# Undergraduate and Postgraduate syllabus
# Department of Biological Science
# Presidency University, Kolkata

The Department of Biological Science in Presidency University has been created by merging together the pre-existing Departments of Botany, Zoology, Physiology, Molecular Biology, Biochemistry and Biotechnology. The result is a dynamic inter-disciplinary Department with a holistic approach towards the study of Biological Science. The department consists of outstanding faculty who are eminent in their fields, and have joined the University after successful research and teaching careers. The mixture of young and experienced faculty in the Department of Biological Science promises an outstanding academic experience to its students. They will have the opportunity of learning a multitude of inter-disciplinary subjects, and will also have research experience by the completion of their studies.

In the curriculum there will be two semesters each academic year and thus a student enrolled in the Bachelor of Science program will leave with a Bachelors Degree in Biological Science after completion of Six semesters . Students who have completed a B Sc Honours in any branch of Biological Science can enroll for the M Sc program which consist of Four semesters of curriculum .

All students will study the same course modules in the semesters 1, 2 and 3 and these modules will comprise mostly of the fundamentals of Biological Science, from diversity and evolution to biochemistry and genetics. There will be laboratory based / field study based practical modules with theoretical papers. The objective is to generate the knowledge base of the students, upon which they will build up their education.

Upon completion of Semester 3, students will have the liberty of choosing theory papers of their personal interest, with the corresponding laboratory modules or they can opt for subject specialization. An advisory committee of Departmental faculty will assist each student at this stage to select their courses for semesters 4, 5 and 6 based on their interests and their future career goals. The total number of modules a student can take will be based on UGC guidelines. The Department will reserve the right to limit the number of students for a particular module, when preference will be given by merit.

# CURRICULUM STRUCTURE OF BIOSCIENCE

## UG SEMESTER-1

**BIOS 0101 Major-1 (Theoretical): Plant and Animal Diversity, Organic Evolution and Ecology**
[50 marks; 4 credits]
Module 1: Plant and Animal Diversity [20 marks]
Module 2: Organic evolution [15 marks]
Module 3: Ecology [15 marks]

**BIOS 0191 Major-2 (Practical): Plant and Animal Diversity, Organic Evolution and Ecology**
[50 marks: 6 credits]
Module 1: Plant and Animal Diversity
Module 2: Organic Evolution
Module 3: Ecology
Module 4: Histology
Module 5: Local excursion
Module 6: Group discussion by students

## UG SEMESTER-2

**BIOS 0201 Major-3 (Theoretical): Biophysical Principles, Biochemistry and Biostatistics**
[50marks; 4 credits]
Module 1: Biophysical Principles [15 marks]
Module 2: Biochemistry [20 marks]
Module 3: Biostatistics [15 marks]

**BIOS 0291 Major-4 (Practical): Biophysics and Biochemistry**
[50 marks; 6 credits] Module 1: Biophysics
Module 2: Biochemistry
Module 3: Group discussion by students

## UG SEMESTER-3

**BIOS 0301 Major-5 (Theoretical): Cell Biology, Molecular Biology and Genetics**
[50 marks; 4credits]
Module 1: Cell Biology [15 marks]
Module 2: Molecular Biology [20 marks]
Module 3: Genetics [15 marks]

**BIOS 0302: Major-6 (Theoretical): Microbiology, Biology of Diseases and Immunology**
[50 marks;4 credits]
Module 1: Microbiology [15 marks]
Module 2: Biology of Diseases [15 marks]
Module 3: Immunology [20 marks]

**BIOS 0391 Major-7 (Practical): Cell Biology, Molecular Biology, Genetics, Microbiology and Immunology** [50 marks; 6 credits]
Module 1: Cell Biology
Module 2: Molecular Biology
Module 3: Genetics
Module 4: Tissue Staining
Module 5: Microbiology
Module 6: Immunology
Module 7: Group discussion by students

## SUBJECT BASKETS FOR SEMESTER 4, 5, 6

***Following modules will be offered in the basket. A candidate will be given option to choose the modules accordingly so that the required credit as per the following format is achieved. The Advisory committee can guide a candidate regarding choosing of the modules if anyone desires to restrict him/herself to any specialization.***

### UG SEMESTER -4

**BIOS 0401 (A-F) Major-8 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0402 (A-F) Major-9 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0491 Major-10 (Practical)** [50 marks; 6 credits]

**Theoretical modules offered:** Candidates have to take any two theoretical modules, each of 4 credits, and the corresponding practical, of 6 credits.

| Serial # | Module | Course contents |
|---|---|---|
| 1 | BIOS 0401A | Plant architecture and systematics |
| 2 | BIOS 0402A | Lower plant groups |
| 3 | BIOS 0401B | Functional morpho-anatomy of non-chordates |
| 4 | BIOS 0402B | Functional morpho-anatomy of chordates |
| 5 | BIOS 0401C | Enzymology |
| 6 | BIOS 0402C | Blood, body fluids, hematology, cardiovascular system and respiration |
| 7 | BIOS 0401D | Digestion, nutrition, excretion and thermal homeostasis |
| 8 | BIOS 0401E | Applied nutrition and dietetics |
| 9 | BIOS 0402D | Maintenance, expression and regulation of the genome |
| 10 | BIOS 0401F | Microbe- man interaction: beneficial and harmful aspects |
| 11 | BIOS 0402E | Industrial microbiology |
| 12 | BIOS 0402F | Overview of immunity and the immune system |
| 13 | BIOS0491 | Related practicals |

### UG SEMESTER – 5

**BIOS 0501 (A-D) Major-11 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0502 (A-D) Major-12 (Theoretical Optional)** [50 marks; 4 credits]

**BIOS 0503 (A-D) Major-13 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0591 Major-14 (Corresponding Practical)** [50 marks; 6 credits]
**BIOS 0592 Major-15 (Corresponding Practical)** [50 marks; 6 credits]

**Theoretical modules offered:** *Candidates have to take any three theoretical modules; each of 4 credits, and two corresponding practicals, of 6 credits each.*

| Serial # | Module | Course contents |
|---|---|---|
| 1 | BIOS 0501A | Mycology and plant pathology; ethnobotany and pharmacognosy |
| 2 | BIOS 0502A | Gymnosperms; paleobotany and palynology |
| 3 | BIOS 0501B | Animal physiology, parasitology and vector biology |
| 4 | BIOS 0502B | Taxonomy and adaptation; wildlife biology and ethology |
| 5 | BIOS 0501C | Bioenergetics, intermediary metabolism |
| 6 | BIOS 0502C | Nervous system, physiology of nerve and muscle, sensory physiology |
| 7 | BIOS 0503A | Endocrinology, neuroendocrinology and human reproduction |
| 8 | BIOS 0503B | Behavioral and cognitive neuroscience |
| 9 | BIOS 0503C | Fundamentals of cell biology |
| 10 | BIOS 0501D | Environmental microbiology |
| 11 | BIOS 0503D | Microbial ecology and food microbiology |
| 12 | BIOS 0502D | Basic immunology |

## UG SEMESTER -6

**BIOS 0601 (A-C) Major-16 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0602 (A-C) Major-17 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0603 (A-C) Major-18 (Theoretical Optional)** [50 marks; 4 credits]
**BIOS 0691 Major-19 (Corresponding Practical)** [50 marks; 6 credits]
**BIOS 0692 Major-20 (Corresponding Practical)** [50 marks; 6 credits]
**Theoretical modules offered:** *Candidates have to take any three theoretical modules; each of 4 credits, and two corresponding practicals, of 6 credits each.*

| Serial # | Module | Course contents |
|---|---|---|
| 1 | BIOS 0601A | Plant physiology |
| 2 | BIOS 0602A | Plant biotechnology and plant breeding |
| 3 | BIOS 0603A | Animal histology, animal development and economic zoology |
| 4 | BIOS 0602B | Biophysical methods |
| 5 | BIOS 0602C | Social physiology, stress physiology, ergonomics and sports physiology |
| 6 | BIOS 0603B | Pathophysiology of common human diseases and pharmacological drug design |
| 7 | BIOS 0601B | Biostatistics and bioinformatics |
| 8 | BIOS 0603C | Fundamentals of genetics |
| 9 | BIOS 0601C | Applied immunology |

## PG SEMESTER -1

**BIOS 0701 Major 21 (Theoretical)** [50 marks; 4 credits]
Methods and Experimental Design

**BIOS 0702 Major 22 (Theoretical)** [50 marks; 4 credits]
Module 1- Advanced Cellular Biology [25 marks]
Module 2- Developmental Biology [10 marks]
Module 3- Fundamentals of Neurobiology [15 marks]

**BIOS 0703 Major 23 (Theoretical)** [50 marks; 4 credits]
Module 1- Advanced Biochemistry [25 marks]
Module 2- Advanced Molecular Biology [25 marks]

**BIOS 0791 Major 24 (Practical)** [50 marks; 6 credits]
**BIOS 0792 Major 25 (Practical)** [50 marks; 6 credits]

## PG SEMESTER – 2

**BIOS 0801 Major 26 (Theoretical)** [50 marks; 4 credits]
Module 1- Advanced Microbiology [25 marks]
Module 2- Immunology [25 marks]

**BIOS 0802 Major 27 (Theoretical)** [50 marks; 4 credits]
Module 1-Advanced Genetics [30 marks]
Module 2- Environmental Science [20 marks]

**BIOS 0803 Major28 (Theoretical)** [50 marks; 4 credits]
Module1- Research conduct and Bioethics [20 marks]
Module 2- Emerging field of Science [30 marks]

**BIOS 0891 Major 29 (Practical)** [50 marks; 6 credits]
**BIOS 0892 Major 30 (Practical)** [50 marks; 6 credits]

## PG SEMESTER 3

***Semester 9 and 10 will be for specialization. The following modules will be offered to the students. Advisory Committee will guide regarding selection of modules to any candidate to aid with specialization. Credits to be achieved as follows:***

**BIOS 0901 (A-E) Major 31 (Theoretical)** [50 marks; 4 credits]
**BIOS 0902 (A-E) Major 32 (Theoretical)** [50 marks; 4 credits]
**BIOS 0903 (A-F) Major 33 (Theoretical)** [50 marks; 4 credits]
**BIOS 0991 Major 34 (Practical)** [50 marks; 6 credits]
**BIOS 0992 Major 35 (Practical)** [50 marks; 6 credits]

**Theoretical modules offered:** *Candidates have to take three theoretical modules, each of 4 credits (or six modules of 2 credits each), and the corresponding practicals, of final 12 credits.*

| Serial # | Module | Course contents | Credits |
|---|---|---|---|
| 1 | BIOS 0901A | Animal structure and function | 4 |
| 2 | BIOS 0902A | Animal taxonomy, ecology, evolution and behavior | 4 |
| 3 | BIOS 0903A | Animal physiology and animal development | 4 |
| 4 | BIOS 0901B | Molecular biology and biochemistry of diseases | 4 |
| 5 | BIOS 0902B | Current trends and advances in cell and molecular biology | 4 |
| 6 | BIOS 0902C | Biophysical methods | 4 |
| 7 | BIOS 0903B | Critical analysis of biochemical literature | 4 |
| 8 | BIOS 0903C | Medical microbiology and virology | 4 |
| 9 | BIOS 0903D | Transplantation, tumor immunobiology and immune deficiency | 4 |
| 10 | BIOS 0901C | Circulatory, neuromuscular physiology and biostatistics | 4 |
| 11 | BIOS 0902D | Alimentary, excretory, respiratory, endocrine and reproductive systems | 4 |
| 12 | BIOS 0903E | Man and environment (work and stress) and sensory physiology | 4 |
| 13 | BIOS 0901D | Plant systematic; Plant anatomy and pharmacognosy | 2+2 =4 |
| 14 | BIOS 0901E | Palaeobotany and palynology; Plant pathology | 2+2 =4 |
| 15 | BIOS 0902E | Plant physiology; Plant breeding and crop biotechnology | 2+2 =4 |
| 16 | BIOS 0903F | Plant biotechnology; Applied botany | 2+2 =4 |

## PG SEMESTER 4

**This semester will cover the dissertation projects and project related topics as well as developing research skills as preparation for PhD.**

**BIOS 1001** **Major 36 (Theoretical)** [50 marks; 4 credits]
Introduction to research: Writing skills- project/ grant proposal (30 marks), journal club (20 marks)

**BIOS 1002** **Major 37 (Theoretical)** [50 marks; 4 credits] Project related theory

**BIOS 10013** **Major 38 (Theoretical)** [50 marks; 4 credits] Review of literature

**BIOS 1091** **Major-39 (Practical)** [50 marks; 6 credits] Project related lab

**BIOS 1092** **Major-40 (Practical)** [50 marks; 6 credits]
Dissertation (30 marks) and oral presentation (20 marks)

# DETAILED SYLLABUS OF BIOSCIENCE

## UG SEMESTER-1

**Major-1 (Theoretical): Plant and Animal Diversity, Organic Evolution and Ecology**

Module 1: Plant and Animal Diversity

1. **Classification of plant phyla:** Classification of extant plant phyla (upto 'class' in case of algae, fungi, bryophytes, pteridophytes and gymnosperms and upto 'family' in case of angiosperms).
2. **Classification of animal phyla:** Classification of extant major phyla (upto 'class' in case of invertebrates and upto 'order' in case of vertebrates).
3. **Plants with structural and functional specializations:** Insectivorous plants (pitcher plant, *Drosera* sp., *Aldrovanda* sp.), parasitic plants (*Cuscuta reflexa, Santalum album*), orchids, xerophytic plants (*Opuntia* sp.), mangroves of Sunderbans.
4. **Structural and functional specializations in animals:** Polymorphism in *Siphonophora*, bioluminescence in firefly, accessory respiratory organ in fishes, electric organ in fishes, neoteny in *Axolotl* larva, poison gland and biting mechanism in poisonous snakes, echolocation in bat, echolocation in dolphin.
5. **Elements of Human System Physiology I:** Basic system biology of human: outline of Alimentary, Circulatory, Nervous and Excretory system.
6. **Elements of Human System Physiology II:** Basic system biology of human: outline of Endorine, Reproductive, Homeostasis and Integrative physiology.

Module 2: Organic evolution

1. **Origin of life:** Abiotic origin of life with reference to Miller's experiment, physical and chemical catalysis of formation of macromolecules, Oparin's 'proteinoid droplet' concept and Crick's 'Nucleic acid first' hypothesis.
2. **Geological era:** Climatic, floral and faunal characteristics of different geological era.
3. **Classical theories of evolution:** Critical review of Lamarckism, Darwinism and mutation theory of de Vries.
4. **Synthetic theory of evolution:** Basic concept with reference to Hardy-Weinberg equilibrium in populations and factors destablising such equilibrium (mutation, migration, genetic drift).
5. **Other concepts of evolution:** Goldschmidt's concept of micro- and macroevolution; Gould and Eldredge's 'punctuated equlibrium hypothesis'.
6. **Isolating mechanisms, allopatric speciation and sympatric speciation:** Basic concepts.

Module 3: Ecology

1. **Ecosystem function:** Energy flow in ecosystem, energy vs. eMergy, food chain, food web and ecological pyramids; Productivity in terrestrial and aquatic ecosystems.
2. **Population Ecology:** Characteristics of population, population growth curves, *r* and *k* selections, population regulation by density-dependent and density-independent factors, concept of self-regulation of population.
3. **Community Ecology: Habitat** and niche concept; Keystone species and dominant species; Ecotone and edge effect; Heterospecific associations with reference to competition, protocooperation, commensalism and mutualism.
4. **Ecological succession: Causes**, types and process, climax concept, theories on ecological succession.
5. **Pollution Biology and impact on human:** Air pollution - source and effect of major air pollutants,

greenhouse gases and greenhouse effect, ozone hole, physical and chemical control of air pollution; Water pollution - major causes and consequences with special reference to arsenic pollution in West Bengal; Sound pollution and its auditory and non-auditory effects. Stress physiology and physiological consequences.

**Major-2 (Practical): Plant and Animal Diversity, Organic Evolution and Ecology**

Practicals based on theoretical syllabus.

