Course Description and Syllabus – ENVR 421 – Environmental Health Microbiology

Course Description:

ENVR 421: Environmental Health Microbiology

Spring 2016

Lectures: Tuesday and Thursday 2:00-3:15PM, 3204 McGavran-Greenberg Hall
Labs: Wednesdays 3:30PM-,?, Room 1204 Michael Hooker Research Center

(ENVR teaching lab)

Instructor: Prof. Mark D. Sobsey Office: Room 149 Rosenau Hall Phone: 966-7303 E-mail: sobsey@email.unc.edu Office hours: by appointment	TA: AJ Karon E-mail: karon@email.unc.edu

Overview

In this course we will explore microbes of public health significance from environmental exposures and microbiological aspects of the environment as related to human health. The role the environment in the transmission of infectious diseases, the specific microbes that cause environmentally transmitted disease of public health importance, their prevention and control by technological and other measures and how the health risks posed these microbes are assessed will be explored. We will consider the microbes and their diseases transmitted by wastes, water, air, food and vectors, the ways that these disease agents enter, survive and spread through the environment to result in human exposures, how their risks are assessed and measured and how these risks are prevented and controlled through engineered/technical, policy and regulatory approaches. The course has a broad focus, from local to global, addressing the topic for both developed and developing world settings, conditions and populations.

The laboratory component of the course will use techniques for detecting, identifying and quantifying some of these health-related microbes in the environmental, their survival in environmental media and their removal and destruction by technological measures.

The course consists of lectures, applied laboratory skills and student participation, including presentations.

In the course, you will study:

- The significant microbes and infectious diseases of health concern and the environmental routes of their transmission
- The biology and ecology the microbes spread by human and animal waste, water, air, food and vectors

- Basic skills for working with microbes and how to detect them in environmental media
- Estimation and characterization of human disease risk from environmental exposures, assessment of infection and disease risk using microbial risk assessment and investigation and characterization of patterns of disease spread, such as outbreaks and other epidemiological evidence and its investigation
- The methods used to remove or destroy microbes in environmental media to prevent human exposure via wastes, water, food, air and vectors

Lecture topics for most classes will be supported by PowerPoint presentations that will be posted to the class website

Required (or Very Strongly Recommended) Text:

- Routledge Handbook of Water and Health, J. Bartram editor. Routledge, New York. Available online through UNC Libraries
- Principles of Public Health Microbiology [Paperback], Robert S. Burlage, Jones & Bartlett Learning; 1st edition (May 4, 2011). ISBN-10: 0763779822. ISBN-13: 978-0763779825. This book is not available online at UNC Libraries.

NOTE: CHAPTERS WILL BE ASSIGNED EARLY IN THE COURSE AS BACKGROUND READING TO SUPPORT LECTURES, PRESENTATIONS AND OTHERS READINGS.

Useful Texts

Environmental Microbiology of Aquatic and Waste Systems, Nduka Okafor, 2011. Springer; 1st Edition (July 1, 2011). ISBN-10: 9400714599. ISBN-13: 978-9400714595. Available online through UNC libraries

Recommended additional texts and reference books

- Communicable Disease Control Manual
- Brock's Biology of Microorganisms or other basic microbiology text
- Various World Health Organization documents available on the web. These documents or sections/chapters in them will be recommended readings for various class sessions.
- Selected chapters from other reference or textbooks, which will be identified for specific class sessions. Efforts are made to provide access to these chapters via links in the course syllabus at the Sakai site for ENVR 421

Assignments

There will be **two in class exams**. These will be objective with questions that are multiple choice, fill-in-the blank, true or false, definitions and some calculations.

There will be **2 case study assignments** during the semester. These assignments will be done in groups or teams of students. You will choose a reading for each assignment from lists I will provide. You will write a short (500 word maximum) case study on this topic and give a 12-16

minute presentation in class as a team. If you are unable to be in class for your group's case study presentation, you will be required to do a separate case study writing assignment for credit.

For some lectures, there are assigned readings that you are expected to read before that class period. Some of these assignments will be book chapters, technical publications, journal articles or other documents available on the class website or from other sources. I will call on students at random to **give a brief explanation of some aspect of the class assignment and answer questions about the content**. You will receive **participation points for these contributions**. There will be multiple opportunities to earn these points throughout the semester.

