BILLINGS PUBLIC SCHOOLS

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ATOMIC CIRCUS CURRICULUM

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH

ABOUT THE ATOMIC CIRCUS

- Built on the power of partnerships and community engagement, the Authentic Community Engagement in Science (ACES) project is to build knowledge and interest in biomedical and STEM careers throughout Eastern Montana including rural and tribal communities. The Atomic Circus Show is the core inspiration for the project, held annually at Montana State University Billings.
- This curriculum resulted from a three year partnership between Montana State University Billings and the Billings Public Schools. Our goal was to expand on the work started with the Atomic Circus Show and help 5th grade students see connections between the show and the Billings Community.
- We focused on water, given both the prominence of the Yellowstone River to our community and the importance of water to our lives.

DEVELOPMENT TEAM

- Billings Public School Curriculum Team
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- Central Washington University, Dr. Amanda Obery
- Montana State University Billings, Dr. Matt Queen & Rob Massee

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- Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Institutes of Health.

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ATOMIC CIRCUS 5TH GRADE CURRICULUM OVERVIEW

WATER AND THE BILLINGS COMMUNITY

The City of Billings sources its drinking water from the Yellowstone River. Beginning in the Absaroka Mountains, the Yellowstone runs north, through Billings and eventually flows into the Missouri River on the eastern edge of Montana.

ALIGNMENT TO NATIONAL STANDARDS

5-PS1-1.	Develop a model to describe that matter is made of particles too small to be seen.
5-PS1-3.	Make observations and measurements to identify materials based on their properties.
3-5-ETS1-2.	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
CCSS.ELA-LITERACY.SL.5.4	Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.

ATOMIC CIRCUS 5TH GRADE CURRICULUM IMPLEMENTATION

CURRICULUM SEQUENCE

- The curriculum is five lessons as outlined below:

1. Context
   - Where does our water come from?
2. Problem
   - Why is treating water important?
3. Initial Test
   - How can I filter water?
4. Super Filter
   - Given constraints, what filters water most effectively?
5. Presentation
   - How can I share scientific information?

ATOMIC CIRCUS MATERIALS

1	T-Shirt material (1 bag)
2	Cheese Cloth (1 bag)
2	Gauze Roll (10 count)
4	Sponges (4 count), cut in half
1	Cotton Balls (100 count)
50	Large Cups (~20 oz)
50	Small Cups (~4 oz)
1	Soil (bag)
1	Paper Towel (roll)
15	Funnels

GLOSSARY OF CRITICAL TERMS

Term	Definition
Matter	Anything that takes up space is called matter. Air, water, rocks, and even people are examples of matter.
Particles (size)	A small portion of matter
Macroscopic/Visible	Visible to the naked eye; able to be seen with the naked eye, macro = big
Microscopic/Invisible	Visible only with a microscope; unable to be seen; not visible to the eye, micro =small
Atom(ic) (e.g., atomic level)	Basic building block of all matter. Too small to be seen by a microscope
Molecule	A group of atoms bonded together
Filter(ing)	Separating substances by size
Variable	An item in an experiment that can change
Properties	Traits that define the matter (e.g., state of matter, hardness)
Mixture	Combination of two or more substances that can be separated (e.g., salt water)
Solution	A mixture of two or more dissolved substances
Potable	Safe to drink (non-potable = not safe to drink)
Constraints	Limitation or restriction
Criteria	Standard by which something may be judged or decided

LESSON EXTENSION
Quizlet on vocabulary

ATOMIC CIRCUS, LESSON ONE

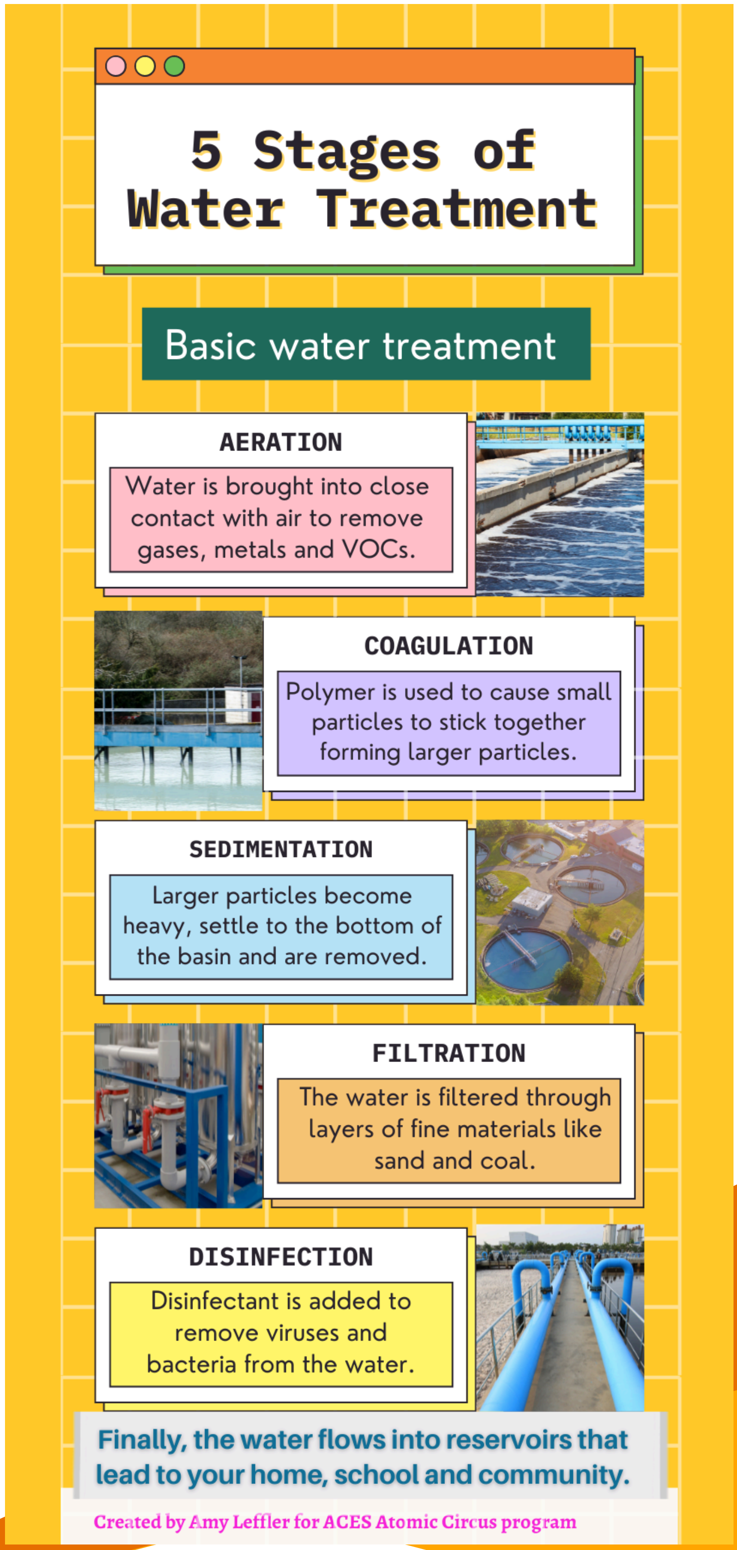
WHERE DOES OUR WATER COME FROM?

