Artful Bacteria:
Educating Children About Healthy Behaviors and Healthcare Professions Through the Beauty of Microbes

Submitted by
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Biomedical Diagnostic and Therapeutic Sciences: Medical Laboratory Science

To
The Honors College
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In partial fulfillment of the
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Abstract

This project explores bacteria collecting, testing, and identification as a means to compile a presentation for children that incorporates pictures of bacteria art. This project is meant to inspire an interest in science in these children, to educate them on various sources of environmental microbes, and to reveal the medical laboratory science healthcare profession to them. Multiple environmental sources of bacteria were investigated and bacteria were differentiated and subcultured from mixed cultures. Multiple specimens were cultured on multiple growth mediums, including specialized chromogenic agars that produced colorful colonies of yeast. As the bacteria propagated, they formed pictures or images referred to as bacteria art. The bacteria art is unique because it has not been used previously as a teaching tool. Using the pictures of bacteria art, the presentation shows what types of bacteria grow around people when they do not have proper hygiene, food safety techniques, or wash their hands. The presentation also includes information about the medical laboratory science profession which routinely works in microbiology and identifying organisms. A pre- and post-questionnaire could be used to determine the effectiveness of the presentation.

Introduction

Children younger than 19 years are at a greater risk of infection due to their immature immune systems. Teaching hygiene, handwashing, and food safety at a young age is a good method for preventing the spread of many infections (Stenger et al., 2013). Many children understand that handwashing is necessary after using the toilet or touching animals, but not always after playing outside or reading a book. If a child's hands do not look dirty, the child may

not feel it is necessary to wash his or her hands unless there is a parent or teacher telling him or her to do so (Eves et al., 2010).

Bacteria art has not been used as a method to teach about bacteria and hygiene. With bacteria art, children can actually see what bacteria look like on agars, not a textbook picture of bacteria at a cellular level, and not a cartoon germ with legs. While previous methods of teaching students about hygiene, hand washing and food safety have been effective in some cases, bacteria art may serve as a useful visual of actual bacteria since bacteria can not typically be seen with the naked eye.

Because this teaching technique may interest students to learn more about science and microbiology, it would be beneficial to include examples of healthcare professions, such as medical laboratory science. Many children note that they want to work in healthcare as adults and often cite a desire to become a doctor or a nurse, since these are the professionals that they see in a healthcare setting. However, if children are afforded an opportunity to learn about healthcare professionals that work on the behalf of a patient without ever seeing a patient, they are more likely to consider other aspects of healthcare for their future livelihood.

Although providing brightly colored visuals of bacteria art will interest children, it is important that children realize the dangers of some bacteria and how easily it can spread if his or her hands are not washed. Therefore, a handwashing experiment was conducted to show the difference in the number of bacteria removed when using different products for handwashing.

It is hypothesized that bacteria art created using identified microbes collected from environmental sources will be a useful tool to express the importance of hygiene, handwashing, and food safety. Students will gain knowledge on the hidden health profession of medical laboratory science and will be able to identify sources of bacterial contamination.

Materials and Methods

Bacteria Culturing and Identification

Swabs were used to collect bacteria by wiping the surface of a steering wheel, cell phone, laptop, TV remote, light switch, toilet, door knob, bird bath, and shoe sole. Swabs were also used to collect bacteria from beach sand, pond water, raw egg, raw chicken, compost, a person's mouth, and a cat's mouth. Blood agars or TSA agars were immediately inoculated, labeled, and taken to the lab. Loops were used to streak the agars in three to four quadrants to culture the bacteria to grow in individual colonies which were separated for identification tests and subcultures. The agars were placed in a 36 °C incubator for 24 hours to allow the bacteria to grow. Subcultures were made by using a loop to collect an individual colony of each type of bacteria from the first agar and inoculating and streaking separate blood agars (Figure 1). Individual colonies of each type of bacterium was used to run tests for identification.

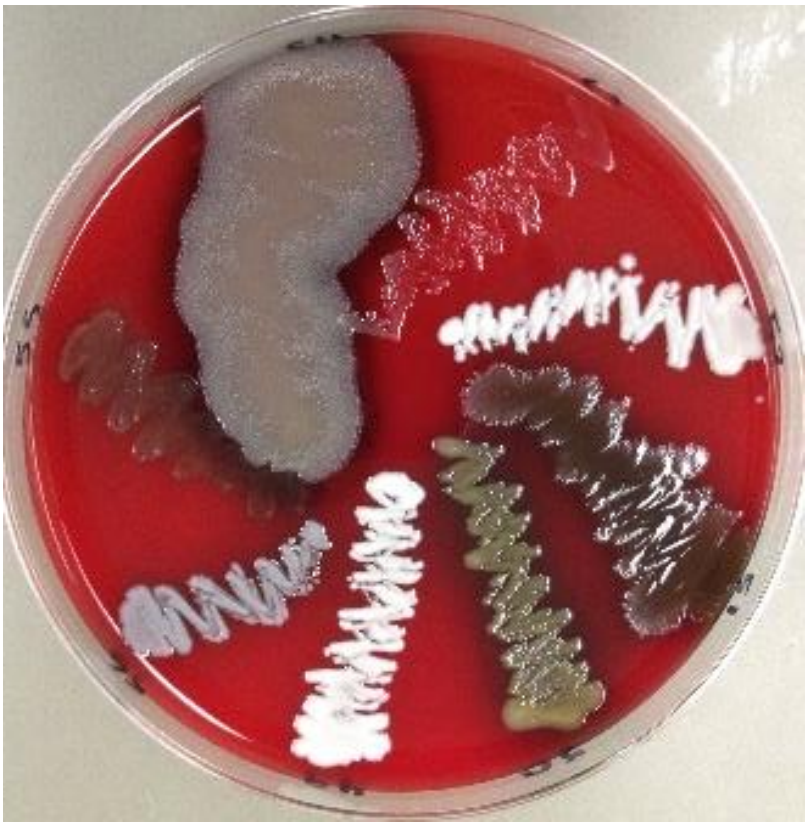

Figure 1. Blood agar with bacteria subcultures.

