

Context of the Course:

This is a Post-Baccalaureate level Microbiology & Immunology course. Students will have Bachelor's degrees in biology or other healthcare-related majors. They should have basic knowledge of anatomy, physiology, and cell biology, but not all students would have taken an Immunology and/or Microbiology course. These students are primarily interested in gaining pre-requisites and knowledge to help them with MCATs and applying to Medical School.

Within the context of the course, students will have completed the Immunology and Parasitology units, so will have some idea about human pathogens and how our bodies respond to them, but this unit will be their first introduction to prokaryotes (single-celled organisms without membrane-bound organelles, i.e. Archaea and Bacteria). This lesson falls after the following lessons:

1. Introduction to Bacteria: Bacterial classification and structure
2. Introduction to Bacteria: Bacterial genetics and metabolism
3. Antibiotics, Antibiotic Resistance, and Disinfection
4. Gram-positive Pathogens I: Staphylococcus & Streptococcus species
5. Gram-positive Pathogens II: Streptococcus species continued...

Then will be this lesson #6: **Gram-negative Enterics I: *Vibrio cholerae* & *E. coli* (ETEC, EPEC, EHEC/STEC)**

Students will enter this lesson likely having heard of the disease Cholera, but they will likely not know the organism or any details about how the disease happens. They likely think of Cholera as a disease of history if they are from the United States or other countries where it is not prevalent. However, some international students may be from areas of active outbreak and would have more personal experience or feelings about it. Regarding *E. coli*, they have probably heard of it in the news, know it's a diarrheal disease, contaminates food, but again no specific details about the mechanisms involved, or what the different strains do that we will go over.

Lesson Plan:

Readings/Resources posted to Canvas beforehand:

- *Sherris Medical Microbiology* – Chapter 32 “Vibrio, Campylobacter, and Helicobacter” pg. 565-571
- *Sherris Medical Microbiology* – Chapter 33 “Enterobacteriaceae” pg. 579-595
- Henry Stuart Talk by Dr. Sarah Fouch - “E. coli strains: UPEC, STEC, ETEC, and EPEC (<https://doi-org.libproxy.temple.edu/10.69645/PKAG7265>) You may skip the UPEC section, log in with your Temple login.
- Henry Stuart Talk by Dr. Sarah Fouch – “Vibrio cholerae” (<https://doi-org.libproxy.temple.edu/10.69645/IFEP3242>) Log in with your Temple login.

In class:

I. Review Activity Warm-Up (5 minutes):

- a. Large-group discussion: Fill in part of our concept map that we are building each session, together
 - i. The concept map categorizes by Gram-stain, morphology, and some key diagnostic tests to differentiate similar bacteria.
 - ii. We will fill in where the Streptococcus species, that we went over in the last lecture, fit into the map.
 - iii. We'll write in brief terms the name of the bacteria, the disease(s), key virulence factor(s), and anything special about treatment/vaccine.
- b. Purpose: model the idea of concept mapping to help students organize this overwhelming list of information. (Will encourage students in a later review session to independently reorganize information in a different way than the one I've given them, to practice that skill.)

II. Lesson Hook (2 minutes):

- a. Start with a personal story – my trip to Zambia during my undergrad, to shadow Malaria researchers there that my school partnered with for a few weeks. (Show a couple pictures of the lab, etc.) We did some tourist things as well. (Show pictures from the tour through the wildlife preserve in Botswana.) Transition to my picture of Victoria Falls. Ask “Does anyone recognize this waterfall?”
- b. “Can anyone think of how this relates to our topic today?”
- c. Cite the fact: “Worldwide, there are approximately 10 million cases of diarrhea daily. The amount of fluid stool produced every day equals the amount of water going over Victoria Falls within 1 minute.”
- d. “So today we're going to begin going over Gram-negative enterics: diarrheal diseases”
- e. Purpose: To help with motivation. It is a silly anecdote but hopefully should pique their interest.

III. Explain Objectives (2 minutes):

- a. Remember the scientific name, morphology, and Gram-stain of major human pathogenic bacteria.
- b. Given a disease scenario, identify the likely causative pathogen.
- c. Assess the likely efficacy of a given treatment, prevention, and/or diagnostic strategy based on pathogen characteristics.
- d. Compare common and unique virulence strategies used by important human pathogens.
- e. As these objectives apply to the following pathogens: *Vibrio cholerae*, Enterotoxigenic *E. coli* (ETEC), Enteropathogenic *E. coli* (EPEC), and Shiga-toxin-producing/Enterohemorrhagic *E. coli* (STEC/EHEC)

IV. Activity 1 – Padlet answered by text (3 minutes)

- a. Poll brainstorming characteristics of GI tract diseases – specific names, symptoms, transmission, etc?
- b. Purpose: Ungraded assessment of prior knowledge (do they know anything about these diseases? Are there any common misconceptions popping up?) Plus, this is an opportunity to connect what we are about to learn to what is already established in their mind.