Final Exam. A final exam will be required as per University policy. Each student will give a final presentation (approx 10-15 minutes) at the end of the semester as an element of the final exam. The other element of the final exam will be a take home exam that will be turned in on the day of the final exam period when student presentations will be made. Further guidelines for these presentations and take-home final exams will be provided in class.

Lab. This class includes a laboratory component. There will be about 7-8 lab exercises and up to 6-7 lab reports. Reports will be due 1-2 weeks after the lab exercise is complete and the class data are compiled. You will work in groups in lab, but each individual student must complete a lab report. Labs will require some time outside of class to observe results of multi-day experiments.

Grading

In class exams: 20 pts. each, 40 pts. total	90-100%: H (grad) or A (undergrad)
Case studies (2): 5 pts. each, 10 pts. total	70-90%: P (grad) or B or C (undergrad)
Labs (up to 7-8): 20 pts. total	60-70%: L (grad) or D (undergrad)
Discussion participation: 10 pts.	<60: F (grad and undergrad)
Final presentation and take-home exam: 20 pts.	(scores may be scaled)

Honor Code and Ethics
All students are expected to comply with the UNC Honor Code on all assignments, presentations, examinations, lab reports and other assignments. All students are expected to practice ethical behavior with respect to taking credit for work done by not copying, plagiarizing or otherwise taking credit for the work of others.

Syllabus:

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Course Syllabus from Sakai:

Date	Lecture	Readings / Resources
Tues 01/12	Introduction and Overview: Microbes and Health Risks	REQUIRED: Environmental and Human Pathogenic Microorganisms, Lebaron, P. et al., 2015, Ch. 15 in: Environmental Microbiology: Fundamentals

		and Applications, Bertrand, J-C et al (eds) Springer. ISBN: 978-94-017-9117-5 (Print) 978-94-017-9118-2 (Available online at UNC library) Routledge Handbook of Water and Health. 2015. Routledge: London and New York. J. Bartram et. al., eds. (Available online at UNC library) • Ch. 3: Bradley classification of disease transmission routes for water hazards • Ch. 4: Waterborne and water-washed disease • Ch. 58: Water monitoring and testing • Ch. 59: Indicators of microbial quality • Ch. 67: Dr. John Snow and the Broad Street Pump RECOMMENDED Assessing microbial safety of drinking water: Improving approaches and methods, 2003. A. Dufour, M. Snozzi, W. Koster, J. Bartram, E. Ronchi and L. Fewtrell, eds., IWA Publishing, London for WHO, Geneva. (Only some chapters are relevant to the initial lecture and lab topics; please read selectively.) Principles of Public Health Microbiology, by R.S. Burlage, 2011, Chapters 1, 2, 3 (Monitoring section) and 4 Indicators for Waterborne Pathogens, National Research Council, National Academy of Sciences, National Academy Press, Washington, DC, 2004. – Chapters 1, 3 and 4 recommended Okafor, N. 2011. Environmental Microbiology of Aquatic and Waste Systems. Springer. – Chapters 7 and 8 recommended Techniques in Microbiology: A Student Handbook, Ed. 1, by J.M. Lammert, Benjamin Cummings
Wed 01/13	Lab Period Introduction, Background, Training,	See readings for 01/12 above

	Safety Basics of Lab Safety Biosafety in Microbiology Lab Demonstrations of fundamental methods and techniques and key equipment and materials	
Thurs 01/14	Indicator Microrganisms and Indicator Concepts	See readings for 01/12 above
Tues 01/19	Environmentally Transmitted Pathogens and Transmission Routes. Part 1	See above. Also: REQUIRED Routledge Handbook of Water and Health. 2015. Routledge: London and New York. J. Bartram et. al., eds. (Available online at UNC library) • Ch. 3: Figures 1 and 2 • Ch. 12: Introduction to Exposure Pathways • Ch. 13: Drinking Water Contamination • Ch. 15: Water and Foodborne Contamination • Ch. 55: Epidemiology RECOMMENDED Bradley, DJ. 2009. The Spectrum of Water-related Disease Transmission Processes. Pages 83-96 In: Global Issues in Water, Sanitation, and Health: Workshop Summary. Board on Global Health. The National Academies Press Washington, D.C Guidelines for drinking-water quality, 4th ed. 2011, WHO-Geneva. - Chapters 7 and 11 Modern Infectious Disease Epidemiology: Concepts, Methods, Mathematical Models, and Public Health, A. Kramer, M. Kretzschmar, K. Krickeberg, Springer, 2010, Ch. 5. Available online at UNC libraries. (read selectively) Mims, C.A. et al. (2001) Mims Pathogenesis of Infectious Disease. 5th ed, Academic Press, San

