KOLHAN UNIVERSITY, CHAIBASA

Proposed Syllabus for FYUGP, NEP-2020
B.Sc. (Hons.) Zoology
(Effective from Academic Year 2022-23 onwards)

Draft Prepared by:

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DEPARTMENT OF ZOOLOGY, K.U. FYUGP 2022 ONWARDS

Credit distribution for the course:

Semester	Course Code	Course Name/ Paper	Credits (Theory + Practical)
I	MDC-1/2/3	Human Physiology	3 + 0
	MN-1A	Food, Nutrition & Health	3 + 1
	MJ-1	Diversity of Life- Protists to Echinoderms	3 + 1
II	MN-2A	Minor from Vocational studies/ Discipline-2	3 + 1
	MJ-2	Diversity of Chordates	3 + 1
	MJ-3	Comparative Anatomy of Vertebrates	3 + 1
III	MN-1B	Apiculture	3 + 1
	MJ-4	Principles of Ecology	3 + 1
	MJ-5	Cell Biology and Histology	3 + 1
IV	MN-2B	Minor from Vocational studies/ Discipline-2	3 + 1
	MJ-6	Animal Physiology - I	3 + 1
	MJ-7	Fundamentals of Biochemistry	3 + 1
	MJ-8	Evolutionary Biology	3 + 1
V	MN-1C	Sericulture	3 + 1
	MJ-9	Animal Physiology - II	3 + 1
	MJ-10	Metabolism	3 + 1
	MJ-11	Developmental Biology	3 + 1
	IAP	Internship/ Apprenticeship/ Field Work/ Dissertation/ Project	4 + 0
VI	MN-2C	Minor from Vocational studies/ Discipline-2	3 + 1
	MJ-12	Genetics	3 + 1
	MJ-13	Molecular Biology	3 + 1
	MJ-14	Microbiology	3 + 1
	MJ-15	Immunology	3 + 1
VII	MN-1D	Medical Diagnostics	3 + 1
	MJ-16	Biotechnology	3 + 1
	MJ-17	Biostatistics and Bioinformatics	3 + 1
	MJ-18	Animal Behaviour and Chronobiology	3 + 1
	MJ-19	Endocrinology	3 + 1

VIII	MN-2D	Minor from Vocational studies/ Discipline-2	3 + 1
	MJ-20	Tools and Techniques	3 + 1
	RC or AMJ-1 AMJ-2 AMJ-3	Research Internship/Field Work/Dissertation or Entomology (Disciplinary/Interdisciplinary Major) Proteogenomics (Disciplinary/Interdisciplinary Major) Fish and Fisheries (Disciplinary/Interdisciplinary Major)	12 or 3 + 1 3 + 1 3 + 1
		Total Credits	**160**

Examination Framework for B.Sc. (Hons.) Zoology

Zoology Paper Type	Credits	Full Marks	Pass Marks	Semester Internal Examination	End Semester Examination
Major (Theory)	3	75	30	15	60
Major (Practical)	1	25	10	--	25
Minor (Theory)	3	75	30	15	60
Minor (Practical)	1	25	10	--	25

SEMESTER INTERNAL EXAMINATION (SIE):

- For Semester Internal Examination (SIE 15 marks),15 Marks in Theory Examination will include 10 Marks questions from Written Examination/Assignment/Project/Tutorial wherever applicable whereas 5 marks will be awarded on the attendance/overall class performance in the semester. Range for conversion of attendance into marks is as follows: Attendance upto 45%, 1 mark; 45%<Attd.<55%, 2 marks; 55%<Attd.<65%, 3 marks; 65%<Attd. <75%, 4 marks; 75%<Attd, 5 marks.

