NUTR370

Nutritional Biochemistry and Physiology: Macronutrients

Fall 2022

Time: Tuesdays, Thursdays (10 AM-12 noon), and 1 or 2 Fridays/month (10:30 AM-12 noon)

Location: J105. However, when necessary, either by Friedman School guidance or guest-instructor preference, we will meet via zoom at the following link:

https://tufts.zoom.us/j/96185148847?pwd=bldjaWFKVlFpdXVXZ3dQZC8wQXlDdz09

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Tufts Graduate Credit: 4.5 credits

Prerequisites: Graduate Biochemistry (BCHM 223)

Course Description: NUTR370 is an advanced course in the nutrition sciences. Students are expected to be familiar with the material covered in introductory nutrition as well as the biochemistry and physiology courses offered at Tufts. These courses will serve as the foundation for the material we will explore in this course. NUTR370 will cover topics related to: energy metabolism, carbohydrates and fiber, lipids and lipoproteins, and amino acids and proteins. These topics will be covered in 3 sections, each of approximately 4 weeks duration. Class format will include lectures, student presentations, and class discussion/student participation/team-based learning.

Course material will all be available on **Canvas**: https://canvas.tufts.edu

Course objectives:

1) To expand the knowledge of how carbohydrates, lipids, and proteins are digested, absorbed, transported in the blood, and metabolized in the whole organism using principles of physiology, biochemistry, cell biology, and molecular biology.
2) To explain how metabolic pathways are regulated during different dietary and environment conditions.
3) To integrate information of macronutrients in health and disease, with particular emphasis on the most prevalent nutrition-related diseases: cardiovascular disease, obesity, diabetes, cancer, and sarcopenia.
4) To provide the forum for discussing experimental approaches to studying macronutrient metabolism and function.

Grading:	% of final grade
Quizzes	25%
Student proposal and presentation (Carbs and Lipid sections)	15%
Abstract (Protein section)	15%
Team-based learning	10%
Class participation	10%
Final exam	25%

For assignments that are turned in late, a one letter grade deduction will be applied for every day that the assignment is late.

Course text and material: There is no required textbook but selected chapters from *Modern Nutrition in Health and Disease* (Editors: A. Catharine Ross, Benjamin Caballero, Robert J. Cousins, Katherine L. Tucker, and Thomas R. Ziegler; 11th Edition, Lippincott Williams and Wilkins, Baltimore, MD, 2012) will be assigned throughout the semester. This book is available online through the Hirsch Health Sciences Library under "e-books". Selected papers will also be assigned for reading before each lecture.

Academic Conduct: Each student is responsible for upholding the highest standards of academic integrity, as specified in the Friedman School's Policies and Procedures manual (http://nutrition.tufts.edu/documents-and-forms/policies-and-procedures-students) and Tufts University policies (http://students.tufts.edu/student-affairs/student-life-policies/academic-integrity-policy). It is the responsibility of each student to understand and comply with these standards, as violations will be sanctioned by penalties ranging from failure on an assignment to dismissal from the school.

Diversity and Inclusion: The diversity of student experiences and perspectives is essential to the deepening of knowledge in this course. We consider it part of our responsibility as instructors to address the learning needs of all the students in this course. We will present materials that are respectful of diversity in race, color, ethnicity, gender, age, disability, religious beliefs, political preference, sexual orientation, gender identity, socioeconomic status, citizenship, language, or national origin among other personal characteristics. We will strive to cultivate a learning environment where all students are treated equitably, have equal access to learning, and feel welcome, valued, and supported in their learning.

Description of assignments, participation, exam and other required activities:
Readings: Readings will be assigned for all class meetings. The list of readings will be provided at the beginning of each section. **Read assigned material prior to the class**. Selected papers will be discussed in class. Preparation will maximize your benefit from each lecture and enable you to contribute to class discussions.

Quizzes: There will a quiz at the end of each week (posted to Canvas by Friday afternoon), covering the lecture material, reading material, and discussions covered during that week. Students are expected to complete them by the beginning (Mondays, 12 noon) of the following week.

