Antibiotic Resistance Unit

Lesson 1. Exploration of MRSA and other Antibiotic Resistant Cases

45-90 min (Depending on length of Frontline Video.)

Goals for the lesson

1. Students develop a basic awareness of the problem of antibiotic resistance.
2. Students develop an interest in exploring the underlying science of antibiotic resistance.
3. Provide a context for students to learn and apply how natural selection occurs in populations.
4. Provide a context for students to review and apply the following scientific concepts:
    a. Bacterial cell structure
    b. Protein synthesis
    c. Effects of gene mutations on proteins.

Instructional Sequence	Materials
Instructor presents guiding questions for the unit: 1. How and why do antibiotics become useless? 2. How can what we know about antibiotics be applied to other biological issues?	Guiding Questions and Skills Objectives Handouts
Class watches the first 9 Minutes of the Frontline video "Hunting the Nightmare Bacteria." The segment introduces the issue with MRSA and antibiotic resistant bacteria through the story of a little girl who dies from a pan-resistant infection. http://www.pbs.org/wgbh/pages/frontline/hunting-the-nightmare-bacteria/ An alternative (newer) video to generate interest could be the Frontline video "The Problem with Antibiotics." This segment investigates the growing issue of antibiotic resistance through two stories: the use of antibiotics in agriculture and the case of a resistant infection in the NIH. http://www.pbs.org/wgbh/pages/frontline/trouble-with-antibiotics/	Computer Projector with speakers
Introduce need to inquire into the purpose and reliability of the source. Quickly discuss the purpose and reliability of the Frontline segment.	Knowing Your Sources Handout
Students work in small groups with each person accessing a different text. The texts provide different information for a series of questions about bacteria, antibiotics, and MRSA. Students answer questions using their assigned source. Additionally, students complete a brief evaluation of each resource using their "Knowing Your Sources" handout. 1. Case text (CT)-Personal account of dealing with MRSA, *Personal Blog*: http://tutusandtantrums.blogspot.com/2012/02/my-experience-with-mrsa.html 2. CT-Personal account of dealing with MRSA, *Daily Strength Support Group*: http://www.dailystrength.org/c/Methicillin_Resistant_Staphylococcus_Aureus/forum/7578667-my-experience-ca-mrsa 3. CT-Popular media account with an embedded case, *USA Today article*: http://www.usatoday.com/story/news/nation/2013/12/16/mrsa-infection-community-schools-victims-doctors/3991833/	MRSA Case Exploration Handout

4. CT-Medical website pictures and descriptions, *MedicineNet slideshow*: http://www.medicinenet.com/mrsa_picture_slideshow/article.htm
5. Optional texts for use after individuals complete their text or if there are more than 4 students in a group
   a. CDC MRSA fact sheet: http://www.cdc.gov/mrsa/community/
   b. MRSA website-multiple personal stories: http://www.mrsaresources.com/mrsa-education/personal-mrsa-stories/
 	
Once students investigate their individual sources, they share their results, filling in questions they weren't able to answer from just one source.	

Conclude this initial investigation and exploration with a whole-class discussion. This discussion may help address additional questions students may have. Some questions to begin the discussion include: 1. Why is the issue of antibiotic resistance important to us? 2. Does anyone have personal stories about antibiotic resistant infections or MRSA? 3. How reliable were your sources? How did you make these conclusions? 4. What additional questions do you have about antibiotic resistance? (Class might want to write these questions down for reference as unit develops.)	

Formative Assessment

Instructor will gain an understanding of what students do / don't know about MRSA, antibiotic resistance, and natural selection through the whole class discussion.

NOTE: At this point, do not use the words natural selection or evolution. The goal is for students to build a conceptual understanding without using terminology that could create bias.

Antibiotic Resistance Unit

Lesson 2. Bacteria Evolution Exploration—Part 1

90 min

Goals for the lesson

1. Using proper sterile technique, students engage in Day 1 of a microbiology lab with *Bacillus megaterium* to develop an understanding of the following scientific concepts:
    a. How antibiotics generally limit bacterial survival and growth.
    b. How streptomycin, specifically, targets bacterial ribosomes to kill bacteria.
    c. How gene mutations in *B. megaterium* incur resistance to streptomycin.
        i. Efflux pumps
        ii. Ribosome shape
2. Students predict Day 3 and Day 5 results for *B. megaterium* Lab using four different antibiotic resistance models to develop an understanding of natural selection.

