

NUTR 245
Scientific Basis of Nutrition: Micronutrients
Fall 2018

Meets: Fridays 9 am - 12 pm in Jaharis 118

Course Director:

Edward Saltzman, MD

Email: Edward.Saltzman@tufts.edu

Phone: (617) 636-6633

Office: Jaharis 269

Office hours by appointment: Contact Patty Dawson, Patty.Dawson@tufts.edu, (617) 636-2467

Teaching Assistant:

Lauren Bloomberg

Email: Lauren.Bloomberg@tufts.edu

Office hours by Appointment

Tufts Graduate Credit: 3 Semester Hour Units

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.

This course will cover micronutrient sources; digestion, absorption and 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.

Course Goals:

1. Integrate the multiple processes and factors that determine micronutrient status.
2. Explain fundamental micronutrient functions.
3. Identify risks for, and manifestations of, major deficiency and toxicity syndromes.
4. Explain how micronutrient requirements can be assessed.
5. Understand the basis of micronutrient controversies.

Course Texts and Materials:

The course will utilize two electronic textbooks, both of which are available online through the Tufts Health Sciences Library website:

- 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.

- 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.

Readings will be assigned from these books and a variety of other sources. All required and supplemental reading 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 (<https://nutrition.tufts.edu/sites/default/files/documents-forms/2018-2019PolProc.pdf>) 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 will be assessed by online plagiarism detection tools.**

Description of Course Elements:

- **Lectures:** Lectures will be provided most weeks. Lectures will be recorded and posted on Canvas. In-class activities involving small groups will not be recorded.
- **Readings:**
 - All readings will be posted on Canvas.
 - **Required readings:** It is expected that required readings will be completed prior to class. Content from required reading may be reflected in course assignments.
 - **Supplemental readings:** Supplemental readings are not required and are intended to complement lecture material or provide a deeper understanding of course material. Content from supplemental readings will not be reflected in course assignments.
- **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. All class members should be prepared to participate in paper discussions.
- **Weekly assignments:** The purpose of weekly assignments is to assess comprehension of that week's topic and integrate the topic into course concepts. There will 11 weekly assignments, each of which follows a lecture. Each assignment will reflect the learning objectives as well as some prior course material. **Each student must submit a minimum of 8 weekly assignments.** If more than 8 assignments are submitted, the highest scoring 8 assignments will count towards the course grade. Assignments will generally be able to be completed in 3-5 pages. Assignments will be due prior to the beginning of the next week's class.

- **Team-based learning:** There will be two team-based learning (TBL) sessions that will require prior preparation outside of class. At the beginning of each TBL session students will complete a brief written quiz to assess comprehension of assigned readings. Following the quiz, students will be assigned to small groups and each small group will receive the same questions to discuss as a group. For the second half of the session the entire class will reconvene for discussion of questions.
- **Interviews:** Each will interview an expert in a relevant topic of interest and will submit a written summary of the interview. The interview process will take place in several stages, with each stage associated with a deadline over the semester:
 - Students will initially define a relevant topic of interest and submit a brief (2-3 page) concept note that summarizes background and provides justification for the topic. Concept notes will be submitted and will be subject to peer-review in class.
 - Students will propose interview questions and those questions will be submitted and peer-reviewed in class.
 - Individuals with expertise in topics will be identified and invited.
 - Interviews will be conducted in person or electronically (by phone, WebEx or Skype).
 - A written summary of the interview will be submitted and will be due at the end of the final examination period. The format of the written summary will be explained in class.
- **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 on time and wish to request an extension must contact the instructor and TA by email **prior to the submission deadline** and include a specific date and time by which the assignment will be submitted. **Assignments received after deadlines without approved extensions will not be graded or counted towards the final course grade.**

Assignments and Grading:

| Activity (number during course, % contribution per each) | Contribution to Final Grade (%) |
|--|---------------------------------|
| Weekly Assignments (8, 8% each) | 64 |
| Interview Concept Note (1) | 8 |
| Interview Questions (1) | 8 |
| Interview Summary (1) | 10 |
| Team Based Learning (TBL) Quiz (2, 5% each) | 10 |

