SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF ZOOLOGY

CURRICULUMM.Phil (2YEARS) PROGRAM

SESSION 2019 and Onwards

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SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

DEPARTMENT OF ZOOLOGY

SCHEME OF STUDIES FORM. Phil(2 YEARS)

SESSION: 2019 AND ONWARDS

SEMESTER-I

Course Title	Course Codes	Theory	Practical	Credit hours
Conservation Biology	ZOL-711	2	1	3
Advances in Immunology	ZOL-712	2	1	3
Optional Course	ZOL-	2	1	3
Optional Course	ZOL-	2	1	3
			Total credit hours	**12**

SEMESTER-II

Course Title	Course Codes	Theory	Practical	Credit hours
Statistical Analysis	STAT-702	2	1	3
Applied Reproductive Physiology	ZOL-721	2	1	3
Optional Course	ZOL-	2	1	3
Optional Course	ZOL-	2	1	3
			Total credit hours	**12**

3rd and 4th semester will comprise of Research Thesis of 06 credit hours with course code ZOL-899

MAJOR COURSES					
Serial No.	**Course Title**	**Course Codes**	**Theory**	**Practical**	**Credit hours**
1	Conservation Biology	ZOL-711	2	1	3
2	Advances in Immunology	ZOL-712	2	1	3
5	Applied Reproductive Physiology	ZOL-721	2	1	3
6	Research and Thesis	ZOL-899	0	6	6
MINOR COURSES					
7	Statistical Analysis	STAT-702	2	1	3

DETAILS OF CURRICULUM M.Phil (2 YEARS) PROGRAM (SESSION 2019 AND ONWARDS)

SEMESTER-I

Course Title	Course Codes	Theory	Practical	Credit hours
Conservation Biology	ZOL-711	2	1	3
Advances in Immunology	ZOL-712	2	1	3
Optional Course	ZOL-	2	1	3
Optional Course	ZOL-	2	1	3
			Total credit hours	**12**

COURSE NAME: Conservation Biology	**COURSE CODE:** ZOL-711
COURSE STRUCTURE: Lectures: 3, Lab: 1	**CREDIT HOURS:** 4

Objectives:

The objective of this course is

1. to enable the student to understand and investigate the diversity of living world,
2. to understand the effect of human activities on species, communities and ecosystems;and
3. to develop a practical interdisciplinary approach to protect and restore biological diversity.

Outcomes:

Upon successful completion of this course, the student will be able to:

1. ACQUIRE theoretical knowledge about the phenomena that affect the maintenance, loss, and restoration of biological diversity.
2. UNDERSTANDtheecological and evolutionary principles of biological diversity which influence the conservation of wildlife at spatial and temporal scales in Pakistan as well as abroad.
3. SOLVEthe conservation issue by applying the scientific principles and modern technologies.

4. ANALYSE,interpreting and synthesize data and other information about the determinants of the conservation problems.
5. EVALUATEthe conservation actions taken by the biologists for solving the conservation problems across biological scales (genes to landscapes) and geographical scales (local to global).
6. DEMONSTRATEsound research skills based on ecological and evolutionary principles in investigating problems in conservation biology.

Course Contens:

1. **Introduction to Conservation Biology:**
   a) Definition,
   b) History and
   c) Scope.
2. **Biodiversity:**
   a) Species Diversity; Genetic Diversity; Ecosystem Diversity;
   b) Measurement of Biological Diversity;
   c) AnOverview of World's Biodiversity;
   d) The Value of Biodiversity
3. **Threats to Biodiversity:**
   a) Human Population Growth;
   b) Habitat Destruction; Habitat Fragmentation;
   c) Environmental Degradation and Pollution;
   d) Global Climate Change;
   e) Overexploitation;
   f) Invasive Species
4. **Extinctions:**
   a) Extinction and Mass Extinctions;
   b) Rates of Extinction; Island Biogeography;
   c) Vulnerability to Extinction;
   d) Problems of Small Populations; Minimum Viable Population (MVP);
   e) Loss of Genetic Diversity; Effective Population Size;
   f) Demographic and Environmental Stochasticity
5. **Conserving Populations and Species:**

a) Applied Population Biology; Monitoring populations; Population viability analysis; Metapopulations,
b) International agreements for conservation of fauna and flora; Role of national and International Laws in Protection of Species;
c) Ex Situ Conservation Strategies; Zoos; Aquariums; Botanical gardens; Seed banks.
d) ProtectedAreas and theirEstablishment and categories;
e) Managing Protected Areas; Challenges to Protected Areas Management.
f) Unprotected Public and Private Lands
g) Ecosystem Management
h) Integration of Local Community in Conservation
i) Restoring Damaged Ecosystems

6. **Sustainable Development:**
   a) Challenges Involve in Conservation and Sustainable Development at the Local Level
   b) International Approaches to SustainableDevelopment
   c) Funding for Conservation by the World Bank and international NGOs;
   d) Conservation Education and the Role of Conservation Biologists

Practicals

1. Conservation issues in protected areas of Pakistan.
2. Study of the role of local community in protected areas of Pakistan.
3. Challenges to sustainable development and their solution in Pakistan.

Books Recommended:

1. Richard B. Primack, 2012. A Primer of Conservation Biology; 5th Edition: Sinauer Associates, Inc. Publishers Sunderland, MA U.S.A.
2. Groom, M.J., G.K. Meffe and C.R. Carroll, 2006, Principles of Conservation Biology, 3rd edition, Sinauer Associates, Sunderland, MA.
3. Malcolm L. Hunter, Jr. 2001. Fundamentals of Conservation Biology, 2nd Edition. Blackwell Science Inc.
4. Mills, L.S. 2007. Conservation of Wildlife Populations: Demography, Genetics and Management. Blackwell Publishing, USA.

5. Richard B. Primack. 2002. Essentials of Conservation Biology. 3rd Edition. Sinauer Associates Inc. Publishers, Sunderland, Massachusetts, U.S.A.

COURSE NAME: Advances in Immunology	**COURSE CODE:** ZOL-712
COURSE STRUCTURE: Lectures: 3, Lab: 1	**CREDIT HOURS:** 4

Objectives:

The objectives of the course are:

1. To provide the knowledge about the components and role of the immune system.
2. To provide students with knowledge of different mechanisms of the immune system.
3. The students will be able to describe immunological response and how it is triggered and regulated.
4. To describe the roles of the immune system in both maintaining health and contributing to diseases.

OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **Explore** the basic knowledge of the mechanisms of immune system
2. **Describe** the concepts about the role of immune system.
3. **Interpret** the problems using immunological techniques for diagnosis of immune disorders.
4. **Identify** the problems using immunological diagnostic tools.
5. **Detect** the problems using the same techniques for other disorders.
6. **DEMONSTRATE** individually the ELISA and other Assays/Tests.

Course outline:

1. **Introduction**
   1. Components of the immune system
   2. Antigens and Pathogens
2. **Innate Immunity and Inflammation**
   a. Different types of leukocytes
   b. Inflammation and Fever
3. **Recognition and Responses to foreign antigens**
   a. Pattern recognition receptors
   b. Innate immune signaling

c. The complement system
d. Complement activation pathways

4. Antibodies

a. B lymphocytes
b. Antibody structure and function
c. Monoclonal and polyclonal antibodies
d. Hybridoma technology

5. Lymphocyte Development and Diversity

a. Lymphocyte development
b. Clonal selection and expansion
c. Differences between B and T lymphocytes
d. The generation of lymphocyte receptor diversity

6. T Cell Activation by Antigens

a. Antigen presentation
b. The role of dendritic cells
c. The lymphatic system and delivery of antigen to lymph nodes
d. Adaptive immune activation in secondary lymphoid tissues

7. T Cell-Dependent B Cell Responses

a. T Cell activation of B cells
b. Isotype switching and affinity maturation
c. Helper T cell functions
d. The role of helper T cells in disease
e. Cytotoxic T cell functions
f. Selection and expansion of cytotoxic T cells
g. Therapies that target cytotoxic T cell functions

8. Hematological Diseases

a. Acute Leukemias
b. Overview of Lymphoma Classification
c. Hodgkin's disease
d. T-Cell Lymphomas
e. B-Cell Lymphomas
f. Plasma Cell Dyscrasias

g. Multiple Myeloma
h. Cryoglulinemia
i. Amyloidsis

9. Tumor Immunology

a. Detection and identification of Tumor Antigens
b. Immune Escape Mechanisms of Tumor Antigens
c. Immunotherapeutic Strategies (I)
d. Immunotherapeutic Strategies (II)

10. Transplantation of Autologous

1. Bone Marrow/Heatopoietic Stem Cells
2. Transplantation of Allogenic Bone Marrow/Hematopietic Stem Cells
3. Clinical Aspects of Organ Transplantation

Books Recommended:

- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell (5th ed. 2008, Garland)
- Thomas J Kindt, Richard A Goldsby, Barbara A Osborne, Janis Kuby: Immunology (2003, Freeman).
- Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. RoittRoitt: Roitt's Essential Immunology (12th ed. 2012, Blackwell)
- AbulAbbas , Andrew H. Lichtman, Shiv Pillai. Cellular and Molecular Immunology , 9th edition, 2017. Elsevier Pub Co.
- Gerd R. Burmester, Antonio Pezzutto Color Atlas of Immunology, 2006. Thieme Stuttgart, New York.