Lab Materials for each Lab Group
1 Culture tube with *B. megaterium*
Pipet and pipet tips
1 LB agar plate
1 LB agar plate with Streptomycin
Sterile glass beads for spreading
Parafilm
1 Culture tube containing 3 ml of LB media
Covered container with bleach
Sharpie for labeling.

Class Lab Materials
Incubator set to 28^{o}C
Test tube racks
Shaker—*B. megaterium* must be gently shaken for oxygen

Teacher Preparation Prior to Day 1 of Lab
See *Bacillus megaterium* Lab Preparation

Instructional Sequence	Materials
Quickly review what students learned about MRSA and antibiotic resistance in Lesson 1. Instructor explains that we will use a bacterial lab and models to develop a scientific explanation of how and why antibiotics become useless.	Refer back to materials from Lesson 1.
Bacillus megaterium Lab—Contact ReSTEM (ReSTEM@missouri.edu) for details on the laboratory protocol.	*B. Megaterium* Lab Protocol handout Lab materials listed above
Students are each given an "Antibiotic Resistance Models" handout and a "Bacteria Plates Predictions" handout. Instructor explains that we are going to look at four scientific models that	Antibiotic Resistance Models Handout Bacteria Plate

might explain how and why antibiotics become useless. Today, we are going to use these models to make predictions about what might happen in our lab. As time goes on, we will hopefully be able to pick a model that best explains why and how antibiotics become useless. As a class, make sense of Model 1: Initial variation only. Discuss what the model is explaining. Then, fill out the predictions sheet based on this model. Once class has a good understanding of how to use the models to make predictions, students should work with their lab groups (staying as a group of 4 or pairing off within the group) to make predictions about lab results based upon the remaining three models.	Predictions Handout SMARTBoard and projector with Models and Prediction Sheets.
Closure: Instructor facilitates a whole-class discussion so students can share their predictions and reasoning with each other.	SMARTBoard and projector with Models and Prediction Sheets.

<u>Formative Assessment</u>

While students work on the models in small groups, the instructor should assess student thinking and misconceptions by listening to their conversations. Thinking and misconceptions can be further detected in the whole group discussion.

Antibiotic Resistance Unit

Lesson 3. Bacteria Evolution Exploration—Part 2

90 min

Goals for the lesson

1. Using proper sterile technique, students engage in Day 3 of a microbiology lab with *Bacillus megaterium* to develop an understanding of the following scientific concepts:
   a. How antibiotics generally limit bacterial survival and growth.
   b. How streptomycin, specifically, targets bacterial ribosomes to kill bacteria.
   c. How gene mutations in *B. megaterium* incur resistance to streptomycin.
      i. Efflux pumps
      ii. Ribosome shape
2. Students determine how Day 3 data from *B. megaterium* Lab provides evidence for or against the four different antibiotic resistance models to develop an understanding of natural selection.
3. Students review / learn the basic structure and function of major bacterial cell parts.

Lab Materials for each Lab Group

3 ml cell culture of *B. megaterium* that has been growing since the previous class period
Pipet and sterile pipet tips
1 LB agar plate
1 LB agar plates with Streptomycin
Sterile glass beads for spreading
Parafilm
Container of bleach
Sharpie for labeling

Class Lab Materials

Incubator set to 28^{o}C
Test tube racks
Shaker—*B. megaterium* must be gently shaken for oxygen

Instructional Sequence	Materials
Quickly review what students did in the lab on Day 1 and importance of certain protocol ▪	*B. Megaterium* Lab Protocol handout
Bacillus megaterium Lab—Contact ReSTEM (ReSTEM@missouri.edu) for details on the laboratory protocol.	*B. Megaterium* Lab Protocol handout Lab materials listed above Whiteboard or SMARTBoard for class data collection
In their lab groups, students determine if the Day 3 Data (from their group and the class) provides evidence for or against the four models proposed the previous class.	Antibiotic Resistance Models Handout Bacteria Plate

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Questions students should consider:

Is the group data consistent with the class data? What might these similarities or differences tell them?
Does the group data and/or class data match any of their predictions?
What is the purpose of the LB Plate? Would we expect there to be growth? Why or why not?
If there is growth on the LB / Strep Plate, what might be inferred?
Is the amount of growth on the LB / Strep Plate the same as the LB Plate? What might these similarities or differences suggest?
Based upon the data, which model(s) are or are not supported by today's evidence?