## UG SEMESTER-2

**Major-3 (Theoretical): Biophysical Principles, Biochemistry and Biostatistics**

Module 1: Biophysical Principles

1. **Forces stabilizing atomic and molecular interactions:** Formation, properties and biological significance of Van der Waals force, hydrogen bond, ionic bond, covalent bond and hydrophobic interaction.
2. **pH and buffer:** Derivation of upper and lower limits of pH; Biological significance of pH; Characteristics of buffer; Deduction of Henderson-Hasselbalch equation of pH of buffer; Principal buffers of extracellular and intracellular fluids and their function.
3. **Colligative properties of solutions:** Osmosis and osmotic pressure; Van't Hoff's laws and determination of osmotic pressure; Isosmotic and istotonic solutions; Effect of hyper- and hypotonic media on cells; Survival of marine and freshwater fishes in their respective hyper- and hypotonic environments; Depression of freezing point and Raoult's laws; Cryoscopic constant and determination of its value; Survival of polar fish at subzero temperature.
4. **Thermodynamics, reaction kinetics and energy transduction:** Isolated, closed and open systems; First and second laws of thermodynamics and their biological significance; Activation energy and transition-state theory; Different orders of chemical reactions, free energy and chemical reaction; Mitochondrial electron transport chain and oxidative phosphorylation; Photophosphorylation.

Module 2: Biochemistry

1. **Carbohydrate chemistry:** Classification and properties of carbohydrates with emphasis on stereoisomerism, optical isomerism, epimerization, mutarotation and reducing action of sugars.
2. **Protein chemistry:** Classification of proteins; primary, secondary, tertiary and quaternary structure of proteins; Properties of proteins with emphasis on isoelectric pH, salting in and out, biuret test and heat coagulation.
3. **Lipid chemistry:** Classification and properties of lipids with emphasis on saponification number, iodine number, acetyl number, Reichert-Meissel number, hydrogenation and rancidity of fats.
4. **Nucleic acid chemistry:** elementary concept of nucleoside, nucleotide, polynucleotide; elementary concept of RNA

Module 3: Biostatistics

1. **Introduction to Biostatistics:** Variable and attribute; Population vs. sample; Census vs. sample survey; Arrangement of data; Frequency distribution.
2. **Graphical presentation of data:** Line diagram; Bar diagram; Pie chart; Histogram.
3. **Measures of central tendency:** Arithmetic mean; Mode; Median.
4. **Measures of dispersion:** Variance; Standard deviation; Standard error of mean; Standard score.
5. **Testing of hypothesis and goodness of fit:** Null hypothesis, Level of significance, Probability, Normal distribution, Error of inference, Student’s t-test, Paired t-test, Fisher's t-test, Chi-square test.

**Major-4 (Practical): Biophysics, Biochemistry**

**Practicals based on theoretical syllabus.**

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## UG SEMESTER-3

**Major-5 (Theoretical): Cell Biology, Molecular Biology and Genetics**

Module 1: Cell Biology

1. **Cell structure:** Comparison between plant and animal cells; Cell wall; Plasma membrane; Electrical properties of membrane, Modification of plasma membrane and intracellular junctions; Organization of plant cell wall.
2. **Introduction to cytoplasmic organelles and cytoskeleton:** Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome, Ribosome; Centriole; Nucleus
3. **Chromosomes, chromatin and nucleosome:** Chromosome structure in bacteria and eukaryotes, centromere, telomere, Hetero- and euchromatin, Nucleosome model and radial-loop scaffold model.
4. **Overview of Cell cycle:** Stages of cell cycle, Mitotic and meiotic cell division; Distinction between mitosis in plant and animal.

Module 2: Molecular Biology

1. **Nucleic acids structure:** DNA as genetic material, Watson-Crick model, A, B and Z forms of DNA; RNA types, distinctions between RNA and DNA
2. **The Central Dogma:** Genetic brief overview of synthesis of DNA, RNA and protein
3. **The genetic code:** Genetic code and its properties, Code is degenerate, Code is nearly universal
4. **Genomic DNA cloning and cDNA cloning:** Restriction endonuclease and cloning vector, genomic DNA cloning and cDNA cloning, screening of cloned DNA.

Module 3: Genetics

1. **Mendelism:** Mendelian Laws and chromosome theory of inheritance.
2. **Allele concept:** Dominant, recessive and co-dominant alleles; Muliple allelism with reference ABO blood group; Pseudoallelism with reference to eye colour in Drosophila.
3. **Linkage and crossing over:** Coupling and repulsion phase of linkage; linkage group complete and incomplete linkage; cytological proof of crossing over.
4. **Mutation and mutagens:** Diverse types of point and gross mutations, mutagenic action of ionising and non-ionising radiations and common chemical mutagens.

**Major-6 (Theoretical): Microbiology, Biology of Diseases and Immunology**

Module 1: Microbiology

1. **Microbial diversity:** cellular (bacteria, algae, fungi, protozoa) and acellular (virus) microbes, morphological, metabolic and molecular criteria for the classification, including extremophiles.
2. **Architecture of bacteria and virus.**
3. **Microbial nutrition, growth and its control:** Nutritional requirements in bacteria and nutritional categories, different types of cultural media, microbial culture, kinetics of microbial growth.

4. **Microbial replication strategy:** bacteria and virus (lytic, lysogenic cycle)
5. **Genetic recombination in bacteria:** basic concept of transformation, conjugation, and transduction.
6. **Basics of microbial pathogenesis:** host, pathogen, pathogenicity factors, Koch's postulates, parasitism and synergism.
7. **Microbial control:** concepts on β-lactam antibiotics and their mode of action.

Module 2: Biology of Diseases

**Common diseases of plants, animals, humans**: mechanistic overview; life-style and social diseases.

Module 3: Immunology

1. **Immunity in plants:** Defensive role of ethylene, lignin, callose, tannin, hydrogen peroxide and lectin-enzyme complex in plants; Phytoalexin vs. antibody.
2. **Elements of immunity in animals:** Innate vs. acquired immunity; Passive vs. active immunity; Passive immunization vs. vaccination.
3. **Antigenicity of molecules:** Immunogen vs. antigen; Characteristics and types of antigens; Epitope.
4. **Immunoglobulins:** Molecular structure, classification and function; various forms of antigen-antibody reaction.
5. **Humoral and cell-mediated immune response:** Basic mechanism of humoral and cell-mediated immune response.
6. **Hypersensitivity:** Elementary concept of immediate and delayed-type hypersensitivity. Clinical immunology
7. **Immune suppressive disorders.**

**Major-7 (Practical): Cell Biology, Molecular Biology, Genetics, Microbiology, Immunology**

Practicals based on theoretical syllabus.

## UG SEMESTER 4

**DBS 4-1 (Plant architecture and systematics)**

**Morphology:**

1. Infloresence: Types with examples.
2. Flower: Types; Parts-Calyx (modification), Corolla (Forms and aestivation), Stamen (adhesion and cohesion, attachment of anther), Carpel (apocarpous and syncarpous), Placentation (types) Ovules (types and structure).
3. Fruit: Types and examples.
4. Pollination: Types, contrivances.

**Anatomy:**

1. Cell wall:cUltra-structure, chemical nature, growth and thickening.
2. Apical meristem: Organization of shoot-apex (Tunica-Corpus), root-apex (Korper-Kappe) concept.
3. Stomata: Types (Metchalfe and Chalk), Ontogeny.
4. Stele: Types and Evolution.
5. Mechanical Tissue: Types

6. Secondary growth: Normal (intra- and extra-stelar), Anomalous (with common examples)

**Plant taxonomy and Systematics:**

1. Introduction*:* Components of Systematics: Nomenclature, Identification, Classification; Taxonomy and its phases: Pioneer, Consolidation, Biosystematic and Encyclopaedic; Documentation: Flora, Monographs, Journals, Online Journals and Keys; Herbarium preparation and management: important herbaria and botanical gardens of the world and India.
2. Nomenclature*:* Elementary knowledge of ICBN: Concept of taxa; categories and hierarchy; species concept (taxonomic, biological, evolutionary); principles and rules of nomenclature; ranks and names; type method, author citation, valid publication; rejection of names, principle of priority and its limitation; names of hybrids and cultivars.
3. Classification*:* Broad outline of Bentham and Hooker (1862-1883), Cronquist's (1988) system of classification with merits and demerits, brief reference of Angiosperm Phylogeny Group (APG) Classification.
4. Biometrics and numerical taxonomy: Role of Computers in systematic: Characters and attributes; Operational Taxonomic Units (OTU), character weighing and coding; cluster analysis, phenograms, cladistics.
5. Data sources in Taxonomy: Supportive evidences from morphology, palynology, cytotaxonomy, chemotaxonomy, serology, and molecular systematics.
6. Diagnostic features, systematic position (Bentham and Hooker), and economic importance of the following families:

   *Dicotyledons:* Magnoliaceae, Leguminosae, Euphorbiaceae, Apiaceae, Solanaceae, Scrophulariaceae, Acanthaceae, Malvaceae, Cucurbitaceae, Asteraceae.

   *Monocotyledons:* Alismataceae, Arecaceae, Poaceae, Liliaceae, Zingiberaceae, Orchidaceae.

**Practicals based on theoretical syllabus.**

**DBS 4-2 (Lower plant groups)**

**Microbiology**

1. Cyanobacteria: life history, ecology, importance, evolutionary significance.
2. Microbes in agriculture: Biofertilizers - Bacterial, Cyanobacterial and Azolla. Mass production of *Rhizobium* and *Azotobacter*.
3. Environmental microbiology: degradation of cellulose, hemicelluloses, lignin.
4. Food microbiology: principles of food preservation- Asepsis, Removal of microorganisms, anaerobic condition - High and low temperature, Drying, Food additive. Canning, contamination and spoilage of canned food.
5. Applied microbiology: Industrial production of cheese and ethanol, bread making, single cell protein.
6. Microbial production of lactic and citric acid, lysine, α-amylase, β-amylase, protease, griseofulvin.

**Algae**

1. Classification of algae following Lee upto groups with general characters and examples. Thallus organization and life cycle pattern in algae.
2. Endosymbiotic theory: origin of plastid. Origin and evolution of sex in algae.
3. Flagella and flageller root system in Chlorophyta.
4. Economic importance of algae: as medicine, food, phycocolloids. Algal toxin.

**Bryophyte**

1. Classification of Bryophytes by (a) Proskaur upto class with characters and (b) Crandall Stotler.
2. Origin of Bryophyte (algal and pteridophytic hypothesis). Origin of alteration of generation.
3. Bryophytes as food, fodder and medicine.

4. Applied Bryology: Biotechnological and pharmacological significance.
5. Bryophytes in plant succession.

**Pteridophyta**

1. General characters and classification:
   i) General features of sporophyte and gametophyte, habitat diversity
   ii) Classification (Stewart and Rothwell, 1994) upto class with brief characters and examples.
2. Telome theory of Zimmerman and Enation theory of Bower.
3. Structure and Life History (Extant genera):
   i) Basic concepts of life cycle patterns of homosporous and heterosporous pteridophytes
   ii) Apospory and Apogamy,
   iii)Vegetative and reproductive morphology of sporophyte, structure and development of gametophyte and embryogeny of the following genera: *Psilotum*, *Lycopodium*, *Selaginella*.
4. General account of fossil taxa:
   i) Rhyniopsida: General characters , Distribution (geological and geographical) and life cycle of *Rhynia*.
   ii) Structural and anatomical features of *Lepidodendron* (reconstructed) and *Calamites* (reconstructed) and causes for their extinction.
5. Economic importance of pteridophytes as food, medicine and agriculture.

**Practicals based on theoretical syllabus.**

**DBS 4-3 (Functional Morpho-anatomy of Non-chordates)**

1. Feeding and reproduction in Protozoa.
2. Aquiferous system and endoskeleton in Porifera.
3. Coral and coral reef formation
4. Parasitic adaptation in Helminthes
5. Locomotion and excretion in Annelida
6. Respiration and excretion in Arthropoda. Anatomical peculiarities, affinities and systematic position of *Peripatus, Limulus* and *Sacculina*
7. Social and colonial life in Insects.
8. Nervous system and respiration in Mollusca.
9. Water vascular system in Echinodermata.
10. *Balanoglossus* - anatomy, affinities and systematic position
11. Structure and significance of trochophore, crustacean larvae, glochidium, echinoderm larvae and tornaria.
12. Minor phyla with reference to Ectoprocta and Entoprocta.

**Practicals based on theoretical syllabus.**

**DBS 4-4 (Functional Morpho-anatomy of Chordates)**

1. Affinities and systematic position of *Dipnoi*
2. Comparative account -Lamprey and Hagfish, Elasmobranchii and Teleostomi, *Lacertilia* and *Ophidia*, *Ratitae* and *Carinatae*
3. Filterfeeding in protochordates; progressive and retrogressive metamorphosis in Chordata
4. Anatomy and affinities of sphenodon
5. Aerodynamics of bird flight.
6. Air sacs and double respiration in birds
7. Affinities and systematics of Monotremata and Marsupialia
8. Exoskeletal structure in amniotes.

9. Comparative anatomy of heart and aortic arch
10. Comparative anatomy of kidney
11. Ruminant stomach
12. Migration in fish and bird

**Practicals based on theoretical syllabus.**

**DBS 4-5 (Enzymology)**

1. Basics of enzymology: Definition, examples of holoenzymes, Apoenzyme.
2. Cofactors: definition, examples of a) metal ions b) coenzymes c) prosthetic group
3. Classification of enzymes: IUPAC system, Name and examples of each class
4. Enzyme Kinetics: concept of enzyme catalysis: active site, activation energy and Arrhenius concepts, specificity of enzymes-geometric and stereo specificity with example, lock and key hypothesis, induced fit hypothesis, derivation of Michaelis-Menten equation for uni-substrate reactions. Different plots for the determination of $K_m$ and $V_{max}$ and their physiological significances. Importance of $K_{cat}/K_m$. Kinetics of zero and first order reactions. Classification of multi-substrate reactions with examples of each class. Ping Pong, random and ordered Bi-Bi mechanisms.
5. Quantitative assay of enzyme activity: Unit of enzyme activity, specific activity, molecular activity/turnover number, molar activity, katal.
6. Factors affecting enzyme catalyzed reaction: concentration, temperature, pH, time and cofactors.
7. Inhibition of enzyme catalyzed reaction: reversible and irreversible inhibition, linear-mixed type inhibitions and their kinetics, Suicide inhibitor.
8. Mechanism of Enzyme Action – Enzyme catalysis- acid-base, covalent and metal ion catalysis, proximity-orientation effect, strain and distortion theory. Experimental approaches to determine the mechanism of enzyme action. Mechanism of action of chymotrypsin, lysozyme, glyceraldehyde-3-phosphate dehydrogenase, aldolase, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase.
9. Isozymes with examples, abzymes, synzymes, nonprotein enzymes.
10. Regulation of enzymes: allosterism, sequential and concerted model, feedback inhibition and feed-forward stimulation, reversible (glutamine synthase and phosphorylase) and irreversible (proteases) covalent modifications of enzymes. Monocyclic and multicyclic cascade systems with specific examples; flip flop mechanism.
11. Methods of enzyme purification and characterization - dialysis, ultra-filtration, ultracentrifugation, molecular exclusion chromatography, isoelectric precipitation, salting in, salting out, solvent fractionation, electrophoresis- paper and SDS-PAGE, ion exchange chromatography, adsorption chromatography, affinity chromatography. Basic concepts of proteomics and enzyme identification.

**Practicals based on theoretical syllabus.**

**DBS 4-6 (Blood, Body Fluids, Hematology, Cardiovascular system and Respiration)**

1. **Blood and body fluids:** Bone marrow. Formed elements of blood. Plasma proteins Haemoglobin: types, abnormalities, biosynthesis and catabolism. Different types of anaemia and their causes. Blood volume; Hemostasis –factors, mechanism, anticoagulants. Disorders of hemostasis; Blood group; Blood transfusion and its hazards. Lymph and tissue fluids; Lymphatic organs.
2. **Physiology Of Heart:** Anatomy of the heart. Properties of cardiac muscle. Cardiac action potential; cardiac impulse. The cardiac cycle-Heart sounds. Cardiac output-Electrocardiography –the normal electrocardiogram, electrocardiographic leads, vectorial analysis, the vectorcardiogram, the mean electrical axis of heart. The His bundle electrogram. Principles of Echocardiography. Cardiac Arrhythmias –Myocardial Infarctions. Cardioplegic solutions.

