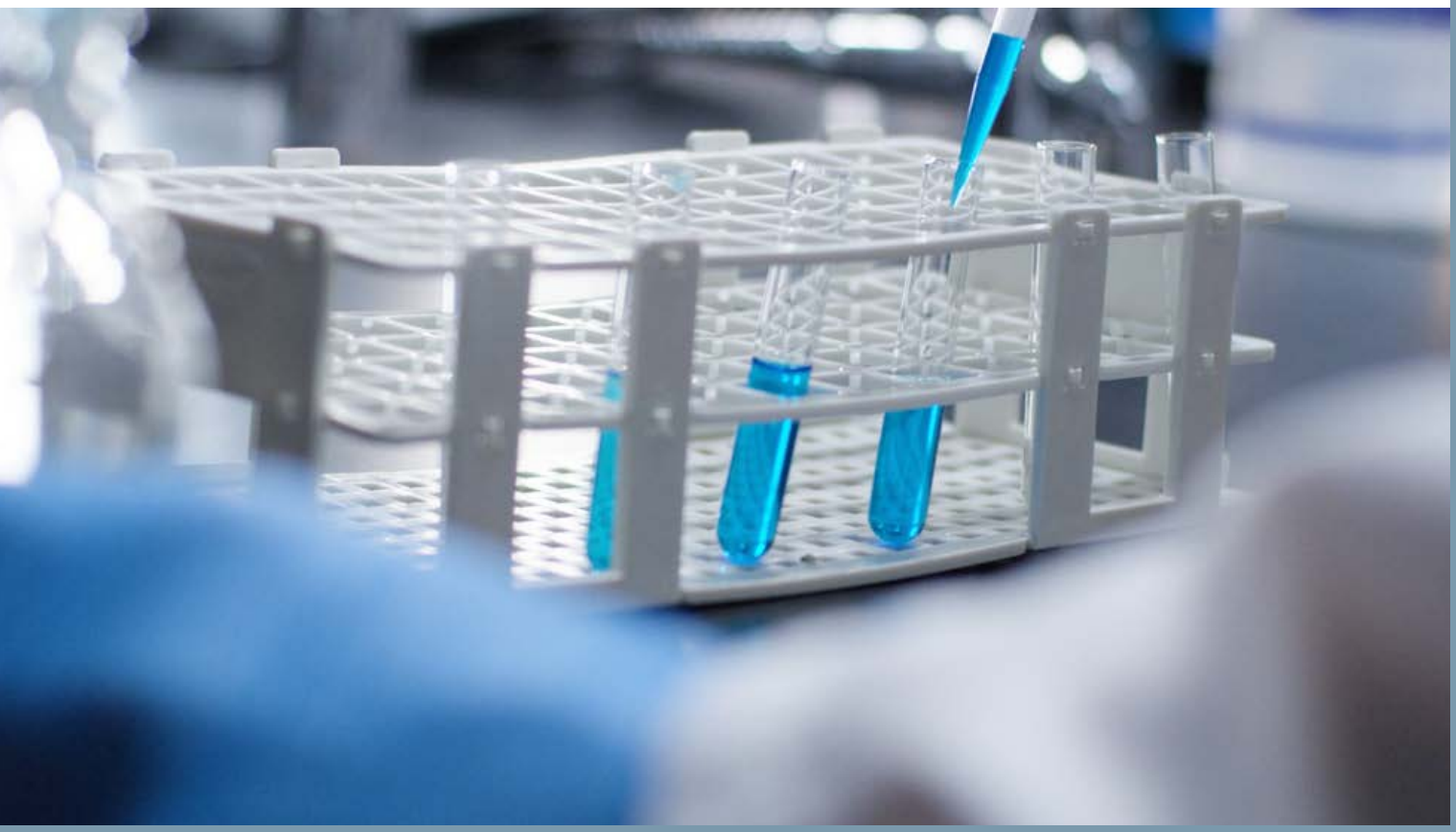
ROI

INDIANA UPLANDS | PROUD PARTNER

Grade 3-5 STEM Challenge

Science, Cells, & Bacteria, Oh My!

Inspired by Trae, a Pharmaceutical Scientist in the Indiana Uplands.



