NUTR 245
Scientific Basis of Nutrition: Micronutrients
Fall 2017

Meets: Tuesdays 1:30 pm – 4:30 pm Jaharis 118

Course Director:
Edward Saltzman, MD
Email: edward.saltzman@tufts.edu
Phone: (617) 636-6633
Office hours: By appointment

Teaching Assistant:
Sara Scinto
Email: Sara.Scinto@tufts.edu
Office hours: By Appointment

Tufts Graduate Credit: 1.0 credit

Prerequisites: Undergraduate chemistry and biology, or by instructor permission.

Course Description:

NUTR 245 is one course of a pair of courses designed to provide students with an in-depth understanding of nutrition and its scientific underpinnings. NUTR 245 focuses on micronutrients, including fat- and water-soluble vitamins and minerals. The second course of the sequence, NUTR 246, focuses on macronutrients and energy.

The course will cover micronutrient sources; digestion and absorption; bioavailability; homeostasis; functions throughout the lifecycle including roles in promotion of health and prevention of disease; and deficiency and toxicity states. Additional concepts will include micronutrient fortification and supplementation, gene-diet interactions, and the social and biological determinants of micronutrient status. The course has been designed to review and build upon students’ existing knowledge of chemistry and biology, and will provide instruction in biochemical and physiologic principles necessary to understand the aspects of micronutrients described above.

Course Goals:

1. Summarize factors related to food and physiology that influence micronutrient bioavailability.
2. Choose appropriate methods for assessment of micronutrient intake.
3. Appreciate the range of mechanisms that contribute to nutrient homeostasis.
4. Understand the scientific basis of methods for assessment of micronutrient status.
5. Describe fundamental functions for each micronutrient.
6. Appreciate how micronutrient functions and requirements change with life stage.
7. Improve critical thinking skills about gaps in scientific knowledge and controversies regarding micronutrients.
8. Express informed opinions about micronutrient fortification and supplementation.

Course Texts and Materials:
The course will utilize two electronic textbooks, both of which are available online through the Tufts Health Sciences Library website:
1. Netter's Essential Physiology (2016), Susan E. Mulroney et al. (eds): this textbook may be useful for optional background reading in basic science topics necessary to understand course material.
2. Modern Nutrition in Health and Disease, 11th edition (2014), A. Catherine Ross et al. (eds): several chapters from this textbook will be assigned as required reading.

Additional reading and other course materials will be posted on Canvas.

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.

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://www.nutrition.tufts.edu/student/documents/policies-procedures/) 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. Written assignments submitted via Canvas will automatically be assessed by online plagiarism detection tools.

Description of Course Elements:

- **Lectures:** Lectures will be provided most weeks. If requested by students, lectures may be recorded and posted on Canvas.
- **Readings:** Required and supplemental readings will be posted on Canvas. Required readings that accompany a lecture should ideally be completed in advance of that lecture. Required reading may be necessary for completion of weekly assignments (see below). Required reading for paper discussions (see below) must be completed prior to class. Supplemental reading complements lecture material and is recommended if a deeper understanding is desire.
- **Paper discussions:** Scientific publications will be included in required readings for some weeks. The publication will be discussed in detail in class and must be read prior to class.
- **Weekly assignments:** There will 12 weekly assignments, each of which will be released on Canvas at the conclusion of each class session. Each assignment will focus on that week’s topic and will reflect the learning objectives, but may include cumulative material. In most cases, assignments can be completed in 2-3 pages. Assignments will be due prior to the beginning of the next week’s class.
- **Final Assignment:** A final take-home assignment will be posted on Canvas at the
conclusion of the final lecture. The final assignment will be cumulative and will reflect course goals. The final assignment will be longer than weekly assignments, but questions will be similar in nature to weekly assignments.

- **Team-based learning:** There will be two team-based learning (TBL) sessions that will require prior preparation outside of class in order to participate. During each TBL students will first complete a brief graded quiz to assess comprehension of assigned reading(s). Students will then be assigned to small groups and will be provided discussion questions; each small group will receive the same questions to discuss as a group. The entire class will then reconvene for discussion of questions.

- **Elevator speeches:** Each student is required to provide a brief 3-minute oral presentation that expands upon topics covered in class. Students are free to choose the topic of each presentation, but the topic should relate to a nutrient already covered in class and should reflect new material beyond what was covered in class and in readings. A rubric for quality of presentations will be posted on Canvas and will serve as the basis for grading. Students who have concerns regarding public speaking should meet with the course instructor at the beginning of the course.

