



नेपाल सरकार

पशु स्वास्थ्य तथा पशु सेवा व्यवसायी परिषद

(क) श्रेणीमा नाम दर्ताको लागि लिइने परीक्षाको पाठ्यक्रम  
(नियमावलीको नियम १० को उपनियम (१) संग सम्बन्धित)

पशु स्वास्थ्य तथा पशु सेवा व्यवसायी परिषद ऐनको दफा १७ अनुसार मान्यताप्राप्त विश्वविद्यालय वा शिक्षण संस्थाबाट सम्बन्धित विषयमा स्नातकोत्तर वा विद्यावारिधी उत्तीर्ण गरि “क” वर्गको लागि योग्यता पुगेका पशु स्वास्थ्य तथा पशु सेवा व्यवसायीलाई परिषदमा नाम दर्ताको लागि लिइने लिखित परीक्षाको पाठ्यक्रम

यो पाठ्यक्रमलाई निम्नानुसार तीन भागमा वर्गिकरण गरिएको छः

| S. no. | Section                                                           | Full Mark | Remark                  |
|--------|-------------------------------------------------------------------|-----------|-------------------------|
| 1.     | Section-A: Information Related to the Council and Animal Services | 15        | For All                 |
| 2.     | Section-B: Subject Related Knowledge                              | 85        | Any one related subject |
|        | B.1. Livestock Production and Management                          | 85 or     |                         |
|        | B.2. Animal Breeding and Genetics                                 | 85 or     |                         |
|        | B.3. Animal Nutrition and Feeding                                 | 85 or     |                         |
|        | B.4. Pasture / Forage and Agro-forestry                           | 85 or     |                         |
|        | B.5. Aquaculture                                                  | 85 or     |                         |
|        | B.6. Fisheries                                                    | 85 or     |                         |
|        | B.7. Dairy Science                                                | 85        |                         |

परीक्षा योजना (Examination Scheme)

| क्र.स. | खण्ड/विषय                               | पूर्णाङ्क | उत्तिराङ्क | परीक्षा प्रणाली           | प्रश्न संख्या | समय      |
|--------|-----------------------------------------|-----------|------------|---------------------------|---------------|----------|
| १.     | परिषद तथा पशु सेवासँग सम्बन्धित जानकारी | १००       | ४०         | बहुवैकल्पिक प्रश्न (MCQs) | १५            | ९० मिनेट |
| २.     | विषयसँग सम्बन्धित ज्ञान                 |           |            |                           | ८५            |          |

द्रष्टव्यः

१. यो पाठ्यक्रमको योजनालाई एउटै चरणमा परीक्षा लिनेगरी तयार गरिएको छ ।
२. लिखित परीक्षाको प्रश्नपत्रको माध्यम भाषा पाठ्यक्रमको विषयवस्तु जुन भाषामा दिइएको छ सोही भाषाको आधारमा नेपाली वा अंग्रेजी मध्ये कुनै एक मात्र भाषा हुनेछ । तर विषयवस्तुलाई स्पष्ट गर्नुपर्ने अवस्थामा दुवै भाषा समेत प्रयोग सकिने छ ।
३. लिखित परीक्षाको माध्यम भाषा नेपाली वा अंग्रेजी अथवा नेपाली र अंग्रेजी दुवै हुनेछ ।
४. लिखित परीक्षा एकैदिनमा एकैपटक लिइनेछ ।

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५. वस्तुगत बहुवैकल्पिक (Multiple Choice) प्रश्नको गलत उत्तर दिएमा प्रत्येक गलत उत्तर बापत २० प्रतिशत अङ्क कट्टा गरिनेछ। तर उत्तर नदिएमा त्यस बापत अङ्क दिइने छैन र अङ्क कट्टा पनि गरिने छैन।
६. वस्तुगत बहुवैकल्पिक हुने परीक्षामा परीक्षार्थीले उत्तर लेख्दा अग्रेजी ठूलो अक्षरहरू (Capital letters): A, B, C, D मा लेख्नुपर्नेछ। सानो अक्षरहरू (Small letters): a, b, c, d लेखेको वा अन्य कुनै सङ्केत गरेको भए सबै उत्तरपुस्तिका रद्द हुनेछ।
७. बहुवैकल्पिक प्रश्न हुने परीक्षामा कुनै प्रकारको क्याल्कुलेटर (Calculator) प्रयोग गर्न पाइने छैन।
८. विषयगत प्रश्न हुनेका हकमा प्रत्येक खण्डका लागि छुट्टाछुट्टै उत्तरपुस्तिकाहरू हुनेछन्। परीक्षार्थीले प्रत्येक खण्डका प्रश्नको उत्तर सोहीखण्डको उत्तरपुस्तिकामा लेख्नुपर्नेछ।
९. परीक्षामा सोधिने प्रश्नसंख्या, अङ्क र अङ्कभार यथासम्भव सम्बन्धित पत्र विषयमा दिइए अनुसार हुनेछ।
१०. यस पाठ्यक्रम योजना अन्तर्गतका पत्र/विषयका विषयवस्तुमा जेसुकै लेखिएको भए तापनि पाठ्यक्रममा परेका कानून, ऐन, नियम तथा नीतिहरू परीक्षाको मिति भन्दा ३ महिना अगाडि संशोधन भएका वा संशोधन भई हटाईएका वा थप गरी संशोधन भई। कायम रहेकालाई यस पाठ्यक्रममा परेको सम्झनु पर्दछ।
११. पाठ्यक्रम लागू मिति: २०८३/५/१०

