

Department of Science
Grande Prairie Regional College

Biochemistry 3300

Nucleic Acid Chemistry & Molecular Biology

Course Outline
2006-2007

Instructor

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Course Description: This course is intended to provide students with a comprehensive introduction to the biochemistry of nucleic acids. It covers the structure and properties of nucleotides and nucleic acids; DNA-based information technologies; genes and chromosome structure; molecular mechanisms in DNA replication, repair and recombination; RNA metabolism; protein synthesis and targeting; the regulation of gene expression.

Pre-requisites: BC 2000, CH 1020 and CH 2630

Notes:

1. Students with grades of less than B- in pre-requisite courses require consent of the department.
2. This course may not be taken for credit if credit has already been obtained in BC 2030 or BC 2050.

Transferability: Biochemistry 330 – University of Alberta

Text-book: Lehninger Principles of Biochemistry (4th edition)
David Nelson & Michael Cox
W.H. Freeman and Co. (2005)

Requirements: Since participation in lectures and completion of assignments are essential to achieving success in this course, regular attendance at classes is highly recommended. Those who chose not to attend must assume whatever risks are involved. In this regard, your attention is directed to the Academic Guidelines of Grande Prairie Regional College.

Evaluation:

Mid-term Exam I	30%
Mid-term Exam II	30%
Final Exam	40%

Mid-term Exam I will test knowledge of material covered in the first third of the course.

Mid-term Exam II will test knowledge of material covered since the first mid-term exam.

The Final Exam will be cumulative and test knowledge of the entire course.

BC 3300 – Topic Outline & Required Readings

Hours	Topic	Readings
2	Nucleotides and Nucleic Acids	
	Basics	
	Bases	274
	Ribo- and deoxyribonucleosides and nucleotides	274-276
	Phosphodiester bonds	276
	5' and 3' ends	277
	hydrolysis of nucleic acids	277
	sequence conventions	278
	functional groups on bases; hydrogen bonds	279
	storage of genetic material	280-281
	Nucleic Acid Structure	
	Distinctive base composition (Chargoff's Rules)	281
	Antiparallel nature and complementary strands	282-283
	3-D forms of DNA (B, A and Z forms)	283-285
	unusual structures in DNA	285-287
	Structure of RNA	287-290
	Nucleic Acid Chemistry	
	Denaturation of double-helices	291-293
	Induced & spontaneous alterations of chemical structure	293-295
	methylation	296
1	Biosynthesis and Degradation of Nucleotides	
	Purine Nucleotides	
	<i>De novo</i> synthesis (PRPP)	864-866
	regulation	866-867
	Pyrimidine Nucleotides	
	<i>De novo</i> synthesis (PRPP)	867-868
	regulation	868
	General	
	Conversion of NMP to NTP	868-869
	Deoxynucleotides from ribonucleotides	869
	Ribonucleotide reductase	869-872
	Production of thymidylate	872-873
	Catabolism	
	Global overview (uric acid vs. ammonia)	873-875
	Salvage pathways for recycling bases	875
	Lesch-Nyhan Syndrome	875
	Gout	875-876
	Chemotherapy	876-878

3	Genes and Chromosomes	
	The Central Dogma	921-922
	Chromosomes and Chromosomal Elements	
	Tertiary packing of DNA into chromosomes	923
	Chromosomal elements; genes and regulatory sequences	924
	Compacting DNA; viruses, bacteria, eukaryotes	925-928
	Eukaryotic genes and chromosomes (intron, exons, SSRs, centromeres, telomeres)	928-930
	DNA Supercoiling	
	Theory	930-932
	Cellular DNA is underwound	932-933
	Topological linking number and topoisomerases	933-937
	Plectonemic vs solenoidal	937-938
	Chromosome Structure	
	Chromatin	938-939
	Histones	939
	Nucleosomes	940-941
	High order packing of nucleosomes	942-943
	Condensed chromosome structures	943
	Bacterial DNA and nucleoids	943-944
8	DNA Metabolism	
	Overview	
	The enzymes of replication	948-950
	<i>E. coli</i> proteins involved in DNA metabolism	949
	Naming of bacterial genes and proteins	949
	DNA Replication	
	Fundamental rules of replication	950-952
	Nucleases	952
	Pol I and DNA polymerases (elongation, primer, template, proofing)	952-955 955-957
	Other DNA polymerases (Pol I, II and III)	
	Mechanism of action of polymerases	957-958
	Replisome / DNA replicase system	958-960
	Initiation	960-963
	Elongation and ligases	962-964
	Termination	964-966
	Variations in eukaryotic cells; linking to Cell Cycle	466-467
	Oncogenes, Tumour Suppressor Genes, Programmed Cell death	
	Apoptosis	
	DNA Repair	
	Mutations and cancer	966-967
	Multiple repair systems in all cells	967