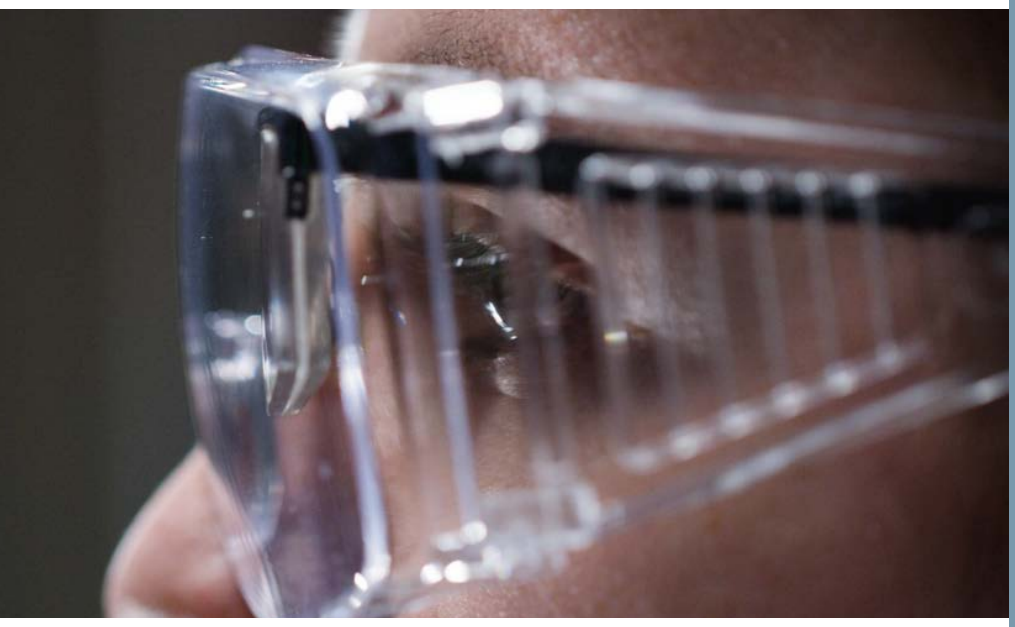
Published by Regional Opportunity Initiatives

GRADE 3-5 STEM CHALLENGE

Science, Cells, & Bacteria, Oh My!

Inspired by Trae, a Pharmaceutical Scientist in the Indiana Uplands.

Students will explore how bacteria are spread and isolate DNA from strawberry cells.



CAREER CONNECTION AND LESSON OVERVIEW

Trae is a pharmaceutical scientist at Singota Solutions in Bloomington, Indiana. Singota Solutions manufactures medical compounds and chemicals for other organizations. Trae's job at the lab is to find the best way to manufacture functional products for the client and to ensure that their products are not contaminated. Trae's career focuses heavily on biology, chemistry, and biochemistry but anyone who conducts scientific research to solve a problem can be called a scientist. Trae pursued this career because he was interested in cells—how they grow, how they behave, and how they can be modified to make things humans need.

In this activity, students will explore cells and DNA to understand how they are used in pharmaceutical research.

LESSON TIMELINE

DAY 1 60 Minutes

- Show the inspiration video, "Trae - Associate Pharmaceutical Scientist" http://www.regionalopportunityinc.org/trae/
- Set up bacteria culture plates*

DAY 2 60 Minutes

- Optional DNA extraction investigation

DAY 3 60 minutes

- Bacteria data collection*
- Results analysis

*Allow at least 48 hours between plating and data analysis!

Recommended Supplies

For Bacterial Cultures:

- 10 pack agar pre-poured agar plates (1 plate per 2-3 students)
- Clean cotton swabs
- Tape
- 10 zip-top plastic bags

For DNA Extraction (2 students per group)

- 1 zip-top plastic bag
- 2-3 strawberries
- 1 small plastic cup (~8oz)
- 1 coffee filter or white cotton fabric
- 2 plastic or wooden stir sticks (straws or skewers work also)
- 1/2 cup cold isopropyl rubbing alcohol
- 2 teaspoons of DNA extraction liquid Recipe:
  - 1 cup water
  - 4 teaspoons liquid dish detergent
  - 2 teaspoons salt

IN THIS CHALLENGE, STUDENTS WILL:

- Conduct an experiment about germs and bacteria growth.
- Extract DNA from a strawberry (Optional, most appropriate for grades 4-5).
- Learn about cells and how scientists use them to help people.

Standards

Science & Engineering Process Standards
SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

English/Language Arts
3.SL.3.1 Retell, paraphrase, and explain the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
4.SL.3.1 Summarize major ideas and supportive evidence from text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
5.SL.3.1 Orally summarize or respond to a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

Computer Science Standards
3-5.NC.2 Use productivity technology tools for individual and collaborative writing, communication and publishing activities.

Science Standards
3.LS.2 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
4.LS.2 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction in different ecosystems.

