The Good, the Bad and the Ugly: An Exploration of *E. coli* and other Microbial Fiends Friends

or Are YOU going to eat THAT?

Jessica Mahoney
Trenton High School

**Abstract:**
This action research project will immerse 9th grade students in an intensive, hands on, biotechnology based curriculum unit focused on emerging bacterial pathogens with the intention of generation learning gains and student interested in a population that is historically disinterested in science. The action research will take place in two 85-minute classes, where all learning styles will be addressed. Students will participate in a variety of activities, ranging from traditional lessons, to advanced gel electrophoresis, and student production of public service announcement films.

**Rationale:**
This project will target 9th grade students in an Integrated Science I course. At our school, this course targets lower level students, with little to no interest in science. Due to the varied topics covered in this course, it becomes a survey style class, intended to peak student interested. Historically however, at my school, the quick change of topics between the 4 major strands of science with only a superficial coverage of content leads to even more disinterest in science education.

“Good, Bad and Ugly” will expand the study of prokaryotic cells into an in-depth research unit that will fully engage the students by the use of various biotechnology methods, the emerging pathogenic effect of virulent strains of *E. coli* and other bacteria on public heath and food industry. By engaging in an in-depth study focused on a central topic with various tactics students will become more focused on the relevance of science education and ideally take a greater interest in science study.

**Description of teaching unit or module(s), including expected outcomes:**
This teaching unit, which will span approximately 7 instructional weeks, will focus on the following Life Science NGSSS:

- SC.912.L.14.3- Compare/Contrast Prokaryotic and Eukaryotic cells
- SC.912.L.14.6- Pathogenic Agents
- SC.912.L.17.6- Symbiotic Relationships

The learning outcomes are as follows:

- Students will differentiate between prokaryotic vs eukaryotic cells
- Students will understand the symbiotic nature of humans and microbes
- Students will identify pathogenic microbial agents found in human food sources
- Students will describe how pathogenic microbial agents could be introduced into human food sources

The student learning outcomes will be achieved through the completion of the following activities:

- Lesson: The Diverse World of Prokaryotes
• “Find Me” Giant Microbes
• Water Microarray Simulation
  o Students will then research one of the pathogens found in their “water samples” in pairs and present their findings to the class
• Lesson: Symbiotic Relationship with *E. coli* - Thank you, Microbes!
• Viewing of *Food, Inc.*
  o Discussion series with articles: How do microbes “go wrong” and how does our food become contaminated
• Begin growing bacterial colonies: *Sarcina aurantiaca* and *Serratia marcescens*
  o Lesson: Sterile technique and colony counting
• PSA project: Students will write, film and edit short PSA’s about pathogens in human food sources
  o Lesson: Introduction to Biotechnology
  o Micropipetting and Designer Plates
• Mahoney Visits Germany Lab (aka Outbreak!)
• Protein digest and SDS PAGE analysis of classroom bacterial colonies

**Data collection techniques and/or student assessments:**
• Unit Pre-Test
• Class Presentation of Microbe Research (from simulated microarray results)
• “The Good” virtual poster: an explanation of human symbiosis with microbes
• “The Bad and sometimes Ugly” PSA: Dangerous microbes in our food (after watching *Food, Inc.*)
• Lab Reports (Outbreak! Lab, Protein SDS PAGE for bacterial protein comparison)
• Post Test

**Use of equipment lockers and/or UF visit (either in the classroom or UF campus):**
• Giant Microbes with question/answer cards Locker
• Pipetting Stations Locker
• Advanced Gel Electrophoresis Locker
• Protein Electrophoresis
• Microarray Simulation Kit (Dr. Lawrence)

**ICORE summer institute elements specifically included (UF connections):**
• Topics from Dr. Morris’ lecture on “The Age of Pandemics”
• Outbreak! Lab
• Protein Extraction and SDS-PAGE

**Literature cited:**
Benskin, Jonathan. “Student Bacterial Protein Extraction Protocol” In DRAFT. 2011.

**Budget and budget justification:** $200
<table>
<thead>
<tr>
<th>Item</th>
<th>Vendor/Source</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>211208 Outbreak! Fingerprinting Virus DNA 6-Station Kit</td>
<td>Carolina</td>
<td>$89.00</td>
</tr>
<tr>
<td>No.:90084 B-PER (250mL)</td>
<td>Thermo Scientific / Fisher Scientific</td>
<td>$187.06</td>
</tr>
<tr>
<td>L563464 Sarcina aurantiaca</td>
<td>Frey Scientific</td>
<td>$15.25</td>
</tr>
<tr>
<td>L563473 Serratia Marcescens</td>
<td>Frey Scientific</td>
<td>$15.25</td>
</tr>
<tr>
<td>D526787 Nutrient Agar-Pre Poured Plates (set of 10)</td>
<td>Frey Scientific</td>
<td>$11.69</td>
</tr>
<tr>
<td>NP0336BOX NuPAGE® 4-12% Bis Tris Gel 1.5 mm, 15 well (1 box of 10 gels)</td>
<td>Invitrogen</td>
<td>$131.00</td>
</tr>
<tr>
<td>NP0007 NuPAGE® LDS Sample Buffer (4X) (10 ml)</td>
<td>Invitrogen</td>
<td>$11.96</td>
</tr>
<tr>
<td>NP0004 NuPAGE® Sample Reducing Agent (10X) (250 ul)</td>
<td>Invitrogen</td>
<td>$11.96</td>
</tr>
<tr>
<td>BP101-25 Brilliant Blue R-250 (25g)</td>
<td>Fisher Scientific</td>
<td>$88.81</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td><strong>$561.98</strong></td>
</tr>
</tbody>
</table>

*Additional costs will be covered by local and district funds.*
TITLE: The Bad, The Ugly and the Sometimes Deadly: Bacteria in our Food PSA’s

KEY QUESTION: How have changes modern in farming affected the levels of “bad” bacteria in food sources?