V. Activity 2 – Lecture (13 minutes)

- a. Outline diarrheal diseases, including ones from next lecture we will go over later.
 - i. Define secretory vs. inflammatory diarrhea (we are going over secretory diarrhea today).
- b. Summarize/explain *Vibrio cholerae* and ETEC:
 - i. Transmission, symptoms, disease mechanisms, diagnosis
 - ii. Commensal-to-pathogen evolution of *E. coli* from microbiome member to causing disease.
 - iii. Make sure to use plenty of diagrams. I have some that I think are easier to understand than the textbook.
- c. Purpose: provide and prioritize the most important foundational knowledge, use medical terminology in context, explain diagrams showing complex bacterial lifecycles and mechanisms.

VI. Activity 3 – Think-pair-share (5 minutes)

- a. Analyze a figure from an article about the Type III secretion system (a type of machinery bacteria use to control host cell behavior for their own purposes)
 - i. What is the research question? Method? Result?
 - ii. Conclusion: *E. coli* that has this machinery can cause disease by controlling host gut cells' behavior to facilitate their lifecycle
- b. Purpose: To introduce the next section of lecture – both EPEC and EHEC use this machinery (as do other pathogens we'll talk about later) and it sets them apart from ETEC. This gives them practice looking at scientific data.

VII. Activity 4 – Lecture (15 minutes)

- a. Summarize/explain EPEC and EHEC/STEC
 - i. Transmission, symptoms, disease mechanisms, diagnosis
 - ii. Use plenty of diagrams.

- b. Conclusion: Summarize key characteristics that secretory diarrhea-associated pathogens have in common (they do not invade past the gut barrier, they do not trigger a strong immune response, they cause fluid loss).
 - i. Bring it back to the outline we originally talked about in the first half of lecture
- c. Purpose: provide and prioritize the most important foundational knowledge, use medical terminology in context, explain diagrams showing complex bacterial lifecycles and mechanisms.

VIII. Activity 5 – Case study practice questions (5 minutes)

- a. Cases give a hypothetical patient scenario, or one from literature.
- b. 1 question – identify which species of *Streptococcus* or *Staphylococcus* is causing disease, from previous lectures
- c. 1 question – identify which bacteria is causing secretory diarrhea, from this lecture
- d. Questions should be straightforward or “textbook” cases of these diseases. These can be multiple choice for quickness of response, using PollEverywhere to gauge performance of the class.
- e. Purpose: To give students practice applying the information they learned this class and ones previous.

Next session(s):

Start next class with a review of these pathogens by adding to the concept map, and also put in practice case-based multiple choice questions, wherever possible.

Course Objectives

Course Objectives Addressed:

1. (Foundational Knowledge) Remember the scientific name, morphology, and Gram-stain of major human pathogenic bacteria.
 - This learning goals is addressed by the readings ahead of class and by the lecture portions of the lesson.
 - This will be assessed by graded multiple choice exams. Plus, lack of the foundational knowledge will make other levels of thinking difficult.
2. (Application) Given a disease scenario, identify the likely causative pathogen.
 - Students will practice this skill in Activity #5 using the case study practice questions.
 - The foundational knowledge provided by the lectures and out-of-class materials is essential to achieving this goal.
 - Exams will include application questions asking for the jump from symptoms to disease. Additionally, graded group presentations will be based on cases and

open-ended questions about the cases and the thought processes leading to a diagnosis.

3. (Application) Assess the likely efficacy of a given treatment, prevention, and/or diagnostic strategy based on pathogen characteristics.
 - This learning goal is somewhat addressed simply by providing the foundational knowledge of the kinds of diagnostic tests one would use for these infections. And by providing reasonings for recommendations against antibiotics in such cases.
 - This goal is not addressed to a deep level of thinking in this lesson.
 - Exams will include questions about treatment options. I am not asking them to memorize treatments (that comes later in Medical School), but they should know, given multiple choices, which treatments don't make sense given the bacterial structure and characteristics that I do expect them to remember. Additionally, the case presentation assignments will capture the students' understanding of appropriate kinds of diagnostics.
4. (Integration) Compare common and unique virulence strategies used by important human pathogens.
 - Students will be taught about a new important virulence strategy and already shown two examples of strains that utilize it. Hopefully the emphasis here through Activity 3 will keep it at the forefront of their minds for later lessons where this machinery will come up again.
 - This lesson also integrates ideas from lesson #2 in this unit, both in that metabolism of the bacteria contributes to our ability to diagnose it, but also that genetics were transferred from other pathogens into *E. coli* to make it a pathogen rather than a harmless member of the microbiome.
 - The ability to compare virulence factors between pathogens will be invaluable for the concept-mapping activity I mentioned in "I. Review Activity" that I'd like to use both to help students learn how to study by reorganizing data themselves, and to collect to for an ungraded formative assessment, to correct any misinterpretation before they hit the formal exam.
5. (Learning how to learn) Identify reliable sources of information regarding infectious diseases.
 - In Activity 3, the analysis of a figure from a scientific paper will provide some practice learning how to read and interpret sources like this.
 - This will be assessed largely in the formative or low-stakes assessments, such as the patient educational materials assignment I submitted last time. I want students to practice this skill, but it is not the main focus of the course and should not make up a large portion of the grade.