SEMESTER II

Course Title	Course Codes	Theory	Practical	Credit hours
Statistical Analysis	STAT-702	2	1	3
Applied Reproductive Physiology	ZOL-721	2	1	3
Optional Course	ZOL-	2	1	3
Optional Course	ZOL-	2	1	3
			Total credit hours	**12**

STATISTICAL ANALYSIS (STAT-702)

Theory: 2
Practical: 1
Credit hours: 3

Course Objectives:

The main objective of this course is to provide the basics of statistics and enable the students to perform statistical analysis independently in their research work.

Intended Learning Outcomes:

Course Contents:

Basic Univariate statistical methods; Review of basic concepts, summary measures, hypothesis testing, t-test.Analysis of variance; Chi-Squared test; Regression and Correlation. Multivariate statistical methods; Principal Concept analysis, Factor Analysis, Discriminant Analysis, Cluster analysis, Multidimensional Scaling, Hidden Markov models, Log linear Models, Bayesian Statistics.

Books Recommended:

1. Oakes. M.P.(1998,2005). "*Statistics for Corpus Linguistics*."Edinburgh Textbooks in Empirical Linguistics. Edinburgh University Press, Edinburgh.

2. Walpole, R.E. (1982). "*Introduction to Statistics*."3rd Edition, Macmillan Publishing Co. Inc. New York.

3. Johnson, R.A Wichern, D.W. (2002). "*Applied Multivariate Statistical Analysis*" 5th Edition, Prentice Hall, New Jersey.

4. Clark, G.M. and Cooke, D. (1998), "A Basic Course in Statistics" 4th ed, Arnold, London.

COURSE NAME: Applied Reproductive Physiology	**COURSE CODE:** ZOL-721
COURSE STRUCTURE: Lectures: 2, Lab: 1	**CREDIT HOURS:** 3

<u>Objectives</u>

The objectives of the course are:

1. To introduce modern reproductive biotechnologies applied in the field of animal agriculture, medicine and conservation
2. To demonstrate various reproductive problems of medical and veterinary significance
3. To impart knowledge about practical application of reproductive physiology using recent published reports

OUTCOMES:

Upon successful completion of the course, the student will be able to:

7. **IDENTIFY** and **EXPLAIN** both normal and pathological processes of the male and female reproductive system
8. **APPLY** their knowledge and understanding of reproductive physiology for genetic improvement of farm animals
9. **DEVELOP** reproductive biotechnologies for conservation of threatened wild species.
10. **UPDATE** themselves with current research in the field of reproductive biotechnologies.

Outline:

1. Assisted Reproductive techniques: an overview
2. Semen Collection & Evaluation
   a. Semen collection methods
   b. Initial assessment : Appearance, volume & concentration
   c. Sperm motility: Computer Aided Sperm Analysis
   d. Sperm Morphology
   e. Acrosome status
   f. Chromatin integrity
3. Semen cryopreservation
   a. Properties of Semen Extenders
   b. The cryopreservation technique
   c. Application in farm animals & endangered species and humans
4. Artificial insemination
   a. Introduction and history of Artificial insemination
   b. Artificial insemination procedures
5. Estrus synchronization
6. In vitro fertilization (IVF)and in vitro embryo production (IVEP)
   a. IVEP & Transfer for genetic improvement of farm animals
   b. IVF and ICSI for treatment of infertility in human
7. Superovulation and Embryos transfer
8. Assisted Reproductive techniques for conservation of endangered species
   a. Sperm cryobanking
   b. Embryo freezing

9. Causes of sterility in domestic animals.

10. Infertility in male

11. Infertility in female

12. Sperm sexing for sex pre-selection.

13. Contraception

14. Student's presentation: recent research paper/ review article in the field

15. Student presentation: recent research paper/ review article in the field

16. Student presentation: recent research paper/ review article in the field

Practical:

- Morphological & morphometric studies of sperm in buffalo/cattle.
- Morphological &morphometric studies of ova in buffalo/cattle.
- Collection and cryopreservation of sperm in farm animals.
- Artificial insemination in buffalo/cattle.
- Motility assessment of sperm.
- Staining of live and dead sperm.
- Acrosomal analysis of sperm.
- Aspiration and in vitro maturation of oocytes

Books Recommended:

1. Andrology by E. Nieschlag, H. M. Behre and S. Nieschlag**.** 3rd edition (2010). Published by Springer, USA.
2. Knobil& Neill's Physiology of Reproduction by *T. M. Plant and A. J. Zeleznik*. 4th edition (2014). Published by Springer, USA.
3. Reproduction in Farm Animals by E. S. E. Hafez and B. Hafez. 7th edition (2013). Published by Wiley-Blackwell, NY. USA.
4. Applied Animal Reproduction by H. J. Bearden, J. W. Fuquay and S. T. Willard. 6th edition (2004). Published by Pearson Prentice Hall, USA.

LIST OF OPTIONAL COURSES FOR M.Phil(ZOOLOGY)

S. No.	Course Title	Course Codes	Theory	Practical	Credit Hours
1.	Advances in Aquaculture	ZOL- 725	2	1	3
2.	Clinical Endocrinology	ZOL- 726	2	1	3
3.	Advanced Biological Techniques	ZOL-727	2	1	3
4.	Advances in Cancer Biology	ZOL-728	2	1	3
5.	Cancer Genetics	ZOL-729	2	1	3
6.	Advanced Enzymology	ZOL-730	2	1	3
7.	Applied Genetics	ZOL-731	2	1	3
8.	Applied Parasitology	ZOL-732	2	1	3
9.	Fish and Aquatic Toxicology	ZOL-733	2	1	3
10.	Desert Zoology	ZOL-734	2	1	3
11.	Clinical Teratology	ZOL-735	2	1	3
12.	Molecular Genetics	ZOL-736	2	1	3
13.	Neurobiology	ZOL-737	2	1	3
14.	Population Biology	ZOL-738	2	1	3
15.	Wetlands Management	ZOL-739	2	1	3
16.	Advances in Epidemiology and control of parasitic diseases	ZOL-740	2	1	3
17.	Herpetology	ZOL-741	2	1	3
18.	Advances in Forensic Biology	ZOL-742	2	1	3
19.	Climate Change and Ecosystem Stability	ZOL-743	2	1	3
20.	Mariculture Technology	ZOL-744	2	1	3
21.	Arachnology	ZOL-745	2	1	3
22.	Fish Physiology and Breeding	ZOL-746	2	1	3

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DETAILS OF OPTIONAL COURSES FOR M.Phil(ZOOLOGY)

COURSE NAME: Advances inAquaculture	**COURSE CODE:** ZOL-725
COURSE STRUCTURE: Lectures: 2, Lab: 1	**CREDIT HOURS:** 3

Objectives:

The course aims to-

1. Impart knowledge about history, needs and importance of fisheries and aquaculture.
2. Describe the cultureable fish species and their biology.
3. Elaborate the basics of fish culture and aquaculture facilities.
4. Provide knowledge about fishing gears and post-harvest techniques.

Outcomes:

Upon successful completion of the course, the student will be able to:

- Acquire knowledge about history, needs and importance of fisheries and aquaculture.
- Discuss various fish species characteristics and understand their culture requirements.
- Understand basics of pond fish culture and other advanced culture practices.
- Define various types of fishing gears, capturing methods and post-harvest technology.

Course Contents

1. Introduction to fisheries and aquaculture, national and international trends. Fish morphology and diversity in size and shape. Distribution of fishes in Pakistan, commercial fishes, marine and freshwater.
2. Types of ponds, planning construction and pond preparation. Pond fertilization, dosage and methods of application.
3. Food and feeding habits of fishes, feed types, artificial and natural fish feeds, feeding strategies of artificial fish feeds.
4. Aquatic habitats, ecology and extant of distribution, Water quality parameters (abiotic: temperature, light, salinity, pH, turbidity etc.) and their effects on fish health and production.

5. Biotic parameters (plankton, insects, aquatic vegetation etc.) of ponds, lakes, rivers, and impacts on fish growth.
6. Induced breeding techniques.
7. Fish diseases and their control.
8. Fishing gears, fishing techniques, fishing communities.
9. Fisheries co-management.
10. Fish preservation, processing, transportation and marketing.

Practical:

1. Morphological characters of a typical fish
2. Identification of commercially important fish species, meristic counts, fin formula, scale formula etc.
3. Dissection of common fish to study its various systems.
4. Practical demonstration of induced fish breeding.
5. Introduction to artificial feed ingredients.
6. Fish disease diagnosis and identification.
7. Demonstration of fishing gears and methods of fish capture.

Books Recommended:

1. Stickney R.R. 2016. Aquaculture an introductory text, CABI. Publishing, London, UK.
2. Fitzsimmons, K., R.S.N. Janjua and M. Ashraf, 2015. *Aquaculture Handbook—Fish Farming and Nutrition in Pakistan.*
3. Sharma, O. P. 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, Udaipur, New Delhi, India.
4. Stickney, R. R. 2009. Aquaculture: An Introductory Text. CABI Publishing, London, UK.
5. Pillay, T.V.R. and M.N. Kutty 2005. Aquaculture: Principles and Practices. Blackwell Science Limited. New York.
6. Ali, S.S. 1999. An Introduction to Freshwater Fishery Biology. University Grants Commission, H-9 Islamabad.

COURSE NAME: Clinical Endocrinology	**COURSE CODE:** ZOL-726
COURSE STRUCTURE: Lectures: 2, Lab: 1	**CREDIT HOURS:** 3

Objective:

Recent advancements in the field of endocrinology with specific reference to clinical aspects.

Diseases of the endocrine system.