SCIENCE SUBJECT: Biology: Microbiology

GRADE AND ABILITY LEVEL: 9th grade, Regular Ed

SCIENCE CONCEPTS: Identify key science topics. Try not to be too narrow.

OVERALL TIME ESTIMATE: 4-85 minute class periods (3 class periods if students have editing capabilities at home)

LEARNING STYLES: Visual, auditory, and synthesis

VOCABULARY

- CFO
- E. Coli O157:H7
- Industrial Farming
- Pastoral Farming

LESSON SUMMARY:

In this multiday lesson students will screen the documentary Food, Inc. focused on bacterial interactions, both symbiotic and pathogenic. The teacher will prompt discussions at various stages of the documentary screen process, for clarification, debate, as well as social and political awareness. Students will produce 2-3 minute long public service announcements regarding the safety of industrial farmed foods and bacteria exposure risks.

STUDENT LEARNING OBJECTIVES WITH STANDARDS:

1. The student will be able to identify at least 2 sources of bacteria introduction into food sources. (SC.912.L.17.6- Symbiotic Relationships)
2. The student will produce a 3-minute public service announcement addressing bacterial infections in “industrial foods.” (SC.912.L.14.6- Pathogenic Agents)

MATERIALS:

ESSENTIAL:

1 flipcam (or other video camera) per group (3-4 students),
1 computer/laptop per group

SUPPLEMENTAL:

poster board, makers/paint, other costuming and props as needed

ADVANCE PREPARATION:
• Screen the film: Food, Inc.
• Determine what discussion points would be most relevant for the students (or in most need of clarification)
• Obtain supplemental sources such as articles from Monsanto, copies of “Kevin’s Law” and the Food, Inc Participant Guide

PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:
Day one (~65 minutes): Screen first half of Food, Inc.
  o At teacher deemed times, pause the film and ask the following discussion questions. (give 5-7 minutes for whiteboarding and discussion for each question)

Day One Discussion Questions:
  • State 2 possible issues that arise from monoculture.
  • Explain the relationship between corn fed cattle and E. coli. Contrast that relationship with grass fed cattle and E. coli.

Day Two (~45 minutes): (optional) Screen second half of Food, Inc
NOTE: the majority of the important content is in the first 50 minutes of the film. I usually allow students to finish the film, because they have high interest at this point.

Day Two, con’t (~30 minutes): Pass out grading rubric, explain expectations (take any student generated questions for clarification/discussion as necessary) and have students start scripting their PSAs.
  • Collect student requests for props, etc.

Day Three (85 minutes): Student filming and editing of PSAs.

Day Four (85 minutes): PSA premiers and student critiques.

ASSESSMENT SUGGESTIONS:
For Objectives 1 and 2: Students will write, direct, star, edit and present 2-3 minute public service announcements to address to increasing risk and presence of pathogenic strains of bacteria in public food sources.

NOTE: As students have nearly 2 days of “structure free” worktime, structured bell ringer questions and exit slips for each day may be a good idea, to keep students focused on the point of the activity, not that they are “playing with cameras and computers.”
ACTIVITIES:
  Letter writing to senators/Monsanto/local farmers.

LITERATURE:
  "Food Inc.: A Participant Guide: How Industrial Food is Making Us Sicker, Fatter, and Poorer-And What You Can Do About It edited by Karl Weber
  The Omnivore’s Dilemma: A Natural History of Four Meals by Michael Pollan

RESOURCES/REFERENCES:


The Good, the Bad and the Ugly: An Exploration of *E. coli* and other Microbial Friends

or

Are YOU going to eat THAT?

Jessica Mahoney
Trenton High School

Abstract:
This action research project immersed 9th grade students in an intensive, hands on, biotechnology based curriculum unit focused on emerging bacterial pathogens with the intention of generation learning gains and student interest in a population that is historically disinterested in science. The action research took place in two 85-minute classes for 17 days, or approximately 4 student weeks, was delivered to a diverse student population, including LD, ELL & economically disadvantaged individuals. Students participated in a variety of activities, which ranged from traditional lessons, to advanced gel electrophoresis, and student production of public service announcement films. As anticipated the action research unit was successful, showing learning gains in 100% of students.

Rationale for the Implantation of Action Research:
This project targeted primarily 9th grade students in an Integrated Science I course. At our school, this course targets lower level students, with little to no interest in science. Due to the varied topics covered in this course, it becomes a survey style class, intended to peak student interested. Historically however, at my school, the quick change of topics between the 4 major strands of science with only a superficial coverage of content leads to even more disinterest in science education. “Good, Bad and Ugly” expanded the study of prokaryotic cells into an in-depth research unit that fully engaged the students by the use of various biotechnology methods, the emerging pathogenic effect of virulent strains of *E. coli* and other bacteria on public health and food industry. By engaging in an in-depth study focused on a central topic with various tactics overall students became more focused on the relevance of science education and took a greater interest in science study, which is evidenced by their journal entries, some of which will be discussed later in this paper.

