

EHS 100: Introduction to Environmental Health Sciences

Fall 2015 (Saturday, 8:00 am to 12:00 noon)

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Text: No textbook, but a published paper that will serve as an overview for concepts of the course: Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation-Lancet Commission on planetary health. Lancet [Epublished 16 July 2015].

Public Health Course Learning Objectives for Environmental Health: By the end of the course, students will be able to meet all of the American Society of Public Health's (ASPH) Core Competency requirements in Environmental Health listed below. Requirements that cut across public health disciplines, achieved in the process of achieving the core learning objectives for environmental health, are listed as subheadings (a, b, c, etc.).

1. Describe the direct and indirect human, ecological and safety effects of major environmental and occupational agents.
 - a. Articulate how biological, chemical and physical agents affect human health
 - b. Analyze determinants of health and disease using an ecological framework
2. Describe genetic, physiologic and psychosocial factors that affect susceptibility to adverse health outcomes following exposure to environmental hazards.
 - a. Describe the roles of, history, power, privilege and structural inequality in producing health disparities
 - b. Identify the ethical, social and legal issues implied by public health biology
 - c. Explain how genetics and genomics affect disease processes and public health policy and practice
3. Describe federal and state regulatory programs, guidelines and authorities that control environmental health issues.
 - a. Apply evidence-based biological and molecular concepts to inform public health laws, policies, and regulations
 - b. Analyze the potential impacts of legal and regulatory environments on the conduct of ethical public health research and practice
 - c. Distinguish between population and individual ethical considerations in relation to the benefits, costs, and burdens of public health practice
 - d. Appreciate the importance of working collaboratively with diverse communities and constituencies
4. Specify current environmental risk assessment methods.
 - a. Use information technology to access, evaluate, and interpret public health data
 - b. Integrate general biological and molecular concepts into public health
5. Specify approaches for assessing, preventing and controlling environmental hazards that pose risks to human health and safety.
 - a. Apply biological principles to development and implementation of disease prevention, control, or management programs
 - b. Discuss sentinel events in the history and development of the public health profession and their relevance for practice in the field
6. Explain the general mechanisms of toxicity in eliciting a toxic response to various environmental exposures
 - a. Specify the role of the immune system in population health

- b. Explain the biological and molecular basis of public health
- 7. Discuss various risk management and risk communication approaches in relation to issues of environmental justice and equity.
- 8. Develop a testable model of environmental insult.

Session 1: 29 August 2015 Introduction to environmental health sciences
 History of environmental health sciences
 Past, present and future of the Earth
 Population and ecosystems
 Limited resources (Spaceship Earth)/ sustainability
 Biotic effects on the environment and vice versa
 Agriculture and environment
 Energy and environment
 Chemical principles

The goal of the first session will be to define the rationale behind the course and to define environmental health sciences. There will be a description of the attempts to quantify the impact of the environment on human health. A major goal will be to put the history of the Earth and the future of the Earth into a context with respect to environmental factors that impact biological systems. There will be a discussion of the universe and how we can use information from cosmology to understand principles that are relevant to the Earth. The concepts of limited resources and sustainability will be defined. There will be a discussion of the overview of environmental health and the relevance of specific parameters including population, consumption, agriculture, and energy. There will be some consideration of urban issues and the built environment. There will also be some discourse on chemical principles that will be helpful in understanding some of the environmental health issues (e.g. organic versus inorganic chemicals, valence state issues, partition coefficients, nanoparticles).

References:

- (1) Gross M. Rapid population rise bad for our health? *Current Biology* 22(17): R702-R705 (11 September 2012).
- (2) Bettencourt L, West G. A unified theory of urban living. *Nature* 467(7318): 912-913 (2010).
- (3) Chu S, Majumdar A. Opportunities and challenges for a sustainable energy future. *Nature* 488: 294-302 (2012).
- (4) Gross M. Will our civilization survive this century? *Curr Biol* 23(23): R1017-1020 (2 December 2013).
- (5) Steffen W, Richardson K, Rockström J, Cornell SE, Fetzer I et al. Planetary boundaries: Guiding human development on a changing planet. *Science* 347(6223): 1259855-1-1259855-10 (2015 Feb 15).

