)**	**6**	**90**

Morphometric and meristic study
Study of morphological structures, i.e. skulls, toes, claws, feathers and measurements;
Species profiling.
Wildlife survey techniques
Quadrat/plot sampling;
Transect sampling;
Point sampling;
Tracks and sign surveys;
Questionnaire surveys;
Ecological assignments and Field exercises.

Designing and performing a behavioural study
Types of study designs;
Categorizing behaviours;
Behavioural metrics;
Recording methods;
Data procession and analysis;
Behavioural assignments and Field exercises;
Animal preservation techniques
Wet preservation;
Dry preservation (taxidermy).
Bioinstrumentation
Camera trapping;
Aerial survey/ UAV methods;
GPS, telescope;
Animal handling tools;

Bird ringing.
Assignment Project

References

Altman, J. 1974. *Observational study of behavior: Sampling methods*. Behaviour. 49: 227-267. Martin, P. and Bateson, M., and P. Martin. 2021. Measuring behaviour: an introductory guide. 4th edition. Cambridge university press.

Rabinowitz, A. 1997. *Wildlife Field Research and Conservation Training Manual*. Wildlife Conservation Society, USA.

Khan M.A.R. 1982. *Wildlife of Bangladesh*. The University of Dhaka, Dhaka, 174 pp.

Khan, M.A.R. 2010. *Wildlife of Bangladesh from Amphibia to Mammalia- a Checklist*. Shahitya Prakash, Dhaka, Bangladesh

Khan, M.A.R. 2015. *Wildlife of Bangladesh*: *Checklist and Guide*. Dhaka, Chayabithi publication.

ZW 656	**Thesis (Gr-B)**	**6 credits**
ZW 657	**Review and Seminar**	**2 credits**
ZW 658	**Viva voce**	**2 credits**

MS in Zoology (Parasitology and Public Health)

Course No.	Course Title	No. of Credits	Credit Hours
ZP 635	**Parasite Systematics and Biology**	**2**	**30**

Parasite Systematics

Parasite systematics: Classification and phylogenetic relationship within taxa and among different taxa of parasitic animals from Protista to Arthropoda;

Parasite systematics in twenty first century: Opportunities and obstacles.

Parasite Biology

Parasite life cycle and development stages: From protista to arthropoda; historical perspective of parasite life cycle; an overiew of parasite life cycle; the establishment of infection: a) parasite entry into the host organism, b) resistant and dormant forms, c) active entry; site selection within the host: entry into specific organs and cells, maintenance and establishment in the host.

Parasite adaptation: Morphological, physiological/biochemical, life history, behavioural and immunological;

Reproduction strategies in different groups of parasites.

Transmission of parasites: Effective transmission; strategies other than high fecundity to achieve transmission; mathematical models to provide a useful tool to predict transmission rates'; common pathways of transmission, strategies to reduce parasite transmission.

References

Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, R. 2001. *Parasitism: the diversity and ecology of animal parasites.* University Press. Cambridge, UK.

Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.

Kennedy, C.R. 1975. *Ecological Animal Parasitology.* Blackwell Scientific Publication, Oxford, UK.

Lewis, E.E., Campbell, J.F. and Sukhdeo, M.V.K. 2002. *The behavioral ecology of Parasites.* CABI Publishing, UK.

Nobel, E.R. and Nobel, G.A. 1971. *Parasitology, The biology of animal Parasites.* Henry Kimpton, London.

Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology.* Wm. C. Brown Publishers, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 636	**Parasite Physiology and Biochemistry**	**2**	**30**

Parasite Physiology

Feeding and Nutritional Physiology

Structure of helminths aid in obtaining nutrition, ultrastructure of tegument and its role in feeding;

Alimentary canal as biotope for parasites, Surface enzymes in parasites;

Transtegumentary absorption of nutrients, mechanisms of solute entry and transport of molecules into parasites.

Oxygen consumption in helminths; requirements and utilization, O_2 as a terminal electron acceptor.

Carbohydrate, Protein, Lipid Metabolism and energy production

Carbohydrate, protein and energy metabolism in helminths, end-products of carbohydrate catabolism.

Role of oxygen in parasite energy metabolism; Homolactate fermentation; Malate dismutation; Electron transport in helminths.

Excretory System, Nitrogen Excretion, Water and Ionic Regulation

End-products of nitrogen metabolism; Ionic regulation and water balance.

Reproduction

Synchronization of parasite and host reproduction.

Parasite Transmission

Physiological mechanisms for locating the host; Physiological mechanisms for penetrating the host.

Establishment and growth of parasites

Physiological aspects of hatching mechanisms; Physiological aspects of migration and site selection.

Biochemistry

Biochemical Aspects of Developmental Processes

Egg shell formation in cestode, trematode and nematode;
Transformation of larval stages;
Hormones influencing development (Pheromones and other reproductive cues);
In-Vitro development in cestode, trematode and nematode.

Invasion Mechanism

Cellular invasion by protozoa and helminths;
Specific steps and pathways of invasion by helminths.

