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Activities to accompany the peer-reviewed article by Maura Meade-Callahan, Ph.D.:
"Microbes: What They Do and How Antibiotics Change Them" (Jan. 2001)
http://www.actionbioscience.org/evolution/meade_callahan.html

Microbes: Too Smart for Antibiotics? (Dec. 2002)

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Grades & Levels:

- **Handout 1:** grades 6-12 (general)
- **Handout 2:** grades 9-12 (advanced/AP) – undergraduate (year 1)

Time Recommendations:

Handout 1

- 1-2 days for article discussion and attention-getter activity
- 1-3 days for projects in Student Handout 1
- (optional) 1-2 days for extension activities suggested in the "Educator Resources" section at the end of Meade-Callahan's article

Handout 2

- 2-5 days for article discussion and completion of projects in Student Handout 2
- (optional) 1-5 days for extension activities suggested in the "Educator Resources" section at the end of Meade-Callahan's article

NSES (USA) Content Standards, 5-8 and 9-12

- 1.2. Unifying Concepts & Processes: evidence, models, and explanation
- 1.4. Unifying Concepts & Processes: evolution & equilibrium
- 2.1. Science as inquiry: abilities necessary to do scientific inquiry
- 4.3. Life Science: biological evolution
- 4.6. Life Science: behavior of organisms
- 7.1. Science in Personal & Community Perspectives: personal & community health
- 7.5. Science in Personal & Community Perspectives: natural and human-induced hazards

Note: View the NSES content standards on this site to choose other curricular applications for additional activities at:
http://www.actionbioscience.org/educators/correlationcharts.html

Learning Objectives: Students will…

- investigate how bacteria ("germs") are spread
- understand the threat of antibiotic-resistant bacteria
- explore the benefits of microorganisms
- consider pollution of the environment by antibiotics
- learn methods of curbing antibiotic resistance

Key Words Include

antibacterial, antibiotic resistance, antiseptic, archaea, bacteria, bacteriostatic, biodegrade, bioremediation, biosynthesis, chromosome, microbes, disinfectant, fungi, "germs," gene transfer, microorganism, nutrients, pathogen, plasmid, protist, virus

Preparation

Article Discussion:

Make copies or have students download copies of the article "Microbes: What They Do and How Antibiotics Change Them" at http://www.actionbioscience.org/evolution/meade_callahan.html. After students have read the article, conduct article review and discussion. Questions are provided below in the "Article Discussion" section.

- **Attention-Getter Activity (to accompany article discussion):** Suggestions are provided on page 3 for an attention-getter (especially appropriate for grades 6-12 [general]), which can be conducted before or after the article discussion.

Student Handouts:

Several group projects are presented in Handouts 1 and 2. Additional activities are listed under "Extension Activities" in the "Educator Resources" section at the end of the online article, including downloadable lab experiments with bacteria.

Acknowledgments:

The attention-getter "experiment A" was adapted from "Caught Red Handed," *Meet the Microbes through Microbe World Activities*, (Microbial Literacy Collaborative, 1999).

For Educators: Article Discussion

About the article by Maura Meade-Callahan, Ph.D.:
"Microbes: What They Do and How Antibiotics Change Them"
http://www.actionbioscience.org/evolution/meade_callahan.html

Have students review and discuss the article in groups of three or four.

Content questions:

1. What organisms make up the world of microorganisms?
2. When we talk about "germs," what do we mean?
3. How do bacteria benefit the environment?
4. How can bacteria be good for our health?
5. Describe some ways that bacteria can be used in industry.
6. How do antibiotics get into the environment and then into organisms?
7. a) Describe some ways that bacteria can acquire resistance to antibiotics.
   b) What are some of the things we can all do to lessen this problem?
8. The article criticizes the use of antibiotics for diseases like the common cold and the flu. Explain why the author opposes the use of antibiotics in these cases.

Extension questions:

1. What effect does the use of antibacterial agents have on our environment? Hypothesize how these agents will affect the evolution of antibiotic-resistant bacteria.
2. How many products do you know about that are manufactured with the help of bacteria?
3. Imagine what might happen if bacteria that play a role in each category listed under the article's "Beneficial functions of microorganisms" were destroyed. For example: If you lost all your beneficial bacteria from your intestines, what would happen?
4. Hypothesize what would happen if all bacteria in the world were destroyed.
5. What do you suggest would be an effective message on prescription antibiotic labels that would help consumers better understand antibiotic use?

For Educators: *Attention-Getter* Activity

WHAT IS THE BEST WAY TO WASH YOUR HANDS?

