One Health and Antimicrobial Resistance Module

Part 1: What is One Health?

Applicable Standards:

1. HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity

Learning Goals:

1. Define One Health
2. Identify the three domains of health included in One Health.

Vocabulary:

Asthma - A disease affecting the body's airways, which are the tubes through which animals breathe. Asthma obstructs these airways through swelling, the production of too much mucus or a tightening of the tubes. As a result, the body can expand to breathe in air, but loses the ability to exhale appropriately.

Black Carbon - Particles of carbon that are released when fossil fuels, wood or other carbon-based materials are burned.

Chronic - A condition, such as an illness (or its symptoms, including pain), that lasts for a long time.

Climate Change - Long-term, significant change in the climate of Earth. It can happen naturally or in response to human activities, including the burning of fossil fuels and clearing of forests.

Conservation - The act of preserving or protecting something. The focus of this work can range from art objects to endangered species and other aspects of the natural environment.

Ecology - A branch of biology that deals with the relations of organisms to one another and to their physical surroundings.

Ecosystem - A group of interacting living organisms — including microorganisms, plants and animals — and their physical environment within a particular climate.

Fossil Fuel - Any fuel — such as coal, petroleum (crude oil) or natural gas — that has developed within the Earth over millions of years from the decayed remains of bacteria, plants or animals.

Host - The organism (or environment) in which some other thing resides. Humans may be a temporary host for food-poisoning germs or other infective agents.

Lyme Disease – An illness caused by bacteria transmitted by ticks. It can cause a fever, rash, pain in your joints, and heart problems.

Occupational Health - The branch of medicine dealing with the prevention and treatment of job-related injuries and illnesses.

One Health – An approach to health which recognizes that human, animal, and environmental health are all connected.

Outbreak - The sudden emergence of disease in a population of people or animals.

Pandemic - An outbreak of disease that affects a large proportion of the population across much or most of the world.

Respirator - A device worn over the mouth and nose to prevent the inhalation of dust, smoke, or other harmful substances

Smoke - Plumes of microscopic particles that float in the air. They can be comprised of anything very small. But the best known types are pollutants created by the incomplete burning of oil, wood and other carbon-based materials.

Tick – A small animal related to spiders that suck a host's blood. Often, they can spread infectious diseases.

Vector - An organism, typically a biting insect or tick, that transmits a pathogen, disease, or parasite from one animal or plant to another

Vector-Borne Disease – An infectious disease transmitted by a vector like a mosquito, tick, or flea.

Virus - Tiny infectious particles consisting of genetic material (RNA or DNA) surrounded by protein. Viruses can reproduce only by injecting their genetic material into the cells of living creatures.

Zoonotic disease – A infectious disease that can be transmitted from animals to humans.

Activities:

1. Watch the video "What is One Health" and use infographics from CDC to introduce and define One Health.
2. Have students read the article "Protecting forests may help head off future pandemics". Discuss in small groups or pairs what they think the main points of the article are.
3. Work as a class to complete a Venn Diagram worksheet on one of the examples used in the video or the example from the article.
4. Discuss with students other problems they can think of that might fit under the One Health approach.
5. Introduce the example of One Health in Washington State – Wildfire Smoke
    a. Read Article and have students review health resources independently or in teams
    b. Discuss how wildfires impact the environment and are made worse by climate change.
    c. Discuss similarities and differences between advice and information for animals and humans.
6. Have students work independently to complete a Venn Diagram for the Washington State Example.
7. Review the Venn Diagram together or have them turn it in to be graded.

