

# **BIOLOGY CURRICULUM**

## *Overview of New UG-Biology courses*

<b>Semester</b>	<b>Courses</b>	<b>Credits</b>
First (Aug)	DB 101 and DB 101L	2:1
Second (Jan)	DB 102 and DB 102L	2:1
Third (Aug)	DB 103 and DB 103L	2:1
Fourth (Jan)	DB 104 and DB 104L	2:1
	DB 105	2:0
	DB 106	3:0
	DB 107	2:0
	DB 108	2:0
Fifth (Aug)	DB 109	0:2
	DB 110	0:2
Sixth (Jan)	DB 111	0:2
	DB 112	0:2
Seventh (Aug)	DB113	0:2
	DB114	0:6
Eighth (Jan)	DB115	0:16

### *NEW UG COURSES IN BIOLOGY*

#### **First semester (AUG)**

##### **DB 101 and DB 101L (AUG) 2:1**

##### **DB 101: Introductory Biology-I (Life on Earth and Evolution of Diversity)**

Cell as a unit of living organisms, cellular organelles: Structure and function, organization of cytoskeleton and nuclei, ER-Golgi modifications, Vesicle-mediated protein transport, endocytosis and exocytosis, mitochondria and respiration. Cell permeability, transport across membranes: facilitated diffusion, active transport and receptor mediated. Basic introduction to the study of evolution and animal behaviour, evidence for evolution, the theory of natural selection, introduction to ethology, evolution of behaviour, levels of natural selection, social life in animals, insect societies, human behaviour. Ecology of populations, resources and intra-specific competition, life histories, populations and metapopulations. Ecology of species interactions, Inter-specific competition, Predation, Parasitism, mutualism and other species interactions. Ecology of communities, Patterns and drivers of species diversity, food webs and trophic interactions. Ecology of ecosystems; Biogeochemical cycles, ecosystem structure, function and services, climate change and impacts. Diversity of Life, a brief survey of biological diversity (Tree of life). Animal diversity and life histories. Plant diversity and life histories.

### **DB 101L**

Light Microscopy, sample preparation and examination, identification of microorganisms, staining techniques (Gram's, Acid fast), fluorescence microscopy to examine intracellular compartments, Cell fractionation and centrifugation methods, isolation of intracellular compartments by differential centrifugation techniques, nuclei, mitochondria, RER etc. Basics of cell culture methods: cell counting, culture media preparation. Sampling of animal behavior. Estimating species diversity of plant and animal taxa. Estimation of animal populations. Methods of estimating soil nutrients. Identification of plant and animal families. Experiments relating to the general concepts covered in the theory class.

### **Second semester (JAN)**

#### **DB 102 and DB 102L (JAN) 2:1**

#### **DB 102: Introductory Biology-II (Elementary Biochemistry, Molecular Biology and Genetics)**

Concepts of pH/pKa, structures of water, amino acids, peptides and proteins; chemistry of DNA, RNA, proteins, lipids and carbohydrates; elementary enzymology and molecular biology (central dogma, replication, transcription, genetic code and translation); examples of post-transcriptional and post-translational modifications; genetic methods of gene transfer in bacteria; Mendelian genetics (segregation and independent assortment), sex determination and sex linkage in diploids; cytoplasmic inheritance; pedigrees, markers and mapping; genetic disorders; gene frequencies and equilibrium; Hardy-Weinberg principle, and introduction to various model organisms.

#### **DB 102L**

Titration of amino acids, estimations of reducing non-reducing sugars, proteins, DNA, RNA, lipids, paper chromatography/TLC, SDS-PAGE, isoelectric focusing, DNA melting curves, PCR analysis, preparation of bacterial competent cells, transformation, transduction, conjugation,  $\beta$ -galactosidase assay, Drosophila crosses using red eye and white eye mutants, observation of Barr body in buccal mucosa cells, and karyotyping using human metaphase plate photos.