3. **Vascular Physiology:** Functional morphology of arteries, arterioles, capillaries, venules and veins, sinusoids. General pattern of circulation; the pulse – Hemodynamics of blood flow; Blood pressure – factors affecting. Cardiac and vasomotor centers, baroreceptors and chemoreceptors, cardiac and vasomotor reflexes. Cardiovascular homeostasis.
4. **Regional circulation:** Cerebral, Coronary, Hepatic, Splanchnic and skeletal muscle circulation.
5. **Pathophysiologyof circulation**: Haemorrhage, Hypovolemic and hypervolemic shock. RTI andatherosclerosis.
6. **Physiology of respiration:** Anatomy and histology of the lung and airways. Mechanics of breathing -- Lung volumes and capacities. Alveolar surface tension and surfactant, work of breathing. Ventilation- perfusion ratio Dead space and uneven ventilation. Spirometry. Pulmonary circulation. Transport of gases in body. Partial pressure and composition of normal atmospheric gases in inspired, expired, alveolar airs and blood. Oxygen dissociation curve of hemoglobin and myoglobin – factors affecting. Carbon dioxide dissociation curve. Regulation of respiration -neural and chemical, respiratory centers, chemoreceptors, baroreceptors, pulmonary receptors. Hypoxia – Asphyxia, Voluntary hyperpnoea, Apnoea, Cyanosis, Periodic breathing, Asthma, Emphysema. Lung function tests. Artificial respiration. Concept of non-respiratory functions of lung, normal values, origin and functions.

**Practicals based on theoretical syllabus.**

**DBS 4-7 (Digestion, Nutrition, Excretion and thermal homeostasis)**

1. **Alimentary system:** Anatomy and histology of alimentary canal. Digestive glands – Deglutition and Movements of alimentary canal and their regulations. Composition, functions and regulation of the secretion of salivary, gastric, pancreatic and intestinal juices and bile. Synthesis of Bile acids. Enterohepatic circulation. Digestion and absorption of carbohydrates, lipids, proteins and nucleic acids. Feces and defecation. GALT. Basic concepts of Peptic Ulcer, Jaundice and Gallstones.
2. **Nutrition and Dietetics:** Nutrition, health and malnutrition; Constituents of food and their significance. Basal metabolic rate -factors, determination by Benedict Roth apparatus. Respiratory quotient. Specific dynamic action. Calorific value of foods. Body calorie requirements – adult consumption unit. Dietary requirements symptoms of deficiency and excess. Balanced diet and principles of formulation of balanced diets for growing child, adult man and woman, pregnant woman and lactating woman. Nitrogen balance. Biological value of proteins, supplementary value of protein. Protein efficiency ratio and net protein utilization of dietary proteins; Dietary fibers. Principle of diet survey. Composition and nutritional value of common foodstuffs. Physiology of starvation and obesity. Elementary idea of glycaemic index; functional foods, nutraceuticals, probiotics and food supplements.
3. **Renal physiology:** Anatomy of kidney; Histology of nephron. Renal circulation – Formation of urine. Counter-current multiplier and exchanger. Renal regulation of osmolarity and volume of blood fluids. Diabetes insipidus. Formation of hypertonic urine. Renal regulation of acid-base balance, acidification of urine. Renal function tests. Physiology of urinary bladder and micturition. Composition of urine. Abnormal constituents of urine, renal dialysis. Non-excretory functions of kidney.
4. **Skin and body temperature regulation:** Structure and functions of skin. Cutaneous circulation. Sweat glands Sweat formation, secretion and its regulation. Insensible perspiration. Regulation of body temperature in homeotherms, pyrexia, hyperthermia and hypothermia. Concept of Q10.

**Practicals based on theoretical syllabus.**

**DBS 4-8 (Behavioral and cognitive neuroscience)**

1. **Cognitive neuroscience and higher functions:** Limbic system: structure, connections and functions. Physiology of emotion. Electrophysiology of brain: spontaneous electrical activity of brain, EEG and ECoG, evoked potential, DC potential. Isolated cortex. Higher functions of nervous system: conditioning, learning, short-term and long-term memory. Speech and Aphasia. Asymmetrical organization of certain cognitive functions-split brain. Reticular formation: organization, connection and functions of ascending and descending reticular formation. Physiological basis of sleep and wakefulness.
2. **Molecular neurobiology:** General concept of ionotropic and metabotropic receptors. Structure, sub-types, and functions of nicotinic and muscarinic acetylcholine receptors. Adrenoceptors, glutamate receptors (NMDA and AMPA receptors), GABA, opiate, serotonin, dopamine and histamine receptors.
3. **Neural pathways:** Ascending and descending tracts: origin, courses, termination and functions. Lower and upper motor neurones. Functions of the spinal cord with special reference to functional changes following hemisection and complete section of spinal cord – Brown-Sequard syndrome, Spinal animal. Pain production, perception and regulation. Referred pain.
4. **Neural homeostasis and concept of Cyberatics:** Decerebrate rigidity, Decorticate rigidity, Postural reflexes and regulation of Posture. Muscle spindle and Golgi tendon organ: their structure, innervations and functions, regulation of muscle tone. Structure, connections and functions of cerebellum. Structure and functions of vestibular apparatus. Nuclei, connections and functions of thalamus and hypothalamus. Basal nuclei: structure, connections and functions. Cerebral cortex: histological structure, localization of functions. Concept of cybernatics.
5. **Biological rhythms and Human system**: Different types of physiological rhythms – ultradian, circadian, infradian. Different zeitgebers and their relation with circadian clock. Hormonal biorhythms and their significance: adrenocortical, pineal and prolactin. Body temperature rhythm.

   Neural basis of biological clock and role of supra chiasmatic nuclei. Sleep-wakefulness cycle. Time keeping genes. Jet lag and shift work.

**Practicals based on theoretical syllabus.**

**DBS 4-9 (Maintenance, expression and regulation of the genome)**

1. **Organization of the genome:** Organization of bacterial genome. Structure of Eukaryotic genomes, non-repetitive and repetitive DNA sequences, Mitochondrial DNA organization, Chloroplast genome organization.
2. **DNA Replication, Recombination and Repair:** Chemistry of DNA synthesis, Mechanism of DNA Replication in prokaryotes, Replication errors and repair, DNA damage and repair, Homologous recombination, site specific recombination and Transposition of DNA, Mutations.
3. **Transcription and post-transcriptional processing**: RNA polymerase and the transcription cycle in bacteria, Spliceosome machinery, alternative splicing, exon shuffling, RNA editing, mRNA transport, a brief overview on transcription in eukaryotes.
4. **Translation:** Translation mechanism in prokaryotes, The Genetic Code, Codon Anticodon interaction, Ribosomes, A brief overview on Protein Synthesis in Eukaryotes.
5. **Regulation of gene expression:** Operon concept with reference to lac operon and trp operons in *E. coli*; Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, regulation of gene expression during development, role of chromatin in regulating gene expression and gene silencing.
6. **Molecular Biology techniques:** Kinetics of qualitative and quantitative PCR with special reference to SYBR green and Taqman technology, primers and probes, cloning and expression vectors with examples, GATEWAY and TA cloning systems, Gel blotting and hybridization technologies

(Southern, Northern, Western, In situ), genomic, cDNA and expression library preparation, colony hybridization, library screening, different types of promoters and concept of TFBS.

**Practicals based on theoretical syllabus.**

**DBS 4-10 (Microbe- Man interaction: beneficial and harmful aspects)**

1. Normal microbial flora of human body, opportunistic pathogens, use of probiotics.
2. General attributes and virulence factors of bacteria causing infections.
3. Bioterrorism with examples (anthrax, small pox), Biological Weapons Convention.
4. History of discovery of microbes as potential therapeutic agents.
5. Production of pharmaceutical compounds through microbes - hormones, diagnostic proteins.
6. Pharmaceutically valuable microalgae, pigments and H2 gas from cyanobacteria.
7. General mechanisms for antibiotic action, antibiotic resistance, resistance mechanisms, significance. Resistance Tests. Combination therapy: Significance, side effects.
8. Bacteriocins: mode of action of some common bacteriocins; difference with antibiotics and uses. Antifungal agents: examples and sites of action of some commonly used antifungal agents, Antiviral and anti-parasitic drugs.

**Practicals based on theoretical syllabus.**

**DBS 4-11 (Industrial Microbiology)**

1. General concepts of industrial microbiology, Principles of exploitation of microorganisms and their products.
2. Idea of Fermentation, Cell growth, Metabolism, Regulation of Metabolism, Substrate Assimilation / Product Secretion. Different fermentative system. Batch and Continuous processes, Surface and Submerged liquid substrate Fermentation, Solid substrate Fermentations.
3. Industrial fermentations - Fermentor Design, Types of Bioreactors, Recovery and purification of intracellular and extracellular products, Fermentation Raw Materials, Down Stream Processing, Bio Mass Production.
4. Food Fermentation (Alcohol, Cheese, Bread, Soya based food, Meat Fermentation, Vinegar).
5. Microbial production of lactic and citric acid, steroids, vitamin B12, lysine, α-amylase, β-amylase, protease, lipase.
6. Production of genetically modified food, agar agar, alginates, diatomaceous earth. Production of Industrial Solvents (Acetone, Butanol), Nutraceuticals.
7. Concepts of Immobilized Enzymes.

**Practicals based on theoretical syllabus.**

**DBS 4-12 (Overview of immunity and the immune system)**

1. Properties and overview of Immune responses
2. Cells, tissues and organs of the immune system.
3. Innate and acquired immunity.
4. Humoral and cell mediated immunity.
5. Immunogens and antigens.
6. Antigens- epitopes.
7. Antibodies-structure, classes and functions.
8. Antigen-antibody reactions.
9. Adjuvants and Haptens.
10. Complement system;
11. Immuno techniques: ELISA, RIA; Immumo electrophoretic techniques; Hybridoma technique for monoclonal antibody production.

**Practicals based on theoretical syllabus.**

## UG SEMESTER 5

**DBS 5-1 (Mycology and Plant Pathology; Ethnobotany and Pharmacognosy)**

**Mycology:**

1. Introduction: Importance of Mycology; General characteristics; Cell wall composition; nutrition and growth; Reproduction and spores; factors affecting sporulation, spore dispersal, spore dormancy and germination. Heterokaryosis and parasexuality; Sexual compatibility; Life cycle patterns; Classification of fungi.
2. Fungal diversity: general characteristics, thallus organization, ecology and reproduction of fungi belonging to the different fungal groups:

    i) Myxomycota
    ii) Oomycota: *Phytophthora*.
    iii) Zygomycota: *Rhizopus*.
    iv) Ascomycota: *Saccharomyces*, *Penicillium* and *Ascobolus.*
    v) Basidiomycota: *Puccinia, Agaricus*
    vi) Deuteromycota: *Fusarium, Colletotrichum*

3. Ecology of fungi - fungi in different ecosystems: saprophytes, parasites and predators, symbionts - lichens and mycorrhizas.
    i) Lichen Biology: Occurrence; nature of association of algal and fungal partners; Growth forms and range of thallus organization; Reproduction; Ecological significance and Economic importance.
    ii) Mycorrhiza- Types, Salient features and importance.

**Plant Pathology:**

1. Introduction: History; Concept of Plant Disease; Terms and Definitions; classification (based on occurrence and causal organism); Koch's postulates, Importance of plant pathology.
2. How pathogens attack plants: Mechanism of infection (Brief idea about Pre-penetration, Penetration and Post-penetration).
3. How plants defend themselves against pathogens: Structural and Biochemical Defenses- Phytoalexin
4. Plant Disease Management: Quarantine; Cultural; Physical; Chemical; Biological; Integrated.
5. Causal organism, etiology, and control of important Plant Diseases: Black Stem Rust of wheat,Bacterial Blight of Rice,Tobacco Mosaic Disease. Disease caused by Nematodes, Parasitic plants and Algae.

**Ethnobotany:**

1. Concept, research and applications.
2. Traditional healing, survey, data collection, documentation.
3. Ethnopharmacology: role in drug discovery.

**Pharmacognosy:**

1. Pharmacognosy and its importance, Crude drugs, Classification of drugs-chemical and pharmacological Drug evaluation.
2. Definition of secondary metabolites and difference with primary metabolites. Inter-relationship of basic metabolic pathways with secondary metabolite biosynthesis (outlines only). Major types - terpenoids, phenolics, flavonoids, alkaloids and their protective action against pathogenic microbes and herbivores.
3. Pharmacologically active constituents, source plants (one example), parts used and uses of Steroids (Diosgerun. Digitoxin). Tannin (catechin), Resins (Gingerol, Curcuminoids) Alkaloids (Quinine, Strychnine, Reserpine, Vinblastine).

**Practicals based on theoretical syllabus.**

**DBS 5-2 (Gymnosperms; Palaeobotany and Palynology)**

1. Gymnosperm: Introduction and economic importance of gymnosperms, Classification of gymnosperms by Sporne 1965- diagnostic characters of different classes with examples.
2. Morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum*, brief general account of fossil gymnosperms- *Williamsonia* and *Cordaites*, evolution of seed habit in Gymnosperm, whole genome sequencing of conifer and the major evolutionary conclusions drawn.
3. Palaeobotany: The evolutionary time scale and dominant plant groups; Eras, periods and epoch; Major events in the evolutionary time scale; concept of plant fossils, Principles of nomenclature (concept of genera and form genera)
4. Palynology: Micro-gametogenesis, pollen dispersal and pollination, taxonomic classification of spores, pollen wall- sporopollenin, pollen viability, application of palynology in human health and forensic sciences

**Practicals based on theoretical syllabus.**

**DBS 5-3 (Animal physiology, parasitology and vector biology)**

**Group – A (Animal physiology)**

1. Respiratory pigments and respiratory gas transport in animals
2. Origin and propagation in nerve impulse
3. Physiology of hearing and vision in mammals
4. Hypertonic urine formation and its control in mammals
5. Osmoregulation in vertebrates
6. Thermoregulation in poikilotherms and homotherms

7. Spermatogenesis, reproductive cycles in and hormonal control in mammals

**Group – B (Parasitology and vector biology)**

1. Interspecific interaction – symbiosis, mutualism, commensalism and parasitism.
2. Parasitic adaptations.
3. Protozoan and helminth parasites – life cycle, pathogenecity and control.
4. Characteristic feature of vector organism.
5. Mosquito, sand fly, tick and mite as a vector.

**Practicals based on theoretical syllabus.**

**DBS 5-4 (Taxonomy and Adaptation; Wildlife Biology and Ethology)**

**Group – A (Taxonomy and adaptation)**

1. Concept of systematics and taxonomy, alpha, beta and gamma taxonomy, phenon, taxon, taxonomic category, Linnean hierarchy
2. Principles and theories of animal classification
3. Nomenclature of animal taxa and International code of zoological nomenclature
4. Different species concept, their merit and demerits
5. Adaptations in animals – primary and secondary aquatic adaptation, primary and secondary volant adaptation, cursorial adaptation, arboreal adaptation, fossorial and desert adaptation.
6. Adaptive radiation in vertebrates

**Group – B (Wild life biology and Ethology)**

1. Biodiversity – different levels and values of biodiversity, threats to biodiversity, biodiversity hotspots.
2. Animal conservation – aims, in-situ and ex-situ strategies of conservation
3. Wild life sanctuary, National park, Biosphere reserve
4. Threatened and endangered animals of India
5. International bodies for conservation with reference to red data book
6. Conservation of Tiger and Rhino India
7. Concept of innate and learning behavior
8. Eusociality and Elements of social behaviors in animals (selfishness, altruism, kinship and cooperation)
9. Communication – channels of communication, bee dance, role of pheromone in regulating communication.
10. Parental care in fish and amphibian.

**Practicals based on theoretical syllabus.**

**DBS 5-5 (Bioenergetics and metabolism)**

**Group A - Bioenergetics** (15 marks)

Biochemical reaction mechanism; Temperature dependency from Arrhenius law; Theoretical prediction of rate constant: Interpretation of batch kinetic data; analysis of intra-particle diffusion and reaction; Kinetics of substrate utilization, product formation and biomass production; Chemical mechanisms of biological energy conversion in mitochondria and chloroplasts, Photosynthesis energy transfer kinetics; DNA base recognition and replication fidelity; Gibbs Free Energy; Protein folding and stability; Ligand binding; Protein-Protein and Protein-DNA interactions; Osmosis,

Dialysis

**Group B-Intermediary metabolism** (35 marks)

**Unit I: Carbohydrate and Energy metabolism**

1. Introduction: Concept of metabolism, catabolism, and anabolism, experimental approach to study of metabolism using intact animals, bacterial mutants, and radioactive isotopes.
2. Carbohydrate metabolism: Intracellular metabolism of glucose - glycolysis, reaction and energetic of TCA cycle, gluconeogenesis, glycogenesis, glycogenolysis, reactions and physiological significance of pentose phosphate pathway, regulation of glycolysis,TCA cycle, and glycogen metabolism. Photosynthesis- light and dark reaction (in C3, C4 and CAM), photorespiration.
3. Oxidative phosphorylation and electron transport chain: Structure of mitochondria, sequence of electron carriers, ATP synthesis, inhibitors of ETC, basic concept of oxidative phosphorylation, inhibitors and uncouplers of oxidative phosphorylation, photophosphorylation.

