Introduction to the Teacher

Timeline and Discipline	Big Idea and Essential Questions	Lesson Overview	Eliciting and Engaging the Student	Developing the Ideas	Checking for Understanding
Timeline: ~1 day Discipline: Any	BIG IDEA 1: How the case study may be different than what students are used to and what the expectations are. Essential Questions: 1. How does the case study differ from what I (a student) may be used to in the classroom? 2. What will I (a student) be expected to do? 3. How and why do people work in teams?	In these three lessons students are introduced to the case study approach. Lesson 1-1 asks students to discuss how they prefer to learn. Lesson 1-2 is a description of the what the students should expect. Lesson 1-3 is a discussion the challenges, strategies, and benefits of working in teams.	Lesson 1-1: Introduction to learning styles Lesson 1-2: Expectations for the case study Lesson 1-3: Working in teams		Ask the Questions: 1. What concerns do you have about the upcoming case study? What are you excited about? 2. Have you worked in teams before? What was it like?
Timeline: ~1 day Discipline: Science	**Inception** BIG IDEA 2: Antibiotic resistance has a major impact on modern medicine. Essential Questions: 1. What is the impact of antibiotic resistance on	In these lessons, students are introduced to the topic of the case study and become invested in it. Students are polled on antibiotic	Lesson 2-1: Polling the students Lesson 2-2: Inception video		Ask the question: 1. Who does antibiotic resistance impact?

	our society and how we treat infections?	resistance and watch an inception video on a superbug.			
<u>Timeline</u>: ~2 days <u>Discipline</u>: Environmental Studies, Science	**Engagement** <u>BIG IDEA 3</u>: Defining antibiotic resistance <u>Essential Questions</u>: 1. What is antibiotic resistance? 2. Will the resistant bacteria spread through the population? 3. Why do we use antibiotics so frequently?	Through these lessons students become engaged in the topic of antibiotic resistance. Students will discuss the question of if colistin can still be used as a last-resort antibiotic, and will create a class list discussing the engagement question. Each team will pick a solution to antibiotic resistance.		Lesson 3-1: Engagement Question and Antibiotic Resistance Lecture Lesson 3-2: Topic Exploration	Ask the question: 1. List the pros and cons of three different solutions to the resistance of E. coli to colistin.
<u>Timeline</u>: ~1 week <u>Discipline</u>: Science	**Research** <u>BIG IDEA 4</u>: Scientific inquiry skills can be used to address antibiotic resistance <u>Essential Questions</u>:	In these lessons, students collect background information on their topic, write a research question, and collect data	Lesson 4-1: Topic diagram Lesson 4-3: Form a hypothesis Lesson 4-4:	Lesson 4-2: Writing a research question Lesson 4-5: Conducting the research	Discuss with each team whether they have gathered enough information to answer their research question. Do they have the

	1. What is known about this topic? What is not known? 2. How do you write a research question? 3. How should I collect my information? 4. Which sources are reliable and reputable?	and information to answer their research question.	Designing the study		evidence to support their position? Are they missing a piece of information?
<u>Time</u>: ~1-2 days <u>Discipline</u>: Science,	**Create** <u>BIG IDEA 5</u>: Scientific communication can be used to address antibiotic resistance <u>Essential Questions</u>: 1. How do you draw conclusions from research and data? 2. Who would benefit most from hearing your conclusion? 3. How do you articulate your conclusion clearly and scientifically? 4. How could your research impact antibiotic resistance?	In these lessons, students will draw a conclusion based on their research, communicate their conclusion to an audience outside the classroom, and present their team's project to the class.	Lesson 5-1: Drawing a conclusion	Lesson 5-2: Communicating your findings Lesson 5-3: Peer-editing Lesson 5-4: Presenting	Ask the following questions: Compare and contrast yours and your classmates communication pieces. What do you think these communication pieces will accomplish?
<u>Time</u>: ~1 day <u>Discipline</u>: Any	**Reflect** <u>BIG IDEA 6</u>: Reflection is a tool for improving your scientific inquiry	In this lesson students will reflect on their process recognize their	Lesson 6-1: Reflect		N/A

	skills and for identifying the next steps for addressing antibiotic resistance <u>Essential Questions</u>: 1. What have I learned? 2. What have I done well? 3. How can I improve?	strengths, their opportunities for growth, and what they have learned and accomplished.			