References

Smyth, J.D. 1969. The Physiology of Cestodes. Oliver and Boyd.
Smyth, J.D. 1966. The Physiology of Trematodes. Oliver and Boyd.
Smyth, J.D. 1994. Introduction to Animal Parasitology. Cambridge University Press.
Lee, D.L. 1965. The Physiology of Nematodes. Oliver and Boyd.
Saleuddin, A.S.M. and Fenton, M.B. 2004. Canadian Journal of Zoology. Vol. 82 (2). Chappell, L.H, Physiology of Parasites

Course No.	Course Title	No. of Credits	Credit Hours
ZP 637	**Molecular Biology of Parasites**	**2**	**30**

Molecular Phylogeny

Molecular phylogeny of helminths. The importance of phylogenetic study in the evolution of Parasites.

Molecular Biology

Molecular biology of protozoa and helminth parasites. Genetics and Gene expression. Advantages and launching of genetics investigations. Transcription in *Trypanosomes* and Nematodes. Trans-splicing mechanism.

Parasite genomics.
RNA processing in parasitic organisms: trans-splicing and RNA editing.
Transcription
Post-transcriptional regulation
Antigenic variation in African trypanosomes and malaria
Genetic and genomic approaches to the analysis of *Leishmania* virulence

Molecular interaction of transmission

Molecular aspects of an intimate association between trematode and snails.

References

Molecular Medical Parasitology, J. Joseph Marr, M.D., Timothy W. Nilsen, Richard W. Komuniecki
Boothroyd, J. C. and Komuniecki, R. 1995. *Molecular approaches to parasitology.* Vol. 2.
Lee, D. L. *The Physiology of Nematodes.* 1965. Oliver and Boyd.
Marr, J. J. and Mukker, M. 1995. *Biochemistry and molecular biology of parasites.* Academic Press, Harcourt Brace and Company, New York.
Saleuddin, A. S. M. and Fenton, M. B. 2004. *Canadian Journal of Zoology.* 82 (2).

Smyth, J. D. *Introduction to Animal Parasitology.* 1994. Cambridge University Press.
Smyth, J. D. *The Physiology of Cestodes.* 1969. Oliver and Boyd.
Smyth, J. D. *The Physiology of Trematodes.* 1966. Oliver and Boyd.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 638	**Immunology**	**2**	**30**

Components of Immune System

Introduction to the immune system; Cells, tissues and organs of the immune system; Antibodies and immunoglobulins; Complement; T cell receptors and MHC molecules.

Modes of Immune Response

Mechanisms of innate immunity; Antigen presentation and processing; T cell maturation, activation and differentiation; B cell generation; Activation and differentiation; Immune responses in tissues.

Defence Against Infectious agents

Immunity to viruses; Immunity to bacteria and fungi; Immunity to protozoa and worms; Primary immunodeficiency; AIDS and secondary immunodeficiency; Vaccination.

Immune Responses against tissues

Immunological tolerance; Autoimmunity and autoimmune diseases; Transplantation and rejection; Immunity to cancers.

Hypersensitivity

Immediate hypersensitivity type I; Hypersensitivity type II; Hypersensitivity Type IV.

Immunological Techniques

References

Roitt, I., Brostoff, J. and Male, D. 2001. *Immunology.* 6th edition. The University of Wisconsin Press, Medison, Wisconsin, USA.
Osborne, B.A. and Kuby, J. 2000. Immunology. 7th edition. Macmillan International Publication, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 639	**Pathology and Medical Microbiology**	**2**	**30**

General Pathology

Etiology of diseases. Histopathology of infected host tissues; Types of cellular changes. Inflammation and its types. Healing processes. Tumors, ulcers and anemia. Pathology of parasitic diseases of fish, birds and mammals.

Clinical Pathology

Planning a clinical chemistry laboratory. Collection and transport of specimens. Biochemical analysis; Constituents of blood and urine. Techniques for examination of- stool, urine and blood.

Medical Microbiology

Clinical manifestation, Pathogenesis, virulence factors and control of the following pathogenic microbes**:** *Mycobacterium tuberculosis, Vibrio cholerae, Escherichia coli, Salmonella typhi*.

Virus: Influenza, measles, mumps, chicken pox.

Fungi: *Tinea versicolor*, *Candida*.

References

Cheesbrough, M. 1987. *Medical Laboratory Manual for Tropical Countries.* ELBS Publishing, UK.
Jawed, E., Melnik J.L. and Edward, A. 1980. *Review of Medical Microbiology*. Adel berg, Lange Medical Publications, California, USA.

Khaleque, K.A. and Mannan, K.Z. 2001. *Practical Pathology and Microbiology.*Aleya House, Dhaka, Bangladesh.
Ribulin, W.E. and Migaki, G. 1975. *Pathology of fishes.* The University of Wisconsin Press, Wisconsin, USA.
Bacterial Pathogenesis: A Molecular Approach / By Abigall A. Salyers and Dixie D. Whitt –
ASM Press, 2002 (2nd Ed.).
Jawetz, Melnick and Adelberg's Medical Microbiology / Edited by Karen C. Carroll, Stephen A. Morse, Timothy Mietzner, Steve Miller – McGraw Hill Education, 2016 (27th Ed.).
Principles of Virology (2 Vol. Set) / By S. Jane Flint, Lynn W. Enquist, Vincent R. Racaniello, Anna Marie Skalka – ASM Press, 2008 (3rd ed.).
Chester W, Chapman H.,Kwon-Chung.,Medical mycology,third edition.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 640	**Parasite-Host Ecology and Behaviour**	**2**	**30**

Parasite-Host Ecology

Introduction to parasite ecology: Definition; host as an environment; existence of parasites in the host as a milieu; Factors favoring the establishment of ecto-and endo-parasite; The role of parasites in the food web and ecosystem. Parasite effects on host ecology. Parasites as bioindicators of ecosystem health.

