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=bldjaWFKVIFpdXVXZ3dQZC8wQXIzDz09

Course Director: Stefania Lamon-Fava, MD PhD, Cardiovascular Nutrition Laboratory, HNRCA 520
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Teaching Assistant: Haihan Zeng, M.S. (Haihan.Zeng@tufts.edu)

Guest Instructors | Room | E-mail
--- | --- | ---
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Dayong Wu, MD PhD | HNRCA 613 | dayong.wu@tufts.edu

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 be 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 be 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**

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