Resources:

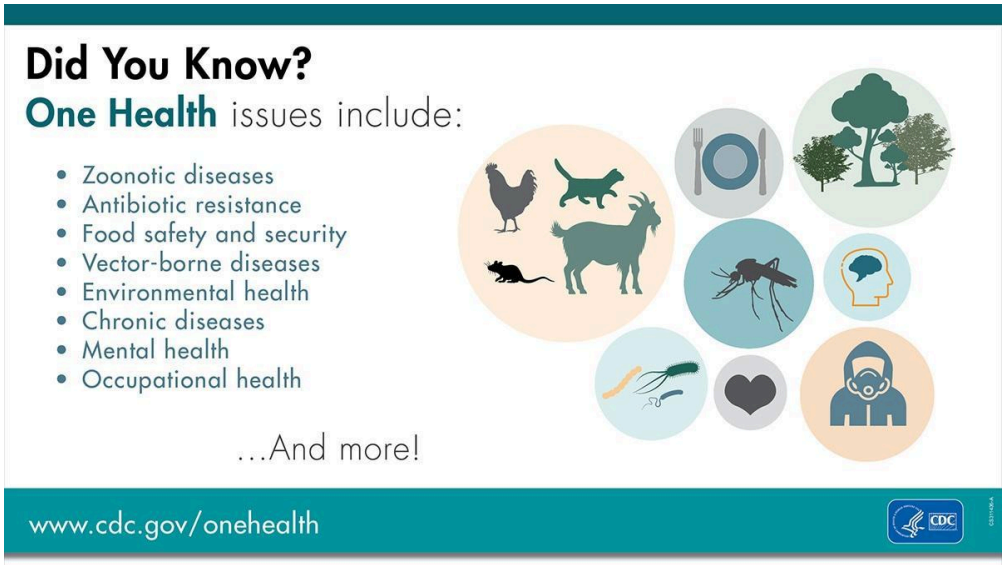
Article: "Protecting forests may help head off future pandemics"
https://www.snexplores.org/article/protecting-forests-bats-habitat-prevent-future-pandemics

Video: "What is One Health" (end at 2:18) https://www.youtube.com/watch?v=S_pWw8AdBMk

Infographics:

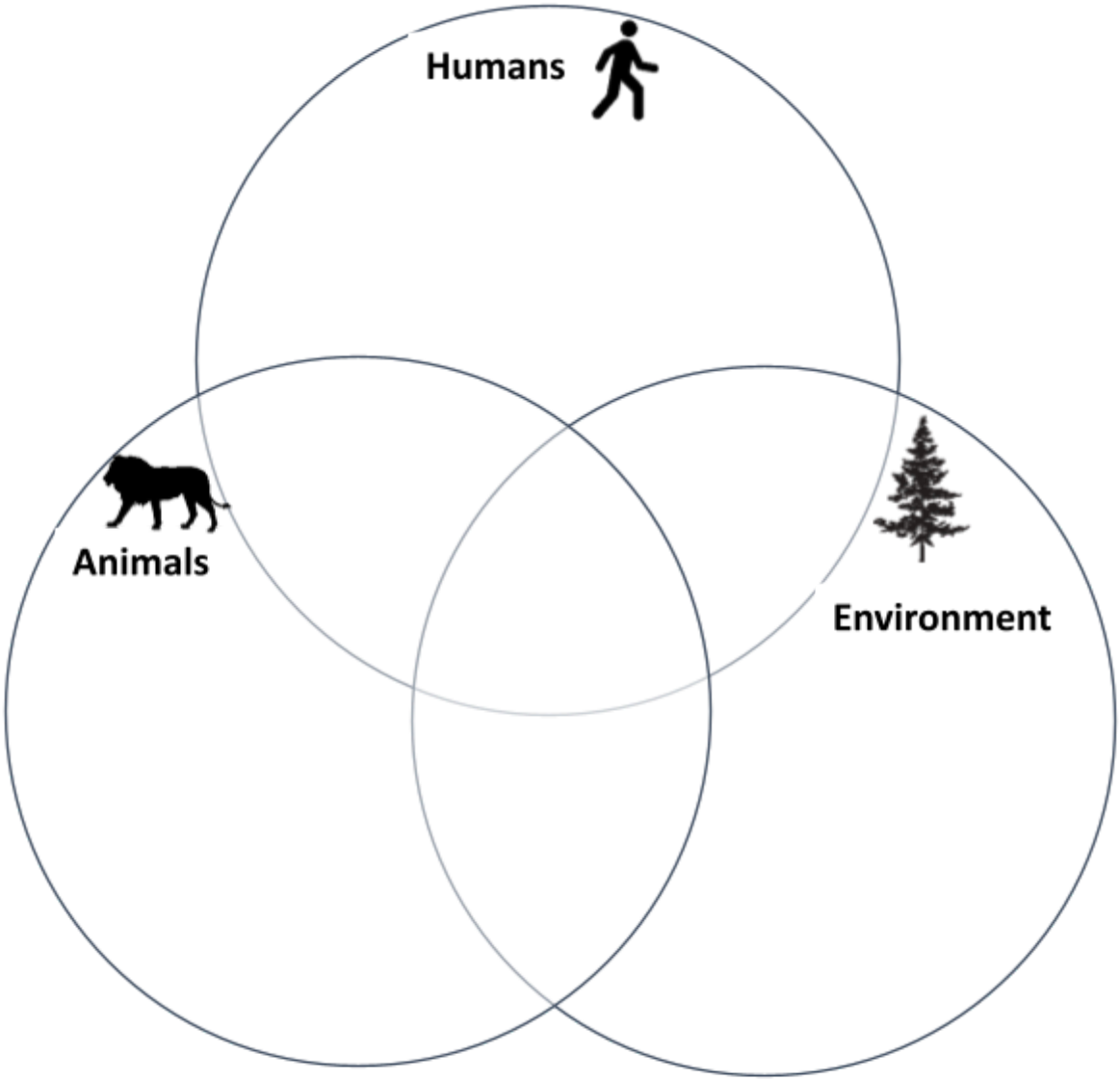
https://www.cdc.gov/onehealth/images/social-media/what-is-one-health-fb.jpg