**खण्ड क (A) परिषद् तथा पशु सेवा सम्बन्धी जानकारी**

१. परिषद्को परिचय, प्रकार, कानुनी हैसियत तथा वर्गीकरण अनुसारका विशेषताहरूबारे सामान्य जानकारी।
२. पशु स्वास्थ्य तथा पशु सेवा व्यवसायी परिषद्को इतिहास, वर्तमान अवस्था तथा गठन प्रक्रियाबारे सामान्य जानकारी।
३. पशु स्वास्थ्य तथा पशु सेवा व्यवसायी परिषदसँग सम्बन्धित तथा सो परिषदअन्तर्गत बनेका ऐन, नियमावली, विनियम, कार्यविधि, निर्देशिका तथा अन्य नीतिगत व्यवस्थाबारे सामान्य जानकारी।
४. पशु स्वास्थ्य तथा पशु सेवा व्यवसायीहरूको वर्गीकरण तथा न्यूनतम शैक्षिक योग्यतासम्बन्धी सामान्य जानकारी।
५. पशु स्वास्थ्य तथा पशु सेवा व्यवसायीहरूले पालना गर्नुपर्ने नैतिक मूल्य, मान्यता तथा व्यावसायिक नैतिक आचारसंहितासम्बन्धी सामान्य जानकारी।
६. पशु स्वास्थ्य तथा पशु सेवा व्यवसायीहरूले पालना गर्नुपर्ने आचारसंहिता।
७. पशु स्वास्थ्य तथा पशु सेवा व्यवसायी उत्पादन गर्ने शैक्षिक संस्थाहरूमा आवश्यक पर्ने न्यूनतम भौतिक पूर्वाधार, प्रयोगशाला, उपकरण तथा अन्य आधारभूत सुविधाहरू।
८. पशु स्वास्थ्य तथा पशु सेवा व्यवसायी उत्पादन गर्ने उद्देश्यले तयार गरिने शैक्षिक पाठ्यक्रममा समावेश हुनुपर्ने आवश्यक विशेषताहरू।

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## Section-B: Subject Related Knowledge