Methods:
This teaching unit, which spanned 17 days or approximately 4 instructional weeks, focused on the following Life Science NGSSS:
- SC.912.L.14.3- Compare/Contrast Prokaryotic and Eukaryotic cells
- SC.912.L.14.6- Pathogenic Agents
- SC.912.L.17.6- Symbiotic Relationships

With the following Student Learning Outcomes:
- Students will differentiate between prokaryotic vs eukaryotic cells
- Students will understand the symbiotic nature of humans and microbes
- Students will identify pathogenic microbial agents found in human food sources
- Students will describe how pathogenic microbial agents could be introduced into human food sources

The student learning outcomes were achieved through the completion of the following activities (all resources for each lesson can be found in the appendix of this paper, unless a direct activity/mini curriculum unit was borrowed from UF CPET):
Day 1:

- Pre-test: *Emerging Pathogens-Biotechnology & Bacteria*
  Please see the “Assessments” section of the Appendix for a copy of the Pre-Test. See results in the data section below.

- Pre Journal Entry
  See prompts and sample student entries below.

- Review of Bacteria
  Please see “Lesson Notes” in the Appendix for details.

Day 2:

- Fuzzy Microbes Activity
  “Meet the Pathogens” borrowed locker from UF CPET. This activity was used without modification.

- Symbiosis Lesson
  Please see “Lesson Notes” in the Appendix for details.

- Culturing Bacteria from around Campus
  Students worked in pairs to collect four samples from the classroom and classroom building using sterile swabs and pre-poured nutrient agar culture plates.

Day 3:

- “Good, Bad & Ugly” Bacteria Want Ads-part I-Research
  A creative rubric based project in which small teams of students (2 or 3 members per team) choose a bacteria and create a want ad to display basic information about the bacteria. See the “Rubrics” section of the Appendix.

Day 4:

- “Good, Bad & Ugly” Bacteria Want Ads-part II-Class Presentations

- Emerging Pathogens & YOU Lesson
  Please see “Lesson Notes” in the Appendix for details.

Day 5:

- Your Immune System and the Pathogens Lesson
  Please see “Lesson Notes” in the Appendix for details.

Day 6:

- Biotechnology Tools and Techniques Lesson
  Please see “Lesson Notes” in the Appendix for details.

- Designer Plates Pipetting Activity
  This activity is a borrowed locker from UF CPET. This activity was used without modification.
Day 7:
- OUTBREAK! Lab- “Mahoney Survives Germany”
This lab is a modification of Carolina’s OutBreak! Fingerprinting Virus DNA Kits, run using “E-Gel” rigs by Invitrogen instead of traditional cast agarose gels electrophoresis rigs. A mini lesson stage setter was used beforehand to “hook” the students into determining which patient samples were contaminated with an unknown strain of *E. coli*. See the Appendix section “Lesson Notes” for the stage setter and the “Labs” section for the student handout.

Day 8:
- The DNA-Protein Relationship Lesson

Day 9 (3 hour combined class):
- Bacteria Protein Digest & SDS-PAGE Experiment
This experiment was a modification of Bio-Rad’s Comparative Proteomics Kit I: Protein Profiler Module. Two purchased bacteria stab cultures of *Sarcina aurantiaca* and *Serratia Marcescens* from Fischer Scientific were used in place of the fish muscle. The student protocol is available in the “Labs” section of the Appendix.

Day 10:
- Bacteria Digest Experiment Results and Wrap Up
- Unit Review

Day 11:
- Post-test: Emerging Pathogens-Biotechnology & Bacteria
Please see the “Assessments” section of the Appendix for a copy of the Pre-Test. See results in the data section below.

Days 12-13:
- Watch *Food, Inc.* and class discussion
Students screened the documentary *Food, Inc.* by filmmaker Robert Kenner, analyzing for persuasive tone and bias. Student discussions were led by both teacher and student questioning in addition to prompting with quotes from the *Food, Inc. Participant Guide* edited by Karl Weber.

Days 14-16:
- Write/Film/Edit PSA’s on Bacteria in our Modern Food System
Please see the “Rubrics” section of the Appendix for more details.

Day 17:
- PSA Premiere Day!
- Post Journal Entry-Revisiting your Initial Thoughts
See prompts and sample student entries below.

Daily “Bell Ringers”, or activities that students complete during the first 5 minutes of class, were also used either to review a concept, to introduce a new idea or jump start critical thinking skills. The complete set of Bell Ringers written and used for this unit can be referenced in the Appendix.
Results & Outcomes:

The ultimate goal of this project was to see if student gains were made on a very advanced unit of study that while rooted in “ninth grade level” standards delved into very rigorous and complex topics such as emergence and reemergence of disease, protein structure and proteomics, and biotechnology protocols through primarily hands on experiences. Ideally this action research would be completed in two “matched” classes, with one as a control group, receiving “classic” instruction with only demonstrations or modeling of advanced laboratory techniques and the research group receiving the hands on-laboratory experiences and more “inquiry style” instruction.

However, while those ideal settings were not possible for this action research project the following pre-unit multiple choice assessment test as compared to the post-unit multiple choice assessment test shows that 100% of the students showed some learning gains.