Session 2: 12 September 2015 Exposure Assessment
 Occupational Health
 Environmental Epidemiology
 Principles of toxicology
 Carcinogenesis
 Teratogenesis

Gene-environment interactions

The goal of this session is to start to discuss the ways in which the environment can impact human health. This will initiate with a discussion of the field of exposure assessment. A major component of the exposure of every individual is their occupational exposure, as well as food, water and air, so some discussion will be focused on this topic (as well as the broader topic of occupational health). The next component of the course will be to discuss the ways in which various agents (physical, chemical, and biological) can impact human health. There will be a definition of the exposome. To initiate discussion of the impact of the environment on health there will be an introduction to the overall concepts of environmental epidemiology along with the strengths and weaknesses of this field (and for the most part epidemiology will be minimally discussed because you will have a course on the topic). Then, there will be an introduction to the field of toxicology and the future horizons for this discipline. This session will delve more deeply into concepts of toxicology by addressing issues of carcinogenesis (process of causing cancer) and teratogenesis (process of causing birth defects) with the idea of using these two outcomes to demonstrate concepts about how the environment may perturb human health. Furthermore, there will be a discussion of the principles of genetics and how the interaction of environmental factors and genes can cause health problems.

References:

- (1) Kreiss K, Day GA, and Schuler CR. Beryllium: A modern industrial hazard. *Annu Rev Publ Health* 28: 259-277 (2007).
- (2) Cohen S, Janicki-Deverts D, Doyle WJ, Miller GE et al. Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. *Proc Natl Acad Sci USA* 109(16): 5995-5999 (2012).
- (3) Knudsen TB, Keller DA, Sander M, Carney EW, Doerrer NG et al. Future Tox 11: in vitro data and in silico models for predictive toxicology. *Toxicol Sci* 143(2): 256-267 (Feb 2015).
- (4) Jumpathong W, Chan W, Taghizadeh K, Babu IR, Dedon PC. Metabolic fate of endogenous molecular damage: Urinary glutathione conjugates of DNA-derived base propenals as markers of inflammation. *Proc Natl Acad Sci USA* 2015 Aug 17 [Epub].
- (5) Goodson WH, Lowe L, Carpenter DO, Gilbertson M, Manaf Ali A et al. Assessing the carcinogenic potential of low-dose exposures to chemical mixtures in the environment: the challenge ahead. *Carcinogenesis* 36 Suppl 1: S254-S296 (2015).

Session 3: 26 September 2015 Environmental microbiology
Zoonoses
Vectors
Human immunity

This session will be used to address the role of microorganisms in biogeochemistry. Also, there will be a discussion of the role of bacteria, viruses, fungi, protozoa, prions and algae in

human health. There will also be deliberations on how these microbes are interwoven into the environment and how the environment impacts these microorganisms. There will be some discourse on the role of public health measures in fighting infectious disease (e.g. sanitation, antibiotics, immunizations) and the role of the immune system in this process. There will be a consideration of the human microbiome as well as the hygiene hypothesis.

References:

- (1) Wolfe ND, Dunavan CP, Diamond J. Origins of major human infectious diseases. *Nature* 447(7142): 279-283 (2007).
- (2) Köser CU, Holden MTG et al. Rapid whole-genome sequencing for investigation of a neonatal MRSA outbreak. *N Engl J Med* 366: 2267-2275 (2012); Sequencing tracks outbreak. *Nature* 486: 296 (2012).
- (3) Rook GA. Regulation of the immune system by biodiversity from the natural environment: An ecosystem service essential to health. *Proc. Natl. Acad. Sci USA* 110(46): 18363-18367 (2013).
- (4) Polley S, Louzada S, Forni D, Sironi M et al. Evolution of the rapidly mutating human salivary agglutinin gene (DMBT1) and population subsistence strategy. *Proc Natl Acad Sci USA* 112(16): 5105-5110 (2015 Apr 21).
- (5) Holt KE, Wertheim H, Zadoks RN, Baker S, Whitehouse CA et al. Genomic analysis Of diversity, population structure, virulence, and antimicrobial resistance in *Klebsiella pneumoniae*, an urgent threat to public health. *Proc Natl Acad Sci USA* 112(27): E3574-E3581 (2015 Jul 7).

