**Bacterial Invasion Lesson Activity Template**

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| **5-Part Plan Title:** | **Bacterial Invasion** |
| **Engineering Grand Challenge Covered:** | **Engineer Better Medicines/ Engineer the Tools of Scientific Discovery** |
| **Fellow Contributor(s) / Group Number:** | **Alexa Choy** |
| **Grade Level(s):** | **6-8** |

1. **Subject Area(s):** Biology, Science
2. **Associated Unit or Lesson**: None
3. **Time Required**: One class period for the initial set up and two days of observation
4. **Group Size**: 4
5. **Expendable Cost per Group**: ~$28.55
6. **Summary**: Students will be exposure to various bacteria found on common surfaces such as their hands, desks, keyboard, etc. by taking samples and spreading it on three agar petri dishes. They will then observe the effects a synthetic antibacterial soap/hand sanitizer has on the growth and proliferation of the bacteria using one of the previously swiped petri dishes. These observations will be contrasted to the bacterial growth on a second petri dish that was treated with an all-natural antibacterial solution created by each student group. In order to create their unique antibacterial solution, students will previously be asked to research natural accessible compounds and bring 1 or 2 items to class. Students in groups will contemplate which combination of compounds will produce the most effective all-natural antibacterial solution. After the initial set-up, students will observe the growth of the bacteria over the span of two days. On the third day, students in groups will make several measurements to quantify the zones of growth and inhibition in each dish. Using their newly discovered knowledge concerning natural antibacterial compounds, students will extrapolate these concepts and contemplate their global implications.
7. **Engineering Connection**: A great strength of engineers is the ability to take previously standardized methods and re-design them in order to create an even more effective, economical, and sustainable solution that can be widely accessible. In this activity, students are asked to discover alternatives to synthetic antibacterial soap/hand sanitizers by using combinations of common natural compounds. Additionally, engineers utilize bacteria in biofuel in order to remove waster and other by-products thus it is important for students to discover and learn how bacteria grows and proliferates.
8. **Key Search words**: Bacteria, Science, Medicine, Global Impact
9. **Educational Standards:** See attached standards grid for a complete mapping to all pertinent STEM standards.
   1. Common Core Math Standards: 6.SP.1, 6.SP.3, 6.SP.5.a, 6.SP.5.b, 6.SP.5.c, 6.SP.5.d
   2. NC Essential Science Standards: 6.P.2.3, 6.P.3.3, 6.L.2.1, 6.L.2.2, 6.L.2.3, 7.L.1.1, 7.L.1.2, 7.L.1.3, 7.L.2.1, 7.L.2.3, 8.L.1.1, 8.L.1.2, 8.L.2.1, 8.L.3.1, 8.L.3.2, 8.L.4.2, 8.L.5.1
   3. NC Engineering Connection Standards
   4. Next Generation Science Standards
10. **Pre-Requisite Knowledge**: None
11. **Learning Objectives** (After this activity, students should be able to):
    1. Know that bacteria can be hidden everywhere, especially in commonly used surfaces
    2. Understand that there are multiple natural compounds with innate anti-bacterial properties
    3. Compare and contrast the effects of all-natural anti-bacterial solution to a synthetic solution
    4. Identify regions of inhibition and growth on an agar petri-dish
    5. Understand the potential impact all-natural homemade anti-bacterial soaps may have in third world countries
    6. Comprehend potential hazards to overusing antimicrobial agents
12. **Materials List**: (Per group)
    1. Three swabs
    2. Antibacterial hand soap
    3. One cup
    4. Two transfer pipets
    5. Three pieces of PARAFILM
    6. Ruler
    7. Bleach (for usage by instructor only)
13. **Introduction / Motivation:** Bacteria are a group of microorganisms that can be found anywhere from water, air to your palm and even inside volcanoes and artic ice. Have you ever seen mold around your house? Remember seeing fuzzy blobs on bread or a pink ring around the water in a toilet bowl? Well those are all examples of microorganisms! Through this activity we will take samples from the surface of commonly used items and swab them onto an agar petri-dish. You will see how in two days, bacteria is able to grow and thrive with very little. A lot of microorganisms only need air, water and sugar (agar) to survive.

With bacteria everywhere, it is important to wash our hands with antibacterial soap in order to ward off infection and potential illnesses. In this activity, we will see how effective a synthetic commercially available antibacterial soap is against the proliferation of bacteria. We will compare this to an all-natural anti-bacterial solution that you will design and create.