85%

### B.1. Livestock Production and Management/Animal Science

1. Cattle and Buffalo 15%  
Cattle (Native, exotic, crossbred, Yak/Nak, Chauri) and Buffalo (Native, Murrah, Murrah Crossbred, Niliravi)
  - 1.1 Care and Management of calves to breeding age
  - 1.2 Breeding and feeding management of heifers,
  - 1.3 Management of AI and ET in cattle
  - 1.4 Care and feeding, Management and health of pregnant heifers and adult animals
  - 1.5 Management of Steaming Up in advanced pregnant animals
  - 1.6 Improved Housing Management for calves, heifer and pregnant animals and milking animals
  - 1.7 Management of Crossbred bulls (Cattle / Buffalo) production for breeding purpose
  - 1.8 Sexed semen
  - 1.9 Milk Production, Process of lactation, Hormonal influence in lactation, Release of milk from the udder, Definition of milk and composition, Preparation of dairy product (Khuwa, Paneer, Yoghurt, Chhurpi, Ghee, Cheese) with low cost, Equipment Management
2. Sheep and Goat 15%
  - 2.1 Sheep and Goat Production/ Management System in the mountain, Hills and Terai in Nepal
  - 2.2 Management system: Transhumance system and Sedentary System
  - 2.3 Sheep Breed: Native and Exotic Breed of Sheep in Nepal
  - 2.4 Goat Breed: Exotic and Native breed of Goat in Nepal
  - 2.5 Sheep / Goat: Reproductive behavior and Breeding systems, Breed Improvement, Mating Systems, Artificial Insemination, Reproduction in Doe, Fertility in doe, Objectives of breeding plan
  - 2.6 Management of kids / Lambs, breeding does / ewes, breeding Bucks / rams and Improved housing management for goats in Hills and Terai
3. Meat Production: Growth and Carcass Quality, Body Growth and Development, Bone and Nervous systems, Essential organs- Heart, Brain, Liver, Bones, Muscle, Fat, Definition of Carcass, offal (Edible and non-edible), Dressing Percentage, Factors influencing the pattern of growth and development of meat animals, Slaughter house and hygienic meat production 10%
4. Wool Production (Sheep and Angora Rabbit): Properties of wool, Strength and elasticity, Effect of moisture, Durability and shrinking, Crimps, Growth and development of fleece, Factors affecting wool and quality 10%
5. Swine Production: Exotic and Native breed, Care and Management of piglets, weaning, gilt, pregnant sows and breeding boar, Environmentally sound, Improved housing management for piglets, pregnant, dry sows and boar 10%
6. Poultry Production and Management: Intensive poultry production system, Semi-intensive and free range system (Scavenging poultry production) 10%
7. Management of Hatching, Brooding, Grower, Layers management for efficient egg production and Breeding management, Culling, Selection of laying hens, Replacement of old laying poultry flock with new pullet 10%
8. Rabbit (wool and meat type) production / management 5%
9. Livestock marketing system and situation in Nepal 5%
10. Livestock development History in Nepal (Cattle, Buffalo, Sheep, Goats, Swine and poultry) 5%
11. Livestock (Cattle, Buffalo, Sheep, Goats, Swine and poultry) Production System in Nepal 5%

### B. 2. Animal Breeding and Genetics 85%

1. Principles of Genetics and Population Genetics: Definition, importance and history of genetics, Study of animal cell, Chromosomes, types of chromosomes and number of chromosomes in different animals, Cell division, Mendelian principles, Dihybrid and polyhybridization, Genetic constitution of population-frequencies of genes and genotypes, Gene interaction, Sex controlled inheritance and sex determination, Mutation and chromosomal aberrations, Cytoplasmic inheritance, Quantitative

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- inheritance, Heredity and environment, Genetic forces changing gene frequencies-selection, migration, mutation and population size, Coefficient of inbreeding and genetic relationship 25%
2. Principles of Animal Breeding: Definition, importance, achievements and history of Animal Breeding, Application of genetic principles in Animal Breeding, Gene and genotypic frequencies, Qualitative and quantitative inheritance, Heredity and environment, Principles of mating systems, Basis and methods of selection; Selection differential, Selection intensity, Generation interval, Breeding values, Progeny testing, Hybrid vigour/heterosis, Genetic gain/Response to selection, Heritability, Repeatability, Correlations-Genetic, phenotypic and environmental, Concept of genetic resistance for disease and parasites 20%
  3. Molecular Genetics: Definition, importance and history of Molecular Genetics, Application of Molecular genetics, Structure of DNA, Replication of DNA, Isolation of DNA, Polymerase Chain Reaction (PCR) and DNA Finger Printing 15%
  4. Biotechnology: Definition, scope and importance of Biotechnology, Application of Biotechnology tools in Animal Improvement 20%
    - 4.1 Artificial Insemination techniques, Collection, processing, evaluation and storage of fresh and frozen semen, Pregnancy Diagnosis, Embryo collection, embryo transfer technology in livestock development
    - 4.2 In vitro fertilization, Animal cloning, Reproductive disorders and their corrective measures
  5. Reproduction and Physiology: Reproductive systems of domestic animals, Reproduction parameters in domestic animals, estrous cycle, Hormones involved in reproduction, Heat synchronization, and Reproductive efficiency 10%
  6. Domestic Animal Genetic Resources: Identification of indigenous breeds of domestic animals, Characterization of indigenous breeds of domestic animals, Status of indigenous breeds in relation to conservation, Positive attributes of indigenous breeds, Methods of conservation and Breeding Plan for livestock and poultry 10%