Session 4: 10 October 2015 Ecological issues in environmental health
 Agriculture
 Nutrition
 Food

A topic for this session will be the principles of ecology and how these concepts are of relevance to human environmental health. This topic will incorporate such concepts as endangered and keystone species, biodiversity and sustainability. There will be a discussion of the ecological concepts of disease. The session will also be devoted to agriculture and the food that we derive from it. This discussion will initiate with the question of how much of the Earth's resources should be devoted to the production of food (e.g. land use, water use, energy use). There will be discussions of the use of fertilizers and the subsequent issues with nutrient cycles, as well as the use of water on arid lands. The ecological issues associated with decreasing biodiversity will be addressed. The use of pesticides will be discussed. There will be aspects devoted to pesticide use and the subsequent environmental issues with these compounds. There will be discussion of nutrition and how it impacts all aspects of health including all the previously discussed issues in toxicology. Finally, there will be a discussion of foods including topics such as food allergies, organic foods, genetically-modified foods, and concerns about microbiological contamination of food products.

References:

- (1) Estes JA, Terborgh J, Brashares JS, Power ME et al. Trophic downgrading of planet Earth. *Science* 333: 301-306 (2011).

- (2) Kau AL, Ahern PP, Griffin NW, Goodman AL, Gordon JI. Human nutrition, the gut microbiome and the immune system. *Nature* 474: 327-336.
- (3) Myers SS, Zhanobetti A, Kloog I, Huybers P, Leakey ADB et al. Increasing CO₂ threatens human nutrition. *Nature* 510: 139-142 (5 June 2014).
- (4) Van Boeckel TP, Brower C, Gilbert M, Granfell BT, Levin SA et al. Global trends in antimicrobial use in food animals. *Proc Natl Acad Sci USA* 112(18): 5649-5654 (2015 May 5).
- (5) Landrigan PJ, Benbrook C. GMOs, herbicides and public health. *N Engl J Med* 373(8): 693-695 (2015 Aug 20).

Session 5: 24 October 2015 Risk assessment and management
 Environmental management and policy
 Environmental justice
 Environmental valuation
 Radiological health

There will be a presentation of the principles of risk assessment and then this will be followed with the concepts of risk management. There will also be a discussion of environmental economics and how to evaluate environmental parameters and assess the value of ecosystem services. The session will also address the issues of environmental management and policy. There will be a discussion of what management strategies have been successful in decreasing environmental degradation. Radiological health will be discussed from a historical perspective. Positive and negative aspects of nuclear power will be addressed including the long-term waste issue.

References:

- (1) Hardin G. The tragedy of the commons. *Science* 162(5364): 1243-1248 (1968).
26): 10421-10425 (2011).
- (2) Victor P. Questioning economic growth. *Nature* 468: 370-371 (18 Nov 2010).
- (3) McMichael AJ, Butler CD. Promoting global population health while constraining The environmental footprint. *Annu. Rev Public Health* 32: 179-197 (2011).
- (4) Costanza R, Kubiszewski I, Giovannini E, Lovins H, McGlade J, Pickett KE, Ragnarsdóttir K, Roberts D, De Vogli R, Wilkinson R. Development: Time to leave GDP behind. *Nature* 505: 283-285 (2014).
- (5) Muller NZ. Economics. Boosting GDP growth by accounting for the environment. *Science* 345(6199): 873-874 (2014).
- (6) Hoekstra AY, Wiedmann TO. Humanity's unsustainable environmental footprint. *Science* 344: 1114-1117 (2014).
- (7) Kamiya K, Ozasa K, Akiba S, Niwa O, Kodama K et al. Long-term effects of radiation exposure on health. *Lancet* 386(9992): 469-478 (2015 Aug 1).

