NUTR 0371: Nutritional Biochemistry and Physiology: Micronutrients
Spring 2019

Class Meetings: Mondays 1:30-3:00 PM, Jaharis Room 118; Wednesdays 1:30-4:30 PM, 75 Kneeland Room 844

Instructor(s): Ligi Paul, Ph.D., Email: Ligi.Paul_Pottenplackel@tufts.edu

Instructor Office Hours: By appointment

Co-Instructor: Mathieu Lalonde, PhD; Email: lalonde@fas.harvard.edu

Co-Instructor Office hours: By appointment.

Teaching Asst.: TBD

Teaching Asst. Office Hours: TBD

Semester Hour Units: 4.5 SHUs

Prerequisites: Graduate biochemistry and NUTR 202 or equivalents, or by instructor permission.

Course Description:

NUTR 371 is an advanced course in the biochemistry and physiology of micronutrients. Students are expected to be familiar with the material covered in an introductory nutrition course as well as graduate biochemistry, and have a basic familiarity with physiology. NUTR 371 covers fat soluble nutrients, water soluble nutrients, and minerals. Topics that will be covered include nutrient bioavailability, transport, function at biochemical and physiological levels, measurements of nutrients and nutrient status, and current controversies. Lectures will be provided in face-to-face format. In-class activities in addition to lectures will include team based learning (TBL) and each student will provide both brief and more detailed presentations or discussions.

Course Objectives:

By successful completion of this course, for each of the micronutrients covered, students should be able to:

- Explain mechanisms of digestion and absorption.
- Discuss factors influencing bioavailability and provide examples.
- Describe biochemical and physiological functions of the nutrient and illustrate roles of nutrients in these functions.
- Explain mechanisms of nutrient homeostasis in the body.
- Discuss methods to assess nutrient status and the strengths and weaknesses of these methods.
- Describe manifestations of deficiency and toxicity states and relate biochemical and physiological roles of nutrients to these manifestations.
- Identify scientific gaps in knowledge and controversies, and propose approaches to resolve these gaps or controversies.
Texts or Materials:

Lists of required and optional reading will be posted on Canvas under each lecture topic. Several topics will utilize the online textbook Modern Nutrition in Health and Disease (2014), which is available through the Tufts University Health Sciences webpage. Other reading will be posted to Canvas.

Academic Conduct: Each student is responsible for upholding the highest standards of academic integrity, as specified in the Friedman School’s Policies and Procedures Handbook 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 and the course to dismissal from the school.

Classroom Conduct: Students should treat each other and faculty with respect. Class will begin and end on time and students should arrive for class on time. Preparation for class, including completion of assigned reading, is necessary to fully participate in class activities.

Assessment and Grading: Grading for the course will be based on the below distribution:

- Two in-class exams (20% each): 40%
- Final Exam: 25%
- Nutritional Anemia Abstract: 15%
- Elevator speech: 5%
- Three TBL quizzes (5% each): 15%

Class participation by all students is expected during discussions and team based learning. Participation during lectures and other activities is encouraged. Although there will be no formal score assigned for participation, the instructors reserve the right to increase a student’s final course grade on the basis of exceptional participation as evidenced by obvious advance preparation and regular contributions.

A passing grade in the course is B- or better. Course grades will be based on the below (subject to revision during the course):

- A > 94%
- A- 90 - <94%
- B+ 87 - <90%
- B 84 - <87%
- B- 80 - <84%

Instructions for Submission of Assignments and Exams: Assignments should be submitted via Canvas. If Canvas is not operational, the assignment should be emailed to both of the course instructors prior to the time the assignment is due. Students who are unable to complete an assignment or exam on time and wish to request an extension should notify the course instructors prior to the assignment deadline either in person, by email or by phone to provide a brief explanation for why the extension is needed. Assignments received after deadlines will not be accepted unless an extension was granted prior to the deadline.

Accommodation of Disabilities: Tufts University is committed to providing equal access and support to all students through the provision of reasonable accommodations so that each student may access their curricula and achieve their personal and academic potential. If you have a disability that requires reasonable accommodations please contact the Friedman School Assistant Dean of Student Affairs at 617-636-6719 to make arrangements for determination of appropriate accommodations. Please be aware that accommodations cannot be enacted retroactively, making timeliness a critical aspect for their provision.