Mechanism of the hypothalamic releasing factors

Neurotransmitters

Growth hormones

Adrenocorticotropins (ACTH)

Gonadotrophins (FSH, LH, LTH)

Thyroid stimulating hormone (TSH)

Oxytocin

Vasopressin

Thyroid hormones

Insulin and glucagons

Adrenal hormones

Gastrointestinal hormones

Organs of uncertain endocrine functions; their synthesis, biochemistry & biological actions.

Practical:

Anatomical studies of endocrine organs, including their histology; thyro-parathroidectomy in lab.Animals; adrenalectomy; water load of and renolectomized animals and replacement therapy.

Books Recommended:

1. Neischalg, E. And Behre, H.M. 1997. Andrology. Springer Publications. USA.
2. DeGroot, I.J. (Eds). 1995. Endocrinology (3 volumes). W.B. Saunders Publications. USA.
3. Turner, C.D. and Bagnara, J.T. 1976. General Endocrinology. W.B. Saunders Publications. USA.

COURSE NAME: Advanced Biological Techniques	**COURSE CODE:** ZOL-727
COURSE STRUCTURE: Lectures: 2, Lab: 1	**CREDIT HOURS:** 3

Objectives:

The course aims to:

a) Familiarize the students with advance biological equipements and technique
b) Develop basic understanding of the equipment handling in reserch.
c) Develop scientific and technical expertise, culture and work habits.

OUTCOMES:

After studying this course student must be able to:

a) Understand advanced boiological techniques
b) Apply practical and research skills
c) Operate and use the lab equipement efficiently.

Course Contents:

UV Spectroscopy/Separations, Flame Atomic Absorption Spectroscopy, Spectrofluorimetry, Thin Layer Chromatography (TLC), Gas Chromatography, High Performance Liquid Chromatography (HPLC), Amino acid sequening, Blotting techniques, Centrifugation techniques,PCR, DNA Sequencing, Electrophoresis, Isoelectric Focusing Apparatus, Lyophilizer, Microarray Technology, Microscopy, Microtomy, Nuclear Magnetic Resonance Instrument, principles and application, Geographic Information Systems and Remote sensing, ELISA, Cell culture.

Books Recommended:

1. Chemical Analysis: Modern instrumentation, methods and techniques, Francis Rouessac and AnnickRouessac, John Wiley & Sons, 2000, ISBN 0-471-97261-4.

2. Principles of Instrumental Analysis (5th ed), Douglas A. Skoog, F. James Holler and Timothy A. Nieman, Brooks Cole, 1997, ISBN 0-03-002078-6.

3. Spectrometrischeanalysetechnieken, M.T.C. de Loos - Vollebregt, Heron reeks - Bohn Stafleu Van Loghum, 2004, ISBN 90-313-4142-8.

ADVANCES IN CANCER BIOLOGY (ZOL-728)

Contact Hours:	**Credit Hours:**
Theory =32	Theory =**2.0**
Practical = 48	Practical =1.0
Total =80	Total = **3.0**

Course Objectives

The objectives of the course are:-

4. To enhance the knowledge in the area of Cancer Biology.
5. To provide core concepts involved in the transformation of normal cell in to cancer cell.
6. To introduce the major signaling circuitry programs contributing towards cancer.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **ACQUIRE** the advanced knowledge of Cancer Biology.
2. **UNDERSTAND** the concepts of transformation of normal cell in to tumor cell.
3. **ANALYZE** the signaling pathways contributing towards Cancer.
4. **EVALUATE** the problems related to genetic mutations and tumor suppressor genes, etc.

Course outline:

1. **Introduction**
   1. Introduction of Cancer
   2. General features and types of cancers,
   3. The nature of Cancer,
   4. Arise of Cancer from normal and specialized cells.
   5. Monoclonal growth of tumor cells.
   6. Physical and chemical carcinogens
   7. Mutagens causing cancers.

2. **Tumor Viruses**
   a. RNA viruses
   b. DNA Viruses causing cancer.
   c. Transformation of cells by tumor viruses.

3. **Cellular oncogenes:**
   a. Oncogenes in the cell
   b. Proto-oncogenes,
   c. Activation of proto-oncogenes,
   d. myc oncogene

4. **Growth factors, Receptors, and Cancer**

   a. Receptors and their ligands,
   b. Growth factor genes,
   c. EGF receptor,
   d. TGF

5. **Signaling Circuitry programs**

   a. Introduction to signaling pathway,
   b. The Ras protein
   c. Tyrosine phosphorylation
   d. Cascade of kinases.

6. **Cell Cycle**

   a. Cell cycle,
   b. Cell cycle regulation,
   c. Tumor suppressor genes,
   d. Apoptosis.

e. Significance of apoptosis
f. Extrinsic and Intrinsic apoptosis.

Practical

- Study of cell cycle
- Study of prepared slides of cancer cells,
- Slides showing conversion of epithelia in to metaplastic/ hyperplastic/dysplastic conditions.

Reference books:

5. Zhang, W., & Fuller, G. N. (Eds.). (2004). Genomic and Molecular Neuro-Oncology. Jones & Bartlett Learning.
6. Cooper, G. M. (1995). Oncogenes. Jones & Bartlett Learning.
7. Hicky, R., Clark, R. L., &Cumbley, R. W. (1986). Year book of cancer. Chicago: Year book.
8. Weinberg, R. (2013). The biology of cancer. Garland science.
9. Hejmadi, M. (2009). Introduction to cancer biology. Bookboon.

CANCER GENETICS (ZOL-729)

Contact Hours:	**Credit Hours:**
Theory =48	Theory =**2.0**
Practical = 0.0	Practical =1.0
Total =48	Total = **3.0**

Course Objectives

The objectives of the course are:-

7. To enhance the knowledge in the area of Cancer Genetics.
8. To provide core concepts involved in the activation of proto-oncogenes.
9. To introduce the major genes involved in signaling circuitry programs contributing towards cancer.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

5. **ACQUIRE** the basicknowledge of Cancer Genetics.
6. **UNDERSTAND** the concepts of genes involvedin signaling circuitry programs of tumor cell.
7. **ANALYZE** the activation of proto-oncogenes in to oncogenes.
8. **EVALUATE** the problems related to genetic mutations and tumor suppressor genes, etc.,

Course outline:

7. **Introduction**
   8. Genetic basis of cancer.
   9. Oncogenes,
   10. Proto-oncogenes
   11. Tumor Suppressor Genes.

8. **Cell Cycle Control Genes**
   d. Types of Cyclins
   e. CDKs,
   f. pRb,
   g. E2F transcription factor,
   h. Myconcoprotein

9. **DNA Repair Pathways**
   e. Genes involved in Repair pathways.
   f. p53
   g. Mdm2
   h. ARF

4.Oncogenes and cancer metastasis:

a. How faulty genes lead to cancer.
b. Proto-oncogenes.
c. Tumor suppressor genes.
d. DNA repair genes.
e. Metastasis suppressor genes.
f. Genetic instability and cancer.

9. **Apoptosis**

   e. Introduction to apoptosis,
   f. Proapoptotic genes,
   g. Antiapoptotic genes,
   h. How cell maintains balance between pro and antiapoptotic genes

10. **Genetic Screening for Cancer.**

   e. SNP and Cancer.
   f. Case Studies:
   g. P53
   h. BRCA1
   i. RRCA2

Practical:

Slides showing conversion of epithelia in to metaplastic/ hyperplastic/dysplastic conditions.

Study of prepared slides of cancer cells

Study of cell cycle control genes

Reference books:

10. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M.,& Walter, P. (2013). Essential cell biology. Garland Scienceiology. Garland Science
11. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2002). Biochemistry, W. H.Lewin, (Latest Edition). Genes VIII.
12. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2014). Lewin's genes XI. Jones & Bartlett Publishers.
13. Articles Published in Nature Review Cell & Molecular Biology. (Latest Edition).
14. Articles Published in Nature Review Immunology. (Latest Edition).

Advanced Enzymology (ZOL-730)

Credit Hours:

Theory =**2.0**

Practical: 1

Total= 3.0

Course Objectives

Objectives:

The course aims to:

1. To Introduce students to various theoretical and practical aspects of enzymology
2. Tostimulatestudents interest in learning the structure, function and kinetics of enzymes and their role as catalyst and regulator of cell metabolism.
3. To understand the mechanism of enzymes action and important components of the enzyme molecules.
4. To evaluatethe basics of enzyme kinetics, pathways, mechanisms of their control and the importance of the parameters describing the kinetics.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course the student will be able to:

11. **ACQUIRE** the basic knowledge ofthe major classes of enzymes and their functions in the cell; role of co-cofactor in enzyme catalyzed reaction.
12. **UNDERSTAND** between equilibrium and steady state kinetics and analyzed simple kinetic data and estimate important parameter (Km, Vmax, Kcatetc).
13. **ANALYZE**thestructure/function relationships in bio-catalyzed reactions
14. **EVALUATE**the different possible catalytic mechanisms of given reaction types
15. **DEMONSTRATE**the strategies for the analysis of kinetic mechanisms of catalyzed reactions

Course outline:

1. Introduction and History of Enzymes

a. Historical aspects

b. Discovery and chemistry of enzymes

c. Function and importance

d. Enzymes in Biotechnology

2. Characteristics and Properties

a. Catalytic power and specificity
b. Enzyme-substrate interactions
c. Lock and key model
d. Induce fit model
f. Transition state model
g. Quantum tunnelling model
h. Enzymes as proteins
i. Non-protein cofactors-metal ions
j. Organic cofactors

3. Multi-substrates Reactions and Substrate Binding Analysis

a. Multi-substrates reactions
b. Ordered and random mechanisms
c. Sequential and Non-sequential mechanisms
d. Substrate binding analysis

4. Determination of Enzyme-Substrate Dissociation Constants

a. Equilibrium dialysis
b. Equilibrium gel filtration
c. Ultracentrifugation
d. Spectroscopic methods

5. Experimental analysis of catalytic and kinetic mechanisms

a. Spectrometry, X-ray crystallography, stopped flow, isotope effects, structure/reactivity relationships).
b. Mathematical data analysis (regression analysis, model discrimination).
c. Modelling of enzymatic reactions. Stereo chemistry (mechanisms). Structure/function relationships (protein folding, mutagenesis, enzyme inhibition.
d. Catalytic mechanism, catalytic antibodies, catalytic nucleic acids ribozymes, catalytic DNA.