### **Third semester (AUG)**

#### **DB 103 and DB 103L (AUG) 2:1**

#### **DB 103: Introductory Biology-III (Microbiology, Immunology and Neurobiology)**

The microbial world and the five kingdom concept, growth and sporulation, and some organism of special interest; plant and animal viruses, classification, life cycle, assays, structure, replication, latency and persistence; viruses of special interest and viral diseases; microbes and diseases: tuberculosis, malaria, leishmaniasis, giardiasis; control of microorganisms: physical and chemical agents, antibiotics, antiviral agents;

host-microbe interaction: infection and host defense mechanisms; microbial toxins; environmental microbiology: food microbiology; aquatic microbiology, soil microbiology; and microorganism in biotechnology. Introduction to the immune system, innate immunity – the players and the mechanism, adaptive responses, BCR and immunoglobulins, T cell activation and differentiation, MHC, immune deficiencies and hyperactivation (allergies, autoimmunity, HIV), vaccines and evolution of the immune system. Overview of the nervous system (from neuron to brain), ionic basis of resting membrane potential and action potentials, neurotransmitters and neuromodulators, second messengers, birth of neurons, brain wiring and critical periods, sensation and perception: vision, hearing, taste and smell, touch and pain, motor system, memory systems and synaptic plasticity, neural basis of cognition: attention, and language; disorders of the brain.

### **DB 103L**

Bacterial plating, transformation, tests for antibiotic resistance, zone of inhibition, bacterial auxotrophs, M13 infection, plaque assay BOD and COD of water samples; Observation of immune organs and isolation of cells from lymph node, spleen and thymus. FACS staining of immune cells. Lymphocyte and macrophage activation studies, nitrite detection and cytokine ELISA. Isolate sera from rabbits and determine the titre of Igs using ELISA, using unimmunized and immunized sera. Study of Neuroanatomy (dissection of vertebrate nervous system: rodent mammalian brain and cranial nerves). Tissue sectioning techniques (microtomy and cryostat-demonstration). Brain slice culture techniques (Hippocampal and slice cultures. Theory and demonstration of imaging neurons in living brain slices and primary neuronal culture (Preparation of primary neuronal cultures from different regions of the mouse brain.

### **Fourth semester (JAN)**

#### **DB 104 and DB 104L (JAN) 2:1**

##### **DB 104: General Biochemistry (Enzymes and intermediary metabolism)**

Introduction to enzymes – molecular properties, classes of enzymes, functions of enzymes etc.; physico – chemical properties of enzymes – specificity, selectivity and stereospecificity; kinetic properties of enzymes, enzyme inhibition, allostery, enzyme regulation; compartmentalization of biochemical reactions; introduction to metabolism; examples of evolutionary metabolic relationships across phyla and kingdoms; general principles of metabolism; metabolism of carbohydrates, fats, lipids and other food types; interrelationships between metabolic pathways; catabolism and anabolism; metabolism and bioenergetics; thermodynamic principles of energetic; energy flux and contribution from fundamental reactions involving different chemical compounds; synthesis of high energy molecules - oxidative phosphorylation and electron transport; introduction to photosynthesis, light reaction, dark reaction, carbon fixation; Comparison of photosynthetic organisms and ecological niches they occupy.

### **DB 104L**

Purification of enzymes – wheat germ acid phosphatase and enzyme activity; estimation of kinetic parameters of enzymes; redox reactions using electrochemical methods; redox couples in the TCA cycle along with donor acceptor groups will be experimented with electrochemically and enzymatically; identification of key metabolites in metabolic pathways; isolation of chlorophyll pigments and their physicochemical characterization.

### **DB 105 (JAN) 2:0**

#### **Developmental Biology**

Animal development: Introduction, history and concepts of developmental biology; the current understanding on the mechanisms of development of organisms using vertebrate (mouse, chick, frog, fish) and invertebrate (fly, worm) models; how does a complex, multicellular organism arise from a single cell; the beginning of a new organism (fertilization), the creation of multicellularity (cellularization, cleavage), reorganization into germ layers (gastrulation), cell type determination; creation of specific organs (organogenesis); molecular mechanisms underlying morphogenesis and differentiation during development; stem cells and regeneration; evolution of developmental mechanisms. Plant development: structure of plant body; fundamental differences between animal and plant development; embryogenesis – classical and modern views using *Fucus* and *Arabidopsis* as models; axis specification and pattern formation in angiosperm embryos; organization and homeostasis in the shoot and root meristems; patterning in vegetative and flower meristems; growth and tissue differentiation in plants; evolution of developmental mechanisms in plants.

### **DB 106 (JAN) 3:0**

#### **Introductory structural biology**

Structure and function in biology, small and large molecules of living cells, molecular conformation, basics of protein structure and folding, nucleic acid structure and organization, membrane structure and transport, oligosaccharide structure; structural biology related to metabolic pathways, and structural biology in gene expression, DNA replication, transcription, translation, protein folding and degradation, and membrane proteins.