Employability Skills Standards
3-5.WE.4 Complete tasks or activities with prompting and guidance from adult educators.
3-5.WE.5 Demonstrate perseverance to complete tasks and activities.
3-5.LS.2 Communicate with others by applying a variety of speaking skills.
3-5.LS.3 Communicate with others using a variety of technology.
3-5.LS.4 Relate personal interests, abilities, and leisure time activities to possible occupational choices without stereotyping.
3-5.LS.13 Utilize effective questioning and brainstorming techniques.

Planning and Implementation

SCIENCE, CELLS, AND BACTERIA, OH MY!

Essential Vocabulary

- CELLS: The fundamental unit of all life. Every living organism is made up of one or more cells.
- NUCLEUS: A membrane-bound area within the cells where DNA is kept.
- DNA: A long thin molecule made up of nucleotides (sometimes called bases). The order of nucleotides in the molecule give cells their instructions on what do.
- CHROMOSOMES: Long, organized chains of DNA

BACTERIA: Tiny, single-celled microorganisms that are everywhere around us.

In this challenge, students will:

- View the job shadow video, Trae-Associate Pharmaceutical Scientist
- Conduct an experiment about germs and bacteria growth
- Create a presentation
- Learn about cells and how scientists use them to help people
- Extract DNA from a strawberry (Optional, most appropriate for grades 4-5)

Day 1

Introduction (20 Minutes)

Introduce students to the career of pharmaceutical scientist in the field of life sciences. Ask students: “What do you think a scientist does?"

- Record student responses on the board or chart paper
- Elicit student responses until the ideas convey an idea of what a career as a scientist might look like

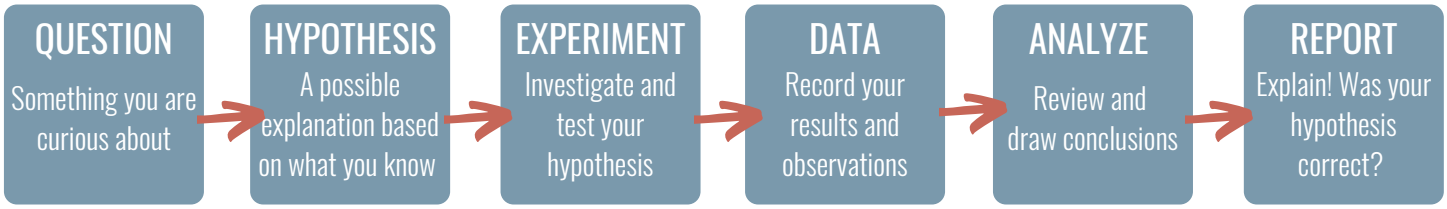
Prepare students to view Trae - Associate Pharmaceutical Scientist (3:11), available at http://www.regionalopportunityinc.org/trae/.

> *"The scientist in the video we will watch today is a pharmaceutical scientist. That means he works for a company that develops substances used to manufacture medicines that people need. Trae uses his knowledge of biology and chemistry to make sure that the ingredients used in medicines will work to keep people healthy."*

Either project the Pharmaceutical Scientist Career Profile or give a copy to each student. Here they can read more about Trae's work. Show the video and reflect by asking students what they think is interesting about Trae's job and if they have any questions.

Introduce the Challenge

Explain that they will begin learning about Trae's job by using scientific methods to explore bacteria and how they grow. Scientists like Trae take a lot of precautions to make sure that the environment they work in are completely clean. They also wear protective equipment such as gloves, goggles and lab coats to make sure that the substances they are working with are not contaminated by bacteria they may be carrying. Students will conduct an experiment to help them understand why scientists wear protective equipment in addition to simply washing their hands.
In the experiment they will compare different methods of handwashing and in will draw conclusions from the results of the experiment.



Question and Hypothesis (20 minutes)

Pass out the SCIENTIFIC PROCESS student handout and a copy of "Biology for Kids: The Cell," available at https://www.ducksters.com/science/the_cell.php. The article is written at a 4th grade reading level but is an appropriate "read aloud" for younger students. The article has vocabulary that will likely be new to students. Reviewing the vocabulary as a class before reading may be beneficial.

The first two components of the scientific process are QUESTION and HYPOTHESIS. In this lesson, the class will work to answer the question:

> *Why is it necessary for scientists to wear protective equipment to keep bacteria out of their work?*

To form a HYPOTHESIS students need to make a prediction about WHY good clean technique is important to Trae's job based on what they already know. Remember: a hypothesis is a possible explanation for something. To help them build background knowledge encourage them to think about:

- "The Cell," which they either read on their own or had read to them
- The information from the video and career profile to form a hypothesis
- Other information they may know about cells or living things

Students will complete the HYPOTHESIS section of the student handout before moving on.