6. Enzyme Purification and Assay

a. Enzyme units of activity
b. Turnover number and properties
c. Purification and assessment
d. Methods for measurements

7. Enzyme Engineering and Design

a. Substitution
b. Insertion
c. Hybrid proteins
d. Genes for novel enzymes
e.Engineering more stable enzymes
f. Incorporation of non-natural amino acids into enzymes
g. Protein engineering by combinatorial methods
h. DNA shuffling

Practical:
Study of enzyme structure

Study of Induce for model
Study of lock and key model
Study of induce fit model
Study of model of enzyme reaction

Reference books:

1. Bisswange, H., 2011. Practical Enzymology.Wiley-VCH.Publishers.
2. Bowden, A.C., 2012. Fundamentals of Enzyme Kinetics 4th Edition.Wiley-Blackwell.
3. Okotore, R.O., 2015. Essentials of Enzymology.Publisher XLIBRIS.
4. Sauro, M.H., 2012. Enzyme Kinetics for Systems Biology Ambrosius Publishing
5. Voet, D., Voet, J. G. and Pratt, C. W., 2002. Fundamentals of Biochemistry; John Willey and Sons. Inc., New York
6. Mckee, T. and Mckee, J. R. 2011. Biochemistry, the Molecular Basis of Life.5th edition, Oxford University Press, New York.

APPLIED GENETICS (ZOL-731)

Credit Hours:
Theory =**2.0**
Practical = 1
Total = **3.0**

Course Objectives

The objectives of the course are:-

1. To give basic understanding of genetic transformation processes.
2. To develop understanding of Transposable elements and their mechanism of Transposition
3. To enable the students to understand the genetic factors influencing human development and behavior.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **Describe** the phenomenon involved in transformation of genetic material.
2. **Understand** the Transposable elements and bacterial transposition.
3. **Interpret** the regulation of gene expression in prokaryotes and eukaryotes.
4. **Outline** the roles of various genes and genetic factors in development and human behavior.

Course outline:

Nucleic acids.
a. Plant and animal viruses
b. Tumor viruses
c. Retroviruses

Genetic Transformation

a. Conjugation
b. Transformation
c. Transduction
d. Integration of viral DNA

Transposition

a. Transposable Elements
b. Detection of Transposition In Bacteria
c. Types of Bacterial Transposons
d. Modes of Transposition In Bacteria

Gene expression

a. Regulation of Gene expression in Prokaryotes
b. Regulation of gene expression in Eukaryotes

Quantitative Genetics of Human Behavior

a. Intelligence
b. Personality

A genetic perspective on development

a. Maternal effect genes
b. Determination of dorsal-ventral and anterior posterior axis
c. Body segmentation
d. Organ formation

PRACTICAL:

Study of gene expression in Prokaryotes

Study of gene expression in Eukaryotes

Study of Gene mapping

Reference books:

Alberts, B., A. Johnson, J. Lewis, M. Raff, K .Roberts, and P. Walter.Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc.New York.2002.
2. Watson, J,D., T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick. Molecular biology of the gene.Pearson Education. 2004.
3. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
4. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004

APPLIED PARASITOLOGY
(ZOL-732)

Credit Hours:

Theory = **2.0**
Practical : 1
Total = **3.0**

Course Objectives

The course objectives are:

a. To enable students get familiarized with the most important parasites of humans and domestic animals
b. Their transmission patterns, diagnosis, treatment, prevention, control
c. Their economic and medical importance.

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

a. Discover the most important parasites of humans and domestic animals
b. Examine transmission patterns, diagnosis, treatment, prevention, control, their economic and medical importance

Course outline

1. **Chemicals and reagents used in preservation of parasitic materials**

a. Collection, processing and identification of parasites

b. Recovery of parasite eggs, oocysts and larvae from faecal specimens

c. Determination of parasite resistance to pesticidal chemicals and chemotherapeutic drugs.

2. **Control and Vaccine Development Against Parasitic Infections.**

3. **Chemotherapeutic agents used against parasitic infections**

a. eg. anthelmintics, insecticides etc.

b. The mode of action of chemotherapeutic agents.

c. The mechanisms of parasite resistance to drugs.

4. **Methods of Vaccine Development**

a. Various approaches will be discussed for example: Helminths use of 3 types of antigens viz: Irradiation-attenuated live helminths,

b. Somatic extracts of helminthes

c. Metabolic or excretory/secretory (E/S) antigens produced by the in vitro culture of helminths.

d. Genetic engineering. the application of genetically engineered vaccines will be discussed. Cultivation of Parasites tissue culture techniques, cryopreservation

Practicals:
Culture, isolation and separation of parasitic larvae from soil and herbage material.

Baerrmann technique for nematode larvae separation

McMaster technique for egg per gram counting,

Field herbage collection for carpological examination.

Reference books:

1. William Charles Marquardt, Richard S. Demaree, Jr., Robert Burton Grieve., 2000. Parasitology & Vector Biology. 2nd Edition.
2. Chandler, A.C. and Read, C.P. 1961. Introduction to Parasitology. 10th ed. Wiley Toppan, New York, USA
3. Handler, A. M. James, A.A. (Eds.).2004. Insect Transgenesis: Methods and Applications, Comprehensive review of insect gene transfer, its methodologies, applications and risk assessment and regulatory issues. CRC Press.
4. Erlich, H. 1992. PCR Technology: Principles and Applications for Amplification. W.H. Freeman & Company, New York.

FISH AND AQUATIC TOXICOLOGY

ZOL-733

Credit Hours:
Theory = 2.0
Practical =1.0
Total = 3.0

Course Objectives

The objectives of the course are:-

10. To review the basic toxicological principles of uptake, elimination, and bioaccumulation, emphasizing processes unique to aquatic organisms.
11. To learn the relationships between abiotic and biotic processes of aquatic environments and their effects on contaminant distribution and subsequent exposure, accumulation, and toxicity in aquatic environments.
12. To become familiar with the concept of risk assessment and to extend its use to assess ecological risks resulting from aquatic pollution.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

11. **ACQUIRE** the knowledge of the various toxic agents and their sources in aquatic ecosystem
12. **UNDERSTAND**the effects of toxic substances on fishes and other aquatic organisms
13. **SOLVE** the pollution problems in aquatic system
14. **ANALYZE** the toxicity on different organs of fish

15. **EVALUATE**the bioaccumulation pattern of pollutants in aquatic organisms
16. **DEVELOP** critical thinking to solveaquatic pollution problems

Course outline:

11. Introduction to Aquatic Toxicology

12. History of Aquatic Toxicology
13. Main Present and Future Challenges
14. Classification and Types of Toxicity
15. Effects of Aquatic Toxicology on Organisms
16. Bioindicators and Biomarkers

12. Sources and Causes of Aquatic Contamination

i. Major Sources of Pollutants
j. Transport of Pollutants in the Environment
k. Metals, Metalloids, and Organometallic Compounds
l. Other Inorganic Compounds, Including Factors Causing Eutrophication
m. Organic Compounds
n. Nanomaterials
o. Radiation
p. Genetic Modification

13. Uptake, Distribution, Detoxification and Excretion of Compounds in Aquatic Organisms

i. Uptake of Compounds by Organisms
j. Distribution and Storage Sites of Chemicals in Organisms
k. Biotransformation and Detoxification
l. Cellular Excretion
m. Excretion from Gills, Kidney and Other Excretory Organs
n. Excretion in Bile Via the Intestine
o. Excretion From Multicellular Plants and Algae

14. General Principles of Toxicology in Fishes

i. Bioavailability of Chemical Contaminants in Aquatic Systems
j. Toxicokinetics in Fishes
k. Toxicodynamics in Fishes
l. Biotransformation in Fishes
m. Bioaccumulation of Toxicity in Fishes
n. General approaches to diagnosis and treatment of toxicity

15. Toxicity in Fishes

j. Toxicity caused by metal and non-metals,
k. Phytotoxins
l. Drug toxicity and toxicity caused by agrochemicals.
m. Mycotoxins
n. Bacterial toxins

16. Key Target System in Fish and Organismal Effects

g. Liver Toxicity in Fishes
h. The Osmoregulatory System of Fish
i. Toxic Responses of the Fish Nervous System
j. The Endocrine System
k. The Immune System of Fish: A Target Organ of Toxicity
l. Chemical Carcinogenesis in Fishes
m. Toxicity Resistance in Fishes

Practical:

- Study of eutrophication
- Study of behavioral responses of aquatic organisms to toxicants
- Spot tests for metals
- Demonstration of drug toxicity
- Detection of heavy metal poisoning
- Study of biotoxicity assay for LC_{50}
- Case studies in toxicology

Reference books:

15. Marquardt, H., Schafer, S.G., Mcclellan, R. and Welsch, F., 1999.*Toxicology*, Academic press, San Diego.
16. Rand, G.M., *Fundamentals Of Aquatic Toxicology: Effects, Environmental Fate And Risk Assessment.* 2nd Edition.
17. Nikinmaa, M., 2014. *An Introduction to Aquatic Toxicology*. 1st Edition. Academic Press.
18. Giulio, R.T.D. and Hinton, D.E., 2008. *The Toxicology of Fishes*. CRC Press, Taylor and Francis Group.
19. Whitacre, D. M. (Editor) 2012. *Reviews of EnvironmentalContamination and Toxicology*. Vol. 223. Spriger, Switzerland.