- **Extra credit and makeup assignments:** Students in jeopardy of failing the course may be offered assignments (either remediation of previously completed assignments or additional assignments) to achieve a passing grade. No other assignments for additional or extra credit assignments will be offered.

**Instructions for Submission of Assignments:**

Assignments should be submitted via Canvas. If Canvas is not operational, the assignment should be emailed to the course instructor and TA prior to the time the assignment is due. Students who are unable to complete an assignment or exam on time and are requesting an extension should notify the course director and/or TA by email prior to the assignment deadline with a brief explanation for why the extension is needed. Assignments received after deadlines without approved extensions will not be accepted or graded.

**Assignments and Grading:**

The contribution of course activities to the course grade is found in the table below:

<table>
<thead>
<tr>
<th>Activity (number during the course, % contribution per each)</th>
<th>Contribution to Final Grade (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly Assignments (12, 5% each)</td>
<td>60</td>
</tr>
<tr>
<td>Final Assignment (1)</td>
<td>15</td>
</tr>
<tr>
<td>Elevator Speeches (1)</td>
<td>5</td>
</tr>
<tr>
<td>In Class Participation (Discussions and TBL)</td>
<td>10</td>
</tr>
<tr>
<td>Team Based Learning Quizzes: (2, 5% each)</td>
<td>10</td>
</tr>
</tbody>
</table>
Course Schedule: All classes meet from 1:30 pm – 4:30 pm in Jaharis room 118.

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topic</th>
<th>Assignments Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9/5/2017</td>
<td>Course Introduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iron Part 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9/12/2017</td>
<td>Iron Part 2</td>
<td>Weekly Assignment 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paper Discussion</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>9/19/2017</td>
<td>Iodine, Zinc and Copper</td>
<td>Weekly Assignment 2</td>
</tr>
<tr>
<td>4</td>
<td>9/26/2017</td>
<td>Micronutrients in Bone and Dental Health</td>
<td>Weekly Assignment 3</td>
</tr>
<tr>
<td>5</td>
<td>10/3/2017</td>
<td>Micronutrients in Bone and Dental Health</td>
<td>Weekly Assignment 4</td>
</tr>
<tr>
<td>6</td>
<td>10/10/2017</td>
<td>Minerals and Blood Pressure: Lecture/TBL</td>
<td>Weekly Assignment 5, Elevator Speech Group 1</td>
</tr>
<tr>
<td>7</td>
<td>10/17/2017</td>
<td>Vitamin K, Carotenoids and Vitamin A</td>
<td>Weekly Assignment 6, Elevator Speech Group 2</td>
</tr>
<tr>
<td>8</td>
<td>10/24/2017</td>
<td>Antioxidant Nutrients: Vitamin C, Vitamin E and Selenium</td>
<td>Weekly Assignment 7, Elevator Speech Group 3</td>
</tr>
<tr>
<td>9</td>
<td>10/31/2017</td>
<td>Vitamin B12 and Folate</td>
<td>Weekly Assignment 8, Elevator Speech Group 4</td>
</tr>
<tr>
<td>10</td>
<td>11/7/2017</td>
<td>No Class (Friday Schedule)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11/14/2017</td>
<td>Micronutrients in Energy and Macronutrient Metabolism Part 1: Thiamine, Niacin, Chromium</td>
<td>Weekly Assignment 9, Elevator Speech Group 4</td>
</tr>
<tr>
<td>12</td>
<td>11/21/2017</td>
<td>Micronutrients in Energy and Macronutrient Metabolism Part 2: Riboflavin, Pantothenic Acid, Biotin, Vitamin B6, Iodine</td>
<td>Weekly Assignment 10, Elevator Speech Group 5</td>
</tr>
<tr>
<td>13</td>
<td>11/28/2017</td>
<td>Vitamin B12, Folate, and Nutritional Anemia</td>
<td>Weekly Assignment 11, Elevator Speech Group 6</td>
</tr>
<tr>
<td>14</td>
<td>12/5/2017</td>
<td>TBL: Micronutrient Fortification and Supplementation</td>
<td>Weekly Assignment 12, Elevator Speech Group 7</td>
</tr>
<tr>
<td>15</td>
<td>12/12/2017</td>
<td>No Class - Reading Period</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12/19/2017</td>
<td>Final Assignment</td>
<td></td>
</tr>
</tbody>
</table>

Course Schedule, Reading and Assignments

**Week 1: Course Introduction; Iron Part I**

Learning Objectives:
1. Define micronutrients and explain how micronutrients can be classified.
2. Define and provide examples of essential, non-essential, and conditionally essential nutrients.
3. Differentiate between methods used for dietary assessment.
4. Define food matrix and describe how the food matrix can influence bioavailability.
5. Describe essential processes in digestion and absorption.
7. Contrast the food sources and mechanisms of digestion and absorption for heme and non-heme iron absorption.
8. Explain the mechanisms by which dietary components inhibit or enhance non-heme iron absorption.

