Course Identifier: (e.g. TLC801) **MMG522**

Course Name: **Medical Microbiology and Immunology**

Department: **Microbiology and Molecular Genetics**

Colleges: **Human Medicine and Osteopathic Medicine**

Primary contact name, phone number, and email (*normally this will be the lead instructor*)

**Cindy Grove Arvidson, PhD. 884-5363 arvidso3@msu.edu**

Faculty and Staff Involved in Developing and Offering the Course *please list full name, position at MSU, email address, and project role for each person*

<table>
<thead>
<tr>
<th>NAME</th>
<th>MSU Affiliation</th>
<th>PROJECT ROLE</th>
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<tbody>
<tr>
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Which Competition Are You Entering (select one):

___ FULLY ONLINE COURSE (no required face to face component)
___ BLENDED/HYBRID COURSE (some face to face learning is replaced by online learning)
**X** TECHNOLOGY-ENHANCED LEARNING INNOVATION (one specific technology innovation in a face-to-face or online course)

Semester(s) offered in 2011-2012 and number of students enrolled:

<table>
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<tr>
<th>SEMESTER</th>
<th># STUDENTS</th>
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<td>Spring</td>
<td>518</td>
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Please address these categories:

I. Course Description (400 word limit)

Medical Microbiology and Immunology (MMG 522) is a 5 credit course required of all first year students in the Colleges of Human and Osteopathic Medicine. The course presents the basic principles of immunology as well as the basic biology of microbes (bacteria, viruses, fungi and parasites). A sound understanding of these areas provides the foundation needed to
understand: 1) the host-microbe interactions which can cause infectious disease; 2) the response of the immune system to invasion by microbes; 3) the development of immune diseases. Further study of infectious and immune diseases take place in the second year of the preclinical curriculum, at which time the diseases caused by specific pathogens are further emphasized.

The course is taught as a series of lectures, divided into three units based on content. Assessments include multiple choice exams, on-line quizzes, and a lab report generated during a live laboratory exercise. Unit II is the Bacteriology unit, which includes 16 lectures, a 2 hr live laboratory exercise, and a Virtual Interactive Bacteriology Laboratory (VIBL) designed to prepare the student for the live laboratory session. An on-line quiz is given that depends on use of the VIBL to answer questions correctly to ensure that the student has gone through the exercises prior to attending the live lab.

The VIBL is a set of virtual, interactive bacteriology lab exercises which allow a student to learn a variety of tests that are done in a diagnostic microbiology laboratory. The VIBL is hosted at a non-secure site that the student can access anytime during the course or after it has been completed. These exercises replace live laboratory sessions in which a student would typically learn how to culture bacteria and to perform various tests and interpret their results in order to identify a given bacterial isolate. The concepts learned by doing the virtual exercises are the same as those that would be learned in the live laboratory sessions. The virtual exercises are used in this course as a preparation for a live laboratory session where the student is provided with a case history and a biological sample (real or mock) and is then expected to identify the infectious agent using the techniques learned in the virtual lab exercises.

![Virtual Interactive Bacteriology Laboratory](http://learn.chm.msu.edu/vibl/)

II. Learning and Interaction Goals of the Course or Technology-enhanced Innovation

The rationale behind the design of VIBL was to be able to teach techniques used in a diagnostic bacteriology laboratory to first year medical students. These students will not likely need to actually perform these exercises on a regular basis as physicians, however, it is felt that they must have a clear understanding of the tests that they might order and the reports they would need to interpret in the diagnosis of an infectious disease. The first year curriculum for students in the Colleges of Human and Osteopathic Medicine includes several basic science
courses that are taught to a combined class of more than 500 students at four geographic locations in Michigan. In order to maximize the use of laboratory and faculty resources, the VIBL was developed to replace two of the three live 2-hr laboratory sessions that are part of MMG522. The students are expected to do all of the exercises in the VIBL prior to the live laboratory session as preparation for that session. To ensure that they do so, an on-line quiz, administered through Angel, is given that the students may complete in their own time and ideally while they are going through the exercises.