Materials: liquid hand soap, antibacterial liquid hand soap, UV/black light, Glo Germs Kit that contains powder and liquid (can be purchased from companies such as Glo Germ Co., Moab, Utah).

Preparation: The goal is to engage students and pique their interest with experiments that *simulate* the spread of germs. Before class, sprinkle glo germs in places you know students touch (doorknob, paper, etc.). After students get the powder on their hands, tell them you have a magic light that makes "germs" glow. Walk around the room with the UV/black light and point out all the "germs" on their hands.

Discussion: Ask "What do you think is the best way to get rid of these germs?" Some student will respond, "Hand washing." "What do you think is the best way to wash your hands?" Students will come up with many ideas. Lead the discussion to soap and warm water. Ask: "How much time should you spend washing your hands?" Write the times on the board. Present experiment A (below) to find out how much time is best for washing hands. Ask students for the variable (time) and control (someone not washing their hands).

Experiment A: Choose volunteers to represent the times you have written on the board and the control (example: 5, 10, 15, 20 and 25 seconds plus the control). Using the liquid glo germs, pump two squirts of glo germs on volunteers' hands. The students rub the glo germs into their hands like lotion. Have the students wash their hands, each using the same handwashing technique, for the assigned amount of time. Then have a "Panel of Experts" (students) use the black light to place the volunteers in order of cleanest (least amount of glowing) to dirtiest (most amount of glowing). Discuss the best way to wash hands. (Longer is better but findings suggest the minimum is 20 seconds.)

Experiment B: Ask **"**Do you think antibacterial soap will work any better?" Discuss ideas. Conduct this experiment using a new variable (different types of soap). Have students wash their hands for 20 seconds with one person using regular soap, one using antibacterial soap, and one using no soap as a control. Conclusion: Does using antibacterial soap work better?

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Student Handout 1

1. Concept Map

Based on the article by Maura Meade-Callahan, "Microbes: What They Do and How Antibiotics Change Them," make a concept map of all the ways that bacteria help us. http://www.actionbioscience.org/evolution/meade_callahan.html

2. Microbe News

You are the producer of a local news program. Design a three-minute television news story to tell about the dangers of antibiotic resistance and how resistance can be prevented. You may want to present the story "live" in class or videotape it.

3. Media Campaign

As a member of a non-profit public health organization, you have been assigned to develop a one-minute TV commercial to convince the public about the need to curb the spread of antibiotic resistance. Present your commercial "live" in class, as a Power Point presentation, or on video.

4. Bacteria Chef

Create a page for a recipe book about how to make yogurt or cheese. Include a special feature about the importance of bacteria in the manufacturing process.

5. Hungry Microbes

Create a poster or other visual presentation for an environmental fair to explain how microbes can provide nutrient recycling.

6. Busy Microbes

Create a visual presentation, such as a web page or poster, to help parents who come to your school's science fair understand the similarity and differences in these processes:

- biotransformation
- bioactivation
- bioremediation

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Student Handout 2

1. Training Hospital Volunteers

It's your job to train new hospital volunteers about antimicrobial agents. Create a presentation to explain these agents, such as disinfectants and antiseptics, to people who are not medically literate. Your presentation should also explain the difference between these agents: bactericidal and bacteriostatic.

2. Microbes 'R Us

You and your partners have started a bioremediation company. You need to impress your first potential customer with your product. Put together a presentation that describes:

- your special formulation of microbes plus any other ingredients
- step-by-step instructions for the product's use
- the benefits of the product
- a pitch for bioremediation as a problem-solver

Note: Choose one application area for the product, e.g., crude oil spills, toxic waste, pesticide contamination.

3. Microbe News

You are the producer of a local news program. Design a ten-minute news story to tell about the dangers of antibiotics in the environment. Include examples of the diversity of antibiotics that are entering the environment and how they are dispersed. You can present the story "live" in class, videotape it, record it, or create a Power Point demo.

4. Fun with Microbes

Create cartoons or other humorous presentations to illustrate how bacteria can exchange DNA. Display the material in class and answer any questions about your intended message.

5. Xenobiotics

Create a presentation for a student microbiology conference that examines:

- xenobiotics as a field of study
- the beneficial role of microbes in biodegradation of xenobiotics, with examples
- whether the resulting products are always less toxic when microbes utilize xenobiotics
- why some xenobiotics are recalcitrant to degradation, with examples
- at least one scientific case study that claims xenobiotics are harmful to one or more species