Tufts WebEx: Friedman’s on-campus courses may be offered by Tufts WebEx (https://it.tufts.edu/webex) on days when the Boston campus is closed due to weather or a temporary cancellation issue. Students should expect to be notified by email in the event that class is cancelled and will be provided with the WebEx link for students to use for any remote...
class sessions. Also, any relevant course slides or materials will be made available on Canvas. The WebEx will be recorded and posted on Canvas when completed. If an on-campus Examination/Presentation was scheduled on a day when the Boston campus is closed due to weather or a temporary cancellation issue, the exam/presentation will be rescheduled for an alternate on-campus class session date.

**Diversity Statement:** We believe that 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 of the students in this course. We will present materials that are respectful of diversity: 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.

**Course Topics and Assignment Schedule at a Glance:**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>DATE OF CLASS</th>
<th>COURSE TOPIC</th>
<th>LECTURER</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Wed Jan 16</td>
<td>Iron, Zinc &amp; Copper</td>
<td>Saltzman</td>
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<td></td>
<td>Mon Jan 21</td>
<td><strong>MLK Day no classes</strong></td>
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<tr>
<td>2</td>
<td>Wed Jan 23</td>
<td>Chromium, Fluoride &amp; Iodine</td>
<td>Lalonde</td>
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<td>3</td>
<td>Mon Jan 28</td>
<td>Vitamins K and D</td>
<td>Booth</td>
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<td>4</td>
<td>Wed Jan 30</td>
<td>Calcium, Phosphorus &amp; Magnesium</td>
<td>Paul</td>
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<td>5</td>
<td>Mon Feb 4</td>
<td>TBL: Bone Health</td>
<td>Paul</td>
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<tr>
<td>6</td>
<td>Wed Feb 6</td>
<td>Selenium</td>
<td>Lalonde</td>
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<td>7</td>
<td>Mon Feb 11</td>
<td>Minerals and Blood Pressure Lecture and Discussion</td>
<td>Saltzman</td>
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<tr>
<td>8</td>
<td>Wed Feb 13</td>
<td>Structured Review: Classes 1-7</td>
<td>Paul &amp; Lalonde</td>
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<td></td>
<td>Mon Feb 18</td>
<td><strong>President’s Day no classes</strong></td>
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<td>9</td>
<td>Wed Feb 20</td>
<td>Exam 1 covering classes 1-7</td>
<td>Paul</td>
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<td>10</td>
<td>Mon Feb 25</td>
<td>Oxidative Stress</td>
<td>Paul</td>
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<td>11</td>
<td>Wed Feb 27</td>
<td>Vitamin E: Lecture &amp; Discussion</td>
<td>Wu</td>
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<td>12</td>
<td>Mon Mar 4</td>
<td>Vitamin C</td>
<td>Lalonde</td>
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<td>13</td>
<td>Wed Mar 6</td>
<td>Vitamin A and Carotenoids</td>
<td>Wang</td>
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<td>14</td>
<td>Mon Mar 11</td>
<td>Polyphenols</td>
<td>Paul</td>
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<td>15</td>
<td>Wed Mar 13</td>
<td>TBL: Antioxidants</td>
<td>Paul</td>
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<td></td>
<td>Mar 18 &amp; 20</td>
<td><strong>Spring break no classes</strong></td>
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<td>Date</td>
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<tr>
<td>16</td>
<td>Mon Mar 25</td>
<td>Structured Review: Classes 10-15</td>
<td>Paul &amp; Lalonde</td>
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<tr>
<td>17</td>
<td>Wed Mar 27</td>
<td>Exam covering classes 10-15</td>
<td>Paul</td>
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<td>18</td>
<td>Mon Apr 1</td>
<td>Vitamin B12</td>
<td>Paul</td>
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<td>19</td>
<td>Wed Apr 3</td>
<td>Folate &amp; Folic Acid Discussion</td>
<td>Paul &amp; Lalonde</td>
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<td>20</td>
<td>Mon Apr 8</td>
<td>Vitamin B6</td>
<td>Lalonde</td>
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<td>21</td>
<td>Wed Apr 10</td>
<td>Niacin, Sirutins and Aging</td>
<td>Lalonde &amp; Kaushik</td>
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<td>Mon Apr 15</td>
<td><strong>Patriot’s day no classes</strong></td>
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<td>22</td>
<td>Wed Apr 17</td>
<td>Nutritional Anemia</td>
<td>Saltzman</td>
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<tr>
<td>23</td>
<td>Mon Apr 22</td>
<td>Thiamin, Patothenic Acid, Biotin</td>
<td>Paul</td>
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<td>24</td>
<td>Wed Apr 24</td>
<td>Riboflavin Discussion: Microbiota and Vitamins</td>
<td>Paul</td>
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<td>25</td>
<td>Mon Apr 29</td>
<td>TBL: Global Micronutrient Issues</td>
<td>Saltzman</td>
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<td>26</td>
<td>Wed May 1</td>
<td>Structured Review classes 18 -25</td>
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<td></td>
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<td>Nutritional Anemia Abstract Due</td>
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<td>27</td>
<td>Mon May 6</td>
<td>Exam in class</td>
<td>Paul</td>
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This schedule is subject to modification at the instructor’s discretion.