		Diego, Calif. (read selectively)
Wed 01/20	Lab 1. Detection of Total and Fecal Coliform Bacteria and Escherichia coli by Broth Culture, Quantal ("Most Probable Number") Methods: Multiple Fermentation Tube (MFT) and Defined Substrate Methods and the Compartment Bag Test (CBT) for *E. coli* MPN	See readings for 01/12 above Data Sheet (blank) BAM Appendix 2: Most Probable Number from Serial Dilutions Estimations of Bacterial Densities by Means of the "Most Probable Number" Multiple-tube method for thermotolerant (faecal) coliforms IDEXX Quanti-Tray®/2000 MPN Table Microbiological Methods for Monitoring the Environment
Thurs 1/21	Microbial Quantification: Basics and Application to Environmental Analysis	See readings for 01/12 above
Tues 01/26	Environmentally Transmitted Pathogens and Transmission Routes, Part 2 Handout version	See readings for 01/21
Wed 01/27	Lab 2. Detection of Total and Fecal Coliforms and E. coli by Enumerative (Colony Count) Methods: Membrane Filtration, Pour Plates and Spread Plates	See readings for Lab 1. Membrane Filtration, Pour Plate and Spread Plate Methods Lab handout to be provided Data spreadsheet
Thurs 01/28	Pathogen and Host Properties Handout version	See readings for 1/21 Lawrence C. Madoff and Dennis L. Kasper. Introduction to Infectious Diseases: Host-Pathogen Interactions. Ch. 119 in Harrison's Online. Available online at UNC libraries. Casadevall, A. and L.-A. Pirofski (1999) Host-Pathogen Interactions: Redefining the Pathogenicity Basic Concepts of Virulence and Pathogenicity. Infect. Immun. 1999, 67(8):3703.

		Casadevall A, Pirofski LA. (2000) Host-pathogen interactions: basic concepts of microbial commensalism, colonization, infection, and disease. Infect Immun., 68(12):6511-8. Casadevall A, Pirofski L. Host-pathogen interactions: the attributes of virulence. J Infect Dis. 2001 Aug 1;184(3):337-44. Epub 2001 Jun 27. Casadevall et al., Microbial Virulence as an Emergent Property: Consequences and Opportunities. PLoS Pathogens, www.plospathogens.org, 1 July 2011, Volume 7, Issue 7 e100213
Tues 02/02	Epidemiology - Water-, Food- and Air-borne Disease, Part 1	REQUIRED: Routledge Handbook of Water and Health. 2015. Routledge: London and New York. J. Bartram et. al., eds. (Available online at UNC library) • Ch. 12: Introduction to Exposure Pathways • Ch. 13: Drinking Water Contamination • Ch. 15: Water and Foodborne Contamination • Ch. 55: Epidemiology • Ch. 65 Cholera Epidemic in Hamburg, Germany 1892 • Ch. 66 The Discovery of the Aetiology of Cholera Payment P et. al. 1991. A Randomized Trial to Evaluate the Risk of Gastrointestinal Disease due to Consumption of Drinking Water Meeting Current Microbiological Standards. Am J Pub Hlth 81(6):703-708. Chapter 16 Surveillance, Monitoring and Communication, pp. 365-377 In; Principles of Public Health Microbiology, 2nd ed., R.S. Burlage, Jones and Bartlett Learining. M. F. Craun et al. Waterborne outbreaks reported in the United States. Journal of Water and Health, 04.Suppl 2, 2006