<table>
<thead>
<tr>
<th></th>
<th>Number of Students Tested</th>
<th>Lowest Score</th>
<th>Highest Score</th>
<th>Median Score</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Unit Test</td>
<td>34</td>
<td>4/30* or 15%</td>
<td>22/30 or 75%</td>
<td>14.5/30 or 48%</td>
<td>15.9/30 or 46.5%</td>
</tr>
<tr>
<td>Post-Unit Test</td>
<td>34</td>
<td>14/30 or 47%</td>
<td>50/30 or 100%</td>
<td>25/30 or 85%</td>
<td>24.4/30 or 81.2%</td>
</tr>
</tbody>
</table>

*30/30 points possible for a 100% score on both the pre and post unit tests.

While the numbers tell a nice, neat story of improvement across the board, with 76% of students showing a mastery score of 80% or better on the post unit test and an average increase of percentage points at 34.7 points (range of percentage point increase is from 10-70 points) the better gauge of success comes directly from the students own words, not their ability to correctly answer multiple choice questions. For this unit I used journaling as a way to collect student thoughts, opinions and knowledge of the subject area.

Pre-Unit Journal Prompt: Based on your current knowledge discuss:

- What you think an “emerging pathogen” is.
- What biotechnology is and how it could be used to study health issues.
- If scientists make any contributions to improving society, especially health issues.

Sample Student Pre Journal Responses:
Sample 1: *I have no clue what an emerging pathogen is. I’m guessing something in a bacteria that is out of place or striking out because that means emerging.*
Sample 2: *I think an emerging pathogen is either bacteria forming and invading the body or something forming to fight off bacteria. Biotechnology is the use of electronics and other technology to study the body and how it works.*
Sample 3: *I think emerging pathogens are big blue monsters that eat your insides. Biotechnology is the study of the human body. They do because if scientist didn’t study all the time then we wouldn’t have medicines.*
As demonstrated by the pre-unit journal responses, students did not have a grasp on any of the key concepts of the unit. Some students, such as Sample 1, tried to activate background knowledge, using the basic vocabulary terms. Others, such as Sample 3, apparently had no background knowledge to activate, but at least this student got very creative, which I always appreciate.

Post-Unit Journal Prompt: Based on your knowledge and experience, having finished the Emerging Pathogens unit discuss the following, using examples to support your ideas:

- What biotechnology is and how it is used to study health issues, particularly emerging pathogens.
- How scientists, especially biotechnologists, make contributions to improving society.

In a second paragraph please give me your feedback on the unit, including:

- If you think it was interesting/should be repeated in the future.
- Activities you liked and activities you dislike/would like changed.

Sample Student Post Journal Responses:

Sample 1: Based on my knowledge and experience, having finished the emerging pathogens I now know that it is a substance capable of causing disease. Biotechnology is “applied biology” the scientist conduct experiments using biotechnology.

Sample 2: I think this unit was very interesting and should definitely be repeated in the future. There really wasn’t anything that I disliked about the activities because I found everything very interesting, whether it was doing the actual extraction, using the pipettor, analyzing the patterns after the gel electrophoresis, or lectures explaining what we were actually doing. The thing I would change is having more explanation and longer lectures, because I found this very interesting, but maybe I’m just a science geek ;)

Sample 3: I have learned more from the labs and the hands on stuff. You can tell me how to do something but if you don’t show me I will forget it.

The post unit surveys were very interesting because I could see, in the student’s terms that they had learned a great deal from the unit. For example, Sample 1 accurately used one of the definitions we used for biotechnology during the unit. The interest level was obviously quite high as well, because the student Sample 2 actually requested “more explanation and longer lectures” a request I’ve never received before! Lastly, student Sample 3, teaches myself and hopefully all educators the most important lesson of science education—“...show me [or] I will forget it.”

Modifications/Suggestions for Future Implementation

To make this unit truly student led and inquiry based I would spend time developing materials, such as new releases, articles, similar items of interest that students would explore in small teams to learn about the types of bacteria and immune responses. I would also spend more time ensuring students have a better understanding of what proteins are, and the variances in protein structure before performing the protein extraction and SDS-PAGE biotechnology lab.
Personal Reflections/Dissemination

Anytime I have the opportunity to step back and really examine the strengths and weaknesses of my teaching style and curriculum choices through action research projects I discover something many things that I could improve upon. I realized during this action research project that I still fall back on classic lecture when a concept is complex or when time is at a premium. However, I truly believe from observation, student feedback and assessment data that this generation of students do learn and retain information better when they obtain it via self discovery. That is why I am hoping to prep more inquiry lessons, like the one outlined in the “Modifications/Suggestions for Future Implementation” section.
# ICORE-Emerging Pathogens