Gram stains were created for each organism. To create a gram stain, a glass slide with a drop of water was smeared with a colony of bacteria and allowed to dry. A primary crystal violet stain was applied to the heat-fixed slides to stain gram-positive organisms. Heat-fixed slides were created when the glass slides were swiped over a Bunsen burner to solidify the bacteria on the slide. The crystal violet stain was rinsed off and iodine was applied. Iodine was rinsed off and acetone was lightly used to remove any excess stain and then rinsed again. Lastly, the safranin stain was used, which stains the gram-negative organisms. The four stains were used to make bacteria visible, microscopically. Slides were viewed under 40X and 100X to identify gram-positive or gram-negative and cocci or bacilli. Catalase tests and coagulase tests were also used to differentiate organisms.

Bacteria Art

After identifying the bacteria and learning the color it produced, clear TSA agars and blood agars were inoculated with the different bacteria to form unique pictures, or bacteria art, on the agars. Bacteria was collected from the original agar using a loop and then applied to the art agar. Loops were used as a paint brush. Each time a new organism was used, the loop was replaced to prevent contamination. During incubation, the bacteria grew into the picture that was drawn with the loop. The designs were meant to interest students and also represent the environments in which bacteria were found (Figure 2).

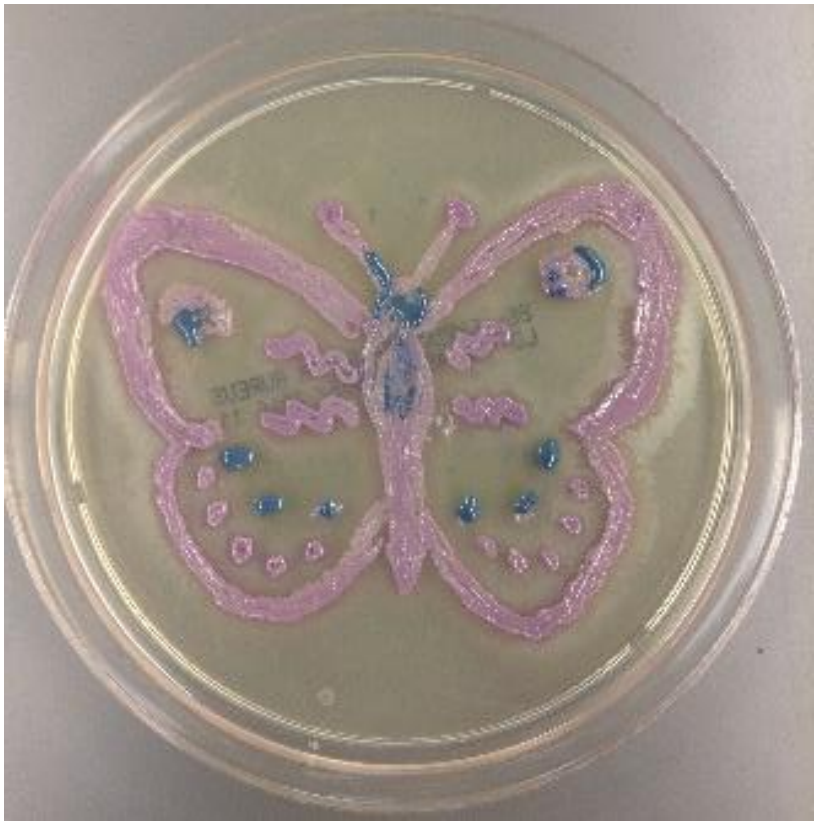

Figure 2. Butterfly bacteria art design on CHROMagar *S. aureus*. *Staphylococcus aureus* (*S. aureus*) is pink and *Klebsiella pneumoniae* is blue.

Other agars used were chromogenic agars, such as CHROMagar *Staphylococcus Aureus* and CHROMagar Orientation. Chromogenic agars are very useful in differentiating some bacteria because of the bright colors produced; however, theses agars are very expensive (Rank, 2012). Pictures were taken of the process, as well as before and after pictures of the agars to show growth and the bacteria art.

The *S. aureus* chromogenic agars grew *S. aureus* as pink and other bacteria as either blue or inhibited (did not grow colonies; Figure 2). The Orientation chromogenic agars grew *Escherichia Coli* as dark pink, *Enterococcus* as turquoise blue, *Klebsiella*, *Enterobacter* and *Citrobacter* as metallic blue, *Proteus* as brown, *Pseudomonas* as cream, *S. aureus* as gold and *Staphylococcus saprophyticus* as light pink ("CHROMAGAR" 2017).

Yeast Art

In addition to creating art with bacteria, yeast specimens were used on CHROMagar *Candida* agars to create a large 20 agar finale picture. The chromogenic agars were specific for *Candida species*. The yeast *Candida glabrata, Candida krusei, Candida tropicalis,* and *Candida albicans* appear white, pink, metallic blue, and green, respectively ("CHROMAGAR", 2017).

