

Biology

Semester I (AUG)

UB 101 and UB 101L (2:1)

UB 101: Introductory Biology- I (Organismal Biology and the Molecular Basis of Life)

Introduction to the world of living organisms; levels of biological organisation; diversity of life on earth; history and evolution of life on earth; mechanisms of evolution; genetic basis of natural selection; measuring the rate of natural selection; organisms and their environment; adaptation; behaviour and ecology; biological species diversity; environmental degradation, conservation and management; the future of life on earth.

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; Introduction to various model organisms. 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.

UB 101L

Methods of describing, observing, counting and estimating the abundance, diversity and behaviour of living organisms. Light Microscopy, sample preparation and examination, identification of microorganisms, staining techniques, 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. Titration of amino acids, estimations of reducing non-reducing sugars, proteins, DNA, RNA, lipids, paper chromatography/TLC, SDS-PAGE, isoelectric focusing, DNA melting curves.

Instructors: Raghavendra Gadagkar, Dipankar Chatterji

Suggested books:

1. Carson, R. *Silent Spring*, Fawcett World Library, New York, 1967.
2. Dawkins, R. *The Blind Watchmaker*, Longman Scientific & Technical, England, 1986.
3. R. Gadagkar, *Survival Strategies – Cooperation and Conflict in Animal Societies*, Harvard University Press and Universities Press, Cambridge, Massachusetts, USA and Hyderabad, India, 1997, 1998.
4. D. Sadava, D. M. Hillis, H. Craig Heller, M. Berenbaum, *Life, the science of biology*, W. H. Freeman, 9th edition, 2009.

5. Wilson, E. O. *The Future of Life*, Alfred A. Knopf, 2002.
6. Wilson, E.O. Life on Earth. Freely available at: <http://eowilsonfoundation.org/e-o-wilson-s-life-on-earth>
7. H. Lodish, A. Berk, C. A. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira, *Molecular cell biology*, W.H. Freeman, 6th edition, 2008.
8. J. E. Krebs, E. S. Goldstein & S. T. Kilpatrick, *Lewin's Genes X*, Jones and Bartlett Publishers, 10th edition, 2011.
9. D. L. Nelson, M. M. Cox, *Lehninger Principles of Biochemistry*, W.H.Freeman, 5th edition, 2009.
10. J. M. Berg, J. L. Tymoczko, L. Stryer, *Biochemistry*, W.H.Freeman & Co., 6th edition, 2006.
11. D. Voet, J. G. Voet, *Biochemistry*, Wiley, 4rd edition, 2010.

Semester 2 (JAN)

UB 102 and UB 102L (2:1)

UB 102: Introductory Biology- II (Microbiology, Molecular Biology and Genetics)

Introduction to the microbial world and its diversity; importance of microbes in exploration of basic principles of biology; bacterial growth and its modulation by nutrient availability in the medium; structure and function of a bacterial cell; structure of cell wall; isolation of auxotrophs; life cycles of temperate and lytic bacteriophages, structure and function of extra-chromosomal elements and their applications in molecular microbiology. 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); introduction to polytene and lampbrush chromosomes; sex determination and sex linkage in diploids; cytoplasmic inheritance; pedigrees, markers, mapping and genetic disorders; gene frequencies and Hardy-Weinberg principle, and introduction to various model organisms.

UB 102L

Light microscopy, identification of microorganisms, staining techniques (Gram's, acid fast), bacterial plating, tests for antibiotic resistance, M13 infection, plaque assay, preparation of bacterial competent cells, transformation, transduction, conjugation, β -galactosidase assay, Drosophila crosses using red eye and white eye mutants, observation of Barr body in buccal mucosa cells, preparation of mitotic/polytene chromosomes from Drosophila larvae, and karyotyping using human metaphase plate photos.

Instructors: Umesh Varshney, Arun Kumar

Suggested books:

1. J. M. Berg, J. L. Tymoczko, L. Stryer, *Biochemistry*, W. H. Freeman & Co., 6th edition, 2006.
2. R. Y. Stanier, E. A. Adelberg, J. L. Ingraham, *General Microbiology*, MacMillan Press, 5th edition, 2007.
3. M.W. Strickberger, *Genetics*, Prentice-Hall, India, 3rd edition, 2008.
4. Daniel Hartl, *Essential Genetics: A genomics perspective*, Jones & Bartlett 3rd edition, 2002
5. T. Strachan, A.P. Read, *Human Molecular Genetics*, Garland Science, 3rd edition, 2004.