Experiment (20 minutes)

For this part of the investigation, students hands should NOT be freshly washed. Returning to class from a social activity (like recess or a special area class) will yield the best (and germiest!) results.

Explain to students that they goal of the experiment is to see which handwashing method is most effective. Each group will prepare a petri dish using a different method. Students will work in groups of 2-4 for this activity.

Each group of students should have:

- 1 pre-poured luria broth (LB) agar petri dish
- 2 cotton swabs, clean, and placed on a tissue
- Tape to label and seal the lid of the petri dish
- Marker for labelling

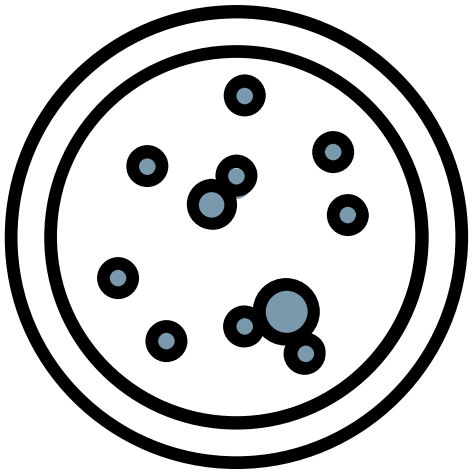
Assign each group one of the following six hand washing methods (more than one group testing each is fine, it just generates more data points for analysis!)

Group 1: No hand washing! This is the CONTROL group.	**Group 2** Wash with cold water ONLY, no soap.	**Group 3** Wash with warm water ONLY, no soap.
Group 4: Wash with cold water and soap.	**Group 5** Wash with warm water and soap.	**Group 6** Alcohol-based hand sanitizer only.

Within each group, students will be the Test Subject, Materials Supervisor, Lab Assistant, or the Field Researcher. For smaller groups, Materials Supervisor and Lab Assistant may be combined. For pairs, the Field Researcher should gather all materials and collect samples. The student protocol to collect samples from their hands is as follows:

1. Test Subject washes their hands using the assigned method. The Materials Supervisor will turn off the water and get paper towels for the Test Subject to dry their hands and make sure they return to their group without touching anything on the way. The no-wash control group will skip this step.
2. The Field Researcher will take a clean cotton swab and swipe it all over the Test Subject's hands, making sure they hit the fronts AND the backs.
3. The Lab Assistant will then gently remove the lid to the petri dish. The Field Researcher will then take the swab and swipe it across the dish in a zig-zag motion to move any collected bacteria to the growth medium.
4. The Materials Supervisor will then place the lid on the petri dish and tape it closed--make sure they can see the surface of the agar through the lid! They will place the plate in a zip-top bag and label it with the group name and what hand washing method they used.

Collect the labeled petri dishes and store them in a dry, room temperature (or slightly warmer) area of the classroom.

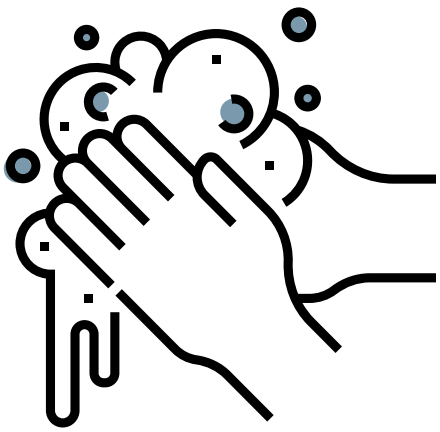


Safety Note: As tempting as it is, it is important that students do not re-open the petri dishes once they have been streaked with the samples, especially after the bacteria have been given time to grow. Explain that if bacteria were transferred to the plates they will divide and reproduce until they form a colony. This colony may look like a small dot but it is really a pile of MILLIONS of tiny cells! Since we don't know for sure that these are not bacteria that could make you sick we don't want to open the dishes and expose ourselves to something dangerous.

Once the groups have inoculated their places and put them away, have ALL students wash their hands following the United States Centers for Disease Control hand-washing recommendations (while they are waiting for the results of their own experiment!)

Follow these five steps every time (poster included at the end of this lesson):

- WET your hands with clean, running water (warm or cold), turn off the tap, and apply soap.
- LATHER your hands by rubbing them together with the soap. Lather the backs of your hands, between your fingers, and under your nails.
- SCRUB your hands for at least 20 seconds. Need a timer? Hum the “Happy Birthday” song from beginning to end twice.
- RINSE your hands well under clean, running water.
- DRY your hands using a clean towel or air dry them.