### **B.3. Animal Nutrition and Feeding 85%**

1. Feedstuffs: Terms and definitions, Proximate and detergent analysis of feeds, Energy value of feeds, Protein values of feeds, Measuring the intake and utilization of energy and nutrients of feeds 15%
2. Nutritional Requirements of Animals: Energy, Protein, Minerals, vitamins and additives, Feeding Standards 10%
3. The Nutritional Characteristics of Some Common Feeds: Classification of feedstuffs, Basal feeds, Protein, Vitamin and mineral supplements and additives, Forages and roughages 10%
4. Ration Formulation: Feed formulation for cattle, Buffalo, swine & rabbit, poultry, sheep and goats, Preparation of mixed mineral supplements, Linear programming of feed mixtures 15%
5. Winter, summer and perennial fodder cultivation status of Nepal 10%
6. Digestive system of ruminant and non-ruminant animals and factors affecting on digestibility of nutrients 10%
8. Classification of Feed Stuffs 5%
9. Animal feed processing for improving the quality of feed stuffs 5%
- 10 Nutrient Metabolism 20%

### **B.4. Pasture /Forage and Agro-forestry 85%**

1. Forage Physiology: plant metabolism, nitrogen metabolism, photosynthesis and respiration, Crop seed physiology, seed development, seed dormancy, germination, vigor and other physiological processes associated with seed production and storage of economically important pasture/ forage and fodder tree seeds 15%
2. Forage Breeding: Principles and Factors of breeding, Genetic and cytogenetic, Breeding methods, Forage and pasture crop evolution 15%
3. Forage Agronomy: Plant introduction, utilization and evaluation, Fertilization, Cutting and Irrigation management, Factors affecting crop adaptation, production, utilization and conservation, Cropping

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- systems, crop rotation, inter-cropping, mixed cropping, multiple cropping and mixed farming systems, 15%
4. Marginal land utilization for pasture, forage and fodder trees Production Technology, Production technology of temperate species in rangelands and pasturelands 5%
  5. Grazing and Range Management: Grazing practices, Aspects grazing management, Efficiency of grazing, Stocking rate and grazing pressure, Factors affecting grazing behavior, Fodder and feed from trees and shrubs, grassland productivity, livestock units and carrying capacity, productivity influencing factors, range reseeding and fertilizing 10%
  6. Herbage Quality and Nutritive Value: Nutritive value, digestibility, palatability and voluntary intake, Estimation of intake and digestibility, nutritive value and herbage quality and animal productivity, Feeding value of grass, legume and its products 10%
  7. Agro-forestry: Definition, scope and advantage, classification of agro-forestry systems, silvi-pasture system, agri-silvi-pasture system, productive agro-forestry systems, protective agro forestry systems, multipurpose agro-forestry systems, management of trees in agro forestry systems, Economics of agro-forestry systems 5%
  8. Forage Conservation: Principles of conservation, Silage making, Hay making Forage 5%
  9. Forage Diseases and their Control, Diseases of pasture/forage and fodder trees, seed borne, soil borne and air borne diseases 5%
  10. Forage Insect Management and their Control: Survey and surveillance of forage insect pests, Principles of insect- pest control, physical and mechanical control, cultural control, biological control, chemical control and host plant resistance, Major pests of pasture/forage and fodder trees and their control measures 10%
  11. Understanding the climate smart agriculture, selection of fodder species for low methane production from the ruminants, carbon sequestrations from the forage and tree fodders 5%

## B.5. Aquaculture

### Unit 1: Advanced Aquaculture Systems & Global Trends 15%

- **Concepts:** Principles, global and national paradigms of sustainable aquaculture. High-density and intensive production economics.
- **Modern Technologies:** Recirculating Aquaculture Systems (RAS) engineering, Bio-floc Technology (BFT) dynamics, IPRS (In-pond Raceway system), Aquaponics, and Periphyton-based aquaculture.
- **Open Systems:** Ocean cage culture, pen culture, raceway designs for cold-water and warm-water species.
- **Mariculture & Brackish Water:** Global status of shrimp/prawn culture, crab fattening, and seaweed farming.
- **Carrying Capacity:** Estimation of carrying capacity in open water bodies, environmental modeling for aquaculture expansion.

### Unit 2: Systematics, Molecular Taxonomy & Evolutionary Biology 10%

- **Advanced Taxonomy:** Phylogenetics, cladistics, and modern evolutionary classification of finfish and shellfish.
- **Methods:** Morphometrics vs. Meristics; Osteology and otolith studies in fish identification.

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- **Molecular Techniques:** DNA Barcoding, PCR-based identification, genetic markers (SSR, SNP) in stock identification.
- **Geographical Distribution:** Zoogeography of freshwater fishes of the Indian subcontinent and Nepal's river systems.