BACKGROUND KNOWLEDEGE: WATER AND THE BILLINGS COMMUNITY

The City of Billings sources its drinking water from the Yellowstone River. Beginning in the Absaroka Mountains, the Yellowstone River runs north, through Billings and eventually flows into the Missouri River on the eastern edge of Montana.

The City of Billings Water Treatment facility, located on the eastern side of the city by Mystic Park, is where the city collects and treats water from the Yellowstone River and it is then distributed across the city.

The “Water Treatment Facility,” cleans the water from the Yellowstone River that is sent to your house. By contrast, the water that leaves your house goes to the “Wastewater Treatment Plant.” The focus of this lesson is on the Water Treatment Facility, looking at how Billings sources clean water and how turning river water to drinking water requires investigation at multiple size scales.



ATOMIC CIRCUS, EXPANDED LESSON ONE

WHERE DOES OUR WATER COME FROM?

STANDARDS, OUTCOMES, & ASSESSMENTS:

Title	Outcomes	Standard	Assessments
Where does our water come from?	• Identify particle size (macroscopic, microscopic, atomic) • Recognize the process water takes to go from the Yellowstone River to our homes.	5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.	Card Sort & "Should Dr. Queen Drink Water Out of the Yellowstone River" Student Response Sheet

MATERIALS:

- Video Links
- Student Response Sheet: "Ask a Biomedical Professional"

KEY VOCABULARY:

- Macroscopic / Visible- Able to be seen with the naked eye
- Microscopic / Invisible - Unable to see with the naked eye,
  - Visible using a microscope
- Atomic - Too small to be seen with a microscope,
  - All matter is made up of atoms

STUDENTS MUST COMPLETE THE PRE-SURVEY PRIOR TO STARTING THE LESSON

ATOMIC CIRCUS, LESSON ONE

BEFORE STARTING, STUDENTS MUST COMPLETE THE PRE SURVEY

ACTIVATE:

- Ask students where their drinking water comes from?

Show "The Atomic Circus Summarizes Water Contamination Size Scales" https://www.youtube.com/watch?v=QzH4JWdoev4

- Pause video at 0:21 and ask students to discuss in small groups or pairs, "Should Dr. Queen drink the water?"
- Write down student ideas or come to a consensus
- Finish watching the video
- Re-pose the question "Should Dr. Queen drink the water? Why or why not?"
- Make a list, or add to the list, of the reasons why Dr. Queen should not drink the water.

The Atomic Circus Summarizes Water Contamination Size Scales VIDEO LINK

EXPLORE:

- Discuss water treatment and that the City of Billings manages a facility that treats water from the Yellowstone River and transports it to our taps.
    - “Where does your Drinking Water Come from?” https://youtu.be/rj--pjKAt4o?feature=shared
- Pass out the Particle Size Card Sort Activity for the Billings Water Treatment Facility. In small groups, have students match the contaminant with the water treatment step when it was removed.
- Discuss results as a class and come to consensus. May need to discuss mud, dirt, and chemicals more closely and answer the question, "When would the preliminary treatment filter out mud and dirt and what might remain in the sample that need to be filtered out?"
  “What’s smaller: chemicals or dirt?”

“Where does your Drinking Water Come from? VIDEO LINK

ATOMIC CIRCUS, LESSON ONE

EXPLAIN:

- Share the following vocabulary words with students:
  - Macroscopic
    - Visible to the naked eye
  - Microscopic
    - Not visible to the naked eye
    - Able to be viewed using a microscope
  - Atomic
    - Not visible to the naked eye or a microscope
    - Made up of individual atoms
- Discuss how matter is made up of molecules too small to be seen. Each time water is collected from the Yellowstone River, the Water Treatment Facility must consider how to remove contaminants or harmful things at the macro, micro, and atomic level.

ELABORATE:

- In small groups, have students return to the "Water Sample" cards and sort based on their size. Share results out as a class and discuss each.

EVALUATE:

- Return to the video snippet of Dr. Queen almost drinking the water from the Yellowstone. Ask students, "Should Dr. Queen drink the water?"

- On the response sheet, have students draw what a possible water sample from the Yellowstone River would look like prior to treatment. They must identify and label at least one component that is macroscopic, microscopic, and atomic.

PARTICLE SIZE CARD SORT ACTIVITY

Part 1:

- Have students match the water sample cards with where in the water treatment process they are filtered out or treated for as the water travels from the Yellowstone to our drinking fountains.

