PGET Syllabus for MSc. Bioinformatics

1. GENERAL SCIENCE

Physics

Laws of thermodynamics, entropy, enthalpy, Gibbs free energy. Heat transfer: conduction, convection, radiation. Ideal and real gases, equations of state. Concept of entropy in biological and computational systems. Basics of light and optics (relevant to microscopy).

Chemistry

Acid-base chemistry, pH, buffer systems. Thermodynamics and kinetics: reaction rates, energy changes. Molecular structure, hybridization, chemical bonding. Nucleophilic substitution reactions: SN1 & SN2. Equilibrium and Le Chatelier's Principle.

2. BIOLOGICAL SCIENCES

Biochemistry

Structure and function of biomolecules: proteins, nucleic acids, carbohydrates, lipids. Enzyme kinetics, inhibition, and regulation (competitive, non-competitive). Bioenergetics: ATP, redox reactions. Photosynthesis, photorespiration, oxidative phosphorylation. Techniques: chromatography, spectrophotometry, electrophoresis.

Cell and Molecular Biology

Cell structure: organelles, membranes, transport systems. Cell division: mitosis and meiosis. DNA/RNA: structure, replication, transcription, translation. Transcription regulation, mRNA processing, genetic code. DNA repair mechanisms; chromatin structure and epigenetics.

Genetics & Developmental Biology

Mendelian and non-Mendelian inheritance. Gene and genome organization. Linkage, recombination, genetic mapping, Mutation types, mutagens, population genetics. Human genetic disorders. Developmental biology: gametogenesis, fertilization, embryogenesis.

Immunology

Innate vs. adaptive immunity. Cells of the immune system. Antigen-antibody interactions. Immunoglobulin structure and function. Vaccines and immunological memory.

Physiology and Bioenergetics

Cellular respiration and metabolic pathways: glycolysis, TCA cycle, PPP, ETC. Photosynthesis and Z-scheme (light and dark reactions). Transport across membranes: passive, active, symport, antiport. Gaseous exchange, osmosis, thermoregulation.

3. BIOTECHNOLOGY & MOLECULAR TECHNIQUES

Recombinant DNA Technology

Cloning vectors: plasmids, phages, cosmids, YACs, BACs. Restriction enzymes, ligases, modification enzymes. PCR: principle, types, and applications. Gene cloning, transformation, selection, screening.

Instrumentation & Techniques

Microscopy (light, fluorescence, electron). Centrifugation, filtration, ultrafiltration. UV-Vis Spectroscopy, NMR, Mass Spectrometry, Chromatography: TLC, HPLC, GC. Electrophoresis: agarose, SDS-PAGE. Blotting techniques: Western, Southern, Northern.

4. MICROBIOLOGY & ENVIRONMENTAL BIOTECHNOLOGY

Microbial Biology

Structure, growth, and classification of microbes. Microbial metabolism (aerobic & anaerobic). Genetic mechanisms: plasmids, conjugation, transformation, transduction. Host-pathogen interactions. Industrial applications: fermentation, enzyme production. Role of microbes in health and disease.

Environmental Biotechnology

Biodiversity: concepts, conservation, hotspots. Bioprospecting, biopiracy, biosafety. Bioremediation and biofertilizers. Waste management: composting, vermiculture. GMOs and ethical concerns. Sustainable biotechnology and environmental impact

5. BIOINFORMATICS & COMPUTATIONAL BIOLOGY

Bioinformatics Fundamentals

Biological databases: NCBI, EMBL, UniProt, PDB, KEGG. Sequence file formats: FASTA, GenBank. Sequence alignment: pairwise (Needleman-Wunsch, Smith-Waterman), multiple (ClustalW, MUSCLE). Homology and phylogenetics. BLAST, PSI-BLAST, scoring matrices (PAM, BLOSUM). Protein structure: primary to quaternary levels, domain analysis. Protein modeling, docking basics.

Mathematics, Statistics & Computer Science

Sets, probability, statistics (mean, SD, p-value, t-test, chi-square). Linear algebra basics: matrices, vectors. Data interpretation and visualization. Basics of algorithms and data structures. Introductory programming: Python, R, or Perl (loops, functions, file I/O).