

CURRICULUM/SCHEME OF STUDIES

BSC (HONS) FISHERIES & AQUACULTURE

**PROPOSED SCHEME OF STUDIES FOR
B.Sc. (HONS.) FISHERIES AND AQUACULTURE (4 years)**

Program objectives

Fishfarming is playing an important role in alleviation of poverty, human recourse development and sustainable developments of freshwaters in the country. The Fisheries and Aquaculture program offers students experience raising local fish and shrimp species, and enriches them with diverse fisheries management field experiences. Students will also have opportunities to conduct independent research on addressing new available technologies in fisheries and aquaculture.

Eligibility Criteria:

A candidate must have passed the F.Sc (Pre-Medical) an equivalent examination securing at least 50% marks. And Candidates having F.Sc Pre-Engineering with 50 % marks will be eligible subject to study deficiency course in Biology BIO-301, 3(2-1) (Essentials of Biology). Candidates having F.Sc Pre-Agriculture with 50 % marks will be eligible subject to study deficiency course in Biology BIO-301, 3(2-1) (Essentials of Biology)

No. of Seats - 50

A total number of 50 seats will be available for admission and equal opportunity will be provided to female candidates.

Total Credit hours: 136

Major courses

Course No.	COURSE NAME	Credit Hours
FSAQ-301	Introductory Freshwater Biology	4(3-1)
FSAQ-303	Plant Diversity	3(2-1)
FSAQ-302	Ichthyology	4(3-1)
FSAQ-304	Introductory Fish Culture	4(3-1)
FSAQ-401	Aquatic Microbiology	3(2-1)
FSAQ-403	Plant Physiology	3(2-1)
FSAQ-405	Fish Behavior	3(2-1)
FSAQ-407	Fish and Fisheries Biology	4(3-1)
FSAQ-402	Developmental Biology	4(3-1)
FSAQ-404	Fish Nutrition	4(2-2)
FSAQ-406	Animal Physiology	3(2-1)
FSAQ-408	Ecology	3(2-1)
FSAQ-410	Fresh Water Invertebrates	4(3-1)
FSAQ-412	Cell and Molecular Biology	4(3-1)

FSAQ-501	Limnology	4(3-1)
FSAQ-505	Genetics	4(3-1)
FSAQ-507	Fishery Technology	4(3-1)
FSAQ-509	Phycology	4(3-1)
FSAQ-502	Water Pollution	4(3-1)
FSAQ-504	Biotechnology in Aquaculture	4(2-2)
FSAQ-506	Fish Breeding and Conservation	4(3-1)
FSAQ-508	Aquatic Macrophytes and Management	4(2-2)
FSAQ-510	Fish Immunology	3(2-1)
FSAQ-601	Integrated Fish Farming	3(2-1)
FSAQ-603	Inland Fisheries Management	3(2-1)
FSAQ-605	Fish Post-harvest Technology	3(2-1)
FSAQ-607	Fish Parasitology	3(2-1)
FSAQ-609	Preparation of Research Project and Scientific Writing	2(1-1)
FSAQ-611	Fish Hygiene and Disease Management	4(2-2)
FSAQ-613	Aquatic Toxicology	3(2-1)

SUPPORTING COURSES:

Course No.	Course Name	Credit Hours
BIOCHEM-401	Biochemistry	3 (3-0)
ENG-301	Composition and Communication Skills	3(3-0)
IS-401	Islamic Studies OR	3(3-0)
SSH-402	Ethics (for Foreign/Non-Muslim Students)	
STAT-302	Introductory Statistics	2(2-0)
BBAA-101	Functional English	3(3-0)
SSH-302	Pakistan Studies	2(2-0)
ZOOL-101	Zoology-I	3(2-1)
ZOOL-102	Zoology-II	3(2-1)
CS-301	Computer science and information technology	2(0-2)
SRT-301	Social and Religious Tolerance	Audit
UAM-302	Citizenship Education and Community Engagement	Audit

Semester wise Description

1st Semester

Course No.	Title of Course	Credit Hours
FSAQ-301	Introductory freshwater biology	4(3-1)
FSAQ-303	Plant diversity	3(2-1)
ENG-301	Composition and Communication Skills	3(3-0)
IS-401	Islamic Studies OR	3(3-0)

SSH-402	Ethics (for Foreign/Non-Muslim Students)	
STAT-302	Introductory Statistics	2(2-0)
ZOOL-101	Zoology-I	3(2-1)
Total		18

2nd Semester

Course No.	Title of Course	Credit Hours
FSAQ-302	Ichthyology	4(3-1)
FSAQ-304	Introductory fish culture	4(3-1)
FSAQ-406	Animal Physiology	3(2-1)
ENG-302	Functional English	3(3-0)
SSH-302	Pakistan Studies	2(2-0)
ZOOL-102	Zoology-II	3(2-1)
SRT-301	Social and Religious Tolerance	Audit
Total		19

3rd Semester

Course No.	Title of Course	Credit Hours
FSAQ-401	Aquatic Microbiology	3(2-1)
FSAQ-403	Plant Physiology	3(2-1)
FSAQ-405	Fish Behavior	3(2-1)
FSAQ-407	Fish and Fisheries Biology	4(3-1)
BIOCHEM-401	Biochemistry	3(3-0)
CS-301	Computer Science and Information Technology	2(0-2)
UAM-302	Citizenship Education and Community Engagement	Audit
Total		18

4th Semester

Course No.	Title of Course	Credit Hours
FSAQ-402	Developmental Biology	4(3-1)
FSAQ-404	Fish Nutrition	4(2-2)
FSAQ-408	Ecology	3(2-1)
FSAQ-410	Fresh Water Invertebrates	4(3-1)
FSAQ-412	Cell and Molecular Biology	4(3-1)
Total		19

5th Semester

Course No.	Title of Course	Credit Hours
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FSAQ-501	Limnology	4(3-1)
FSAQ-503	Fish Parasitology	3(2-1)
FSAQ-505	Genetics	4(3-1)
FSAQ-507	Fishery Technology	4(3-1)
FSAQ-509	Phycology	4(3-1)
Total		19

6th Semester

Course No.	Title of Course	Credit Hours
FSAQ-502	Water Pollution	4(3-1)
FSAQ-504	Biotechnology in Aquaculture	4(2-2)
FSAQ-506	Fish breeding and Conservation	4(3-1)
FSAQ-508	Aquatic Macrophytes and Management	4(2-2)
FSAQ-510	Fish Immunology	3(2-1)
Total		19

7th Semester

Course No.	Title of Course	Credit Hours
FSAQ-601	Integrated Fish Farming	3(2-1)
FSAQ-603	Inland Fisheries Management	3(2-1)
FSAQ-605	Fish Post-harvest Technology	3(2-1)
FSAQ-609	Preparation of Research Project and Scientific Writing	2(1-1)
FSAQ-611	Fish Hygiene and Disease Management	4(2-2)
FSAQ-613	Aquatic Toxicology	3(2-1)
Total		18

8th Semester

Course No.	Title of Course	Credit Hours
FSAQ-610	Internship	6(0-12)

Course Scheme

FSAQ-301 Introductory Freshwater Biology 4(3-1)

Learning Objectives

After studying this course the students would be able to:

- Name and describe important freshwater resources of Pakistan
- Explain the zonation of different aquatic habitats.
- Describe the fauna and flora of freshwater bodies

Theory:

Brief description of freshwater resources of Pakistan, types of freshwater habitats and their zonation. Study of life form, structure, reproduction and economic significance of Bacteria and Cyanobacteria (*Nostoc*, *Anabaena* and *Oscillatoria*) with specific reference to biofertilizers, pathogenicity and industrial importance. Freshwater Algae: Chlorophyta (*Chlamydomonas*, *Spirogyra*, *Volvox*); Charophyta (*Chara*); Xanthophyta (*Vaucheria*); Bacillariophyta (*Pinnularia*); Phaeophyta (*Ectocarpus*); Rhodophyta (*Batrachospermum*). Study of life form, structure, reproduction and economic significance of Protozoan, Shrimps, Crayfish, Snails, Crustaceans, Molluscs.

Practicals:

- Study of various economic common freshwater algae and animal forms given in theory.
- Collection, identification and preservation of different groups of freshwater animals and plants.