Possible products for students:

Students might create white board that shows their thinking with the following components.

Claim 1: Which models are supported?
Evidence: Students might include pictures and a data table.
Reasoning: This is the students' analysis and synthesis of the evidence that supports the claim.
Claim 2: Which models are not supported?
Evidence that refutes these models
Reasoning: This is the students' analysis and synthesis of the evidence that refutes specific model(s).
Conclusion: Final statement that pulls evidence and reasoning together.

Students might record the thinking listed above on a worksheet or in their notebook.

Instructor leads a full class discussion about conclusions we can draw up to this point. If students recorded their conclusions on whiteboards, they might do a round robin to analyze each other's boards for similarities and differences before the whole-class discussion. If students recorded thinking on a worksheet or in a notebook, the instructor might shuffle the groups so they can share their thinking.
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<td>
Predictions Handout
SMARTBoard and projector with Models and Prediction Sheets.
Notebook, whiteboards, or Day 3 Conclusions Handout
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Bacteria Study Guide

Using a variety of resources, students complete the study guide individually or in pairs to learn or review basic structure and function of major bacterial cell parts.
If this is not finished in class, student can complete as homework.

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<td>
Bacteria Study Guide Handout
Class textbooks or on-line resources
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</table>

<u>Formative Assessments</u>

1. During the review about the previous day, the instructor can ask students questions about what students did in the lab and why those steps are important. The instructor might also ask questions about the reasoning behind the students' predictions for each antibiotic resistance model.
2. Instructor should carefully observe the conclusions students make about the antibiotic resistance models, both while students work and during the class discussion.

Antibiotic Resistance Unit

Lesson 4. Bacteria Evolution Exploration—Part 3

90 min

Goals for the lesson

1. Using proper sterile technique, students engage in Day 5 of a microbiology lab with *Bacillus megaterium* to develop an understanding of the following scientific concepts:
    a. How antibiotics generally limit bacterial survival and growth.
    b. How streptomycin, specifically, targets bacterial ribosomes to kill bacteria.
    c. How gene mutations in *B. megaterium* incur resistance to streptomycin.
        i. Efflux pumps
        ii. Ribosome shape
2. Students determine how Day 3 data from *B. megaterium* Lab provides evidence for or against the four different antibiotic resistance models to develop an understanding of natural selection.
3. Students review / learn the basic structure and function of major bacterial cell parts.

Lab Materials for each Lab Group
Day 3 Plates

Instructional Sequence	Materials
Quickly review what students did in the lab on Day 3, the importance of certain protocol, and the conclusions students drew from Day 3 Data.	*B. Megaterium* Lab Protocol handout Antibiotic Resistance Models Handout Student Notes about Day 3 Conclusions (Either in notebooks, on whiteboards, or on a worksheet.)
Bacillus megaterium Lab—Contact ReSTEM (ReSTEM@missouri.edu) for details on the laboratory protocol.	*B. Megaterium* Lab Protocol handout Lab materials listed above Whiteboard or SMARTBoard for class data collection
In their lab groups, students determine if the combined Day 3 and Day 5 data (from their group and the class) provides evidence for or against the four models proposed the previous class. • Questions students should consider: o Is the group data consistent with the class data? What might	Antibiotic Resistance Models Handout Bacteria Plate Predictions Handout SMARTBoard and

these similarities or differences tell them?
  ○ Does the group data and/or class data match any of their predictions?
  ○ If there is growth on the LB / Strep Plate, what might be inferred?
  ○ Is the amount of growth on the Day 5 LB / Strep Plate the same as the Day 3 LB / Strep Plate? What might be inferred by this information?
  ○ Based upon the data, which model(s) are or are not supported by today's evidence?
• Possible products for students:
  ○ Students might create white board that shows their thinking with the following components.
    ▪ Claim 1: Which models are supported?
    ▪ Evidence: Students might include pictures and a data table.
    ▪ Reasoning: This is the students' analysis and synthesis of the evidence that supports the claim.
    ▪ Claim 2: Which models are not supported?
    ▪ Evidence that refutes these models
    ▪ Reasoning: This is the students' analysis and synthesis of the evidence that refutes specific model(s).
    ▪ Conclusion: Final statement that pulls evidence and reasoning together.
  ○ Students might record the thinking listed above on a worksheet or in their notebook.
 	