Communities and determinants of parasites: The kinds of communities of parasites; the kinds of parasites found in communities; the composition of parasite communities- species richness; parasite characteristics as determinants of species richness; ecological determinants of parasite species richness

Host specificity: Definition; kinds of parasite-host specificity; establishment of host-parasite system; phylogenetic aspects and factors responsible for host specificity. Comparative host specificity to genus and species levels. Ecological consequences of specificity.

Inter- and intra-specific relationships within a host: Intra-specific competition and crowding effects; Inter-specific relationships and ecological consequences of inter-specific reactions.

Dispersion of parasites within a host-parasite system: Definition; types of host-parasite system; Dispersion of parasites throughout a host population concerning age, behavior, movement, and sex of host.

Parasite-Host Behavior

Introduction to Behavioral Ecology: Causation of behavioral ecology: Host finding, host acceptance and infection. Behavior of infected host/ modified host behavior owing to parasites; Behavior of parasites within their host.

Behavioral interactions of parasite-host: Parasite manipulation of host behavior; Functional role of manipulation of behavior; Phylogenetic evolution of manipulation; Mechanisms of manipulation.

Parasite manipulation of vector behavior: Introduction, model of blood-feeding behavior-Haematophagy; steps of blood-feeding: The appetitive search, the activation and orientation, attraction and landing & probing.

Behavioral alterations and parasite transmission: Introduction, transmission by intermediate hosts, transmission by arthropod vectors, behavior enhances host-parasite survival, parasitic castration & host behavior, and fecundity reduction & altered behaviors.

References

Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, R. 2001. *Parasitism: the diversity and ecology of animal parasites.* University Press. Cambridge, UK.
Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.
Kennedy, C.R. 1975. *Ecological Animal Parasitology.* Blackwell Scientific Publication, Oxford, UK.

Lewis, E.E., Campbell, J.F. and Sukhdeo, M.V.K. 2002. *The behavioral ecology of Parasites.* CABI Publishing, UK.
Nobel, E.R. and Nobel, G.A. 1971. *Parasitology, The biology of animal Parasites.* Henry Kimpton, London.
Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology.* Wm. C. Brown Publishers. USA.
Janice Moore 2002. Parasites and the behavior of animals. Oxford University Press.
Goater T.M, Goater C.P, and Esch G.W 2014. Parasitism, the diversity and ecology of animal parasites. Cambridge University press.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 641	**Parasite diversity and Population dynamics**	**2**	**30**

Parasite diversity

Basic concepts: Origins and known diversity of parasites; A primer in parasite ecology.

Estimating parasite diversity: Recognizing parasite diversity; sampling effects and extrapolating diversity; Extrapolation of global parasite species richness; The parasites basic reproductive number, Ro; Host features and Parasite species richness; Epidemiological Models and Parasite Ecology.

Hosts as drivers of parasite diversity: Host Parasite co evolution: Association by descent and colonization; Hosts as islands; Host traits and parasite species richness; Relationship between parasite diversity and host diversity.

Parasite features and parasite diversification: Intra host speciation and congeneric parasites; Parasite body size and parasite diversification; Other parasite features and parasite diversification.

Parasite biogeography and phylogeography: Historical biogeography and parasite diversity; Parasites are where the hosts are; Latitudinal gradients in parasite diversity; other gradients in parasite diversity; Host introductions and parasite species richness.

Parasite extinctions: Causes of parasite extinctions; Dynamics of local parasite extinctions; Estimated rate of global parasite extinctions.

Parasite diversity driving host evolution: Parasites and host life history traits; Host metabolism and parasites; Parasites and Host investment in immune functions; Parasites and evolution of the MHC; Parasites, host sex and host sexual selection.

Study and value of biodiversity: Parasite biodiversity- past, present and future; Why bother about parasite diversity; Parasite diversity as a conservation target.

Population Dynamics

Basic concepts: Speciality of parasite population dynamics; factors governing parasite population dynamics; models of parasite population dynamics. Transmission thresholds: Direct and indirect transmission in microparasite and macro parasites. Breakpoints in parasite transmission, population dynamics of malaria.

References

Bush, A.O., Fernandez, J.C., Esch, G.W. and Seed, R. 2001. *Parasitism: the diversity and ecology of animal parasites.* University Press. Cambridge, UK.
Poulin, R. and Morand, S. 2004. *Parasite Biodiversity.* Smithsonian Books, Washington DC, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 642	**Epidemiology and disease control**	**2**	**30**

Epidemiology

Introduction and basic concept, Scope of Epidemiology in Parasitology, Modes and dynamics of disease transmission.

Measuring the occurrence of disease – mortality, morbidity, proportion, standardization, rates and ratios. Measures of disease occurrence and measures of association.

Transmission and exposure status.

Epidemiological analysis and biological monitoring.

Natural history of disease, types of epidemiological studies, environmental epidemiology.

Association and causation, Case control study, Cohort study.

Estimating risk, estimating the potential of prevention.

Epidemiology, health services and health policy, ethical and professional issues in epidemiology.