The VIBL was developed over a four year period in which early versions were tested by providing them as a supplement to the wet lab experiences. In the first year of testing (2008), computers were set up in the actual laboratory. Students were asked to try the virtual labs after having done the same exercise in the lab. For example, the student would perform a gram stain from a culture provided to them. They would view their own slide under a microscope, and would then observe gram stains of several bacteria that were prepared by the lab instructors. The student would then perform the gram stain virtual exercise. The students were asked to provide written feedback, answering a series of questions including: Did performing the test effectively illustrate the concept compared to doing the same test at the lab bench? What was your visual impression compared to the analogous wet lab experience? What would you suggest for improvements? The feedback from students was generally positive and also informative with respect to suggestions for improvement. In the second year of testing, the students were provided a link to the virtual exercises after having completed the wet lab experience. The link was through a secure course management site (Angel) such that the number of uses could be tracked. Approximately 2/3 of the students logged in to the VIBL at least once during the course, with many of the log-ins the days immediately before the course exam, suggesting they were using the modules for review purposes. In 2010, the lab experience was modified to use VIBL as a replacement for the first two sessions, with the students instructed to do the exercises as a preparation for the third, case-based, wet lab experience. Again, the responses from students were positive. The students liked being able to do the exercises at their own pace, repeat them as needed, and use them to study for exams as well as prepare for the wet lab exercise, all without the mess of a wet lab.

III. Points of Interest and Innovation

The VIBL website (site [http://learn.chm.msu.edu/vibl/](http://learn.chm.msu.edu/vibl/)) was designed to host all the virtual interactive bacteriology lab modules independent of the course. It uses interactive menus and strives to provide a straightforward and usable navigation for ease of use and quick access to materials in the site. Each available lab is listed on the left menu (see home page above) and are arranged following a logical and visual hierarchical menu structure where each labs is listed in a clearly defined area and also visually “nested” to show how different categories of labs are grouped together (see image left).
Each lab is presented to the user with a brief description; module instructions are PDF format and a link is available to open the module in a new window to provide maximum real estate use of the screen and module interaction. In addition, some of the modules include 2-3 sec video clips of steps that can be accessed in any order by clicking on that step in the list.

Clicking on step 4 starts a video of disposing the toothpick into a biohazard waste container

Having the descriptions and instructions within the website makes the VIBL truly a stand-alone experience. The exercises can be done during the course as well as after. Since many of the basic concepts learned in the first year courses in medical school are expanded upon and reinforced in later years, the ability to access these labs while taking other courses with bacteriology lab content will provide a resource for review. Finally, access to the VIBL after the course is a real benefit for medical students as they prepare for their licensure (board) exams later in their medical school curriculum, which typically include questions on laboratory diagnosis of bacterial infections.

1) Gram Stain: This technique is one of the most frequently used tests in a diagnostic laboratory for the initial assessment of a biological sample obtained from a patient with a bacterial infection. It is a rapid assessment that can often suggest early treatment for a serious, acute infection. In the gram stain module, the student begins by placing the bacterial sample on the slide and then continuing the processing up through visualizing the result microscopically. There are two bacteria in the “sample” that are morphologically distinct with differing Gram stain characteristics (gram-positive cocci and gram-negative rods). If the student skips a step or does them in the incorrect order, the slide viewed at the end will show what would happen in a real situation where such an error is made. For example, if the primary stain (crystal violet) step is skipped, but the remainder of the exercise done correctly, the gram-positive bacteria in the sample will look gram-negative (pink) instead of gram-positive (purple). The fact that the student cannot see that an error was made until the end, when the slide is viewed, is very much
the same as would happen in a live lab setting. In addition, this helps the student to reinforce the concept of what each step is doing to the sample, which is very helpful for visual learners.

At the end of the exercise, the student can click on “examine examples” to view micrographs of commonly encountered pathogens that have been Gram stained. The advantage to these is that they are actual micrographs instead of graphics, giving the student the opportunity to see what they will encounter in reality.
2) Streak plate: A common method for the isolation of a pure culture from a mixture is by "streaking" plates. The inoculum is streaked over the solid agar surface to isolate colonies on at least a portion of the plate. Unless well isolated colonies are obtained, the plate is useless. Pure cultures can be obtained by picking well isolated colonies and restreaking these on fresh agar plates. Biochemical tests to identify bacteria are only valid when performed on pure cultures. In the streak plate module, the student performs the same steps as they would in a lab, including flaming the loop. Errors made such as streaking in the wrong place on the plate or not selecting an isolated colony will result in an error message. At the end of the "incubation" step, the result seen is the same pattern struck by the student using the virtual loop, much like one would see in an actual streak plate.