**Unit II: Metabolism of non-carbohydrates**

4. Lipid metabolism: Metabolism (anabolism and catabolism) of triglyceride, Transport of fatty acid into mitochondria, Beta-oxidation of fatty acids, reactions and energetic of beta oxidation, biosynthesis of saturated and unsaturated fatty acids, metabolism of ketone bodies, biosynthesis of phospholipids and cholesterol.
5. Amino acid metabolism: general reactions of amino acid metabolism (oxidative deamination, transamination, decarboxylation etc), glucogenic and ketogenic amino acids, urea cycle, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid), inborn errors of amino acid metabolism.
6. Nucleotide metabolism: Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine).
7. Porphyrin metabolism: Biosynthesis and degradation of porphyrins, biosynthesis of bile pigments.

**Practicals based on theoretical syllabus.**

**DBS 5-6 (Nervous system, physiology of nerve and muscle, sensory physiology)**

1. **Physiology of muscle**: Microscopic and electron microscopic structure of skeletal, smooth and cardiac muscles. The sarcotubular system. Red and white striated muscle fibers. Single-unit and multi-unit smooth muscle. Muscle groups: antagonists and agonists. Properties of skeletal muscle: excitability, contractility, all or none law, summation of stimuli, summation of contractions, effects of repeated stimuli, genesis of tetanus, onset of fatigue, refractory period, tonicity, conductivity, extensibility and elasticity. Optimal load, optimal length of fibers. Muscle proteins. Mechanism of skeletal and smooth muscle contraction and relaxation: Excitation- contraction coupling. Dihydropyridine receptors and Ryanodine receptors. Mechanical components of muscle. Isometric and isotonic contractions –Chemical, thermal and electrical changes in skeletal muscle during contraction and relaxation. Electromyography.
2. **Physiology of nerve:** Structure, classification and functions of neurons and neuroglia. Cytoskeletal elements and axoplasmic flow. Myelinogenesis. The resting membrane potential, action potential, electrotonic potentials, current of injury and compound action potential. Propagation of nerve impulse in different types of nerve fibers.
3. **Properties of nerve fibers:** Indefatigability, Synapses: types, structure, synaptic transmission of the impulse synaptic potentials. Neurotransmitters, cotransmitters, and neuromodulators. The neuromuscular junction: structure, transmission, end-plate potential, MEPP and post-tetanic potentiation. Motor unit and Motor point. Injury to peripheral nerves –degeneration and

regeneration in nerve fiber, changes in the nerve cell body, Thermal changes of nerve during activity. Nerve growth factors.

4. **Organization of nervous system:** A brief outline of organization and basic functions (sensory, motor and association) of the nervous system (central and peripheral). Structural organization of different parts of brain and spinal cord.

5. **Reflex action**: definition, reflex arc, classification and properties Autonomic nervous system: organization, outflow, ganglia, centers and functions. Chemical transmission and central control of autonomic nervous system. CSF: formation, circulation and functions Blood-CSF and Blood-Brain barrier. AMPA receptors, GABA, opiate, serotonin, dopamine and histamine receptors.
6. **Sensory receptors and functional properties:** Classification of general and special senses. Receptors as biological transducers. Muller's law of specific nerve energies. Weber-Fechner law, Steven's power law. Sensory transduction in Pacinian corpuscle. Adaptation of receptors.
7. **Physiology of Olfaction and Gustation:** Structure and functions of the receptor organs, nerve pathways, centers. Properties of olfactory and gustatory sensation and their transduction and coding. Electro-olfactogram (EOG). Abnormalities of olfactory and taste sensation.
8. **Acoustic physiology:** Sound waves, decibel. Structure and function of auditory apparatus Organ of Corti. Auditory transduction. Auditory pathways and centers. Mechanism of hearing and its modern theories. Different electrical potentials of internal ear. Discrimination of sound frequency and loudness. Localization of sound source. Audiometry, Deafness.
9. **Physiology of vision**: Structure of the eyeball. Structure of lens. Formation of cataract and glaucoma. Mechanism of accommodation. Pupillary reflexes, light reflex, near response. Errors of refraction and their corrections. Histological details of retina, peripheral retina, fovea and blind spot. Retinal detachment. Visual pathway and centers. Effects of lesion in visual pathway. Photopic and scotopic vision. Chemical and electrical changes in retina on exposure to light. Visual processing in the retina. Electroretinogram. Positive and negative after- images. Contrast phenomenon. Light and dark adaptation. Color vision and its modern concept. Color blindness. Visual field-perimetry. Visual acuity –factors affecting. Critical fusion frequency (CFF).

**Practicals based on theoretical syllabus.**

**DBS 5-7 (Endocrinology, Neuroendocrinology and human reproduction)**

1. **Biology of Informational Molecules:**
   i) Classification of endocrine glands and hormones. Methods of study of endocrine functions.
   ii) Growth factors –EGF, TGF, PDGF, IGF and FGF. Chemical nature, mode of action, functions.
   iii) Regulation of secretion of the hormones.
2. **Receptors and Bio signaling:** Cell surface receptor proteins – ion channel coupled, G-protein coupled and enzyme coupled. Intracellular messengers – cAMP, cGMP, IP3, DAG, Protein kinases, $Ca^{++}$, CO, NO. Signal transduction pathways – Phosphatidylinositides, MAP kinase, JAK-STAT, SMAD. Intracellular receptor- structure-function relationship.
3. **Neuroendocrinology:** Hypothalamus as a neuroendocrine organ. Pineal gland – histological structure. Chemical nature, biosynthesis, mode of actions, functions and regulation of secretion of melatonin.
4. **Role of Hormones in Metabolism:** Anterior and posterior pituitary -- histological structure of the gland. Chemical nature, mode of action, functions and regulation of secretion of their hormones. Hypo- and hyperactive states of the gland. Thyroid and parathyroid -- Chemical nature, mode of action, functions and regulation of secretion of the hormones. Hypo- and hyperactive states of the glands. Thymus -Adrenal cortex and medulla -- Chemical nature functions and regulation of

secretion of the cortical hormones. Biosynthesis and catabolism of catecholamines. Heart as an endocrine organ. Prostaglandins and Kinins. Pancreatic islets -- Chemical nature, mode of action, and functions of hormones secreted diabetes mellitus. Gastro-intestinal hormones – source and functions.

5. **Biology of Human Reproduction:** Physiology of puberty. Histology of testis. Endocrine functions of testis. Spermatogenesis. Hypothalamic control of testicular functions. Histology of ovary. Ovarian hormones and their functions and control. Oogenesis, folliculogenesis and ovulation. Corpus luteum and leuteolysis. Estrous cycle. Menstrual cycle Onset of menopause and post-

menopausal changes. Fertilization, Preliminary ideas of implantation. Structure and functions of placenta. Maintenance of pregnancy and the bodily changes during pregnancy. Pregnancy tests. Parturition. Mammogenesis, Galactopoesis: Hormonal control.

**Practicals based on theoretical syllabus.**

**DBS 5-8 (Applied nutrition and Dietetics)**

Nutrition, malnutrition and health: concept, definition and scope; Constituents of food and their significance. Minimum energy requirement and RDA. Energy requirement in humans, basal metabolic rate -factors, determination by Benedict Roth apparatus. Respiratory quotient. Specific dynamic action. Calorific value of foods. Body calorie requirements – adult consumption unit; Dietary requirements of carbohydrates, proteins, lipids and other nutrients. Growth and development from infancy to childhood; Balanced diet and principles of formulation of balanced diets for growing child, adult man and woman, pregnant woman and lactating woman. Nitrogen balance. Essential fatty acids, PUFA, MUFA; Essential amino acids. Proteins sparers. Supplementary value of protein. Protein efficiency ratio, net protein utilization of dietary proteins, Biological value of proteins. Dietary fibers. Principle of diet survey. Composition and nutritional value of common food stuffs. Physiology of starvation and obesity. Elementary idea of functional foods, Neutraceuticals, Probiotics and food supplements. Malnutrition – PCM, marasmus, kwashiorkor, arasmickwashiorkor. Endemic goiter, nutritional anemias, rickets, osteomalacia, xeropthalmia, beriberi, anaemia, rickets; Implications of diabetes, CHD**.** Concept of community nutrition, nutritional assessment and surveillance; nutritional assessment by nutritional anthropometry and diet survey; Nutritional intervention programs; food borne diseases; Basic concept of diet therapy.

**Practicals based on theoretical syllabus.**

**DBS 5-9 (Fundamentals of Cell Biology)**

1. Origin of eukaryotic cell: Endosymbiotic hypothesis and its recent status.
2. Membrane structure and function: Structure of model membrane; ion channels; ion pumps; active transport; mechanism of sorting and regulation of intracellular transport; electrical properties of membrane.
3. Cellular transport: Brief outline of protein targeting to Mitochondria, Chloroplast, Endoplasmic reticulum and Nuclear transport; Protein modifications, Folding, Vesicular transport, Secretion, Endocytosis – brief idea only.
4. Cell Architecture: Cytoskeleton and its components – Organization and properties of Microfilaments, Intermediate filaments and Microtubules; Molecular motors – brief idea.
5. Cellular communication: Brief idea about signaling molecules and receptors; an overview of different signaling pathways.
6. Cell division and Cell death: Different phases of Cell cycle; MPF; Checkpoints in Yeast and Mammalian cell cycle; Stem cells- properties; Preliminary idea of Programmed Cell Death.

7. Cancer – Preliminary idea of Oncogene, Proto-oncogene and Tumor suppressor gene.

**Practicals based on theoretical syllabus.**

**DBS 5-10 (Environmental Microbiology)**

1. Microbial population dynamics: commensalism, synergism, mutualism, competition, amensalism, predation, parasitism.
2. Role of microbes in the food chain: carbon cycling.
3. Soil microorganisms and their association with vascular plants: phyllosphere, *Rhizobium*, Rhizoplane associative nitrogen fixation.
4. Biofertilizers - Bacterial, Cyanobacterial and *Azolla*.
5. Biopesticides - Bacterial, Viral and Fungal.
6. Aquatic Microbiology - Ecosystems - Fresh water (ponds, lakes, streams - marine - estuaries, mangroves, deep sea). Water zonations, eutrophication - food chain, potability of water - microbial assessment of water quality, water purification - water borne diseases (typhoid fever, giardiasis) and preventive measures.
7. Biological Waste Treatment: Types of wastes - characterization of solid and liquid wastes. Waste treatment and useful byproducts, solid waste treatment- saccharification - gasification - composting - liquid waste treatment - aerobic, anaerobic methods.

**Practicals based on theoretical syllabus.**

**DBS 5-11 (Microbial ecology and food microbiology)**

**Group A: Microbial ecology**

1. Importance of Microbial Ecology.
2. Microbiology of the Extreme Environment - Microbial life in hyper saline environments – eco-physiological aspects, sea and salt lakes; Microbial life at low temperatures, deep sea and space.
3. Extremophilic microbes and their applications– Halophiles, Thermophiles, Barophiles.
4. Anaerobic Microorganisms – eco-physiological aspects, principles and techniques for the isolation, enumeration and identification of Methanogens.
5. DissimilatorySulphate reducing and Anoxygenic Phototrophic bacteria.
6. Geo-microbiological processes – physiological and biochemical aspects, Methods in Geo-microbiology.

**Group B: Food microbiology**

1. Importance of microorganisms in food microbiology - mold yeast and bacteria - General characteristics, classification and importance.
2. Principles of food preservation - Asepsis, Removal of microorganisms, anaerobic condition - High and low temperature, Drying, Food additive. Canning, contamination and spoilage of canned food.
3. Food and water borne diseases – Gastroenteritis, Botulism, Salmonellosis, bacterial toxins in spoiled food, Detection of food borne pathogen.
4. Microbiology of milk - pasteurization - various types of microbiological analysis of milk. Contamination and spoilage of milk and milk products.
5. Microbial cells as food- SCP, mushroom cultivation.

**Practicals based on theoretical syllabus.**

**DBS 5-12 (Basic Immunology)**

1. Immunoglobulins; organization, expression and regulation of immunoglobulin genes; class switch; generation of antibody diversity;
2. B and T lymphocytes –types, activation and development;
3. MHC – protein structure and function; MHC- gene structure and expression; antigen processing and

presentation;

4. B and T cell receptors; cytokines and lymphokines; signal transduction mechanisms; cell mediated and humoral immune responses; Toll like receptors, RLRs.
5. Mechanism of cell-mediated killing of infected and neoplastic cells.

**Practicals based on theoretical syllabus.**

## UG SEMESTER 6

### DBS 6-1 (Plant physiology)

**Group A: Plant Physiology:**

1. Water and Plant cells-Water transport processes in plants, Water balance of plants. The Soil-Plant-Atmosphere continuum.
2. Solute transport: Passive and Active transport, Ion transport in roots.
3. Translocation in the phloem: Pathways, patterns and mechanism of translocation.
4. Mineral nutrition: Essential nutrients, deficiencies and plant disorders.
5. Plant hormones – Strigolactone Biosynthesis, storage, breakdown and transport
6. Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement.
7. Dormancy and senescence.
8. Stress Physiology: Responses of plants to abiotic stress- osmotic stress, temperature stress, oxidative stress.

**Group B: Plant Embryology and development:**

9. Gametogenesis In Angiosperms - Microsporogenesis - Megasporogenesis - Ovule ontogeny - types - Embryosac – synergid.
10. Pollination: Syngamy, Triple Fusion, Post Fertilization.
11. Endosperm: Ultra structure - Types - Histogenesis and Organogenesis of monocot and dicot embryos.
12. Polyembryony: Apomixis – Parthenogenesis
13. Embryology of Plant Breeding.
14. Meristems- Shoot apical meristem, Root apical meristem
15. Leaf Development-Abaxial and adaxial identity
16. Cell differentiation- non-cell autonomous signaling in plant development
17. Role of cytokinesis in pattern formation.

**Practicals based on theoretical syllabus.**

### DBS 6-2 (Plant biotechnology and plant breeding)

1. **Plant breeding:** Maintenance and conservation of germplasm, Cryopreservation, Mass selection and Pure line selection, Heterosis and hybrid seed production, Male sterility, types and its use in plant breeding. Polyploidy breeding-types of polyploids, origin and effects of auto and allopolyploids in plants; application of auto and allopolyploids in plant breeding; limitations. Mutation breeding- types: chemical mutagens, radiation, transposons; handling and release of mutagenic varieties.
2. **Plant Tissue culture:** Culture media; composition, preparation and sterilization – Totipotency: definition and importance - Dedifferentiation and redifferentiation - Callus and suspension culture, meristem culture - Somaclonal variation - Somatic embryogenesis , Synthetic seeds -Anther culture and production of haploids - protoplast culture – somatic hybrids –cybrids
3. **Emergence of Biotechnology- Recombinant DNA and Molecular cloning:** Restriction Endonucleases- Ligases and other DNA modifying enzymes (cutting, modifying and joining DNA

molecules)

4. **Cloning vectors:** Plasmids-Bacteriophages-Hybrid Vectors-Binary and shuttle vectors; PBR322, PUC, λphage. Ti and Ri Plasmids. Construction of recombinant DNA methods.
5. **Polymerase chain reaction:** methodology-essential features-application
6. **Getting DNA into cells:** Vector method *Agrobacterium* mediated gene transfer-Direct DNA uptake-Electroporation-shot gun method-microinjection
7. **Strategies of molecular cloning:** Screening, selection and analysis of recombinants, Molecular probes- Colony Hybridisation- insitu hybridization-Southern, Northern, Western blotting- RFLP-RAPD, -FISH- DNA and RNA Fingerprinting- Genomic Library- cDNA Library and Gene bank-Brief account of: Antisense RNA technology; Gene Silencing; RNA interference; Microarray and Biosensors
8. **Genomes:** Genomes can be mapped both genetically and physically- Genome sequencing produces the ultimate physical map- DNA Sequencing method- Human Genome Project and plant genome project.
9. **Applications of Biotechnology:**

   i) **Biotechnology of photosynthesis-** Chloroplast genome organization- Gene content and arrangement- regulation of gene expression. Regulation of gene expression in the nuclear coded gene and plastid gene-improvement of photosynthesis.

   ii) **Gene transfer technique for the improvement of agronomic characters-** Pest Resistance-Herbicide Resistance- drought resistance- enrichment of storage protein (Mechanism of gene action)- Flower colour, Shape, fruit ripening, colour and flavour- Improvement of the nutritional quality of seeds- post harvest preservation.

   iii) **Recombinant DNA technology and society-** Biotechnology and Bio ethics – an overview of Genetic screening for any predisposition symptoms, Gene therapy- DNA fingerprinting-GMOs, food safety- environmental concerns- Slow ripening fruits- controlled ripening. Cotton without insecticide- Biosafety issues and GMOs- Genetic screening and privacy- Role of multi national companies – Agribusiness- Golden Rice- (with vitamin-C) Terminator Genes. Economic, and Legal issues. Bio Ethics- Patenting Life forms- Biotechnology, Patents and the Third World. Biotechnology and the future of Agriculture- Stem cell research- sociopolitical issues. HGP and ethical questions.

   iv) **Nano biotechnology-** Basics of Nanobiotechnology: Introduction- Background and definition of nanotechnology - nanosystems in nature- nanoscaled bio molecules (nucleic acids and proteins) –chemical synthesis of artificial nanostructures.-Technologies for visualization of biological structures at the Nanoscale- Atomic force microscope- magnetic resonance force microscopy- Nanoscale scanning electron microscope- Nanoparticles - Applications of nanotechnology in life sciences- Nano biotechnology and systems biology- nanobiology and the cell- biosensing of cellular responses.