Supplemental Reading:

Assignments Due: None

Week 2: Iron Part 2; Paper Discussion: Collings et al (see required reading)

Learning Objectives:
1. Describe the major functions of iron in humans.
2. Summarize the mechanisms of iron homeostasis.
3. Explain how inflammation can influence iron homeostasis and status.
4. Describe mechanisms involved in gene expression.
5. Differentiate between genetic and epigenetic.
6. Identify risk factors for iron deficiency.
7. Discuss if iron absorption from whole diets followed the predicted pattern in the assigned reading by Collings et al.

Required Reading:

Supplemental Reading:

Assignments Due:
1. Weekly Assignment 1

Week 3: Zinc, Copper and Fluoride

Learning Objectives:
1. Provide examples of zinc and copper functions.
2. Explain how zinc is distributed in body compartments.
5. Contrast genetic disorders of zinc and copper transport.
6. Explain how copper deficiency can cause iron deficiency.
7. Explain how zinc supplementation can cause copper deficiency.
8. Describe the mechanism by which fluoride promotes resistance to dental caries.
9. Discuss the rationale for fluoridation of drinking water.

Required Reading:

Supplemental Reading:
Assignments Due:
1. Weekly Assignment 2

Week 4: Micronutrients in Bone and Dental Health

Learning Objectives:
1. Summarize dietary and non-dietary factors that influence calcium absorption.
2. Diagram and explain calcium homeostasis, including roles played by calcium sensing, vitamin D, and organs (liver, kidney, intestine, bone and skin).
3. Summarize vitamin D metabolism, including synthesis, hydroxylation, and degradation.
4. Describe biomarkers of vitamin D status, providing advantages and limitations of each.
5. Discuss possible implications of genetic variation in vitamin D metabolism.
6. Defend your opinion regarding vitamin D supplementation with consideration of age, gender, race/ethnicity, health history.
7. Discuss the effects of calcium and vitamin D intake at each life stage in promotion of bone health and prevention of age-related bone disease.
8. Summarize physiologic roles of phosphorous.
9. Discuss the implications of phosphorous food additives.

Required Reading:

Supplemental Reading:

Assignments Due: Weekly Assignment 3

Week 5: Bone Health and Brief Introduction to Sodium and Iodine

Learning Objectives:
10. Summarize markers of bone formation, bone resorption, and bone mineral content.
12. Explain how dietary protein could promote or impair bone health.
13. Discuss the effects of dietary calcium, vitamin D and other relevant dietary factors at each life stage in promotion of bone health and prevention of age-related bone disease.
14. Discuss the implications of phosphorous food additives on health.
15. Contrast homeostasis of iron and zinc to homeostasis of sodium.

Required Reading:
**Supplemental Reading:**

**Assignments Due:**
1. Written Assignment 4.

**Week 6: Minerals and Blood Pressure: Team Based Learning**

**Learning Objectives:**
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:**
1. Written Assignment 5.

**Assignments Due:**
1. Weekly Assignment 5
2. Elevator Speech Group 1

**Week 7: Vitamin A, Carotenoids, Vitamin K, Microbiome**

**Learning Objectives:**
1. Explain the intestinal and hepatic regulation of vitamin A concentrations, including regulation of pro-vitamin A carotenoid metabolism.
2. Summarize the major functions of the active forms of vitamin A and provide examples of each.
3. Explain functions of carotenoids in humans.
4. Contrast biomarkers of vitamin A intake and status.
5. Identify risk factors for vitamin A deficiency and excess.
6. Provide examples of manifestations of vitamin A deficiency and excess.
7. Discuss the evidence to-date regarding high dose carotenoid supplementation for prevention of disease.
8. Define microbiota, microbiome, probiotic and prebiotic.
9. Provide examples of how microbial production of micronutrients may contribute to micronutrient status.
10. Explain how dietary factors could influence composition of the microbiota.
11. Differentiate between the two major forms of vitamin K in regard to source and function.
12. Describe the major biochemical function of vitamin K.
13. Contrast biomarkers of vitamin K intake and status.