- For Semester Internal Examination (SIE 10 marks, 1Hr Exam), there will be two group of questions. Question No.1 will be very short answer type in Group A consisting of five questions of 1 mark each. Group B will contain descriptive type two questions of five marks each, out of which any one to answer.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

- For End Semester Examination (ESE 60 marks, 3Hrs Exam), there will be two group of questions. Group A is compulsory which will contain three questions. Question No.1 will be very short answer type consisting of five questions of I mark each. Question No. 2 & 3 will be short answer type of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

Semester I

Major Paper 1 (MJ 1) : Diversity of Life- Protists to Echinoderms

Credits: Theory: 03
Practical: 01
Total: 04

Theory (03 Credits): **45 hours**

UNIT I: Introduction to Animalia **2 hours**
General Characteristics of Kingdom Animalia and Basis of Classification

UNIT II: Protista **4 hours**
Protista: General characteristics and Classification up to classes; Locomotion and Reproduction in Protista

UNIT III: Porifera **4 hours**
Porifera: Introduction to Parazoa; General characteristics and Classification up to classes; Canal system in sponges

UNIT IV: Cnidaria **5 hours**
Evolution of Metazoa, Cnidaria: General characteristics and Classification up to classes; Polymorphism in Cnidaria.

UNIT V: Ctenophora **3 hours**
Ctenophora: General characteristics and evolutionary significance

UNIT VI: Helminthes **5 hours**
Platyhelminthes and Nemathelminthes: General characteristics and Classification up to classes; Parasitic adaptations in helminthes.

UNIT VII: Annelida **4 hours**
Annelida: General characteristics and Classification up to classes; Role of Nephridia in excretion among Annelids.

UNIT VIII: Arthropoda **6 hours**
Arthropoda: General characteristics and Classification up to classes, Vision and Respiration in Arthropoda

UNIT IX: Onychophora **2 hours**
Onychophora: General characteristics and Evolutionary significance.

UNIT X: Mollusca **5 hours**

Mollusca: General characteristics and Classification up to classes; Torsion and detorsion in Gastropoda.

UNIT XI: Echinodermata **5 hours**

Echinodermata: General characteristics and Classification up to classes; Water-vascular system in Echinoderms.

Recommended Readings:

- Barnes, R.D. (2006) Invertebrate Zoology. VII Edition, Cengage Learning, India.
- Barnes, R. S. K.; Calow, P.; Olive, P. J. W.; Golding, D. W.; Spicer, J. I. (2002) The Invertebrates: a Synthesis, Blackwell Publishing.
- Pechenik, J. A. (2015) Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Hickman, C.; Roberts, L.S.; Keen, S.L.; Larson, A. and Eisenhour, D. (2018) Animal Diversity, McGraw-Hill.
- Holland, P. (2011) The Animal Kingdom: A Very Short Introduction, Oxford University Press.
- Barrington, E.J.W. (2012) Invertebrate Structure and Functions. II Edition, EWP Publishers.
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003) Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India.

Practical (01 Credit): **30 hours**

1. Study of following permanent slides/ specimens: *Amoeba, Paramecium*, *Sycon, Obelia, Physalia, Taenia solium*, Male and female *Ascaris lumbricoides*, *Aphrodite, Nereis, Pheretima, Hirudinaria, Palaemon, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Chiton, Dentalium, Pila, Unio, Octopus, Pentaceros, Echinus, Cucumaria.*
2. Study of Digestive and Nervous system of Earthworm.
3. Mounting of septal nephridia.
4. Submission of project report on study of animals in nature during a survey of a National Park/ Biodiversity parks/ Zoological Museum.
5. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: **(25 Marks)**

1. Spotting (8 Marks)
2. Dissection and mounting (4+3 Marks)
3. Visit Report (4 Marks)
4. Practical record (3 Marks)
5. Viva-voce (3 Marks)

Minor Paper 1A (MN 1A): Food, Nutrition & Health

Credits: Theory:03
Practical: 01
Total: 04

Theory (03 Credits):

UNIT I: Basic concept of food and nutrition **11 hrs**

Food components: Major and supplementary components; Concept of a balanced diet, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, school children, adolescents and elderly.