### **Unit 3: Fish Physiology, Endocrinology & Reproductive Biotechnology 10%**

- **Systemic Physiology:** Advanced respiratory, cardiovascular, digestive, neuro-sensory, and osmoregulatory mechanisms under varying environmental stressors.
- **Endocrinology:** Hypothalamic-pituitary-gonadal (HPG) axis, roles of GnRH, GtH-I, GtH-II, and steroids in gametogenesis and maturation.
- **Biotechnology:** Cryopreservation of fish milt/eggs, chromosome manipulation (polyploidy: triploidy, tetraploidy), gynogenesis, androgenesis, and sex reversal protocols.
- **Selective Breeding:** Marker-assisted selection (MAS), family selection, and genetic improvement programs (e.g., GIFT Tilapia, genetically improved carps).

### **Unit 4: Hatchery Engineering, Seed Biotechnology & Larval Energetics 15%**

- **Design & Engineering:** Structural layout, water filtration systems (UV, Ozone, Biofilters), and bio-security protocols of modern hatcheries.
- **Induced Breeding:** Advanced hypophysation techniques, formulation and application of synthetic hormones (Ovaprim, Ovotide, HCG, LHRHa).
- **Larval Nutrition:** Nutritional energetics of fish larvae, micro-encapsulated feeds, co-feeding strategies, and automated live-feed production enrichment (HUFA, Vitamin C enrichment of Artemia/Rotifers).

### **Unit 5: Bio-Energetics, Advanced Feed Technology & Nutraceuticals 15%**

- **Nutritional Energetics:** Energy partitioning (GE, DE, ME, NE), protein-to-energy ratio (P:E), and metabolic demand of fishes.
- **Formulation & Processing:** Linear programming in feed formulation, extrusion cooking technology (floating vs. sinking pellets), anti-nutritional factors (ANFs) and their detoxification.
- **Functional Feeds:** Use of immunostimulants, prebiotics, probiotics, synbiotics, organic acids, and exogenous enzymes in commercial fish feed.
- **Quality Assurance:** Mycotoxins, lipid peroxidation, feed storage dynamics, and international feed quality standards (ISO/HACCP).

### **Unit 6: Advanced Limnology, Aquatic Eco-Dynamics & Environmental Management 15%**

- **Limnological Processes:** Nutrients cycling (N, P, C, Si), nutrient budgeting, internal loading, and carbon sequestration in aquatic ecosystems.
- **Pollution Ecology:** Eutrophication modeling, heavy metal bio-accumulation, microplastics contamination, and biomonitoring using macro-invertebrates.

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- **Climate Change:** Impacts of global warming, ocean acidification, and altered river hydrology on fish migration and spawning.
- **Environmental Assessment:** Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) protocols for mega-aquaculture projects in Nepal.

#### **Unit 7: Molecular Immunology, Epidemiological Pathology & Biosecurity 10%**

- **Immunology:** Molecular structure of fish immunoglobulins (IgM, IgD, IgT), Major Histocompatibility Complex (MHC), cytokine networks, and cell-mediated cytotoxicity.
- **Vaccine Technology:** Development of DNA vaccines, recombinant vaccines, killed/attenuated vaccines, and delivery methods (injection, immersion, oral).
- **Advanced Diagnostics:** Polymerase Chain Reaction (PCR), RT-PCR, ELISA, Western Blotting, and histopathological analysis of emerging diseases (e.g., TILV, KHV, WSSV, EUS).
- **Epidemiology:** Disease surveillance, risk assessment, quarantine protocols, and transboundary aquatic animal disease management (OIE/WOAH guidelines).

#### **Unit 8: Post-Harvest Biotechnology, Value Chain & Agri-Business 10%**

- **Spoilage Mechanisms:** Rigor mortis, biochemical, microbial, and enzymatic changes in post-mortem fish.
- **Preservation Tech:** Modified Atmosphere Packaging (MAP), IQF (Individual Quick Freezing), cold chain logistics, and biopreservation.
- **Value Addition:** Product diversification (surimi, fish silage, collagen extraction from fish scales, gelatin production).
- **Economics & Marketing:** Global trade WTO agreements, SPS (Sanitary and Phytosanitary) measures, supply chain management, and international seafood certification (MSC, ASC).

### **B.6. Fisheries Management**

#### **Part I: Systematics, Molecular Taxonomy & Evolutionary Biology 20%**

##### **1. Advanced Systematics & Evolutionary Classification**

- **Phylogenetics & Cladistics:** Principles of phylogenetic systematics, cladistic methods, cladograms, and evolutionary classification of finfish and shellfish.
- **Modern Taxonomic Tools:** Application of Integrative Taxonomy combining morphology, osteology, and molecular data.
- **Fish Identification Methods:**
- **Traditional vs. Modern Methods:** Morphometrics (Traditional vs. Truss Network System) and Meristics.
- **Osteology:** Comparative skeleton analysis in taxonomy.