Suggested Readings

1. Moss, B.R., 2010. Ecology of Fresh Waters: A View for the Twenty-First Century. 4thed. Wiley-Blackwell, USA.
2. Bronmark, C. and Hansson, L., 2005. The Biology of Lakes and Ponds. Oxford University Press, UK.
3. J.G. Needham, J.G., 1962. Guide to the Study of Freshwater Biology 5thed. McGraw-Hill , USA. Maitland, P.S., 1990. Biology of Fresh Waters. Springer , USA.

FSAQ-302 Ichthyology 4 (3-1)

Learning Objectives

After studying this course the students would be able to:

- Identify and classify the fishes at least up to generic level
- Describe the structure and functions of different body systems of fish
- Assess the age of fish by using different methods

Theory:

Introduction to Ichthyology, Classification of fish. Biology of commercial food fishes of Pakistan (Morphology, anatomy, ecology and distribution). Scales in fishes (structure, types, importance identification, classification and age determination). Gas bladder, types of fins and their function. Physiology of digestion (food, feeding habits, feeding adaptations), Circulatory

system, Nervous system, Respiration (structure and working of gills, aerial respiration) Excretion and Osmoregulation (renal, gills, difference between freshwater and marine fish) Reproduction (sexual dimorphism, maturity, fecundity, breeding habits, parental care), Fish migration and fish ladders, Different environmental factors and their effects on fish behavior.

Practicals:

- Identification of commercially important fish of Pakistan.
- Museum survey.
- Study of external features and skeleton of fish.
- Preparation of permanent slide of Fish scales.
- Dissection of fish to expose its internal features, especially digestive, circulatory, respiratory, excretory and reproductive system.

Suggested Readings

1. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2012. Ichthyology. John Wiley and Sons, Inc., New York.
2. Ali, S.S. and Narejo, N.T., 2009. Fundamentals of Ichthyology. Sindh University Press, Jamshoro.
3. Kapoor, G. B. and Khana, B., 2004. Ichthyology hand book. Springer.
4. Ali, S.S., 1999. Freshwater Fisheries Biology. Naseem Book Depot, Pakistan.

FSAQ-303

Plant Diversity

3 (2-1)

Learning Objectives

After completion of this course, the students would be able to:

- Understand the diversity of plants, their structure and economic significance
- Describe, classify and appreciate the biology and evolution of plant architecture
- Demonstrate the technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan

Theory:

Comparative study of life form, structure, reproduction and economic significance of Viruses (RNA and DNA types) with special reference to TMV; Bacteria and Cyanobacteria (*Nostoc*, *Anabaena*, *Oscillatoria*) with specific reference to bio-fertilizers, pathogenicity and industrial importance; Algae (*Chlamydomonas*, *Spirogyra*, *Chara*, *Vaucheria*, *Pinnularia*, *Ectocarpus*, *Polysiphonia*) Fungi (*Mucor*, *Penicillium*, *Phyllactinia*, *Ustilago*, *Puccinia*, *Agaricus*), their implication on crop production and industrial applications. Lichens (*Phycia*) Bryophytes, *Riccia*, *Anthoceros*, *Funaria*, Pteridophytes, Fossils and fossilization, Psilopsida (*Psilotum*), Lycopsidea (*Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Marsilea*), Seed Habit, Gymnosperms *Cycas*, *Pinus*, *Ephedra*

Practicals:

- Maintenance and preservation of microorganisms
- Study of morphology and reproductive structures of the types mentioned in theory
- Collection, identification and preparation of slides

Suggested Readings

1. [Gibson](#), J.P. and [Gibson](#), T.R., 2007. Plant Diversity: The green world. Infobase Publishing, USA.

2. Ingrouille, M. and Eddie, B., 2006. Plants: Diversity and Evolution. Cambridge University Press, UK.

FSAQ-304

Introductory Fish Culture

4 (3-1)

Learning Objectives

After studying this course, student would be able to:

- Know the importance of fish in human diet
- Familiarize with Culturable fish species of Pakistan
- Help fish farmer in designing, constructing and maintaining fish farm

Theory:

Status of fish in human diet; History of fish culture; Fish culture systems and types; Culturable fishes of Pakistan; Criteria for farm site selection; Designing, construction, liming and fertilization of fish pond; Criteria for selection of fish species for culture; Stocking, feeding and maintenance of fish farms; Ingredients of supplementary fish feed; Introduction to integrated fish farming. Water quality monitoring and management in fish pond; Fish enemies and their control; Methods for handling, processing and preservation of fish (drying, salting, curing, smoking and freezing); Common fish diseases and their control.

Practicals:

- Visit of fish processing unit.
- Calculation and use of different organic, inorganic fertilizers and feed in fish ponds.
- Visit to fish farms and hatcheries.
- Quality analysis of pond water.

Suggested Readings

1. Boyd, C.E. and McNevin, A.A., 2014. Aquaculture, Resource Use, and the Environment. Wiley-Blackwell, USA.
2. Parker, R., 2011. Aquaculture Science. 3rd ed. Delmar Publishing, USA.
3. Sharma, O.P., 2009. Handbook of Fisheries and Aquaculture. Agrotech Publishing Academy, India.

Learning Objectives

After completing this course, students would be able to:

- Describe the importance of zoology and its relation with other sciences
- Correlate the life with its chemical basis
- Draw and explain structure and functions of organelles of cell

Theory:**Place of Zoology in Science**

A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is zoology. The classification of animals; the scientific method.

The Chemical Basis of Animal Life

Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.

Cells, Tissues, Organs, and Organ System of Animals

Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.

Energy and Enzymes: Life's Driving and Controlling Forces

Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.

Practicals:

- Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).
- Plasmolysis and deplasmolysis in blood.
- Protein digestion by pepsin.

Suggested Readings

1. [Smith](#), D.G. and Schenk, M.P., 2014. Exploring Zoology in the Laboratory 2nd ed. Morton Publishing Company, USA.
2. Hickman, C.P., Roberts, L.S. and Larson, A., 2013. Integrated Principles of Zoology. 16th ed. (International). McGraw Hill, Singapore.
3. Miller, S.A. and Harley, J.B., 2012. Zoology. 9th ed. (International). McGraw Hill, Singapore.
4. [Wallace](#), R.L. and [Taylor](#), W.K., 2002. Invertebrate Zoology Laboratory Manual. 6th ed. Pearson Education.

Learning Objectives

After completing this course, students would be able to:

- Describe the structure and role of chromosome in heredity
- Explain the history of evolution and the role of heredity in evolution
- Compare different shades of animal behavior and learning.

Theory:**Cell Division**

Mitosis, cytokinesis and the cell cycle: an overview; control of the cell cycle; Meiosis: the basis of sexual reproduction; gamete formation.

Inheritance Patterns

The birth of modern genetics; Mendelian inheritance patterns; other inheritance patterns; environmental effects and gene expression.

Chromosomes and Gene Linkage

Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure.

Molecular Genetics: Ultimate Cellular Control: DNA

the genetic material; DNA replication in eukaryotes; genes in action; control of gene expression in eukaryotes; mutations; applications of genetic technologies; recombinant DNA.

Animal Behavior

Four approaches to animal behavior; proximate and ultimate causes; anthropomorphism; development of behavior; learning; control of behavior; communication; behavioral ecology; social behavior.

Evolution; A Historical Perspective

Pre-Darwinian theories of change; Lamarck: an early proponent of evolution; early development of Darwin's ideas of evolution and evidences; the theory of evolution by natural selection; evolutionary thought after Darwin; biogeography.

Evolution and Gene Frequencies

The modern synthesis: a closer look; the Hardy-Weinberg theorem; evolutionary mechanisms: population size, genetic drift, natural selection, gene flow, mutation, and balanced polymorphism; species and speciation; rates of evolution; molecular evolution; mosaic evolution.

Practicals:

- Study of mitosis in onion root tip.
- Study of meiosis in grasshopper testis (students should prepare the slide).
- Multiple alleles study in blood groups.
- Study of cytochemical detection of DNA in protozoa and avian blood cell.

Suggested Readings

1. [Smith](#), D.G. and Schenk, M.P., 2014. Exploring Zoology in the Laboratory 2nd ed. Morton Publishing Company.
2. Miller, S.A. and Harley, J.B., 2012. Zoology. 9thed (International). McGraw Hill, Singapore.
3. Miller, S.A., 2002. General Zoology Laboratory Manual. 5th ed. McGraw Hill, Singapore.
4. Hickman, C.P. and Kats, H.L., 2000. Laboratory Studies in Integrated Principles of Zoology. McGraw Hill, Singapore.