UNIT II: Nutritional Biochemistry **11 hrs**

Carbohydrates, Lipids, Proteins: their dietary source and role; Vitamins: their dietary source and importance; Minerals: their biological functions. Dietary Fibres: definition, their dietary source and nutritional importance. Elementary idea of Probiotics, Prebiotics, Organic Food.

UNIT III: Health **12 hrs**

Definition and concept of health, Major nutritional Deficiency diseases- (kwashiorkor and marasmus), Deficiency disorders, their causes, symptoms, treatment, prevention and government programmes, if any. Life style related diseases- hypertension, diabetes mellitus, obesity- their causes and prevention through dietary and lifestyle modifications.

UNIT IV: Food hygiene **11 hrs**

Food and Water borne infections; Bacterial infection: Cholera, typhoid fever, dysentery; Viral infection: Hepatitis, Poliomyelitis; Protozoan infection: amoebiasis, giardiasis; Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention.

Recommended Readings:

- Shashi Goyal & Pooja Gupta. Food, Nutrition and Health (ISBN: 9788121940924)
- Linda Tapsell. Food, Nutrition and Health. I Edition, Oxford (ISBN: 978-0195518344)
- Gibney MJ et al. (eds) (2009) Introduction to Human Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd, Nutritional Society.
- Mann J and Truswell SA, Essentials of Human Nutrition, Oxford University Press
- Yuan Kun Lee and Seppo Salminen: Handbook of Probiotics and Prebiotics, second ed., John Viley & Sons, Inc.
- James Robinson, Deborah J McCornick, Concepts in Health and Wellness, Delmar Cenage Learning, 1st ed

- Jeremy Hawker, Norman Begg, Iain Blair, Ralf Reintjes, Julius Weinberg, Communicable Disease Control Handbook, 2nd ed
- Clive de W Blackburn, Food Spoilage Microorganisms, Woodhead Publishing Limited, cambridge
- Avantina Sharma. Principles of Therapeutic Nutrition and Dietetics.. CBS Publishers and Distributors Pvt. Ltd.
- Elia M et al. (eds) Clinical Nutrition. Wiley-Blackwell A John Wiley & Sons Ltd.

Practical (01 Credits): 30 hours

1. To detect adulteration in a) Ghee/Butter b) Sugars c) Tea leaves and d) Turmeric.
2. Ascorbic acid estimation in food by titrimetry.
3. Study of the stored grain pests from slides/photographs (*Sitophilus oryzae, Trogoderma granarium, Callosobruchus chinensis*and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
4. Report on visit to food testing lab /or any agency of food standards.
5. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: (25 Marks)

1. Adulteration Expt. (8 Marks)
2. Estimation Expt./Spotting (7 Marks)
3. Visit Report (4 Marks)
4. Practical record (3 Marks)
5. Viva-voce (3 Marks)

Semester II

Major Paper 2 (MJ 2) : Diversity of Chordates

Credits: Theory: 03
Practical: 01
Total: 04

Theory (03 Credits): **45 hours**

UNIT I: Introduction to Chordates **2 hours**

General characteristics and outline classification of Chordates.

UNIT II: Protochordata **6 hours**

Specific characteristics of Hemichordata, Urochordata and Cephalochordata; Retrogressive metamorphosis in Urochordata

UNIT III: Origin of Chordates **2 hours**

Dipleurula concept and the Echinoderm theory of origin of chordates

UNIT IV: Agnatha **2 hours**

Specific characteristics of Agnatha and classification up to Class

UNIT V: Pisces **6 hours**

Specific characteristics of Pisces*, Classification up to class, Migration and Osmoregulation in Fish

*Comparative account or difference between classes should be discussed and emphasis also will be given to lateral line system.