Disease Control

Concept and history of disease control.

Geo-medical aspects of parasitic diseases.

Parasite control – principles, designs and case studies; challenges of parasite control.

Vector control – principles, designs and case studies.

References

Gordis, L. Epidemiology. 4th Edition. Saunders, an imprint of Elsevier Inc. PP- 375.

Basheer, A. 1995. Environmental Epidemiology. Rawat Publications. New Delhi. India. PP-174.

Fletcher, R. H. and Fletcher, S. W. 2005. Clinical Epidemiology – The Essentials. 4th Edition. Lippincott Williams & Wilkins, USA. Pp- 252.

Rothman, K. J., Greenland, S. and Lash, L. T. 2008. Modern Epidemiology. 3rd Edition. Lippincott Williams & Wilkins, USA. Pp- 758.

Nelson, K. E. and Williams, C. M. Infectious Disease Epidemiology: Theory and Practice. 2nd Edition. Jones and Bartlett Publishers. London/Toronto. PP-1207.

Cox, F.E.G. 1993. *Modern Parasitology*. 2nd edition. Blackwell Science, UK.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 643	**Public Health Parasitology**	**2**	**30**

Public health: Basic concept, significance, history and evolution of public and community health, terms related to public health.

One Health: Concept of one health, principles of one health application, one health in Bangladesh.

Concept of health and disease: Definition of health, concept of health, changing concept of health, dimensions of health, determinants of health, health indicators, indicators selected to monitor the progress of health for all, health care of the community, comprehensive health care, primary health care (PHC). Definition of disease, concept of disease, theories of disease causation, factors, surveillance, prevention of diseases.

Public health management: Principles of public health management, laws and ethics.

Public health biology: Definition and classification of diseases of public health interest, epidemiology of communicable diseases (respiratory infections, intestinal infections, arthropod-borne infections, zoonosis, etc.), epidemiology of non-communicable diseases, emerging and re-emerging diseases. Modern travel and transmittable diseases.

Public health and nutrition: Nutritional status and problem in Bangladesh, nutritional diseases and their prevention, food safety, and hygiene.

Environment and health: Definition of environment, environmental factors on public health, water and water-borne diseases, air pollution and airborne diseases, noise and factors related to its harmful effects, radiation and effects of radiation, meteorological environment and green-house effects, humidity, housing, disposal of wastes and excreta, soil pollution, risk assessment of environmental health and climate health.

Health programs in Bangladesh: Introduction**,** Sustainable developmental goals (SDG), Millennium Developmental Goals (MDG), Health and population sector programs (HPSP), Health nutrition and population sector programs (HNPSP), and Residential field site training (RFST).

International health organizations and NGOs

International organizations working with health in Bangladesh:

World Health Organization (WHO), United Nations Development Programme (UNDP), United Nations Fund for Population Activities (UNFPA), International Red Cross & Red Crescent Movement, International Centre for Diarrheal Disease Research Bangladesh (ICDDR'B), United Nations International Children's Emergency Fund (UNICEF), United Nations Environment Programme (UNEP), World Bank, Food and Agriculture Organization (FAO), United States Agency for International Development (USAID), and Asian development Bank (ADB).

Some international NGOs include Helen Killer International, CARE, The Asia Bangladesh, and Save the Children Fund.

Local/National GOs/NGOs: DPH (Department of Public Health), Bangladesh Rural Development Committee, Gonoshasthya Kendra, Community Health Research Association, Bangladesh National Society for the Blind, Bangladesh Red Crescent Society, Rotary and Lions Club in Bangladesh, Bangladesh Rural Advancement Committee (BRAC).

Merits and demerits of non-govt. organization.

References

Park, K. 2014. *Park's Text Book Preventive and Social Medicine.* 22nd edition. M/s BanarsidasBhanot Publishers, India.

Rahman, M., Alamgir, A.K.M and Hafez, A. (ed.). 2012. *Rashid, Kabir, Hyders' Text book of Community Medicine and Public Health.* 5th edition, MAP Publishers, Dhaka, Bangladesh.

Rashid, K.M. Rahman, M. and Hyder, S. 2004. *Community Medicine and Public Health*. 4th edition. RHM Publishers, Dhaka, Bangladesh.

Reza, S. 2014 -2015. *The Essential of Community Medicine.* 12th Edition. Media Plex Medical Publisher and Distributor, Dhaka, Bangladesh.

Roger D., J. Mcewen, R. Beaglehole., and H. Tanaka. 2002. *Oxford textbook of Public Health Ed.* Oxford University Press (OUP) 4th Edition: 28.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 644	**Veterinary Parasitology**	**2**	**30**

General introduction; parasites of livestock and companion animals. Opportunities and importance of veterinary parasitology.

Protozoology: Brief biology, distribution, veterinary importance and control of following parasites: *Eimeria tenella, Sarcocystis neurona, Trypanosoma equiperdum, T. evansi, Cytauxyzoonosis felis, Babesia divergens, Haemoproteus columbae, Histomonas meleagridis, Leucocytozoon symondi, Plasmodium gallinaceum.*

Helminthology: Brief biology, distribution, veterinary importance and control of following parasites: *Ascaridia galli, Ascaris suum, Capillaria hepatica, Haemonchus contortus, Ancylostoma canium,*

Dicrocoelium dendriticum, Dictyocaulus viviparous, Dipylidium caninum, Dirofilaria immitis, Echinococcus granulosus, E. laeophorapoeli, E. schneideri, Fasciola giganticus, Fascioloides magna.

