**Syllabus for Advanced Biotechnology**

**Text: Biotechnology: Science for the New Millennium (2007) by Ellyn Daugherty**

**First Semester**

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| Chapter  Section | Lesson Objective | Key Concepts in Lecture/Discussion/Lesson |
| 1.1  1.2 | Defining Biotechnology  Biotechnology Products | * Biotechnology definition/description/domains * Examples of products and companies * Genetically engineered products |
| 1.3 | Selecting Potential Products | * Product Development Plan * Research and Development, manufacturing * Testing/clinical trials, regulation |
| 1.5 | Biotech Careers | * Types of Jobs/Careers * Educational Requirements |
| 1.6 | Bioethics | * Morals and ethics * Values Clarification Model for Decision-making |
| 2.1  2.2 | Organisms and their Parts  Cellular Organization | * Levels of biological organization * Prokaryotic versus eukaryotic cells * Model organisms and product manufacture * Cell structure and role in biotech, |
| 2.3 | Molecules of Cells  (2 class meetings) | * Survey of carbohydrates, lipids, proteins, and nucleic acids |
| 2.4 | The New Biotechnology | * Central Dogma of Biology * Recombinant DNA * Synthesis of genetically engineered products |
| 4.1 | DNA Structure and Function | * Double helix of nucleotide chains * Nitrogenous bases and base pairing * Semi-conservative replication * Protein synthesis |
| 4.2  4.3 | Sources of DNA  Isolating DNA | * Prokaryotic, eukaryotic, viral DNA * Gene expression * Media prep, bacterial cell culture, sterile technique * Vectors and rDNA technology * Transformation |
| 4.4 | Studying DNA using Gel Electrophoresis | * How a gel box separates molecules * Agarose gel electrophoresis * Data from agarose gels |
| 5.1 | Protein Structure Protein Function | * Protein functions * Importance of antibodies and enzymes |
| 5.2 | Protein Production | * Protein synthesis * Transcription, Translation |
| 5.3 | Enzymes | * Enzyme activity |
| 5.4  5.5 | Studying Proteins  Applications of Protein Analysis | * Polyacrylamide gel electrophoresis * Protein Indicators * Data from PAGE gels |
| 6.1  6.2 | Sources of Products  Product Assays | * Products from nature * Comprehensive Product Development Plan * Assays and their applications |
| 6.3 | Searching for New Products | * Herbal remedies, Rainforest products * Active ingredients * Antibiotics and antiseptics |
| 6.4  6.5 | Plant Products  Producing rDNA Products | * Plant protein products * Recombinant DNA Products |
| 8.1 | Steps in Genetic Engineering  (2 class meetings) | * Locating “genes of interest” * Restriction enzymes and recombinant DNA * Cloning and manufacturing |
| 8.2 | Transforming Cells  (2 class meetings) | * Transformation, transduction, and transfection * Making rDNA, endonucleases, and RFLPs * Performing a transformation, selection of transformants |
| 8.3 | After Transformation | * Scale-up of transformants * Products Assays |
| 8.4 | Fermentation, Manufacturing, and GMP | * Kinds of fermentation * Growing cultures, bacterial and mammalian cell culture * cGMP |
| 9.1 | Harvesting Protein Product | * Protein recovery from cell culture * Introduction to column chromatography |
| 9.4 | Product Quality Control  (2 class meetings) | * Quality Control, Quality Assurance, QC/QA testing * Clinical Testing |
| 9.5 | Marketing and Sales | * Factors that affect sales * Proprietary/Patent Rights |
| 10.1 | Plant Propagation | * Sexual versus asexual reproduction (cloning) * Meiosis and sex cell formation * Pollination and fertilization |
| 10.2  10.3 | Plant Anatomy  Plant Growth and Structure | * Plant cells, tissues, and organs * Meristematic tissue * Isolating Plant DNA * Mitosis and growth * Seed germination |
| 10.4  10.5 | Plant Breeding  Statistical Analysis | * Alternation of generations * Genotypes and phenotypes * Selective breeding and Punnett squares * Averages, 10% rule, standard deviation, and Chi square analysis |
| 11.1  11.2 | Cloning Plants  Tissue Culture | * Asexual plant propagation, plant tissue culture * Plant hormones * Starting and maintaining cultures |
| 11.3 | Biotech in Agriculture and Horticulture | * Selective breeding, inbreeding, genetic testing * Genetically modified crops * Hydroponics * Plant-based Pharmaceuticals |
| 11.4  11.5 | Plant Genetic Engineering | * Isolating and characterizing plant DNA * Modifying plant DNA, *Agrobacterim*, and Ti plasmid * *Arabidopsis* as a “model” organism |
| 12.1  12.2 | Drug Discovery  Combinatorial Chemistry | * Medical biotechnology, drug development, drug discovery * Organic synthesis, combinatorial chemistry, parallel synthesis, screening |
| 12.3 | Peptide and DNA synthesis | * Peptide synthesizers * DNA synthesizers |
| 12.4 | Protein/Antibody Engineering | * Antibody specificity * Flow cytometry, vaccines |
| 13.1 | DNA Synthesis | * DNA synthesis in vivo * Chromosomes and homologous pairs * DNA replication and DNA polymerase * In vitro DNA synthesis |
| 13.2 | DNA Synthesis Products/Application | * DNA probes, primers * Southern blots * Microarrays |
| 13.3 | Polymerase Chain Reaction (PCR) | * Performing and analyzing a PCR reaction * Thermal cyclers * PCR optimization |
| 13.4 | Applications of PCR | * DNA fingerprinting, criminalistics, and more * VNTRs * Forensics |
| 14.1 | DNA Sequencing | * Reasons to sequence * Dideoxynucleotide sequencing * Sequencing results and “BLAST” * Human Genome Project |
| 14.2 | Genomics | * Genomics and bioinformatics * Other genome projects * RNA and genomics |
| 14.3 | Protein Studies | * Proteomics * X-ray crystallography, mass spectrometry, NMR, * ELISA, Western blots |
| 14.4 | Other Applications of Biotechnology  (2 class meetings) | * Pharmacogenetics, personalized medicine * Environmental Biotechnology * Biodefense/Bioterrorism |