Handwashing Experiment

The handwashing experiment included using water alone, non-antibacterial soap, antibacterial soap, or hand sanitizer. Hands were pressed on blood agars and labeled "before." Hands were then washed using one of the four products. Washing was defined as putting hands under running water, applying product, and vigorously rubbing for thirty seconds before rinsing. To prevent contamination from paper towels, a separate person turned the faucet handle off while the person washing let their hands air dry. For hand sanitizer, hands were rubbed vigorously for thirty seconds without using water. Hands were then pressed on blood agars

labeled “after.” The “before” and “after” agars were incubated at 36 °C and observed 24 hours later.

Results

Bacteria Collection

The bacteria identified in commonly touched environments were unsurprising. After collecting the bacteria, a log was created to keep track of what was found in each source (Table 1). Some bacteria were only named at the genus level since more testing would be needed to speciate it. Locations which people touch mostly with hands such as electronics and the steering wheel, had *Staphylococcus aureus, Staphylococcus epidermidis, Pseudomonas stutzeri, and Corynebacterium*. These bacteria, except *Pseudomonas stutzeri*, are normal flora of the skin and typically do not cause problems. The skin is a barrier which normally prevents invasion by harmful organisms. However, a wound on the surface of the skin gives bacteria an opportunity to infect people and are therefore called opportunistic bacteria (Nakamizo et al., 2015). *Pseudomonas stutzeri* is commonly found in the environment such as soil, stagnant water, or sewage, but rarely causes infection.

Table 1. The bacteria isolated from various environments.

Environment	**Isolated Bacteria**
Steering wheel	*Corynebacterium, Pseudomonas stutzeri*
Cell phone	*Staphylococcus aureus, Staphylococcus epidermidis*
Laptop	*Bacillus, Micrococcus, Staphylococcus epidermidis*
Bottom of shoe	*Corynebacterium, Pseudomonas stutzeri, Staphylococcus aureus*
Beach sand	*Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Vibrio*
Pond water	*Bacillus cereus, Bacillus mycoides, Clostridium, Staphylococcus*
Human mouth	*Bacillus, Staphylococcus aureus, Streptococcus pyogenes*
Toilet	*Alcaligenes faecalis, Clostridium difficile, Staphylococcus*
Compost	*Bacillus cereus, Bacillus mycoides, Clostridium tetani*
Cat mouth	*Bacillus, Pasturella multocida*
Raw egg	*Salmonella, Staphylococcus aureus*
Raw chicken	*Salmonella, Staphylococcus aureus*
Bird bath	*Bacillus, Bacillus cereus, Bacillus mycoides, Corynebacterium, Escherichia coli*
Bathroom door knob	*Corynebacterium, Staphylococcus aureus*
Light switch	*Staphylococcus aureus*
TV remote	*Bacillus cereus, Staphylococcus, Streptococcus pyogenes*

Streptococcus pyogenes, like *Staphylococcus aureus*, can be normal flora of the skin, but is more commonly normal flora of the mouth. It can cause strep throat if the person's immune system is not functioning properly.

Escherichia coli, Bacillus mycoides, and *Clostridium tetani* are commonly found in soil, water, and feces. They were discovered in beach sand, pond water, and compost which are all found in locations where children might play. *E. coli* can cause vomiting and bloody diarrhea in more severe cases and *Clostridium tetani* can cause tetanus, commonly known as lockjaw (Vollman, Acquisto, & Bodkin, 2014).

Commonly associated with raw eggs and raw meat is *Salmonella spp*. It is the second most common cause of gastrointestinal food poisoning leading to fever, diarrhea, and cramps (Singh, Batish, & Grover, 2012).

Handwashing Experiment

A handwashing experiment was conducted to show the difference in the number of bacteria present after washing with different products (Figure 3).

Figure 3. Handwashing experiment results. A. Before handwashing, B. After handwashing.

The "before" agars all showed growth as expected. After using each of the products, the greatest difference in number of bacteria before and after was with hand sanitizer and the least difference was with water. Surprisingly, there was more bacteria growth on the "after" water agar. It is possible there was bacteria present in the water causing contamination. This would also explain why hand sanitizer, which did not involve water, showed the least number of bacteria. Considering hand sanitizer and antibacterial soap are both antibacterial, it was expected that they would have similar results.

Presentation Methods

For an effective teaching method, information should be presented differently, depending on the subject matter as well as the age of the audience. Various methods, such as videos, worksheets, fun facts, stickers, and posters have been used to teach how some infections can be prevented by washing hands, cleaning surfaces and basic hygiene (Chittleborough et al., 2013). Previous lessons on handwashing have included glitter (Chittleborough et al., 2013) to represent bacteria and glow gel to demonstrate how well children washed (Fishbein et al., 2011). Although cartoons and animations work well for young children, they are too juvenile for older children. In addition, teachers disliked lessons where germs were represented by cartoons with legs or skateboards as it was unrealistic. Worksheets may be too difficult for young children, but may be easier to grasp for older children (Chittleborough et al., 2013). For older students, a scientific approach such as tracking the spread of a hypothetical infection in a high school using an ultraviolet detectable powder may hold their attention more than cartoons (Baltezore and Newbrey, 2007). Other programs communicate their message on handwashing and food safety via social media sites (Stenger et al., 2013).

Benefit to a Bacteria Art Presentation

It is anticipated that teaching through the innovative use of bacteria art will interest students and educate them about the bacteria present when good hygiene and food safety are overlooked. With all the surfaces people touch every day, good hygiene and food safety are important life skills.