https://www.cdc.gov/onehealth/images/social-media/one-health-issues-twitter.jpg



Worksheet:

One Health



Example in Washington State: Wildfire Smoke and Health

1. Article about Wildfires and Air Pollution in Washington State: https://www.snexplores.org/article/wildfires-worsen-extreme-air-pollution-us-northwest
2. EPA Handouts about Protecting Animals from Smoke:

   https://www.airnow.gov/sites/default/files/2021-06/protect-your-large-animals-and-livestock-from-wildfire-smoke.pdf

   https://www.airnow.gov/sites/default/files/2021-06/protect-your-pets-from-wildfire-smoke.pdf

3. CDC Information about Wildfires: https://www.cdc.gov/disasters/wildfires/duringfire.html
4. Department of Health Information Sheet:

   https://doh.wa.gov/sites/default/files/legacy/Documents/4300/Smoke_sensitive%20populations%20Everyone_English.pdf?uid=64c14163ef308

5. LNI Information Website: https://lni.wa.gov/safety-health/safety-topics/topics/wildfire-smoke

Resources To Go Deeper:

1. One Health Ted Talk: https://www.youtube.com/watch?v=cZfzP3J2VxY
2. Scientific American Article: https://www.scientificamerican.com/article/leaving-pet-poop-on-the-sidewalk-isnt-only-bad-manners-its-hazardous/
3. Article on Health Impacts of 2020 Wildfires: 10.1029/2020GH000359
4. Scientific Article on Areas Where One Health is Useful: https://www.annualreviews.org/content/journals/10.1146/annurev-publhealth-031912-114426

Part 2: What is antimicrobial resistance and why should we care?

Applicable Standards:

1. HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Learning Goals:

1. Define antimicrobial resistance.
2. Understand that antimicrobial resistance can apply to bacteria, fungi, and other microbes.
3. Discuss the health impacts of antimicrobial resistance in humans.
4. Interpret graphs showing antimicrobial resistance trends.

Vocabulary:

Antimicrobial Resistance - When bacteria, viruses, fungi and parasites no longer respond to antimicrobial medicines. As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become difficult or impossible to treat.

Antibiotic - A bacteria-killing substance, usually prescribed as a medicine (or sometimes as a feed additive to promote the growth of livestock). It does not work against viruses. Sometimes they also inhibit the growth of bacteria instead of killing them

Antifungal – A substance that kills or inhibits the growth of fungi.

Antiparasitic – A substance that kills or inhibits the growth of parasites.