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- Otolithology: Otolith morphology, micro-structure analysis, daily growth increments, and stock identification.

## 2. Molecular Taxonomy & Biotechnological Applications

- DNA Barcoding: Mitochondrial genes (*COI*, *16S rRNA*, *Cyt b*) in fish species identification.
- Genetic Markers in Taxonomy: Short Tandem Repeats (SSR/Microsatellites), Single Nucleotide Polymorphisms (SNPs), Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), and Random Amplified Polymorphic DNA (RAPD).
- Environmental DNA (eDNA): Concepts, sampling techniques, and application of eDNA metabarcoding in aquatic biodiversity monitoring and invasive species detection.

## 3. Zoogeography & Spatial Distribution

- Zoogeography: Geographic distribution patterns of freshwater fishes in the Indian Subcontinent.
- Ichthyofauna of Nepal: River system-wise distribution (Koshi, Gandaki, Karnali, Mahakali, and southern medium rivers), endemic species, cold water fisheries, and migration corridors.

## Part II: Fish Physiology, Excretion & Reproduction 20%

### 1. Digestive, Respiratory & Circulatory Physiology

- Digestive Physiology: Comparative digestive anatomy across trophic modes (herbivorous, carnivorous, omnivorous); Mechanisms of ingestion, digestion, enzymatic activities, assimilation, and egestion.
- Bioenergetics & Metabolism: Standard, routine, and active metabolic rates; Physiological effects of temperature, dissolved oxygen, pH, activity, and body size.
- Respiratory Mechanisms: Comparative anatomy of gills and accessory respiratory organs; Aquatic gas dynamics, counter-current exchange, gill ventilation, and hemoglobin-oxygen binding dynamics.
- Circulatory & Cardiac Control: Cardiac anatomy, intrinsic and extrinsic regulation of heart rate; Cardiac responses to exercise, digestion (specific dynamic action), thermal stress, hypoxia, and amphibious survival ("fish out of water").

### 2. Excretion, Osmoregulation & Stress Physiology 20%

- Osmoregulation & Ion Balance: Kidney anatomy and nitrogenous waste excretion (ammonotelism); Ion transport mechanisms in freshwater vs. marine teleosts; Physiological adaptations in Euryhaline and Diadromous (Anadromous/Catadromous) species.
- Endocrine Control of Osmoregulation: Hormonal regulation via prolactin, cortisol, growth hormone, and thyroid hormones during environmental transitions.

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- Stress Response & Ecotoxicology: Primary, secondary, and tertiary stress responses in fish; Biomarkers of aquatic pollution and endocrine disrupting chemicals (EDCs) affecting physiological homeostasis.

### 3. Reproductive Physiology & Endocrinology

- Reproductive Strategies & Systems: Comparative anatomy of gonads, modes of reproduction (oviparity, viviparity), fecundity, and reproductive strategies.
- Gonadal Development & Spawning: Gametogenesis (Oogenesis and Spermatogenesis), follicular atresia, environmental cues (photoperiod, temperature, rainfall) regulating breeding cycles.
- Endocrinology of Reproduction: Hypothalamic-Pituitary-Gonadal (HPG) axis; Role of GnRH, Gonadotropins (*GtH I* & *GtH II*), steroids ( $17\alpha, 20\beta$ -DHP, Testosterone, Estradiol- $17\beta$ ), and maturation-inducing hormones (MIH).
- Reproductive Dysfunction: Contaminant-induced reproductive impairment, intersex condition, and artificial propagation techniques (induced breeding protocols).

## Part III: Aquatic Ecology, Biodiversity & Environmental Management 20%

### 1. Ecosystem Dynamics & Limnology

- Lentic & Lotic Ecosystems: Zonation, hydrology, water circulation, light penetration, and thermal dynamics.
- Physico-Chemical Dynamics: Thermal stratification and overturns; Seasonal dissolved oxygen dynamics; Carbon, Nitrogen, and Phosphorus cycling; Sediment chemistry and nutrient exchange.
- Biological Communities:
- Phytoplankton & Periphyton: Taxa composition, primary productivity ( $C^{14}$  and Light/Dark bottle methods), algal bloom dynamics, and cyanotoxins.
- Zooplankton & Benthos: Major groups, grazing impacts, diel vertical migration (DVM), trophic cascade, and benthic macroinvertebrates as bioindicators.