Instructor leads a full class discussion about conclusions we can draw up to this point. If students recorded their conclusions on whiteboards, they might do a round robin to analyze each other's boards for similarities and differences before the whole-class discussion. If students recorded thinking on a worksheet or in a notebook, the instructor might shuffle the groups so they can share their thinking. Discussion Questions / Topics include:
• All questions listed above for students to consider.
• Is the data consistent from group to group? Why or why not? (The topic of sampling error might come up at this point.)
• Our original question was, "How and why do antibiotics become useless?" At this point, how would you answer that question?
• What questions do you still have?
	projector with Models and Prediction Sheets.
	
	Notebook, whiteboards, or Day 3 Conclusions Handout

Class Notes about Antibiotics, Bacterial Structure, and Antibiotic Resistance—Instructor transitions students to class notes to clarify questions and develop understanding about the following information: • What antibiotics are and how they generally limit bacterial growth and/or survival. • Bacteria structure. • Specifically, how streptomycin targets bacterial ribosomes to limit survival. • Two types of gene mutations on the *B. megaterium* chromosome that allow for resistance to streptomycin.	Antibiotic Resistance Notes PowerPoint. Student notebooks (or handout for notetaking) Bacteria Study Guide Handout
Exit Slip—Students should individually answer the following prompt. They	Notebook Paper

may use all materials, but should record their own thinking for the instructor. • Based upon our findings in the *B. megaterium* Lab, how and why do antibiotics become useless?	

Formative Assessments

1. Instructor should carefully observe the conclusions students make about the antibiotic resistance models, both while students work and during the class discussion.
2. Exit Slip—instructor should read the exit slips before the next class. Instructor might:
    a. Correct misunderstandings directly on students' slips.
    b. Note misconceptions to address with the whole class.
    c. Give feedback for description, analysis and communication.
    d. ?

Antibiotic Resistance Unit

Lesson 5. Bacteria Evolution Review

45 min

Goals for the lesson

Students should review to build a deeper understanding of the following concepts:

1. How antibiotics generally limit bacterial survival and growth.
2. The basic structure and function of major bacterial cell parts.
3. How streptomycin, specifically, targets bacterial ribosomes to kill bacteria.
4. How gene mutations in *B. megaterium* incur resistance to streptomycin.
    a. Efflux pumps
    b. Ribosome shape
5. How *B. megaterium* Lab provides evidence for antibiotic resistance models explaining natural selection in bacteria. (Note: The words Natural Selection are still not used.)

<table>
<tr><th>Instructional Sequence</th><th>Materials</th></tr>
<tr><td>Quick review of Bacterial Structure
Students individually identify and explain the major function of important bacterial structures
Quick class review of which Antibiotic Resistance Model(s) were supported and why.

Partner review of how antibiotics attack bacteria and how bacteria may be resistant.
Students turn to a partner.
One partner explains how streptomycin kills bacteria. Important words include:
Ribosomes
Translation
Proteins
The other partner then explains how bacteria may be resistant to antibiotics (specifically how B. megaterium may be resistant). Important concepts include:
Mutation on chromosomal DNA → Transcription / Translation → Proteins in ribosomes that are different shape and therefore different shape ribosomes
Mutation on chromosomal DNA → increased Transcription / Translation of Efflux pumps → pump out antibiotic</td><td>Bacteria Structure Review (This can be posted on projector or copies can be made for each student.)</td></tr>
<tr><td>Students work in groups of 2-4 to develop their own models that show how B. megaterium are killed by streptomycin and how they may be resistant.
Show the students the Bacterial Models Across the Levels on a projector
On whiteboards, students create models that explain what happens at the molecular, cellular and population levels when bacteria do not have resistance and when they do have resistance.
Groups view each other's boards. Students may present, jigsaw, do a</td><td>Bacterial Models Across the Levels Handout

Student whiteboards and markers</td></tr>
</table>

round robin for this sharing.
• Students return to original boards and fix / add to their models if necessary.
• Follow-up may include:
  o Individuals return to seats to make their own models.
  o Whole class discussion of the models to emphasize strengths and address misconceptions.
  o Students take pictures of their boards for further reference / studying.	