UNIT VI: Amphibia **6 hours**

Origin of Tetrapoda, Amphibia: Specific characteristics and classification up to order; Introduction to Parental care in Amphibians

UNIT VII: Reptilia **6 hours**

Reptilia: Specific characteristics and classification up to order; Poison apparatus, feeding and biting mechanism in snakes

UNIT VIII: Aves **6 hours**

Aves: Specific characteristics and classification up to order; Flight adaptations and migration in birds

UNIT IX: Mammals **6 hours**

Mammals: Specific characters and classification up to order, Adaptive radiation with reference to locomotory appendages

UNIT X: Zoogeography **3 hours**

Zoogeographical realms, Distribution of vertebrates in different realms

Recommended Readings:

- Young, J. Z. (2004) The Life of Vertebrates. III Edition. Oxford university press.
- Hickman, C.; Roberts, L.S.; Keen, S.L.; Larson, A. and Eisenhour, D. (2018) Animal Diversity, McGraw-Hill.
- Holland, P. (2011) The Animal Kingdom: A Very Short Introduction, Oxford University Press.
- Darlington P.J. (1966). The Geographical Distribution of Animals, R.E. Krieger Pub. Co.

Practical (01 Credit): **(25 hours)**

1. Study of following specimens: *Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Myxine, Scoliodon, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis, Salamandra, Bufo, Hyla, Chelone, Chamaeleon, Draco, Vipera, Naja, Crocodylus*, Any three common birds from different orders, *Bat, Loris.*
2. Key for identification of poisonous and non-poisonous snakes on the basis of tail, scales, fangs, nature of venom and other morphological features.
3. Types of beaks and claws in birds.
4. Submission of project report on study of animals in nature during a survey of a National Park/ Biodiversity parks/ Zoological Museum.
5. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: **25 Marks**

1. Spotting (5 specimens × 2 marks) (10 Marks)
2. Key for Identification of poisonous and non-poisonous snakes. (3 Marks)
3. Types of beaks and claws in birds (3 Marks)
4. Visit Report (3 Marks)
5. Practical record (3 Marks)
6. Viva-voce (3 Marks)

Major Paper 3 (MJ 3) : Comparative Anatomy of Vertebrates

Credits: Theory: 03
Practical: 01
Total: 04

Theory (03 Credits): (45 hours)

UNIT I: Integumentary System 5 hours

Structure and derivatives of integument, functions of skin.

UNIT II: Skeletal System 12 hours

Outline of axial and appendicular skeleton (tetrapod): basic plan of bones of skull, girdles and limbs. Classification of vertebrae, structure of a typical vertebra (basic layout), Jaw suspensorium, Visceral arches.

UNIT III: Digestive System 4 hours

Alimentary canal and associated glands, dentition.

UNIT IV: Respiratory System 4 hours

Skin, gills, lungs and air sacs; Accessory respiratory organs.

UNIT V: Circulatory System 6 hours

General plan of circulation, Evolution of heart and aortic arches.

UNIT VI: Urinogenital System 6 hours

Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

UNIT VII: Nervous System 5 hours

Comparative account CNS, PNS, ANS with special emphasis on brain (from formation to partitioning); Cranial nerves in mammals.

UNIT VIII: Sense Organs 3 hours

Classification of receptors (organ of special senses); Brief account of visual and auditory receptors in man.

Recommended Readings:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

- Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001). Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.
- C.K Weichert and W. Presch (1970). Elements of Chordate Anatomy, IV Edition, McGraw- Hill.
- Pough.H. (2018). Vertebrate Life.X Edition. Pearson International.

Practical (01 Credit): (25 hours)

1. Study of placoid, cycloid and ctenoid scales of fish through temporary mounts/permanent slides/photographs.
2. Study of different types of feathers of birds through demonstrations/photographs.
3. Comparative Osteology: Disarticulated skeleton of Frog, *Varanus*, Fowl, Rabbit (Limb bones, Girdles).
4. Study of carapace and plastron of turtle/tortoise through specimen/ model/photographs.
5. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: 25 Marks

1. Spotting- Osteology- at least one from each class (2 marks each) (8 Marks)
2. Scales (1) and Feathers (1) Identification (5 Marks)
3. Carapace/Plastron Identification (4 Marks)
4. Practical record (4 Marks)
5. Viva-voce (4 Marks)

Semester III

Major Paper 4 (MJ 4) : Principles of Ecology

Credits: **Theory:03**
Practical: 01
Total: 04

Theory (03 Credits): **45 hours**

UNIT I: Introduction to Ecology **3 hrs**

History and Scope of ecology, Autecology and synecology, Laws of limiting factors, Study of physical factors: Temperature and Light.