Semester 3 (AUG)

UB 201 and UB 201L (2:1)

UB 201: Introductory Biology-III (Cell Biology, Immunology and Neurobiology)

Eukaryotic cells and organelles, cell membranes and cell function. Introduction to animal viruses with examples, life cycle and host-virus interactions. Introduction to the immune system – the players and mechanisms, innate immunity, adaptive responses, B cell receptor and immunoglobulins, T cell activation and differentiation and Major Histocompatibility Complex encoded molecules. Overview of the nervous system (from neuron to brain), ionic basis of resting membrane potential and action potentials, neurotransmitters, neuromodulators and second messengers, motor systems, neural basis of cognition: attention, and language and disorders of the brain.

UB 201L

Animal cell culture and microscopy, Immune organs and isolation of cells from lymph node, spleen and thymus. Lymphocyte and macrophage activation studies, nitrite detection, ELISA and cell cycle analysis. Gross anatomy of the human brain; staining of mouse brain sections; generation of action-potential; psychophysical and cognitive neurobiology experiments.

Instructors: Dipankar Nandi, Saumitra Das, Shyamala Mani

Suggested Books:

1. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira, *Molecular Cell Biology*, W. H. Freeman; 6th edition, 2007.
2. Bruce Alberts, *Molecular Biology of the Cell*, Garland Science, 5th edition, 2008
3. T. Kindt, R. Goldsby, B. A. Osborne, *Kuby Immunology*, W. H. Freeman, 6th edition, 2006.
4. David M. Knipe, Peter Howley, *Fields Virology*, Lippincott Williams & Wilkins, 6th edition, 2013.

5. M. Bear, B. Connors, M. Paradiso, *Neuroscience: exploring the brain*, Lippincott Williams & Wilkins, 3rd edition, 2006.

Semester 4 (JAN)

UB 202: General Biochemistry (2:0) (Core course for BIO major and minor)

Basic concepts of enzymes and enzyme kinetics, allosteric proteins, catalytic strategies, regulatory strategies of enzymes, basic concepts of metabolism and its design, catabolism and anabolism, energy generation and storage, glycolysis, citric acid cycle, oxidative phosphorylation, pentose phosphate pathway, gluconeogenesis, glycogen metabolism, fatty acid metabolism, amino acid degradation and urea cycle, biosynthesis of membrane lipids and steroids, biosynthesis of amino acids and heme, biosynthesis of nucleotides, integration of metabolism, photosynthesis.

Instructors: D. N. Rao and Siddhartha Sarma

Suggested Books:

1. D. Voet, J. G. Voet, *Biochemistry*, Wiley, 4rd edition, 2010.
2. J. M. Berg, J. L. Tymoczko, L. Stryer, *Biochemistry*, W. H. Freeman & Co., 6th edition, 2006.

UB 203: Introductory structural biology (3:0) (Core course for BIO major)

Structure and function in biology, small and large molecules of living cells, molecular conformation, Stereochemistry of peptides, basics of globular protein structure and folding, Hierarchical organization of protein structures, solvent accessibility and hydrophobicity. Comprehension and analysis of protein structures, evolution of protein structures, protein folding and stability, membrane proteins, nucleic acid structure and organization.

Instructors: M. R. N. Murthy and N. Srinivasan

Suggested Book:

1. A. Liljas, L. Liljas, J. Piskur, G. Lindblom, P. Nissen, M. Kjeldgaard, *Textbook Of Structural Biology*, World Scientific Publishing Company, 2009.

UB 204: Introductory Physiology (2:0) (Core course for BIO major)

Mammalian physiology: Introduction to physiology, internal environment, control of internal environment by feedback systems, 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.

Instructors: Rajan Dighe, C. Jayabhaskaran, R. Medhamurthy

Suggested Books:

1. J. E. Hall, *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 12th edition, 2011.
2. J. L. Jameson, L. J. De Groot, *Endocrinology*, Elsevier, 6th Edition, 2010.
3. L. Taiz, E. Zeiger, *Plant Physiology*, Sinauer Associates, 5th edition, 2010.