Assign *B. megaterium* Lab Paper • Explain criteria for lab papers—which will be written individually. • Allow students time to ask for clarification on the labs, models, and paper criteria.	*B. megaterium* Lab Write-Up Hand out and Rubric

<u>Formative Assessments</u>

1. Review of bacteria structure, bacteria evolution models, and mechanisms for antibiotic resistance.
2. Instructor should carefully observe the conclusions students make about Bacterial Models across the Biological Levels of Organization, both while students work in groups and during the class discussion.

<u>Summative Assessment</u>

B. megaterium Lab Paper—Due Lesson 8

Antibiotic Resistance Unit

Lesson 6. Netlogo Bacteria Modeling

45 min

Goals for the lesson
Students will manipulate variables in a Netlogo bacteria simulation to construct an understanding of how natural selection occurs with different traits in different populations. Terms that are explicitly introduced include:

1. Variation
2. Population
3. Reproduction, Inheritance, and Over-reproduction
4. Environmental Pressure, Environmental Change, and Limited Resources
5. Adaptation
6. Fitness

Instructional Sequence	Materials
Check in to see if there are any questions about the *B. megaterium* Lab Paper	
Netlogo Bacteria Modeling • Explain that we are going to look at how change might occur in other populations. Instead of looking for antibiotic resistance in bacteria, we are going to run a simulation that looks at bacteria with different numbers of flagella. We are going to determine which bacteria survive best in different environments. • Model how to access the Netlogo program and walk students through some of the parameters as well as how to change different settings. • Instruct students to walk thoughtfully through the simulation using the handout as a guide. Students should pay particular attention to new terms and answer each question as they move through the simulation. • Students can work individually or in partners, based upon the number of computers available.	Netlogo Bacteria Modeling Handout Netlogo Bacteria Modeling Program loaded on 15-30 computers / laptops

Whole Class Discussion about Netlogo Bacteria Modeling to highlight the main points of the activity.
 	
Possible questions to guide the discussion include:
• How would you define the following terms?
  ○ Variation
  ○ Population
  ○ Environmental Pressure
  ○ Adaptation
  ○ Fitness
• What is binary fission? How is it similar to mitosis? How is it different?
• What role did bacterial reproduction play in the simulation?
• Did a certain bacteria always have the advantage, i.e., was it always best
	Netlogo Bacteria Modeling Handout
	
	Front computer and projector?

to have the most flagella? Why or why not? Walk through discussion questions at the end of the packet. Discuss the challenge problem. Did anyone get to it? Succeed? Perhaps they could model on the front computer how they succeeded? Explain to students that this activity will act as notes for them. They are responsible for understanding the concepts and terms they have explored.	

<u>Formative Assessments</u>

1. Listen while students work through the Netlogo Bacteria Model
2. Whole-class discussion
3. Possible Exit Slip / Free write—Compare and contrast this simulation with what we have learned about antibiotic resistance through the *B. megaterium* Lab

<u>Summative Assessment</u>

B. megaterium Lab Paper—Due Lesson 8

Antibiotic Resistance Unit

Lesson 7. Mountain Sheep Model

45 min

Goals for the lesson

Students will use data to evaluate models explaining a change in mountain sheep horn size to construct an understanding of how natural selection occurs in a sexually reproducing population. Terms that are reviewed include:

1. Variation
2. Population
3. Reproduction, Inheritance, and Over-reproduction
4. Environmental Pressure, Environmental Change, and Limited Resources
5. Adaptation
6. Fitness

<table>
<tr><td>Instructional Sequence</td><td>Materials</td></tr>
<tr><td>Quick partner review of the terms and concepts from Lesson 6. On a piece of paper or on a printed piece of paper, students individually define the following terms:
• Variation
• Population
• Inheritance
• Over-reproduction
• Environmental pressure
• Adaptation
• Fitness
Then students turn to each other to compare and fix definitions. Then students explain what happened to the bacterial populations in the Netlogo simulation in different environments using the terminology they've defined.</td><td>Netlogo Bacteria Review</td></tr>
<tr><td>Introduce the next activity. We are going to see how populations change when the population is a sexually reproducing population. Lead students through a lesson which features modeling of evolutionary changes to mountain sheep populations. Contact ReSTEM for these materials (restem@missouri.edu).