### 2. Aquatic Biodiversity & Conservation Biology

- Biodiversity Frameworks: Genetic, species, and ecosystem diversity; Species richness, evenness, and biodiversity indices.
- Bio-monitoring Tools: Concept and calculation of Index of Biotic Integrity (IBI) for river ecosystem health assessment.
- Threats & Conservation Status: IUCN red-listing criteria, CITES regulations, drivers of aquatic biodiversity loss (habitat fragmentation, damming, invasive species, overexploitation), and native fish conservation practices.

### 3. Aquatic Pollution, Climate Change & Eco-Restoration

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- Water Quality & Pollution: Eutrophication drivers and remediation; Heavy metal bioaccumulation and biomagnification; Microplastics and industrial effluent impacts.
- Climate Change Impacts: Global warming effects on thermal regimes, dissolved oxygen availability, altered river hydrology, shifts in fish distribution, and phenology changes.
- Ecological Restoration: Biomanipulation techniques, watershed management, construct wetlands, and river habitat restoration strategies.

#### **Part IV: Fisheries Genetics, Population Structure & Breeding 20%**

##### **1. Molecular Genetics & Variation Analysis**

- Genetic Architecture: Nucleic acids (DNA/RNA structure), nuclear vs. mitochondrial DNA (*mtDNA*), gene expression, and protein synthesis.
- Sources of Genetic Variation: Mutation, recombination, sexual reproduction, chromosomal alterations, and phenotypic plasticity.
- Genotyping Technologies: Principles and protocols for RFLP, RAPD, AFLP, SSR, SNP discovery, high-throughput Next-Generation Sequencing (NGS), and transcriptomics.

##### **2. Population Genetics & Stock Management**

- Population Genetics Principles: Hardy-Weinberg Equilibrium (HWE) and factors causing deviation (selection, drift, mutation, gene flow, non-random mating).
- Stock Identification: Concept of evolutionary significant units (ESUs) and management units (MUs); Estimation of allele frequencies, heterozygosity, and  $F_{ST}$  statistics.
- Mixed Stock Analysis (MSA): Application of genetic markers in identifying contribution of different stocks in mixed fisheries.
- Conservation Genetics: Genetic drift, bottleneck effect, effective population size ( $N_e$ ), inbreeding depression, and outbreeding depression in wild and managed populations.

##### **3. Hatchery Genetics & Selective Breeding**

- Genetic Traits: Inheritance patterns of qualitative vs. quantitative traits; Estimation of additive genetic variance and narrow-sense heritability ( $h^2$ ).
- Selection Methods: Mass selection, family selection, marker-assisted selection (MAS), genomic selection, and response to selection (Realized Heritability).
- Breeding Strategies: Inbreeding control protocols, pedigree tracking, cross-breeding, hybridization (interspecific/intergeneric), chromosome set manipulation (gynogenesis, androgenesis, polyploidy), and sex reversal techniques.
- Hatchery-Wild Interactions: Genetic risks of escaped/stocked farm fish on wild stocks, domestication selection, fitness reduction, and integrated hatchery management strategies.

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## B.7. Dairy Science 85%

### 1. Introduction to milk and milk products. Importance of indigenous dairy products in Nepalese dairy industry. 15%

- Dahi and Dahi-based dairy products; production technology, packaging
- Nauni and ghee: Production technology, packaging and marketing
- Chhurpi: Production technology, packaging and marketing
- Kheer: Production technology, packaging and marketing
- Kurauni (khoa): Nutritive value of Kurauni, methods of manufacture, packaging and preservation, factors affecting yield of Kurauni, physicochemical changes during manufacture and storage of Kurauni
- Kurauni-based confections: Burfi, Peda, milk cake, kalakand, Lalmohan, compositional profile, manufacture practices, nutritive value of Kurauni-based sweets
- Chhanna: Methods of manufacture, packaging and preservation
- Chhanna-based sweets: Mechanization of manufacturing process, its prospects
- Paneer: Nutritive value of paneer, methods of manufacture, packaging and preservation, physicochemical changes during manufacture and storage

### 2. Milk Processing and Marketing 20%

- Hygienic milk production, collection and transportation
- Different techniques used in milk preservation and storage
- Milk separation, factors affecting milk separation and creaming
- Clarification and bactofugation of milk
- Milk homogenization, effect of homogenization, theories of homogenization
- Judging and grading of milk, defects in milk, their causes and prevention
- Standardization of milk
- Milk pasteurization: LTLT, HTST
- Different types of milk pasteurizers used in dairy industry
- UHT milk and sterilized milk
- Types of milks: Recombined milk, toned milk, double toned milk, homogenized milk, soft curd milk, flavored milk, vitaminized milk, etc.
- Effect of heat treatment in milk and its efficiency judgment
- Packaging of market milk
- Plant operation efficiency
- Operational losses in milk processing
- Milk marketing and distribution system
- Cleaning and sanitization of dairy plants

