

BIOLOGY I

Course content • Academic year 2026–2027

Year 1 • Semester 1 • Compulsory course • Duration: 13 weeks

Teaching methods

Activity	Format and focus
Lectures	3 hours/week
Tutorials	Deeper understanding, clinical applications and clarification of questions
Laboratory practicals	Practical skills (bioinformatics, microscopy, subcellular fractionation)
Small-group teaching	Deeper understanding, critical thinking skills, literature searches and critical scientific writing

Lecture topics

Topic	Content
Introduction	Introduction to molecular and cell biology. Origin of life and evolution. The common ancestor of all living organisms and the three domains of life. Life at the cellular level: the flow of genetic information and the central dogma. General characteristics of cells. Microscopy. Introduction to the morphology of prokaryotic and eukaryotic cells. Similarities and diversity of cells. Subcellular ultrastructure; cell organelles: morphology, composition and function. Emergent properties of living matter. Evolutionary conservation of DNA and proteins; phylogenetic trees. Homologous proteins. Approaches to studying biological systems. Model organisms. Proteins: from structure to function. The importance of correct folding; molecular chaperones. Principles of protein function regulation. Post-translational modifications (phosphorylation, methylation, acetylation and ubiquitination). Binding and hydrolysis of nucleoside triphosphates. Protein machines.
DNA as the genetic material: structure and expression	DNA: DNA structure, structural and functional properties, and its role as the genetic material. Structure of prokaryotic and eukaryotic genes; roles of their individual structural and functional components. Flow and decoding of genetic information. Gene transcription: prokaryotic operons, eukaryotic genes, mechanisms and factors, processing of the primary transcript, RNA splicing in eukaryotic cells and production of mature mRNA. The genetic code. mRNA translation: structural and functional components and mechanism. The ribosome. Protein degradation. Functional properties of RNA and its evolutionary history.
Chromosomes and the regulation of gene expression	Structure, morphology, organisation and function of eukaryotic chromosomes. Concepts of chromatin, euchromatin and heterochromatin. Human chromosomes. Chromosomes and mechanisms regulating gene expression. The molecular profile of a eukaryotic cell. Differential gene expression. Activators and repressors; regulatory elements. Transcription factors. Nucleosomes. Histone modifications and the histone code. Molecular switches. Cell specialisation. Epigenetic regulation. Cellular “memory”.
DNA replication, DNA damage and repair mechanisms; genome editing and CRISPR	Replication, the asymmetric replication fork, Okazaki fragments, the primosome and RNA primers, composition and function of the replication machinery, and proofreading by DNA polymerase. Roles of topoisomerase and telomerase. Primary alterations (damage) to DNA structure; endogenous and exogenous factors causing DNA damage; types of damage. DNA repair mechanisms and the relationship between the type of damage and the repair mechanism. Formation of mutations and their consequences. Genome editing, CRISPR.

Topic	Content
Intracellular compartments and transport	Cell compartmentalisation, intracellular transport, membrane-bound organelles as part of the endomembrane system, protein sorting and signal sequences, vesicular transport, vesicle recognition and fusion, protein secretion pathways, the Golgi apparatus as a sorting centre for exocytosis, the endosome as a sorting centre for endocytosis, intracellular trafficking of substances, and protein quality control.
The cytoskeleton	The cytoskeleton and the internal organisation of the cell. Protein filaments: actin filaments, microtubules and intermediate filaments; their roles in the cell (nuclear envelope, cell cortex, motor proteins, cilia, flagella, cell crawling, microvilli, muscle contraction). Links to diseases and drugs (laminopathies, epidermolysis bullosa, Taxol). Cell–cell junctions.
Cell communication	General principles of cell signalling. Endocrine, paracrine, autocrine, contact-dependent and neuronal signalling. Basic principles of cell signalling: types of signals, transmembrane and intracellular receptors, molecular switches, second messengers, phosphorylation cascades and resetting. Receptor types and signalling pathways, and their characteristics. Notch, steroid hormone receptors, NO, G protein-coupled receptors, cAMP, phospholipase C, the role of calcium ions in signal transduction, calmodulin and CaM kinases, enzyme-linked receptors, the MAP kinase pathway, and Ras.
Cell division, regulation of cell proliferation and apoptosis	Processes and mechanisms of cell division. Phases of mitosis, cytokinesis, the anaphase-promoting complex, and cohesins. Meiosis: biological significance and differences between mitosis and meiosis. Nondisjunction and aneuploidy. The cell cycle and its phases. The central cell-cycle control system: cyclin-dependent kinases and inhibitors. Cell-cycle checkpoints. The DNA damage response and the role of p53. Cell-cycle exit and the role of pRb. Programmed cell death/apoptosis. Caspases, the apoptosome, cytochrome c, and pro-apoptotic and anti-apoptotic proteins of the Bcl-2 family.
Tissues, stem cells and regeneration	How cells form tissues. Extracellular matrix, basic lamina, collagen, laminin, proteoglycans. Ehlers-Danlos syndrome. Cell junctions, tight junctions, gap junctions, cadherins, desmosomes, adherens junctions. Attachment to the extracellular matrix, integrins, hemidesmosomes, focal adhesions, leukocyte adhesion deficiency. Embryonic stem cells and development, stem cells and differentiation, tissue regeneration, induced pluripotent stem cells, clinical applications.