End the lesson with a whole class discussion lead by the following questions:
• Which model best explains how and why the average size of male horns in the mountain sheep population has decreased over time?
• Are there any changes we could make to the best model to make it even better?
• How is this model similar to our antibiotic resistance model? Are there any differences?
• How might the Netlogo Bacterial Model and the Mountain Sheep Model help you with your B. megaterium Lab Paper? What concepts and terms might you use when describing and analyzing what happened in the lab?</td><td></td></tr>
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Formative Assessments

1. Listen while students work through the Mountain Sheep Evidence and Models
2. Whole-class discussion

Summative Assessment

B. megaterium Lab Paper—Due Lesson 8

Antibiotic Resistance Unit

Lesson 8. General Model for Natural Selection

45 min

Goals for the lesson

Students will develop and explain a conceptual model of natural selection that accounts for a) genetic variation associated with particular traits, b) selective pressure that leads to differential reproductive success linked to these traits, and c) changes in trait frequencies within the population.

Instructional Sequence	Materials
Turn in the *B. megaterium* Lab Paper	Extra *B. megaterium* Lab Paper Rubrics
General Model of Natural Selection—students will use what they learned with the previous three models to create their own model of natural selection. This is the first time the words "natural selection" are used in the classroom. Use the General Natural Selection Lesson PowerPoint to lead students through the process of creating their own Natural Selection Models.	General Natural Selection Handout General Natural Selection Lesson PowerPoint Student Whiteboards

Formative Assessments

Listen while students make Natural Selection Models—take pictures to post for students.

Summative Assessment

B. megaterium Lab Paper

Antibiotic Resistance Unit

Lesson 9. Culminating Activity

135-180 min

<u>Goals for the lesson</u>
Students will:

1. Explain a conceptual model of natural selection that accounts for a) genetic variation associated with particular traits, b) selective pressure that leads to differential reproductive success linked to these traits, and c) changes in trait frequencies within the population.

2. Use the model (1) as a basis for reasoning about novel problem situations.

3. Describe a representation of a cellular mechanism that confers bacterial resistance to antibiotics. Students will review mutations that occur on bacterial chromosomes and build an understanding of lateral gene transfer.

4. Demonstrate socio-scientific reasoning in response to complex SSI. Specifically, students will create a response to the complex SSI of antibiotic resistance.
    a. Identify and discuss sources of issue complexity.
    b. Identify areas of uncertainty and ask related questions.
    c. Analyze the issue from multiple perspectives.
    d. Identify and discuss ways in which scientific evidence can inform issue resolution as well as limits on the use of scientific evidence.

Instructional Sequence	Materials
Review natural selection by applying the conceptual model to a new population. • Lead whole class through the Deer Mouse PowerPoint. • Students individually describe (write in notebooks) how the two deer mouse populations have different color fur using the tenets of natural selection. • Students share their answers with a partner and make corrections as needed. • Share a couple answers as a class and evaluate for accuracy. •	Deer Mouse PowerPoint Deer Mouse Review Handout Notebooks or scrap paper
Return to the issue of antibiotic resistance by playing the "Snowball Activity." • Again, students write a description, based upon our model of natural selection of how antibiotic resistance occurs on a piece of scrap paper. • Students ball their answers up and throw across the room. • Pick up a "snowball" and make any necessary corrections to the description. • Students throw their "snowballs" one more time. • Once students pick up their second snowball, form a circle. Share the answers as a class and evaluate them for accuracy. Note: all answers are anonymous. Students should then come back to their desks. After reviewing the two	Scrap paper Lateral Gene Transfer PowerPoint Student notebooks "Germ Warfare" Article "Germ Warfare" Handout