**Practicals based on theoretical syllabus.**

**DBS 6-3 (Animal Histology, Animal development and Economic Zoology)**

**Group – A (Animal Histology)**

1. Histology of mammalian stomach, liver, kidney, thyroid, pancreas and gonads
2. Ultrastructure of sarcomere and neurone
3. Fixation - Non-additive and additive fixatives and their mode of actions
4. Histological dyes – physical and chemical classification of dyes, mordanting, metachromasia
5. Animal histochemistry – Gomori's reaction, Saccaguchi's reaction, PAS reaction and Faulgean

reaction

**Group – B (Animal Development)**

1. Spermatogenesis and oogenesis in animals
2. General account of cleavage and fate map in animals
3. Morphogenetic movements and gastrulation in chick
4. Organogenesis – development of vertebrate heart, brain, eye and kidney in chick
5. Extra embryonic membrane in chick
6. Placentation in rabbit

**Group – C (Applied Zoology)**

1. Prawn, Pearl culture.
2. Induced breeding and hybridization techniques in Fish, Composite fish culture and capture.
3. Industrial Entomology – sericulture, apiculture and lac culture
4. Pest biology – bionomics and control of jute, brinjal and sugarcane pests
5. Strategies of Integrated pest management
6. Poultry farming and management
7. Concept of dairy technology with reference to cryopreservation and in vitro fertilization technique.

**Practicals based on theoretical syllabus.**

**DBS 6-4 (Biophysical methods)**

Chemical principles in Biology (thermodynamics, intermolecular forces); Biological reactions and interactions - function aspects of various bio-molecules particularly ion channels and motor proteins; Biophysical techniques (chromatography, electrophoresis, diffusion, sedimentation, light scattering); Principles of spectroscopy and microscopy; phase contrast microscopy, fluorescent microscopy, inverted microscopy, stereo microscopy, electron microscopy (EM), TEM and SEM; absorption spectroscopy, circular dichroism, emission spectroscopy, crystallography, Nuclear Magnetic Resonance (NMR), Mass spectrometry, Isothermal calorimetry (ITC)

**Practicals based on theoretical syllabus.**

**DBS 6-5 (Social physiology, stress physiology, ergonomics and sports physiology)**

1. **Social physiology:** Population problem – principles and methods of family planning. Problem of infertility, IVF. Malnutrition – PCM, marasmus, kwashiorkor, marasmic kwashiorkor. Endemic goiter, nutritional anemias, rickets, osteomalacia, xeropthalmia, beriberi and their social implications. Implications of Diabetes, CHD**.** Principles and social importance of immunization against diseases. Epidemiology and prevention of cholera, malaria, polio, tetanus, leprosy, tuberculosis, typhoid, hepatitis and AIDS.
2. **Work, Exercise and Sports Physiology:** Concept of work. Physical work—its definition and nature. Power and capacity relation, Classification of work load. Exercise inducing equipment – Aerobic and anaerobic power—concept, factors affecting, methods of measurement and significance of maximal oxygen consumption and excess post exercise oxygen consumption. Energetics of exercise – Short-term and long term, Mechanism of Fatigue and recovery. Concept of endurance, strength and speed in sports activities. Principles of training and detraining. Brief general idea about nutritional aspects of sports, Idea on doping. Lactate threshold, lactate tolerance and their usefulness. Concept of physical fitness and its assessment by Harvard and modified Harvard Step Tests.
3. **Stress Biology:** Concept of Stress, Stressors and Stress response. Idea of Internal and external

stressors. Principles of acclimatization and adaptation. Effects of exposure to hot and cold environment. Acclimatization to hot and cold environment. Heat disorders and its preventive measures. Effects of hypobaric and hyperbaric environment. Caisson's disease. Preventive measure for hypobaric and hyperbaric effects. Acclimatization to high altitudes. G forces. Stress and Aging

**Practicals based on theoretical syllabus.**

**DBS 6-6 (Pathophysiology of common human diseases and pharmacological drug design)**

1. **Pathophysiology of common Human Diseases:** Discussion of common diseases such as Cancer, Diabetes, artherosclerosis and heart disease, Malaria, Dengue.
2. **Xenobiotics and antioxidants:** Definition and classification of Xenobiotics.Brief outline of zenobiotic metabolism (no detail).Examples of xenobiotics – free radicals and antioxidants.
3. **Pharmacology:** Basic concept of pharmacology. Pharmacokinetics: Drug-receptor interaction, Desensitization of receptors, Absorption, Distribution, Elimination, Half-life. Definition of drug, agonist and antagonist partial agonist and antagonist, Receptors- drug interaction, Spare receptors. Pharmacodynamics: dose-response curves. Beneficial versus toxic effects of drugs**.** Drug biotransformation. Bioavailability. Drug accumulation. Therapeutic index. Cholinergic system, Cholinomimetic and suppressive agents. Neuromuscular blockers, Organ system effects and mechanism of action of adrenoceptor agonists and antagonists: a and ß adrenergic stimulants and blockers. Anti anginal drugs calcium-channel blocker Anesthetics: types and mechanism of action of general anesthetics. Sedatives, Diuretics and Analgesics. Target specific drug and its delivery, Basic concept of forensic toxicology.

**Practicals based on theoretical syllabus.**

**DBS 6-7 (Biostatistics and Bioinformatics)**

1. **Statistical methods**: Scope of statistics: utility and misuse. Principles of statistical analysis of biological data. Sampling parameters. Presentation of data-frequency distribution, frequency polygon, Degrees of freedom, Probability. Normal distribution. Student's t distribution. Testing of hypothesis - Null hypothesis, errors of inference, levels of significance, t test and Z score for significance of difference. Distribution-free test - Chi-square test. Linear correlation and linear regression.
2. **Bioinformatics:** Introduction to GenomicData and Data Organization. Sequence Data Banks – Introduction to sequence data banks – protein sequence data bank, NBRF-PIR, SWISSPORT, Nucleic Acid sequence data bank – GenBank, EMBL. Structural data bank – protein data bank, SCOP and CATH, The Cambridge Structural database (CSD); Genome data bank – Metabolic pathway data; Microbial and cellular data banks, Sequence Analysis – Analysis tools for sequence data banks, Pair – wise alignment – NEEDLEMAN AND WUNSCH ALGORITHM, SMITH WATERMAN. Multiple alignments – CLUSTAL, BLAST, FASTA algorithm to analyze sequence pattern, motifs and profiles. Systems Biology – mapping biological systems, case studies. Use of Adobe photoshop and Image J for image analysis and quantitation.

**Practicals based on theoretical syllabus.**

**DBS 6-8 (Fundamentals of Genetics)**

1. **Extension of Mendelism:** Epistasis and its different types present in plants and animals; Penetrance, Expressivity; Pleiotropism.
2. **Crossing over and Gene mapping**: Holiday model of recombination; Diploid mapping – Three point test cross; coincidence and interference; Haploid mapping – Tetrad analysis.
3. **Numerical and Structural variations in chromosome**: Aneuploids and Polyploids in plants and animals and their meiotic behavior; Deletion, Duplication, Inversion, Translocation and their

meiotic behavior. Position effect; Polytene chromosome in Diptera.

4. **Human Cytogenetics**: Human karyotype; Banding techniques; Use of human cytogenetics in medical science; inborn errors of metabolism; Aneuploidy in humans.
5. **Sex determination and Sex linkage**: Sex determination patterns in animals and flowering plants; Dosage Compensation; Pedigree analysis: Symbols used; Pedigrees of sex-linked and autosomal traits and patterns of inheritance.

**Practicals based on theoretical syllabus.**

**DBS 6-9 (Applied Immunology)**

1. Immune receptors and signal transduction
2. Cytokines
3. Inflammation.
4. Autoimmunity.
5. Hypersensitivity disorders
6. Ig-E dependent Immune response and allergic disease
7. Vaccination vs. passive immunization; types of vaccines; live, attenuated and killed pathogens; macromolecular vaccination with reference to subunit vaccine; recombinant and DNA vaccine.
8. Congenital and acquired immunodefficiencies.
9. Transplantation and tumor immunology. Immunological detection techniques
10. Cancer and immune system.

**Practicals based on theoretical syllabus.**

## PG SEMESTER -1

**Major 21 (Theoretical)**

**Methods and Experimental Design** [50 marks; 4 credits]

1. Molecular biology and recombinant DNA methods: Isolation and purification of various RNA, DNA and proteins; different separation methods and principles of nucleic acids and proteins by gel electrophoresis; isoelectric focusing; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.
2. Expression of recombinant proteins using bacterial, animal and plant vectors; different PCR methods or isolation of specific DNA sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; in vitro mutagenesis and deletion techniques; gene knock out in bacterial and eukaryotic organisms.
3. Protein sequencing methods, detection of post translational modification of proteins; DNA sequencing and strategies for genomic sequencing, methods for analysis of gene expression at RNA and protein level, large scale expression analysis, such as micro array based techniques; isolation separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD and AFLP techniques.
4. Histochemical and inmunocytochemical techniques: Antibody generation, detection of molecules using ELISA, RIA, Western Blot, immunoprecipitation, flow Cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.
5. Biophysical methods - Analysis of biomolecules by using UV-visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction and NMR; analysisusing light scattering, different types of mass spectrometry and surface plasma resonance methods.
6. Statistical Methods- Measures of central tendency and dispersal; probability distributions {Binomial, Poisson and normal}; Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; levels of significance; Regression and Correlation; t-test; Analysis of variance; X2 test; Basic introduction to Muetrovariate statistics, etc.
7. Radiolabeling techniques- Properties of different types of radioisotopes Normally used in biology, their detection and measurement, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.
8. Microscopic techniques- Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.
9. Electrophysiological methods- Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulant of brain, pharmacological testing PET, MRI fMRI, CAT.
10. Methods in field biology- Methods of estimating population density, ranging patterns through direct, indirect and remote observations, sampling method in the study of behavior, habitat, characterization ground and remote sensing methods.

**Major 22 (Theoretical)** [50 marks; 4 credits]

**Module 1- Advanced Cellular Biology** [25 marks]

1. Biomembrane – Structural organization; Transmembrane transport of ions and small molecules; Membrane targeting of proteins; vesicular trafficking between membranes, Post-translational modifications, protein sorting.
2. Cell Wall, Extracellular matrix and Cell interaction - Cell –cell interaction; Cell matrix interaction
3. Cell communication – Signaling molecules; Receptors: G- protein coupled receptor, Receptor Tyrosine Kinase, Cytokine receptors; Pathways of Intracellular Signal Transduction

4. Cytoskeleton - Microfilaments; Microtubules; Intermediate filaments; Molecular motors.
5. Nuclear Transport –Import and Export of protein; Export of different RNAs
6. Eukaryotic Cell Cycle - Cyclin and Cyclin-dependent Kinase; Molecular mechanisms of Checkpoint regulation.
7. Stem cells and differentiation
8. Apoptosis – Caspase; Pathways of Apoptosis; Distinctive features in insects , nematodes and mammals .
9. Cancer – Phenotypic characters of cancer cells ; Genetic basis of cancers : Protooncogene , Oncogene , Tumor suppressor genes ; Oncogenesis ;Cancer Immunotherapy

**Module 2- Developmental Biology** [10 marks]

1. Basic concept of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; role of reference organisms in developmental processes
2. Cell fate and cell lineages, stem cell-types, genesis and differentiation in both animals and plants
3. Molecular biology of stem cell and its regulatory molecules, emerging trend and clinical applications;
4. Germ cells, nuclear programming and gene networks
5. Genomic equivalence and the cytoplasmic determinants;
6. Axis determination in plant and animal, non-coding RNA s in development, non-cell autonomous signaling in plant development
7. Imprinting; mutants and transgenics in analysis of development.
8. Gametogenesis and fertilization
9. Morphogenesis and organogenesis
    i) Animals - cell aggregation and differentiation, patterning and shaping of the early embryo, limb development and regeneration, neurogenesis, environmental regulation of normal development, sex determination.
    ii) Flower development, floral and inflorescence meristems, different physical and physiological factors including flower induction, ABC model and beyond. Genetics of flower development in monocotyledonous flowers, floral asymmetry and gametogenesis

**Module 3- Fundamentals of Neurobiology** [15 marks]

1. Introduction to neurons, glia and muscle.
2. Membrane Potentials: Advanced concept of resting membrane potential: equilibrium potentials, Nernst equation and constant field equation or Goldman-Hodgkin-Katz (GHK) equation. Action potential: generation and propagation, key experiments that led to the current understanding, squid giant axon, conduction velocity in unmyelinated and myelinated axons, multiple sclerosis as a disease of demyelination.
3. Ion Channels and Ion Pumps: Ion channels, ion pumps, Ohm's law, the membrane as a capacitor, mechanisms of ion channel function, gating, 'ball and chain' model, inactivation, relationship between structure and function of ion channels, mechanisms underlying the selective permeability of ion channels: sodium and potassium ion selectivity as a case study, sodium channels, potassium channels, calcium channels, acetylcholine receptor channels, NMDA receptor channels, diversity of potassium channels. Voltage clamp and patch clamp recording techniques.
4. Drugs and toxins as tools in neuroscience research.
5. Muscle Contraction: Mechanism of muscle contraction

6. Synapse: Electrical synapses, chemical synapses, molecular and cellular mechanisms of synaptic transmission, SNARE hypothesis, neuropharmacology of synaptic transmission, calcium regulation of synaptic transmission.
7. Neural System and Behavior: Functional neuroanatomy of human central nervous system. Neurotransmitter systems, G protein-coupled receptors and effectors. Learning as a model of cognitive behaviour. Molecular and cellular mechanisms of memory consolidation, synaptic plasticity, long-term potentiation (LTP), hippocampus, adult neurogenesis. Biology of sleep-wakefulness cycle.
8. Chemical senses: Gustation and olfaction. Vision. Auditory and vestibular systems. Sensation of touch. Thermoreception. Pain and the placebo effects.
9. Homeostasis in the Nervous System: Cybernetic approach to nervous system: an introduction. Neuronal homeostasis: key experiments, mechanisms and biological significance.
10. Diseases of Nervous System: Neurobiology of affective disorders or mood disorders; dopamine and addiction; current research on Alzheimer's disease, Parkinson's disease, Huntington's disease, autism spectrum disorders (ASD) and Japanese encephalitis.
11. Methods in Neurobiology: Single neuron recording, intracellular recording, extracellular recording, ECG, EEG, lesion and stimulation of brain, MRI, fMRI, PET, CAT, Morris water maze assay.

**Major 23 (Theoretical)** [50 marks; 4 credits]

**Module 1- Advanced Biochemistry** [25 marks]

1. Enzymology and enzyme technology:
   i) Enzyme regulation- allosteric enzyme, definition and example, allosteric modulators, feedback inhibition, kinetic properties of allosteric enzyme, Hill and Scatchard plots, regulation by covalent modification (like phosphorylation), regulation by proteolytic cleavage of protein, zymogens with example
   ii) Multienzyme system - Occurrence, isolation and their properties: Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.
   iii) Enzyme technology - Large-scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods, effect of partition of kinetics and on changes in pH and hydrophobicity. Industrial and clinical applications of enzyme.
2. Macromolecular interaction: Protein-ligand interaction, protein-nucleic acid, protein-protein, protein-carbohydrate interaction, hormone-receptor, methods to analyze the macromolecular interaction
3. Metabolic diseases
   i) Intermediary metabolism
   ii) Disorders of Carbohydrate Metabolism - Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia.
   iii) Disorders of Lipids - Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann- Pick disease, ketone bodies, Abeta lipoproteinemia.
   iv) Inborn Errors of Metabolism - Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia.
   v) Abnormalities in Nitrogen Metabolism - Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance.