Antiviral – Medications that are used to treat viral infections

Bacteria - Single-celled organisms. These dwell nearly everywhere on Earth, from the bottom of the sea to inside other living organisms (such as plants and animals). Bacteria are one of the three domains of life on Earth.

Fungi - One of a group of single- or multiple-celled organisms that reproduce via spores and feed on living or decaying organic matter. Examples include mold, yeasts and mushrooms.

Germ - Any one-celled microorganism, such as a bacterium or fungal species, or a virus particle. Some germs cause disease. Others can promote the health of more complex organisms, including birds and mammals.

Infection - A disease that can spread from one organism to another. It's usually caused by some type of germ.

Microbe - Short for microorganism.

Antimicrobials – Drugs that are designed to kill microbes.

Microorganisms - A living thing that is too small to see with the unaided eye, including bacteria, some fungi and many other organisms such as amoebas. Most consist of a single cell.

Activities:

1. Watch video to introduce the topic of antimicrobial resistance.
2. Lead whole class discussion:
    a. Have students previously heard about AMR?
    b. Do they know anyone who has had a resistant infection?
    c. What do they think the implications are of AMR? Encourage them to think about animals and the environment as well.
3. Have students read article about AMR related deaths.
    a. Think/Pair/Share about what they learned from article
4. Either in class or as homework have students complete worksheet on trends in AMR over time.

Resources:

1. Video: Antimicrobial resistance (AMR) - What does it mean and why it matters (Stop at 3:00) https://www.youtube.com/watch?v=MENdrA8B0N4
2. Article: “Drug-resistant germs kill some 35,000 Americans each year” https://www.snexplores.org/article/drug-resistant-germs-kill-35000-americans-each-year
3. Worksheet: AMR Trends Over Time

Antimicrobial Resistance Worksheet

1. What are antimicrobial drugs?

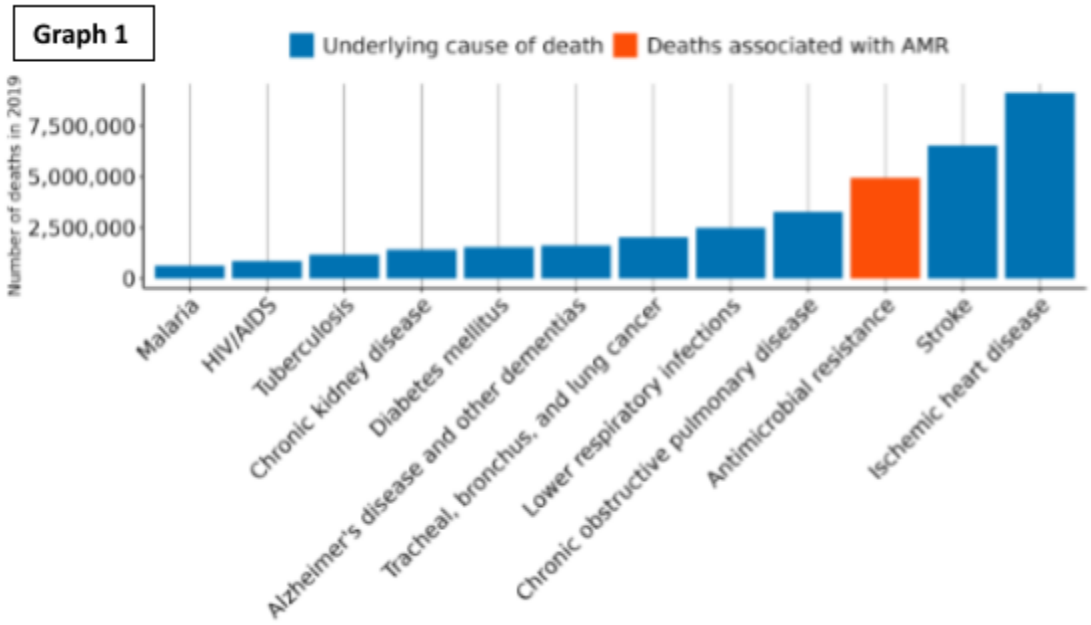
2. Do all antimicrobial drugs work against all microbes?