A good presentation requires a few components. It should catch the audience's attention with pictures or diagrams pertaining to the information presented, include minimal text, and use

pleasing colors. Children have especially short attention spans and will not stay focused if the vocabulary is too difficult or if there are too many words.

The bacteria art presentation includes a theme and is in the format of a story following the life of someone, the places he or she goes, and the bacteria he or she picks up along the way. The story segment follows a short, basic introduction on what bacteria are and how they are cultured in the lab. The presentation includes mainly pictures taken during the microbe collection and bacteria art creation. Minimal text is included to label pictures or list symptoms of a bacterial infection (Figure 4).

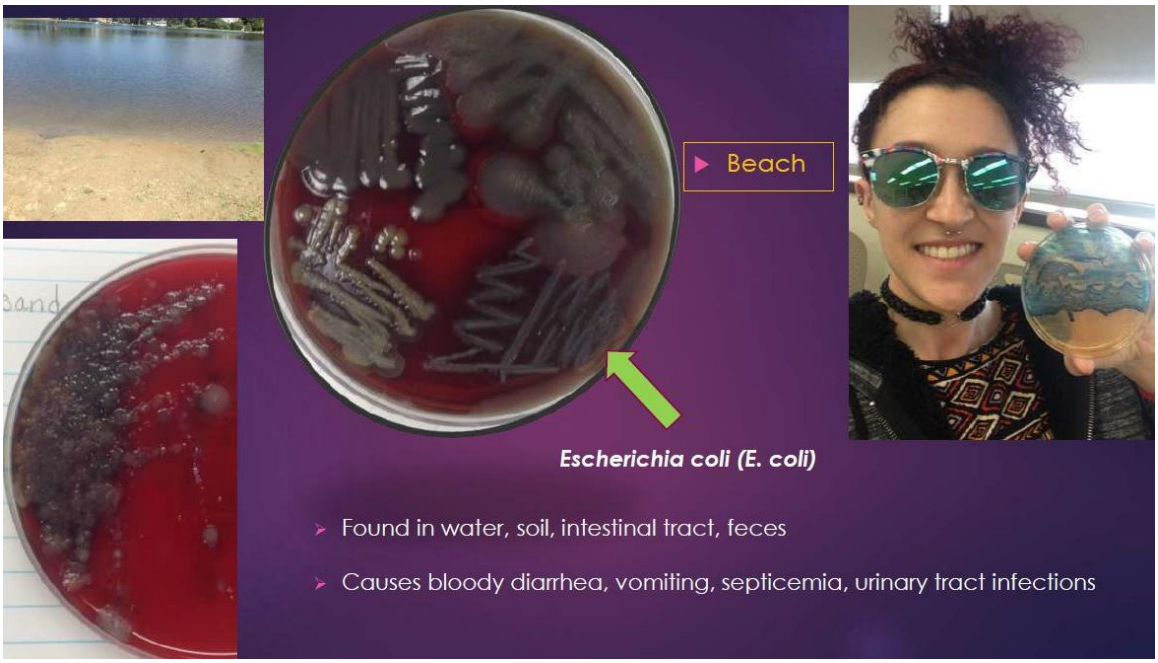

Figure 4. Presentation sample slide. A story format, with minimal words and relevant pictures.

The presentation flows from the fun bacteria art, including realistic and dangerous symptoms in a story format, followed by a realistic handwashing experiment to emphasize that bacteria are everywhere, and finishes with a description of the healthcare career, medical laboratory science. The handwashing experiment provides an actual depiction of what is present

on people's hands. The bacteria art is visually appealing with designs and colors, but may create unrealistic views of bacteria and lessen the impact of the dangers. The final section about the healthcare career is important to tie together how useful it is to identify bacteria while also demonstrating that science can be creative and colorful. It has been noted through years of research that,

> Visual literacy has always been relevant to young children's literacy development; however, with the rapid development of technology, children are making meaning with visual images with greater frequency and in unique ways (Serafini 2014). As children's understanding develops, a strong connection to visual literacy supports learning in literacy as well across the content areas, such as diagrams, maps or timelines that can be used in math, social studies, science, or language arts (Moline 2011). Visual literacy incorporates color, shape, spatial representation, print, messages, meaning and communication. When teachers use visual methods as a tool for thinking and communicating, students can experience new ways of learning that builds on their identities and knowledge outside of school (Rowsell et al. 2012). (Wiseman, Mäkinen & Kupiainen, 2016)

There is an expected benefit to using a bacteria art presentation over previously designed methods of presenting because it incorporates visually appealing art with the realistic handwashing experiment and explanation of a career option, covering more overall information. It is expected to be more useful than glow gel, glitter, stickers, and caricatured germs. Children can see the bacteria art while reading about the dangerous symptoms that can occur, which integrates two literacy strategies, both visual and written (Wiseman, Mäkinen & Kupiainen,

2016). With the other teaching methods, children are not presented with the full details on the dangers of bacteria.

To conclude the presentation to children ages 12 to 14, after a period of sitting and listening, it is anticipated that a large finale art image will provide a lasting memory (Figure 5). It is important to get the point across while also keeping their attention. Therefore, after the explanation of the healthcare profession, a final visual leaves them with something to remember. In addition to the presentation, pre- and post-questionnaires would be provided to determine the effectiveness of the presentation. It is expected that the questionnaires would demonstrate growth in their knowledge of basic hygiene and interest in science careers.

Figure 5. Candida species on CHROMagar Candida. A presentation finale.