Day 2 (optional)

Strawberry DNA Lab (40 minutes)

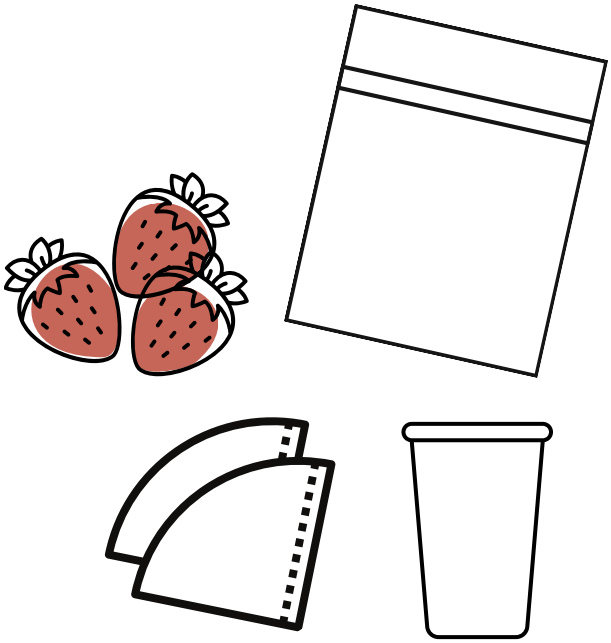
Before Class:

- Prepare (or have students prepare) the DNA extraction liquid prior to beginning the lab.
  - 1 cup (237 mL) water
  - 4 teaspoons (20 ml) liquid dish detergent
  - 2 teaspoons salt (about 12 g)
- Rubbing alcohol can be measured and passed out to groups in additional cups or containers OR the teacher can circulate to each group.

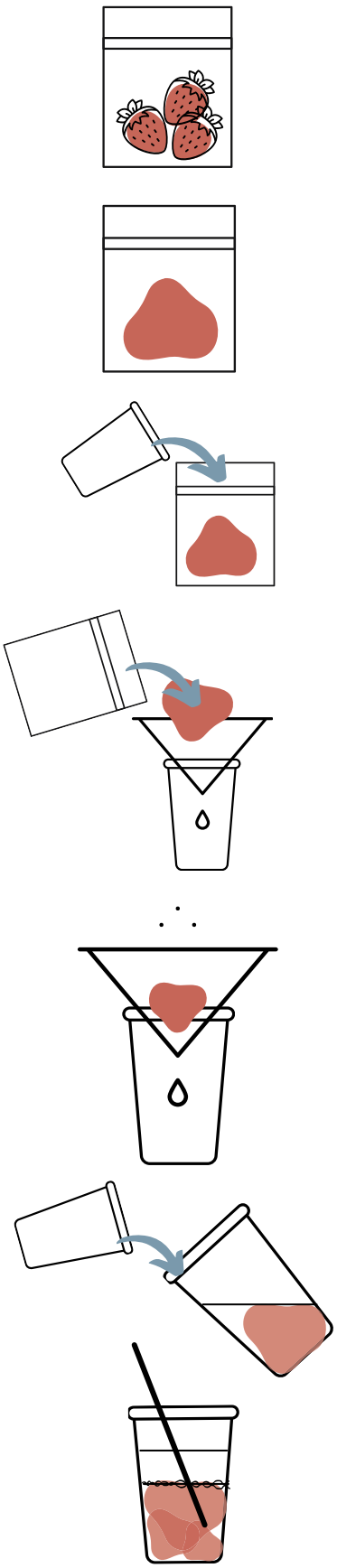
An important part of what pharmaceutical scientists do is to use cells to make medicines by giving them new instructions in the form of DNA. This means using what they know about biology (cells) and chemistry to isolate the things the cells have made and separate it. Today's lab will illustrate for students a simple version of how scientists isolate DNA from cells in the lab. Students learned that a cell has different parts and that the DNA of a cell is in its nucleus. They will be using a physical and chemical process to extract DNA from strawberries today to experience a small part of what a scientist might do in a lab.

Students should work in pairs for this lab. Either pass out materials of have one student from each group gather materials. Materials per group:

- 1 zip top plastic bag
- 2 or 3 strawberries
- 1 small plastic cup (~8oz)
- 1 coffee filter



Provide students with the STUDENT PROTOCOL sheet or walk students through the instructions for DNA extraction as a class.