3. What is antimicrobial resistance?

4. List two facts you learned from reading the article “Drug-resistant germs kill some 35,000 Americans each year”.

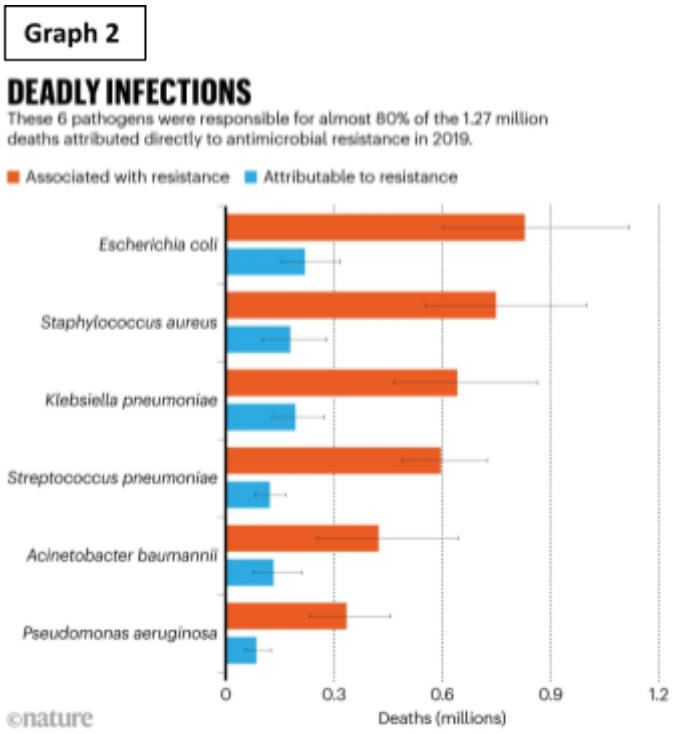
5. What do you think humans could do to prevent antimicrobial resistance?

6. Graph 1 shows the number of deaths for different causes across the globe in 2019. About how many deaths were due to antimicrobial resistance?



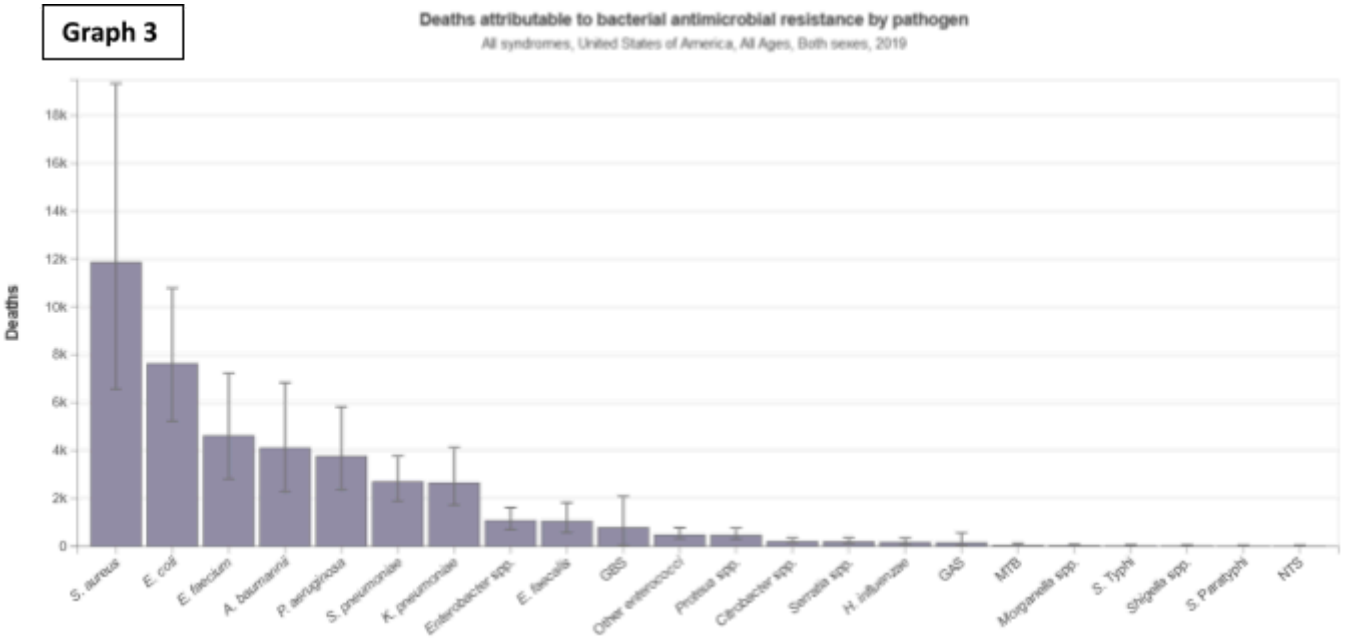
7. Graph 2 shows the number of deaths **globally** that were due to antimicrobial resistance in 2019. For *Acinetobacter baumannii* were more deaths associated with resistance or attributable to resistance? How do you know?