Course Schedule

| Week | Date | Topics | Assignments Due @ 9:00am |
|------|----------|--|---|
| 1 | 9/7/18 | Course Introduction Lecture: Mechanisms of Digestion and Absorption; Dietary Assessment; Iron (Part 1) | |
| 2 | 9/14/18 | Lecture: Iron (Part 2) Activity: Paper Discussion (Collings et al.) | Weekly Assignment 1 |
| 3 | 9/21/18 | Lecture: Zinc and Copper | Weekly Assignment 2 |
| 4 | 9/28/18 | Lecture: Vitamin D, Calcium and Bone Health | Weekly Assignment 3 |
| 5 | 10/5/18 | Lecture: Magnesium, Phosphorus and Fluoride | Weekly Assignment 4 |
| 6 | 10/12/18 | Activity: TBL #1 (Micronutrients and Blood Pressure) | Weekly Assignment 5 |
| 7 | 10/19/18 | Lecture: Vitamin A, Carotenoids, Vitamin K, and the Microbiota | |
| 8 | 10/26/18 | Lecture: Oxidative Stress and Antioxidant Nutrients | Weekly Assignment 6 |
| 9 | 11/2/18 | Lecture: Vitamin B12 and Folate | Weekly Assignment 7 |
| 10 | 11/9/18 | Lecture: Micronutrients in Energy and Macronutrient Metabolism (Part 1) Activity: Peer Review of Interview Concept Note | Weekly Assignment 8 Interview Concept Note |
| 11 | 11/16/18 | Lecture: Micronutrients in Energy and Macronutrient Metabolism (Part 2) Activity: Peer Review of Interview Questions | Weekly Assignment 9 Interview Questions |
| | 11/23/18 | No Class - Thanksgiving Recess | |
| 12 | 11/30/18 | Lecture: Nutritional Anemia; Iodine | Weekly Assignment 10 |
| 13 | 12/7/18 | Activity: TBL #2 (Fortification and Supplementation) | Weekly Assignment 11 |
| | 12/20/18 | | Interview Summary due |

Course Schedule, Reading and Assignments

Week 1: Course Introduction; Mechanisms of Digestion and Absorption; Dietary Assessment; Iron (Part 1)

Class Date: September 7th

Week 2: Iron (Part 2); Paper Discussion: Collings et al.

Class Date: September 14th

Learning Objectives:

1. Contrast advantages and disadvantages of dietary assessment methods discussed in class.
2. Provide examples of mechanisms for transport of micronutrients in and out of cells.
3. Explain the major processes contributing to iron bioavailability and differentiate between heme and non-heme iron.
4. Summarize the purpose and components of the Dietary Reference Intakes.
5. Describe the major functions of iron in humans.
6. Summarize iron homeostasis mechanisms, including genetic and physiologic contributors.
7. Contrast the usefulness and pitfalls of biomarkers of iron status.
8. Identify risk factors for iron deficiency in diverse populations.
9. Summarize how effects of iron deficiency vary by life stage.

10. Discuss if iron absorption from whole diets followed the predicted pattern as reported in the assigned reading by Collings et al.

Required Reading:

1. Modern Nutrition in Health and Disease: Chapter 10: Iron.
2. Collings et al., The absorption of iron from whole diets: a systematic review. Am J Clin Nutr 2013 doi: 10.3945/ajcn.112.050609.

Supplemental Reading:

1. Basic science background
 - a. Netter's Essential Physiology. Chapter 22: Overview of the Digestive Tract.
 - b. Netter's Essential Physiology. Chapter 26: Digestion and Absorption.
2. Gulec et al., Mechanistic and regulatory aspects of intestinal iron absorption. Am J Physiol Gastrointest Liver Physiol 2014;307:G397–G409.

Assignments Due:

1. Weekly Assignment #1 due on Friday 9/14/18 @ 9:00am.
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Week 3: Zinc and Copper

Class Date: September 21st

Learning Objectives:

1. Summarize mechanisms of zinc and copper absorption.
2. Discuss factors that influence zinc and copper bioavailability.
3. Summarize risk factors for zinc and copper deficiency.
4. Describe long-term implications of zinc deficiency in children.
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.