Student Presentations: During the Carbohydrate and the Lipid Sections, students will be provided a scientific question. Students will write a short proposal addressing the question and prepare a slide presentation. We expect that all students will have reviewed the literature on the chosen topics and will be prepared to contribute their opinion during the discussion following the presentation. Each presentation will be approximately *30 minutes (20 minutes for student presentations and 10 minutes for general discussion).* Further details of the assignment will be given in class. Presentation grade will be as described below.

Abstract: During the Protein section, all students will be given protein turnover data (Excel format). Students will be asked to analyze and then prepare a written abstract similar to that for a conference or journal publication. The abstract should follow standard journal guidelines and include background/purpose, methods, results and conclusion and be limited to 300 words. Abstracts will be graded on clarity, study design, interpretation of the results, and final conclusions. Further details of the assignment will be given in class.

Team-based learning: Students will work together for this activity. Reading will be assigned and must be completed in advance. Students will be divided into small groups and questions for discussion will be assigned. The class will then gather for discussion of the assigned questions with each small group reporting. Specific instructions will be provided in class. *Attendance is required to receive credit.*

Student participation: Participation to class activities and discussions will be expected during all class periods. For this reason, your prior preparation is essential. If a situation arises that prevents you from preparing adequately prior to the class, please inform the instructor prior to the class. Likewise, if you will have to miss a class, please inform the instructor in advance.

Grading of student presentation, participation and team-based learning will be as follows:

- 90-100/100 Very good
- 80-89/100 Good
- 50-79/100 Mediocre
- <50/100 Poor
- 0/100 No evident participation

Final exam: There will a two-hour exam at the end of the course. The format of the exam will be open questions and answers, covering all the topics presented in class.

Course Schedule

	NUTR370 - Biochemistry and Physiology: Macronutrients - Course instructor: Dr. Stefania Lamon-Fava					
2022	**Date**	**Day**	**Lecture**	**Time**	**Instructor**	**Lecture Topic**
Energy and Carbohydrate Section						
Sept	6	Tue	**1**	10:00-12:00	Introduction/*Online*	*(Online Module - Carbohydrates etc; Fiber)*
	8	Thur	2	10:00-12:00	Rios	Central control of energy
	9	Fri	3	10:30-12:00	Pothos	Non homeostatic control of energy
	13	Tue	4	10:00-12:00	Das	Energy expenditure
	15	Thur	5	10:00-12:00	Das	Under- and over-nutrition
	20	Tue	6	10:00-12:00	Roberts	Factors affecting energy metabolism
	22	Thur	7	10:00-12:00	Saltzman/Rowan	Gut hormones/Microbiota
	27	Tue	8	10:00-12:00	Kaushik	Insulin resistance
	29	Thur	9	10:00-12:00	Team-based activity + student proposals are due	
	30	Fri		10:30-12:00	Student presentations	
Oct	4	Tue	10	10:00-12:00	Obin	Diabetes
	6	Thur		10:00-12:00	Student presentations	
Lipid Section						
	11	Tue	1	10:00-12:00	Lamon-Fava	Exogenous pathway of lipid metabolism
	13	Thur	2	10:00-12:00	Lamon-Fava	Endogenous pathway of lipid metabolism
	14	Fri	3	10-30-11:30	Kaushik	LDL receptor
	18	Tue	4	10:00-12:00	Lamon-Fava	HDL and reverse cholesterol transport
	20	Thur	5	10:00-12:00	Lamon-Fava	Lipids and gene expression regulation
	21	Fri	6		*Online*	*Diabetic dyslipidemia*
	25	Tue	7	10:00-12:00	Ordovas	Gene diet interactions
	27	Thur	8	10:00-12:00	Team-based activity	
Nov	1	Tue	9	10:00-12:00	Wu + student proposals are due	Essential FA and eicosanoids
	3	Thur		10:00-12:00	Student presentations	
	4	Fri	10		*Online*	*(Adipocyte lipid metabolism)*
	8	Tue		10:00-12:00	Student presentations	
Protein Section						
	10	Thur	1	*Online*	*Ausman*	*(Protein basic concepts, etc.)*
	15	Tue	2	10:00-12:00	Fielding (+ abstract assignment)	Sarcopenia and other health outcomes
	17	Thur	3	10:00-12:00	Rivas	Muscle mass and function: effects of aging
	22	Tue	4	10:00-12:00	Whitcomb	Protein modification and degradation
	24	Thur			No class	
	29	Tue	5	10:00-12:00	Maher	Neurotransmitters
Dec	1	Thur	6	10:00-12:00	Maher + abstracts are due	NO production
	6	Tue	7	10:00-12:00	Ausman	Sulfur AA and lysine
	8	Thur	8	10:00-12:00	Lamon-Fava (+ Abstract discussion)	Fuel utilization
	13	Tue		10:00-12:00	**Final exam**	

