Department of Science
Grande Prairie Regional College

Biochemistry 3100

Bioenergetics and Metabolism

Course Outline
2006-2007

Instructor
Philip Johnson B.Sc., M.Sc., Ph.D., M.S.P.H.
office: J224
phone: 539 2863
e-mail: *johnson@gprc.ab.ca*

Course Description:	Designed to enable rigorous study of the molecular mechanisms in bioenergetics and metabolism. It covers: the principles of bioenergetics; the reactions and pathways of carbohydrate, lipid, and nitrogen metabolism, and their regulation; oxidative phosphorylation and photophosphorylation; carbohydrate biosynthesis in plants; the integration and hormonal regulation of mammalian metabolism.
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 310 – University of Alberta
Text-book:	Lehninger Principles of Biochemistry (4^{th} 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 3100 – Topic Outline & Required Readings

Hours	Topic	Readings
1	- general introduction of metabolism	27-28, 481-488
	- overall purposes	
	- catabolism / anabolism	
	- general properties	
	- in balance / dynamic steady state	
	- bioenergetically separate	
	- pathways	
	- enzyme catalyzed reactions under mild conditions	
	- reaction types	
	- pathway flow via sequential reactions	
	- far from equilibrium / near equilibrium reactions	
	- possible regulation / control	
	- major pathways in humans	892-893
	- tissue / organ specialization	
	- integration	
2	Principles of Bioenergetics	489-517
	- bioenergetics and thermodynamics	
	- ATP and phosphoryl-group transfers	
	- redox reactions in biology	
	- coenzymes and water soluble vitamins	
1	- principles of metabolic regulation	571-575
3	Glycolysis and Gluconeogenesis	
	- glycolysis	522-533
	- feeder patheways for glycolysis	535-537
	- fates of pyruvate under anaerobic and aerobic conditions	538-606
	- gluconeogensis	543-549
	- coordinated regulation of glycolysis and gluconeogenesis	575-583
1	Pentose phosphate pathway	549-555
1	Metabolism of glycogen	562-570
	- coordinated regulation of glycogen synthesis and breakdown	583-591
1	Citric acid cycle	
	- reactions of the citric acid cycle	608-620
	- regulation	621-623
	- glyoxylate pathway link to fatty acid catabolism	623-626, 780-781
4	Oxidative Phosphorylation	
	- mitochondria	691
	- electron transfer reactions	692-704
	- ATP synthesis	704-714
	- shuttles	714-716
	- regulation and uncoupling	716-718

2	Photosynthesis	723-743
1	Carbohydrate biosynthesis in plants	751-766
2	Catabolism of Fatty Acids	
	Introduction lipids in metabolism	
	- brief review: storage lipids	
	- fatty acid structures and chemical properties	343-345
	- triacylglycerols	345-347
	- Summary 10.1 Storage Lipids	348
	Digestion, mobilization and transport of fatty acids	
	- introduction	631-632
	- dietary fats absorbed in the small intestine / chylomicrons	632-633
	- phospholipases vs lipoprotein lipases	346 & 632
	- hormones trigger mobilization of stored TAGs	634
	- fatty acids are activated and transported into mitochondria	634-637
	Oxidation of fatty acids	
	- introduction	637
	- β oxidation of saturated fatty acids four basic steps	637-639
	- four steps repeated yielding acetyl-CoA and reduced coenzymes	639
	- acetyl-CoA further oxidized in citric acid cycle	639
	- oxidation of unsaturated fatty acids requires 2 additional reactions	639-642
	- oxidation of odd-numbered fatty acids takes 3 additional reactions	642
	Ketone body metabolism	
	- names and structures	650
	- formed in the liver, transported to other organs as fuel	650-652
	- introduction: ketone bodies elevated in starvation and diabetes	652
7	Lipid Biosynthesis (7 lectures)	
	Biosynthesis of fatty acids (1.5)	
	- introduction	787
	- malonyl-CoA and ACC	787-788
	- fatty acid synthesis is a repeating reaction sequence	788-789
	- fatty acid synthase complex has seven active sites	789-790
	- repeated reactions form palmitate	790-793
	- fatty acid synthesis occurs in cytosol	794
	- acetate shuttled out of mitochondria as citrate	794-796
	- extention of saturated fatty acids from palmitate	797
	- destaturation of fatty acids by a mixed-function oxidase	798-800
	- coordinated regulation of fatty metabolism	642-643, 795-797
	- eicosanoids from 20 C polyunsaturated fatty acids	800-803
	- eicosanoid metabolism and inhibition of cylooxygenase	358