DNA Extraction Student Protocol

1. Pull any green leaves off of strawberries.
2. Place strawberries in the plastic bag and seal the bag.
3. Gently smash the berries for 2 minutes. This will begin to physically break open the cells.
4. Carefully open the bag and add 2 teaspoons of DNA extraction liquid. The soap and salt in the extraction liquid substance will help chemically break down the strawberry cell membranes and allow DNA to be released.
5. Reseal the bag and continue to smash the contents of the bag GENTLY for one minute. Be careful not to create too many soap bubbles.
6. One partner will now place the coffee filter in the cup as shown. The other partner will carefully pour the strawberry mixture from the bag into the filter.
7. CAREFULLY squeeze the coffee filter (it may tear rip easily), allowing the liquid to drip into the cup.
8. Discard the filter with the remaining strawberry mixture.
9. Teacher: provide each group with cold rubbing alcohol.
    - One partner will now take the cup with filtered strawberry liquid and tilt it 45 degrees as shown.
    - The other partner will slowly pour the alcohol down the cup's side into the cup with the strawberry liquid. Make sure that the alcohol first hits the side of the tilted cup and is not poured directly into the liquid.
10. Once the alcohol is completely poured into the cup, return it to a flat surface. DO NOT mix or stir.
11. Students may begin to notice that there is a layer of alcohol sitting on top of the strawberry liquid and that strings of cloudy substance are starting to form.
12. Students can use the stir stick, skewer, or straw provided to pick up the substance and observe it. It should form a slimy ball!

Lab Reflection (20 minutes)

Students will complete the STRAWBERRY DNA LAB section of the student handout. Encourage the students to include as much detail as possible in their drawings and to describe the physical propertie.

Day 3

Data and Analysis

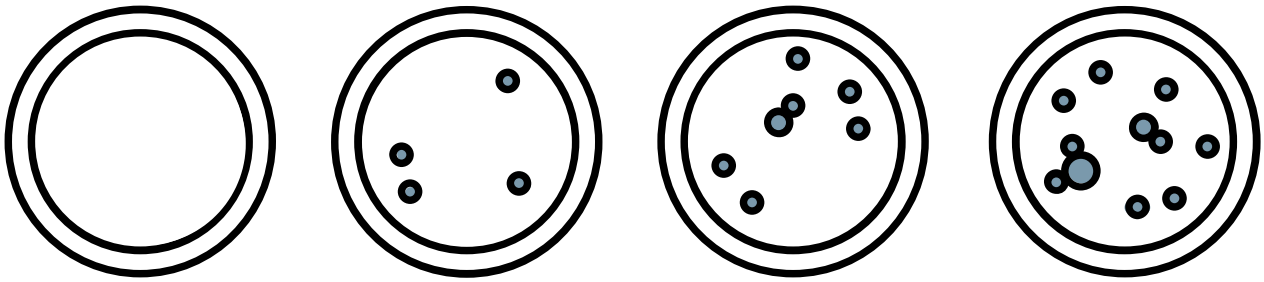
Schedule your activities for Day 3 once the bacteria in your petri dishes has had time to grow. Positive growth will result in small dots, or bacterial colonies. In warmer rooms this will happen within a day or two but growth during cooler months may take up to a week.

Observation Stations

Set up 6 stations around the room, with one petri dish at each station, for students to rotate between. *Leave petri dishes in the zip-top bags. It is safest to keep bacteria contained. Students will need their handouts and either crayons or colored pencils to record their findings. You should look at the plates ahead of time and suggest a few colors that they should bring with them.

At each station, students will find the correct circle in the DATA section of their student handout and draw what they see in that plate. Encourage students to draw the whole area with as much detail as possible. Once students have observed all petri dishes and drawn their pictures, facilitate a brief conversation about what they noticed.

Students will fill out the ANALYZE section of their student handout either individually or with a partner.



Discuss and Report (20 minutes)

Students will work in their small groups or individually to complete the COMMUNICATE box on their handout.

Have students use available technology (or another mode of presentation) to summarize their learning. Presentations should include:

- a summary of the ANALYZE section of their handout.
- an explanation of why clean techniques are important to scientists.

Career Exploration and Extension

Prompt students to think about and research what a career as a scientist might entail.

- What does a scientist do all day? What does Trae do?
- What kind of training would a student need to become a pharmaceutical scientist? What other types of scientists are there?
- What kind of education is needed to be a scientist?

Name: _____

Science, Bacteria, and Cells, Oh My!

Student Investigation Sheet

QUESTION

Why is it necessary for scientists to wear protective equipment to keep bacteria out of their work?

HYPOTHESIS

Using your previous knowledge and what you've read, develop a possible reason why cleanliness is important to science.