4. Plant Biochemistry
   i) Photosynthesis - Light harvesting complexes; mechanisms of electron transport;
   ii) photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.
   iii) Nitrogen metabolism - Nitrate and ammonium assimilation.
   iv) Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.
   v) Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins.
5. Microbial Biochemistry
   i) Bacterial cell membrane - structural diversity including Archaea.
   ii) Membrane transport in prokaryotes- group transport, binding protein transport.
   iii) Fermentation- lactic acid, ethanolic, propionic acid, butanediol, mixed acids, amino acid.
   iv) Biosynthesis - peptidoglycan, lipopolysaccharide, poly-p-hydroxybutyric acid.
   v) Microbial photosynthesis (photoautotrophy)- light absorption, difference in photosynthetic pigments, oxygenic and anoxygenic photosynthesis.
   vi) Alternative bacterial biochemical pathways- Entner Doudoroff pathway, methylglyoxal pathway, reductive TCA cycle, hydroxypropionate pathway.
   vii) Assimilation of organic C1 compounds - methanotrophy, methylotrophy.

**Module 2- Advanced Molecular Biology** [25 marks]

1. Genome organization: Organization of genomes in prokaryotes and eukaryotes, Chromatin organization and packaging; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation, Telomeres and telomerase, DNA topology, Knots and links, Linking number, Writhing and twisting, DNA supercoiling, Topoisomers, Role of DNA topology in replication and transcription. DNA Topoisomerases in prokaryotes and eukaryotes.
2. DNA Replication, recombination, damage and repair: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, Homologous and non-homologous recombination, site specific recombination, Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination, different kinds of DNA damage, DNA repair mechanisms in prokaryotes and eukaryotes, Diseases due to failure of DNA repair.
3. RNA synthesis and processing: RNA world and RNA replication; Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, RNA transport (Emphasis on eukaryotic machinery).
4. Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post- translational modification of proteins (Emphasis on eukaryotic machinery).
5. Molecular evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence, Speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution

**Major 24 (Practical)** [50 marks; 6 credits]
**Major 25 (Practical)** [50 marks; 6 credits]

## PG SEMESTER – 2

**Major 26 (Theoretical)** [50 marks; 4 credits]
**Module 1- Advanced Microbiology** [25 marks]

1. Life cycle (entry, replication and egress) of DNA and RNA viruses.
2. Phage genetics: Lytic and lysogenic cycles of bacteriophage; Virulent and Temperate phage, Prophage; Study of plaque morphology; mapping of phage chromosome by phage crosses.
3. Transfer of genetic material and recombination in bacteria: molecular aspects of transformation, conjugation, transduction. Chromosome mapping by interrupted mating experiment.
4. Bacterial photosynthesis, biogeochemical cycling of sulfur and nitrogen (with special emphasis on nitrogen assimilation by free living and symbiotic bacteria and nif genes).
5. Host pathogen interaction: mechanism of microbial pathogenesis (bacteria and virus), genetics of pathogenicity and virulence.
6. Antimicrobials: types and mode of action.
7. Bioremediation: use of microbes for treating pollutants (hydrocarbons, oils, heavy metals).
8. Microbes in commerce: source, production process and uses of - vaccines (attenuated and live virus), antibiotics, biopolymers, biosensors, biopesticides and biofuels.
9. Use of microbes in genetic engineering.

**Module 2- Immunology** [25 marks]

1. Cells, tissues and organs of the immune system; innate and acquired immunity with reference to Toll-like receptors; T and B cell receptors; Antigens vs. immunogens; Adjuvants; Humoral and cell-mediated immune response; Class switch: Antigen- antibody reactions; Hybridoma technique for monoclonal antibody production;ELISA, RIA, Immunoelectrophoretic techniques.
2. Autoimmunity: Development of autoimmunity against sequestered antigens, shared antigens and altered antigens; Role of autoreactive lymphocytes in autoimmunity; Prevalence of autoimmune disorders in females than in males.
3. Hypersensitivity: Immunological basis of types I to V hypersensitivity reactions with common examples; Common antiallergic drugs and their mode of action.
4. Vaccination: Passive immunization vs. vaccination; types of vaccines; Vaccination using attenuated and killed pathogens; Macromolecular vaccination with reference to sub-unit, recombinant and DNA vaccine; Strategies for new vaccine development; difficulties of vaccination against AIDS and malaria.

**Major 27 (Theoretical)** [50 marks; 4 credits]
**Module 1-Advanced Genetics** [30 marks]

1. Model systems in genetic analysis: *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, Maize, *Drosophila*, *C. elegans*, Zebra fish.
2. Quantitative Genetics: Multilocus control; QTL analysis; Quantitative inheritance in plants and human.
3. Population Genetics: Hardy- Weinberg equilibrium and assumptions; Extension to Multiple allele and Sex-linked allele; Variables of Hardy – Weinberg equilibrium – Mutation, Migration, Small population size, Natural selection.

4. Molecular basis of recombination: Double strand break- repair model; Rec BCD pathway in E. coli; Homologous recombination in eukaryotes; Role of Spo 11 and MRX protein in Meiotic recombination; Gene Conversion.
5. Regulation of Gene expression: Operon in bacteria; Cascades in bacteriophage; Regulation in eukaryotes: Gene rearrangement (Ig gene ; Yeast mating type; Trypanosome VS.G gene); Chromatin remodeling.
6. DNA repair: Excision repair; Mismatch repair; Recombination repair; NHEJ; Translesion DNA synthesis
7. Epigenetics: Genomic imprinting; Histone code; Epigenomics.

**Module 2- Environmental Science** [20 marks]

1. Basic concept of ecology and environment: biotic, abiotic, physical and chemical components of environment; biological diversity and interactions, community ecology; forest and wild life ecology; concept of indicator species and their environmental significance.

2. Conservation: In situ conservation: sanctuaries, biosphere reserves, national parks, nature reserves, preservation plots. Ex situ conservation: botanical gardens, zoos, aquaria, homestead garden, herbarium.
3. Environmental pollutants and pollution: classification of pollutants and mechanism of action; source, effects and control measures of pollution-
   i) Air (photochemical smog, ozone depletion, acid rain, SPM, concept of indoor air pollution)
   ii) Water (eutrophication, pesticide pollution, sewage and ground water pollution, concept of safe drinking water, Principles of water quality monitoring, physicochemical and bacteriological sampling and analysis of water quality; water quality standards; water pollution control; Ganga action plan; marine pollution)
   iii) Noise (Sources and measurement of noise pollution, noise exposure levels and standards; noise pollution control and abatement measures)
   iv) Radiation (radioactivity in the environment and its biological effects), gravitational, thermal pollution.
4. Environmental toxicity: Concept of acute and chronic toxicity; Concept of dose response relationship (LDso, LCso, TL V); roots of entry of toxicants- mechanism and resistance; Bioassay methods; concepts of biomagnifications and bioaccumulation- its effect on different tropic levels; source of heavy metals and its mechanism of action; uptake of toxic substances by plants and animals- detoxification and excretion of toxic substances.
5. Health and environment: occupational hazards and associated diseases, silicosis, anthrax and other lung diseases; WHO standards of working conditions; physical factors effecting occupational health (heat, cold and temperature); prevention of occupational diseases. Various international organizations (WHO, ILO, UNICEF) on human health.
6. Global environmental changes and major drivers of biodiversity changes: climate changes, global warming - causes and consequences.
7. Environmental impact assessment: Environmental impact assessment (EIA) general guide lines for preparation of environmental impact statement (EIS), international organization for standardization (ISO), ISO 14000 standards and certification, environmental clearance for establishing industry, environmental safety, relationship of EIA to sustainable development.
8. Environmental biotechnology: concept and broad outlines of various aspects of biotechnology- waste treatment, biodegradation of xenobiotic compounds, biofuel production, biofertilizer, concepts of integrated pest management and biopesticides.

9. Brief idea of environmental summits and treaties
10. Bioconversion of pollutants: active vs. inactive process, enzymatic degradation. The relationship between occupational hygiene, safety and disease. Health maintenance: survey, analysis and recommendations regarding health and safety problems in the working and living environments.

**Major28 (Theoretical)** [50 marks; 4 credits]
**Module1- Research conduct and Bioethics** [20 marks]

1. Introduction, Overview, and Research Misconduct, rules and regulations in India.
2. Data Management
3. Mentoring, mentor-mentee responsibilities
4. Authorship Guidelines, Publication and Peer Review
5. Intellectual property, plagiarism, patents
6. Collaboration
7. Reporting and representing research, Representing images
8. Bias, Conflicts of Interest
9. Ethical use of animal subjects
10. Protection of Human subjects
11. Stem Cells
12. The Ethics of Plant Use, transgenic crops
13. Agricultural Ethics
14. Ecosourcing-code of practice
15. Radioactive, chemical and biohazard safety, waste management and disposal
16. Social Responsibility and Whistleblowing

**Module 2- Emerging field of science** [30 marks]

1. Nanotechnology: Elementary concept of nanotechnology and its applications; cellular nanomachines; bio-inspired nanomaterials for a new generation of medicine; nanoscience in medicine, delivery system, and vaccine; nanoparticles in medical detection and diagnostics; synthesis of anyone inorganic or organic nanoparticles, characterization, and applications.
2. Synthetic Biology; Basic concepts of synthetic biology; concepts of synthetic genome, organelles, and minimal cell; metabolic engineering; bacterial drug factories; synthetic biology in clinic, and biosensor.
3. Systems Biology: Ttranscriptomics, proteomics, metabolomics, lipidomics, glycomics, and phosphoproteomics. High-throughput screening and sequencing {next-Gen}.
4. Quantitative Biology including various advanced PCR.
5. Personal Genomics. Computational biology. Structural biology and modeling ecology.

**Major 29 (Practical)** [50 marks; 6 credits]
**Major 30 (Practical)** [50 marks; 6 credits]

## PG SEMESTER 3

**DBS 9-1 (Animal structure and function)**
**Group – A (Non-chordates)**

1. Coelom and its evolution.
2. Nutrition biology with reference to insects, mollusks and echinoderms.
3. Blood, respiratory pigments and organs, gaseous exchange with reference to arthropoda and mollusca.
4. Excretory organ and physiology of excretion with reference to annelida and arthropoda.
5. Reproductive biology of major invertebrate groups.
6. Endocrine glands and chemical messengers in invertebrates.
7. Sense organs in invertebrates.

**Group – B (Chordates)**

1. Protochordate biology - current knowledge of notochord microanatomy, tail resorption in Ascidia and endostyle function.
2. Integumentary glands and their derivatives in vertebrates.
3. Anatomical plan and functional significance of different types of jaw suspension in vertebrates.
4. Comparative anatomy and evolution of portal system in vertebrates.
5. Respiratory biology with reference to aquatic and aerial life.
6. Functional areas of vertebrate brain.
7. Receptors organs in vertebrates.

**Practicals based on theoretical syllabus.**

**DBS 9-2 (Animal taxonomy, ecology, evolution and behaviour)**

**Group – A (Animal taxonomy)**

1. Principles of phenetics and cladistics
2. Character states and character state transition.
3. Difficulties of universal application of biological species concept.
4. Modes of speciation – allopatry, sympatry and parapatry.
5. Concept of cytotaxonomy and molecular taxonomy.

**Group – B (Animal ecology)**

1. Population regulation.
2. Life table, survivorship curve, metapopulation concept.
3. Acidification – cause and consequence
4. Eutrophication of water bodies and its impact.
5. Wetland ecology with special reference to West Bengal.
6. Ecology of marine biota.

**Group – C (Evolution)**

1. Population as evolutionary unit with reference to Hardy-Weinberg law and factors affecting Hardy-Weinberg equilibrium.
2. Evolution and tinkering.
3. Punctuated equilibrium hypothesis.
4. Concept of molecular clock and molecular drive.
5. Evolutionary origin of tetrapods, birds and mammals.

**Group – D (Animal behavior)**

1. Foraging behavior of animals with reference to cost and benefit analysis.
2. Aggressive behavior – competition, territoriality and dominance hierarchy; Game theory and evolutionary stable strategy.
3. Nervous control of behavior with reference to hypothalamus, hippocampus and amygdale.
4. Hormonal and genetic control of behavior with reference to role of androgen, prolactin, fixed action pattern and imprinting of behavior.

**Practicals based on theoretical syllabus.**

**DBS 9-3 (Animal physiology and Animal development)**

**Group – A (Animal Physiology)**

1. Structure and function of blood in invertebrates and vertebrates.
2. Physiology of hibernation, aestivation and diapause.
3. Stress physiology of animals – Acclimatization in high altitude, General adaptation syndrome.
4. Neuroendocrine function in animals – neuroendocrine integration, neurosecretory cells vs. neurons, neurohaemal organs, neurosecretion in invertebrates and vertebrates.
5. Estrus cycle and spermatogenesis in animals and their hormonal regulation.
6. Pre-migratory physiological changes in animals.

**Group – B (Animal Development)**

1. Blocks to polyspermy in animals with special reference to role of ZP proteins.
2. Regeneration in animals.
3. Embryonic induction and competence in animals.
4. Natural and artificial parthenogenesis in animals.
5. Axis differentiation in Drosophila and its genetic regulation.
6. Homeotic genes and their significance in animal development.

**Practicals based on theoretical syllabus.**

**DBS 9-4 (Molecular biology and biochemistry of diseases)**

1. **Cancer Biology**: oncogenes, tumor suppressor genes, micro RNAs in cancer, Chromosomal rearrangements and cancer, Viruses and cancer, Chemical carcinogenesis, Cell Cycle Control, G1 and "Go" Signals, Stop Signals, Cell Cycle in Stem Cells, Growth factors and Cancer Signaling, Metastasis, Angiogenesis, Tumor microenvironments and Stroma, Inflammation and Cancer, Therapeutic strategies.
2. **Infectious diseases:** Molecular mechanisms for Host-pathogen interaction**,** Disease models: Cholera, Tuberculosis, Malaria, Influenza, HIV and AIDS, Prion protein diseases.
3. **Neuropathological disorders:** Molecular pathways to neurodegeneration: β-amyloid, Tau, α-Synuclein, misfolding and aggregation of disease proteins, mitochondrial dysfunction, gene-environment interactions in neurodegenerative disease, Parkinson, Alzheimer, Huntington's disease, Creutzfeldt-Jakob disease.
4. **Genetic diseases:** Loss of function mutations, Gain of function mutations, Molecular pathology: from gene to disease, from disease to gene, of chromosomal disorders, molecular basis for Hemophilia, Colour blindness, Sickle cell anemia, Thalassemia, Xeroderma pigmentosum, Cystic fibrosis, Duchenne muscular dystrophy, SLE, Myasthenia gravis.
5. **Molecular mechanisms of metabolic and nutritional diseases:** inborn errors of metabolism,

diseases related to vitamins and minerals, obesity.

**Practicals based on theoretical syllabus.**

**DBS 9-5 (Current trends and advances in cell and molecular biology)**

1. **Historical perspective**: All the landmark discoveries in the field of Molecular Biology, Cell Biology and Genetics.
2. **Gene therapy** - Vectors for somatic cell gene therapy, Enhancement in genetic engineering, Gene therapy for inherited immunodeficiency syndromes, Cystic fibrosis gene therapy, HIV-1 gene therapy. Retroviral mediated gene transfer.
3. **Stem cells and translational medicine** - Embryonic stem cells and therapeutic cloning, multi-potent adult stem cells, pluripotent adult stem cells, transgenic stem cells, Regeneration therapy.
4. **Molecular technologies** – an overview of Genetic screening for any predisposition symptoms, Cancer screening, molecular markers and molecular profiling, DNA fingerprinting (Paternity and Forensics), cloning, *in vitro* fertilization, transgenic organisms, xenotransplantation, GMOs.
5. **Modern Biology approaches**: Functional Genomics; High-throughput Sequencing and its applications, Genome Analysis and Bioinformatics Tools, Proteomics and Systems Biology.

**Practicals based on theoretical syllabus.**

**DBS 9-6 (Biophysical methods)**

Applications of biophysical methods in Biology: Electromagnetic radiation, Vibrational spectroscopy (IR and Raman), EPR, Atomic absorption, Mossbauer spectroscopy, Fluorescence correlation spectroscopy, 3$^{rd}$ generation synchrotron based spectroscopy, Single molecule techniques (fluorescence, optical traps), X-ray protein crystallography and NMR, analytical ultracentrifugation, Radioactivity.

**Practicals based on theoretical syllabus.**

**DBS 9-7 (Critical analysis of biochemical literature)**

This paper helps the student how to read a scientific paper critically, interpret the data and think beyond what the author says. This paper will include oral presentation and group discussion.