Entomology: Brief biology, distribution, veterinary importance and control of following parasites: *Haematomyzuse ephantis, Goniocotes gallinae, Columbicola columbae, Haematopinus suis, Comex lectularius, Nosopsyllus fasciatus, Ctenocephalides* spp., *Xenopsylla cheopis, Tabanus atratus, Musca domestica, Gasterophilus intestinalis, Ixodes* spp., *Dermacenter andersoni, Argas* spp.

Zoonosis: Basic concept, types, factors and potential zoonotic diseases.

Sustainable food production through livestock health management.

References:

Cheng, T.C. 1997. *General Parasitology*. Academic Press, USA.

Reinecke, R. K. 1983. Veterinary Helminthology. Butterworths Professional Publishers, South Africa.

Schmidt, G.D. and Roberts, L.S. 2000. *Foundations of Parasitology*. Wm. C. Brown Publishers, USA.

Soulsby, E.J.L. 1982. *Helminths, Arthropods and Protozoa of Domesticated Animals.* Bailliere Tindall Publishers, UK.

Williams, R. E. 2010. Veterinary Entomology Livestock and Companion Animals. CRC Press, USA.

Wobeser, G. A.1994. Investigation and Management of Disease in Wild Animals. Plenum Press, New York and London.

Course No.	Course Title	No. of Credits	Credit Hours
ZP 654	**Practical Parasitology and Public Health (Gr-A)**	**6**	**90**

Procedures for collection and preservation of specimens for parasitological studies.

Examination of parasites from intestinal tracts of invertebrate and vertebrate hosts.

Collection and preparation of blood and other body fluids for parasitological studies.

Examination of different living animal hosts (domestic and wild fish) for collection, preservation, mounting and identification of ecto- and endo- parasites.

Necropsy and inventory of parasites: case study.

Microscopic examination of blood smears for protozoan parasites.

Study of blood smears for differential count and cell morphology.

Parasitological examination of faecal samples.

Preparation and study of protozoan culture.

Survey of parasitic diseases: Recording data for parasitological research: Epidemiological analysis of parasitic infection.

Histopathological preparation and observation of parasite infected tissues.

Demonstration of molecular techniques: DNA extraction, PCR, gel electrophoresis, ELISA.

Research article and review article writing practices.

Designing plan for parasite control: case studies.

Assignment Project

References

Garcia, L.S. and Ash, L.R. 1975. *Diagnostic Parasitology Clinical Laboratory Manual.* The C.V. Mosby Company, USA.

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Tonguthai, K., Chinabut, S., Somsiri, T., Chanratchakool, P. and Kanchanakhan, S. 1999. *Diagnostic procedures and finfish diseases.* Aquatic Animal Health Institute, Bangkok, Thailand.

Yamaguti, S. 1959. *SystemaHelminthum. Vol. II. The cestodes of vertebrates.*Interscience Publishers Inc., New York.

Yamaguti, S. 1961. *SystemaHelminthum***.** *Vol III. The nematodes of vertebrates.*Interscience Publishers Inc., New York.

Yamaguti, S.1958. *SystemaHelminthum. Vol I. The trematodes of vertebrates.*Interscience Publishers Inc., New York.

ZP 656	**Thesis (Gr-B)**	**6 credits**
ZP 657	**Review and Seminar**	**2 credits**
ZP 658	**Viva voce**	**2 credits**

MS in Zoology (Genetics and Molecular Biology)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 645	Molecular Biology	4	60

Organization of genome

Nuclear genome-components; overview of human genome; chromatin condensation; chromosomal looping, nuclear neighbourhood, higher order chromatin structure, histone variants, centromere, modifications of histone tails, regulation and remodelling of chromatin; overview of circular genome-mitochondria and chloroplast.

DNA structure, mutation and repair of DNA, mt-DNA mutation and associated diseases

Functions of nucleotides, structure, tautomer and UV absorptions of nucleobases, conformations around N glycosidic bond, nomenclature, hydrogen bonding pattern in DNA, X-ray crystallography of DNA;

Chromosomal vs point mutations, types and causes, molecular mechanisms of mutagenesis; molecular mechanism of DNA repair systems;

Basis of mtDNA mutation, function, TCA-ETS dysfunction, cell death and candidate diseases like MELAS, LHON, Leigh syndrome, KSS and Myoclonic epilepsy.

DNA replication

Origin of replication, S-CDK cyclin roles in initiation of replication, signalling for replication, chemistry of DNA synthesis and role of major enzymes, elongation events, repackaging, end replication problem.

Transcription, Gene expression and Regulation

Gene and regulatory elements; mechanism of transcription; mRNA modification- 5' capping and poly A adenylation, alternative splicing; RNA export from nucleus;

Gene expression, control of expression via DNA binding chemistry- activator-repressor competition, ligand binding, inhibitory proteins; epigenetic control-circadian clock, hormones, nutrients; control via RNAs (RNAi, microRNAs).

Translation and its control

Codon chart, ribosome structure and binding sites, tRNA charging, ribosome assembly in prokaryotes and eukaryotes, peptidyl transferase reaction;

Control of translation via antibiotics, nonsense and nonstop mediated decay, proteolysis.