chromosomal mutations we learned about in *B. megaterium*, students should take notes on lateral gene transfer. This is yet another piece of the puzzle that makes antibiotic resistance so complex because it can occur between species. Optional Assignment—students may be required or have the option of reading "Germ Warfare." This article summarizes and adds to student learning that has occurred throughout the unit. It may be an additional resource for students as they prepare for the culminating activity.	
Introduce Culminating Activity Transition students to this activity by explaining that we have learned about the science behind antibiotic resistance, we need to return to and further investigate the complexity of this socio-scientific issue. There are many social perspectives that come into play. In order to complete this activity, students will work in small groups to do further research. Ultimately, individual students will create their own products in the form of Policy Recommendations to a governmental level of their choice. The process and basic product is explained on the student handout, as well as below: 1. Students are assigned to groups of ~4. 2. Everyone in the group should review resources that highlight epidemiological data related to antibiotic resistant bacteria. Then individual students will review a couple resources that present information and perspectives about a particular aspect of the AB-resistance issue: a. Parental and doctor concerns b. Use of antibiotics in international settings c. Government intervention in healthcare issues (like AB-resistance) d. Drug company perspectives on new antibiotics. 3. Each group member is responsible for reviewing information pertinent to her/his assigned perspective AND for sharing the basic ideas about this perspective with her/his group. Each student should be prepared to share information corresponding to the discussion questions (shown in #4). 4. Group discussion. Students should present the information they find relative to each aspect. a. What sources did you access? What is the quality of these sources? b. Describe the aspect on AB-resistance you explored. c. Who is involved with this aspect? What are their likely interests? d. What would the stakeholders represented in your readings recommend in terms of policy for AB-resistance? After presenting information about the various aspects, the groups should brainstorm possible courses of action that could serve as the basis for a policy recommendation. 5. Individual students select a governmental level for policy enactment	Policy Development & Analysis Handout Description of Assigned Perspectives Handout Computers or laptops

and create a policy recommendation.	

Formative Assessments

Deer Mouse Review

Antibiotic Resistance “Snowball” Review

Summative Assessment

Antibiotic Resistance Policy Recommendations

Antibiotic Resistance Unit

Lesson 10. Peer Evaluation of Policy Recommendations

45 minutes

Goals for the lesson

Students will:

1. Explain a conceptual model of natural selection that accounts for a) genetic variation associated with particular traits, b) selective pressure that leads to differential reproductive success linked to these traits, and c) changes in trait frequencies within the population.

2. Use the model (1) as a basis for reasoning about novel problem situations.

3. Describe a representation of a cellular mechanism that confers bacterial resistance to antibiotics. Students will review mutations that occur on bacterial chromosomes and build an understanding of lateral gene transfer.

4. Demonstrate socio-scientific reasoning in response to complex SSI. Specifically, students will create a response to the complex SSI of antibiotic resistance.
    a. Identify and discuss sources of issue complexity.
    b. Identify areas of uncertainty and ask related questions.
    c. Analyze the issue from multiple perspectives.
    d. Identify and discuss ways in which scientific evidence can inform issue resolution as well as limits on the use of scientific evidence.

<table>
<tr><th>Instructional Sequence</th><th>Materials</th></tr>
<tr><td>Present, evaluate, and help revise policy recommendations.
• Break student up into new groups of 4.
• These groups should complete the following tasks:
o Present their policy recommendations to each other by summarizing the major portions of their recommendations. These presentations are informal. It should give the students the opportunity to talk in front of small groups, hear additional ideas, and receive feedback.
o After each student presents, their audience members should evaluate the policy based upon depth of analysis, etc. They should fill out a rubric for each student and add comments.
o Once all students have presented, students should provide each other general feedback based upon their evaluations. Things to comment on would be:
▪ Depth of description when it comes to pros, cons, and multiple perspectives.
▪ Depth of analysis showing the complexity of the issue. Particularly, do students justify how pros outweigh the cons, how some perspectives outweigh other perspectives, etc?
▪ Does the policy thoroughly describe and apply the science behind antibiotic resistance?
o Peer Edit ONE policy recommendation in the group.</td>
<td>Policy Recommendations

Policy Recommendation Rubrics</td></tr>
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▪ Students rotate their papers and help with revisions and edits. Each peer evaluator should, make grammatical edits and add comments about what needs to be added or fixed in the policy. • Bring class back as a whole for a quick class discussion. o What observations did they make about the strength of the policy recommendations? o How did they decide which perspectives outweighed other perspectives? What criteria and evidence did they use to justify their stance? o What things do they need to fix before turning in their policy recommendations?	
Closure • For next class, students should make final revisions of their policy recommendations. These recommendations will be turned in at the beginning of the class. • Students should also study for the content test next class. This test will assess their understanding of natural selection in a variety of contexts. It is important to know all terminology and to know how natural selection can cause changes in populations.	

<u>Formative Assessments</u>
Whole class discussion

<u>Summative Assessment</u>
Antibiotic Resistance Policy Recommendations
Content Test