DESERT ZOOLOGY

(ZOL-734)

Credit Hours: 3

Theory:2
Practical: 1

Objectives:

The course aims to:

- Impart the knowledge in biology and Environmental sciences related to the desert organisms.
- Develop concepts about threats/risk factors of animals in desert.
- Study the history of desertification.
- Explore the ecological processes of desert biomes.
- Demonstrate the identification of desert fauna.

Course Contents:

- **Origin of desert life**
- Exhibited features including soil, water, temperature, atmospheric pressure and oceanic role.
- **Desert Ecology:**Introduction to local habitats,
- identification of local animals
- Morphological and physiological adaptations of desert organisms
- Principles of classifying and naming species.
- **Desert biomes**: (Hot and Dry, semiarid, Costal and Cold).
- Desertification its Causes and impacts on animals. Deserts of Pakistan.
- Conservation of Animals:
- Advantages and disadvantages of Deserts,
- Major threats/risk factors and management strategies to conserve the animals in deserts.

Practical:

- Field trips of deserts
- Collection of samples.
- Visits of National Parks
- Identification of indigenous fauna

Recommended Books:

1. D. Ward, 2016. The Biology of Deserts. Oxford University Press. 416p.
2. G. W Brown, 2013.Desert Biology: Special Topics on the Physical and Biological
3. Aspects of Arid Regions. Elsevier. 148322371X, 9781483223711. 654P.
4. W. G. Whitford, 2002. Ecology of Desert Systems. Academic Press. 343 pages

CLINICAL TERATOLOGY

(ZOL-735)

Credit Hours:

Theory = **2.0**
Practical =1.0
Total = **3.0**

Objectives:

- To introduce the basic concepts of developmental errors and birth defects
- To impart knowledge about the environmental, infectious, genetic and physiological causes of congenital abnormalities

- To develop understandingson the biological mechanismsofteratogenesisand their possible solutions in biomedical sciences

Course Learning outcomes

- The students will be acquainted with the emerging threats of birth defects imposed by various infectious agents, radiation, heavy metals, medicines, drugs,and environmental chemicals (pesticides) in the developing embryos.
- The basic understandings will help the students tosuggest possible precautionary measures and the biomedical and surgical solutions to the parents during the course of pregnancy
- Further exploration will help the studentsto excel this knowledge in reproductive and developmental counseling.

Course Contents:

- Teratogenesis introduction
- Environmental assaults on human development
- Teratogenic agents: Alcohol, Retinoic acid, Hydroflourocarbonsand others
- Role of degradation products used as refrigerants in teratogenesis
- Possible role of drugs and neuro-toxicants such as Heroin in congenital defects
- Heavy metal as teratogens
- Pathogens: *Rubella, Toxoplasma gondii, Treponema pallidum* (Syphilis bacterium) inflicting teratogenesis
- Endocrine disruptors such as diethylstilbestrol (drug used to prevent premature births) causing inborn defects
- Possible roles of Nonylphenol(Plastic wrappings around food) andBisphenol(a water bottles, baby feeders) in prenatal and postnatal developmental errors
- Tobacco and Cannabis causing embryonic and postembryonic disruptions
- Alcoholism and fetal alcohol syndrome
- Antimalarial and antiprotozoal medicines as developmental disruptors
- Role of tranquilizers, anti-nauseant and anti-hyperglycemic medicines in embryonic development
- Oxidative stress and embryonic development
- Ectopic pregnancies
- Placental errors, Breach babies
- Polyhydromenosis and oligohydomenosis
- Major inborn defects like imperforated anus, cardiac sepatal defects, intestinal atresia, cleft lip and cleft palate
- Organ ectopia, hydrocephaly, microcephaly
- Congenial neural tube and nervous system defects
- Testicular dysgenesis and declining sperm counts.
- Developmental biology and future of medicine
- Germ-line gene therapy
- Stem cell therapy

- Regenerative medicine
- Regeneration therapy
- In utero surgeries
- Neonatal surgeries
- Biophysical organ transplants
- Regenerative organs and organoids
- Fraternal and monozygotic twining
- Organ twining

Practicals:

1. Hospital visits to observe the cases of developmental abnormalities.
2. Impact of various Teratogens on J774.2 macrophage like cell line *in vitro*
3. *P*otentially toxic insult of r*eactive oxygen species* generation in response to various teratogens
4. Various environmental toxicants causing membrane dysfunction, **lipid** peroxidation, DNA damage and inactivation of proteins.

Books and Articles Recommended:

1. Gilbert, S.F. (2006). Developmental Biology.
4. Carlson BM (2014) Human Embryology and Developmental Biology, 5th Edition, Mosby Elsevier.
5. Moore K, Persaud T V N, Torchia M (2015) The Developing Human Clinically Oriented Embryology10th Edition. Elsevier inc
6. Ema M, Naya M, Yoshida K and Nagaosa R. (2010).Reproductive and developmental toxicity of degradation productsof refrigerants in experimental animals. Reproductive ToxicologyVolume 29, Issue 1, January 2010, Pages 1-9.
7. Azim HA, PeccatoriFA and Pavlidis N. (2010). A systematic Review C:\Users\akram\Documents\Teratology-cancers in pregnancy 2010.htm - hit2 on the use of cytotoxic, endocrine, targeted agents and immunotherapyduring pregnancy. Part I: Solid tumors. Cancer Treatment Reviews.Volume 36, Issue 2, April 2010, Pages 101-109
8. Bedard PL and Cardoso F. (2008), Recent advances in adjuvant systemictherapy or early-stage breast cancer, *Ann Oncol*19 (Suppl 5) pp. 122–127
9. Powers CM, Yen J, LinneyEA,Seidler FJ, Slotkin TA. (2010). Silver exposure in developing zebrafish (*Danio rerio*): Persistent effects on larval behavior and survival. *Neurotoxicology and Teratology, Volume 32, Issue 3, May-June 2010, Pages 391-397*
10. Cassina M, De-Santis M, Cesari E, van-Eijkeren M, Berkovitch M, Eleftheriou G, Raffagnato F, Di-GianantonioE,Clementi M. (2010). First trimester diclofenac exposure and pregnancy outcome.*Reproductive Toxicology, Available online 1 May 2010*
11. Guidelines for Human Embryonic Stem Cell Research (2005). http://www.nap.edu/catalog/11278.html (free download is available)
12. Understanding stem cells: An overview of the science and issues from thenational academies USA. Copyright © 2009.National Academy of Sciences. All rights reserved.

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MOLECULAR GENETICS
(ZOL-736)

Credit Hours:
Theory = **2.0**
Practical = 1
Total = **3.0**

Course Objectives

The objectives of the course are:-

1. To understand the organization of human nuclear genome and mitochondrial genome.
2. To develop understanding of different types gene families and superfamilies'
3. To equip the student with different modern molecular Techniques.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **Acquire** the basic knowledge of human nuclear genome and mitochondrial genome.
2. **Illustrate** the key features of human genome and certain gene families.
3. **Discover** the role of certain RNA coding genes along with protein coding genes.
4. **Investigate** certain molecular problems with the help of modern molecular techniques.

Course outline:

1. **Genome structure**
   a. Human mitochondrial genome
   b. Human Nuclear genome
   c. Protein Coding gene
   d. RNA genes

2. **Gene Families**
   a. Solitary gene and gene family
   b. Gene superfamily.
   c. Pseudogens
   d. Retrogenes
   e. Cluster gene families
   f. Interspersed gene families

3. **Transposable Genetic Elements**
   a. LINES
   b. SINES
   c. Fossil Transposons

4. **Repeat Instability and Genetic Disorders**
   a. TRED1
   b. TRED2

c. Fragile X- Syndroem
d. Mytonic Dystrophy

10. DNA Methylation and Cancer

a. Differential methylation and cancer
b. Imprinting
c. Epigenetics and its implications in the genome
d. ,Telomere and Telomerase and their role in cancer and aging
e. RNA interference
f. RNAi mediated pathways in nucleus

11. Study of Molecular Techniques

a. Southern blotting
b. Western blotting
c. Northern blotting
d. RFLP
e. RAPDS
f. Microsatellite DNA

Practicals:

Pedigree analysis, ability to taste PTC, human chromosomes (slides), study of inheritance of some human characteristics, hair color, eye color.

Reference books:

Alberts, B., A. Johnson, J. Lewis, M. Raff, K .Roberts, and P. Walter.Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc.New York.2002.
2. Watson, J,D., T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick. Molecular biology of the gene.Pearson Education. 2004.
3. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM, Press, 2003.
4. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

NEUROBIOLOGY
(ZOL-737)

Credit Hours:

Theory = **2.0**
Practical = 1.0
Total = **3.0**

COURSE OBJECTIVES:

1. To Provide the knowledge about the structure and function of cells that comprise the nervous system.

2. To impart understanding of chemical and electrical signaling in the nervous system.
3. To provide knowledge of sensory and motor systems.
4. To understand the brain development and complex brain functions.
5. To provide knowledge how to develop a hypothesis from a set of observations and then suggest experiments to test the hypothesis.