Career Interest at a Young Age

Understanding public health and how bacteria spread is important for students to learn so they know how to stay healthy. Medical laboratory science and the specialization of microbiology are important for the identification of microbes, therefore making bacteria art useful in educating students and promoting an interest in the healthcare profession. Furthermore, there is a huge need for health care providers and medical laboratory science is not a widely-known profession. Medical laboratory scientists require the ability to problem solve, work independently, and teach their findings to a variety of people including pathologists, doctors, and the general public.

Key-figures, such as a professional or a presenter on a topic, influence career exploration. Therefore, it is important that information be presented in a positive light to spark students' interest because,

> The experience of positive emotions, such as excitement or contentment, may sustain the children's approach of given objects/situations and their in-depth exploration. Conversely, children's experiences of negative emotions such as disgust or shame may stimulate the avoidance of given objects/situations and lead to an in-breadth exploration of others. (Oliveira, Taveira, & Porfeli, 2015)

It is imperative that career options be discussed during childhood because children are curious, explorative, and interested in their futures. Childhood may be defined as ages three to fourteen. However, for presenting career options, three years old is too young (Oliveira, Taveira, & Porfeli, 2015). Children approximately 12 to 14 years old are young enough to still be developing an interest in new topics, while also having enough reasonability to understand concepts such as bacteria or medical laboratory science.

Conclusion

In this project, a variety of sources of bacteria was explored. Bacteria was identified and inoculated onto agars to create bacteria art. Bacteria art in a presentation with a story format is a new method of teaching children approximately 12 to 14 years old about cleanliness, hygiene, and the healthcare profession. The presentation integrates two literacy strategies, both visual and written. The bacteria art visuals are useful in creating positive emotions towards science, microbiology, and medical laboratory science due to their uniqueness. The visuals are beneficial because science is often viewed as detailed, calculated or uninteresting and may cause children to view science negatively.

It is hypothesized that, by presenting to children about bacteria and healthcare professions using bacteria art, more children will view science positively and potentially enter a science profession.

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ARTFUL BACTERIA

Pre-questionnaire

Artful Bacteria:
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Do you like science? Yes No

Would you ever consider a career in a science or health field? Yes No

If yes, which careers? _____

Have you ever heard of medical laboratory science? Yes No

If yes, what does a medical laboratory scientist do? _____

_____

If no, what do you think a medical laboratory scientist does? _____

_____

When should you wash your hands? (circle all that apply)

After playing outside	After using the bathroom	After eating
After petting animals	Before eating	After sneezing/coughing

What should you use to clean your hands? (circle all that apply)

Soap Antibacterial soap Hand sanitizer Plain water

What is the purpose of soap? (circle only one)

To kill bacteria

To make it easier for bacteria to fall off

I don't know

Where do you think bacteria could be found? (circle all that apply)

Steering Wheel	Your mouth	TV remote
Cell phone	An animal's mouth	Dirt/compost
Laptop	Raw egg	Light switch
Bottom of shoes	Raw chicken	Your hands
Beach sand	Bird Bath	Toilet
Pond	Door Knob	

Post-questionnaire

Artful Bacteria:
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Do you like science? Yes No

Would you ever consider a career in a science or health field? Yes No

If yes, which careers? _____

Have you ever heard of medical laboratory science? Yes No

If yes, what does a medical laboratory scientist do? _____

_____

If no, what do you think a medical laboratory scientist does? _____

_____

When should you wash your hands? (circle all that apply)

After playing outside	After using the bathroom	After eating
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Post-questionnaire- additional

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Was the presentation informative about bacteria?

Not at all	A little	Neutral	Yes	Very much

Was the presentation informative about medical laboratory science?

Not at all	A little	Neutral	Yes	Very much

Have you ever been taught about bacteria and handwashing before?
Yes No

If yes, how? _____

Were the pictures of bacteria helpful in understanding the importance of handwashing?

Not at all	A little	Neutral	Yes	Very much

Did today's presentation make you interested in a career in medical laboratory science?