Required Reading:

Supplemental Reading:
2. Modern Nutrition in Health and Disease. Chapter 17: Vitamin A.

Assignments Due:
1. Weekly Assignment 6
2. Elevator Speech Group 2

Week 8: Vitamin C; Vitamin E; Selenium; Oxidative Stress and Antioxidants

Learning Objectives:
1. Define oxidative stress and explain how oxidative stress can result in tissue damage and disease.
2. Describe how vitamins C and E act as antioxidants.
3. Explain the relationship between vitamin C and vitamin E in the antioxidant defense network.
4. Explain how regulation of vitamin C homeostasis has potential implications for use of oral vitamin C supplements for disease prevention.
5. Describe the functions of vitamin C and provide examples for each function.
6. Provide examples of how scurvy is manifested.
7. Discuss why vitamin C supplementation trials utilizing in vitro and animal models may not predict results in humans.
8. Describe the mechanisms of vitamin E absorption and its distribution in the body.
9. Summarize the biological functions of vitamin E.
10. Explain emerging evidence for the importance of different forms of vitamin E.

Required Reading:
Supplemental Reading:

Assignments Due:
1. Weekly Assignment 7
2. Elevator Speech Group 3

Week 10: No Class

Assignments Due:
1. Weekly Assignment 9

Week 11: Micronutrients in Energy and Macronutrient Metabolism Part 1: Thiamine; Niacin; Chromium

Learning Objectives:
1. Provide examples of thiamine function and explain how these functions relate to energy metabolism.
2. Summarize risk factors for thiamine deficiency.
3. Describe the major thiamine deficiency syndromes.
5. Illustrate the proposed mechanism for chromium’s role in insulin action.
6. Describe the dietary and non-dietary pathways of NAD synthesis.
7. Summarize niacin functions and differentiate between non-consumptive and consumptive functions.
8. Discuss the potential role for niacin in prevention of aging and chronic disease.
9. Summarize manifestations of niacin deficiency and toxicity.

Required Reading:

Supplemental Reading:

Assignments Due:
1. Weekly Assignment 10
2. Elevator Speech Group 5

Week 12: Micronutrients in Energy and Macronutrient Metabolism Part 2: Vitamin B6; Riboflavin; Biotin; Pantothenic Acid; Iodine

Learning Objectives:
2. Provide examples for the roles of vitamin B6 in intermediary macronutrient metabolism.
3. Propose an explanation for why vitamin B6 is added to products such as energy drinks.
4. Explain riboflavin functions and provide examples.
5. Explain biotin functions and provide examples.
6. Explain pantothenic acid functions and provide examples.

Required Reading:

Supplemental Reading:

Assignments Due:
1. Weekly Assignment 11
2. Elevator Speech Group 6

**Week 13: Vitamin B12 and Folate**

Learning Objectives:
1. Differentiate the major food forms of vitamin B12 and folate.
2. Describe the two main biochemical functions of vitamin B12.
3. Summarize the major risk factors for vitamin B12 deficiency.
4. Explain the basis for the age-related RDA for vitamin B12.
5. Contrast the methods for assessment of vitamin B12 status.
6. Describe the major functions of folate.
7. Contrast the methods for assessment of folate status.
8. Summarize known effects and gaps in knowledge regarding the health benefits and potential harm from folic acid fortification.
9. Explain how deficiencies of folate and vitamin B\textsubscript{12} cause the same type of anemia.
10. Explain how supplemental folic acid may mask the effects of the vitamin B\textsubscript{12} deficiency.

Required Reading:

Assignments Due:
1. Weekly Assignment 8
2. Elevator Speech Group 4

**Week 14: Dietary Supplements and Fortification Team Based Learning**

1. Describe how dietary supplements are regulated by the FDA.
2. Provide examples from earlier in the course where dietary supplements were demonstrated to be beneficial, were demonstrated to not be beneficial, or may have caused harm.
3. Explain why folic acid was recently approved for fortification of corn flour.
4. Provide arguments for and against use of multivitamins.
5. Discuss demonstrated and proposed benefits of micronutrient supplementation during pregnancy and during adulthood.

Required Reading:

Supplemental Reading:

Assignments Due:
2. Weekly Assignment 12.
3. Elevator Speech Groups 7