**Detailed Schedule by Class**

**Wednesday January 16: Iron, Zinc and Copper**

Learning Objectives:

1. Differentiate between the two major types of dietary iron and factors contributing to bioavailability.
2. Explain the concept of nutrient sensing and provide examples for iron, copper and zinc.
3. Contrast mechanisms of homeostasis for iron, zinc and copper.
4. Explain the physiologic basis for commonly used biomarkers for iron, zinc and copper.
5. Provide examples of the risk factors for deficiency of iron, copper and zinc.
6. Describe genetic defects that can result in hereditary iron overload and deficiency of zinc and copper.
7. Summarize types of function and provide examples for each type for iron, copper and zinc.
8. Explain how zinc supplementation can cause copper deficiency

Required Reading:

2. Collins JF, Copper. In Modern Nutrition in Health and Disease 11th
Supplemental Reading:


Assignments Due: None

**Wednesday January 23: Chromium, Fluoride, Iodine**

Learning Objectives:

1. Describe the putative role for chromium in insulin action.
2. Explain the rationale for fluoridation of water.
3. Describe the mechanism by which fluoride protects teeth from acid-induced enamel loss.
4. Explain the rationale for iodine fortification of foods.
5. Summarize thyroid hormone synthesis and homeostasis, and provide an example of the effects of iodine deficiency on homeostasis.

Required Reading:


Assignments Due: None

**Monday January 28: Vitamin K and Vitamin D**

Learning Objectives:

1. Contrast sources of vitamin K.
2. Summarize the biochemical function of vitamin K and the physiological implications.
3. Explain the rationale for defining vitamin D adequacy and the basis for current DRI recommendations for vitamin D.
4. Summarize proposed novel functions for vitamin D and their molecular bases.
5. Describe how manifestations vitamin D deficiency vary with life stage.

Required Reading:

2. Christakos (Links to an external site.), Dhawan (Links to an external site.), P (Links to an external site.), Verstuyf (Links to an external site.), Christakos (Links to an external site.), Dhawan (Links to an external site.), P (Links to an external site.), Verstuyf (Links to an external site.), Carmeliet (Links to an external site.), G (Links to an external site.), Vitamin D: Metabolism, Molecular Mechanism of Action, and Pleiotropic Effects. *Physiol* (Links to an external site.)

Supplemental Reading:


Assignments Due: None

Wednesday January 30: Calcium, Phosphorus and Magnesium

Learning Objectives:

1. Summarize the mechanisms for absorption and homeostasis of calcium, phosphorus and magnesium
2. Differentiate between the effects of PTH on calcium and phosphorus balance
3. Describe multiple biological functions of phosphorus and magnesium
4. Identify gaps in magnesium research that pertain to the role of magnesium in prevention of chronic disease

Required Reading:

3. Assignments Due: None

Wednesday February 6: Selenium

Learning Objectives:

1. Contrast methods to assess Se status and function
2. Describe the main biochemical functions of Se
3. Explain the regulation of selenoprotein synthesis
4. Discuss how increasing selenium intake could result in health benefits or could result in health risk
5. Discuss the interaction between selenium and mercury

Required Reading:


Assignments Due: None
Monday February 11: Minerals and Blood Pressure

Learning Objectives:

1. Describe methods for dietary assessment of sodium and potassium intake
2. Discuss micronutrients proposed to influence blood pressure and describe foods and diet patterns rich in these micronutrients
3. Explain current controversies regarding sodium intake
4. Discuss the relationship between social determinants of health and prevalence of hypertension as well as morbidity associated with hypertension
5. Critique approaches to reduce sodium intake
6. Discuss the advantages and disadvantages of iodination of salt