### **DB 107 (JAN) 2:0**

#### **Fundamentals of Cell Biology**

Formation of cells from molecules and organisms from cells; Structural and functional differences and similarities between Prokaryotes and Eukaryotes; Plasma Membrane – composition, structure, and function; Structure and functions of the nucleus and its components; Mitochondrion, chloroplasts, and eukaryotic cell organelles – structure and function; Cell growth and division in bacterial, yeast systems, and eukaryotes; Structure and function of cytoskeleton in prokaryotes and eukaryotes; Cell adhesion, cell junctions, and extracellular matrix; Signaling in prokaryotic and eukaryotic cells;– Structure, function, and interactions of the cells, organs, and molecules of the immune

system; Stem cells – definition, different types, properties, sources, and use of stem cells.

### **DB 108 (JAN) 2:0**

#### **Introductory Physiology**

*Mammalian physiology*: introduction to physiology, the cell and general physiology, internal environment, control of cell function, membrane transport, Cardiovascular physiology, the heart and circulation, Renal physiology, body fluids and kidneys, urine formation by the kidneys, Cell signalling and endocrine regulation, hormonal regulation of energy metabolism, hormonal regulation of calcium metabolism, hormonal control of reproduction in males and females, pregnancy and lactation. *Plant physiology*: plant cell structure and cell wall, water uptake, photosynthesis and photorespiration, secondary metabolites, phytochrome and light signaling, hormone signaling in plants, control of flowering, stress physiology.

### **Fifth semester (Aug):**

### **DB 109 (AUG) 0:2**

#### **Experiments in Microbiology**

Storage of bacteria and its revival. Bacterial growth curve by OD and CFU analysis. Identification of Bacteria (Gram staining, acid fast staining, biochemical tests, colony morphology). Structural stains (endospore, capsule, flagella). Motility studies. Isolation and identification of microbes from different sources. Visualization of bacteria by electron microscopy. Genetic crosses using *Neurospora*. Tetrad analysis using *S. cerevisiae*. Transformation of bacteria with reporters like luciferase,  $\beta$ -galactosidase and reporter assays. Creating knockouts in *E. coli* and *Salmonella* by using one step deletion strategy and their confirmation. Bacteriophage infection and determination of plaque forming unit. Growth and analysis of static biofilms. Infection of cell lines by bacteria and assessing their intracellular replication. Infection of mouse by different routes (i.v., i.p., s.c., oral). Establishment of animal models by studying the bacterial burden in various organs like spleen, liver, mesenteric lymph nodes.

### **DB 110 (AUG) 0:2**

#### **Experiments in Biochemistry**

Plasmid and genomic DNA isolation, restriction digestion of DNA, PCR, cloning of genes, expression and purification of recombinant proteins. Immunization of rabbits for raising antibodies to antigens, purification of immunoglobulin G from rabbit antiserum by various methods, characterization of antibodies by immunoassays: solid phase / liquid phase/western blotting, labeling of proteins, quantitation of proteins using immunoassays.

## **Sixth semester (Jan):**

### **DB 111 (JAN) 0:2**

#### **Experiments in Molecular Biophysics**

Comparison of native and unfolded states of proteins by spectroscopic methods such as CD, Fluorescence and NMR. Estimation of melting temperature. Analysis of protein structure by Circular Dichroism. Mass Spectrometry based sequencing of peptides. Crystallization of proteins. Acquisition and Interpretation of protein NMR spectra. Estimation of protein - ligand binding constants by titration calorimetry. Estimation of protein - ligand binding constants by Fluorescence. Analysis of cooperative and non-cooperative phenomena by Scatchard plot analysis, time resolved fluorescence and Atomic Force Microscopy.

### **DB 112 (JAN) 0:2**

#### **Experiments in Molecular Reproduction, Development and Genetics**

Animal cell culture: adherent and suspension, monitoring cell growth and doubling time. Tissue processing, sectioning, histochemistry and immunohistochemistry. Radioimmunoassay, receptor-ligand interactions. Selected experiments in developmental biology.