BIOCHEM-401
Learning Objectives

Biochemistry

3 (3-0)

After completion of this course, the students would be able to:

- Gain deep understanding of many of the chemical reactions and structures of biological molecules essential to life on Earth
- Explain/Describe the synthesis of proteins, lipids, nucleic acids, and carbohydrates and their role in metabolic pathways
- Know the Macromolecular separation techniques

Theory:

Amino acids, peptides, proteins and their classification; acid/base properties of amino acid; natural modifications of amino acids in proteins; non-standard amino acids, their structure and role; amino acid composition, cytochrome-c; Macromolecular separation techniques in biochemistry; ion exchange chromatography; isoelectric focusing; density gradient centrifugation.

Enzymes

Introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity; kinetics of bi-substrate and multi-substrate reactions.

Carbohydrates

Classification, types, important characteristics and structure of carbohydrates; history of developments in structure of glucose; monosaccharides; cyanohydrin formation; disaccharides their types structure and function; polysaccharides, storage and structural types; structure and major functions of polysaccharides.

Lipids

Fatty acids, their types and major characteristics; storage lipids, anti-oxidants acylglycerols; waxes; structural lipids in membranes; major functions of lipids; lipoproteins, their types and major functions.

Vitamins and cofactors

Classification of vitamins, their occurrence, structure and biochemical function: modes of action

Bioenergetics

Concept of free energy; standard free energy change: energy rich compounds

Metabolism

Detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; utilization of other carbohydrates in glycolysis; phosphorylation of glycogen and starch; regulation of glycogen metabolism; utilization of dietary polysaccharides (starch) and disaccharides (sucrose and galactose). Bio-synthesis of glycogen, starch and sucrose.

Citric acid (TCA) cycle

Conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle.

Lipid metabolism

oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multi enzyme complex; biosynthesis of unsaturated fatty acids. Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: cholesterol biosynthesis and its regulation; steroid hormones.

Nitrogen metabolism

Metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle; biosynthesis of some amino acids; incorporation of ammonia in glutamate and glutamine; purine and pyrimidine.

Suggested Readings

1. Joshi, R.A. and Saraswat, M., 2002. A Text Book of Practicals: Biochemistry. 1st ed. B. Jain Publishers, India.
2. Wilson, K. and Walker, J., 1994. Practicals: Biochemistry: Principles and Techniques. 4th ed. Cambridge University Press, UK.
3. Plummer, D. T., 1990. An Introduction to Practicals: Biochemistry. 4th ed. McGraw-Hill Book Company, UK.

Learning Objectives

After studying this course the students would be able to:

- Describe general morphology and classification of aquatic microbes
- Correlate environmental factors with presence and abundance of aquatic microbes
- Explain the role of microorganism in biogeochemical cycles, bioremediation and biodegradation

Theory:

Introduction and historical perspective of aquatic microbiology. General classification and characteristics of archaea, bacteria, viruses and fungi. Microbial communities in the aquatic environment: distribution; nutrients, oxygen and pH gradients. Microbial flora of surface and ground waters; Nature of aquatic environment; Extremophiles: halophilic, psychrophilic and barophilic bacteria; nutrient cycling at hydrothermal vents. Role of microbes in biogeochemical cycles. Biodegradation and bioremediation of organic and inorganic pollutants. Metagenomics of the microbes.

Practicals:

- Introduction to basic techniques for sterilization/disinfection, isolation, culture, purification and preservation; Dilution plate technique, Mean plate count, Enumeration of coliform bacteria and fungi from water.

Suggested Readings

1. Maier, F.M., Pepper, I.L. and Gerba, C.P., 2009. Environmental Microbiology. 2nd ed. Academic Press, London, UK.
2. Austin, B. and Austc, D.A., 2007. Bacterial fish pathogens; diseases of farm and wild fish. Springer USA
3. Prescott, L.M., Harley, J.P. and Klein, D.A., 2007. Microbiology, McGraw Hill Inc., USA
4. Duncan, M. and Nigel, H., 2003. The Handbook of water and wastewater Microbiology. Academic Press, UK

Learning Objectives

After studying this course the students would be able to:

- Describe early cleavage and development of vertebrates
- Draw fate maps for different types of egg
- Explain the molecular control of development and growth

Theory:

Introduction: Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis; Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm; Cleavage: Patterns of embryonic cleavage, mechanism of cleavage; Gastrulation: Fate maps, gastrulation in sea urchin, amphibians, birds and mammals. Early Vertebrate Development: Neurulation, ectoderm, mesoderm and endoderm. Cellular Basis of Morphogenesis: Differential cell affinity, cell adhesion molecules; Mechanism of Cellular Differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction; Organogenesis: A brief account; Origin and Migration of Germ Cells in Vertebrates; Factors controlling Growth and Oncogenesis. Hormones as Mediators of Development; Regeneration in Vertebrates.

Practicals:

- Study of structure of gametes in some representative fish species.
- Study of cleavage and subsequent development from prepared slides and/or whole mounts.
- Study of fertilization, early development of fish through induced spawning under laboratory conditions.

Suggested Readings

1. Gilbert, S.F., 2013. Developmental Biology. 10th ed. Sinauer Associates, Sunderland, USA.
2. Balinsky, B.I., 2012. An Introduction to Embryology. 5thed. W.B. Saunders Company, Philadelphia.
3. Oppenheimer, S.S., 2004. Introduction to Embryonic Development. 4th ed. Allen and Bacon, Chicago Press, USA.

Learning Objectives

After studying this course the students would be able to:

- Describe role of water in photosynthesis and other activities of plant life
- Evaluate the importance of photosynthesis for the survival and growth of plants
- Explain the process of growth in plants and the role of photoperiod in growth

Theory:**Water relations**

Water, osmotic and pressure potentials. Absorption and translocation of water; Stomatal regulation.

Mineral nutrition

Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.

Photosynthesis

Introduction, Oxygenic and non-oxygenic photosynthesis mechanisms: light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Differences between C₃ and C₄ plants. Factors affecting photosynthesis, products of photosynthesis.

Growth: Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture.

Photoperiodism

Definition, historical background, classification of plants based on photoperiodic response, role of phytochromes, hormones and metabolites in photoperiodism

Dormancy

Definition and causes of seed and bud dormancy; methods of breaking seed dormancy, Physiological processes during seed germination

Practicals:

- Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
- Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
- Measurement of leaf water potential by the dye method.
- Determination of the temperature at which beet root cells lose their permeability.
- Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer by cobalt chloride paper method.
- Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram.
- Estimation of oxygen utilized by a respiring plant by Wrinkler's method.
- Measurement of carbon dioxide evolution during respiration of germinating seeds by the titration method.

Suggested Readings

1. Taiz, L. and Zeiger, E., 2002. Plant Physiology. 3rd ed. *Sinauer Associates, Inc* publisher, USA.
2. Ihsan, I., 1995. Plant Physiology, Biochemical Processes in Plants. UGC Press, Pakistan.

3. Salisbury, F.B. and Ross, C.B., 1992. Plant Physiology. 5th ed. Wadsworth Publishing Company, Canada.
4. Hopkins, W.B., 1999. Introduction to Plant Physiology. 2nd ed. John Wiley and Sons. USA.
5. Hussain, F., 1989. Field and Laboratory Manual of Plant Ecology. National Academy of Higher Education, Islamabad.

FSAQ-405

Fish Behavior

3(2-1)

Learning Objectives

After studying this course, student would be able to:

- Describe the foraging, predatory, anti-predatory, reproductive, migratory behavior of fish
- Know the learning capability of fish
- Recognize the role of fish learning skills in fisheries and aquaculture

Theory:

Behavioral patterns with respect to Feeding, Reproduction, Parental care, Territory, Navigation, Migration, Attractants, Repellents. Behavior of fish in captive and wild environment. Fish cognition and behavior, learning foraging skill, Learned defenses and counter defenses in predator-prey interaction, social learning, Mimicry, Habituation, chemical alarm cues and the assessment of predation risk by fishes, Learning & Mate Choice, Modulating aggression through experience, Machiavellian intelligence in fishes. Neural mechanisms of learning in teleost fish. The role of fish learning skills in fisheries and aquaculture

Particles

- To compare the boldness, exploratory behavior of wild and captive reared fish
- To study the behavioural changes related to artificial noise exposure
- To determine if a goldfish can be trained to associate the sound of a bell with feeding time
- To determine the motor behavior function of fish in response to toxicant exposure
- To study the learning capability of fish

Suggested Readings

1. Brown, C., Laland, K. N. and Krause, J., 2010. Fish cognition and behavior. Blackwell Science. UK.
2. Sloman, K.A., Wilson, R.W. and Balshine, S., 2006. **Behaviour and Physiology of Fish. Elsevier, Netherlands.**
3. Grubb, T.C. J., 2003. The Mind of the Trout. University of Wisconsin Press, Madison.
4. Lucas, C.M. and Baras, E., 2002. Migration of Freshwater Fishes. Blackwell Science Ltd. UK.
5. Reeb, S., 2001. Fish behavior in the aquarium and in the wild. Cornell University Press, USA.