COURSE LEARNING OUTCOME

By the end of the course, students should be able to:

1. Define the molecular, cellular, and tissue-level organization of the central and peripheral nervous system
2. Understand the properties of cells that make up the nervous system including the propagation of electrical signals used for cellular communication
3. Relate the properties of individual cells to their function in organized neural circuits and systems
4. Understand how the interaction of cells and neural circuits leads to higher level activities such as cognition and behavior
5. Generate testable scientific hypotheses and develop research plans to test these hypotheses
6. Evaluate and discuss primary research literature and evaluate the validity of hypotheses generated by others
7. Work on research projects independently and in small group settings.
8. Communicate effectively orally and in writing

1. Organization of the nervous system
   a. The organization of the nervous system; neurons, types of neurons, nerves
2. Electrical signals of nerve cells;
   a. Membrane permeability; Channels and transporters; Nerve Impulse
3. **Synaptic Transmission**;
   a. Neurotransmitters; their receptors and effects; Intracellular signal transduction;
4. **Sensory somatic system**:
   a. The somatic sensory system; Pain;
5. **Vision**

a. Vision; molecular basis of photoreception, central visual pathways; Neural basis of visual perception, types of eyes, photoreceptor and phototransduction, retinal circuits, visual cortex.

6. **Hearing**

a. Nature of Sound, The auditory system; the vestibular system; Lateral line organs and electroreceptor, The mammalian ear, the auditory nerve fibers. Brainstem auditory pathways, Auditory cortex.

7. The chemical senses;
   a. Taste system, Olfactory system
8. **Motor Neurons/system**
   a. lower motor neuron circuits and motor control;
   b. upper motor neuron control of the brainstem and spinal cord;
   c. modulation of movement by the basal ganglia and the cerebellum;
   d. eye movements and sensory motor integration; the visceral motor system;

9. **Brain development**
   a. brain development; construction of neural circuits; modification of brain circuits as result of experience; plasticity of mature synapses and circuits;
10. **Association Cortices**
   a. The association cortices; Language and lateralization; sleep and wakefulness; emotions; sex, sexuality and brain; human memory.

Practical

1. Demonstration of nervous system organization
2. Study of Sensory organs
3. Culture of embryonic neurons
4. Histology of neuronal tissue
5. Immunohistochemistry
6. Ionic basis of resting potential.
7. Sciatic nerve compound action potential.
8. Introduction to intracellular recording.
9. Recording of action potentials on oscilloscope
10. Study of Synaptic physiology and Synaptic activity with neuromuscular preparations.
11. Experiments on characteristics of skeletal muscle contractions
12. Responses of intestinal muscles

Books Recommended:

1. Neurobiology by Gordon M. Shepherd 3rd ed. ISBN-13: 978-0195088434, ISBN-10: 0195088433
2. The Neuroscience of Intelligence (Cambridge Fundamentals of Neuroscience in Psychology) Paperback – December 28, 2016 by Richard J. Haier
3. Brain & Behavior: An Introduction to Behavioral Neuroscience Fifth Edition by Bob Garrett (Author), Gerald Hough 5th edition, ISBN-13: 978-1506349206, ISBN-10: 150634920X
4. Neuroscience ABCs: Human Brain Physiology Guide [Print Replica] Kindle Edition
5. by Robert Lavine (Author), Publications Staff National Institute of Mental Health (Author)
6. Beatty, J. (2001). The human brain. Sage Publications, Inc.
7. Conn, P. M. (1995). Neuroscience in medicine. J. B. Lippincott Co.
8. Haines, D, E. (1997). Fundamental Neuroscience. Churchill Livingstone. Inc.
9. FitzGerald,M.J.T and Jean Folan- Curran (2002).Clinical neuroanatomy and related neuroscience.Harcourt Publishers Limited.
10. Levitan, I. B. and Kaczmarek, L. K. (1997). The neuron: cell and molecular biology. Oxford University Press. Inc.
11. Matthews, G. G. (1998). Neurobiology. Blackwell Science.
12. Purves, D., Augstine, G. J., Fitzpatrick, D., Katz, L. C., LaManta, A-S., McNamara, J. O., Williams, S. M. (2001). Neuroscience. Sinauer Associates, Inc.
13. Shepherd, G. M. (1994). Neurobiology. Oxford University Press, Inc.
14. Revest, P. and Longstaff. (1998). Molecular neurosciences. BIOS Scientific Publishers. Ltd.
15. Rafael Yuste and Arthur Konnerth (2005). Imaging in neuroscience and development a laboratory manual. Cold spring Laboratory press.

POPULATION BIOLOGY
(ZOL-738)

Credit Hours:
Theory = **2.0**
Practical = 1.0
Total = **3.0**

Course Objectives

The objectives of the course are:-

5. To familiarize the students with the basic concepts of population diversity & ecology
6. To educate the students with the methods of population samplings
7. To educate the students with the population dynamics in an ecosystem and their biotic & abiotic factors

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

17. Acquirethe basic knowledge of biological population and their evolutionary processes
18. Understand the concepts of basic methods of population samplings
19. Evaluate the population dynamics of biotic and abiotic factors of ecosystem

Course outline:

1. **Population**
   a. Population, basic population characters, population dynamics, exponential, logistic,
   b. Forms of population growth, density dependent and independent growth
   c. Animal behavior, ecology and evolution, Structural population, population genetics, adaptation and speciation
2. **Population ecology**
   a. Basic concepts, Population ecology of plants, population simulation,
   b. Community ecology, community analysis, succession, ecotones, predator-prey systems, competition, mutualism, commensalism and carrying capacity
   c. Population estimation methods, relative and absolute measures, age and sex composition
3. **Life history**
   a. Demographic and life history parameters, evolution of life history parameters: R and K selection
   b. Allometry, aging and sexing, life tables, age and stage structures models
   c. Methods of estimation of life history parameters
4. **Population sampling**
   a. Preparation of sampling designs for population estimation
   b. Analysis of census data, Studies of various population parameters and use of census techniques

Practical:

- Population studies mark and recapture method and statistical analysis of collected data
- Community analysis through different sampling techniques (Quadrat and Line transect).
- Adaptive features of animals in relation to food and environment.
- Food chain studies through analysis of gut contents and fecal materials.

- Analysis of polluted and fresh water for biotic and abiotic variations.
- Field visits for study of selected habitat and writing notes.
- Study of different ecosystems: pond, agricultural, grassland and forest.
- Development of an ecological management plan of some selected area.

Reference books:

1. Townsend, C. 2007. Essentials of Ecology. 3rd Ed. Publishing & Co. London, UK.
2. Odum, E.P., 1994. Fundamentals of Ecology. W.B. Saunders.
3. Moles, M.C., 2002. Ecology: Concepts and Applications..McGraw Hill, Boston.
4. Dodson, S.I., Allen, T.F.N., Carpenter, S.R., Ives, A., Jeanne,
5. Kitchell, R.L., J.F., Langston, N.E. and Turner, M.G., 1998. Ecology. Oxford Univ. Press, Oxford.
6. Singby, D. and Cork, D., 1986. Practical Ecology. McMillan Education Ltd., London.
7. Chapman, J.L. and Reiss, M.J., 1997. Ecology. Principles and Application. ambridge Univ. Press, Cambridge.
8. Smith, R.L. 1980. Ecology and Field Biology, Harper and Row.
9. Southwick, C.H., 1976. Ecology and Quality of our Environment. D. Van Norstrand Co, New York.
10. Boyd, C.E. 1981. Water quality in warm water fish ponds. Craft Master Printers Incorporation, Alabama.

WETLANDS MANAGEMENT

(ZOL-739)

Credit Hours: 03

Theory =02

Practical= 01

Total = 03

Course Objectives

The objective of this course is

4. to enable the student to understand basics of wetlands, wetlands in Pakistan and its significance
5. to understand values, valuation and management of wetlands
6. to understand how National and International agencies involved in conservation and management of wetlands

Course Learning Outcomes

Upon successful completion of this course, the student will be able to:

7. ACQUIRE theoretical knowledge about wetlands in Pakistan, its importance with reference to migratory birds.
8. UNDERSTAND the changes in climate affecting wetlands
9. SOLVE the threats to wetlands due to climate change and anthropogenic activities.
10. ANALYSE,interpreting and synthesize data and other information about wetlands and related diversity.

11. EVALUATE the wetland conservation management by government department, National and International organizations
12. DEMONSTRATE the ecological assessment and importance of wetlands to certain area.