Mahoney  Pre/Post Data Comparison

<table>
<thead>
<tr>
<th>Student Identifier</th>
<th>RAW* Pre Data</th>
<th>%-Pre Data</th>
<th>RAW* Post Data</th>
<th>%-Post Data</th>
<th>Increase in Percentage Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA-9-1</td>
<td>16</td>
<td>53.3</td>
<td>23</td>
<td>76.7</td>
<td>23.3</td>
</tr>
<tr>
<td>MB-9-1</td>
<td>15</td>
<td>50.0</td>
<td>27</td>
<td>90.0</td>
<td>40.0</td>
</tr>
<tr>
<td>AC-10-1</td>
<td>11</td>
<td>36.7</td>
<td>24</td>
<td>80.0</td>
<td>43.3</td>
</tr>
<tr>
<td>AD-10-1-F</td>
<td>15</td>
<td>50.0</td>
<td>27</td>
<td>90.0</td>
<td>40.0</td>
</tr>
<tr>
<td>AD-10-1-M</td>
<td>15</td>
<td>50.0</td>
<td>25</td>
<td>83.3</td>
<td>33.3</td>
</tr>
<tr>
<td>TD-12-1</td>
<td>12</td>
<td>40.0</td>
<td>23</td>
<td>76.7</td>
<td>36.7</td>
</tr>
<tr>
<td>BD-9-1</td>
<td>17</td>
<td>56.7</td>
<td>25</td>
<td>83.3</td>
<td>26.7</td>
</tr>
<tr>
<td>MD-11-1</td>
<td>16</td>
<td>53.3</td>
<td>26</td>
<td>86.7</td>
<td>33.3</td>
</tr>
<tr>
<td>KE-9-1</td>
<td>16</td>
<td>53.3</td>
<td>19</td>
<td>63.3</td>
<td>10.0</td>
</tr>
<tr>
<td>MJ-9-1</td>
<td>17</td>
<td>56.7</td>
<td>28</td>
<td>93.3</td>
<td>36.7</td>
</tr>
<tr>
<td>BJ-9-1</td>
<td>15</td>
<td>50.0</td>
<td>20</td>
<td>66.7</td>
<td>16.7</td>
</tr>
<tr>
<td>RM-11-1</td>
<td>19</td>
<td>63.3</td>
<td>30</td>
<td>100.0</td>
<td>36.7</td>
</tr>
<tr>
<td>LM-9-15</td>
<td>15</td>
<td>50.0</td>
<td>22</td>
<td>73.3</td>
<td>23.3</td>
</tr>
<tr>
<td>JM-9-1</td>
<td>7</td>
<td>23.3</td>
<td>28</td>
<td>93.3</td>
<td>70.0</td>
</tr>
<tr>
<td>MR-9-1</td>
<td>17</td>
<td>56.7</td>
<td>28</td>
<td>93.3</td>
<td>36.7</td>
</tr>
<tr>
<td>CS-9-1</td>
<td>10</td>
<td>33.3</td>
<td>19</td>
<td>63.3</td>
<td>30.0</td>
</tr>
<tr>
<td>DS-10-1</td>
<td>13</td>
<td>43.3</td>
<td>28</td>
<td>93.3</td>
<td>50.0</td>
</tr>
<tr>
<td>AS-9-1</td>
<td>9</td>
<td>30.0</td>
<td>21</td>
<td>70.0</td>
<td>40.0</td>
</tr>
<tr>
<td>BT-10-1</td>
<td>14</td>
<td>46.7</td>
<td>28</td>
<td>93.3</td>
<td>46.7</td>
</tr>
<tr>
<td>WW-9-1</td>
<td>17</td>
<td>56.7</td>
<td>22</td>
<td>73.3</td>
<td>16.7</td>
</tr>
<tr>
<td>AB-12-2</td>
<td>14</td>
<td>46.7</td>
<td>25</td>
<td>83.3</td>
<td>36.7</td>
</tr>
<tr>
<td>SB-9-2</td>
<td>13</td>
<td>43.3</td>
<td>24</td>
<td>80.0</td>
<td>36.7</td>
</tr>
<tr>
<td>HC-9-2</td>
<td>8</td>
<td>26.7</td>
<td>14</td>
<td>46.7</td>
<td>20.0</td>
</tr>
<tr>
<td>DC-9-2</td>
<td>22</td>
<td>73.3</td>
<td>29</td>
<td>96.7</td>
<td>23.3</td>
</tr>
<tr>
<td>LC-9-2</td>
<td>13</td>
<td>43.3</td>
<td>27</td>
<td>90.0</td>
<td>46.7</td>
</tr>
<tr>
<td>BD-9-2</td>
<td>12</td>
<td>40.0</td>
<td>25</td>
<td>83.3</td>
<td>43.3</td>
</tr>
<tr>
<td>DD-9-2</td>
<td>11</td>
<td>36.7</td>
<td>22</td>
<td>73.3</td>
<td>36.7</td>
</tr>
<tr>
<td>JF-9-2</td>
<td>20</td>
<td>66.7</td>
<td>30</td>
<td>100.0</td>
<td>33.3</td>
</tr>
<tr>
<td>ML-9-2-F</td>
<td>13</td>
<td>43.3</td>
<td>35</td>
<td>116.7</td>
<td>73.3</td>
</tr>
<tr>
<td>ML-9-2-M</td>
<td>13</td>
<td>43.3</td>
<td>35</td>
<td>116.7</td>
<td>73.3</td>
</tr>
<tr>
<td>TM-9-2</td>
<td>13</td>
<td>43.3</td>
<td>23</td>
<td>76.7</td>
<td>33.3</td>
</tr>
<tr>
<td>AM-9-2</td>
<td>4</td>
<td>13.3</td>
<td>24</td>
<td>80.0</td>
<td>66.7</td>
</tr>
<tr>
<td>TN-9-2</td>
<td>16</td>
<td>53.3</td>
<td>22</td>
<td>73.3</td>
<td>20.0</td>
</tr>
<tr>
<td>KS-11-2</td>
<td>16</td>
<td>53.3</td>
<td>20</td>
<td>66.7</td>
<td>13.3</td>
</tr>
</tbody>
</table>

*Raw Data Scores are points earned out of 30 possible points

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>46.5</td>
<td>82.2</td>
<td>35.7</td>
</tr>
</tbody>
</table>
Emerging Pathogens: Bacteria and Biotechnology

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. Plasmids
   a. are circular pieces of bacterial DNA.
   b. replicate when the organism’s main chromosome replicates.
   c. are often used as vectors in genetic engineering.
   d. All of the above

____ 2. The use of genetic engineering to transfer human genes into bacteria
   a. is impossible with current technology.
   b. causes the human genes to manufacture bacterial proteins.
   c. results in the formation of a new species of organism.
   d. allows the bacteria to produce human proteins.