FSAQ-404

Fish Nutrition

4(3-1)

Learning Objectives

After studying this course the students would be able to:

- Name and describe important types of feeds used in aquaculture
- Formulate different types of feed and evaluate their relative efficiency

Theory:

Fundamentals of fish nutrition, Description of fish growth and important nutrients required for fish growth, feed types (Wet feeds, moist feeds, mashes, pelleted feeds, floating and sinking pellets), Nutrient requirements of cultivable fish (energy, carbohydrate, protein, fat, vitamin and mineral requirements of fish). Methods of feed formulation and manufacturing. Role of binders, antioxidants, enzymes, pigments growth promoters and feed stimulants as feed additives. Use of non-conventional feed ingredients in fish feed formulation, anti-nutritional factors and their management, digestive enzymes, feed digestibility and factors affecting digestibility. Feed conversion ratio, feed efficiency, net protein utilization and biological value. Nutritional deficiency disorders, symptoms and nutrition related diseases in fishes.

Practicals:

- Proximate composition of fish feed ingredients and diets.
- Formulation and preparation of different types of fish feed.
- Methods of feed storage.

Suggested Readings

1. Halver, J.E., 2013. Fish Nutrition. 4th ed. Academic Press, USA.
2. Obedd, G., 2010. Fish Nutrition. Blackwell Publishing, USA.
3. Parker, R.O., 2004. Aquaculture Science. 4th ed. Delmar Learning, UK.
4. Pillay, T.V.R., 1991. Aquaculture, Fishing News Book, U.K

Learning Objectives

After completing this course, students would be able to:

- Describe working of different body system of living beings
- Correlate the physiology of different systems with each other
- To compare different types of homoeostatic activities and evaluate their role and efficiency in general homoeostasis of the body

Theory:

Central themes in Physiology: Structure-function relationship, Homeostasis; Transportation: composition of blood cells (Erythrocytes, leukocytes, Platelets and plasma); Fluid-mosaic model of cell membrane, membrane potential; Circulation; Arterial system; Venous system; Capillaries; Transport of food material; lymphatic system. Excretion: Kidneys; Hypo-osmotic urine; Hyper-osmotic urine; Osmoregulation. Exchange of Gases: Transport of O₂ and CO₂ between respiratory surface and body cells.

Practicals:

- Oxygen consumption in fish
- Analysis of digestive enzymes
- Swimming patterns in fish
- Environmental effects on respiration, excretion and fish tolerance to toxicants

Suggested Readings

1. Randall, D., Burggren, W., French, K. and Fernald, R., 2002. Eckert Animal Physiology: Mechanisms and Adaptations. 5th ed. W.H. Freeman and Company, USA.
2. Bullock, J., Boyle, J. and Wang, M.B., 2001. Physiology. 4th ed. Lippincott, Williams and Wilkins, Jordan.
3. Levy, M.N., Koeppe, B.M. and Stanton, B.A.. 2005. Principles of Physiology. 4th ed. Mosby, USA.

Learning Objectives

After studying this course the students would be able to:

- Compare important fish growth models and their efficiency
- Calculate fish growth by using different methods
- Assess different dynamics of fish life like mortality, natality, fecundity etc

Theory:

Food and feeding behavior and habits of fish, methods of qualitative and quantitative analyses of food. Age and growth studies in fish, growth models, length-weight relationship and condition factor. Recruitments, marking and tagging of fish, methods of population estimation, population size and Population dynamics. Mortality rates, natality and mortality, reproduction, behavior and fecundity of fish. Fundamental links in the life cycles of the fish and their migration,

Practicals:

- Analyses of gut contents.
- Assessment of age and growth of fish.
- Computation of length-weight relationships and condition factor.
- Population estimation of fish.
- Statistical analysis of different fish variables.
- Estimation of fecundity in fish.

Suggested Readings

1. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2012. Ichthyology. John Wiley and Sons, Inc., USA.
2. Payne, A., John, A. and Cotter, R., 2008. Advances in Fisheries Science. John Wiley and Sons, USA.
3. Moyle, P.B. and Cech, J.J., 2004. Fishes: An Introduction to Ichthyology. Pearson Prentice Hall, USA.

Learning Objectives

After completing this course, students would be able to:

- Describe the physical and chemical basis of different types of ecosystem
- Fully grasp different ways and aspects of energy flow in ecosystem.

Theory:

Definition and scope of ecology. Terrestrial and aquatic ecosystems, biotic and abiotic factors of ecosystem, food chain and food web, trophic levels. Source and concept of energy flow; law of thermodynamics, concept of limiting factors. Ecological pyramids of numbers, biomass and energy, community ecology, species diversity, diversity indices, succession and ecological niche.

Practicals:

- Qualitative and quantitative estimation of primary productivity of various aquatic ecosystems
- Food chain studies through analysis of gut contents
- Study of various ecosystems and report writing
- Abundance, frequency and density of animals

Suggested Readings

1. Nicholas, B. D., Krebs, J. R. and West, S.A., 2012. An Introduction to Behavioral Ecology. 4th ed. Wiley-Blackwell Publishing, USA.
2. Thomas, M.S. and Smith, R.L., 2012. Elements of Ecology. 8thed. Benjamin Cummings, USA.
3. Townsend C.R., Begon, M. and Harper, J.L., 2008. Essentials of Ecology. 3rd ed. Blackwell Publishing, UK.

Learning Objectives

After studying this course, student would be able to:

- Understand interactions and phylogenetic relationships between freshwater species
- Know the economic significance of freshwater invertebrates
- Describe the role of environmental factor in the distribution and abundance of benthos

Theory:

Overview of freshwater habitats, Phylogenetic relationships, Life history, Ecology, Economic significance and distribution of the freshwater invertebrates belonging to: Phyla Porifera, Cnidaria, Platyhelminthes, Gastrotricha, Rotifera, Nematoda, Nematomorpha, Nemertinea, Mollusca, Annelida, Bryozoa, Tardigrada, Arthropoda. Influence of environmental factors on the abundance and distribution of benthic organisms, Role of macro fauna in the aquatic ecosystem.

Practicals:

- Collection and study techniques, sampling, preservation and identification of freshwater invertebrates' fauna from various available and accessible freshwater bodies.
- Examination of prepared slides

- Quantitative and qualitative analyses of benthos

Suggested Readings

1. Micheael, D., Pawley, D., Fletcher, M. and Powell, A., 2012. Guide to Freshwater Invertebrates. Ambleside, USA.
2. James, H. T. and Christopher. R., 2011. Field Guide to Freshwater Invertebrates of North America. USA.

Learning Objectives

After studying this course, student would be able to:

- Describe basic biological concepts and principles
- Differentiate between prokaryotes and eukaryotes
- Recognize the different levels of biological organization

Theory:

Introduction to cell biology, Difference between prokaryotes and eukaryotes, Physico-chemical properties of protoplasm, Ultra-structure, chemical composition and functions of cell wall, cell membrane and cellular organelles, Cytoskeleton, Chemical composition and molecular structure of chromosomes. Cell cycle. Cell reproduction, DNA Replication, genetic code, transcription, translation, regulation of gene expression in prokaryotes and eukaryotes. Principles of DNA recombinant technology. Animal cloning.

Practicals:

- Study of different types of Prokaryotic and Eukaryotic cell, and cell organelle. Identification of DNA with staining. Isolation of plant, animal and bacterial DNA. Gel electrophoresis. Study of chromosome morphology and variation in chromosome number.
- Experimental studies integrating genetics and biochemistry in the studies of molecular genetics in prokaryotic and eukaryotic cellular and viral systems.