## **Seventh semester (Aug):**

### **DB 113 (JAN) 0:2**

#### **Experiments in Neuroscience**

Theory and demonstration of stereotactic surgery (rat stereotactic surgery for inserting an electrode into specific hippocampal regions. Sacrificing the animal and fixing the brain to visualize the electrode tract). Fixing brain slices and staining the slices to reveal the morphology and connections of the hippocampus). Transfection of cultures with a fluorescent marker and observation of the cells in culture). Experiment to demonstrate the development of the cerebral cortical layers\_(Injection of BrdU to the pregnant mother at different times during fetal development. Sacrifice the pup at birth. Sectioning of the mouse brain. Immunohistochemistry for BrdU and characterization of the different layers of the cortex by Nissl stain). Theory and demonstration of recording neuronal activity (Preparation and surgery for implanting electrodes in the barrel cortex of rat. Electrophysiological set up and recording of neural activity. Microstimulation of the motor cortex). Introduction into behavioral measurements and statistical analysis of behavioral data (Measurement of psychophysical thresholds. The effect of attention on psychophysical thresholds. Statistical methods for analysis of behavioral measurements. EMG and EEG demonstration).

### **DB 115 (AUG) 0:6**

#### **Student's independent Research Project**

The student would consult faculty labs in the division of Biological Sciences to carry out a research project.

**Eight semester (Jan):**

**DB 116 (JAN) 0:16**

**Research Project**

The student would consult faculty labs in the division of Biological Sciences to carry out a full term open ended research project.

**EXISTING COURSES WHICH MAY BE AVAILABLE TO UG-BIOLOGY  
STUDENTS (Minor and Major)**

***AUGUST SEMESTER***

**DB 202, General Biology, 2:0**

**DB 206 / MB 201, Introduction to Biophysical Chemistry, 2:0**

**BC 201, Cell Biology, 2:0**

**BC 202, Proteins: Structure and Function, 2:0**

**BC 204, Advances in Plant Biotechnology and Molecular Biology, 3:0**

**BC 206, Essentials in Immunology, 2:0**

**EC 301, Animal Behaviour: Mechanisms and Evolution, 2:1**

**EC 302, Plant–Animal Interactions (Ecology, Behaviour and Evolution),  
2:1**

**EC 304, Advanced methods in molecular phylogenetics, 1:0**

**MB 204, Molecular Spectroscopy and Structure, 3:0**

**MB 205, Introduction to X-ray Crystallography, 2:0**

**MB 206, Conformational and Structural aspects of biopolymers, 3:0**

**MB 207, DNA-Protein interaction, Regulation of gene expression,  
Nanobiology, 2:0**

**MB 209, Molecular Basis of Signal Propagation and Synaptic  
Transmission in Neurons, 3:1**

**MC 203/DB 203, Essentials in Microbiology, 3:0**

**MC 204/DB 214, Virology, 2:0**

**MC 205, Host-Pathogen interactions and immune evasion mechanisms,  
2:0**

**MC 206, RNA Biology, 2:0**

**MC 207/DB 211, Molecular Biology, 3:0**

**MC 208/DB 215, Principles of Genetic Engineering, 3:0**

**RD 201/DB 204, Genetics, 2:0**

**RD 203, Concepts in Endocrinology and Reproduction, 2:0**

**RD 204, Principles of Signal Transduction in Biological Systems , 2:0**

**CN 201, Introduction to Neuroscience, 3:0**

**SE 301, Bioinformatics, 2:0**

**SE 303, Chemoinformatics, 2:0**

## **JANUARY SEMESTER**

**DB 201, Mathematics and Statistics for Biologists, 2:0**  
**BC 205/MC 202, Molecular Genetics, 2:0**  
**BC 207, Proteomics, 2:0**  
**BC 208/RD 205, Human Molecular Genetics, 2:0**  
**EC 204/ DB 209, Evolutionary Biology, 2:1**  
**EC 305, Quantitative Ecology: models, research design, and inference, 2:1**  
**MB 208, Theoretical and computational neuroscience, 3:1**  
**MB 301, Protein Structure, Folding and Design, 2:0**  
**MB 302, Macromolecular Crystallography, 3:0**  
**MB 303, Elements of Structural Biology, 3:0**  
**MB 305, Biomolecular NMR Spectroscopy, 3:0**  
**MC 209, Biological Electron Microscopy, 2:0**  
**MC 210, Molecular Oncology, 2:0**  
**RD 202/DB 267, Gene Expression and Development, 2:0**  
**CN 301, Topics in Systems and Cognitive Neuroscience, 2:0**  
**CN 302, Topics in Molecular and Cellular Neuroscience, 2:0**  
**SE 302, Computational Approaches to Drug Discovery, 2:0**