EXPERIMENT

Follow the instructions to conduct your investigation.

Materials (1 set/group)

- 1 petri dish
- 2 clean cotton swabs
- Tape to label and seal the lid of the petri dish
- Marker for labelling

Investigation Team Roles

- **Test Subject**: will wash (or not wash) their hands using the assigned method.
- **Field Researcher**: will use the clean swab to collect a sample from the Test Subject's hands.
- **Materials Supervisor**: Will collect all necessary materials.
- **Lab Assistant**: will assist the Field Researcher in collecting samples by handling and labelling the plates.

Name: _____

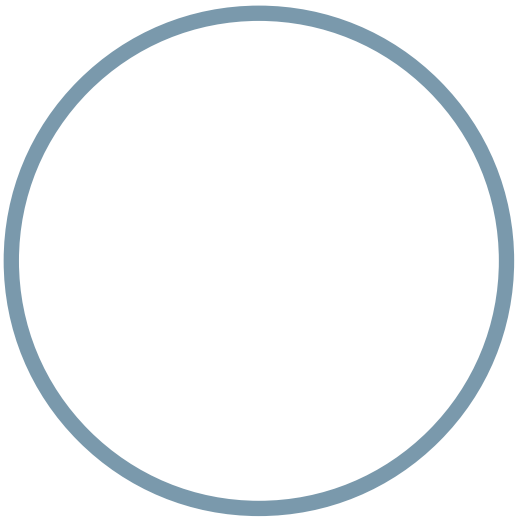
PROTOCOL
Here's what you will do...

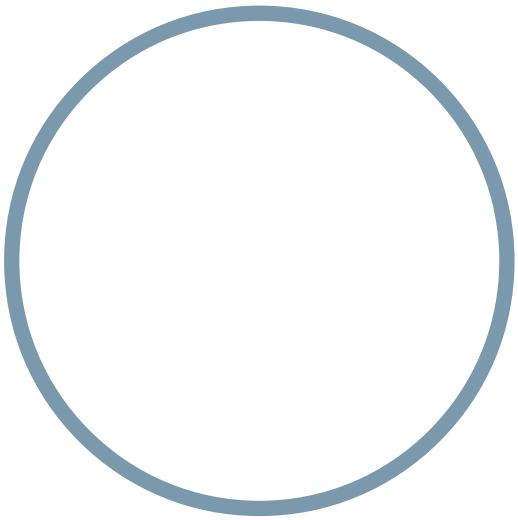
1. TEST SUBJECT washes their hands using the assigned method. The MATERIALS SUPERVISOR will turn off the water and get paper towels for the TEST SUBJECT to dry their hands and make sure they return to their group without touching anything on the way. The no-wash control group will skip this step.
2. The FIELD RESEARCHER will take a clean cotton swab and swipe it all over the TEST SUBJECT'S hands, making sure they hit the fronts AND the backs.
3. The LAB ASSISTANT will then gently remove the lid to the petri dish. The FIELD RESEARCHER will then take the swab and swipe it across the dish in a zig-zag motion to move any collected bacteria to the growth medium.
4. The MATERIALS SUPERVISOR will then place the lid on the petri dish and tape it closed. Make sure they can see the surface of the agar through the lid! They will place the plate in a zip-top bag and label it with the group name and what hand washing method they used.

DATA
Record your results! Make sure you label each drawing.

The plates were swabbed on _____ (date)

My data was collected on _____ (date)





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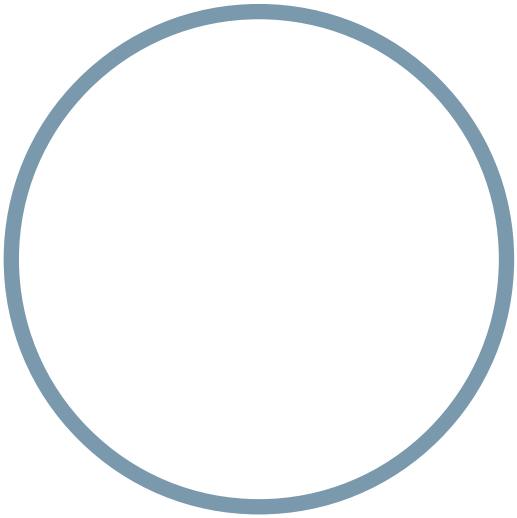
Name: _____

DATA
Continued!