DNA Transposons (mobile gene) / TE elements

Locations, types and typical structures, mechanism of transposition, various applications of TE.

Regeneration and aging

Modern concepts.

DNA manipulation

Recombination, gene transformation and overexpression, mutant or strain development through gene deletion, gene editing technology, use of stem cells in gene therapy, site-specific/ in-vitro mutagenesis, random mutagenesis, genetic modification, hybridization and variety creation in organisms.

References

Alberts B., Johnson A., Lewis J., Raff M., Roberts K. and Walter, P. 2004. Molecular Biology of the Cell (4th edition). Garland Science Publisher, UK.

Brown, T. 2012. Introduction to Genetics: A Molecular Approach. Garland Science Publisher, UK.

Hartl, Daniel L. and Ruvolo Maryellen. 2012. Genetics: Analysis of Genes and Genomes. 8th edition. Jones and Barlett Pvt. Ltd., India.

Klug, W.S. and Cummings, M.R. 2017. Concepts of Genetics. 11th edition. Pearson Education, Inc., New Jersey, USA. (e-Book available: https://smtebooks.com/book/7787/concepts-genetics-11th-edition-pdf)
Lehninger, A.L., Nelson. D.L. and Cox, M.M. 1993. Principles of Biochemistry. CBS Publishers and distributors, Delhi, India.
Snustad and M.J. Simmons. 2015. Principles of Genetics. 7th Ed. John Willey and Sons. Inc. New York, USA. (PDF available: https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599- snustad-simmons)
Turner, P. C., McLennan, A.G., Bates, A.D. and White, M.R.H. 2000. Instant Notes on Molecular Biology. 2nd edition. BIOS Scientific Publishers Limited, Oxford, England.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 646	**Advanced Molecular Genetics**	**4**	**60**

Immunogenetics
Molecular and cellular basis of Immune responses, the humoral and cell mediated immune response,
Clonal theory of immune response, Mechanism of adaptive immune response;
Antibodies: structure, diversity, function and mechanism of action;
Complement activation: mechanism and function;
Recognition of antigen by T cells; Major histo-compatibility proteins.
Disease Genetics
Diabetes mellitus-Type I, Type II and other classes;
Genetic basis of Type-I and II, complications, diagnosis and treatment;
Insulin gene, biosynthesis and secretion of insulin, mechanism of Insulin action;
AIDS-Biology of HIV, mode of transmission, diagnostic test, anti-AIDS drug and vaccine;
Brain diseases- Genetic basis of Alzheimer's, Huntington's and Parkinson's diseases.
Oncogenetics
Cancer: features of cancer cells, oncogenes and tumor suppressor genes; chemical carcinogens;
Cell cycle signalling, control and cancer (with typical signalling example);
Hematological malignancies, leukemia, myeloma;
Chemotherapy, activity of chemotherapy;
Antimetabolites, alkaloids, antibiotics and miscellaneous compounds.
Developmental Genetics
Developmental potential, determination and differentiation;
Genetic mechanism of sex differentiation in *Drosophila*;
Pre-pattern and organization of embryo and its genetic mechanism of development in *Drosophila.*
Microbial Genetics
Chromosomal transfer in bacterial conjugation;
Plaque formation and mapping;
Lytic cycle, Lysogeny.

References
Abbas, A. K., Lichtman, A. H. and Pillai, S. 2014. *Cellular and Molecular Immunology*. 5th edition.
Alberts, B. 2017. *Molecular Biology of the Cell*. 6th edition. Garland Science, USA.
Nelson, D. L., and Cox, M.M. 2016. *Lehninger Principles of Biochemistry*. Sixth Edition. W.H. Freeman and company, New York, USA.
Klug, W.S. and Cummings, M.R. 2017. Concepts of Genetics. 11th edition. Pearson Education, Inc., New Jersey, USA. (e-Book available: https://smtebooks.com/book/7787/concepts-genetics-11th-edition-pdf)

Snustad and M.J. Simmons. 2015. Principles of Genetics. 7th Ed. John Willey and Sons. Inc. New York, USA. (PDF available:https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599- snustad-simmons)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 647	**Functional Genomics, Proteomics, and Bioinformatics**	**4**	**60**

Functional Genomics

Classification of genomics; Gene, genome, genomics, gene structure in DNA (Identification marks of regular sequence, Exon-Intron boundaries), Microbial genomics and genome epidemiology; Evolution and structure of mitochondrial genomes; Whole genome sequencing methods i.e. next generation sequencing vs shot-gun approach; Pyro seq, Mi seq, Hi seq, Nova seq, RNA seq, Oxford Nanopore, Bisulfide sequencing; genome-wide association study (GWAS), Foot printing; microarray; qPCR; metagenomics and methods of metagenomics; concept of nutritional genomics, epigenomics and methods of epigenomics.

Online Genomic databases and Bioinformatic tools

Introducing NCBI and other model organism based data bases, GenBank, Retrieving gene sequence, FASTA file, BLAST (Multiple sequence alignment); Designing PCR Primer, Finding Protein- coding regions; Phylogenetic tree construction; Genotyping, Mutation Identification, typing; Use of MEGA software.