EXTENSION:
Read about arsenic in the Yellowstone River

TEACHER TIP!
Cards are intended to be printed four to a page

Part 2:

- Challenge students to organize the cards based on the size of the water sample components, from largest to smallest
- Next, have students groups the cards based on their particle size: Macroscopic, microscopic, and atomic.
- Debrief the experience, sharing that while sticks and mud are able to be seen with just our eyes, they're also made up of atomic particles that we cannot see.

VOCABULARY

1. Macroscopic
   a. Visible to the naked eye
2. Microscopic
   a. Not visible to the naked eye
   b. Able to be viewed using a microscope
3. Atomic
   a. Not visible to the naked eye or a microscope
   b. Made up of individual atoms

CARD SORT ANSWER KEY

PART 1: TREATMENT MATCHING ACTIVITY

STEP 1- PRELIMINARY TREATMENT

STICKS & BRANCHES

MUD & DIRT

STEP 2- FILTRATION

MUD & DIRT

CHEMICALS

STEP 3- DISINFECTION

MICROORGANISMS

BACTERIA

PART 2: PARTICLE SIZE MATCHING ACTIVITY

MACROSCOPIC

STICKS & BRANCHES

MUD & DIRT

MICROSCOPIC

MICROORGANISMS

BACTERIA

ATOMIC

CHEMICALS

Step 1

Billings Water Treatment Facility

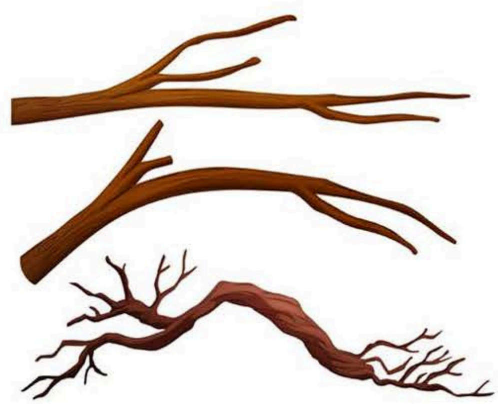
Step 2

Billings Water Treatment Facility

Step 3

Billings Water Treatment Facility

Water Sample



Sticks and Tree Branches

Image by brgfx on Freepik

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Water Sample

Mud & Dirt

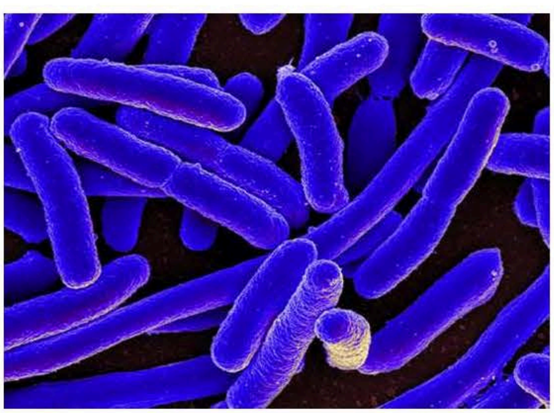
Image by Freepik

Water Sample

Microorganisms
(Small living organisms)

Image by picryl

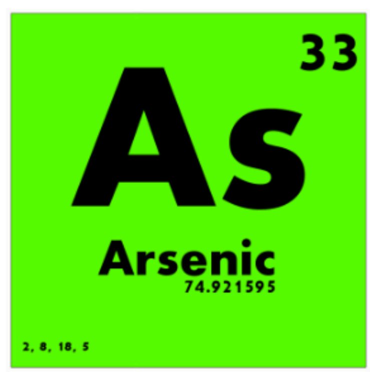
Water Sample



E. Coli Bacteria

Image by Wikipedia commons

Water Sample



Chemicals
(Arsenic)

Creator: Science Activism

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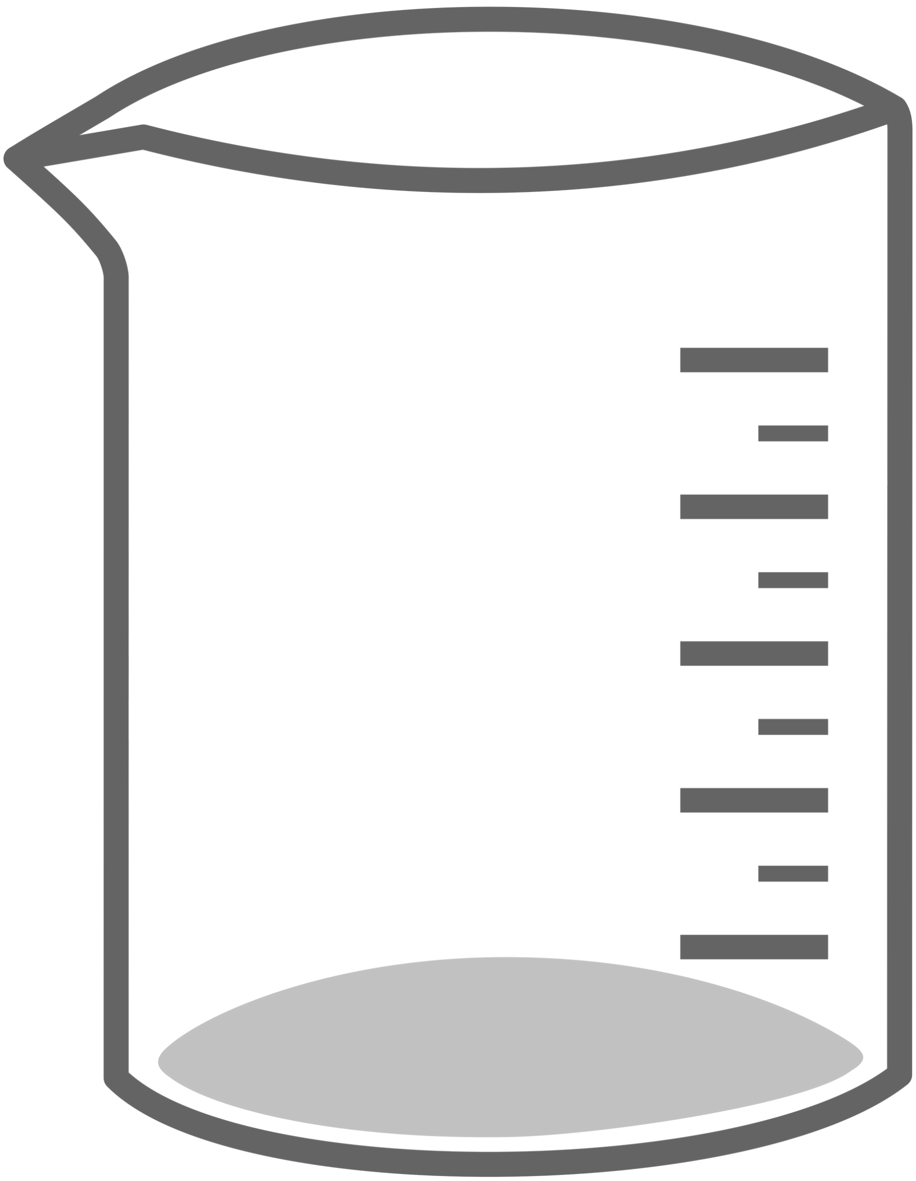
NAME: ________________________