Suggested Readings

1. Karp, G., 2014. Cell and Molecular Biology: Concepts and Experiments, 7th ed. John Wiley and Sons, USA.
2. Alberts, B., 2007. Molecular Biology of the Cell. Taylor and Francis, UK.
3. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M. and Bretscher, A., 2007. Molecular Cell Biology. W. H. Freeman and Company, USA.

Learning Objectives

After studying this course the students would be able to:

- Describe types, characteristics and classification of different freshwater bodies
- Evaluate importance of physical and chemical properties of freshwater
- Correlate the impact of physico-chemical properties of freshwater with survival and distribution of fauna and flora

Theory:

Introduction, history and scope of limnology. Lotic and lentic waters, lakes and reservoirs, streams and their classification. Zonation, thermal stratification; water movements, eutrophication; physical properties of water (temperature, light, colour, turbidity, electrical conductivity, total suspended and dissolved solids), chemical variables (Oxygen, Carbon Dioxide, hardness, alkalinity, pH, nitrogen, phosphorus, other Nutrients) effect of physico-chemical parameters on aquatic life.. Food-chain dynamics in freshwater bodies. Introduction to wetlands and their importance. Introduction to Planktons, including Zooplankton, Phytoplankton

and microplanktons. General characters and species composition of major planktons. Qualitative and quantitative analysis of plankton and their periodicities. Phytoplankton and zooplankton relationship and importance of planktons in food chain of aquatic systems. Economic importance of diatoms.

Practicals:

- Survey of lotic and lentic water bodies.
- Water sampling, preservation techniques and determination of physicochemical parameters.
- Sampling, identification and preservation of phytoplankton and zooplankton.
- Study of temporary and permanent mounts of phytoplankton and zooplankton.

Suggested Readings

1. Dodds, W. K. and Whiles. M. R., 2010. Freshwater Ecology: Concept and Environmental Applications of Limnology. Academic Press, New York, USA.
2. Moss, B. R., 2010. Ecology of Fresh Waters. John Wiley & Sons Inc., New York, USA.
3. Lampert, W. and Sommer. U., 2007. Limnoecology: The Ecology of Lakes and Streams. Oxford University Press, Oxford, UK.
4. Sullivan, P. and Reynolds. C.S., 2004. The Lakes Handbook: Limnology and Limnetic Ecology. Blackwell Science Ltd., Oxford, UK.
5. Wetzel, R.G., 2001. Limnology: Lake and River Ecosystem. 3rd ed. Academic Press, New York, USA.

FSAQ-502

Water Pollution

4 (3-1)

Learning Objectives

After studying this course, student would be able to:

- Understand the properties of water that make it unique
- Describe the types of water pollutants, their sources and fates and health risks associated with water supplies.
- Discuss the criteria and methods proposed to improve water quality.

Theory:

Overview of pollutants. Types and sources of water pollution (domestic, hospital, agricultural and industrial sources. Water quality (Dissolved oxygen - BOD, COD, TOC criteria). Effects of Pollutants on human and other biota; Bio-indicator, Bioaccumulation and bio-magnifications, Pollutants treatment technologies i.e. Primary, secondary and tertiary treatments. Environmental Laws: International Protocols; Case Studies e.g. Characterization of industrial effluents; Examples of treatment systems for selected typical industrial operations i.e. Oil refinery and chemical, food processing, textile plant, tanneries, pulp and paper operations, acid mine drainage and heavy metal problems.

Practicals:

- Analysis of water samples from polluted areas for selected parameters
- Study of pollution indicators
- Visit to polluted water bodies
- Visit to bioremediation/treatment plant

Suggested Readings

1. Patricia, U.O., 2010. Aquatic pollution. LAP Lambert academic Publisher, UK.
2. Goel, O.P.K., 2006. Water pollution and causes, effects and control. New Age International, India
3. Hill, M.K., 2005. Understanding Environmental Pollution, 2nd ed. Cambridge University Press, UK.
4. Peiece, J.J., Weiner, R.F. and Vesilaind, P.A., 1998. Environmental Pollution and Control. 4th ed. Elsevier, USA.

FSAQ-504

Biotechnology in Aquaculture

4 (2-2)

Learning Objectives

After studying this course, the students would be able to:

- Conceptualize the principal bases of biotechnology and emerging issues in fisheries
- Develop Insight into the application of biotechnological advances in aquaculture and fisheries
- Elucidate different aspects of genetic biotechnology and fish genomics with reference to transgenesis, pathogen detection and broodstock management

Theory:

History of Biotechnology, Genetics and Selective Breeding in Aquaculture and Fisheries, Phenotypic variation and environmental effects. Qualitative traits and selection for qualitative traits. Strain evaluation, domestication and strain selection. Population size, Inbreeding, Random genetic drift and maintenance of genetic quality. Gynogenesis, Andogenesis, Intraspecific Crossbreeding, Interspecific hybridization, Polyploiday and Xenogenesis, Sex reversal and breeding, Biochemical and molecular markers, Genetic engineering and gene transfer (transgenic fish). Biotechnologies available for fish nutrition, broodstock improvement and disease diagnosis,

Practicals:

- DNA isolation from fish.
- Electrophoresis, Agarose and polyacrylamind gel electrophoresis.
- Demonstration of amplification of DNA through PCR.

Suggested Readings

1. Dunham,R.A., 2011. Aquaculture and Fisheries Biotechnology: Genetic approaches. CABI,UK.
2. Kumar, R., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.

FSAQ-505

Genetics

4(3-1)

Learning Objectives

After studying this course, student would be able to:

- Understand the basic principle of inheritance
- Know the qualitative and quantitative and sex linkage inheritance
- Familiarize with mutations and molecular basis of mutations

Theory:

Introduction to genetics. Heredity and variation, Mendel's laws of inheritance. Gene interaction; Multiple alleles. Linkage and crossing over, gene mapping. Sex linkage and sex determination. Gene and environment: Mutations and molecular basis of mutations. Extra-nuclear inheritance. Qualitative and quantitative inheritance. Chromosomal aberration, Bacterial and viral chromosomes. Mechanisms of genetic exchange among prokaryotes. Genetic code, recombination and regulation of gene expression. Bacteriophages and recombination, transposons and integrons. Introduction to population genetics. Genetic constitution of a population; Hardy-Weinberg (HW) equilibrium. Changes in gene and genotype frequency.

Practicals:

- Preparation of culture medium and maintenance of *Drosophila* cultures in lab.
- Problems related to Mendelian inheritance, gene interaction, gene mapping.
- Blood groups-ABO blood groups and Rh factors.
- Problems relating to genetic exchange in bacteria and viruses.
- Problems related to gene frequencies and Hardy Weinberg equilibrium.

Suggested Readings

1. Klug, W.S., Michael R.C., Charlotte A.S. and Michael, A.P., 2013. Essentials of Genetics. 8th ed. Pearson Education, USA.
2. Strickberger, W. M., 2008. Genetics. 3rd ed. MacMillan Publishing Co., USA.
3. Primrose, S.B. and Twyman, R.M., 2006. Principles of Gene Manipulation and Genomics. Blackwell Scientific Publications, USA.
4. Snustad, D.P. and Simmons, M.J. 2006. Principles of Genetics. 4th ed. John Wiley and Sons, USA.
5. Hedrick, P.W., 2005. Genetics of Populations. Jones and Bartlett, Sudbury, USA.

FSAQ-506

Fish Breeding and Conservation

4 (3-1)

Learning Objectives

After studying this course the students would be able to:

- Compare the efficiency of different methods of fish breeding in different ecological zones
- Determine the role of hormone in artificial breeding of fish
- Describe/ formulate conservation strategies for fish

Theory:

Fish reproduction (Neuro-endocrine and environmental control), spawning quality, control of fish sex, sexual determination and differentiation and its importance in aquaculture, Brood stock selection and management, Reproductive technology (Hypophysation and Induced breeding, cryopreservation of gametes and egg quality analysis) selective breeding, hybridization. Rearing techniques of fry and fingerlings. Conservation strategies for threatened and endangered species; sustainable use of fisheries resources; stock replenishment program, management of natural

resources (lakes, reservoirs, dams and rivers); habitat management practices and biological conservation policy; national, regional and international conventions; rules and regulations for conservation of natural resources (awareness program and community participation).