3) Kirby-Bauer Antimicrobial Susceptibility: In this exercise, the student is provided with a culture plate that has already been inoculated with bacteria and allowed to grow overnite. The plate contains various disks that have been saturated with an antibiotic that were placed on the plate prior to incubation (letters on disks correspond to antibiotics in the table). The student can visualize how well each antibiotic inhibits the growth of the organism, which is related to the effectiveness of that antibiotic in treating infections with that organism.
The mouse becomes a ruler that the student can use to measure the zone of clearing (killing) around each disk. The student then clicks on the box with the measurement on the table of standardized values (table on the right). If the answer is correct, the box turns green. If incorrect, a red X appears for a second and then disappears allowing the student to try again. The Kirby-Bauer disc diffusion method is one that is commonly used in clinical microbiology laboratories and has been standardized in the US by National Committee for Clinical Laboratory Standards. The Kirby-Bauer method is convenient in that the susceptibility of bacterial pathogens to multiple antimicrobial agents can be determined in a single assay. In the virtual Kirby-Bauer exercise, three different plates of results are randomized such that the student can repeat the exercise and see different antibiotic resistance/sensitivity patterns for different bacteria frequently associated with disease.

4) Differential Media: This module is somewhat unique compared to the others in the VIBL. There is no exercise for the student to do, rather, there are a series of examples of bacterial culture media with a variety of organisms cultured on them. For the visual learner, access to these images is key since it is simply not possible for the plates viewed in the live laboratory to be available for students to review for exam preparation. Knowledge of bacterial culture media and their uses in the identification of pathogens is critical and will be tested repeatedly in the students’ career, which led us to invest a great deal of effort into this module. An image of each type of media is shown uninoculated with an explanation of its content and use. Clicking “examples” opens thumbnail versions of examples of different bacteria cultured on that medium. Clicking on the thumbnail enlarges the image for more detailed viewing. Enlarged images also include an explanation for what is seen on the plate being viewed (see below).
There are a wide variety of media in use to culture bacteria, and there are two things to consider when choosing a media and interpreting the result of culturing a particular sample on the media chosen. First, not all bacteria grow on all media. Some bacteria are fastidious, requiring additional “food” for growth. Media may also contain compounds that kill some bacteria, but not others (i.e. antibiotics). Whether or not a given sample grows on a particular media can provide information leading to the identification of the organism in the sample. In the module, the various media are shown both with various bacteria growing on them as well as with bacteria inoculated onto them that do not grow. Second, bacteria may have a phenotype (look different) on some or all solid medium. Examining the plates for growth as well as colony size, shape, consistency, or even color can aid in the identification of the microbe. For example, all staphyloccoci grow on mannitol salt agar. However, *Staphylococcus aureus* is the only species of staphyloccoci that can change the agar from pink to yellow, due to its unique ability to produce acid on this type of media.
Staphylococcus epidermidis on *mannitol salt agar*. Staphylococcus aureus on *mannitol salt agar*.

Another visual example is culture of bacteria on Hektoen agar. Two important food and water-borne pathogens that cause food poisoning, *Escherichia coli* and *Salmonella enterica*, grow on Hektoen agar but look very different from one another. Hektoen agar contains lactose, a sugar that is fermented by *E. coli* but not *Salmonella*. Hektoen agar changes from green to bright salmon when *E. coli* is cultured on the medium, making it very easy to identify a sample with even a small number of *E. coli* in it.

*Escherichia coli on Hektoen agar*. *Salmonella enteritidis on Hektoen agar*.

Students may use the comparison plates of the various types of agar to differentiate between bacteria with otherwise similar characteristics. For the visual learner, being able to view the various cultures in context with explanations and comparisons helps to reinforce the knowledge as well as relate the observations to what else they learn about the various bacteria studied in the course as well as later in medical school.

5-10) Biochemical Tests: The remaining six modules are a set of rapid biochemical tests routinely done in a diagnostic laboratory to characterize bacteria isolated from a patient sample. Three of these test for the presence of specific enzymes (catalase, coagulase, and oxidase). The remaining three are kits frequently used to distinguish species of closely related bacteria from one other. Each module allows the student to perform the same actions as they would in a live lab setting. Error messages are presented when the student makes an error in the test or in standard microbiology lab procedures. For example, if a toothpick is used to transfer a sample of live bacteria from one place to another, the student must properly “dispose” of the contaminated toothpick. The emphasis on proper sterile technique and handling of potentially infectious materials is a concept critical for physicians, and was therefore incorporated into the modules where appropriate.
Error message that results if a contaminated stick is not disposed of in the biohazard waste.

For each of the biochemical tests, the student carries out the exercise on one sample at a time even though multiple samples may be available. At the end, the student is presented with a question asking for an interpretation of the results. The student must answer correctly in order to continue with the exercise. This allows the student to continually associate the various test results that would be obtained with known bacterial samples, reinforcing laboratory skills along with relating the concepts to knowledge of characteristics of specific bacteria.