**DBS 9-8 (Medical microbiology and virology)**

1. Pathogenicity, epidemiology, laboratory diagnosis, treatment, prevention and control of specific bacterial diseases caused by - *Vibrio cholerae*, *Pneumococcus pneumoniae*, *Salmonella typhimurium*, *Neisseriae gonorrhoeae*, *Mycobacterium tuberculosis*, *Clostridium botulinum*, and *Haemophilus influenzae*.
2. Properties of viruses - Detection of viruses in clinical specimens - Serological diagnosis of viral infections. Cultivation of viruses.
3. Some common viral diseases- Hepatitis viruses, Rabies, Pox, Herpes, Rota and AIDS viruses.
4. Oncogenic viruses: History; Human (EBV, KSHV, HPV, HTLV-1, HCV, HBV, MCPyV) and non-human oncogenic viruses (SV-40, Adenoviruses) –mode of entry, molecular pathogenesis and therapeutic interventions.
5. Pathogenic fungi- introduction, morphology and taxonomy. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses.
6. Yeasts of medical importance- dimorphic fungi causing systemic mycoses.
7. Pathogenicity, epidemiology, laboratory diagnosis, treatment, prevention and control of protozoan diseases - Amoebiasis, Giardiasis, Malaria, Toxoplasmosis, Leishmaniasis.
8. Pathogenicity, epidemiology, laboratory diagnosis, treatment, prevention and control of common

parasitic metazoan diseases – Hook worm, Filariasis, *Taenia solium* infection.

9. Hospital acquired infections and their control; effective disposal of hospital waste.

**Practicals based on theoretical syllabus.**

**DBS 9-9 (Transplantation, tumor immunobiology and immune deficiency)**

1. Transplantation Immunology: Distribution, structure, function and genetic control of MHC glycoproteins; HLA typing; Mechanisms of graft rejection; Basic concept of bone marrow transplantation; Foetus as an allograft and survival of foetus against maternal graft rejection mechanisms.
2. Tumor Immunobiology: Evasive mechanisms of tumor cells; Tumor specific antigens; Immunosuppression in tumor microenvironments; Immunotherapy of cancer using monoclonal antibody and cytokines; NK cells and dendritic cell therapy of cancer; Vaccine against human cervix cancer.
3. Immune deficiency disorders: Concept of primary immune deficiency with reference to Di George syndrome, agammaglobuninemia and SCID; etiology, symptoms and treatment of AIDS.

**Practicals based on theoretical syllabus.**

**DBS 9-10 (Circulatory, Neuromuscular Physiology and Biostatistics)**

1. **Electrophysiology:** Electrophysiology of excitable tissues. Membrane theory of Bioelectric phenomena, origin of various forms of biopotentials and their physiological significance use of Patch clamp technique in the study of membrane physiology; recording of biopotentials, transducers and electrodes different types and uses. Goldman-Hodgekin – Katz equation for propagation of nerve impulse.
2. **Nerve Muscle Physiology:**

   Neuron: Molecular and Cellular Mechanisms

   i) Molecular neurobiology – Molecular biology of the neuron; Transcription factors; Molecular technology for studying nerve cells, Functional analysis of expressed proteins.

   ii) The synapse- types synapses at the central nervous system, molecular components of the synaptic vesicles, and pre and post synaptic membranes, molecular mechanism of the synapse,

   synaptic potentials and synaptic integration, integrative organization of the nerve cell; second messengers and neuromodulators.

   iii) Developmental neurobiology – Brain development: an overview : cellular mechanisms, Neuronal birth, cell migration, cell growth and growth factors cell differentiations,

   Development of the synapse; Establishment of synaptic connections; Maturation cell death; new neurons in old brains? Regeneration and plasticity; Problems of regeneration of neurons in brain.

   Muscle:

   i) Mechanics and energetics of muscle: Mechanical properties (different types of muscle contraction) heat production; chemical changes in muscle

   ii) The Contractile mechanism of muscle (the sliding filament theory, structure of the contractile, machinery the nature of cross bridge action)

   iii) Activation of muscular contraction (E-C coupling, the molecular basis of activation

   iv) Junctional transmission: (Junctional features and mechanism of transmission at different types of muscular junction) Blockers toxins and pathological conditions affecting neuro-muscular transmission on their mechanisms of action.

3. **Biostatistics:**
   i) Testing of Hypothesis: Null hypothesis and alternative hypothesis; levels of significance; critical scores; errors of interference, Z- scores.
   ii) Probability distributions: Properties, applications and assumptions of normal bionomial and Poisson distribution.
   iii) Nonparametric statistics: G test for goodness of fit, Mann-Whitney U –test, Wilcoxon's signed rank test, Median test. Odd Ratio test.
   iv) Correlations: Product moment correlation: assumptions, properties, computations and significance tests. Kendall's rank correlation coefficient. Correlations involving qualitative variables point biserial r. bisrial r phi coefficient, tetrachoric, contingency coefficient. First order partial correlation. Multiple linear correlations with three variables.
   v) Regressions: Linear regression Models, assumptions. Properties and computations of simple linear regression, multiple linear regression.
   vi) Analysis Variances: Models and types of Anova one way anova – Assumptions computation and interpretation of variance ratio, multiple comparison t tests, Scheffe's F- test and Gabriel's SS-STP. Kruskal-Wallis non-parametric ANNOVA and Mann-Whintey multiple comparison. U. Test. Two way ANOVA without replication.
   vii) Application of Statistical principles in physiological problems.
4. **Blood and Body Fluids**
   i) Haematopoiesis: Embryogenesis and early stem cell development, histogenesis, Regulation of haematopoiesis.
   ii) Erythrocytes: Structural architecture, hemoglobin, iron-ferritin-transferrin system. Anaemia, Thalassemia, Porphyrins.
   iii) Leukocytes: Lymphocytes, mast cells, plasma cells, macrophages and their involvement in immune network; Leukemia, Eosinophilia, thrombolytic agents.
   iv) Hemostasisand Thrombosis: Role of platelets, blood coagulation mechanisms, regulation of blood coagulatioin; Fibrinolysis, pathogenesis of thrombosis and thrombolytic agents.
   v) Blood antigen, Blood transfusion, Clinical use of hematological techniques
   vi) Other fluid systems of body: Tissue fluid, Lymph and CS
5. **Cardiovascular System and Haemodynamics:**
   i) Biology of myocardial cell, developmental aspects
   ii) Cardiac Electrophysiology: ECG – use in cardiac abnormalities, heart block, ventricular hypertrophy, atrial and ventricular fibrillation, Vector and vector analysis, vector cardiogram - Different loops and their clinical significance.
   iii) Cardiac work and mechanics: Analysis of work diagram.
   iv) Cardiac metabolism and energetics, cardiovascular and cardiovisceral reflexes
   v) Cardiac remodeling; regenerative capacity of heart
   vi) Angiogenesis: interaction between endothelium and smooth muscle spring Molecules; role of signaling molecules in cardiovascular system
   vii) Maintenance of vascular tone: role of ion channels
   viii) Obesity - -linked cardiovascular pathology
   ix) Stem cell modification of vascular function.

**Practicals based on theoretical syllabus.**

**DBS 9-11 (Alimentary, Excretory, Respiratory, Endocrine and Reproductive Systems)**

1. **Gastrointestinal system:**

i) Control of gastrointestinal functions – neural and endocrine
ii) Chemistry and mechanism of action of defensive and aggressive factors.
iii) Role of hepato-biliary and pancreatic secretions in gastrointestinal functions
iv) Immune function of G.I. tract
v) Assessment of gastric, pancreatic and intestinal functions in different pathophysiological conditions including its different diagnostic techniques.

2. **Excretory System:**
   i) Kidney functions: Methods of study of renal tubular functions; tubular transport mechanisms and transtubular potential; countercurrent multiplier and exchanger system in urinary osmolarity; diuretics; renal regulation of sodium ion exchange, body fluid volume; titrable acidity of urine with special reference to tubular protein exchange.
   ii) Kidney as an endocrine gland
   iii) Cytometry and higher control of micturition
   iv) Assessment of renal functions: Perfusion technique; peritoneal dialysis and artificial kidney.
3. **Respiratory System and its Applied aspects:**
   i) Morphology of lung: Elastic forces, lung volumes, pressure / volume relationship of the lung and thoracic cage; measurement of compliance and lung volumes, elastic recoil of the lungs and thoracic cage; principle of lung function tests.
   ii) Respiratory system resistance: Physical principles of gas flow and resistance; respiratory system resistance, factors affecting respiratory resistance; muscular control of airway diameter; work breathing; respiratory gas equation and alveolar air equation; alveolar ventilation and perfusion ratio.
   iii) Non-respiratory functions of the lung: Fixation; defense against inhaled substances; the endocrine lung.
   iv) Respiratory functions in altered conditions: Respiratory changes in parental and neonatal conditions, respiration in submarine, space microgravity and biosphere, respiration in deep sea diving and in high altitude; hypoxia hyperoxia and oxygen toxicity.
   v) Artificial ventilation: Methods used for resuscitation; physiological effects of artificial ventilation; non-invasive ventilation.
   vi) Respiratory system and immune function
4. **Endocrinology and Neuroendocrinology:**
   i) Principles of Endocrinology: General concept of endocrine, autocrine and paracrine action of hormones, hormone receptors.
   ii) Hormones and hormone action – the function of hormones (reproduction, growth and development, maintenance of internal environment, energy production, utilization and storage),

   interaction of hormones (one hormone, multiple actions, one function, multiple hormones), the chemical nature of hormones, hormone synthesis, storage and release transport, feedback relationships, biorhythms, endocrine pathology (subnormal hormone production, hormone excess production of abnormal hormones, resistance to hormone action abnormalities of hormone transport and metabolism, multiple hormone abnormalities, autoimmune endocrine disorders)
   iii) Hormone Receptors: Cell surface – types, structural features, hormone binding and translocation, genomic and non genomic events.
   iv) Hormone Receptors: Intracellular types, structural features, ligand binding and translocation, genomic and non genomic events.
   v) Assay of hormones: Bioassay and immunoassay – principles, techniques, advantages and

disadvantages

vi) Neuroendocrinology: Modern views of neuroendocrinology, neural control of glandular secretions secretomotor control and neurosecretion, the hypothalamus pituitary unit as neuroendocrine organ (anatomy, hypophyseotropic hormones of the hypothalamus), regulation of secretion of tuberohypophyseal neurons (dopaminergic, noardenergic, central adrenergic, central serotoninergic, central cholinerginc, amino acid neurotransmitters, central peptidergic pathways), neuroendocrine control of individual pituitary hormones (general considerations of feedback concepts and biorhythms in neuroendocrinology, thyrotopin regulation, corticotrophin secretion, prolactin regulation, growth hormone regulation, neuroendocrine aspects of reproduction and sexual function), the pineal gland and circumventricular organs- their role as neuroendocrine organs.

5. **Reproductive Physiology:**

i) Structural organization of the testes, physiology of testicular function (hypothalamus-pituitary testicular axis, androgen physiology, spermatogenesis and fertilization, phases of normal testicular function (embryonic male sexual differentiation, neonatal life, puberty, adulthood, old age), assessment of testicular function (Leydig cell function, seminiferous tubule function, estrogenic function).

ii) The normal ovary and ovarian function (early development of the ovary; fetal ovary, childhood and premenarchal ovary, the ovary of the reproductive years; structural organization of the mature ovary, physiology of ovarian function: hypothalamic-pituitary-ovarian axis, ovarian hormone synthesis, coordination of ovarian function the menstrual cycle).

iii) Onset of puberty – physiological changes and hormonal regulation.

iv) Gametogenesis, fertilization and early development – production of gametes, sperm transport, capacitation, cell surface molecules in sperm egg recognition, fertilization, zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers.

v) Implantation and pregnancy – physiology, placental structure and hormones, endocrine, genetic and immunological factors influencing pregnancy.

vi) Parturition and lactation – recent concept of physiological mechanism of parturition, hormonal control of lactation and physiological importance.

vii) Principles and techniques of fertility control in male and female

**Practicals based on theoretical syllabus.**

**DBS 9-12 (Man and environment (work and stress) and sensory physiology)**

1. Concept of Biological work: Evaluation and measurement of work
2. Energetic of Exercise: Short term and Long term
3. Physiological adaptations to graded exercise
4. Mechanism of fatigue
5. Quantitative evaluation and physiology of static, dynamic and isokinetic work
6. Elements of Biomechanics, Low back pain
7. Efficiency of performance
8. Principles of training, sports specific training
9. Ergogenic aids; principle, agents, procedures, positive and negative aspects, International views.
10. Sports injury and its management
11. Motivation and psychosomatic fitness
12. Sports rehabilitation and sports medicine
13. Sports and environment
14. Sex differences in sports personnel and their performance

15. Premenopausal and premenarch sports performance.

**1. Ergonomics and Occupational Management**

i) Concept of systems.

ii) Man-Machine Environment System: Human factors in the system, compatibility and optimization of a system.

iii) Development of Ergonomics.

iv) Basic methods for analysis of different components of system work study, time and motion study etc.

v) Anthropometry and Somatotyping – application in ergonomics.

vi) Elements of Biomechanics and Motor Control, human performance.

vii) Application of Ergonomics in Agriculture and Industry – one or two examples with case studies.

viii) Accident and Safety, protection device etc.

ix) Concept of occupational health and disease.

x) Basic elements of human behavior analysis.

**2. Man and Environment: Community Health:**

i) The Environment: Physical environment, biotic environment; biotic and abiotic interactions

ii) Habitat and niche: Concept of habitat and niche width and overlap; fundamental and realized niche; resource portioning; character displacement.

iii) Population ecology: Characteristics of a population; population growth curves; population regulation, life history strategies (r and K selection) concept of metapopulation – demes and dispersal, interdermic extinctions age structured populations

iv) Community ecology: Nature of communities; community structure and attributes levels of species diversity and its measurement; edges and ecotones

v) Ecological succession: Types; mechanisms, changes involved in succession concept of climax.

vi) Concept of Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian Ecosystems.

vii) Biology of communicable diseases

**3. Stress Physiology and its Management:**

i) Stress and responses, stress response adaptation, stress disorder

ii) Heat stress, Acclimatization to heat stress, human performance to heat stress

iii) Thermal distress; Measurement indices, physiological responses-dehydration and heat cramps, heat exhaustion, heat stroke, strategies of thermal stress management

iv) Cold stress; Frost bites and hypothermia

v) Stress, society and reproduction

**4. Biological Rhythms:**

i) Biological Rhythms: Definition of terms, types of rhythms, zeitgebers, circadian rhythms, basic types of exogenous rhythms in the human and their significance.

ii) The Circadian Clock: Evolution and adaptive significance, genetic and molecular mechanisms, resonating clocks, clocks for constant environments, the role of SCN in the human, photic and non photic pathways, pacemaker function of the SCN, role of melatonin and other neuro transmitters in circadian control.

iii) Disorders of Circadian Rhythms:

a) Entertainment related blindness, jet lag, work-shift syndrome, and delayed and advanced sleep-phase syndrome.

b) Pacemaker related: irregular s/w syndrome, decreased amplitude syndrome, aging and its endocrine consequences.
c) Affective disorders: Definition, SAD and light therapy.

**5. Sensory Systems:**

i) Chemical senses: The taste system (Taste receptors, taste transduction – molecular basis, sensory processing, taste pathways); the olfactory system (Olfactory receptors, olfactory transduction-molecular basis, processing of odor information, plasticity, neurotransmitters and neuromodulators, olfactory system and olfactory cortex.

ii) The sense of Balance: The sense organ of balance the labyrinth structure of hair cells, sensory transduction, central vestibular pathways, vestibular function responses to rotational acceleration and linear acceleration, the vestibular system and weightlessness.

iii) Hearing :(Sound waves, auditory receptors, auditory signal transduction mechanisms, functions of outer and inner hair cells in frequency discrimination, action potentials in auditory nerve fibers, brainstem auditory pathways cochlear nucleus ascending pathways, primary auditory cortex, other cortical areas concerned with audition, audiometry, deafness.

iv) Vision :(Retinal circuits-anatomical and functional cell types, basic response properties of retinal cells, retinal neurotransmitters, visual signal transduction, Central visual pathways, primary visual cortex and cortical processing. Other cortical areas concerned with vision.

v) Other aspects of visual function – molecular basis of visual adaptation and color vision.)