Class Objectives

Required readings and supplemental readings will be posted on Canvas approximately one week prior to each class.

ENERGY AND CARBOHYDRATES SECTION

Class 1: September 6
Topic: *Online Module - Carbohydrate Classification, Digestion, Transport, and Controversies*
Instructor: Edward Saltzman, MD
Learning Objectives
Upon completion of this class, students will:

- know the structure and classification of carbohydrates
- have learned the food sources of different types of carbohydrates
- have learned the digestion and absorption of carbohydrates
- know the different transporters involved in carbohydrate absorption and cellular uptake
- have learned how to assess glucose homeostasis
- have learned about fructose metabolism and health effects
- understand the concept of glycemic index and glycemic load

Topic: *Online Module - Fiber*
Instructor: Edward Saltzman, MD
Learning Objectives
Upon completion of this class, students will:

- know the definition and classification of different types of fiber
- know the food sources of fiber
- understand the physiological effects of fiber on energy regulation, cardiovascular disease, insulin resistance, and colon cancer

Class 2: September 8
Topic: Central Control of Energy
Instructor: Maribel Rios, PhD
Learning Objectives
Upon completion of this class, students will:

- learn the central nervous system (CNS) regions involved in the regulation of food intake
- learn the neurotransmitters and cells involved in appetite regulation
- know the anorexigenic and orexigenic input signals in the brain

Class 3: September 9
Topic: Non-Homeostatic Control of Energy Intake
Instructor: Emmanuel Pothos, PhD
Learning Objectives
Upon completion of this class, students will:

- know the difference between homeostatic and non-homeostatic CNS signals
- know the neurotransmitters involved in non-homeostatic control of energy
- understand the biological and psychological implications of non-homeostatic control of energy intake

Class 4: September 13
Topic: Energy Expenditure
Instructor: Sai Krupa Das, PhD
Learning Objectives:
Upon completion of this class, students will:

- know the different components of total energy expenditure
- know the different laboratory methods to assess energy expenditure

Class 5: September 15
Topic: Under- and Over-Nutrition
Instructor: Sai Krupa Das, PhD
Learning Objectives
Upon completion of this class, students will:

- know how to define under-nutrition and over-nutrition
- understand the changes in the different components of energy expenditure during under-nutrition and over-nutrition
- understand adaptation to under- and over-feeding
- know carbohydrate, lipid, and protein metabolism in under-nutrition

Class 6: September 20
Topic: Factors Affecting Energy Metabolism
Instructor: Susan Roberts, PhD
Learning Objectives
Upon completion of this class, students will:

- understand the effects of age on energy metabolism
- understand the effects of gender on energy metabolism
- know the hormones that influence energy expenditure and why
- know how diet influences energy metabolism

Class 7A: September 22
Topic: Gut Hormones
Instructor: Edward Saltzman, MD
Learning Objectives
Upon completion of this class, students will:

- understand what is sensed by the gut and how it is sensed
- understand how information is conveyed to the brain
- be able to describe how different types of bariatric surgery could influence these sensing mechanisms

Class 7B : September 22
Topic: Microbiota
Instructor: Sheldon Rowan, PhD
Learning Objectives:
Upon completion of this class, students will:

- learn how the field of microbiota has developed
- know what is currently known about composition and function of microbiota
- learn about the role of microbiota in metabolism