	Mismatch repair	968-971
	Base-excision repair	971-972
	Nucleotide-excision repair	972-973
	Direct repair	974-976
	SOS response	976-978
	Bacterial regulation	
	DNA Recombination	
	Introduction	978
	Homologous genetic recombination	979-984
	Mechanism of recombination in bacteria	
	Repairing stalled replication forks	984
	Site-specific recombination	984-988
	Transposable genetic elements / immunoglobulin gene assembly	988-991
5	RNA Metabolism	
	Overview	
	RNA, transcription, mRNA, tRNA, rRNA	995-996
	DNA-dependant Synthesis of RNA	
	Compared with replication	996
	RNA polymerases and RNA synthesis	996-998
	Promoters, initiation and elongation	998-1001
	Termination	1001-1003
	DNA footprinting	1002
	Eukaryotic cells and three RNA polymerases	1003
	RNA Pol II	1003-1006
	RNA processing	
	Introduction	1007-1008
	mRNA capping	1008
	introns / exons and splicing	1008-1012
	the 3' end	1011-1014
	differential processing	1014-1015
	RNA-dependant Synthesis of RNA and DNA	
	Introduction	1021
	Reverse transcriptase	1021-1022
	Cancer and AIDS	1023-1024
	Common evolutionary origin of transposons, retroviruses, introns	1023-1025
	Telomerase (specialized reverse transcriptase)	1025-1027
4	Protein Metabolism	
	Overview	1034
	The Genetic Code	
	Introduction	1034-1035
	Reading frames, ORFs, codons, degeneracy	1035-1039

	Wobble Hypothesis	1039-1044
	Translational frameshifting and mRNA editing (Box)	1040-1041
	Variations in the genetic code (Box)	1042-1043
	Protein Synthesis	
	Introduction to the five stages	1044-1045
	The ribosome	1045-1049
	tRNA structure	1049-1050
	attaching amino acids to tRNAs	1051-1054
	initiation tRNA in prokaryotes and eukaryotes	1054-1056
	formation of initiation complex in <i>E. coli</i>	1056-1057
	initiation in eukaryotes	1057-1058
	elongation and peptide bonds	1058-1061
	termination	1061
	energy cost of protein synthesis	1061
	polysomes and rapid translation	1062-1063
	antibiotic inhibitors of protein synthesis	1065-1067
7	Regulation of Gene Expression	
	Principles of Gene Regulation	
	Cellular steady-state concentrations of protein	1081-1082
	RNAP binding to promoters (housekeeping vs regulated genes)	1082-1083
	Regulation of initiation (specificity factors, repressors, activators, enhancers)	1083-1084
	Regulation of operons (<i>lac</i> operon and negative regulation)	1084-1087
	DNA-binding domains	1087-1088
	Helix-turn-helix	1088-1089
	Zinc-finger	1090
	Homeodomain	1090
	Protein-protein interaction domains	1090
	Leucine zipper	1091
	Basic helix-loop-helix	1091
	Regulation of gene expression in Prokaryotes	
	<i>Lac</i> operon and positive regulation (catabolite repression)	1093-1094
	<i>Trp</i> operon and attenuation	1094-1097
	SOS response (coordinated gene expression)	1097-1098
	Translational regulation	1098-1099
	Regulation of gene expression in eukaryotes	
	Eukaryotes have a restricted ground state	1102
	Chromatin remodelling	1103
	Eukaryotic promoters are positively regulated	1103-1104
	Basal transcription factors, transactivators, coactivators	1104-1105
	Regulation by inter- and extracellular signals	1108-1109
	Eg. Regulation by steroid hormones	465-466
	Translational repression	1108-1109
	RNAi	1109-1111

5 DNA-based Information Technologies

Introduction to DNA Cloning

Sequence determination	296-298
Automated synthesis	298-299
General procedures	306-308
Restriction endonucleases, DNA ligases	307-310
Cloning vectors (plasmids, phages, BACs, YACs)	311-314
Hybridization	314-315
Expression vectors	315-316
Mutagenesis to modify proteins	316-317

Genomics – From genes to proteins

Gene libraries and cDNA libraries	318-319
Polymerase chain reaction	319-321
Genome sequences and the Human Genome Project	321-325
DNA finger-printing, Southern Blotting	322-323
Northern Blotting	

Proteomics

Sequence and structural relationships	325-326
Cellular expression patterns	326-329
Protein-protein interactions	327-330
Production of recombinant proteins	

Genome Alterations and New Products of Biotechnology

Ti plasmid and cloning in plants	330-333
Mammalian cell clones and transgenic animals	333-335
Human gene therapy	336-337