Required Reading:

1. King et al. Biomarkers of Nutrition for Development – Zinc Review. J Nutr 2016;146(Suppl):858S–85S.
2. Collins JF. Copper. In Modern Nutrition in Health and Disease 11th edition.

Supplemental Reading:

1. King and Cousins. Zinc. In Modern Nutrition in Health and Disease 11th edition.

Assignments Due:

1. Weekly Assignment #2 on Friday 9/21/18 @ 9:00am.
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Week 4: Vitamin D, Calcium and Bone Health

Class Date: September 28th

Learning Objectives:

1. Summarize vitamin D metabolism, including synthesis, hydroxylation, and degradation.
2. Discuss the advantages and disadvantages of biomarkers of vitamin D status.

3. Recognize possible implications of genetic variation in vitamin D metabolism.
4. Summarize factors that influence calcium bioavailability.
5. Diagram and explain calcium homeostasis, including roles played by calcium sensing, vitamin D, and organs (liver, kidney, intestine, bone and skin).
6. 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.
7. Defend your opinion regarding vitamin D and calcium supplementation with consideration of age, gender, race/ethnicity, and health history.
8. Summarize markers of bone formation, bone resorption, and bone mineral content.
9. Explain the basis for the current Dietary Reference Intake recommendations for vitamin D and calcium.
10. Explain how dietary protein could promote or impair bone health.

Required Reading:

1. Mitchell et al. Life-course approach to nutrition. *Osteoporos Int* (2015) 26: 2723–2742.
2. Netter's Essential Physiology. Chapter 31: Calcium Regulating Hormones.
3. Kahwati et al. Vitamin D, Calcium, or Combined Supplementation for the Primary Prevention of Fractures in Community-Dwelling Adults: Evidence Report and Systematic Review for the US Preventive Services Task Force. *JAMA*. 319(15):1600-1612, 2018.

Supplemental Reading:

1. Christakos et al., Vitamin D: metabolism, molecular mechanism of action, and pleiotropic effects. *Physiol Rev* 96: 365–408, 2016.
2. Modern Nutrition in Health and Disease. Chapter 7: Calcium.
3. Shams-White et al. Dietary protein and bone health: a systematic review and meta-analysis from the National Osteoporosis Foundation. *Am J Clin Nutr* 2017;105:1528–43.
4. DRI for Calcium and Vitamin D: <http://www.iom.edu/Reports/2010/Dietary-Reference-Intakes-for-Calcium-and-Vitamin-D/Report-Release.aspx>

Assignments Due:

1. Weekly Assignment #3 on Friday 9/28/18 @ 9:00am.

Week 5: Magnesium, Phosphorus, and Fluoride

Class Date: October 5th

Learning Objectives:

1. Identify common mechanisms as well as contrast differing mechanisms in the homeostasis of magnesium and phosphorus vs. homeostasis of calcium.
2. Summarize physiologic roles of magnesium and phosphorus.
3. Summarize proposed health effects of magnesium intake.
4. Discuss the implications of phosphorous food additives.
5. Explain the mechanism by which fluoride promotes resistance to dental caries.
6. Propose alternatives to fluoridation of water.

Required Reading:

1. Modern Nutrition in Health and Disease. Chapter 8: Phosphorous.
2. Alawi et al. *International Journal of Endocrinology* Volume 2018 <https://doi.org/10.1155/2018/9041694>.
3. Calvo et al. Phosphorus. *Adv Nutr* 2015;6:860–2, doi:10.3945/an.115.008516.

4. Kanduti et al., Fluoride: A review of use and effects on health. *Mater Sociomed.* 2016 Apr; 28(2): 133-137 DOI: 10.5455/msm.2016.28.133-137.

Assignments Due:

1. Weekly Assignment #4 on Friday 10/5/18 @ 9:00am.
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Week 6: Team Based Learning #1: Micronutrients and Blood Pressure

Class Date: October 12th

Learning Objectives:

1. Describe advantages and disadvantages of methods for dietary assessment of sodium and potassium.
2. Discuss micronutrients proposed to influence blood pressure and identify foods and diet patterns rich in these micronutrients.
3. Explain current controversies regarding sodium intake and propose research to resolve controversies.
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.