Not at all	A little	Neutral	Yes	Very much


Artful Bacteria:
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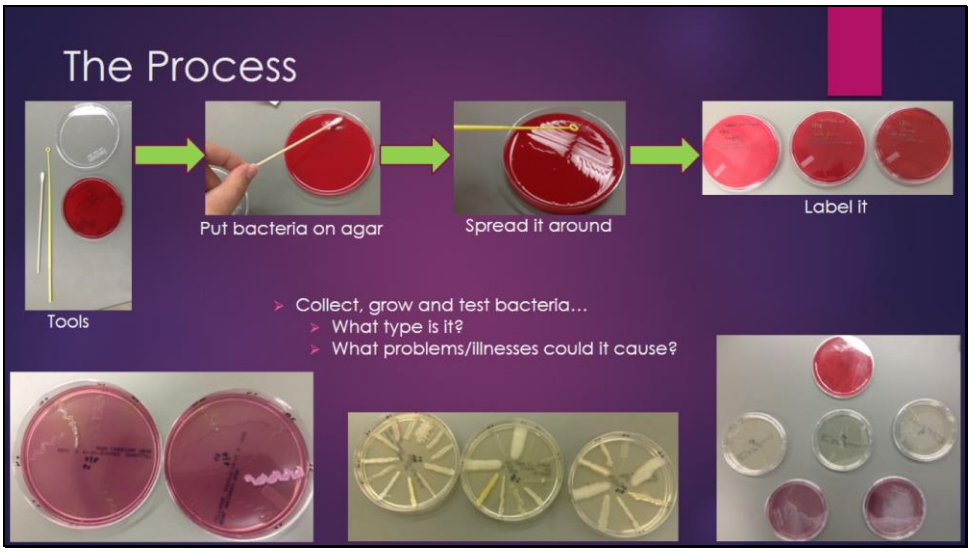
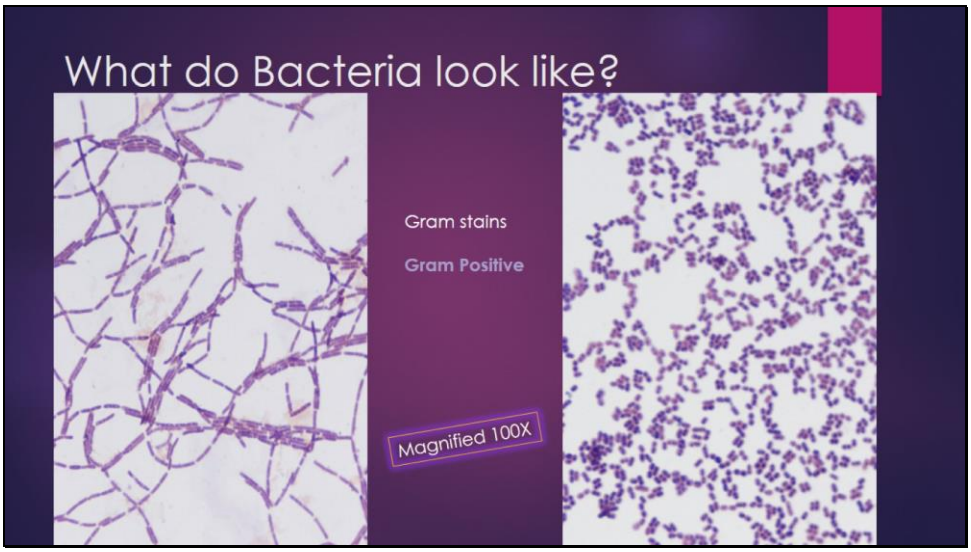
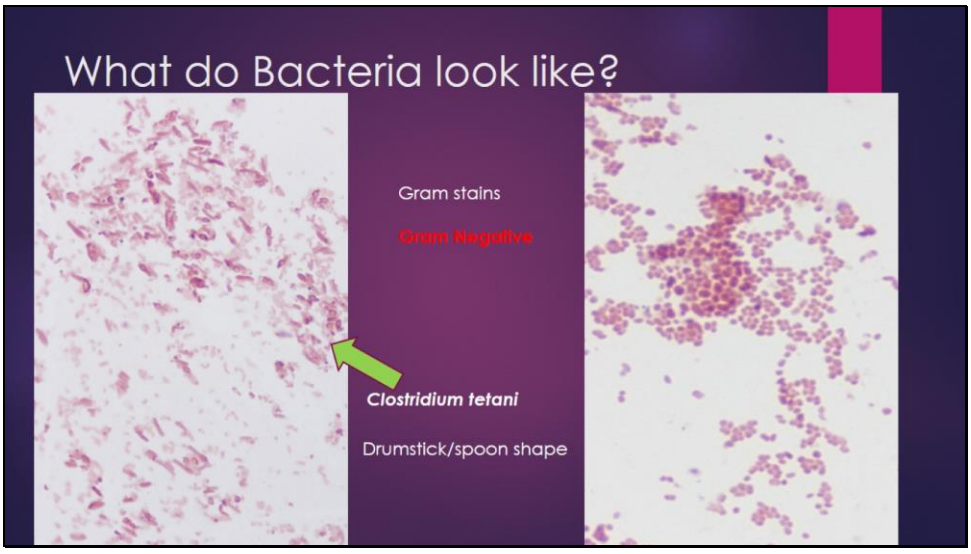
HELLO
MY NAME
IS
Lauren
See


Who I am…
Avondale graduate
Oakland University for Medical Laboratory Science
Honors College thesis
Paper cutting, kayaking, drawing


The Process
Tools
Put bacteria on agar
Spread it around
Label it
Collect, grow and test bacteria…
What type is it?
What problems/illnesses could it cause?

ARTFUL BACTERIA





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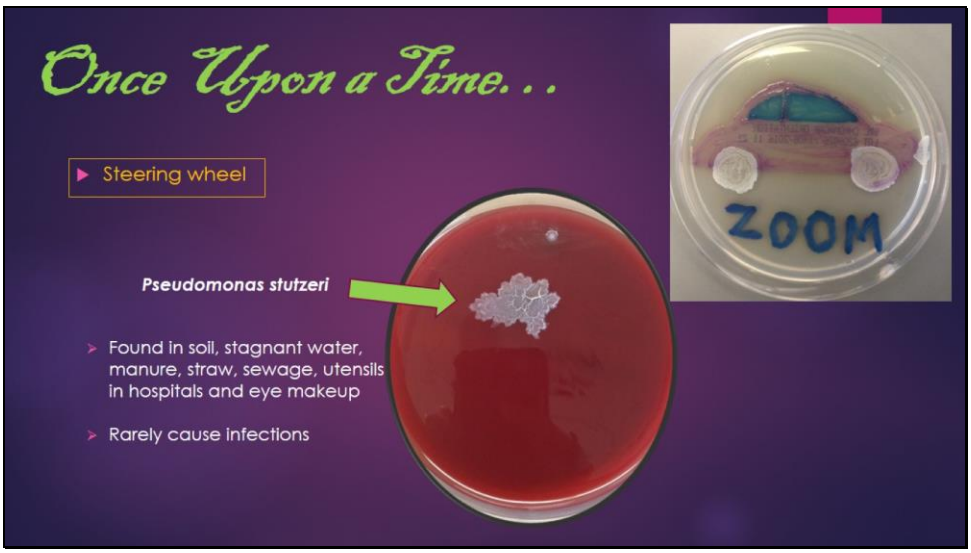