Functional Proteomics

History and Basic concepts of Proteomics *i.e* chemical structure of proteins; conformation of the polypeptide chain; protein folding patterns; concept of binding and docking; post-translational modifications; Metabolites, Metabolic profiling, Metabolic pathways and engineering.

Proteomic techniques and Bioinformatic tools

SDS PAGE, 2D PAGE, Protein localization technology, Protein- Protein interaction (Yeast-2-hybrid system), ΔH calculation, polysome profiling, Different chromatographic techniques (gel filtration, ion-exchange, affinity, HPLC, Gas), MS/MS Spectrometry, Protein identification by peptide mass fingerprinting, and Capillary electrophoresis, FTIR, X-ray crystallography, Tomography, Electron microscopy, NMR, ELISA; Bioinformatic tools for proteomics - NCBI, PDB database, nucleotide to amino acid sequence, predicting secondary structure of a protein etc. Application of Proteomic techniques in pharmacology, pathology, toxicology and cell biology.

References

Andreas, D.B. and Francis O.B.F. 2005. *Bioinformatics – a practical guide to the analysis of genes and proteins*. John Wiley and Sons, USA.

Bino RJ, Hall RD, Fiehn O, Kopka J, Saito K, Draper J, Nikolau BJ, Mendes P, Roessner-Tunali U, Beale MH, Trethewey RN, Lange BM, Wurtele ES, Sumner LW. 2004. *Potential of metabolomics as a functional genomics tool. Trends in Plant Science 9*: 418-425.

Campbell, A.M. and Heyer, L.J. 2009. *Discovering Genomics, Proteomics, and Bioinformatics.* 2nd edition. Pearson Education, Inc., UK.

Dan, E.K. and Michael, L.R. 2003. *Fundamental Concepts of Bioinformatics.* Pearson Education Inc., UK.

Dunn WB, Ellis DI. 2005. Metabolomics: current analytical platforms and methodologies. *Trends in Analytical Chemistry 24*: 285-294.

Klug, W.S. and Cummings, M.R. 2003. *Concepts of Genetics.* 7th edition. Pearson Education Pvt. Ltd., Singapore.
Lesk, A.M. 2007. *Introduction to Genomics.* Oxford University Press Inc., New York, USA.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 648	**Recombinant DNA Technology**	**4**	**60**

Molecular Techniques

Fundamental techniques

Introduction, Fundamental techniques of gene manipulation, Agarose and Poly acrylamide Gel Electrophoresis; Southern, Northern, Western and other blotting techniques; electroporation, Polymerase Chain Reaction Technique, Principle of Primer design.

Restriction enzymes and Vectors

Types, nomenclature and applications of restriction enzymes; cutting and joining DNA molecules; plasmid, cosmids, phasmids, Yeast Artificial Chromosomes (YAC) and other advanced vector.

Gene cloning Strategies

Cloning in *Escherichia coli* and other bacteria; cloning in *Saccharomyces cerevisae* and other fungi.

DNA Library construction

Construction of genomic DNA and cDNA libraries.

Marker genes

Selectable markers, screen able markers, non-antibiotic markers, etc.

Sequencing methods

Maxam Gilbert, Sanger, NGS, RNA-sequencing and other techniques.

Applied Recombinant DNA Technology

Medical application

Diagnosis of diseases; transgenic animal models of human diseases; gene medicine; DNA vaccines; HBV, antigen; production of insulin and growth hormone.

Industrial application

Production of food-beverages, antibiotics; antimicrobials; vaccines and enzymes.

Agricultural application

Improving agronomic traits by genetic modification: *Bt* gene, resistant strains; benefits and risks of Genetically modified foods (GMOs).

DNA fingerprinting

Principles of DNA fingerprinting; application of DNA fingerprinting in criminal investigation (person identification), paternity dispute, immigration, identification of missing children or bodies found in accidents.

Ethical and Environmental issues

Biosafety regulations to protect producers, consumers and nature; Ethical and environmental issues concerning use of cloned gene in medicine, industry and agriculture.

References

Brown, T. 2012. Introduction to Genetics: A Molecular Approach. Garland Science Publisher, UK.
Glick, B.R and Pasterniak, J.J. 2003. *Molecular Biotechnology- Principles and Applications of Recombinant DNA.* 4th edition. ASM Press, Washington, DC, USA. (https://www.academia.edu/28272521/Molecular_BiochemistryBernard_R_Glick_Jack_J_Pasternak_Cheryl_L_Patten_pdf)
Primrose, S.B. and Twyman, R.M. 2010. *Principles of Gene Manipulation and Genomics.* 7th edition. Blackwell Publishing, UK.

Sambrook, J. and Russell, D.W. 2001. *Molecular Cloning (A Laboratory Manual)*, Vol. 1, 2 & 3, 3rd edition. Cold Spring Harbor Laboratory Press, USA.

Snustad D.P. and M.J. Simmons. 2015. *Principles of Genetics*. 7th Ed. John Willey and Sons. Inc, USA. (PDF available: https://www.slideshare.net/hijobaba/principles-of-genetics-6-e-isbn-978-0470903599-snustad-simmons)

Course No.	Course Title	No. of Credits	Credit Hours
ZG 649	**Molecular Ecology and Conservation Genetics**	**4**	**60**

Molecular Ecology

Introduction to Molecular Ecology

Definition and scope of molecular ecology; Importance of molecular tools in ecological research; Applications in biodiversity studies, species interactions, and ecosystem dynamics.