UNIT II: Population **18 hrs**

Unitary and Modular populations; Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, equation and patterns, *r* and *k* strategies, Population regulation; Density-dependent and independent factors; Population interactions; Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition and predation.

UNIT III: Community **8 hrs**

Community characteristics: species richness, dominance, diversity, abundance, Guilds, Ecotone and edge effect; Ecological succession with examples and types; Theories pertaining to climax community.

UNIT IV: Ecosystem **12 hrs**

Types of ecosystems with detailed study of any one: Forest Ecosystem, Pond or Lake ecosystem, Mangrove and Coral reef ecosystem. Vertical stratification in Forest and Aquatic ecosystem, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies, Nutrient and biogeochemical cycle with one example of Nitrogen cycle.

UNIT V: Applied Ecology **4 hrs**

Ecology in wildlife conservation and management, Biodiversity types, Importance & threats, Protected areas: National Parks, Bioreserves and Sanctuaries, Global climate change and its mitigation.

Recommended Readings:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Smith, R. L. (2000). Ecology and field biology. Harper and Row publisher
- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.

- Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Press.

Practical (01 Credit): (30 hours)

1. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.
2. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of area, temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), chemical oxygen demand and free CO2, alkalinity.
3. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary.
4. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: 25 Marks

1. Spotting (2 spotting × 2.5 marks = 5 Marks)
    a. Any one phytoplankton
    b. Any one zooplankton
2. Determination of population density and calculation of diversity index or Determination of pH and dissolved oxygen content in given water sample. (10 Marks)
3. Visit Report (3 Marks)
4. Practical record (3 Marks)
5. Viva-voce (4 Marks)

Major Paper 5 (MJ 5) : Cell Biology and Histology

Credits: **Theory: 03**
Practical: 01
Total: 04

Theory (03 Credits): (45 hours)

UNIT I: Overview of Cells **2 hrs**
Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions

UNIT II: Plasma Membrane **5 hrs**
Various models of plasma membrane structures, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions, structures and functions: Tight junctions, adherens junctions, gap junctions

UNIT III: Endomembrane System **12 hrs**
Structure and Functions: Endoplasmic Reticulum, Signal hypothesis, Vesicular transport from ER to Golgi apparatus; Protein sorting and transport from Golgi apparatus; Golgi apparatus, Vesicular transport: Coated Vesicles; Lysosomes; Peroxisomes.

UNIT IV: Mitochondria **6 hrs**
Structure, Semi-autonomous nature, Endo-symbiotic hypothesis; Respiratory chain, Chemiosmotic hypothesis and ATP Synthase.

UNIT V: Cytoskeleton **4 hrs**
Structure and Functions: Microtubules, Microfilaments and Intermediate filaments.

UNIT VI: Nucleus, Cell Division and Cell Signalling **8 hrs**
Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Transport of molecules across nuclear membrane, Nucleolus, Mitosis, Meiosis, Cell cycle and its regulation, Basics of Cell Signalling, Apoptosis.

UNIT VII: Histology **8 hrs**
Introduction to tissues. Epithelial tissue: types, structure and characteristics. surface modifications. Basement membrane: structure and characteristics. Connective tissue cells. Blood: structure and functions. Structure and function of loose, dense and adipose tissue. Structure of Cartilage and bone. Muscular tissue: ultrastructure of smooth, skeletal and cardiac muscles. Structure and classification of neurons. Types of supporting (glial) cells and their function. Membranes of the brain and spinal cord.