Class 8: September 27
Topic: Insulin Resistance
Instructor: Virendar Kaushik, PhD
Learning Objectives:
Upon completion of this class, students will:

- understand the definition of insulin resistance (IR) and type 2 diabetes mellitus
- understand the integrated action of insulin
- know the sensing of energy demands by the cell via AMP-activated protein kinase (AMPK) and Silence Information Regulator 2.1 (SIRT1)

- know how to clinically assess IR and diabetes

Class 9: September 29
Topic: Team-based learning activity-To be determined
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives:

- Team-based learning

Class 10: October 4
Topic: Diabetes
Instructor: Martin Obin, PhD
Learning Objectives
Upon completion of this class, students will:

- understand that the Metabolic Syndrome as a critical stage in development of T2DM
- understand the role of adipocytes in glucose and fatty acid homeostasis
- know the function of adipose tissue as an endocrine organ- adipokines, lipokines
- know the effect of dysregulated adipokines and adipose tissue inflammation on insulin resistance
- have learned about therapeutic effects of TZDs, incretins, and bariatric surgery

LIPIDS SECTION

Class 1: October 14
Topic: Exogenous Pathway of Lipid Metabolism
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives
Upon completion of this class, students will:

- know how dietary fat digestion and absorption occurs and how lipids are delivered to target tissues
- have learned the role of the gut in lipid homeostasis

Class 2: October 13
Topic: Endogenous Pathway of Lipid Metabolism
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives
Upon completion of this class, students will:

- know the metabolism of VLDL, IDL, and LDL
- understand the biological functions of LDL and other atherogenic lipoproteins
- have learned about Lipoprotein(a) and its association with cardiovascular disease
- be able to describe the pathogenesis of cardiovascular disease and the role of dietary fat on lipoprotein metabolism and on the pathogenesis of cardiovascular disease

Class 3: October 14
Topic: Regulation of LDL Metabolism
Instructor: Virendar Kaushik, PhD
Learning Objectives
Upon completion of this class, students will:

- understand the membrane cycling of the LDL receptor
- understand the different pathways of LDL regulation (SREBP, PCSK9. IDOL, etc.)

Class 4: October 18
Topic: HDL and Reverse Cholesterol Transport Pathway
Instructor: Stefania Lamon-Fava, MD PhD

Learning Objectives
Upon completion of this class, students will:
- understand the role of HDL in reverse cholesterol transport
- know other anti-atherosclerotic functions of HDL
- be able to describe genetic and secondary causes of low HDL-C and high HDL-C levels
- understand the role of life-style factors on HDL-C levels

Class 5: October 20
Topic: Lipids and Regulation of Gene Expression
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives
Upon completion of this class, students will:
- understand the role of lipid molecules as transcriptional regulators of gene expression
- understand the role of lipid molecules as regulators of gene expression in signal transduction
- understand how these roles affects lipid utilization and storage, and cell function
- be able to describe the molecular mechanisms of regulation of plasma lipids by dietary lipids and carbohydrates

Class 6: October 21
Topic: *Online Module – Diabetic Dyslipidemia*
Instructor: Henry Ginsburg, MD
Learning Objectives
Upon completion of this class, students will:
- understand the interrelation between insulin resistance and cardiovascular disease
- understand the plasma lipid alterations associated with insulin resistance
- know the mechanism of the insulin resistance-related dyslipidemia

Class 7: October 25
Topic: Gene-Diet Interactions
Instructor: Jose Ordovas, PhD
Learning Objectives
Upon completion of this class, students will:
- understand the concept of personalized nutrition
- understand the interaction between genetics and nutrition and its role in lipid metabolism, obesity, and inflammation
- learn about the function of microRNA in gene expression

Class 8: October 27
Topic: Team-based learning activity-To be determined
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives:
- Team-based learning

Class 9: November 1
Topic: Essential FA, Eicosanoids, and Immune Function
Instructor: Dayong Wu, MD PhD
Learning Objectives
Upon completion of this class, students will:
- have reviewed the essential fatty acids structure and PUFA biosynthesis
- know the pathways of eicosanoid biosynthesis
- understand the function of prostaglandins, thromboxanes, and leukotrienes
- understand the role of eicosanoids and other PUFA-derived mediators in inflammation and in the resolution of inflammation