Required Reading:


Assignments Due: None

Wednesday February 13: Structured Review: Classes 1-7

Learning Objectives: To review course material to-date in anticipation of Exam 1

Required Reading: None

Assignments Due: None

Wednesday February 20: Exam 1 covering classes 1-7

Monday February 25: Oxidative Stress

Learning Objectives:

1. Define oxidative stress
2. Explain how oxidative stress can damage molecules or biological systems and biomarkers for this damage
3. Provide examples of antioxidant defense systems and their biomarkers
4. Provide examples of inter-relationships of biological antioxidant defense systems

Required Reading:

Recommended Reading:

2. Teaching the basics of redox biology to medical and graduate students: Oxidants, antioxidants and disease mechanisms. Redox Biology 1 (2013) 244–257.

Assignments Due: None

**Wednesday February 27: Vitamin E**

Learning Objectives:

1. Define vitamin E and summarize the structures and relative biopotency of different forms of dietary vitamin E
2. Explain the current Dietary Reference Intake and how it is determined, as well as the main dietary sources of vitamin E
3. Explain absorption, storage, transport and metabolism of vitamin E; compare different forms of vitamin E as well as natural and synthetic forms of α-tocopherol
4. Summarize the biological functions of vitamin E, including protection against chronic diseases
5. Discuss the current progress in vitamin E research, in particular on non-α-tocopherol vitamin E
6. Discuss the controversial issues regarding the DRI for vitamin E

Required Reading:


Assignments Due: None

**Monday March 4: Vitamin C**

Learning Objectives:

1. Summarize mechanisms for vitamin C absorption and homeostasis
2. Explain determinants of plasma and tissue concentrations
3. Discuss the relationships between plasma concentration and health outcomes
4. Describe at least 4 different biochemical functions of vitamin C
5. Discuss possible confounders of cell, animal and human studies of supplemental vitamin C
6. Summarize research that links vitamin C to health outcomes
7. Explain confounders of cell, animal and human studies of supplemental vitamin C
8. Propose methods and study designs to address possible confounders

Required Reading:

Assignments Due: None

**Wednesday March 6: Vitamin A and Carotenoids**

Learning Objectives:

1. Compare and contrast chemical structures of major naturally-occurring carotenoids and retinoids
2. Illustrate metabolic pathways of provitamin A carotenoids and non-provitamin A carotenoids
3. Describe distribution, metabolism, and excretion of carotenoids and vitamin A, including the role of binding proteins
4. Summarize methods for biochemical analysis of carotenoids and vitamin A
5. Describe the process of homeostatic control of plasma retinol concentration
6. Explain the molecular modes of action for carotenoids and vitamin A
7. Describe the role of carotenoids/retinoids in chronic disease prevention
8. Choose appropriate methods for assessment of vitamin A status based on the scenario

Required Reading:


Assignments Due: None

**Monday March 11: Polyphenols**

Learning Objectives:

1. Explain the basis for the classification schemes of dietary phytonutrients and dietary polyphenols
2. Provide examples of dietary flavonoids and foods in which they occur naturally
3. Summarize factors that influence bioavailability of flavonoids
4. Explain the role of the gut microbiota in flavonoid nutrition
5. Provide examples of mechanisms that could relate polyphenol intake to chronic disease prevention

Required Reading:


Assignments Due: None

**Wednesday March 13: TBL: Antioxidants**

The TBL will be preceded by a brief in-class quiz on assigned reading for the TBL.

Learning Objectives:
1. Propose mechanisms to explain possible adverse outcomes of high-dose beta carotene from supplements in the setting of cigarette smoking and ethanol intake.
2. Summarize the body of evidence characterizing trials of beta carotene and/or vitamin E supplementation to-date.
3. Discuss current theories of how antioxidant nutrients may prevent cancer.
4. Describe potential confounders in in vitro, animal and human studies of vitamin C.