SHOULD DR. QUEEN DRINK WATER OUT OF THE YELLOWSTONE RIVER?

CIRCLE ONE: YES NO

Draw what the water Dr. Queen is about to drink might look like.
Label or draw arrows to at least one thing in your drawing that is macroscopic, microscopic, or atomic.



MACROSCOPIC

MICROSCOPIC

ATOMIC

ATOMIC CIRCUS, LESSON TWO

WHY IS TREATING WATER IMPORTANT?

BACKGROUND KNOWLEDGE: UNTREATED WATER ISSUES

Water is an essential part of our health and daily lives. Clean water continues to be a fundamental issue in the world today and understanding the steps needed to make water potable makes us better consumers, as well as helps us to understand the importance of conservation.
This lesson will be focusing on what constitutes clean water with an emphasis on bulk material including microscopic matter. Just for your (teacher) reference, the naked eye can see particles as small as 50-60 microns. A grain of fine sand is about 60 microns. White blood cells are about 25 microns and many bacterium are between 1-10 micron.

Non-potable (pow·tuh·bl) water which is not safe for human consumption is also called gray water. So how do we remove contaminants from gray water to make it potable, or safe to drink?

Contaminants can be:

- Physical: particles of soil or organic matter from soil erosion
- Chemical: elements or compounds that are natural or human-made, such as pesticides, bleach, nitrogen, human and/or animal drugs, metals, or toxins produced by bacteria. Some chemical contaminants (such as cesium, plutonium and uranium) are also dangerous because they can emit radiation.
- Biological (or Microbial): organisms that live in water, such as bacteria, viruses, protozoan, and parasites

ATOMIC CIRCUS, LESSON TWO

WHY IS TREATING WATER IMPORTANT?

STANDARDS, OUTCOMES, & ASSESSMENTS:

Title	Outcomes	Standard	Assessment
Why is treating water important?	• Describe the relationships between particle sizes. • Identify ways to separate solutions based on particle size.	5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.	"Ask a Biomedical Professional" Student Response Sheet

MATERIALS:

- Video Links
  - Atomic Contamination: https://youtu.be/EndnqDYwf_k
  - Microscopic Contamination: https://youtu.be/gc8X9NHmyWw
  - Macroscopic Contamination: https://youtu.be/VNyl2yTjVU4
- 'Ask a Biomedical Professional' Student Sheet

KEY VOCABULARY:

- Matter- Anything that takes up space is called matter. Air, water, rocks, and even people are examples of matter. The tiny particles called atoms are the basic building blocks of all matter.
- Particle- A small portion of matter
- Macroscopic / Visible- Able to be seen with the naked eye
- Microscopic / Invisible - Unable to see with the naked eye,
  - Visible using a microscope
- Atomic - Too small to be seen with a microscope,
  - All matter is made up of atoms

ATOMIC CIRCUS LESSON TWO

The Atomic Circus Summarizes Water Contamination Size Scales VIDEO LINK

ACTIVATE:

- **Re-watch the** video: The Atomic Circus Summarizes Water Contamination Size Scales
- After the video, ask, "What happens if Dr. Queen drinks the water?" and "Where did the salt go?"

Demo for students:

- Have a clear glass of water- ask students to share:
- What do you see and is it safe to drink?
  - Water should be clear and potable.
- Add a small amount of mud to the glass- ask students to share: "What do you see and is it safe to drink?"
  - Water should still be clear but no longer potable.
- Add a few more drops of muddy water to the glass - ask students to share: What do you see and is it safe to drink?
  - Water should start to appear muddy and is no longer potable.
- Elbow partners into class discussion- Is water that appears clear always safe to drink? Why or why not?

TEACHER TIP!
Use salt instead of mud in the demonstration and have a student try the water

DESCRIBE:

- Share with students:
- What we see in water (at the macroscopic level) is made up of tiny particles too small to be seen (microscopic and atomic level). The water breaks salt apart, just like mud, and carries it around; dissolving it. If you add a lot of salt, the water cannot carry it and you will see it in the glass, just like when you see muddy water. The water cannot dissolve all of the mud, so you can see it!