Graph 2



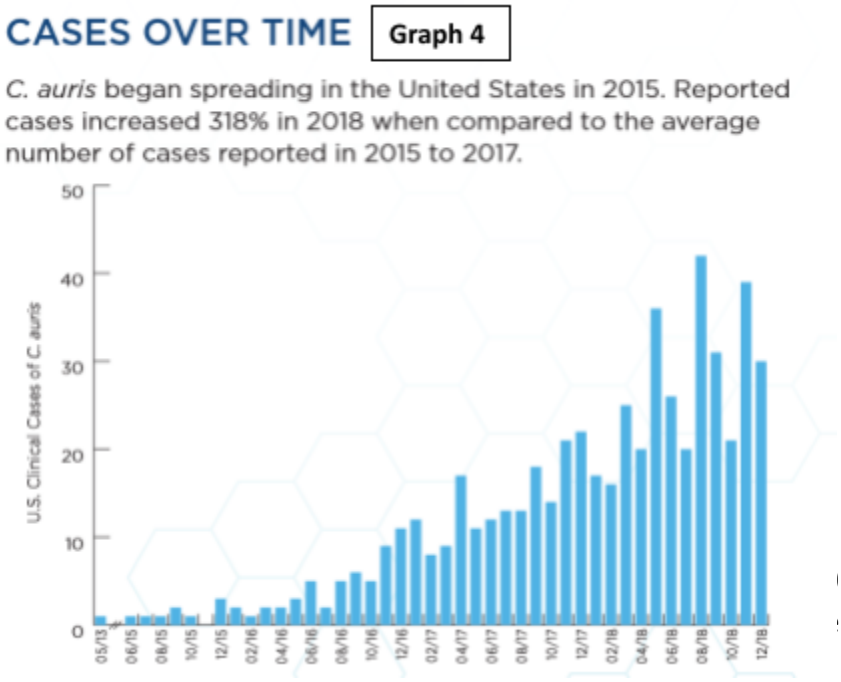
8. Graph 3 shows the number of deaths in the **United States** attributable to antimicrobial resistance in 2019. What pathogen had the most attributable deaths? How many deaths were attributable to *E. coli?* Were more deaths attributable to *P. aeruginosa* or *E. faecais?*

Graph 3



8. Comparing Graph 2 and Graph 3 was the bacteria that had the most attributable deaths globally the same as the one that has the most attributable deaths in the United States?

9. Looking at Graph 4, about how many cases of *C. auris* were reported in 06/18? Was this more cases or fewer cases than were reported in 05/18?