- know the different molecular aspects of the anti-inflammatory effects of aspirin

Class 10: November 4
Topic: Online - Adipocyte Lipid Metabolism
Instructor: Susan Fried, PhD
Learning Objectives
Upon completion of this class, students will:

- understand the regulation of adipose cell metabolism in obesity
- know how triglyceride metabolism (synthesis and hydrolysis) is regulated during feeding and fasting
- know the role of adipose tissue as an endocrine organ
- know the modulation of insulin resistance by the adipose tissue

PROTEIN SECTION

Class 1: November 10
Topic: Online: Protein basic concepts, protein requirements, quality, and energy malnutrition
Instructor: Lynne Ausman
Learning Objectives
Upon completion of this class, students will:

- understand protein structure and organization
- understand amino acid classification
- describe nitrogen cycle
- describe protein digestion and absorption
- explain the DRI for proteins
- know the methods to measure protein quality

Class 2: November 15
Topic: Sarcopenia and Other Health Outcomes
Instructor: Roger Fielding, PhD
Learning Objectives
Upon completion of this class, students will:

- have learned the definition of sarcopenia
- know the role of protein intake and protein metabolism on sarcopenia
- know the effect of exercise on muscle mass in the elderly

Class 3: November 17
Topic: Muscle Mass and Function: Effects of Aging
Instructor: Donato Rivas, PhD
Learning Objectives
Upon completion of this class, students will:

- understand the concept of muscle plasticity
- learn anabolic resistance in muscle cells
- learn the major metabolic and molecular determinants of anabolic resistance
- know the role of exercise on insulin sensitivity in muscle cells and its mechanism of action

Class 4: November 22
Topic: Protein Modification and Degradation
Instructor: Elizabeth Whitcomb, PhD
Learning Objectives
Upon completion of this class, students will:

- know the different systems that break down proteins inside cells.
- know why and what kind of proteins need to be degraded

- have learned methods to monitor intracellular protein degradation

Class 5: November 29
Topic: Neurotransmitters: Phenylalanine and Tryptophan
Instructor: Timothy Maher, PhD
Learning Objectives
Upon completion of this class, students will:

- have learned the metabolism of AA serving as precursors of neurotransmitters (choline, tryptophan, tyrosine, histidine, threonine)
- know how AA are transported into the brain and their role in cognition and other effects

Class 6: December 1
Topic: NO production
Instructor: Timothy Maher, PhD
Learning Objectives
Upon completion of this class, students will:

- know the metabolism of arginine and the effects of its metabolite ADMA
- know the synthesis of NO from arginine and the effects of NO on the vascular system

Class 7: December 6
Topic: Sulfur AA Metabolism, Lysine and Threonine
Instructor: Lynne Ausman, DSc
Learning Objectives
Upon completion of this class, students will:

- be able to discuss the concept of amino acid pattern and complementation vis-à-vis the importance of methionine and cysteine sufficiency
- be able to describe the transmethylation, transulfuration, and transamination pathways of sulfur amino acid metabolism and how they are regulated
- understand the chemical role that sulfur plays as a component of sulfur amino acids and their metabolites
- know taurine production and its importance in nutrition
- understand the important role of the liver in metabolizing/catabolizing the amino acid influx from the portal vein
- know the structures of lysine and why its structure predicts some of the roles that it plays
- be able to explain the important catabolic steps for lysine

Class 8: December 8
Topic: Macronutrients: Metabolism, Storage and Regulation of Fuel Utilization
Instructor: Stefania Lamon-Fava, MD PhD
Learning Objectives
Upon completion of this class, students will:

- learn about macronutrients interconversion and storage
- understand tissue-specific differences in fuel utilization
- know the body's regulation of fuel utilization during fasting and starvation
- know the regulation of fuel utilization in the feeding state by different organs and tissues
- understand the regulation of fuel utilization by muscle tissue during exercise
- understand gender differences in fuel utilization