ATOMIC CIRCUS LESSON TWO

Atomic Circus Videos

Macroscopic

Microscopic

Atomic

ACTIVITY:

1. As a class, watch three videos, collecting information using the 'Ask a biomedical professional' student response sheet. Each video will consider the need for water treatment at one of three levels
   a. Three videos:
      i. Macroscopic level- PA, Billings Clinic- what would happen if I drank a lot of mud?
      ii. Microscopic level- Medical Lab Scientists, Billings Clinic- what would happen if I drank bacteria?
      iii. Atomic level- Energy Labs- what would happen if there's chemicals in the water I drink?
2. After the videos, conduct a class discussion:
   a. Can we see mud, microscopic life, or chemicals in water?
   b. Do these impact whether or not it's safe to drink the water?

DESCRIBE:

Share with students:

Tiny particles that cannot be seen with just your eye can change the properties of the whole glass of water.

Bulk matter that is visible to the eye is made up of tiny particles that the water cannot dissolve.

Both things we cannot see (microscopic & atomic) and things we can (macroscopic) all can make water not safe to drink. From the Yellowstone River, we need to filter and treat our water to make sure that we can drink out of our taps.

NAME: __________________________

ASK A BIOMEDICAL PROFESSIONAL:

WHAT WOULD HAPPEN IF I DRANK BAD WATER?

From the videos, share what the biomedical professionals said would happen:

Physician's Assistant, Billings Clinic	Chemist, Energy Labs	Medical Lab Scientist, Billings Clinic
Stop and Talk Question: What would happen if I drank a lot of muddy water?	Stop and Talk Question: What other chemical contaminants could end up in drinking water?	Stop and Talk Question: What would happen if I drank water contaminated with microscopic life?
Can we see mud with just our eyes? **Circle One. Yes / No**	Can we see chemicals with just our eyes? **Circle One. Yes / No**	Can we see microscopic life with just our eyes? **Circle One. Yes / No**
What was the Physician Assistant's biggest concern?	**How did the Chemist know it was there?**	**How did the Medical Lab Scientist know it was there?**

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ATOMIC CIRCUS, LESSON THREE

HOW CAN I SEPARATE SUBSTANCES BY SIZE?

BACKGROUND KNOWLEDGE: WATER FILTRATION

Water filtration provides safe, potable water for human usage and consumption. Without proper filtration, water remains non-potable as it contaminants. These contaminants can be both micro and macroscopic. Modern filtration technology includes processes such as sedimentation, disinfection using chemicals and UV light, and filtering using large-scale filter systems.

In Lesson Three, students explore the question of, how can we filter water? Students will compare material choices based on their ability to filter effectively with constraints (e.g., time and clarity). Each one of the materials students can select will have the ability to filter at different grain sizes. Larger grain sizes will filter water quickly but small particulates will pass through. Smaller grain sizes will filter water slowly, by contrast, but not allow as many small particulates through. The trade off will be in time over clarity and students should grapple with the constraint in light of the larger context of water filtration.

Key Vocabulary

- Mixture- a material made up of two or more different chemical substances which are not chemically combined.
- Solution- a liquid mixture in which the minor component (the solute) is uniformly distributed within the major component (the solvent).

ATOMIC CIRCUS, LESSON THREE

HOW CAN I SEPARATE SUBSTANCES BY SIZE?

STANDARDS, OUTCOMES, & ASSESSMENTS:

Title	Outcome	Standards	Assessment
How can I filter water?	• Compare material choices based on their ability to filter effectively with constraints (e.g., time, clarity, and cost)	5-PS1-3. Make observations and measurements to identify materials based on their properties. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	Initial Filter Creation Student Sheet

MATERIALS AND SUPPLIES:

- Filtering materials:
  - coffee filters (*ONLY for use with students who need additional support*), cheesecloth (or gauze), cotton (t-shirt), sponge, and cotton balls
- Funnels
- Large cups to hold funnels
- Small cups to hold dirty water

TEACHER TIP!
Dirty water mixture is used for BOTH lessons 3 & 4, keep leftover mixture for the next lesson

DIRTY WATER MIXTURE

This will be used for both lesson 3 and 4. You will need to stir this each time before giving to the students as it will settle.

- For making the dirty water, use a 5 gallon bucket and fill about 1/3 full with water.
  - Add 2 cups of soil to the water (optional- playground dirt)
  - Add 2 drops of food coloring
  - Add 1/2 cup salt
- Stir to mix

ATOMIC CIRCUS, LESSON THREE

ACTIVATE:

- Whole Class- Introduce criteria and constraints. Each material used to filter will come with limitations and benefits. The materials used have a cost and some have properties that help filter water faster or remove smaller particles from water. Our goal is to see how effectively materials can filter dirty water. How clear the filtered water is (water clarity) will help us identify which materials work best. However, each material has constraints or limitations of time and cost. For example, some materials might filter well (good clarity) but are expensive or it might take days for water to pass through the filter.

- Show students a beaker of settled muddy water (dirty water that is left to sit for several hours).
  - Ask the class: “Besides settling, what are some other ways to remove particles from water?”
  - Ask the class: “What types of substances make water dirty?
- Share the available materials to create the filter tests.

- Have students complete the prelab questions 1 & 2 on the Atomic Circus Lesson 3: Initial Filter Creation Student Sheet

ATOMIC CIRCUS, LESSON THREE

LABORATORY PROCEDURE:

The lab can be organized as a whole class or small group activity. For example, stations can be setup around the classroom with all of the materials and you can gallery walk the room as a class. Alternatively, small groups can test all or only one material and report back to the class with the results.