### 3. Dairy Products 15%

- Cream: Efficiency of cream separation and factors affecting it. Control of fat concentration in cream. Preparation of different types of cream.
- Butter: Technology of butter manufacture; overrun in butter. Control of fat losses in buttermilk. Packaging and storage of butter, transportation, defects in butter.
- Ghee and butter oil: Method of ghee making. Utilization of sub standard milk and old stored butter in the manufacture of ghee.

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- Technology of Ice-cream production, packaging and storage, Role of milk constituents in the manufacture of ice-cream mixes. Composition standard of ice-cream.
- Cheese basic principles, history of yak cheese production in Nepal. Manufacture of varieties of cheese: Yak cheese, Kanchan Cheese, Mozerella Cheese etc. Processed Cheese and Cheese spread. Physiochemical changes during ripening of cheese
- Condensed and dried milk products.
- Dairy byproducts utilization (buttermilk, whey, skim milk/casein, ghee residue)

### 3. Milk Quality Control 25%

- Hygiene and sanitation of processing and manufacturing of milk products: Hygiene of milk processing, processing equipment and machinery, personnel handling milk and milk products, containers and packaging materials.
- Hygiene in production of milk products: Market milk, milk powder, condensed milk, butter, cheese, ice-cream, fermented milk products.
- Hygiene of storage, transport and sales of milk products: Demand and norms of storage condition, hygiene of transport and sales.
- Influence of milk on human health: Value of milk, spreading of diseases through milk.
- Quality control and assurance: Quality control of processing, manufacturing and marketing, Food Act, legislation, quality standards of dairy products, quality assurance and quality management systems, hazard analysis and critical control point system in dairy industry.
- Preservatives, neutralizers and adulterants in milk and their detection
- CIP Cleaning: Introduction to cleaning, CIP cleaning, design of CIP systems, centralized CIP systems, cleaning effect, mechanical cleaning, manual cleaning.
- Composition and functions of different detergents: Alkalies, acids, polyphosphate, sulphates, selection of cleaning detergent, control of cleaning solutions
- Sterilization: Definition of sterility and sanitation, sterilization theory and methods of sterilization, use and composition of different sterilization agent, sanitizing machinery, equipment and process, verification of sterilizing effect – introduction, point of control (HACCP), method of taking samples, testing sterility, formation of resistance microorganisms, control of sterilizing 4
- Corrosion of dairy equipment
- Basic methods to arrange hygienic systems in dairy plant
- Industrial Waste and its treatment and disposal
- Bacteriological control of processing and manufacturing of products

### 4. Design of Dairy equipment 15%

- Sanitary pipes, fittings, gaskets, installation, care and maintenance of pipes and fittings
- Description of equipment, working and maintenance of can washers, crate washers, factors affecting washing operations, and power requirements
- CIP cleaning and design of system
- Mechanical separation, fundamentals involved in separation, different types of separators, clarifiers, its care and maintenance
- Homogenizer, its classification, single- and two-stage homogenizers, its care and maintenance
- Batch and continuous pasteurizers, flow diversion valve, pasteurizer controls, its care and maintenance
- Different types of sterilizers, in-bottle sterilizers, UHT sterilizers, aseptic packaging, and equipment, care and maintenance
- Filling machines, types, pouch and bottle filling machines, care and maintenance

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- Evaporators, Compressors and Condensers- basic mechanisms, its construction, operation, types, basic concepts of multiple effect evaporators, care and maintenance
- Principles of drying, types of dryers, drum and spray dryer, air heating system, atomization, and feeding systems, spray dryer controls, cyclone separators, bag filters, care and maintenance
- Application of fluidization techniques in drying, batch fluidization, fluidized bed dryers
- Membrane processing, ultra-filtration, reverse osmosis, effect on milk constituents, membranes for electro-dialysis

#### 5. Dairy Microbiology 5%

- Microbiology of raw milk and Market milk
- Starter culture
- Microbiology of fermented milk
- Microbiology of ice-cream
- Microbiology of Cheese

#### 6. Dairy Chemistry 5%

- Milk proteins, fat, carbohydrates
- Minerals and vitamins in milk
- Milk Enzymes- lipase, phosphatase and lactoperoxidase

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