Practicals:

- Study of gonadal development in carps and other cultivable finfishes.
- Collection and identification of cultivable freshwater finfish seed.
- Packing and transportation of fish seed.
- Induced breeding (striping and fertilization) of fishes through various inducing agents
- Evaluation of carp milt and egg; estimation of fecundity, fertilization and hatching success.
- Preparation of brood and larval feed for different cultivable finfish.
- Visit to different finfish hatcheries.
- Field survey of different natural aquatic habitats.
- Practicals: methods of conservation of natural resources.

Suggested Readings

1. Gjedrem, T. and Baranski, M., 2009. Selective breeding in Aquaculture: An Introduction. Springer, USA.
2. Gjedrem, T., 2005. Selection and Breeding Programs in Aquaculture. Springer, Netherland.
3. Rothschild, M. and Scott, N., 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI
4. Thomas, P.C., Rath, S.C. and Mohapatra, K.D., 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publisher, India

FSAQ-507

Fishery Technology

4 (3-1)

Learning Objectives

After studying this course the students would be able to:

- compare the efficiency, merits and demerits of different methods of fish capture
- describe main features of post harvest /capture technology

Theory:

Introduction to capture fishery and its role in world food production, reasons of fish decline and development potential, stock assessment techniques, various fishing methods, fishing vessels; river crafts; large fishing boats; fishing gears (nets); harvesting; live hauling; on board handling; initial handling of netted fish; icing procedures; offloading; transportation to fish markets; common fishing gears and crafts with special reference to Pakistan. Methods of fish handling and processing, transportation and preservation, by-products of fish industry, marketing strategies. Processing techniques and fishery by-products.

Practicals:

- Fish stock assessment of lakes.
- Study of nets (composition design and operation, methods of gear selectivity and efficiency, visits to fish landing and marketing centers, fish netting.

- Study of fishing gears and crafts.

Suggested Readings

1. Kumar, P.S., 2009. Fishery Technology APH Publishing, India.
2. Hameed, M.S. and Boopendranath, M .R., 2000.Modern Fishing Gear Technology. Daya Publishing House, India.
3. Ali, S.S., 1999. Freshwater Fishery Biology. Naseem Book Depot, Pakistan.
4. Hall, D.G.M., 1997. Fish Processing and Technology. Springer, USA.

FSAQ-508 Aquatic Macrophytes and Management 4 (2-2)

Learning Objectives

After studying this course, student would be able to:

- Identify common aquatic macrophytes through the use of keys
- Understand the role they play in the ecosystem.

Theory:

Introduction to macrophytes, characteristics, classification of common macrophytes, methods of identification and preservation; qualitative and quantitative analyses (quadrant, plotless and Bitterlich); concept of cover, abundance and productivity; influence of vegetation on aquatic biota; brief account of vegetation of saline and marshy areas; economic importance of macrophytes, control measures of aquatic weeds in ponds, lakes and reservoirs.

Practicals:

- Sampling techniques.
- Identification and preservation of macrophytes.
- Exercise relating to quantitative and qualitative analyses of macrophytes.

Suggested Readings

1. Capello, R., 2014. Macrophytes: Biodiversity, Role in Aquatic Ecosystems and Management Strategies. Nova Science Publishers.
2. Caffrey, J.M., Dutartre, A., Hauray, J., Murphy, K.M. and Wade, P.M., 2010. Macrophytes in Aquatic Ecosystem: From Biology to Management. Springer, Dordrecht, Netherlands.

FSAQ-509 Phycology 4 (3-1)

Learning Objectives

After studying this course, student would be able to:

- Identify and classify Algae and Bryophytes
- know economic importance of Algae and Bryophytes

Theory:

Introduction to the science of Phycology: General account of algae based on criteria for classification; pigment pattern; plastids; flagellation and movement pattern; cell wall structure;

storage products; nucleus; morphological diversity; reproduction (sexual and asexual), life cycle patterns, ecology, evolution and economic importance. Ecology of freshwater algae, their flora and communities: Springs, streams, rivers, ponds and lakes; the soil, snow and ice flora, aerial epiphytic and epilithic algae, epipelagic, endophytic, endozoic, epizoic algae. Algal blooms. Systematic accounts of the phylum, structure and reproduction of genera belonging to fresh water algae.

Practicals:

- Collection of fresh water benthic algae from ponds, pools, ditches, water reservoirs, lakes, rivers and soil surfaces.
- Identification of algae.
- Preparation of temporary/permanent slides of various algae.

Suggested Readings

1. Vashishta, B.R., Singh, V.P. and Sinha, A.K., 2014. Botany for Degree Students. S. Chand and Company, India.
2. Hoek, C.V.D., Mann, D.G. and Jahns, H.M., 2009. Algae: An introduction to Phycology. Cambridge University Press, UK.
3. Linda, E., James, G., Graham, M. and Wilcox, L.W., 2008. Algae. 2nd ed. Benjamin Cummings, USA.

FSAQ-510

Fish Immunology

3 (2-1)

Learning Objectives

After completing this course, students would be able to:

- Know the Specific immune system (cellular defenses, humoral defenses) of fish
- Describe the functions of immune organs

Theory:

General concepts in immunology, Fish immunology , Cells and Tissues of the immun system of fish, the non-specific immune system (cellular defenses, humoral defenses), specific immune system (cellular defenses, humoral defenses), primary immune response, secondary immune response, difference in primary and secondary immune response, lymphocytes, B-cells and T-cells, ontogeny of immune response, ontogeny of lymphoid organ development, Environmental factors in fish immunology, Immunostimulation , immunosuppression.

Practicals:

- To study the innate immune response of fish before and after challenge to pathogens
- To study the immune response of fish after feeding immunostimulant.

Suggested Readings

1. Secombes, C.J. and Ellis, A.E., 2012. The Immunology of Teleosts: in Fish Pathology. 4th ed. Blackwell, UK.
2. daDouglas P. A., 2003. Textbook of Fish Immunology: Diseases of Fishes. Narendra Publishing, India.

Learning Objectives

After studying this course, student would be able to:

- Know how to produce fish in combination with other agricultural/livestock farming operations
- Utilize the available resources in best suitable way
- Demonstrate how waste or byproduct from one system is effectively recycled

Theory:

The biology of major freshwater-cultivated fishes in Pakistan, artificial propagation of major carp, grass carp, silver carp and bighead, pond fertilization and fish feeds, rearing of fry and fingerlings, pond culture of food fish. Introduction to Chinese integrated fish farming and its major models, the statistical methods of planning and management of integrated fish farms. Fish cum poultry cum livestock cum agriculture integration. Designing and construction of an integrated fish farm.

Practicals:

- Visits of fish cum poultry cum livestock cum agriculture integrated farms.
- Report writing.

Suggested Readings

1. Pandey, N., 2008. Integrated Fish Farming. Daya Publishing House, India.
2. Sandhu, G.S., 2007. Applied Ichthyology. Dominant Publishers, India.
3. Little, D. and Edwards, P., 2003. Integrated Livestock-fish Farming Systems. Food and Agriculture Organization of the United Nations. USA.

Learning Objectives

After studying this course, student would be able to:

- Know the nature of inland water and inland fish population
- Learn fishing techniques, inland fishery resource evaluation and inland fisheries management
- Accustom with biodiversity and conservation issues

Theory:

The nature of inland waters (lakes, reservoirs, rivers, flood-plains, swamps, marshes, rice fields, lagoons), nature of inland fish populations, fisheries and fishing communities, fishing techniques, inland fishery resource evaluation, inland fisheries management, habitat management, inland fisheries enhancement, mitigation and rehabilitation of inland fisheries, biodiversity and conservation issues. Management of fish feeding. Nutritional fish diseases. Factors affecting fecundity, ecological conditions for the gonad development. Aquatic insect and their control; common freshwater aquatic weeds and their control.

Practicals:

- Assessment of age and growth with the help of fish scale, operculum and otolith
Computation of length-weight relationship and condition factor

- Techniques of fish tagging and recovery
- Fish stock assessment and report writing

Suggested Readings

1. Helfman, G., Collette, B.B., Facey, D.E., 2009. Diversity of Fishes: Biology, Evolution, and Ecology . John Wiley & Sons, Singapore.
2. Bone, Q. and Moore, R., 2008 . Biology of Fishes. Garland Science, USA.
3. Moyle, P.B. and Cech, J.J., 2004. Fishes: An Introduction to Ichthyology. 5thed. Pearson Prentice Hall, USA.
4. Kapoor, B.G. and Khanna, B., 2004. Ichthyology Handbook. Springer Science & Business Media
5. Lagler, K.F., Baradach, J.E. and Miller, R.R., 2003. Ichthyology. John Wiley and Sons, USA.