Required Reading:

1. Eyles et al., Achieving the WHO sodium target: estimation of reductions required in the sodium content of packaged foods and other sources of dietary sodium. *Am J Clin Nutr* 2016; doi: 10.3945/ajcn.115.125146.
2. O'Donnell et al., Salt intake and cardiovascular disease: why are the data inconsistent? *European Heart Journal* (2013) 34, 1034–1040.
3. Hawkins et al., Effects of Different Dietary Interventions on Blood Pressure. *Hypertension.* 2016;67:733-739.
4. McDonough and Youn. Potassium Homeostasis. *Physiology* 32: 100–111, 2017.

Assignments Due:

1. Weekly Assignment #5 due Friday 10/12/18 @ 9:00am.

Reminder: There will be a brief written quiz during class to assess comprehension of the assigned readings for the TBL exercise.

Week 7: Vitamin A, Carotenoids, Vitamin K, Microbiota

Class Date: October 19th

Learning Objectives:

1. Summarize vitamin A homeostasis, including regulation of pro-vitamin A carotenoid metabolism.
2. Explain 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 and propose appropriate uses in diverse scenarios.
5. Identify risk factors for, and manifestations of, vitamin A deficiency and excess.

6. Discuss the evidence to-date regarding high dose carotenoid supplementation for prevention of disease.
7. Differentiate between the two major forms of vitamin K.
8. Explain the major biochemical function of vitamin K.
9. Propose appropriate use of biomarkers of vitamin K intake and status.
10. Define microbiota, microbiome, probiotic and prebiotic.
11. Provide examples of how microbial production of micronutrients may contribute to micronutrient status.
12. Explain how dietary factors could influence composition of the microbiota.

Required Reading:

1. Tanumihardjo et al. Biomarkers of Nutrition for Development (BOND)-Vitamin A Review. *J Nutr* 2016;146:1816s-48s.
2. Concepts and Controversies in Evaluating Vitamin K Status in Population-Based Studies. Shea and Booth. *Nutrients* 2016, 8, 8; doi:10.3390/nu8010008.
3. Quigley. Basic Definition and Concepts: The Human Gut Microbiome. *Gastroenterol Clin N Am* 46 (2017) 1–8.

Supplemental Reading:

1. Modern Nutrition in Health and Disease. Chapter 31: Carotenoids.
2. Modern Nutrition in Health and Disease. Chapter 17: Vitamin A.
3. Murtaza. Diet and the Microbiome. *Gastroenterol Clin N Am* 46 (2017) 49–60.

Assignments Due: None.

Week 8: Oxidative Stress and Antioxidant Nutrients: Vitamin C, Vitamin E and Selenium

Class Date: October 26th

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 implications of vitamin C homeostasis on 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 manifests.
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.
11. Describe the role of selenium in antioxidant defense.

Required Reading:

1. Traber, Vitamin E Inadequacy in Humans: Causes and Consequences. *Adv Nutr* 2014;5: 503-514.
2. Modern Nutrition in Health and Disease. Chapter 29: Vitamin C.

Supplemental Reading:

1. Michels and Frei, Myths, Artifacts, and Fatal Flaws: Identifying Limitations and Opportunities in Vitamin C Research. *Nutrients* 2013;5:5161-5192.
2. Rayman, Selenium and human health. *Lancet* 2012; 379: 1256–68.
3. Corcoran et al., Flavonoid Basics: Chemistry, Sources, Mechanisms of Action, and Safety, *Journal of Nutrition in Gerontology and Geriatrics* 2013;31:3:176-189.

Assignments Due:

1. Weekly Assignment #6 due Friday 10/26/18 @ 9:00am.
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Week 9: Vitamin B12 and Folate

Class Date: November 2nd

Learning Objectives:

1. Differentiate the major food forms of vitamin B12 and folate.
2. Describe the 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 B₁₂ cause the same type of anemia.
10. Explain how supplemental folic acid may mask the effects of the vitamin B₁₂ deficiency.