Session 6: 7 November 2015 Water

Wastewater
Solid and hazardous wastes
Green chemistry

There will be a discussion of the hydrologic cycle, types of water sources (surface and ground), and principles of hydrology. The treatment of water and wastewater will be addressed. There will be a discussion of what contaminants and microbes are waterborne. The use of different indicator organisms will be discussed. Also, there will be a discussion of the issues associated with solid and hazardous wastes. Green chemistry will be defined along with the E factor and atom economy as related to the concept of waste.

References:

- (1) Shannon MA, Bohn PW, Elimelech M, Georgiadis JG, Marinas BJ, and Mayes AM. Science and technology for water purification in the coming decades. *Nature* 452: 301-310 (2008).
- (2) Elimelech and Phillip WA. The future of seawater desalination: Energy, technology and the environment. *Science* 333(6043): 712-717 (2011).
- (3) Marston, L, Konar M, Cai X, Troy TJ. Virtual groundwater transfers from overexploited aquifers in the United States. *Proc Natl Acad Sci USA* 112(28): 8561-8566 (2015 Jul 14).
- (4) Brodin T, Fick J, Jonsson M, Klaminder J. Dilute concentrations of a psychiatric drug alter behavior of fish from natural populations. *Science* 339(6121): 814-815 (2013).
- (5) Sheldon RA. Fundamentals of green chemistry: efficiency in reaction design. *Chem. Soc. Rev.* 41: 1437-1451 (2012).
- (6) Castaldi MJ. Perspectives on sustainable waste management. *Ann. Rev. Chem. Biomol. Eng.* 5: 547-562 (2014).

Session 7: 21 November 2015 Air pollution
 Global environmental change

This session will be used to describe fundamental concepts of atmospheric sciences and will use this foundation to discuss issues of air pollution. There will be some discussion of nanoparticles in the environment. Additionally, there will be discussions of global environmental changes addressing such issues as stratospheric ozone depletion, global warming and water acidification.

References:

- (1) Heal MR, Kumar P, RM Harrison. Particles, air quality, policy and health. *Chem Soc Rev* 41: 6606-6630 (2012).
- (2) Raaschou-Nielsen O et al. Air pollution and lung cancer incidence in 17 European cohorts: perspective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE). *Lancet Oncol* 14(9): 813-822 (2013).
- (3) Garcia RR. Atmospheric science: An Arctic ozone hole? *Nature* 478: 462-463 (2011); Manney GL, Santee ML, Rex M et al. Unprecedented Arctic ozone loss in 2011. *Nature* 478: 469-475 (2011).
- (4) Montzka SA, Dlugokencky EJ, Butler JH. Non-CO₂ greenhouse gases and climate

- change. Nature 476: 43-50 (2011).
- (5) Lobell DB, Schlenker W, Costa-Roberts J. Climate trends and global crop production since 1980. Science 333(6042): 616-620 (2011).
 - (6) Smith KR, Desai MA, Rogers JV, Houghton RA. Joint CO₂ and CH₄ accountability for global warming. Proc Natl Acad Sci USA 110(31): E2865-2874 (2013).

Assignments: The only written assignment for the quarter will be a research paper on a topic from the field of environmental health sciences. The goal of this paper will be to find some environmental health issue of interest to you, and to examine the issue in depth using a number of sources from the primary literature. The goal is to examine the scientific issues with respect to the topic that you have chosen. I realize that not all students have a solid scientific background, but a goal of the course is to allow public health professionals to interpret the scientific literature. Please refer to references in your paper by the last name of the first author and the date of the publication. This paper is due the last session (21 November 2015) of the course. However, you may submit the paper at any time during the quarter to get feedback, with the option of making changes and resubmitting it during the final session. An idealistic goal would be to produce a publishable product.

Grading for the course: The course grade will be dependent on attendance and the paper.