		Morbidity and Mortality Weekly Report. Surveillance Summaries / Vol. 60 / No. 12 September 23, 2011. Surveillance for Waterborne Disease Outbreaks and Other Health Events Associated with Recreational Water — United States, 2007–2008 and Surveillance for Waterborne Disease Outbreaks Associated with Drinking Water — United States, 2007–2008 (www.cdc.gov/mmwr) Surveillance Reports for Recreational Water-associated Disease & Outbreaks Reports from 1978-2008
Wed 02/03	Lab 3. Detection of Fecal Streptococci and Enterococci by Quantal and Enumerative Methods	See readings from previous labs Lab handout to be provided Data spreadsheet (Google)
Thurs 02/04	Epidemiology - Water-, Food- and Air-borne Disease, Part 2	See readings from 02/02
Tues 02/09	First Exam	
Wed 02/10	Lab 4. Detection of *Clostridium perfringens*, Sulphite Reducing Clostridia and Hydrogen Sulphide Bacteria by Quantal and Enumerative Methods	Data spreadsheet (Google) 3-tube MPN table Manafi M and J Siegrist. 2011. *Clostridium perfringes* - an Indicator. Khush RS, Arnold BF, Srikanth P, Sudharsanam S, Ramaswamy P, Durairaj N, London AG, Ramaprabha P, Rajkumar P, Balakrishnan K, Colford JM Jr. (2013) H2S as an indicator of water supply vulnerability and health risk in low-resource settings: a prospective cohort study. Am J Trop Med Hyg. Published online May 28, 2013. Yang H, Wright JA, Bain RE, Pedley S, Elliott J, Gundry SW. (2013) Accuracy of the H2S test: a systematic review of the influence of bacterial density and sample volume. J Water Health. 2013 Jun;11(2):173-85. doi: 10.2166/wh.2013.225.

		Jim A. Wright, J.A., H. Yang, K. Walker, S. Pedley, J. Elliott and S.W. Gundry (2012) The H2S test versus standard indicator bacteria tests for faecal contamination of water: systematic review and meta-analysis, Tropical Medicine and International Health, 17(1): 94-105. McMahan L, Grunden AM, Devine AA, Sobsey MD. (2012) Evaluation of a quantitative H2S MPN test for fecal microbes analysis of water using biochemical and molecular identification. Water Res. 2012 Apr 15;46 (6):1693-704. Lab handout to be provided
Thurs 02/11	Microbial Pathogens I	World Health Organization 2011. Guidelines for Drinking-water Quality, 4th ed. • Ch. 11 Microbial Factsheets.
Tues 02/16	Microbial Pathogens II	See readings for 02/11.
Wed 02/17	Lab 5. Quantification of Somatic and Male-specific Coliphages in Water and Wastewater	Lab handout Data spreadsheet (Google)
Thurs 02/18	Microbial Survival in the Environment	Sobsey M and JS Meschke. 2003. Virus survival in the environment with special attention to survival in sewage droplets and other environmental media of fecal or respiratory origin. WHO, draft.
Tues 02/23	Microbial Risk Assessment I	See readings for 02/18
Wed 02/24	Lab 6A. Microbial Survival in the Environment Part I	Lab handout Data spreadsheet (Google)
Thurs 02/25	Microbial Risk Assessment II	See readings for 02/18
Tues 03/01	Case Studies: Waterborne and Foodborne Outbreaks and Excess Disease Risks Student Team Presentations I	Beller M et.al. 1997. Outbreak of Viral Gastroenteritis Due to a Contaminated Well. JAMA 278(7): 563-568. Bruce-Grey-Owen Sound Health Unit. 2000. The Investigative Report of the Walkerton Outbreak of Waterborne Gastroenteritis.

		Causer LM et.al. 2006. An Outbreak of *Cryptosporidium hominis* infection at an Illinois recreational waterpark. Epidemiol. Infect. 134: 147–156. Dondero Jr. TJ et.al. 1980. An Outbreak of Legionnaires' Disease Associated with a Contaminated Air-Conditioning Cooling Tower. NEJM 302(7): 365-370. Enk MJ, Amorim A and VT Schall. 2003. Acute Schistosomiasis Outbreak in the Metropolitan Area of Belo Horizonte, Minas Gerais: Alert about the Risk of Unnoticed Transmission Increased by Growing Rural Tourism. Mem Inst Oswaldo Cruz 98(6): 745-750. Hewitt J et.al. 2007. Gastroenteritis Outbreak Caused by Waterborne Norovirus at a New Zealand Ski Resort. Appl Environ Microbiol 73(24):7853-7857. Kozlika, et al., 2010. Waterborne outbreak of Salmonella I4, [5], 12:i:-, Foodborne Pathogens and Disease, 7(11): 1431-1433. Nygård K et.al. 2006. A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. BMC Public Health 6(141): doi:10.1186/1471-2458-6-141
Wed 03/02	Lab 6B. Microbial Survival Experiments Part II	Allwood PB, Malik YS, Hedberg CW, Goyal SM. Survival of F-specific RNA coliphage, feline calicivirus, and Escherichia coli in water: a comparative study. Appl Environ Microbiol. 2003 Sep;69(9):5707-10. Bitton, G, S.R. Farrah, R.H. Ruskin, J. Butner and Y.J Chou (1983) Survival of pathogenic and indicator organisms in ground water. Ground Water, 21(4):405-410. John DE, Rose JB. Review of factors affecting microbial survival in groundwater. Environ Sci