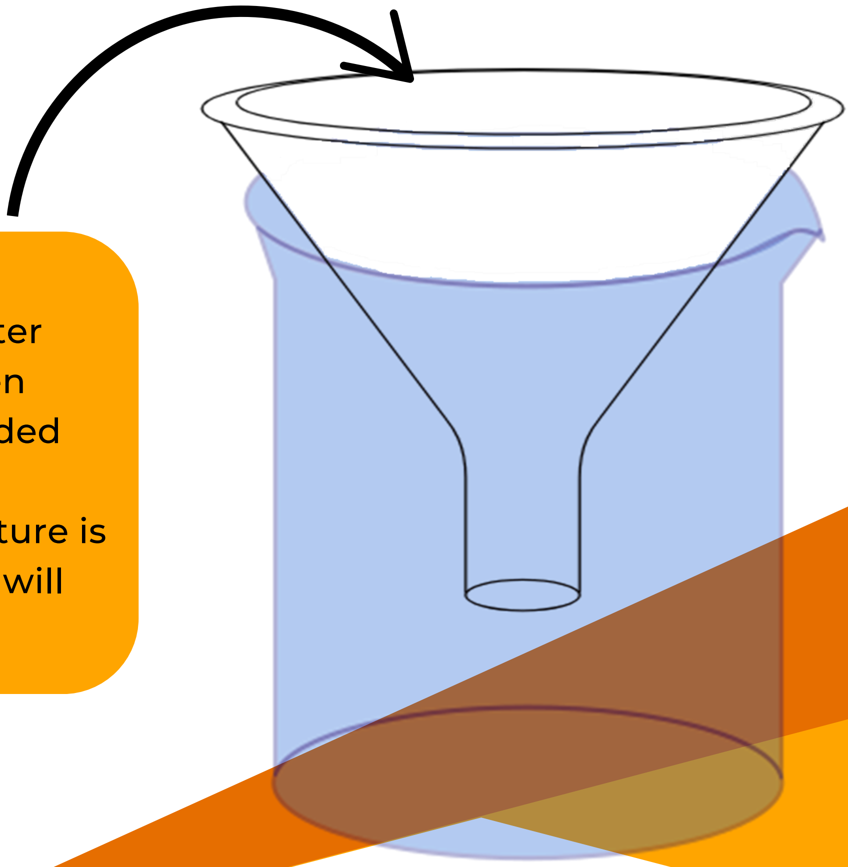
Pre-Lab: Consider defining the CRITERIA and CONSTRAINTS in testing these materials.

As a class, all materials should be tested and observed.

1. Obtain a sample of dirty water (small cup from bin)
2. Set up funnel over a cup or beaker (see image)
3. Insert the selected filter material into the funnel
4. Carefully pour the dirty water into the top of the funnel
5. Observe the water that collects in the cup for up to 5 minutes
6. Write down your observations using the Student Sheet (Data table)

Teacher Tips!
Do not use the coffee filter initially or only use when additional support is needed

The speed in which the mixture is poured through the filter will change the outcome



ATOMIC CIRCUS, LESSON THREE

LABORATORY PROCEDURE CONTINUED:

- No quantitative measures of clarity are taken. All observations are qualitative indicators of filter efficacy; Consider using one of the following approaches to analyze clarity:
    - Line up the filtered samples by color.
    - Side by side comparison
    - Place filtered samples over white sheets of paper
- Clean up and dispose of testing materials.
- Post-Lab:
    - As a whole class, discuss and return to the list of criteria and constraints associated with the initial filter testing process.
    - Ask the question, “Is it safe to drink the clearest filtered water?”

TEACHER TIP!
Keep leftover dirty water mixture for the next lesson; just remix when you go to use it again.

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NAME: ________________________

Initial Filter Creation Student Sheet

Pre-lab Questions:

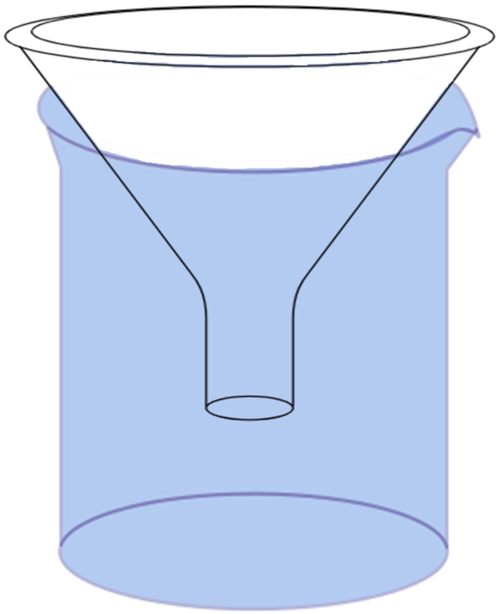
1. Predict what material is going to filter the water best?

2. Why do you think it will filter the best?

Filter materials

Funnel

Beaker



Lab: Data Table

Type of filter material	Observations

Post-lab questions:

Which filter material worked best to meet the criteria of clear water?

Consider the constraints of the materials including the cost and the time it took to filter the water listed in the table.

Which material would you suggest being used to start the process of creating drinking water?

Material	Cost	Time to Filter	Clarity
Cheese Cloth	$5	1 minute	4th place
Coffee Filter	$4	10 minutes	1st place
Cotton	$9	5 minutes	2nd place
Paper Towel	$4	3 minutes	3rd place

Why might using more than one filter material help make the water cleaner?

What two (2) filter materials would you put together to make a “Super-filter”? Why?

ATOMIC CIRCUS, LESSON FOUR

HOW CAN I PURIFY WATER?

BACKGROUND KNOWLEDGE:
ENGINEERING CRITERIA AND CONSTRAINTS

- Criteria - a principle or standard by which something may be judged or decided.
- Constraints - a limitation or restriction.

Unfortunately, in the real world we are rarely faced with unlimited supplies, materials, time and money. Criteria and constraints exist, and are something that must always be acknowledged when engineering a new design.

When creating a water filtration system, the intended use of the water must be thought of. The criteria may change depending on the use for the water. For example, water used for animals on farms has different criteria than household or tap water. The Environmental Protection Agency (EPA) enforces clean water and sets the standard for acceptable water.

When it comes to our drinking water, or tap water, the criteria for the filtration system is potable water. The Safe Water Drinking Act protects the criteria for potable water in the United States.

