**McDaniel Europe, Campus in Budapest**

**BIO 2100 – The Molecular Design of Life**

**Professor:** László Nyitray PhD DSc

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**Availability**
Before or after class time or by e-mail

**Course description**
Understanding life at the molecular level. Role of water, ions, small and macromolecules in life. Relationship of structure, function and complexity. Flow of information within the cell: from DNA to proteins. Flow of energy through living systems: role of ATP. Topics also include gene technology and molecular biology of cancer. The laboratory block includes "hands-on" basic biochemistry and molecular biology techniques.

**Required texts and materials**
Students are supposed to write **lecture notes** (lectures are the main source of exam questions). 26 pages of handout will be distributed to students.
Suggested books:
*Solomon et al.: Biology* (Seventh edition, 2005) Saunders College Publishing
Parts 1-3 (The Organization of Life, Energy Transfer Through Living Systems, The Continuity of Life: Genetics) covers most of the topics.
*Tobin & Dusheck.: Asking about Life* (Third ed., 2005) Thomson, Brooks/Cole

**Assignments & grading**
Course requirements: mid-term and final written tests (multiple-choice), one essay-type short research paper (min. 5 pages) and its presentation, and active participation in class discussions (including short quizzes).
Final grades are calculated based on: the mid-term written exam (25%), final written exam (25%), research paper (25%), class and laboratory activity (25%).

**Honor code**
Students are expected to adhere to the McDaniel College Honor Code.

**Course policies**
Attendance of classes is required and the College's policy of class attendance will be strictly enforced.

**Semester schedule/Topics covered**

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| Week 1 | Biology, science of life. The cell concept. Diversity of life. DNA: the carrier of genetic information. Proteins: life's workhorses |
| Week 2 | General chemistry. Importance of water. |
| Week 3 | Chemical composition of life. Hierarchy of molecular organization. Macromolecules: polysaccharides, lipids, proteins, nucleic acids. Viruses |
| Week 4 | Principles and origin of life. Thermodynamics of life. |
| Week 5 | Cellular organization of life – prokaryotes and eukaryots. |

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| Week 6 | Structure, function and regulation of proteins. Proteins of the immun- and nervous system. |
| **Week 7** | **MID-TERM EXAM** |
| Week 8 | Energy transfer through living systems. Role of ATP. Cellular respiration and photosynthsis. |
| Week 9 | DNA replication and repair. Mutations. The genetic code. Expression of genetic information: Transcription and translation. Genes and development. Molecular bases of cancer. |
| Week 10 | The cell cycle and cell division. Mitosis and meiosis. Principles of heredity. Mendel's laws. Human genetics. |
| Week 11 | The Human Genome Project. Recombinant DNA technology. Cloning of molecules and organisms. |
| Week 12 | "Hands-on" laboratory practices I. **DEADLINE TO SUBMIT AN ESSAY** |
| Week 13 | "Hands-on" laboratory practices II. |
| Week 14 | "Hands-on" laboratory practices III Presentation of essay papers |
| **Week 15** | **FINAL EXAM** |

- GENERAL CHEMISTRY. Atomic theory. Electrons and chemical reactions. Molecular and ionic compounds. Covalent and ionic bonds. Secondary (weak) bonds. The mole concept. Chemical equations, chemical equilibrium. Redox reactions, acids and bases.

- CHEMICAL BASIS OF LIFE. Elemental composition of life. Role of water. Hierarchy of molecular organization: Inorganic precursors, metabolites, building blocks, macromolecules, supramolecular complexes. Proteins, nucleic acids, polysaccharides, lipids: their complexity and their interactions.
- WHAT IS LIFE? Principles of life. Life as an open thermodynamic system. Energy, entropy and information. Metabolism. Self-reproduction. Growth, development, motility. Storage and flow of information. Variability and evolution. Origin of life. Diversity of life.
- CELLULAR ORGANIZATION OF LIFE. Prokaryotic and eukaryotic cells. Membranes and organelles. Nucleus, mitochondria, chloroplast, endoplasmic reticulum, Golgi complex, lysosomes. Ribosomes. The cytoskeleton. Cell types of multicellular organisms. Viruses as cell parasites.
- PROTEINS. Amino acids, peptide bonds, polypeptide chains. Four levels of structural organization. Conformation (shape) and function of proteins. Enzymes as chemical catalysts. Activation energy, active site, cofactors. Proteins in action: conformational changes, interactions and regulation
- ENERGY TRANSFER THROUGH LIVING SYSTEMS. Metabolism and energy transformations. Catabolism (energy-release) and anabolism (biosynthesis). ATP as energy currency. Aerobic and anaerobic respiration (fermantation). Glycolysis, citric acid cycle, electron transport chain, oxidative phosphorylation. Photosynthesis.
- DNA: THE CARRIER OF GENETIC INFORMATION. Evidence that DNA is the hereditary material. Nucleotides, the building blocks. The double helix. Base pairing rules. Semi-conservative DNA replication. DNA polymerases. Fidelity of DNA replication: mutations and repair.
- EXPRESSION OF GENETIC INFORMATION. The central dogma: DNA $\rightarrow$ RNA $\rightarrow$ proteins. Structure and function of RNAs. Transcription: RNA synthesis. The genetic code. Eukaryotic

genes: exons and introns. Translation: protein synthesis. Control of gene expression. Genes and development. Cell differentiation.

- PRINCIPLES OF HEREDITY. Chromosomes. Cell cycle. Mitosis and meiosis. Genetic recombination. Sexual reproduction. Gametes and zygote. Diploid and haploid cells. Mendels's laws. Locuses and alleles. Mono- and polygenic inheritance. The human genome. Human genetics. Chromosomal abnormalities. Genetic diseases. Genetic diagnosis and gene therapy. Polymorphism. The Human Genom Project.
- GENETIC ENGINEERING. Recombinant DNA technology. Molecular cloning. DNA sequencing. Polymerase chain reaction. Cloning from somatic cells. Transgenic organisms (GMOs). Recombinant proteins. Gene therapy.
- MOLECULAR BIOLOGY OF CANCER. Carcinogens and mutagens. Oncoviruses. oncogenes and tumor suppressor genes. Immortal cells. Treatments of cancer.
- MOLECULAR BASIS OF THE IMMUNE AND NERVE FUNCTION. Self and nonself. Antigenes and antibodies (immunoglobulins). Antibody diversity. Immune cells. AIDS. Nerve cells. Action potential as nerve impulse. Chemical synapses. Neurotransmitters. Alzheimer's dieseas
- "HANDS-ON" LABORATORY PRACTICES. Grow and harvest bacterial cells. Visualize DNA after agarose gel eletrophoresis. Work with recombinant DNA. Amplification of specific DNA sequences by polymerase chain reaction. Work with green fluorescence protein, a magic tool in cell biology. Visualization of atomic details of biomolecules (metabolites, drugs, nucleic acids, proteins)