FSAQ-605 Fish Post-harvest Technology 3(2-1)

Learning Objectives

After studying this course, student would be able to:

- Use fish post-harvest technology in fisheries
- Perform the handling, preservation, processing and control of fish quality
- Describe methods of quality control and processing of fish

Theory:

Nutritive value of fish, Concept of freshness, Concept of quality, Hygiene and sanitation, Fish spoilage, Traditional and modern methods of fish preservation, (drying, salting, fermentation, smoking, canning, ice-storage, cold-storage, freezing), Convenient fish food, quality control of fish and fishery products, food Safety management System, quality control of fishery products. Fish icing procedures; offloading; on shore handling; transportation to fish markets; various ways of fish disposal; effects of feed on the product: flavor and taints; texture; fish preservation and processing methods; chilled storage life; freezing and frozen storage; chemistry of freezing; pickling; packaging; fish filleting and packing; shelf life of fish food products; packaging; assessment of fish quantity; fish pastes; special processing procedures (minced fish, surimi products, gelation International standards; food laws; food safety and value addition.

Practicals:

- Preparation of a brief report on the quality of fish collected from the market
- Methods of fish preservation ,
- Proximate composition of fish and shellfish

Suggested Readings

1. Hall, G. M., 2011. Fish Processing: Sustainability and New opportunities. Willey Blackwell, UK
2. Pearson, A.M. and Dutson, T.R., 2004. HACCP in Meat, Poultry and Fish Processing. Kluwer Academic Publishers, India.
3. FDA., 2003. Fish and Fisheries Products Hazards and Control Guidance. US Food and Drug Administration.

4. Lucas, J.S. and Southgate, P.C., 2003. Aquaculture: Farming Aquatic Animals and Plants. Fishing News Books. Blackwell, Australia

Learning Objectives

After studying this course, students would be able to:

- Have knowledge of important ecto and endo parasites of fish
- Know about life style of parasites and their intermediate hosts

Theory:

Define parasitism, ectoparasite and endoparasite concepts , Life styles of parasites and their intermediate hosts, methods which are used for identification, Effects of parasites on fishes, mechanism of illnesses by parasite on fishes, Methods of parasite identification (ecto and endo methods). Important ecto and endo parasites. Some protozoan parasite species on fishes with parasitic characteristics, the diagnosis, the protection and the importance in terms of human health, Some parasite species belonging to phylum Plathelminthes, Nematelminthes and Arthropoda on fishes with parasitic characteristics, the diagnosis, the protection and the importance in terms of human health. Individual and evolutive effects of parasitism on fishes. The medically important parasites, Protection and the treatment of fish parasites.

Practicals:

- To identify some protozoan parasite species n fish with parasitic characteristics
- To identify some parasite species belonging to phylum Plathelminthes, Nematelminthes and Arthropoda on fishes with parasitic characteristics
- To study the life style of fish parasites having intermediate hosts

Suggested Readings

1. Montet, D. and Ray, R. C., 2009. Aquaculture Microbiology and Biotechnology. Science Publishers, USA.
2. Secombes, C.J. and Ellis, A.E., 2012. The Immunology of Teleosts: in Fish Pathology. 4th ed. Blackwell, UK.
3. daDouglas P. A., 2003. Textbook of Fish Immunology: Diseases of Fishes. Narendra Publishing, India.

FSAQ-609 Preparation of Research Project and Scientific Writing 2(1-1)

Learning Objectives:

During the course, Students will be able to:

- Learn about basics of Scientific writing
- Learn about Research project writing

Theory

Basics of Scientific writing, skills; Various written skills of Scientific paper, manuscript; How to write research project its basic parts; Reference writing for books, research papers and conferences; How to improve written skills and abilities; Consulting the relevant literature, Planning and essentials of research plan.

Practical

Training of the student in study and evaluation of problems of livestock industry and to find their solutions through research; Practical: Identification of research problem; Execution of project; Data collection, analysis, formulation of tables & figures and interpretation of results & discussion, conclusion, recommendations; Report writing, submission and presentation.

Suggested Reading:

1. Anonymous.1999.Instructions to Authors. Amer. Soc. Hort. Sci. Alexandria, Virginia.
2. Brown, B.W. 2009. Successful Technical Writing/Instructor's Guide,Goodheart-Willcox Publisher
3. Hardesty, R.E. 2010. Technical and Business Writing for Working Professionals, Xlibris Corporation, Bloomington, IN, USA.
4. Petersen, R.G. 1994. Agricultural Field Experiments–Design and Analysis. Marcel Dekker, Inc. New York, NY, USA.

FSAQ-611 Fish Hygiene and Disease Management 4 (2-2)

Learning Objectives

After studying this course the students would be able to:

- Differentiate between a healthy and diseased fish
- Describe symptoms and treatments for common infectious and non- infectious fish diseases

Theory:

Signs of healthy fish and prophylactic measures taken for prevention of diseases.General signs of diseased fish. Common infectious diseases of fish: viral, bacterial, fungal and parasitic diseases; clinical signs and symptoms, diagnosis and treatment of disease. Non- infectious fish diseases; thermal stress, stress due to oxygen deficiency and excessive carbon dioxide, gas bubble disease, acidosis, alkalosis and poisoning. Principles of fish health management, Predisposing factors, Environmental stress, Defensive mechanisms in fish to combat stress/ foreign organisms. Host pathogen and environment relationship.

Practicals:

- Collection and preservation of fish and crustacean parasites.
- Preparation of parasite slides and their identifications.
- Treatment methods for common diseases of fish.

Suggested Readings

1. Noga, E. J., 2010. Fish Disease: Diagnosis and Treatment. 2nd ed. Willey Blackwell. USA.
2. Wais, K., 2005. Handbook on Fish and Crustacean Diseases in the SAARC region. SAARC Agricultural Information Center.
3. Pandey, B.N., 2004. Fish Research. APH Publishing Corporation, India.
4. Wedemeyer, G.A., Meyer, F.P. and Smith, L., 1999. Environmental Stress and Fish Diseases. Narendra Publishing House, India.

FSAQ-613

Aquatic Toxicology

3 (2-1)

Learning Objectives

After studying this course, student would be able to:

- Understand the basic concept of aquatic ecotoxicology, including bioaccumulation, trophic transport of contaminants, biomarkers, specific challenges, and *in vitro* toxicology.
- Be aware of the behavior of fish in response to toxicants
- To know the factors affecting chronic environmental toxicity

Theory:

Introduction and background of aquatic toxicology, Definitions, sources of contamination: water pollution, General concepts in toxicology. Transport of pollutants, Factor affecting distribution and fate, bioavailability and bioaccumulation, biotransformation, metabolism and de-toxication, Heavy metals, organics. Behavioral responses of fish to toxicants. Toxicity assessments and environmental regulations. Factors affecting the chronic environmental toxicity, Ecotoxicity.

Practicals:

- Determination of physico-chemical parameters in relation to metal's toxicity.
- Determination of acute (LC₅₀ and lethal concentrations) toxicity of metals by using Probit Curve
- Effects of chronic metals toxicity on fish growth

Suggested Readings

1. Walker, C.H., Sibly, R.M., Hopkin, S.P. and Peakall, D.B., 2012. Principles of ecotoxicology, 4th ed. CRC Press, USA.
2. Adel, D., 2007. Water Pollution Biology. CRC Press, USA.
3. Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M., 2005. Environmental Organic chemistry. 3rd ed. Wiley and Sons, USA.
4. Blaise, C. and Ferard, J.F., 2005. Small Scale Freshwater Toxicity Investigation: Toxicity Test Methods. Springer, USA.
5. Mason, C.F., 2002. Biology of Freshwater Pollution. Prentice Hall, USA.

STAT-302

Introductory Statistics

2(2-0)

Learning Objectives

After studying this course the students would be able to

- Apply basic statistical procedures for analysis of data for practical and research.
- Demonstrate statistical reasoning skills correctly and contextually

- Interpret results of commonly used statistical analyses in written summaries

Theory:

Introduction and scope of biostatistics. Types of data. Measurement and measurements Scales. Frequency distribution for continuous and discrete data. Visual representation of data, stem and leaf display, box-whisker plots, Measures of location and measures of variability. Sampling distribution of mean and difference between means and their properties. Testing of hypothesis for mean, proportion, difference between mean and difference between proportions. Measures of diversity. Analysis of variance. Non-parametric methods. Introduction to computers and operating system.