Required Reading:


Assignments Due: None

Monday March 25: Structured Review: Classes 10-15
Learning Objectives: To review course material to-date in anticipation of Exam 2
Required Reading: None
Assignments Due: None

Wednesday March 27: Exam 2 covering classes 10-15

Monday April 1: Vitamin B12
Learning Objectives:

1. Differentiate between the major dietary forms of vitamin B12
2. Summarize vitamin B12 digestion, absorption, transport, metabolism and excretion.
3. Describe the two biochemical functions of vitamin B12
4. Summarize the major risk factors and manifestations of deficiency, and relate these manifestations to biochemical functions.
5. Explain the basis for the age-related RDA for vitamin B12.

Required Reading:


Assignments Due: None

Wednesday April 3: Folate and Folic Acid Fortification Discussion
Learning Objectives

1. Differentiate between the dietary forms of folate/folic acid
2. Describe the major biochemical and physiologic functions of folate
3. Contrast the methods for assessment of folate status
4. Summarize known effects and gaps in knowledge regarding the health benefits and potential harm from folic acid fortification
5. Explain how deficiencies of folate and vitamin B₁₂ cause the same type of anemia as well as the mechanisms by which supplemental folic acid may mask the effects of the vitamin B₁₂ deficiency.

Required Reading:


Assignments Due: None

Monday April 8: Vitamin B6

Learning Objectives:

1. Compare and contrast vitamers of B6
2. Summarize hepatic metabolism of vitamin B6 and its importance.
3. Provide examples for the roles of vitamin B6 in intermediary macronutrient metabolism.
4. Explain proposed roles for vitamin B6 in inflammation, cancer and cardiovascular disease.

Required Reading:


Assignments Due: None

Wednesday April 10: Niacin

Learning Objectives:

2. Summarize manifestations of niacin deficiency and toxicity.
3. Describe the molecular basis of traditional niacin functions.
4. Discuss emerging proposed functions for niacin and summarize supporting evidence to-date.
5. Explain how enzyme activity and metabolic flux are influenced by substrate and product availability.

Required Reading:


Assignments Due: None
**Wednesday April 17: Nutritional Anemia**

**Learning Objectives:**

1. Explain the process of erythropoiesis and identify stages of incorporation of vitamins and minerals
2. Differentiate the effects of vitamin and mineral deficiencies on red blood cell indices.
3. Develop an algorithm for the use of laboratory tests in the assessment of nutritional anemia.

**Required Reading:**


**Assignments Due:** None

**Monday April 22: Thiamine, Pantothenic Acid and Biotin**

**Learning Objectives:**

1. Explain thiamine functions and provide examples.
2. Describe factors that influence thiamine bioavailability.
3. Discuss risk factors for thiamine deficiency and cite mechanisms that lead to deficiency.
4. Summarize the major thiamine deficiency syndromes.
6. Provide examples of how thiamine status could influence neurodegenerative disease.
7. Discuss biochemical functions of biotin and pantothenic acid.
8. Summarize mechanisms by which biotin is digested and absorbed from food sources.
9. Describe biotin recycling and discuss its importance.
10. Identify risk factors of biotin deficiency and provide methods of status assessment
11. Explain the current status of biotin supplementation for hair loss

**Required Reading:**

1. Modern Nutrition in Health and Disease. Chapter 21:
4. In Modern Nutrition in Health and Disease, 2014,

**Assignments Due:** None

**Wednesday April 24: Riboflavin; Micronutrients and the Gut Microbiota**

**Learning Objectives:**

1. State the most common flavins
2. Explain riboflavin functions and provide examples
3. Describe the mechanisms of riboflavin homeostasis
4. Define microbiome and microbiota
5. Explain possible mechanisms for how the gut microbiota could influence micronutrient status
6. Propose methods for assessment of microbiota effects on micronutrient status

Required Reading:


Assignments Due: None

**Monday April 29: TBL: Global Micronutrient Issues**

The TBL will be preceded by a brief in-class quiz on assigned reading for the TBL.

Learning Objectives:

1. Explain how inflammation influences homeostasis of iron and vitamin A
2. Discuss different approaches to adjust nutrient biomarkers for inflammation
3. Differentiate between effects of inflammation on nutrient homeostasis vs. effects of inflammation on nutrient biomarkers (that do not reflect deranged homeostasis)

Required Reading:


Assignments Due: None

**Wednesday May 1: Structured Review of Weeks 18-25**

Learning Objectives: To review course material to-date in anticipation of Exam 2

Required Reading: None

Assignments Due: Nutritional Anemia Abstract
Monday May 6: Final Exam (Cumulative)

This schedule is subject to modification at the instructor’s discretion.