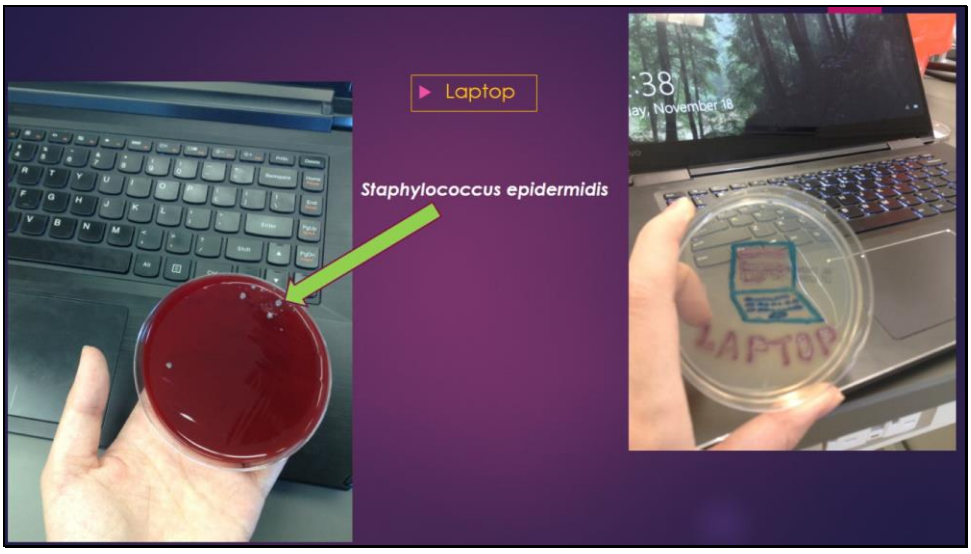

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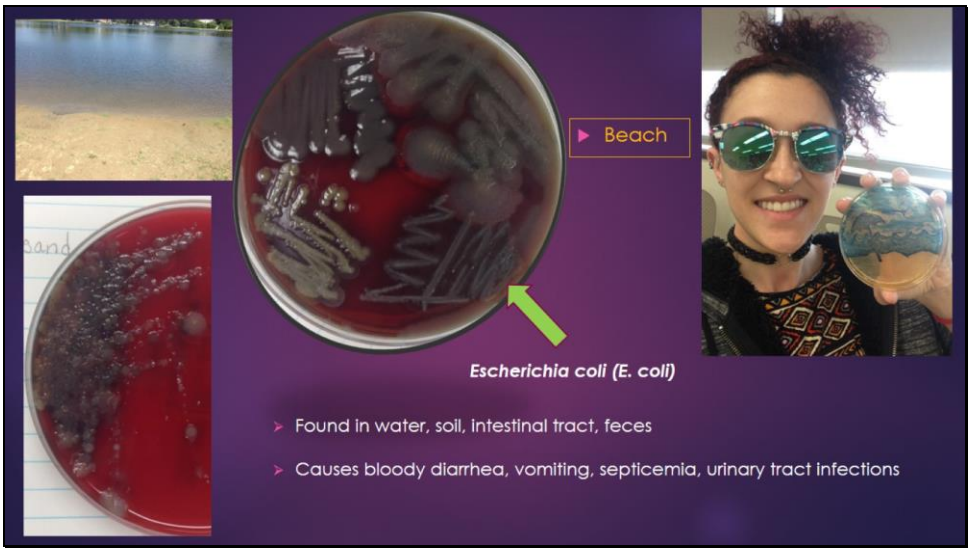