Practicals:

- Working with MS Word and Excel. Use of Minitab biostatistics software packages for data analysis.

Suggested Readings

1. Chaudhry, S.M. and S. Kamal. 2005. Introduction to Statistical Theory. Part-I, II, Ilmi Kitab Khana, Lahore.
2. Clark, G.M. and Cooke, D. 2004. A Basic Course in Statistics. 6th Edition, Arnold London.
Minitab Manual
3. Sharma, A. K 2005. Text Book Of Biostatistics I and II. DPH Mathematics Series Discovery Publishing House

SSH-402

Ethics

3(3-0)

Learning Objectives

After studying this course the students would be able to

- Knowledge about ethics
- Ethical teachings of different Religions

Theory:

Definition, scope and nature of ethics, logic and ethics, concept of good and evil, freedom and responsibilities, ethical teaching of Islam, Christianity, Buddhism and Hinduism, rights of minorities in Islam, general review of business ethics, profit and ethics, business ethics, ethics of stake holders, general review of biomedical ethics, ethics and ecology, rights to livable environment and animals.

Suggested Readings

1. Little, W. 2009. An Introduction to Ethics, Mathuen & Co. Ltd, London.
2. Jonathan, C. 2011. Humanity: A Moral History of the 21st

ENG-301

Composition and Communication Skills

3(3-0)

Learning Objectives

After studying this course the students would be able to

- Have the skills of reading, writing, presentation and communication.
- Write the report, analysis of speech and effective communication.

Theory:

Reading skills; effective reading habits, comprehension, (i) Bromides and Sulphites (Gelett Burgess) (ii) TV Addiction (Marie Winn), Writing skills; personal writing, CV, report writing, letter writing, descriptive writing; argumentative writing; narrative writing; expository writing; précis writing; Grammatical tools; knowledge about parts of speech and their analysis, punctuation, dash, comma, semi colon, capitalization, presentation skills; Communication skills, types of communication, 7 Cs of communication, preparing effective presentations

Suggested Readings

1. Allen, W. Stanard. 2002. Living English Structure.
2. Krizsner, Laurd. G. and Mendall, Stephen R. 2008. Patterns for College Writing. St Martin's Press, New York
3. Ahmad, A. 2009 To the Point (English Grammar and Composition for degree). To the Point Publishers, 5-A Yousaf Market, GhanziStreet, Urdu Bazaar, Lahore.

ENG-302

Functional English

3(3-0)

Learning Objectives

After completing the course, students will be able to:

- Demonstrate proficiency in English grammar and comprehension skills
- Develop competency in producing correct and error free piece of writing
- Exhibit sound vocabulary and skills to use English in professional life

Theory

Parts of Speech: Introducing all its components, Briefly explaining subject, verb and object (Correct English); How to make a mind map; The Paragraph Defined (Handouts): Basic Paragraph Patterns, Defining the Controlling Idea, Writing the Controlling Idea as a Topic Sentence; Grammar: Present Tense revision and exercises, Present perfect, Present continuous, Present perfect Continuous, Present indefinite; Reading Comprehension (Text comprehension and Spelling Bee): What is reading? How to read? Techniques for becoming better readers (skimming and scanning); Grammar: Rules for Punctuation: Rules for using punctuation signs correctly (Correct English); Formal and informal letter writing (ppt& handout) (Functional English); Types of letters, Difference between letter and application; Listening activity; Reading comprehension; Comparison and Contrast, Pattern, Language, Tone, Expression, Genre' of

essay; Mind map (Graphic organizers); Narrative, Descriptive, Expository, Cause and effect, Compare and contrast, Persuasive etc.

Suggested Readings

1. Wilson, K., &J. Wauson. 2012. The AMA handbook of business writing: the ultimate guide to style, grammar, usage, punctuation, construction, and formatting. New York: AMACOM/American Management Association.
2. Murphy, R. 2007 Essential English Grammar, 4th Edition, Cambridge University Press.
3. Howe, D., T. Kirkpatrick, &D. Kirkpatrick. 2006. English for Undergraduates. Karachi, Pakistan: Oxford University Press.
4. Shah, A. S. 2006. Exploring the World of English. IlmiKitabKhana, Lahore.

Shahid, G. M. 2010. Business Communication and Report Writing. Rizwan Publishers, Faisalabad.

CS-301 Computer Science and Information Technology 2(0-2)

Learning Objectives

After the completing the course, students will be able to:

- Know the different parts of computer.
- Know the different programs usually used in daily office routine.
- Use computer in professional life.

Theory:

Introduction of Computer, use of computer in different fields, software, hardware, Introduction to Windows and its different operations (Explanation of Start menu, Taskbar, Icons, Desktop control Panel, Window Explorer, My computer, Recycle bin, Introduction to Microsoft word processing and document handling: creating a document, composing educational documents, Introduction to Microsoft Excel (Home, Insert, Page layout, View), Microsoft Power point (Home, Insert, Page layout, view). Internet and its use in daily life, ISP, web browser, searching.

Suggested Readings

1. Mustafa T. and A.R. Sattar, 2010. Computer for beginners, KitabMarkez, Faisalabad.
2. Mahmood T. and I. Saeed, 2010. Computer Applications in busi
3. Saeed. I, A. Raza and T. Mahmood. 2011. The Concept of Information Technology, IT Series Publishers, Lahore, Pakistan.
4. Shelly, G.B and G.A. Wagoner. 2011. Using Computers: A gateway to Information. Boyd and Fraser Publishers, USA.

FSAQ -609 Preparation of Research Project and Scientific Writing 2(1-1)

Learning Objectives

After studying this course the students would be able to

- Select productive bird and use its genetic potential.
- Conservation of indigenous poultry genetic resources in Pakistan.
- Genetic improve the indigenous chicken,

Theory:

Indigenous poultry species and breeds, opportunities for genetic improvement of indigenous chicken, choices among rural chicken breeds, selecting growing females, selecting breeding hens and cocks, characterizing breeds, documenting breeds using various descriptors, threats to poultry genetic resources. Conservation of indigenous poultry genetic resources in Pakistan: strategies, techniques, scope and problems. National breeding policy for improvement and conservation of poultry breeds. Poultry welfare.

Practicals:

Exercises on selection of productive birds, documenting breeds using phenotypic descriptors.

Suggested Readings

1. Duncan, I.J.H. and P. Hawkins (Eds.). 2010. The Welfare of Domestic Fowl and Other Captive Birds. Springer Science, London, UK.
2. FAO. 2007. The State of the World Animal genetic Resources for food and Agriculture. FAO, Rome <http://www.fao.org/docrep/010/a1250e/a1250e00.htm>
3. Oldenbroek, J.K. 1999. Gene Banks and Conservation of Farm Animal Genetic Resources. DLO Institute for Animal Science and Health, The Netherlands.
4. Oosterwijk, G., D. Van Aken and S. Vongthilath. 2003. A Manual on Improved Rural Poultry Production. Department of Livestock and Fisheries, Ministry of Agriculture and Forestry, Vientiane, Lao PDR.

SSH-302

Pakistan Studies

2(2-0)

Learning Objectives

After studying this course the students would be able to

- Know two nation theory and its necessity.
- Different clarities involved in revelation of Pakistan.
- Knowledge about the brief history of Pakistan.

Theory:

Evolution of two nation concept in the sub-continent; role of two nation theory in the creation of Pakistan; ideology of Pakistan, founding fathers of Pakistan; Mujadid Alf Sani; Shah Waliullah; Sir Syed Ahmed Khan; Allama Iqbal; Quaid-e-Azam, Constitutional development in Pakistan, objective resolution; basic principle committee reports; Bogra formula; salient features of 1956 constitution; foreign policy of Pakistan; determinants of Pakistan's foreign policy; different phases of Pakistan's foreign policy; Pakistan's relations with super powers, United Nations Organization; main organs; special agencies; Pakistan role in the UNO.

Suggested Readings

1. Allana, G. 2010. Our Freedom Fighters. Ferozsons Ltd., Lahore.
2. Amin, S. 2010, Pakistan's Foreign Policy, Oxford University Press, Karachi.
3. Hussain, A. 2010. Encyclopedia of Pakistan. Jahangir Book Depot, Lahore.