Recommended Readings:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- Becker, Kleinsmith, and Hardin (2009) The World of the Cell,VIII Edition, Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments,VI Edition, John Wiley & Sons Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2009) The Cell and Molecular Biology, Lippincott Williams & Wilkins, Philadelphia.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith and Watson James. (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

Practical (01 Credit): (30 hours)

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Study of various stages of meiosis.
3. Preparation of temporary stained mount to show the presence of Barr body in human female blood cells/ cheek cells.
4. Study of types of tissue through permanent slides: epithelial, connective, muscular, nervous.
5. Study of histology of tissues by preparing permanent stained slides through microtomy.
6. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: 25 Marks

1. Spotting (3 spotting × 2 marks = 6 Marks)
    a. Permanent slide of any one mitosis or meiosis stage
    b. Permanent slide of any two types of mammalian tissue
2. Preparation of temporary stained squash of onion root tip or Barr body in human female blood cells/ cheek cells (10 Marks)
3. Practical record (4 Marks)
4. Viva-voce (5 Marks)

MN- 1B: Apiculture

Credits: **Theory:03**
Practical: 01
Total: 04

Theory (03 Credits): **45 hours**

UNIT I: Biology of Bees **10 hrs**

History, Classification and biology of Honey Bees, different species of honey bees- *Apis dorsata*, *Apis cerana indica*, *Apis florea*, *Apis mellifera*, *Melipona* sp. Social Organization of bee colony, behavioural patterns (Bee dance, swarming).

UNIT II: Rearing of Bees **15 hrs**

Artificial bee rearing (Apiary), Beehives- Newton and Langstroth; Bee Pasturage; Selection of bee species for Apiculture- *Apis cerana indica*, *Apis mellifera*; Bee keeping equipment, Methods of extraction of Honey (Indigenous and Modern) and processing; Apiary management- Honey flow period and Lean period.

UNIT III: Diseases and Enemies **6 hrs**

Bee diseases, control and preventive measures; Enemies of bees and their control.

UNIT IV: Bee Economy **7 hrs**

Products of Apiculture Industry (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) and their uses; Modern methods in employing artificial beehives for cross pollination in horticultural gardens.

UNIT V: Entrepreneurship in Apiculture **7 hrs**

Bee Keeping Industries- Recent efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector.

Recommended Readings:

- Singh S. (1962) Beekeeping in India, Indian Council of Agricultural Research, New Delhi.
- Mishra, R. C. (1995) Honeybees and their Management in India. Indian Council of Agricultural Research, New Delhi.
- Prost, P. J. (1962) Apiculture. Oxford and IBH, New Delhi.
- Rahman, A. (2017) Beekeeping in India. Indian Council of Agricultural Research, New Delhi.
- Gupta, J. K. (2016) Apiculture, Indian Council of Agricultural Research, New Delhi.

Practical (01 Credit): **30 hours**

1. Study of the life cycle of honey bee from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker).
2. Study of natural bee hive and identification of queen cells, drone cells and brood.

3. Study of morphological structures of honey bee through permanent slides/photographs: mouth parts, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
5. Visit to an apiary/honey processing unit/Institute and submission of a report.
    a. Study of bee pasturage
    b. Visit to fields/gardens/orchards for studying the bee activity (role in pollination and nectar collection).
    c. Making of herbarium of nectar and pollen yielding flowering plants
6. Submission of a few products obtained from apiculture industry.
7. Group discussion or Seminar presentation from any topic from the paper.

Pattern of Practical Examination: **(25 Marks)**

1. Life cycle of honey bee (3 Marks)
2. Spotting (4 spotting × 3 marks = 12 Marks)
    a. Mouth part/ antenna/ wing/ leg
    b. Sting apparatus
    c. Any type of artificial hive/ bee product
    d. Any beekeeping equipment
3. Visit Report (4 Marks)
4. Practical record (3 Marks)
5. Viva-voce (3 Marks)