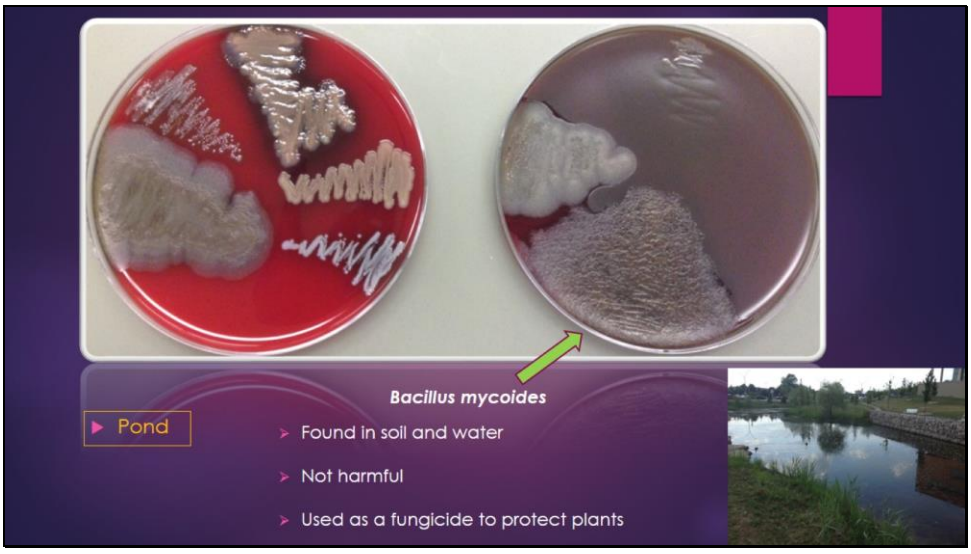

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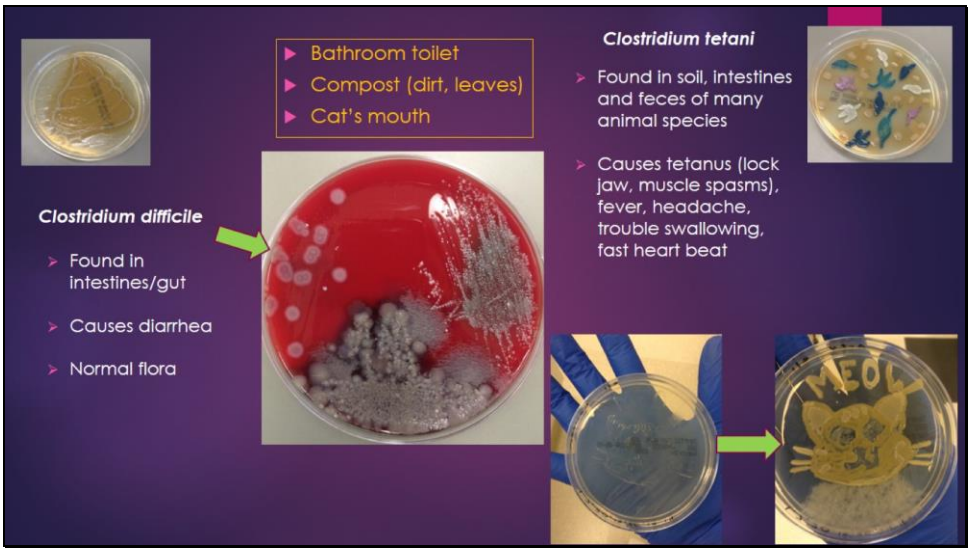

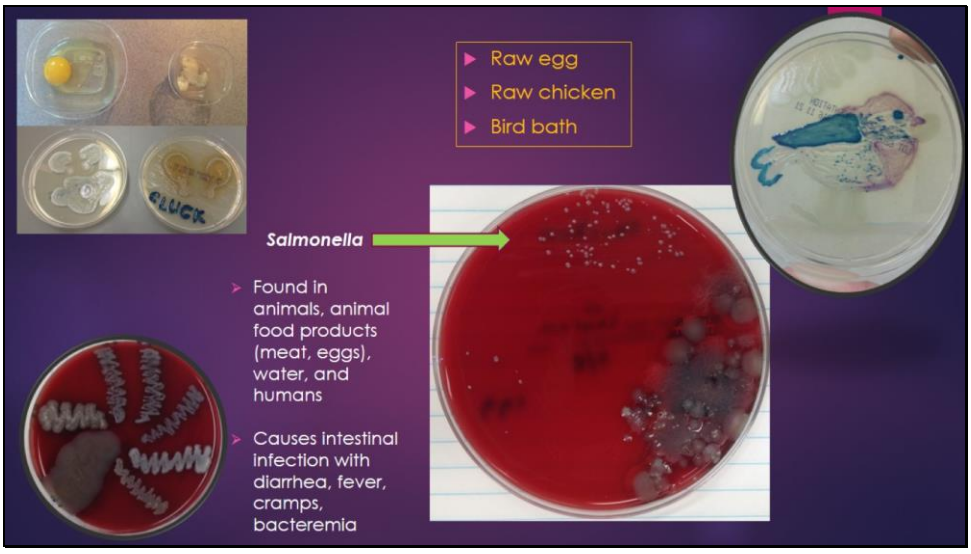

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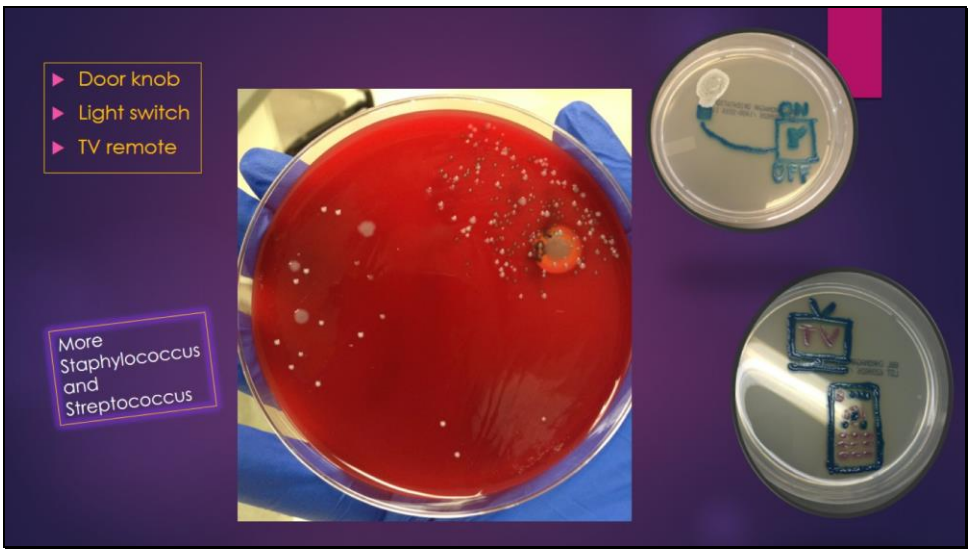

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