Constraints also vary depending on the situation. Time, money, and materials are always a factor when designing. A filtration system designed by someone stranded in the woods and another one designed by a city engineering team will differ greatly, because of the constraints.

ATOMIC CIRCUS, LESSON FOUR

GIVEN CONSTRAINTS, WHAT FILTERS WATER MOST EFFECTIVELY?

STANDARDS, OUTCOMES, & ASSESSMENTS:

Title	Outcomes	Standard	Assessment
Given constraints, what filters water most effectively?	• Generate possible solutions to how to filter water effectively • Evaluate solutions based on criteria and constraints (e.g., time, clarity, and amount)	3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem	Super Filter Student Lab Sheet

MATERIALS AND SUPPLIES:

- Engineering a Water Filter Rubric
- 1 T-Shirt Bag
- 2 Cheese Cloth Bag
- 2 Gauze Roll Boxes (10 ct)
- 4 Sponges (4 Ct, Cut in half)
- 1 Cotton Balls (100 ct)
- 50 Large Cups
- 50 Small Cups
- 1 Soil
- 1 Paper Towel
- 15 Funnels
- Permanent Marker

MINI-LESSON - VARIABLES

- Watch: Variables in Science: Independent, Dependent and Controlled! (3:40; https://www.youtube.com/watch?v=J9kCgWAuB0Y)

- Using butcher paper, create a list of independent, dependent, and controlled variables from Lesson 3.
- Refer to this list as introducing Lesson 4.
- Direct students back to the list throughout Lesson 4.

ATOMIC CIRCUS
LESSON FOUR

ACTIVATE:

- Reminder of problem and purpose
  - Possibly a KWL chart to organize information.
  - Problem- Water restrictions have happened in Billings and the water supply can be limited. Many people are unaware of how filtered water gets into their homes.
  - Purpose- Create a water filter that might help to filter water in case of emergencies.
  - Context- In lesson 3, we tested individual components for filtering, collecting data on their ability to filter water. Students should return to these results prior to engaging in Super Filter building.
- Review criteria and constraint vocabulary. Set the criteria (clarity of water & volume of water), and the constraints (time and material choice and amount of material) for the Super Filter Construction.

LAB:

- Tell students that they will have 10 minutes to build the filters (constraint) after the materials have been obtained (constraint). Once they start pouring the water through, they will have 5 minutes for the water to pass through the filter (constraint). After 5 minutes, they are to mark the water line using a pen (criteria).
- Using the plan they created on their approved filter prototype (constraints of materials and amount), groups should build their Super Filters for 10 minutes, and await testing until all are ready to start the 5 minute timer to pass the water through.

ATOMIC CIRCUS
LESSON FOUR

LAB CONTINUED:

- On the Super Filter Creation Student Sheet, students should keep drawings and notes of work as it is being constructed and filtered (During lab questions).
- No quantitative measures of clarity are taken. All observations are qualitative indicators of filter efficacy. May choose to line up the filtered samples by color.
- <u>Each group will take a picture or make a final color drawing of their Super Filter should be taken as a record for the assessment.</u>

TEACHER TIP!
Keep the Super Filter Student Sheets to hand back for the presentations
Ensure that students have taken a picture of their final filter and result for the presentation in lesson plan 5.

EVALUATE:

- Complete the post-lab questions on the Super Filter Creation Student Sheet
- Have a gallery walk of the Super Filters
- Engage in a class discussions focusing on:
  - How does your design compare to other designs?
  - How did the materials you tested impact how effective the Super Filter worked?
  - Is the water filtered potable? Connect back to lesson plan 1-2 with the need to use a biological filter like the water treatment facility.

NAME: ________________________

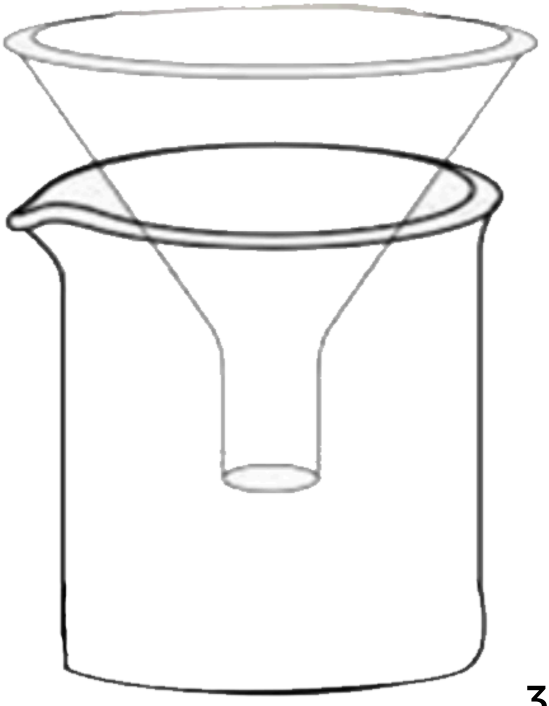
Super Filter Student Sheet

Pre-lab questions

Select 2 materials from your initial filter testing and share evidence for what these materials filter well and what they did not do well. What size particles were filtered out? What size particles do you think are left in the filtered water?

Material (Example: paper towel)	Evidence (Example: removed small pieces of dirt from the water but got clogged with macroscopic pieces)

Draw your Super Filter prototype, label the parts and describe their purpose:



During lab questions:

Share your observations (write or draw) while water is passing through your Super Filter. Example- How fast is water filtering? How clear does the water look after being filtered? Are there issues arising during filtering?

Take a picture of your results and share your results:

- After 5 minutes, use a pen or marker and mark the top of the water line on your cup. What did you water look like after 5 minutes?
- How much water was filtered?________________________
- How clear is the water? Compare your sample to 2 other groups

If your filter wasn't able to filter in 5 minutes:

- How long did it take for water to pass through the Super Filter? ____________________
- What did your water look like then?

CHECKLIST:

Did you take a picture of your filter and filtered water?