Second Semester

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| Unit | Key Concepts in Lecture/Discussion/Lesson | Estimated Time Frame |
| Hallmarks of Cancer | * Self-sufficiency in growth signals * Insensitivity to anti-growth signals * Evading programmed cell death * Limitless replicative potential * Developing blood vessels * Tissue invasion and metastasis * Deregulated metabolism * Evading the immune system * Genome instability * Inflammation | 4 weeks |
| Immunology | * The origin of immunology * Inherent immunity * Humoral and cell mediated immunity * Primary and secondary lymphoid organ * Antigen * B and T cells and Macrophages * Major histocompatibility complex (MHC) * Antigen processing and presentation * Complement | 2 weeks |
| Virology | * dsDNA viruses * ssDNA viruses * dsRNA viruses * (+)ssRNA viruses * (−)ssRNA viruses * ssRNA-RT viruses * dsDNA-RT viruses | 2 weeks |
| Bioinformatics | * Major bioinformatics resources (NCBI, EBI, ExPASy) * Sequence and structure databases * Sequence analysis (biomolecular sequence file formats * Scoring matrices * sequence alignment, phylogeny) * Genomics and Proteomics (Large scale genome sequencing strategies * Comparative genomics * Understanding DNA microarrays and protein arrays) * Molecular modeling and simulations (basic concepts including concept of force fields) | 3 weeks |
| Stem Cell Biology | * Introduction to concepts in stem cell biology (renewal, potency, etc.), definition of terms, intro to tissue stem cells; cell cycle * Germline stem cells and germline-derived pluripotent cells * Embryonic Stem cells * Induced pluripotent stem cells & direct differentiation * Hematopoietic Stem cells – Notch * Prostate and Mammary Stem cells; TGFß and GPCRs * Telomeres in Stem cell Biology * Mesenchymal SCs * Cancer and stem cells; RTKs, TGFß * Therapeautic prospects; tissue engineering * Animal models of regeneration | 2 weeks |
| Epigenetics | * Introduction to epigenetics, basic concept overview and brief history of the field * Epigenetic modifications and gene expression- DNA methylation, histone modifications * Epigenetic modifications and gene expression * Genomic imprinting in mammals * Studying multiple layers of epigenetic regulation; genome-wide analysis of epigenetic marks * Epigenetic programming in cell renewal and pluripotency * Epigenetics in disease: Imprinting disorders, Rett syndrome, ICF syndrome, etc * Cancer epigenetics & epigenetics in drug discovery | 3 weeks |
| Independent research assignment | * Student will choose a topic of interest | Remainder of semester |