Required Reading:

1. *Modern Nutrition in Health and Disease*. Chapter 26: Folic Acid.
2. *Modern Nutrition in Health and Disease*. Chapter 27: Cobalamin (Vitamin B12).

Assignments Due:

1. Weekly Assignment #7 due Friday 11/2/18 @ 9:00am.
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Week 10: Micronutrients in Energy and Macronutrient Metabolism Part 1: Thiamine; Niacin; Chromium

Class Date: November 9th

Learning Objectives:

1. Explain how thiamine and niacin functions relate to macronutrient and energy metabolism.
2. Summarize risk factors for, and manifestations of, thiamine deficiency.
3. Contrast methods for biochemical assessment of thiamine status.
4. Explain the proposed mechanism for chromium's role in insulin action.
5. Describe the dietary and non-dietary pathways of NAD synthesis.
6. Differentiate between non-consumptive and consumptive NAD functions.
7. Discuss the potential role for niacin in prevention of aging and chronic disease.
8. Summarize risk factors for, and manifestations of niacin, deficiency.

Required Reading:

1. Modern Nutrition in Health and Disease. Chapter 21: Thiamin.
2. Modern Nutrition in Health and Disease. Chapter 23: Niacin

Supplemental Reading:

1. Vincent, Chromium: is it essential, pharmacologically relevant, or toxic. Met Ions Life Sci 2013;13:171-198.

Assignments Due:

1. Weekly Assignment #8 due Friday 11/9/18 @ 9:00am.
 2. Interview Concept Note due Friday 11/9/18 @ 9:00am.
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Week 11: Micronutrients in Energy and Macronutrient Metabolism Part 2: Vitamin B6; Riboflavin; Biotin; Pantothenic Acid

Class Date: November 16th

Learning Objectives:

1. Compare vitamers of B6.
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:

1. Modern Nutrition in Health and Disease. Chapter 24: Vitamin B6.

Supplemental Reading:

1. Modern Nutrition in Health and Disease. Chapter 28: Biotin.
2. Modern Nutrition in Health and Disease. Chapter 25: Pantothenic Acid.
3. Modern Nutrition in Health and Disease. Chapter 22: Riboflavin.

Assignments Due:

1. Weekly Assignment #9 due Friday 11/16/18 @ 9:00am
 2. Interview Questions due Friday 11/16/18 @ 9:00am.
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Week 12: Nutritional Anemia and Iodine

Class Date: November 30th

Learning Objectives:

1. Summarize the general processes that can lead to anemia.
2. Identify the roles of micronutrients in development of anemia.
3. Explain complications of anemia at different life stages.
4. Recognize risk factors for nutritional anemia in diverse populations and scenarios.
5. Discuss interventions for prevention and treatment of nutritional anemia in diverse populations.
6. Describe the physiologic functions of iodine
7. Discuss biomarkers of iodine intake and status.

8. Propose alternatives to iodination of salt.

Required Reading:

1. Rohner et al. Biomarkers of Nutrients for Development - Iodine. J. Nutr. 144: 1322S–1342S, 2014.

Assignments Due:

1. Weekly Assignment #10 due Friday 11/30/18 @ 9:00am.
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Week 13: Team-Based Learning #2: Dietary Supplements and Fortification

Class Date: December 7th

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.
6. Contrast biofortification with genetic modification.

Required Reading:

1. Rautiainen et al. Dietary supplements and disease prevention – a global perspective. Nat Rev Endocrinol. 2016;12:407-420. doi:10.1038/nrendo.2016.54.
2. Gernald et al. Micronutrient deficiencies in pregnancy worldwide: health effects and prevention. Nat Rev Endocrinol. 2016;12: 274–289. doi:10.1038/nrendo.2016.37.0.

Supplemental Reading:

1. Bhutta, Meeting the challenges of micronutrient malnutrition Br Med Bull, 2013.

Assignments Due:

1. Weekly Assignment #11 due Friday 12/7/18 @ 9:00am.

Reminder: There will be a brief written quiz during class to assess comprehension of the assigned readings for the TBL exercise.