Course outline

1. **Wetlands of Pakistan**
   a) Aquatic ecosystems
   b) Introduction to Wetlands
   c) Classification
   d) Wetlands hydrology
   e) Clarity on wetlands and Water Use
   f) Wetlands and Water Quality
   g) Wetlands and Environmental Flows
2. **Biogeochemistry**
3. **Wetlands and Climate change**
4. **Human Impacts and Management of wetlands**
5. **Values and valuation of wetlands**
   a) Lakes and rivers
6. **Degradation of aquatic ecosystems**
7. **Wetlands and Nutrient Retention**
8. **Restoration of wetlands**
   a) Passive restorations
   b) Active Restoration
9. **The Ramsar strategic plans**
10. **Research on Sustainable Agriculture and Wetlands**

Practicals

Preparation of a conservation project for wetlands

1. Wetlands without outlets
2. Wetlands with outlets
3. River and marsh lands
4. Coastal wetlands

Books Recommended

1. Mitsch, W. J. and Gosselink, J. G. 2007. Wetlands 4th ed. John Wiley & Sons, Inc.
2. Greipsson, S. 2011, Restoration Ecology, Biology and Physics Department, Kennesaw State University, Kennesaw, Georgia
3. Parikh, J. and Dattye, H. (2003). Sustainable Management of Wetlands Biodiversity and beyond. Sage Publications New Delhi Thousand Oaks London. Pp.444.
4. Verhoeven, J. T. A., Beltman, B., Whigham, D. F., Roland Bobbink. (2006). Wetlands and Natural Resource Management. Verhoeven, J. T. A., Beltman, B., Whigham, D. F., Roland Bobbink (eds). Springer-Verlag Berlin Heidelberg

ADVANCES IN EPIDEMIOLOGY AND CONTROL OF PARASITIC DISEASES (ZOL-740)

Credit Hours:
Theory = **2.0**
Practical: 1
Total = **3.0**

Course Objectives

1. To Describe basic principles of epidemiology, including descriptive/analytical epidemiology
2. To elaborate techniques used to conduct disease outbreak investigations and develop disease prevention programs
3. To describe causal models, distribution/patterns and control of disease or other health-related events in populations.

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

1. Learnbasic principles of epidemiology, including descriptive/analytical epidemiology
2. Demonstrate techniques used to conduct disease outbreak investigations and develop disease prevention programs
3. Compute causal models, distribution/patterns and control of disease or other health-related events in populations.

Course outline

1. **Introduction of Epidemiology**
   a. Significance
   b. Basis terminology
   c. general concepts
2. **Selection of epidemiological parameters**
   a. Surveillance study
   b. Host parasite associations;
3. **Population biology and genetics**
   a. Genetic variability and parasite transmission.
   b. Age- intensity and age prevalence profile of parasite infections
4. **Ecological and evolutionary dynamics of parasites**
   a. Parasite prevalence and seasons
   b. Epidemiological approaches for the control of parasites

c. Application of molecular techniques in Epidemiology of parasitic infections.

Practical:

Culture, isolation and separation of parasitic larvae from fecal/soil/herbage material.Baerrmann technique for nematode larvae separation, McMaster technique for egg per gram counting, field herbage collection for carpological examination.

Reference books:

1. Urquhart, G.M.J., Armour, J.L., Duncan and Jennings, F.W., 2000. "Veterinary Parasitology" 3rd Ed. The English Language Book Society/Longman Scientific and Technical UK.
2. Thrusfied, M., 1997. "Veterinary Epidemiology" 2nd Ed., Blackwell Science Publication.
3. Matrin, S.W., MEEK, A.H. and Willeberg, P., 1993. Veterinary Epidemiology.
4. Toft, C.A., Aeschlimann, A. and Bolis, L., 1991. Parasite Host Association. Oxford University press. New York USA.
5. Wayne, S. and Allan, H., 1987. "Veterinary Epidemiology" Principles and Practices S. and H. Allan, H., 1987. "Veterinary Epidemiology" Principles and Practices. Meek and PrebenWilleberg, lowa State University Press, Ames, lowa, USA.
6. Rollinson. D.R., Anderson, M., 1984. "Ecology and Genetics of Host-Parasite interations" Linnean Society Symposium Series No. 11, Academic press, New York. USA.

HERPETOLOGY

(ZOL-741)

Credit Hours: 03

Theory =02

Practical= 01

Total = 03

Course Objectives

The objective of this course is

7. To enable the student to identify herpetofauna.
8. To understand the factors affecting their distribution
9. To understand how National and International agencies involved in conservation and management of herpetofauna as part of wildlife

Course Learning Outcomes

Upon successful completion of this course, the student will be able to:

13. Acquire theoretical knowledge about the identification, distribution, status, conservation and management of amphibians and reptiles of major importance in Pakistan
14. Understand the critical habitats and biodiversity hotspots with reference to herpetofauna
15. Solve the threats to reptiles and amphibians by applying the scientific principles and modern technologies.
16. Interpretation and synthesis of data and other information about the population of herpetofauna
17. Evaluate the conservation management by government department, National and International organizations
18. Demonstrate the ecological assessment and importance of wildlife to certain area.

Course outline

11. Herpetofauna of Pakistan

h) Introduction
i) Important Definitions
j) Identification
k) Distribution
l) Status
m) Conservation and Management of amphibians and reptiles of major importance in Pakistan

12. Systematics and Zoogeography

13. Factors affecting distribution and abundance of amphibian and reptilian fauna of Indian Sub-continent.

14. Biology of major Herpetofauna

b) Major amphibians
c) Fresh water and Marine Turtle
d) Crocodiles
e) Lizards
f) Snakes

15. Thermo-regulation and its role

a) Aestivation
b) Hibernation
c) Other Eco-Physiological Adaptations

16. Role of temperature in sex determination in reptiles

Practicals

4. An overview of conservation problems and issues of herpetofauna of Indian Sub-continent.
5. Case Studies

Books Recommended

1. Pough, G. 1982. Biology of Reptilia. Academic Press, London.
2.M. S. Khan. 2004. Amphibians and Reptiles of Pakistan. John Willey and Sons. USA.
3. Richard, C. 1969. The World of Reptiles. Chatto and Windus, London.

4. Coleman, J. and G. Olive. 1971. Introduction to Herpetology (2nd Ed.). W.H., freeman.

ADVANCES IN FORENSIC BIOLOGY

(ZOL-742)

Credit Hours:

Theory = **2.0**

Practical = 1.0

Total = **3.0**

Course Objectives

The objectives of the course are:-

1. To give the students basic understanding of forensic Science with reference to biology.
2. To equip the students for biological sample collection, handling and storing from crime scene.
3. To elaborated certain types of test which are involved in forensic biology.

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. **Acquire** the basic knowledge of forensic science and forensic biology.
2. **Understand** the key steps in forensic biology from examination of crime scene to sample collection processing and final interpretation.
3. **Solve** the problems like sexual and physical assault, paternity cases and murder cases.
4. **Analyze** certain types of sample with serology testing, DNA quantification and PCR analysis.
5. **Justify** certain cases with the help of available evidences.

Course outline:

Biological material – collection, characterization and storage

a. Sources of biological evidence
b. Collection and handling of material at the crime scene
c. Identification and characterization of biological evidence
d. Evidence collection
e. Sexual and physical assault
f. Presumptive testing
g. Storage of biological material

Serology Testing

a. Identification of Semen
b. Acid Phosphatase Screening
c. Alternate Light Source or Ultraviolet (UV) Light
d. Microscopic Identification of Spermatozoa
e. Protein Confirmation of Semen

Identification of Blood

a. Presumptive Testing for Blood

b. Species Testing of Blood.
c. ABO Blood Typing
d. Blood Spatter Interpretation

DNA Testing

a. DNA Extraction
b. Differential DNA Extraction
c. DNA Quantification
d. Restriction Fragment Length Polymorphism (RFLP)
e. Early PCR-Based Methods
f. Tandem Repeat (STR) Analysis
g. Mitochondrial DNA (mtDNA) Sequencing
h. Y-Chromosome STR Analysis
i. Single-Nucleotide Polymorphism (SNP) Analysis

Practical:

• DNA Extraction
DNA Quantification
•The polymerase chain reaction.
Presumptive Testing for Blood
Species Testing of Blood
ABO Blood Typing
Low Copy Number (LCN) DNA Testing

Reference books:

1. Goodwin W, Linacre A, Hadi S. An introduction to forensic genetics. John Wiley & Sons; 2011.
2. Mozayani, A. and Noziglia,.The forensic laboratory handbook procedures and practice. Springer Science. 2010.
3. Siegel, J.A. and Mirakovits, K. Forensic science: the basics. CRC Press.2015.

Saferstein, R.,. *Criminalistics*.Pearson Education. 2013.

CLIMATE CHANGE AND ECOSYSTEM STABILITY

(ZOL-743)

Credit Hours: 03

Theory =02

Practical= 01

Total = 03

Course Objectives

The objective of this course is

10. to enable the student to understand ecosystem, climate change, Stability and Ecological constraints.
11. to understand the Regime shift, Assembly rules, Theories and biogeography.
12. to understand how National and International agencies involved in controlling constraints and increasing biotic and Abiotic resistance.

Course Learning Outcomes

Upon successful completion of this course, the student will be able to:

19. ACQUIRE theoretical knowledge about Climate change, causes, impacts and mitigation measures.
20. UNDERSTAND the species compatibility, Ecosystem Threshold and Restoration to Constrain Invasion.
21. SOLVE the problems of climate change and Ecological constraints.
22. ANALYSE,interpreting and synthesize data and other information about Ecosystem Resilience, climatic alterations and Restoration
23. EVALUATE the sustainablemanagement by government department, National and International organizations
24. DEMONSTRATE the Ecological constraints, Restoration of Alternative stable states and Fire management.