0.5	Biosynthesis of triacylglycerols)	
	- TAGs and glycerophospholipids from same precursors	804
	- TAG biosynthesis in anaimals regulated by hormones	804-806
	- adipocytes generate glycerol 3-p by glyceroneogenesis	806-808
3	Biosynthesis of membrane lipids	
	brief review of membrane structure	
	- structure of phospholipids	348-351
	- Summary 10.2 Structural Lipids	355
	- two strategies for attaching phospholipids head groups	808-810
	- anionic phospholipids from CDP-diacylglycerol	811-812
	- pathways to PS, PE, and PC are interrelated	812-813
	- sphingolipids and glycosphingolipid: structure and functions	352-353
	- sphingolipid and glycosphingolipid catabolism	356
	- phosphatidylinositols and sphingosine derivatives	357-358
	- metabolic disorders: Fabry's and Tay-Sach's diseases	356
	-cholesterol, steroids and isoprenoids	
	- introduction	816
	- cholesterol from acetyl-CoA / HMG-CoA reductase	816-820
	- cholesterol has several fates / bile salts	820
	- steroid hormones	359-360/827-828
	- cofactors/vitamins A, D, E, and K	360-363
2	Cholesterol, TAGs and other lipids are carried in the plasma by lipoproteins	
	- plasma lipoproteins	820-824
	- classes of lipoproteins and properties	821
	- functions of major apoproteins	823
	- structure of chylomicrons, VLDL, LDL and HDL	633/821
	- metabolism of VLDL, LDL and HDL in plasma	822
	- lipoprotein lipases	632
	- LCAT reaction	823
	- HDL metabolism / reverse cholesterol transport	824
	- LDL receptors: structure and function / endocytosis	824-825
	- cholesterol biosynthesis regulated at several levels / SREBP	825-826
	- atherosclerosis and statins	827
1	Amino acid oxidation	
	- introduction	656-657
	- dietary protein enzymatically degraded to amino acids	658-660
	- transaminases / pyridoxal phosphate	660-661
	- oxidative deamination by glutamate dehydrogenase	661-662
	- glutamine and alanine transport toxic ammonia in the blood	662-665
1	Urea cycle	665-671
	- amino acid catabolism, **in general**	671
	- amino acids to glucose, others to ketone bodies	671-672
	- several cofactors in aa catabolism	672-674
	- six amino acids to pyruvate	674-677
	- seven amino acids to acetyl-CoA	677-679

	- five amino acids to α-ketoglutarate	681-682
	- four amino acids to succinyl-CoA	682-683
	- branched-chained amino acids not degraded in the liver	683-685
	- asparagine and aspartate to oxaloacetate	685-686
	- genetic defects in amino acid metaboism	675, 677, 679, 685
	- intracellular protein turnover and degradation	1075-1077
1	Nitrogen flow in the biosphere	833-834
	- nitrogen fixation	834-837
	- glutamine synthetase / regulation	837-840
	- essential / nonessential amino acids	670
	- biosynthesis of amino acids, **in general**	841-854
	- SUMMARY 22.2 Biosynthesis of Amino Acids	854
	- biosynthesis of porphyrins and heme (Kings and Vampires)	854-857
	- NO metabolism	860 (Vance #14)
1	Biosynthesis of nucleotides	
	- introduction	862-864
	- review of structures of nucleosides and nucleotides	273-276
	- denovo synthesis of purines / ring atoms of purines	864-866
	- regulation of purine biosynthesis	866-867
	- biosynthesis of pyrimidines ring atoms of pyrimidines	867-868
	- regulation of pyrimidine biosynthesis	868
	- nucleoside monophosphates to triphosphates	868-869
	- deoxynucleotides	869-873
	Catabolism of nucleotides	
	- salvage pathways and strategies	875
	- production of uric acid and urea / gout	873-876
	Chemotherapy	876-878
1	Action of hormones	
	- introduction	881-882
	- bioassay	882-884
	- specific high-affinity cellular receptors	884-886
	- hormones are chemically diverse	886-889
	- regulation via a hierarchy of neuronal and hormonal signals	889-892
	- banned drugs and sports	
1	Integration of metabolism	
	- tissue specificity and division of labor	892-902
	- hormonal regulation of fuel metabolism	902-909
	- during starvation metabolism shifts fuel for the brain	906-908
1	Diabetes mellitus	909-910
1	Obesity and diets	910-911
1	Ethanol metabolism	