Introduction to Teacher

Case studies are a student-driven, situation-based approach to learning science. Students investigate a societal problem through asking questions, researching, drawing conclusions, and communicating their findings. This case study addresses Antibiotic Resistance. Antibiotic resistance refers to the ability for infectious microbes to acquire genes for resistance to antibiotic drugs. Students are introduced to this topic through a report on a strain of E. coli found in the US and resistant to a last resort antibiotic. Later, student teams choose a solution to antibiotic resistance to research further. By the end of the case study each team will have moved the needle forward on antibiotic resistance as it relates to public health.

This high-school level case study is adapted from a college-level science program called the Integrated Concentration in Science (iCons) Program at University of Massachusetts Amherst. Students in this program bring their expertise from a variety of science and engineering majors and work together on interdisciplinary societal problems in the fields of renewable energy and biomedicine. To learn more about the iCons program, you can visit our **website**.

The case study method, which hopes to engage scientific curiosity and inquiry, works in conjunction with lecture style learning in which students focus mainly on basic scientific principles and their significance. The goals of the case study method are focused just as much on the skills students develop from the experience of self-driven learning as they are on the facts they learn. This may be a shift from the students' normal experiences, so it is important to emphasize the value of the learning process before you begin. Then you may proceed through the five steps of the iCons Case Study learning process: inception, engagement, research, create, and reflect.

Inception is the first step in the iCons case study method. The purpose of this step is to introduce the topic of the case study and get the students invested in it. An effective inception material draws attention to a particular time and place, brings relevancy to the societal issue, and leads students into the engagement step.

The **Engagement** step allows students to "buy in" to the case study curriculum before they begin the highly student-driven Research step. The Engagement step is when students become aware of how scientific inquiry will help them address the societal issue. They will gain confidence and motivation to address this societal problem and become curious about the scientific phenomena underlying the societal issue.

The **Research** step requires students to narrow their topic. Teams are challenged to understand one topic completely in order to answer a specific research question and to eventually draw original conclusions. Students have the freedom to conduct an experiment, compile information from other scientists' findings, survey other's understanding and habits, calculate a cost-benefit analysis of a certain object/practice, etc. or a combination of these in order to answer their research question. It is important to give students freedom and to push them to do their best work so that they can exceed their own expectations of what they can accomplish.

In the **Create** step, the students communicate the conclusions they have drawn from their research to an audience outside the classroom and to their peers. This grounds the students' work in reality and reinforces the idea that their work is important, valid, and applicable to a real issue. Students then present their whole research process and communication product to the class.

The **Reflection** step is for students to analyze, critique, and evaluate their process and product, and recognize how they have learned and grown through the case study. It is also a data-collection tool to inform improvements of your case study curriculum design. Students will incorporate feedback from others and draw from their own experiences to answer reflection questions. Reflection questions should cover personal growth, team dynamics, engagement, and societal impact of their research.

Journal Check-in: These optional check-ins are interspersed throughout the case study in places we feel students would benefit from collecting their thoughts and setting goals. They are meant to be 3-5 minute reflection periods during which students respond in journals to prompts related to the previous activity. The purpose of these journal activities is to help students prepare for the reflection step of the case study, process their experiences in this new and possibly uncomfortable learning style, and become self-reflective learners.

The following Next Generation Science Standards can be addressed in this case study:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

*HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
*HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
*HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
*HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

*These standards may be addressed depending on what students choose to investigate for their research and create steps.

During case study days, students work in teams to address the issue of antibiotic resistance through scientific research. Students develop research and collaboration skills throughout the process; therefore, it is not just the final product that can be used as an assessment for learning, personal growth, and team collaboration. Student participation and cooperation are required throughout, and they may need periodic feedback to guide their level of efficiency. This is different from traditional-style curriculum, in which assessment tools like tests and exams are often used to measure individual growth.

In terms of timing, this case study could take a few different forms, depending on the format and schedule of your class. This could be done in a 2-3 week stretch where the case study is the only material being addressed during this time. Another option is for the case study to be interspersed with the regular curriculum two or three days a week for multiple weeks. This is up to your discretion concerning your class structure, student preference and curriculum layout. In addition, depending on the experience and academic level of your class, you may choose to add, edit, or remove activities to this lesson plan to meet the needs of your students. It is our hope that each teacher who uses these case studies makes them their own.

This curriculum was created by Dominique Kiki Carey, Rebecca Howard, Erica Light, Corrine Losch, and Stephanie Purington. We are members of the iCons community at the University of Massachusetts Amherst. This case study was developed based on our experiences teaching case studies in high-school classes. It has been revised to reflect all that we learned through our teaching, and we have incorporated suggestions into the teaching plans. From our experiences, we believe student-centered, case study-based education is an extremely effective and engaging way to learn. We hope to prepare students to be leaders in solving the world's challenges through research and critical thinking.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. National Academies Press.