Course outline

17. The Earth System
- n) Introduction
- o) Climate change
- p) Ecosystem Resilience
- q) Resistance
- r) Stability
- s) Ecological Constraints

18. Alternative Stable States
- a) Regime shift
- b) Restoring Alternative Stable States
- c) Assembly Rules

19. Sequence Introduction

20. Species Compatibility

21. Ecosystem Thresholds and Ecosystem filters

22. Unified Neutral Theory of Biodiversity and Biogeography

23. Invasive species
- g) Process of Invasion
- h) Effects of Invasion on Ecosystem
- i) Methods of control
- j) Eradication
- k) Containment

24. Chemical and Biological Control

25. Restoration to Constrain Invasion
- a) Niche Preemption
- b) Fire Management
- c) Increasing Biotic and abiotic Resistance

Practicals

6. Study of climate change (weatherdata),
7. Resilience and Ecosystem Restoration
8. PHRIA's Metdology.

Reference Books

1. Laird, S. A. 2006. Biodiversity and traditional Knowledge, Viva Books Private Limited.
2. Greipsson, S. 2011, Restoration Ecology, Biology and Physics Department, Kennesaw State University, Kennesaw, Georgia
3. Kumar, H. D. 2006. Global Climate Change, Insight, Impacts and concerns, Vitasta Publishing Pvt. Ltd.
4. Plummer, R., Lundholm, C. And Krasny, M. 2011. Resilience in Social-Ecological Systems, The Role of Learning and Education, Routledge – 224 pages
5. Baumgartner, R. and Hogger, R. (2004). In search of sustainable livelihood systems: Management Resources and change. Sage publications New Delhi Thousand Oaks London.Pp.380.

MARICULTURE TECHNOLOGY
(ZOL-744)

Credit Hours:
Theory = **2.0**
Practical= 1.0
Total = **3.0**

Course Objectives:

The objectives of the course are:-

1. To familiarize the students with integrated aquaculture and management modes of mariculture facilities.
2. To provide an exposure about various preservation techniques of fish and fish products.
3. Demonstrate techniques for shrimp farming, monitoring and management of water quality in aquaculture facilities.
4. Develop skills of artificial breeding technique of marine organisms.

Learning Outcomes:

After completing this course students will be able to:

- Develop understanding about culture of marine organisms and management of mariculture facilities.
- Understand integrated aquaculture and artificial breeding of marine organisms.
- Demonstrate various methods of fish preservation and processing.
- Practical skills of artificial fish breeding of tilapia and marine organisms.

Course Contents:

1. Introduction to mariculture technology.
2. An overview ofmariculture in the world.
3. Artificial breeding of abalone.

4. Techniques of larval rearing and farming in the white shrimp (*Litopenaeusvannamei*).
5. Living food organism and their cultivation,
6. Culture techniques of Scylla.
7. Breeding and rearing of grouper.
8. Oyster farming techniques.
9. Grey mullet culture techniques.
10. Marine algae culture.
11. Tilapia culture.
12. Production techniques for aquatic feeds.
13. Artificial breeding and culture technique of ovate pompano.
14. Marine biodiversity protection and sustainable development of mariculture industry.
15. Disease occurrence and control strategy of mariculture organisms.
16. Monitoring and management of water quality in aquaculture

Practical:

1. Aquaculture techniques of white shrimp (*Litopenaeusvannamei*).
2. Culture techniques of Scylla.
3. Breeding of abalone grouper.
4. Oyster Grey mullet, ovate pompano and tilapia.
5. Production techniques for aquatic feeds.
6. Monitoring and management of water quality in aquaculture facilities.

BooksRecommended:

1. W. Horner & R. Robles, 2007. Fish Products and Processing, Blackwell Publications
2. O. Gabriel,K. Lange, E. Dahm& T. Wendt,2005.Fish Catching Methods of the World IV Edition. Blackwell Publications
3. Anthony T. Charles, 2001. Sustainable Fishery Systems, Blackwell Publications.
4. Bensam, P. 1999. Development of Marine fisheries science in India Daya publishing House-Delhi.

ARACHNOLOGY
(ZOL-745)

Credit hours 3

Theory: 2

Practical: 1

Objectives

The course aims to:

- **Impart in-depth knowledge of Arachnids.**
- **Develop concepts about importance of the classification of class Arachnids.**
- Study the history and importance of Arachnids.
- Demonstrate about identifications of Arachnids.

Course Contents

- Importance and applications of Arachnology.
- Importanceand its future perspectives.
- History of arachnology, Introduction of arachnology according to history
- Structure of the Arachnids
- Characters of Arachnids
- classification position of class Arachnid
- External and internal anatomy
- Life history of Arachnids
- Defense mechanisms.
- Arachnid with relationship to man.
- Role of Arachnids as a biological control
- Arachnidsfamiliesidentification.

Practicals

1. Systematic. Collection.
2. Preservation.
3. Morphological characters of Arachnid.
4. Anatomy of Arachnid.
5. Writing description of identified (Araneae) Arachnid.
6. Preparation of identified specimen's slide.
7. Identification of specimens up to families with the help of keys.
8. Field survey for the collection of arachnids from different habitats.

Recommended Books:

1. Foelix, R. 2011. Biology of spiders. OUP USA.
2. Levi, H. W. 1956. The spider genera Neottiura and Anelosimus in America (Araneae: Theridiidae). Transactions of the American Microscopical Society, 75(4), 407-422.
3. Herberstein, M. E. (Ed.). 2011. Spider behaviour: flexibility and versatility. Cambridge University Press
4. Bristowe, W. S. 1958. World of spiders.

FISH PHYSIOLOGY AND BREEDING
(ZOL-746)

Credit Hours: 3
Theory = **2.0**
Practical = 1.0
Total = **3.0**

Course Objectives

The objectives of the course are:-

13. To provide sufficient knowledge about all physiological phenomena in fishes.

14. To provides practical information to obtain better growth by following physiological aspects during extensive or semi-intensive culture.
15. To emphasize thoroughly in breeding of most cultivable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons.

Learning outcomes.

Upon successful completion of the course, the student will be able to:

20. **Relate**thekeyconcepts of fish physiology and breeding techniques.
21. **Describe** the different systems and their coordination.
22. **Assess** problems associated with natural and artificial breeding.
23. **Determine** the fish production with relation to induced breeding.
24. **Judge** the fish behavior and migration patterns**.**
25. **DEMONSTRATE** the various organs by dissecting the fish and also collection of ill fishes for better understanding of various diseases.

<u>Course Contents:</u>

Fish nutrition

Digestive system;
Stomach less fishes;
Stomach fishes;
Digestion and absorption;
Food; Plant origin; Animal origin;
Feeding; Fresh food; Dry concentrates; Pelleted food.

Transportation:

Blood; Blood cells (Erythrocytes, leukocytes, Platelets and plasma);
Circulation; Arterial system; Venous system; Capillaries;
Transport of food material.

Respiration:

Gills;
Lungs;
Skin;
Swimbladder;
Homeostasis.

Excretion:

Kidneys; Hypo-osmotic urine; Hyper-osmotic urine; Osmoregulation.

Reproduction:

Gonads; Testes and ovaries;
Maturation;
Reproductive cells (egg and sperm);
Artificial fertilization of sex cells.

Breeding:

Natural (seasonal); Artificial;
Hormonal induced breeding;
Temperature & photoperiod;
Control induced breeding.

Growth:

Extensive culture (due to the consumption of natural food);
Semi-intensive culture (due to natural & artificial food);
Intensive culture (due to only dry concentrates).

Fish health:

Water quality;
Hygiene of fish culture facilities;
Hygiene of equipments used in fish culture.

Diseases and their control:

Viral;
Bacterial;
Fungal;
Parasitic;
Protozoan;
Helminths (trematodes, cestodes, nematodes, acanthocephalons); Crustaceans (cladocera); Annelids (leeches); Arthropods (water ticks, water flea, water mites).

Fish migration:

To nursery ground;
To maturation grounds;
Freshwater to marine water;
Marine water to freshwater.

Fish behaviour:

Learning and memory;
Light response for maturation;
Courtship behaviour;
Aquarium fish behavior

Practicals

Study of gut contents, Study of feeding modification and adaptation in fish, Study of respiratory adaptation in fish, Study of blood cells and their counts in normal and diseased fish, Study of water quality parameters (DO, NH_3, hardness, alkalinity, turbidity, transparency, temperature, salinity), Study of various forms of swimbladder as hydrostatic organ, Study fecundity of various fish species, Study the effects of reproductive hormone (GnRH) on fish maturation, Diagnosis of bacterial infection in infected fish, Study of fish parasites, Visit to various fish seed hatcheries during breeding seasons

Books Recommended

1. Kestin, S. C. and Warris, P.D. (Editors). KESTIN FARMED FISH QUALITY, 2002, Blackwell Science, Oxford, UK.

2. Saksena, D.N. ICHTHYOLOGY: RECENT RESEARCH ADVANCES. 1999. **Oscar Publications. India.**
3. Woo, P.T.K FISH DISEASES AND DISORDER. Vol 1. PROTOZOAN AND METAZOAN INFECTIONS. 1995. CABI Publisher.
4. Brenabe, G. AQUACULTURE, Vol. I. 1992. Blackwell Publishing, Oxford. UK.
5. Maseke C. FISH AQUACULTURE. 1987. Pergamon Press, Oxford. UK.
6. Huet M. TEXT BOOK OF FISH CULTURE: BREEDING AND CULTIVATION. 1973. Blackwell Publishing Company
7. Hoars, W.S. FISH PHYSIOLOGY. 1971. Academic Press. UK.
8. Hoars, W.S. FISH REPRODUCTION. 1969. Academic Press. UK.
9. Matty, A.J. FISH ENDOCRINOLOGY. 1985. Timber Press, UK.
10 Gorbman, A. COMPARATIVE ENDOCRINOLOGY. 1st Edition. 1983. John Wiley & Sons. UK