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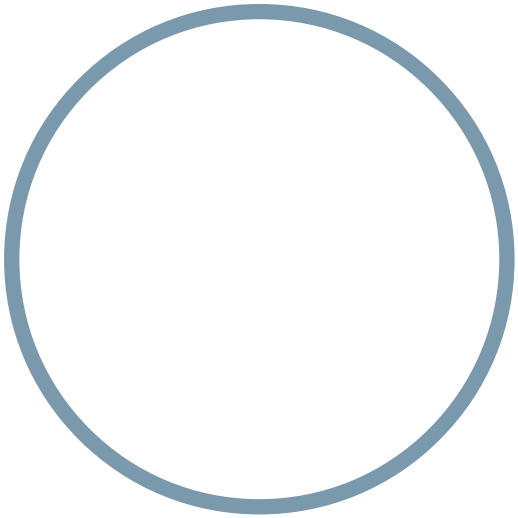

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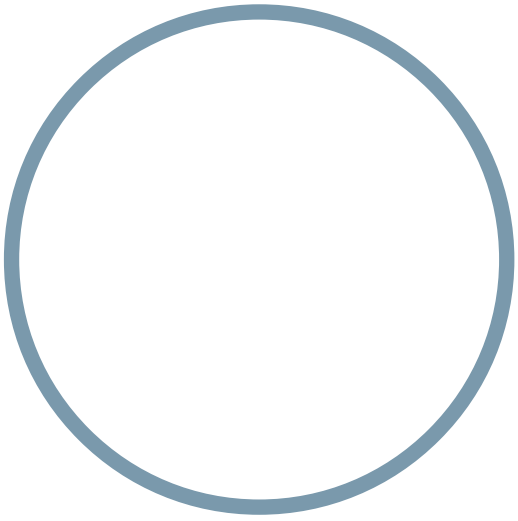

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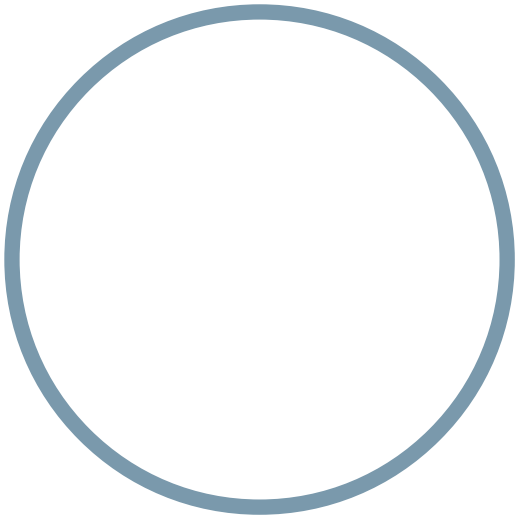


_____

Name: _____

ANALYZE

What conclusions can you draw from your data?

What did you notice when collecting data from the petri dishes?

According to your data, rank the hand-washing methods you tested in terms of effectiveness (with #1 being the best way to wash your hands.)

1. ---

2. ---

3. ---

4. ---

5. ---

6. ---

The U.S. Centers for Disease Control (CDC) recommend washing your hands with soap and either warm or cold water. Based on your experiment data, would you add to or change that recommendation? If yes, what would you add or change?

Name: _____

ANALYZE
Continued!

Hypothesis Check: Why is it necessary for scientists to wear protective equipment to keep bacteria out of their work? Did your answer change?

REPORT and REFLECT
What did you learn?

What did you learn about Trae's job as a pharmaceutical scientist? Why is his job important?

What skills do you think are important for a scientist to have?

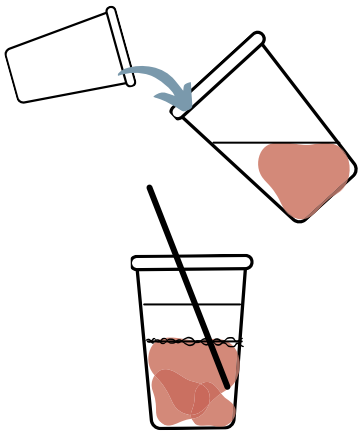
Name: _____

Science, Cells, and Bacteria, Oh My!

Strawberry DNA Lab Extension

OBSERVATIONS

What do you see?



Draw and describe what you observed after adding the alcohol to the strawberry liquid.

ANALYZE

What conclusions can you draw from your data?

Why do you think being able to remove some parts of the cells while keeping other parts would be important for a pharmaceutical scientist?

Science, Cells, and Bacteria, Oh My!

Handwashing Handout

ACKNOWLEDGEMENTS

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Content

Hand-washing guidance courtesy of the United States Centers for Disease Control. https://www.cdc.gov/handwashing/

"Biology for Kids: The Cell" article available at https://www.ducksters.com/science/the_cell.php

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