Instructors: Z. Lygerou, V. Roukos, I. Drosos, A. Kotini

Tutorials

Topic	Content
The eukaryotic cell and evolution	Structure and function of the eukaryotic cell. Basic subcellular organelles and the flow of genetic information. Evolution: diversity and shared characteristics, prokaryotes/eukaryotes, and viruses. Observing living matter (types of microscopy). The discussion is organised around the example of the SARS-CoV-2 life cycle.
Genes and gene expression	Structural and functional characteristics of genes. The role and evolution of nucleic acids. The flow and processing of genetic information and all control points from the nucleus to the cytoplasm. Regulation of gene expression: molecular mechanisms, factors and regulatory elements. Genes and the environment. Epigenetic regulation of gene expression.
Cell signalling	Cell signalling: discussion of signalling mechanisms and their significance for the physiology of the cell and the organism. The discussion is organised around two clinical examples: the EGF receptor and targeted therapies for colorectal cancer; the glucagon pathway and the regulation of blood glucose levels.

Topic	Content
The cell cycle	The cell cycle: understanding the mechanisms that ensure normal cell-cycle progression and regulation, and their importance for genome stability and the survival of the cell and the organism. The discussion is organised around two clinical examples: chromosomal instability in cancer cells and the use of paclitaxel (Taxol) in cancer treatment.
Tissues, stem cells and regeneration	Organisation of cells into tissues, stem cells, the use of stem cells in clinical applications. (examples), differentiation mechanisms and cell regeneration

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Laboratory practicals

Practical	Content
1. Microscopy and cell fractionation	Principles of operation and use of the light microscope. Methods of cell fractionation. Observation of specimens.
2. Bioinformatics applications	Introduction to biological databases. Bibliographic databases and databases of biological molecular sequences. Software for analysing nucleotide and amino acid sequences. Each student is trained in entering, storing and retrieving data in general and specialised databases, and in using bioinformatics software to analyse biological molecular sequences in response to biological questions.

Instructors: I. Drosos, A. Kotini

Technical support: Dr P. Karachalios

Small-group teaching

Topic	Content
Mutations and DNA repair mechanisms	What is a mutation? Mutations arise from DNA damage. DNA is a stable molecule. What types of damage does DNA sustain, and which factors cause them? Distinguishing between heritable and non-heritable mutations (germline and somatic mutations). How often does DNA damage occur? Which endogenous and exogenous factors generate mutations, and how? What are the main DNA repair mechanisms, and what type of repair does each perform? What are thymine dimers, how are they caused, and how are they repaired? Which enzymes play a role in repair mechanisms? Major repair pathways and the damage they repair. Which human diseases are associated with defects in repair mechanisms? The importance of repair mechanisms for both DNA stability and plasticity, and for both the preservation and evolution of species. The importance of genetic heterogeneity for genetic robustness. Teaching is organised around the clinical examples of xeroderma pigmentosum and familial breast cancer.
Academic study and scientific writing skills	Introduction to basic academic study and scientific writing skills: literature searches, preparing assignments, scientific writing, referencing, and academic integrity/plagiarism.

Instructors: V. Roukos, I. Drosos