____ 3. Transferring normal human genes into human cells that lack them
   a. is impossible at this time.
   b. will cause cancer.
   c. will cause antibodies to kill those cells.
   d. is called gene therapy.

____ 4. All organisms in an ecosystem are linked together in a network of interactions. This quality is called
   a. geochemical processes.
   b. isolation.
   c. interdependence.
   d. communication.

____ 5. The earliest known group of living organisms on Earth was
   a. viruses.
   b. fungi.
   c. bacteria.
   d. protists.

____ 6. Bacteria can be classified according to their
   a. type of cell walls.
   b. methods of obtaining energy.
   c. Gram-staining characteristics.
   d. All of the above

____ 7. Bacteria lack a true nucleus and membrane-bound organelles; therefore, they are classified as
   a. prokaryotes.
   b. aerobes.
   c. anaerobes.
   d. eukaryotes.

____ 8. The cytoplasm of bacteria
   a. contains numerous types of organelles.
   b. is divided into compartments.
   c. has varying numbers of chromosomes, depending on the species of bacteria.
   d. contains a single chromosome.

____ 9. A pathogen is an agent that is
   a. beneficial to humans.
   b. harmful only to plants.
   c. harmful to living organisms.
   d. nearly extinct.
10. Which of the following foods is not a fermentation product of bacteria?
   a. sour cream          c. milk
   b. a pickle            d. yogurt

11. Antibiotics
   a. include penicillin and tetracycline.
   b. may prevent bacteria from making new cell walls.
   c. can be effective treatments for bacterial diseases.
   d. All of the above

12. Which of the following is not a way of preventing a foodborne illness at home?
   a. washing kitchen utensils thoroughly in cold water
   b. keeping cooked and raw foods separate during storage
   c. washing fresh fruits and vegetables before eating them
   d. refrigerating leftovers promptly

<table>
<thead>
<tr>
<th></th>
<th>Both organisms benefit from the activity of each other.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>One organism benefits, and the other organism neither benefits nor suffers harm.</td>
</tr>
<tr>
<td>3</td>
<td>One organism obtains its nutrients from another, and the other organism may weaken due to deprivation.</td>
</tr>
</tbody>
</table>

13. Refer to the chart above. The table represents three types of
   a. competition.          c. symbiosis.
   b. rhythmic patterns.    d. secondary succession.

14. How does the DNA of a bacteriophage enter a host cell?
   a. injection
   b. endocytosis
   c. conjugation
   d. binary fission

15. In the bacterium in Figure 18.2, what is the structure labeled B?
   a. pili
   b. DNA
   c. plasmid
   d. flagellum

**FIG. 18.2**

...
16. In the bacterium in Figure 18.2, what is the structure labeled C?
   a. pili
   b. cell wall
   c. plasmid
   d. flagellum

17. Antibiotics are used to fight
   a. viral infections.
   b. fungal infections.
   c. HIV infections.
   d. bacterial infections.

18. Prokaryotes reproduce by
   a. endocytosis.
   b. fermentation.
   c. binary fission.
   d. reverse transcription.

19. In DNA, which of the following determines the traits of an organism?
   a. amount of adenine
   b. number of sugars
   c. sequence of nitrogenous bases
   d. strength of hydrogen bonds

20. Although there are a limited number of amino acids, many different types of proteins exist because:
   a. a given amino acid can have different properties
   b. the arrangement and number of amino acids can vary
   c. the chemical composition of a given amino acid can vary
   d. the size of an amino acid can vary

21. A genome is:
   a. an organism’s collection of genes
   b. a process used to copy DNA
   c. the nucleotide sequence that makes up a particular gene
   d. a fragment of DNA added to a chromosome during a recombinant DNA experiment

22. What piece of laboratory equipment would you use to measure and deliver small volumes (ex: 0.5uL up to 1mL) of liquid material?
   a. centrifuge
   b. pipettor
   c. thermocycler
   d. water bath

23. What is the function of restriction endonucleases?
   a. To add nucleotides to a strand of DNA
   b. To replace nitrogenous bases in DNA
   c. To cut DNA at specific sites
   d. To join complementary DNA strands

24. Why do DNA fragments migrate down a electrophoresis gel?
   a. The phosphate group on DNA is negatively charged
   b. The phosphate group on DNA has a positive charge
   c. DNA does not move in response to electrical currents
   d. All of the above
25. If one band (fragment) of DNA migrates further down an electrophoresis gel, in comparison to a second band, what does that tell the scientist about the first band?
   a. nothing, the scientist needs more information
   b. that the second band must be longer than the first band
   c. that the first band must be longer than the second band
   d. that the bands came from two different species

26. What is the primary difference between DNA gel electrophoresis and running SDS-PAGE?
   a. SDS-PAGE is for protein analysis
   b. SDS-PAGE is the same thing as gel electrophoresis
   c. SDS-PAGE does not separate molecules based on size
   d. SDS-PAGE is a more sophisticated technology.