Genetic Markers and Techniques in Ecology

Types of genetic markers: mitochondrial DNA, nuclear DNA (microsatellites, SNPs); RAPD, RFLP, Species-specific primers, etc.; Techniques: DNA extraction, PCR, sequencing, and genotyping; Application of next-generation sequencing (NGS) in ecology.

Population Genetics in Ecology

Hardy-Weinberg Law; Gene flow, genetic drift, mutation, and selection in natural populations; Measuring genetic diversity: allelic richness, heterozygosity, nucleotide diversity; Population structure and connectivity indices - Fst, AMOVA, etc.

Phylogeography and Species Distribution

Phylogeographic methods for understanding population structure and history; Phylogenetic tree construction and haplotype networks.

Community and Ecosystem-Level Molecular Ecology

Metabarcoding and environmental DNA (eDNA) for community assessment; Applications in species interactions, food webs, and community ecology; Molecular methods for biodiversity monitoring and habitat assessment.

Behavioral Genetics

Genetic basis of behavior; Candidate Genes; Epigenetics in Environmental Response; Phenotypic plasticity and adaptation.

Data Analysis and Bioinformatics for Molecular Ecology

Software for genetic and genomic data analysis (e.g., MEGA, Arlequin, Genepop, DnaSP, GenAlEx, R, etc.); Case studies on interpreting molecular ecological data.

Conservation Genetics

Introduction to Conservation Genetics

Definition and goals of conservation genetics; Importance of genetic diversity for species survival and resilience; Role of conservation genetics in preventing biodiversity loss.

Genetic Diversity and Small Population Management

Measures of genetic diversity and population health; Inbreeding depression, effective population size, and genetic drift in small populations; Genetic risks associated with small and isolated populations.

Conservation Applications of Molecular Markers

Population monitoring and management using markers; Identification of populations and kinship; Assessment of genetic health; DNA barcoding and eDNA for identifying and monitoring rare and endangered species.

Population Fragmentation and Gene Flow

Population fragmentation, gene flow and connectivity in conservation planning; Identification of conservation units- Defining genetic management units; Case studies on fragmented populations and habitat corridors

Conservation Genomics and Adaptive Potential
Using genomic data to assess adaptive potential and resilience; Genome-wide association studies (GWAS) in conservation; Applications of genomics in understanding local adaptation and environmental stress responses.
Conservation Strategies Based on Genetic Data
Genetic management strategies for the wild and farm populations: captive breeding, translocation, and genetic rescue; Assisted gene flow and genetic restoration programs; Case studies on the genetic management of endangered species.
Ethics, Policy, and Social Dimensions of Conservation Genetics
Ethical implications of genetic interventions in conservation; Legal frameworks for biodiversity and genetic resources (e.g., CITES, Nagoya Protocol); Indigenous knowledge, community engagement, and the social context of conservation efforts.

References

Allendorf, F.W. and Luikart, G. 2007. *Conservation and. the Genetics of Populations.* Blackwell Publishing, UK.
Frankham, R., Ballou, J.D. and Briscoe, D.A. 2002. *Introduction to Conservation Genetics.* Cambridge University Press, UK.
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Hedrick, P.W. 2011. *Genetics of Populations.* 4th edition. Jones and Bartlett Publishers, USA.
Pierce, B.A. 2005. *Genetics: A Conceptual Approach.* 2nd edition. W.H. Freeman and Company, New York, USA.
Graham Rowe et al., 2016. An Introduction to Molecular Ecology.

Course No.	Course Title	No. of Credits	Credit Hours
ZG 655	**Practical Genetics and Molecular Biology (Gr-A)**	**6**	**90**

Basic Genetics
Animal models of genetics – Culturing fruit fly, aphid, mosquito, zebra fish, ornamental fish, mouse, etc. as instructed by the course teachers.
Cytogenetics
Karyotyping of selected animal species.
Molecular Genetics
a) Estimation of total protein/nucleic acids; b) Isozyme study using PAGE; c) Genomic DNA isolation and PCR analysis.
Bioinformatics
Gene annotation (BLAST, Annotation programmes); b) Primer design; c) Regulatory elements analysis; d) Multiple sequence alignment; e) Molecular phylogenetic tree construction; f) Protein modelling, docking.
Population Genetics
Data analysis- a) measuring genetic diversity; b) Use of software's (e.g. POPULUS).

Exposure Visit and Demonstration
Assignment Project

References

Dubey R.C. 2014. *A Text Book of Biotechnology*. 5th Ed. SC & Co. Pvt. Ltd. India.
Glick, B.R. and Pasterniak J.J. 2003. *Molecular Biotechnology- Principles and Applications of Recombinant DNA*. 3rd edt. ASM Press, Washington, DC, USA.

Maniatis T. 1991. *Molecular Cloning (A Laboratory Manual),* 1st ed., Cold Spring Harbor Laboratory Press, New York, USA.

Sambrook, J. and Russell, D.W. 2001. *Molecular Cloning - A Laboratory Manual,* Vol. 1, 2 & 3, 3rd edition. Cold Spring Harbor Laboratory Press, New York, USA.

ZG 656	**Thesis (Gr-B)**	**6 credits**
ZG 657	**Review and Seminar**	**2 credits**
ZG 658	**Viva voce**	**2 credits**