Now imagine that you are living in an environment were you and your family cannot get ahold of some antibacterial soap or cleaning supplies, you still do not want to get sick. This is where a natural antibacterial alternative may offer a possible solution. Compounds with anti-bacterial properties are in fact easily available, if you go to your kitchen you can find plenty of them. You will do research regarding these compounds but some examples are garlic, lemon juice, salt water, apple cider vinegar, peppermint oil, and turmeric. We will see which group can come up with the most optimal combination of compounds.

1. **Vocabulary / Definitions**:
   1. Bacteria: a group of unicellular microorganisms that have cell walls but lack organelles or an organized nucleus, some of which can cause disease
   2. Inhibition zones: areas in the agar petri-dishes were bacteria have not grown enough to be visible
   3. Third world country: the underdeveloped nations of the world, especially those with widespread poverty
2. **Procedure:**

* Before the Activity: Students will research and read about the various antimicrobial effects of different widely accessible natural compounds such as garlic, lemon juice, salt water, apple cider vinegar, peppermint oil, and turmeric. Students will thus be asked to bring one or two of these items to class the following day.
* With the Students: Students will take a sterile cotton swab and lightly wet one end in distilled water. Next, they will thoroughly swipe the swab along the palm of their hand or desk. They will spread this end of the swab onto agar medium (in a petri dish), covering the entire surface. This process will be repeated for an additional 2 plates.

Students in groups of four will then discuss which combination of natural compounds will create the most effective antibacterial solution. They will combine their chosen compounds in a small cup. Using a plastic pipet, a few drops of their solution will be placed on the center of one of the previously swiped plates without spreading it. Using another pipet, students will pipet a few drops of a synthetic antibacterial soap/hand sanitizer given out by the instructor on second different plate. Again, it is important for student to **not** spread the soap over the entire surface. Lastly, students will leave the third plate with just the bacteria and no treatment. After setting up these conditions, students will place parafilm on each of the three petri dishes and leave them in a warm place for 1-2 days. After the initial set-up, students will be asked to make predictions about what each of the three plates will look like after 2 days.

After the 1-2 day incubation period, the plates will be observed. In order to quantify the effects of the natural compounds used, students will hold each plate up to the light and search for zone of inhibitions (no growth). If there is a zone then they can use a ruler to measure its diameter. These values will be compared for each of the other two plates. Lastly, the average diameter of the zone of inhibition for all of the groups in the class for each treatment group (control, soap, natural compound) will be calculated.

Another potential activity is for students to design the packaging for their natural antibacterial sanitizer. They should include the ingredients list, a name for their product, and some kind if tagline (based on their data, e.g. “More effective than X Brand Antibacterial Soap”). Students can then vote to see which group came up with the most potentially successful design.

* Cleanup: After the initial set-up, students will be asked to dispose of their remaining natural antibacterial solution. After the entire experiment is completed, the instructor will pour a small amount of household bleach over the petri-dish and resulting colonies over the sink. The instructor should be cautious of not allowing the bleach to touch their clothing or skin. After treating the dishes with bleach, they may be deposed in the trash.

1. **Attachments**: None
2. **Safety Issues**: Although most bacteria collected from the surrounding environment will not be harmful, once millions of colonies start to grow on the petri dish it may be more of a hazard. For this reason, students with cuts should wear rubber gloves and dishes should remain covered with PARAFILM until the experiment is done. Bacteria should then be destroyed using bleach.
3. **Troubleshooting Tips:** Some students may forget to bring their choice of natural compound to class and thus the instructor should have some compounds (garlic, lemon juice, salt water, and apple cider vinegar) as backup.
4. **Investigating Questions:**
   1. What are the benefits and drawbacks to a synthetic antibacterial soap?
   2. What are the benefits and drawbacks to an all-natural antibacterial soap?
   3. Looking at the average zone of inhibition for the entire class, which treatment group ((control, soap, natural compound) was the most successful?
   4. Was there high variability amongst groups? Why?
   5. Which combination of natural compounds resulted in the most efficient all-natural antibacterial soap?
   6. Where the observations and resulting quantification of bacterial inhibition in each dish different from your hypothesis?
   7. How can people living in third world countries without access to the same range of antibacterial soaps/hand sanitizers disinfect their hands, household items, etc.?
   8. How/why might your natural antibacterial solutions be better for your health?
   9. How can the overuse of antimicrobial agents lead to drug-resistant infections?
5. **Contributors**: Alexa Choy
6. **Supporting Program**: **Duke Boeing Grand Challenge K12 Outreach Fellows Program**
7. **Documentation for use of Photos or Images:**

* Figure # 1
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