In the latex agglutination module, the student must score each result (left) and then put that information together to identify the bacteria in the unknown sample (right).

IV. Accessibility

(If it is not a requirement that winning entries be accessible to learners with visual, auditory, mobility, and cognitive disabilities. However, if your course content or technology-enhanced learning innovation is accessible, or if it incorporates an innovative approach to accessibility, please describe.)

V. Evidence of Effectiveness with Students
The VIBL was developed over a four year period in which early versions were tested by students. Students were allowed to carry out tests in the laboratory and then asked to perform the virtual exercise and provide feedback comparing the live and virtual. The feedback from students was generally positive and also informative with respect to suggestions for improvement. In 2010, the lab experience was modified to use VIBL as a replacement for two of the former wet lab sessions, with the students instructed to do the exercises as a preparation for a case-based, wet lab experience. Again, the responses from students was positive. The students liked being able to do the exercises at their own pace, repeat them as needed, and use them to study for exams as well as prepare for the wet lab exercise, all without the mess of a wet lab. This reduced the in-lab time from 6 hrs/student (in three sessions) to a single 2 hr session, a time savings much appreciated by medical students who notoriously carry very heavy course loads. This was also an important consideration with the expansions of both colleges in both size and the number of locations where students were based. Resource availability as well as student accessibility played a role in the decision to develop these labs. Students in the first year of medical school vary tremendously in the amount of prior microbiology experience and having VIBL available allowed the students to either learn or refresh their learning of the laboratory concepts and procedures as needed, regardless of location.

Selected comments from end of the term course evaluations (unedited):

Virtual lab was put together well and I had wonderful time going through it!
The Virtual labs were very helpful, and a nice interactive way to study some of the material.  
Virtual lab was fine. Not the same learning experience as doing it live though. Considering we probably won't be doing these labs ourselves in our professional career, I think this was sufficient. The virtual labs are great preparation for the live lab and also help to give us a full understanding of the lab procedures. Very realistic and much easier than having to perform those experiments in a lab.  
Virtual labs were highly effective and enhanced the learning experience. It is an excellent program especially for students like myself that have never been in a micro lab before. The virtual labs were great. I got a very good idea of what each procedure entails, and as a visual learner, I appreciate seeing all the materials and the "visualized results" of each test. All the labs were very easy to use, I really like how each step was included/tested and how much information was provided about each test.  
I liked the laboratory techniques module, it was a good reference for proper plating procedures and information. I used all of the virtual labs to prepare for the exams as well as the wet lab, and they were very well designed and helpful. I went through the entire lab tutorial and found it incredibly beneficial to understanding the purpose behind using certain biochemical tests in particular. Moreover, it solidified my understanding of topics in lecture (ie. Staph vs. Strep can be distinguished by a catalase test). Very neat design, and very well done. They were easy to use and taught me a great deal. I loved the virtual labs. I was fortunate to have taken a microbiology course with a lab component in undergrad. The virtual lab was identical to what I remember from undergrad lab, minus the issues of getting stain on you. I used all of the virtual labs, and thought all of them were helpful in reinforcing course material in a way that helped me to understand more thoroughly. They made learning the material actually kind of fun.
The virtual lab was really easy to use and straight forward. They thoroughly explained the process of how to perform each test and what exactly they do for you in a laboratory setting. Nice "hands on" learning for students with no access to wet labs. I loved the virtual labs, very smart use of technology to make the lab basics accessible.

VI. Plans for Sustainability

The lab modules were initially available as individual modules accessible through the course Angel site, and only available to students enrolled in the course. After the first two pilot years, I approached Geraud Plantagenest in the CHM Office of Medical Research, Education, and Development (OMERAD) for ideas to make them available to anyone at any time. He created a website to house the modules put together as a stand alone virtual interactive laboratory. This is available to students during and after the course, when they might wish to review them for future courses or licensing examinations. In addition, they are available to anyone off campus. I have received e-mails from faculty at schools around the country who have used them in their courses. I have also received an international request to use the labs.

In order to make them more available, accessible, and visible, we have been able to publish the labs in two peer-reviewed on-line repositories. In December 2009, the Cultivation Media for Bacteria module was published at Microbe Library as a visual resource. Microbe Library is an on-line resource for materials for teaching microbiology supported by the American Society for Microbiology. In September 2010, the McGraw-Hill publishing company ascertained permission from ASM to use parts of the Cultivation Media for Bacteria module in the electronic versions of two of their Microbiology texts. Finally, in October 2011, the entire VIBL was published at MedEd Portal, an on-line resource for medical school teaching materials published and maintained by the American Association of Medical Colleges.