UB 205L: Experiments in Biochemistry and Physiology (0:2) (Core course for BIO major)

Expression of recombinant proteins, purification and characterization. Isolation and characterization of proteins, quantitation of proteins using biochemical assays and physico-chemical characterization of proteins. Purification of Immunoglobulin G from rabbit antiserum. Characterization of antibodies by immunoassays: solid phase, liquid phase and Western blotting. Enzyme assays and determining specific activity of enzymes.

Instructors: Anjali Karande and Rajan Dighe

UB 206: Basic Molecular Biology (2:0)

Genes as carriers of heredity, gene-enzyme relation, spontaneous versus adaptive mutations: origins of bacterial genetics, the transforming principle and the chemical identity of the gene, DNA and heredity, biochemistry of DNA, Chargaff's rule, early models of DNA structure, the double helix and the origins of molecular biology, alternative structures of DNA, unidirectional flow of genetic information - The Central Dogma, the coding problem - elucidation of the genetic code, confirmation of DNA as the genetic material, models for replication of DNA. Gene organization in bacteria: operons and regulons, structure of bacterial promoters, RNA polymerase and initiation of transcription, repressors and activators, restriction-modification systems in bacteria, DNA topology and its homeostasis, DNA repair mechanisms, developmental systems in prokaryotes - lysogeny and sporulation. Chromosome organization in eukaryotes: histones and nucleosomes, gene regulation in eukaryotes: transcription factors and

enhancers, histone modification and epigenetics, gene expression during development, regulation mediated by RNA, molecular evolution, genomics.

Instructor: S. Mahadevan

SuggestedBooks:

1. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, *Molecular Biology of the Gene*, 7th edition, Benjamin-Cummings Publishing Company, 2013
2. G. Stent and R. Calendar, *Molecular Genetics: An Introductory Narrative*, 2nd edition, W H Freeman & Co, 1978

Semester 5 (AUG)

UB 301L: Experiments in Microbiology and Ecology (0:2) (Core course for BIO major)

There are two sets of hand on experiments for Biology majors: In the first part, students will get a hands-on experience in understanding the basic concepts in microbiology. The topics include the microbial growth curve, microbial nutritional requirements, genetic engineering techniques, plasmid isolation, creation of genetic knock out in bacteria, bacterial infection in cell culture system, estimation of infection by colony forming unit (CFU) analysis and fluorescence technique.

In the second part, students will explore key concepts in Ecology, Evolution and Behavior through field observations, manipulative experiments and computer simulations. Topics will include diversity and distributions of organisms, competition and predation, species interactions, mate choice, optimal foraging theory, plant and animal communication, learning and memory, evolutionary evidence and the fossil record, variation and heritability, natural and sexual selection, genetic drift.

Instructors: Dipshikha Chakravorty and Maria Thaker

UB305 and UB305L (2:1)

UB305 GENETICS

Evolution of genetics: genes to genomics; an overview of model systems; Mendelism; extensions of Mendelism; evolution of the concept of gene; an overview of genetic chemistry; transcriptional, post-transcriptional and translational regulation in prokaryotes and eukaryotes; genetic recombination and repair; mobile genetic elements in prokaryotes and eukaryotes; epigenetics; molecular basis of sex determination and dosage compensation in *Caenorhabditis*, *Drosophila* and human; population genetics; DNA recombination technology; genome genetics.

UB305L

Practicals with genetic stocks of *Drosophila*. (1) Genetics of mutants: a) *Drosophila* (b) Zebra fish (c) *Arabidopsis*. (2) Chromatographic analysis of eye pigments in the mutants of *Drosophila* (3) Mitotic (human), meiotic (mouse/grasshopper) and polytene chromosomes (*Drosophila*) (4) Collection of *Drosophila* species from wild/nature to study sympatric diversity of species and pattern of genetic variability. (5) Experiments to demonstrate different patterns of inheritance: genetic crosses and analysis of P1, P2, F1, F2 & test cross progeny: (6) Generation of New mutations in *Drosophila* – this will go till the end of Course – students need to characterize a mutation based on what they learn in theory and practical classes. (7) Experiments on natural selection and genetic drift (8) Quantitative characters: acrostichals and sternopleurals bristles in *Drosophila*: mean, standard deviation, t-test (9) Experiments with genome - nucleic acids: isolation of genomic DNA, restriction digestion profiles, PCR