		Technol. 2005 Oct 1;39(19):7345-56. Nasser AM, Zaruk N, Tenenbaum L, Netzan Y. (2003) Comparative survival of Cryptosporidium, coxsackievirus A9 and Escherichia coli in stream, brackish and sea waters. Water Sci Technol. 2003;47(3):91-6. Noble RT, Lee IM, Schiff KC. Inactivation of indicator micro-organisms from various sources of faecal contamination in seawater and freshwater. J Appl Microbiol. 2004;96(3):464-72. Sinton LW, Finlay RK, Lynch PA.Sunlight inactivation of fecal bacteriophages and bacteria in sewage-polluted seawater. Appl Environ Microbiol. 1999 Aug;65(8):3605-13. Skraber S, Gassilloud B, Schwartzbrod L, Gantzer C. Survival of infectious Poliovirus-1 in river water compared to the persistence of somatic coliphages, thermotolerant coliforms and Poliovirus-1 genome. Water Res. 2004 Jul;38(12):2927-33. Data spreadsheet
Thurs 03/03	Case Studies: Waterborne and Foodborne Outbreaks and Excess Disease Risks Student Team Presentations II	
Tues 03/08	Pathogens and Methods for Their Detection	REQUIRED Environmental and Human Pathogenic Microorganisms, Lebaron, P. et al., 2015, Ch.15 in: Environmental Microbiology: Fundamentals and Applications, Bertrand, J-C et al (eds) Springer. ISBN: 978-94-017-9117-5 (Print) 978-94-017-9118-2 (Available online at UNC library) RECOMMENDED World Health Organization 2011. Guidelines for Drinking-water Quality, 4th ed.

		• Ch. 11 Microbial Factsheets.
Wed 03/09	Lecture, not lab: Immunology and Immunoassay Methods	See readings for 03/08.
Thurs 03/10	Second Exam	
03/11-03/20 SPRING BREAK		
Tues 03/22	Water Supplies, Treatment Processes and Microbial Reductions	REQUIRED Routledge Handbook of Water and Health. 2015. Routledge: London and New York. J. Bartram et. al., eds. (Available online at UNC library) • Ch. 18: Drinking-water Supply • Ch. 19: Drinking Water Treatment RECOMMENDED Environmental Microbiology of Aquatic and Waste Systems, N. Okafor, Ch. 9. Available online at UNC Libraries Hijnen, W and G. Medema. 2007. Elimination of micro-organisms by drinking water treatment processes: A review. Kiwa Water Research, The Netherlands. Smeets, P et. al. 2006. Efficacy of Water Treatment Processes. Microrisk.
Wed 03/22	Lab 7. Microbial Removals by Physical-Chemical Water Treatment Processes	Lab handout Data spreadsheet (Google)
Thurs 03/23	Water and Wastewater Disinfection	Sobsey, MD. 1989. Inactivation of Health-Related Microorganisms in Water by Disinfection Processes. Wat Sci Tech 21(3): 179-195. Chapters 3 and 4. Principles of Public Health Microbiology, R.S. Burlage, 2nd ed. Environmental Microbiology of Aquatic and Waste Systems, N. Okafor, Chs. 9 and