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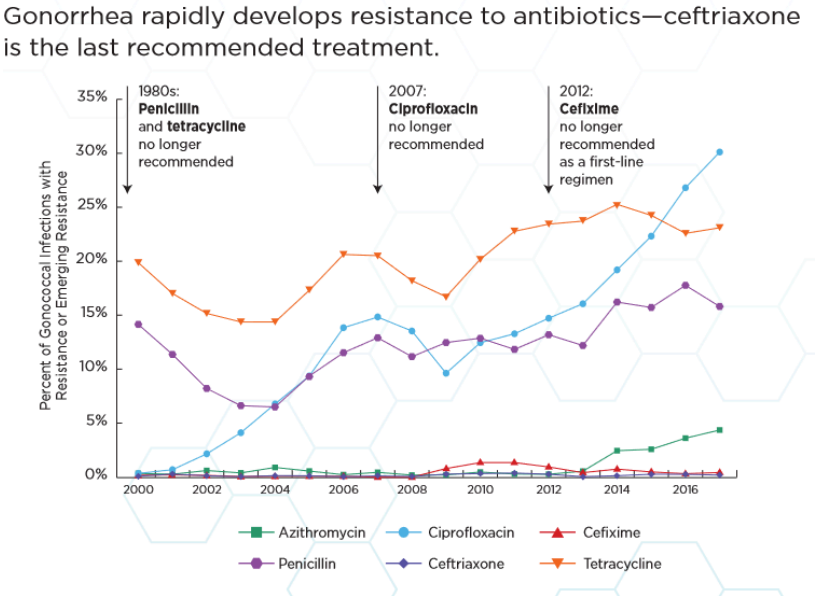

Part 3: How does AMR evolve?

Applicable Standards:

1. 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.

Learning Goals:

1. Understand that selection causes the evolution of antimicrobial resistance in bacteria and fungus.
2. Describe the process by which antimicrobial organisms become more common at the population level.
3. Explain the different ways that an organism can acquire antimicrobial resistance.
4. Link conceptual understandings of antimicrobial resistance to results observed through yEvo.

Vocabulary:

Evolution – Process the results in changes in the genetic material of a population over time

Natural Selection – The process where organisms better adapted to their environment tend to survive and produce more offspring

Mutation – A change in an organism's DNA which may be transmitted to future generations

Activities:

1. What video "Watch antibiotic resistance evolve"
   a. Discuss with class what they think is going on to allow this phenomenon to occur
2. Watch HHMI video on Natural Selection and the Rock Pocket Mouse.
   a. Discuss how predators have preferentially eaten mice they can see better and the evolution of color change
3. Introduce how antibiotic resistance evolves and spreads across a population
   a. Watch Antibiotic Resistance Explained Video
   b. Have students complete the marshmallow and M&M lab in pairs
4. Have students write a description of how antimicrobial resistance develops.
   a. Share with their partner.
   b. Outline steps for the whole class
5. If using yEvo, have students think-pair-share about how their observations from yEvo can be explained through selection.

Resources:

1. Watch Antibiotic Resistance Evolve: https://www.youtube.com/watch?v=yybsSqcB7mE
2. Natural Selection and the Rock Pocket Mouse: https://www.youtube.com/watch?v=sjeSEngKGrg
3. Antibiotic Resistance Explained: https://www.youtube.com/watch?v=CUslKICi5mc

Resources To Go Deeper:

1. Bacterial Evolution: The road to resistance : https://elifesciences.org/articles/52092
2. FDA Animation of Antimicrobial Resistance: https://www.fda.gov/animal-veterinary/antimicrobial-resistance/animation-antimicrobial-resistance-video

Lab Activity:

Materials: Toothpick, mini-marshmallows, M&Ms, timer

You are diagnosed by your doctor with an skin infection caused by bacteria. On the way home from the doctor you pick up your prescription from the pharmacy and immediately take the recommended dose. Now let's think about what is happening in your body after taking the antibiotic.

The mini-marshmallows represent the bacteria that are causing you to feel sick. Start by putting 25 marshmallows on the paper. The toothpick represents the antibiotic your doctor prescribed.

Dose 1: You now have 5 seconds to pick up as many marshmallows as possible using the toothpick (i.e. kill as many bacteria as possible).

How many marshmallows are left after 5 seconds? This is how many harmful bacteria are still alive in your body. Record your results in the table below.