27. Butterflies and caterpillars have the same genome; the main reason they look physically different is
   a. gene mutation
   b. different environmental conditions
   c. different proteins
   d. adaptation

28. What is one way to identify an unknown protein?
   a. peptide mass finger printing
   b. Edman sequencing
   c. hydrolysis to amino acids
   d. PCR the protein

29. Which of the following are important when studying emerging pathogens?
   a. human behavior
   b. evolution of pathogens
   c. environmental changes
   d. all are important

30. Proteins are composed of
   a. amino acids
   b. nucleotides
   c. fatty acids
   d. simple sugars
Emerging Pathogens: Bacteria and Biotechnology
Answer Section

MULTIPLE CHOICE

1. ANS: D  PTS: 1  DIF: 1  OBJ: 13-1.3  STA: SC.H.3.4.2
2. ANS: D  PTS: 1  DIF: 1  OBJ: 13-1.3  STA: SC.H.3.4.2
3. ANS: D  PTS: 1  DIF: 1  OBJ: 13-3.2  STA: SC.H.3.4.6
4. ANS: C  PTS: 1  DIF: 1  OBJ: 18-1.1  STA: SC.G.1.4.1
5. ANS: C  PTS: 1  DIF: 1  OBJ: 23-1.1  STA: SC.G.1.4.1
6. ANS: D  PTS: 1  DIF: 1  OBJ: 23-1.3  STA: SC.G.1.4.1
7. ANS: A  PTS: 1  DIF: 1  OBJ: 23-1.1  STA: SC.G.1.4.1
8. ANS: D  PTS: 1  DIF: 1  OBJ: 23-2.1  STA: SC.G.1.4.1
9. ANS: C  PTS: 1  DIF: 1  OBJ: 3-3.1  STA: SC.G.1.4.1
10. ANS: C  PTS: 1  DIF: 1  OBJ: 23-3.5  STA: SC.H.3.4.6
11. ANS: D  PTS: 1  DIF: 1  OBJ: 23-3.5  STA: SC.H.3.4.6
12. ANS: A  PTS: 1  DIF: 2  OBJ: 23-3.4  STA: SC.H.3.4.3
13. ANS: C  PTS: 1  DIF: 2  OBJ: 20-1.3  STA: SC.G.1.4.1
19. ANS: C  PTS: 1
20. ANS: B  PTS: 1
21. ANS: A  PTS: 1
22. ANS: B  PTS: 1
<table>
<thead>
<tr>
<th></th>
<th>Answer</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>B</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>C</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>D</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>A</td>
<td>1</td>
</tr>
</tbody>
</table>
Emerging Pathogens: Bacteria and Biotechnology-Post Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Plasmids
   a. are circular pieces of bacterial DNA.
   b. replicate when the organism’s main chromosome replicates.
   c. are often used as vectors in genetic engineering.
   d. All of the above

2. The use of genetic engineering to transfer human genes into bacteria
   a. is impossible with current technology.
   b. causes the human genes to manufacture bacterial proteins.
   c. results in the formation of a new species of organism.
   d. allows the bacteria to produce human proteins.

3. Transferring normal human genes into human cells that lack them
   a. is impossible at this time.
   b. will cause cancer.
   c. will cause antibodies to kill those cells.
   d. is called gene therapy.

4. Explain how a commensalitory relationship between a human and a bacteria could best be come parasitic/pathogenic.
   a. geochemical processes.
   b. isolation.
   c. opportunistic infection.
   d. communication.

5. The earliest known group of living organisms on Earth was
   a. viruses.
   b. fungi.
   c. bacteria.
   d. protists.

6. Bacteria can be classified according to their
   a. type of cell walls.
   b. methods of obtaining energy.
   c. Gram-staining characteristics.
   d. All of the above

7. Bacteria lack a true nucleus and membrane-bound organelles; therefore, they are classified as
   a. prokaryotes.
   b. aerobes.
   c. anaerobes.
   d. eukaryotes.

8. What process would a biotechnologist use in order to create many copies of a specific piece of DNA?
   a. DNA extraction
   b. PCR
   c. Reverse Transcription
   d. Translation

9. A pathogen is an agent that is
   a. beneficial to humans.
   b. harmful only to plants.
   c. harmful to living organisms.
   d. nearly extinct.
10. Over use of antibiotics is hypothesized to have caused:
   a. Antibiotic resistant strains of bacteria  
   b. Healthy people  
   c. The treatment of viral infections  
   d. Over use has no effect

11. *E. coli* strains such as 0157:H7 are considered dangerous infections because:
   a. They often kill old and young individuals.
   b. They cause severe diarrhea.
   c. They can cause HUS in ~10% of sick individuals.
   d. All of the above

12. The most common source of *E. coli* related food poisoning is:
   a. washing kitchen utensils in cold water
   b. keeping cooked and raw foods separate during storage
   c. fecal matter on raw vegetables/meat products
   d. not refrigerating leftovers promptly

13. Refer to the chart above. The table represents three types of
   a. competition.  
   b. rhythmic patterns.  
   c. symbiosis.  
   d. secondary succession.