		10. Available online at UNC Libraries
Tues 03/29	Wastewater and Excreta Treatment and Management	REQUIRED Routledge Handbook of Water and Health. 2015. Routledge: London and New York. J. Bartram et. al., eds. (Available online at UNC library) • Ch. 20: Wastewater Treatment RECOMMENDED Pepper, IL. et al. 2006. Part 5. Waste and Water Treatment and Management. In: Environmental and Pollution Science. Academic Press (Available online at UNC library) Chapter 4. Principles of Public Health Microbiology, R.S. Burlage, 2nd ed. Environmental Microbiology of Aquatic and Waste Systems, N. Okafor, Chs. 9 and 10. Available online at UNC Libraries
Wed 03/30	Lab 8. Microbial Removals by Disinfection Processes, Chlorine and UV	Lab handout Data spreadsheet (Google)
Thurs 03/31	Water Reclamation and Reuse, including Biosolids	Chapters 3 and 4. Principles of Public Health Microbiology, R.S. Burlage, 2nd ed. Environmental Microbiology of Aquatic and Waste Systems, N. Okafor, Chs. 9 and 10. Available online at UNC Libraries
Tues 04/05	Case Studies: Quantitative Microbial Risk Assessment Student Presentations I	An YJ, Yoon CG, Jung KW, Ham JH. Estimating the microbial risk of E. coli in reclaimed wastewater irrigation on paddy field. Environ. Monit. Assess. 2007 Jun;129(1-3):53-60. Epub 2006 Oct 28. Gerba CP, Rose JB, and CN Haas. Waterborne rotavirus: risk assessment. Water Res 30 (1996), pp. 2929–2940. Höglund C, Stenström TA, Ashbolt N. Microbial risk assessment of source-separated urine used in agriculture. Waste Manag Res. 2002

		Apr;20(2):150-61 Howard G, Pedley S and S Tibatemwa. Quantitative microbial risk assessment to estimate health risks attributable to water supply: Can the technique be applied in developing countries with limited data? J Water Health 2006 4(1):49-65. Mena KD, Pillai SD. An approach for developing quantitative risk-based microbial standards for fresh produce. J Water Health. 2008 Sep;6(3):359-64. Mota A, Mena KD, Soto-Beltran M, Tarwater PM, Cháidez C. Risk assessment of cryptosporidium and giardia in water irrigating fresh produce in Mexico. J Food Prot. 2009 Oct;72(10):2184-8. Regli S, Rose JB, Haas CN, and CP Gerba. Modeling the risk from Giardia and viruses in drinking water. J Am Water Works Assoc 1991 83(11):76–84. Rose, JB and MD Sobsey (1993) Quantitative Risk Assessment for Viral Contamination of Shellfish and Coastal Water. J. Food Protection, 56(12): 1043-1050. More choices will be provided soon.
Wed 04/06	Lab 9. Microbial detection by molecular methods – lab demo	Lab handout
Thurs 04/07	Case Studies: Quantitative Microbial Risk Assessment Student Presentations II	See readings for 03/22
Wed 04/06	Lab 9. Microbial Removals by Disinfection Processes, Chlorine and UV	Lab handout Data spreadsheet (Google)
Thurs 04/07	Water Reclamation and Reuse, including Biosolids	Chapters 3 and 4. Principles of Public Health Microbiology, R.S. Burlage, 2nd ed. Environmental Microbiology of Aquatic and Waste Systems, N. Okafor, Chs. 9 and 10. Available online at UNC Libraries

Tues 04/12	Framework for Safe Water and Sanitation and Water Safety Plans (Water and Waste Management)	WHO Guidelines for Drinking-water Quality, 4th ed., 2011, Ch. 4 and 5.
Wed 04/13	Field Trip	TBA
Thurs 04/14	Waterborne exposures: recreational waters	US EPA. Recreational Water Quality Criteria. EPA 820-F-12-061, Dec. 2012. US EPA. Recreational Water Quality Criteria. EPA 820-F-12-058, Dec. 2012 Boehm et al., 2009. A sea change for recreational water quality criteria. J. Water Health, 7(1): 9-20 Kay et al., (2004) Derivation of numerical guidelines for recreational water. Water Research, 38(5): 1296-1304
Tues 04/19	Foodborne Exposures and Health	Principles of Public Health Microbiology, R.S. Burlage, 2nd ed., Chapters 7-10.
Wed 04/20	Field Trip	TBA
Thurs 04/21	Food Safety and Foodborne Disease	Principles of Public Health Microbiology, R.S. Burlage, 2nd ed., Chapter 13.
Tues 04/26	Antimicrobials, Antimicrobial Resistant Bacteria, Human Health and the Environment	TBA
Wed 04/27	Microbial Aerosols (Bioaerosols), Airborne Pathogens in the Environment and Health Effects (classroom session - no lab)	TBA