**6. Functions of the Nervous system:**

i) Alert behavior, sleep and the electrical activity of the Brain (The thalamus and the cerebral cortex, the reticular formation and the reticular activating system, evoked cortical potentials, the EEG – physiological basis of the EEG, consciousness and sleep).

ii) Control of Posture and Movement General principles, Corticospinal and corticobulbar system – Anatomy and function, Posture regulating systems, Spinal integration, Medullary components, midbrain components, Cortical components, Basal ganglia, Cerebellum.)

iii) The Autonomic Nervous System (Anatomic organization of autonomic outflow, Chemical transmission at autonomic junctions – transmitters and modulators, Responses of the target organs to Autonomic nerve impulses – gland cells, smooth muscle and cardiac muscle.)

iv) Neural plasticity, neuro degenerative disorder – Autism, Alzheimer, H. Chorea, etc. Role of proteins and gene expression in neural function.

v) Central Regulation of Visceral function (Medulla oblongata, Hypothalamus-Anatomic considerations, hypothalamic functions, Relation to autonomic function, sleep, cyclic phenomena, hunger, thrust, control or anterior and posterior pituitary secretion; temperature regulation.)

vi) Neural Basis of Instinctual Behavior and Emotions (Anatomic considerations, Limbic functions, Sexual behavior, other emotions, Motivation an addiction, Brain chemistry and behavior.)

vii) Higher functions of the Nervous system: Conditioned Reflexes, Learning and related phenomena (Methods of study, Learning and memory; functions of the neocortex).

viii) Concepts of Neuro – Immunology: Immunity and Nervous system.

**Practicals based on theoretical syllabus.**

**DBS 9-13 (Plant systematics)**

1. **Define the terms**: Taxonomy, Systematics and Molecular Systematics, e-Flora, Character and character-state, Angiosperm Phylogeny Group (APG), Monophyly, Paraphyly, Polyphyly, clade, lineage, Cladistics, Phentic, Plesiomorphy, Synapomorphy, Homology and Homoplasy, Principles of Parsimony, Epitype, Isonym, Homonym, Synonym.
2. **Phases of Taxonomy** (Exploratory, Consolidation, Biosystematics and Encyclopaedic); brief history of Angiosperm Taxonomy Research in India.
3. **Concept of ICBN and ICN:** salient features of Melbourne-ICN (2012); brief knowledge of nomenclatural types as per Melbourne-ICN (2012).
4. **Numerical Taxonomy:** Aims and objectives, characters and attributes, OTUs. Coding cluster analyses, merits and demerits.
5. **History of Plant Classification** including recent APG-System (Angiosperm Phylogeny Group); broad outline of APG-III (2009) including its merits and demerits.
6. **Chemotaxonomy:** Role of phytochemicals (especially secondary metabolites) in plant taxonomy.
7. **Molecular approaches to plant taxonomy:** Application of DNA markers in angiosperm taxonomy; molecular phylogeny.
8. **Salient features, Floral range and phylogenetic importance of the following families**:

   *Dicots*- Amborellaceae, Annonaceae, Papilionaceae, Caryophyllaceae, Apocynaceae, Lamiaceae, Droseraceae, Nepenthaceae, Rubiaceae, Ericaceae, Asteraceae, Dipsacaceae.

   *Monocots*- Alismaceae, Potamogetonaceae, Zingiberaceae, Commelinaceae, Orchidaceae, Poaceae, Iridaceae, Juncaceae.
9. **DNA bar-coding** for identification of plants.

**Practicals based on theoretical syllabus.**

**DBS 9-14 (Plant anatomy and pharmacognosy)**

**Group A: Plant anatomy**

1. **Cell wall and development:** Chemistry of Cell wall- cellulose, hemicellulose, and polysaccharides. Organization of primary cell wall. Secondary wall chemical constituents- lignins, suberin, callose; Organization of secondary wall.
2. **Node –nadal patterns**: Unilacunar, trilacunar, multilacunar. Leaf trace and branch trace.
3. **Cambium:** Development of vascular cambium and cork cambium.
4. **Wood Anatomy:** Physical and mechanical properties of wood. Phloem structure, xylem structure, xylem evolution.
5. **Applied Plant Anatomy.** – Application in Bio-medics, Forensic science, Climatology, Arts and Antiques.

**Group B: Pharmacognosy**

1. History and Scope; Origin of secondary metabolites, important types (Alkaloids, Glycosides, Glucosinolate compounds, Volatile oil, Resins), source, properties and examples.
2. Brief account of Acetate Malonate, Acetate Mevalonate and Shikimate pathways, Turnover and degradation of secondary metabolites.
3. Methods of extraction, isolation and characterization of secondary metabolites. Plants as source of drugs, pharmacological action and quality control.
4. Non-medicinal toxic plants: Hallucinogenic, allergenic, teratogenic and other toxic plants.

**Practicals based on theoretical syllabus.**

**DBS 9-15 (Palaeobotany and Palynology)**

1. Sedimentary rocks; Taphonomy; Dating of fossils- isotopic and non-isotopic, dendrochronology, rhythmic bands and molecular clock; nomenclature and reconstruction of fossil plants: different

methods with examples; Stratigraphy; Basic concepts of continental drift and plate tectonics.

2. Palaeobotany in relation to biosphere, geological time scale, geosphere and atmosphere, Origin of life; first prokaryotes; evolution of eukaryotes; geological records of algae, fungi, bryophytes and enigmatic fossils and their evolutionary and ecological significance.

3. Origin and evolution of land plants- different evidences, biogeographical distribution of early land plants (Silurian- early Carboniferous), earliest trees in the fossil record. Permo-Carboniferous floral provinces with climatic condition and endemic genera. Progymnosperms-classification, origin and evolution, of stele.
4. Preovules, hydrasperman reproduction; evolution of closed carpel; heterospory and seed habit
5. Origin of angiosperms, concept of palaeoherbs and eudicots, cladistic and molecular biological approaches to trace phylogeny of angiosperms
6. Pollen Morphology: Sporoderm stratification: Aperture and aperture types; Harmomegathic adaptation; Exine ornamentations.
7. Applied Palaeobotany and Palynology:
   i) Ancient DNA study from angiosperm plant compression, coal and petroleum exploration.
   ii) Palaeopalynology and hydrocarbon exploration; Melissopalynology, Quaternary Palynology; Neopalynology, palaeofloristics, palaeogeography, palaeoecology and palaeoclimatology
   iii) Aerobiology: General Introduction; Pollen Allergy: Concept of pollen allergy (Type-I); Air sampling methods (volumetric only); Diagnosis of allergy (Skin Prick test and ELISA); treatment of pollen allergy.

**Practicals based on theoretical syllabus.**

**DBS 9-16 (Plant Pathology)**

1. Introduction to plant pathogens other than fungi: virus, bacteria, nematodes, and plant diseases caused by them.
2. Host- pathogen interactions - Necrotrophic and biotrophic pathogen induced diseases; Mechanisms and site of actions of enzymes, toxins, growth regulators and other biochemical pathogenic weapons involved in disease development; Physiological and molecular changes in pathogenesis – membrane functions, absorption- transpiration, photosynthesis and translocation; transcription and translation of host genome.
3. Host defense and Resistance - Types and systems of host defense in plant kingdom; Genetic, molecular and biochemical basis of host defense against pathogens:

   i) Hypersensitive reaction - mechanism and biomolecules involved;
   ii) Pathogenesis Related proteins
   iii) Genetics of virulence in pathogens and resistance in hosts

4. Resistance - Local Acquired (LAR), Systemic Acquired (SAR), Induced Systemic (ISR)
5. Plant immunization against pathogens. Defense through Plantibodies.
6. Environmental factors affecting disease development - elements of plant disease epidemics, patterns of epidemics and mathematical relations, disease forecasting.
7. Plant Disease Management - Principles and methods of plant disease control: Exclusion and eradication, protection and therapy including immunization; Regulatory, cultural and biological methods of disease control, chemical control with fungicides - protectants and systemic fungicides including antibiotics; Modern biotechnological approaches for imparting host resistance to pathogens.
8. Application of molecular biology to plant disease control - transgenic approach for crop protection,

genetic and biochemical manipulations of hosts for imparting resistance to pathogens, engineering chemicals that elicit defense response to plants.

**Practicals based on theoretical syllabus.**

**DBS 9-17 (Plant Physiology)**

1. Solute transport and photoassimilate translocation – Transport of solutes across membrane barriers, Membrane transport proteins, mechanisms of loading and unloading of photoassimilates, Assimilate allocation and partitioning.
2. Plant hormones –Auxin: Physiological effects of auxin- Cell Elongation, Phototropism and Gravitropism, Developmental effects of Auxin, Auxin signal transduction pathways. Gibberellins-Physiological mechanisms of gibberillin induced growth, Gibberillin signal transduction. Cytokinins-biological role, cellular and molecular modes of action. Ethylene- developmental and physiological effects, cellular and molecular modes of action. Abscisic acid- developmental and physiological effects, cellular and molecular modes of action, Strigolactone and other plant growth regulators-Physiological role in plant development
3. Plant growth and development- Role of phytochrome and light in plant development, blue light response
4. The control of flowering: Autonomous regulations versus environmental cues, the shoot apex and phase changes, Photoperiodism, Vernalization, Signaling involved in flowering. .
5. Stress biology- Two-phase growth response, Intracellular ion compartmentalization. The oxidative stress paradigm, oxidant and antioxidant signaling in plants, protein oxidation and its regulation, ROS and redox signaling in response of plants to abiotic stress. Perception and transduction of stress signaling (Ca2+, H2O2, NO, ABA, ethylene and Polyamines) – Stress responsive genes.

**Practicals based on theoretical syllabus.**

**DBS 9-18 (Plant breeding and crop biotechnology)**

1. **Molecular Breeding:** Molecular markers: Definition, properties, types of molecular markers, Comparison of different marker systems – Development of mapping population – Marker Assisted Selection (MAS), screening and validation; Mapping genes on specific chromosomes; QTL mapping; Genome wide association mapping (GWAS), Gene pyramiding; Evolution of crop biotechnology from plant breeding to transgenics.
2. **Crop stress and productivity:** General introduction about stress – Abiotic (Osmotic, temperature and Heavy metal stress) and Biotic stress (bacterial, viral, fungal pathogens and herbivores) – Plant physiological and biochemical changes under stress – Perception and transduction of stress signaling (Ca2+, H2O2, NO, ABA, ethylene and Polyamines) – Stress responsive genes and concept of stress tolerant / sensitive germplasms - Integrated Pest Management – Herbicide, weedicide and surfactants.
3. **Genetic engineering for Crop improvement:**
   i) Genetic engineering: Methods of genetic transformation - Agrobacterium mediated gene transfer - Direct DNA uptake – Electroporation - Shot Gun method – Microinjection. Confirmation of transgene integration with host plants.
   ii) Important biotic and abiotic stress genes and their utility in crop improvement: Bacterial resistance, Viral resistance (coat protein mediated, nucleocapsid gene), Fungal resistance (chitinase, 1-3 beta glucanase, RIP, antifungal proteins, thionins, PR proteins), Insect pests resistance (Bt genes, Non-Bt like protease inhibitors, alpha amylase inhibitor), nematodes resistance, herbicide resistance, (phosphoinothricin, glyphosate, sulfonyl urea, atrazine),

Salinity (SOS, NHX, HKT1), Drought (DREB, ABI), thermal stress (COR, ABI, HSF, HVAPX), flooding (ANPs) and submergence tolerance (Sub1A).

iii) Genetic engineering for increasing crop productivity: Enhancing photosynthetic efficiency, nutrient use and nitrogen fixing efficiencies - Manipulation of plant architecture and flowering behavior - Genetic Engineering for improving seed storage proteins, essential amino acids, vitamins and minerals - Heterologous protein production in transgenic plants for agriculture, industrial and pharmaceuticals usage - Biodegradable plastics - Plants as biofactories. Post-

harvest losses, increasing shelf life of fruits and flowers; use of ACC synthase, Polygalacturanase, ACC oxidase, male sterile lines: bar and barnase systems.

4. **Gene silencing for crop improvement:** Role of antisense and RNAi in crop improvement - regulated and tissue specific expression of transgenes for crop improvement - Terminator gene technology - Transgenic and gene knockout technologies. Targeted gene replacement.
5. **Introduction to Intellectual Property and Patents:** Types of IP: Patents, Trademarks, Copyright and Related Rights, Protection of GMOs, IP as a factor in RandD; IPs of relevance to Biotechnology and few Case Studies History of GATT and TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 and recent amendments, Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees, Invention in context of "prior art"; Patent databases; Searching, International Databases.

**Practicals based on theoretical syllabus.**

**DBS 9-19 (Plant biotechnology)**

1. **Plant Tissue Culture:** *Methods of sterilization* - medium composition and preparation - MS media - culture initiation and incubation of culture. Callus induction and establishment. Callus sub-culture and maintenance. Cell suspension culture - characteristics. Micropropagation: methods - axillary and adventitious budding - advantages. Somatic embryogenesis - somatic embryo development and synthetic seed production. Somaclonal variation and applications. Androgenesis and gynogenesis. Plant protoplast isolation, culture and fusion - Mechanism of call wall regeneration from protoplasts and application of protoplast hybridization - Biotransformation and immobilization of plant cells - Hairy root clones - Production of secondary metabolic compounds using cell and tissue culture.
2. **Basics tools in Biotechnology:** *Molecular Tools and Their Applications* - Restriction enzymes, Modification enzymes, Ligation of DNA fragments, Nucleic Acid Purification, Yield Analysis, Nucleic Acid Amplification and its Applications - Gene Cloning Vectors, Restriction Mapping of DNA Fragments and Map Construction, cDNA Synthesis and Cloning - mRNA enrichment, reverse transcription, DNA primers, linkers, adaptors and their chemical synthesis, Library construction and screening, fundamental *in silico* tools used in plant biotechnology
3. **Genetic modification of plants:**
   i) Vectors - Plasmid biology, phage vectors, cosmid and plasmid vectors, artificial chromosome vectors, shuttle vectors and expression vectors - Selection of vectors for copy number - Promoters and Terminators.
   ii) Introducing genes into prokaryotes and plants - Natural gene transfer methods, calcium chloride mediated transformation, Transfection with phage vectors.
   iii) Methods of introduction of foreign DNA in plant system - *Agrobacterium* mediated, *in planta* method, Virus-mediated, Direct gene transfer through Particle bombardment, protoplasts transformation, Chloroplast transformation and alternative methods. Transgene stability, gene silencing, removal of marker genes. Basics of mitochondrial engineering

iv) Confirmation of transgene integration - Southern, Northern and Western Blotting, Dot and Slot blots and Antisense RNA technology.

4. **Genetic transformation by *Agrobacterium:*** *Agrobacterium*-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T- DNA transfer; Disarming the Ti plasmid, *Agrobacterium*-mediated gene delivery, Co-integrate and binary vectors and their utility; Flower dip transformation; Screenable and selectable markers; Monocot transformation, Promoters and poly A signals. Management of transgenic plants, consumer issues, IPRs.
5. **Basic applications of plant genetic engineering:** Abiotic and biotic stress resistance: Pest Resistance - Herbicide Resistance - drought resistance - enrichment of storage protein - Mechanism of gene action - Flower color, Shape and flavor modifications - Modification of fruit ripening process - Improvement of the nutritional quality of seeds - Post harvest preservation. Metabolomics - Applications of Metabolic Engineering - in pharmaceuticals - Bioenergy generation, Bioethanol and biohydrogen.

**Practicals based on theoretical syllabus.**

**DBS 9-20 (Applied botany)**

1. Applied phycology: Phytoplankton Ecology, Algal Biotechnology, algae in industry and pharmacology.
2. Applied Bryology: Bryotechnology, Phytochemistry and pharmacological activities of bryophytes.
3. Algal culture; Tissue culture of bryophyte, pteridophyte and gymnosperms.
4. In vitro production of secondary metabolite and genetic transformations in bryophyte, pteridophyte and gymnosperms.
5. Role of bryophyte in peatland ecology and pollution monitoring.
6. Hyperaccumulation by bryophyte and pteridophyte; indicator species.
7. Genetic recombination in Cyanobacteria
8. Mushroom cultivation- Cultivation practices - pure culture, spawn production, composts and their preparation, Cultivation process of *Agaricus bisporus*. Nutritional value of Mushroom.
9. Fungal biotechnology, Medicinal use of fungi and lichen, Bioconversion of lingo-cellulosic wastes.

## PG SEMESTER 4

**Major 36**
**(Theoretical)**

Introduction to research: Writing skills- project/ grant proposal (30 marks), journal club (20 marks)

**Major 37 (Theoretical)**

Project related theory

**Major 38 (Theoretical)**

Review of literature

**Major-39 (Practical)**

**Major-40 (Practical)**