14. Viruses such as the flu copy their genetic information by:
   a. Injection into the host’s muscle tissue only
   b. Using the cell’s own copying system.
   c. conjugation
   d. binary fission

15. In the bacterium in Figure 18.2, what is the structure labeled B?
   a. pili  
   b. DNA  
   c. plasmid  
   d. flagellum
16. In the bacterium in Figure 18.2, what is the structure labeled C?
   a. pili
   b. cell wall
   c. plasmid
   d. flagellum

17. Antibiotics are used to fight
   a. viral infections.
   b. fungal infections.
   c. HIV infections.
   d. bacterial infections.

18. A proteome is:
   a. Another name for the genome.
   b. All the proteins an organism could have.
   c. binary fission.
   d. reverse transcription.

19. The primary difference between a pathogen and an emerging pathogen is:
   a. amount of adenine in the pathogen
   b. number of sugars in the pathogen’s genome
   c. sequence of nitrogenous bases in the pathogen
   d. the time frame the pathogens is seen

20. Although every cell contains the entire genome, different types of proteins are expressed because:
   a. a given amino acid can have different properties
   b. the arrangement and number of amino acids can vary
   c. cell requirements are different at different times
   d. the size of an amino acid can vary

21. A genome is:
   a. an organism’s collection of genes
   b. a process used to copy DNA
   c. the nucleotide sequence that makes up a particular gene
   d. a fragment of DNA added to a chromosome during a recombinant DNA experiment

22. What piece of laboratory equipment would you use to measure and deliver small volumes (ex: 0.5uL up to 1mL) of liquid material?
   a. centrifuge
   b. pipettor
   c. thermocycler
   d. water bath

23. What is the function of restriction endonucleases?
   a. To add nucleotides to a strand of DNA
   b. To replace nitrogenous bases in DNA
   c. To cut DNA at specific sites
   d. To join complementary DNA strands

24. Why do DNA fragments migrate down an electrophoresis gel?
   a. The phosphate group on DNA is negatively charged
   b. The phosphate group on DNA has a positive charge
   c. DNA does not move in response to electrical currents
   d. All of the above
25. Based on the above diagram, which of the following conclusions can be made about **band 1** as compared to **band 2**?
   a. more information is needed to make a conclusion.
   b. band 2 must be longer than band 1
   c. band 1 must be longer than band 2
   d. band 1 and band 2 are the same length, they are samples from different individuals.

26. What is the primary difference between DNA gel electrophoresis and running SDS-PAGE?
   a. SDS-PAGE is for protein analysis
   b. SDS-PAGE is the same thing as gel electrophoresis
   c. SDS-PAGE does not separate molecules based on size
   d. SDS-PAGE is a more sophisticated technology.

27. Butterflies and caterpillars have the same genome; the main reason they look physically different is
   a. gene mutation
   b. different environmental conditions
   c. different proteins
   d. adaptation

28. What is one way to identify an unknown protein?
   a. SDS PAGE separation, then peptide mass finger printing
   b. Edman sequencing
   c. hydrolysis to amino acids
   d. PCR the protein

29. Which of the following are important when studying emerging pathogens?
   a. human behavior
   b. evolution of pathogens
   c. environmental changes
   d. all are important

30. Proteins are composed of
   a. amino acids
   b. nucleotides
   c. fatty acids
   d. simple sugars
MULTIPLE CHOICE

1. ANS: D  PTS: 1  DIF: 1  OBJ: 13-1.3  STA: SC.H.3.4.2
2. ANS: D  PTS: 1  DIF: 1  OBJ: 13-1.3  STA: SC.H.3.4.2
3. ANS: D  PTS: 1  DIF: 1  OBJ: 13-3.2  STA: SC.H.3.4.6
4. ANS: C  PTS: 1  DIF: 1  OBJ: 18-1.1  STA: SC.G.1.4.1
5. ANS: C  PTS: 1  DIF: 1  OBJ: 23-1.1  STA: SC.G.1.4.1
6. ANS: D  PTS: 1  DIF: 1  OBJ: 23-1.3  STA: SC.G.1.4.1
7. ANS: A  PTS: 1  DIF: 1  OBJ: 23-1.1  STA: SC.G.1.4.1
8. ANS: D  PTS: 1  DIF: 1  OBJ: 23-2.1  STA: SC.G.1.4.1
9. ANS: C  PTS: 1  DIF: 1  OBJ: 3-3.1  STA: SC.G.1.4.1
10. ANS: C  PTS: 1  DIF: 1  OBJ: 23-3.5  STA: SC.H.3.4.6
11. ANS: D  PTS: 1  DIF: 1  OBJ: 23-3.5  STA: SC.H.3.4.6
12. ANS: A  PTS: 1  DIF: 2  OBJ: 23-3.4  STA: SC.H.3.4.3
13. ANS: C  PTS: 1  DIF: 2  OBJ: 20-1.3  STA: SC.G.1.4.1
19. ANS: C  PTS: 1
20. ANS: B  PTS: 1
21. ANS: A  PTS: 1
22. ANS: B  PTS: 1
23. ANS: C  PTS: 1
24. ANS: A  PTS: 1
25. ANS: B  PTS: 1
26. ANS: A  PTS: 1
27. ANS: C  PTS: 1
28. ANS: A  PTS: 1
29. ANS: D  PTS: 1
30. ANS: A  PTS: 1