Certain bacteria may not have been killed by the antibiotic because they are resistant to the antibiotic. Many bacteria are naturally resistant to antibiotics and others develop resistance through beneficial mutations that prevent the antibiotic from working. To represent mutated bacteria, take one marshmallow away and replace it with an M&M. Then to represent binary fission (asexual reproduction), double the number of marshmallows and M&Ms.

Dose 2: Now it is time for the second dose of antibiotics. This time the antibiotic is stronger and you will have 10 seconds to pick up as many marshmallows and M&Ms as possible with the toothpick.

Record how many marshmallows and M&Ms are still in the population. If there are no M&Ms at the end of a dose, a new mutation will arise and you should add one M&M. Now double the number of marshmallows and M&Ms.

Dose 3: Apply a third dose of antibiotics that is the strongest yet. This time you have 15 seconds to pick up marshmallows and M&Ms with the toothpick.

Record how many marshmallows and M&Ms are still in the population. If there are no M&Ms at the end of a dose, a new mutation will arise and you should add one M&M. Now double the number of marshmallows and M&Ms.

You can keep going for 3 more doses, but do not extend the time limit any longer as you are already taking the strongest legal dose of antibiotics.

	Marshmallows		M&Ms	
	Start	Finish	Start	Finish
Dose 1	25		--	--
Dose 2			2	
Dose 3				

Dose 4				
Dose 5				
Dose 6				

Graph the number of marshmallows and M&Ms at the end of each dose (before doubling). Before you begin determine what to plot on the X and Y axes.

X axis: _____

Y axis: _____

Label which line in your plot represents non-resistant bacteria and resistant bacteria

What can you conclude about the influence of the antibiotics on the population of bacteria?

Adapted from Michigan State University's antibiotic resistance lesson by Heather Kittredge

Part 4: How can One Health prevent AMR?

Applicable Standards:

1. HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Learning Goals:

1. Identify how antimicrobial resistance can hurt animals.
2. Understand the role of the environment in antimicrobial resistance.
3. Develop ideas on how to prevent antimicrobial resistance using at least 2 domains of One Health.
4. Predict what will happen to bacteria and fungi in the future if interventions are implemented.

Vocabulary:

Pharmaceuticals – compounds manufactured for use as a medical drug

Wastewater – water that has been used in the home, in a business, or as part of an industrial process

Wastewater Treatment – process which removes and eliminated contaminants from wastewater

Effluent - liquid waste or sewage discharged into a river or the sea

Activities:

1. Remind students of the elements of One Health and previous discussion of One Health using infographics and Venn Diagrams from Part 1.
2. Briefly review how antimicrobial resistance impacts human health.
3. Have students read Scientific American article about farm animals and antibiotic resistance and identify main argument of the article and three pieces of supporting evidence.
4. Introduce that antibiotic and antibiotic resistant bacteria can also be found in the environment.
    a. Show video “It’s Raining Antibiotic Resistance” (Through 5:47)
    b. Have students read UNEP article on Drug Resistant Pathogens or NYTimes Article on Bacteria in the Ganges River and discuss the main points of the article as a class.
5. Divide students into groups of 3-4 and have them discuss possible interventions that could prevent antimicrobial resistance. They should develop at least 2 ideas for each domain of One Health.
    a. Come together as a whole class for each group to share their ideas.
6. For homework , have students expand on two of their ideas from their brainstorming. They should include information on what the intervention is, how they think it should be implemented, and what the outcomes will be for both humans and bacteria/fungi.
    a. If using yEvo, have students specifically state if they think there would be any differences to their findings from yEvo.

Resources:

1. Scientific American article: https://www.scientificamerican.com/article/to-fight-antimicrobial-resistance-start-with-farm-animals/

2. It's Raining Antibiotic Resistance Video: https://www.youtube.com/watch?v=VP09H7zk9Ic
3. UNEP Article: https://www.unep.org/news-and-stories/story/how-drug-resistant-pathogens-water-could-spark-another-pandemic
4. NYTimes Article: https://www.nytimes.com/2019/12/23/health/ganges-drug-resistant-bacteria.html

Resources to go Deeper:

1. Nature article on 5 ways science is tackling the antibiotic resistance crisis: https://www.nature.com/articles/d41586-024-02601-4