Instructor: H. A. Ranganath

Suggested Books:

1. Griffiths A.J.F., Wessler S.R., Carroll S.B. and Doebley J. 2012. Introduction to Genetic Analysis, W.H. Freeman and Company.
2. Pierce BA 2012 Genetics: A Conceptual Approach. W.H. Freeman Palgrave MacMillan.

Semester 6 (JAN)

UB 302 (formerly UB 204): Developmental Biology (2:0) (Core course for BIO major)

Introduction, history and concepts of developmental biology; the current understanding on the mechanisms of development using model organisms including invertebrates, vertebrates and plants; general principles for the making of a complex, multicellular organism from a single cell; the creation of multicellularity (cellularization, cleavage), reorganization into germ layers (gastrulation), cell type determination; creation of specific organs, (organogenesis); molecular mechanisms underlying morphogenetic movements, differentiation, and interactions during development; fundamental differences between animal and plant development; embryogenesis in plant – classical and modern views; 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; stem cells and regeneration; evolution of developmental mechanisms.

Instructors: Usha Vijayraghavan, Upendra Nongthomba, Utpal Nath

Suggested Books:

1. L. Wolpert, C. Tickle, *Principles of development*, Oxford University Press, 4th edition, 2010.
2. S. F. Gilbert, *Developmental Biology*, Sinauer Associates, 9th edition, 2010.
3. J. M. W. Slack, *Essential Developmental Biology*, John Wiley & Sons, 3rd edition, 2012.
4. Leyser, S. Day, *Mechanisms in Plant Development*, Willey-Blackwell, 2003.
5. L. Taiz, E. Zeiger, *Plant Physiology*, Sinauer Associates, 5th edition, 2010.
6. Bruce Alberts, *Molecular Biology of the Cell*, Garland Science, 5th edition, 2008.

UB 303L: Experiments in Molecular Biophysics (0:1) (Core course for BIO major)

UV spectroscopy of proteins (quantitation and determination of extinction coefficient). Fluorescence spectroscopy of proteins. UV spectroscopy of DNA (determination of melting temperature and influence of buffer composition). CD spectroscopy of proteins and calculation of helical contents. CD spectroscopy of DNA and monitoring conversion of B-form DNA [poly(dG-dC)] to Z-form DNA in high salt. Mass spectroscopy of proteins (determination of mass and MS-MS analysis). Study of protein oligomerization by dynamic light scattering. Estimation of free sulfhydryl groups in proteins by DTNB titration and its validation by mass spectroscopy and iodoacetamide labeling.

Instructors: Dipankar Chatterji and Siddhartha Sarma

UB 304L: Experiments in Neurobiology (0:1)

The vertebrate nervous system and its organization. Theory and demonstration of stereotactic surgery in rodents. Demonstration of tissue sectioning techniques. Preparation of primary neuronal cultures and imaging neurons. Theory and demonstration of neuronal activity. Introduction to behavioral measurements and statistical analysis.

Prerequisite: NS201 (AUG) 3:0

Instructors: Vijayalakshmi Ravindranath and Shymala Mani

Semester 8 (JAN)

UB 400: Research Project (0:16)

An independent research project will be performed by all UG-Biology major students under the supervision of faculty. It is recommended that students initiate laboratory work during the summer break post completion of the sixth semester. The progress of the project will be monitored at the end of the seventh semester. The submitted project

report will be graded before the end of the eight semester as follows: faculty assessment (30% marks), independent referee (30% marks) and presentation (40%). Based on the student's performance, the final grade will be determined.

Instructors: Faculty members in the Division of Biological Sciences, IISc

ADDITIONAL COURSES IN SEMESTERS 5, 6, 7 and 8:

Please see courses listed in the Scheme of Instruction for postgraduate students and select appropriate courses in consultation with the faculty advisor and UG-Biology Coordinators.