- ☐ Yes
- ☐ No

Post lab questions:

- Which Super Filter materials worked the best to make the water look clean? Why?

- What evidence do you have to suggest that your Super Filter worked or did not work?

- Is the water that went through the Super Filter safe to drink? What might you need to do to make it safe?

STUDENT NAME(S): ______________________

____

ENGINEERING A WATER FILTER RUBRIC

Category	Proficient	Nearing Proficient	Emergent
Materials	Student chooses materials with an understanding of the desired outcome, with given criterias and constraints.	Student chooses materials by following directions, but doesn't extend thought to the final outcome.	Student chooses materials with no regard to directions or no thought as to how it will change the outcome of how the filter works.
Plan	Student creates a plan which is recorded. Parts are labeled and descriptions of the purpose of various parts are given.	Student has a plan, but it is a basic outline and doesn't contain specific information for others to observe.	Student does not have a plan recorded.
Construction	Student creates filter with consideration of outcomes and intentional effort.	Student creates filter with minimal effort and rushes to the testing stage.	Student doesn't follow directions for constructing a filter and results are unable to be used.
Data Tracking & Worksheets	Student provides a complete record of planning, construction, testing, modifications, reasons for modifications, and some reflection about the strategies used and the results.	Student work contains information and sketches, but some information has been left out or doesn't provide an explanation.	Student does not keep data or the data doesn't contain enough information to be able to tell about the filter.
Testing Filter	Student records and monitors the outcome of filtering water through the filter. They reflect on their results, relating the construction to the end results.	Student watches the water filter and keeps minimal notes.	Student does not make a connection between the construction of the filter and the water that is being filtered.
Understanding	Student is able to explain with confidence and the use of appropriate vocabulary, the construction of their filter and the results of their filter related to their materials.	Student is able to explain how their filter worked.	Student has difficulty explaining how the filter is used.

ATOMIC CIRCUS, LESSON FIVE

HOW CAN I SHARE SCIENTIFIC INFORMATION?

STANDARDS, OUTCOMES, & ASSESSMENTS:

Title	Outcomes	Standard	Assessment
How can I share scientific information?	• Report on the outcome of the filter development • Share model of filter	5.SL.04 - Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.	Student Presentation

MATERIALS AND SUPPLIES:

- Chromebooks, rubrics, drawings and notes from lesson four
- ACES: Group Work and Collaboration Rubric
- Optional- Google Slide Deck Presentation Template, https://bit.ly/acesfilter

ATOMIC CIRCUS, LESSON FIVE

ACTIVATE:

- Hand back the Super Filter Student Sheet and allow students time to recall their filters and results.
- Ensure that each group has access to the photo of their filter in Seesaw/Photos.

TEACHER TIP!
Students can complete presentations through a number of ways such as:
1. PowerPoint/Google
2. SeeSaw
3. Journal

- Group discussion of some of the positive and negative takeaways from the last lesson (Jigsaw style with each member of the group with another group). 8-10 minutes
  - Possible questions
    - Did the materials work as anticipated?
    - What issues did you encounter with the materials?
    - Describe any results you were not expecting. Why might this have happened? Did variables contribute to the results?
    - Will any of the materials create an impact on the environment?
    - Could your filter be scaled up for a larger group of people?
    - (If an Engineering Focus was used) Would your filter be cost prohibitive if scaled to meet the needs of many?
    - Would your filter adequately address your claim?
    - Is the water potable?
    - What steps should be taken to make the water you filtered safe to drink?

ATOMIC CIRCUS, LESSON FIVE

STUDENT PRESENTATIONS;

Students/Groups return to the original Super Filter group and have 30 minutes to complete a presentation.

- Digital option: Water Filter slide show presentation/ Video of their project (videos can be recorded in Screencastify/SeeSaw, FlipGrid or on the Chromebook and uploaded to Google Classroom).
- Journal option: Use the record of information to create an oral presentation using their notebook under the projector. Rubric should be shared with the students prior to work time. (Vocabulary can be provided, if students need additional scaffolding)

Presentations, in journal or using this Google Slide Template should cover:

- Slide 1: Purpose
- Slide 2: Design (upload picture)
- Slide 3: Process (Upload a picture of notes, if they did not take notes on the computer)
- Slide 4: Results/Conclusion
- Slide 5: Changes you would make to create a more effective filter
- Slide 6: What questions has this activity sparked? What do you want to know more about?

Students write/practice presentations (3-4 minute presentation)
Students perform presentations. (ACES: Group Work and Collaboration Rubric completed by teacher and used for data for reporting on report card.)

AFTER COMPLETING, STUDENTS MUST COMPLETE THE POST-SURVEY, HTTPS://FORMS.GLE/7HK2AL4TZGIR4ACV5

TEACHER TIP!
Google Slide Deck Template for the Presentation can be found at shorturl.at/anpX9 or by scanning this QR code

ACES: Group Work and Collaboration Rubric
Design, Build & Test a Water Filter

Student Name: ___________________

Date: ______________

	Emergent	Nearing Proficient	Proficient
Student Role in the Group:	Student • Unable to fulfill their role • Frequently redirected and reminded of expectations but still unsuccessful	Student • Completes most expectations • Some redirection was needed	Student • Completes ALL expectations • No redirection • Asked for clarification if/when needed
Group Norms:	Student • Did not participate with group • Did not follow rules	Student • Minimal participation or dominates the group • Follows most rules	Student • Participates, shows respect, and takes turns • Follows rules
Discussion of Topic: Water filtration	Student • No participation in discussion, simple or one-word responses	Student • Participates only when asked a question directly and doesn't contribute to the discussion otherwise or does not allow others to share in the discussion	Student • Asks and answers questions as part of the discussion • Allows others to ask and answer questions, too

ATOMIC CIRCUS APPENDIX

STUDENT MATERIALS & RUBRICS

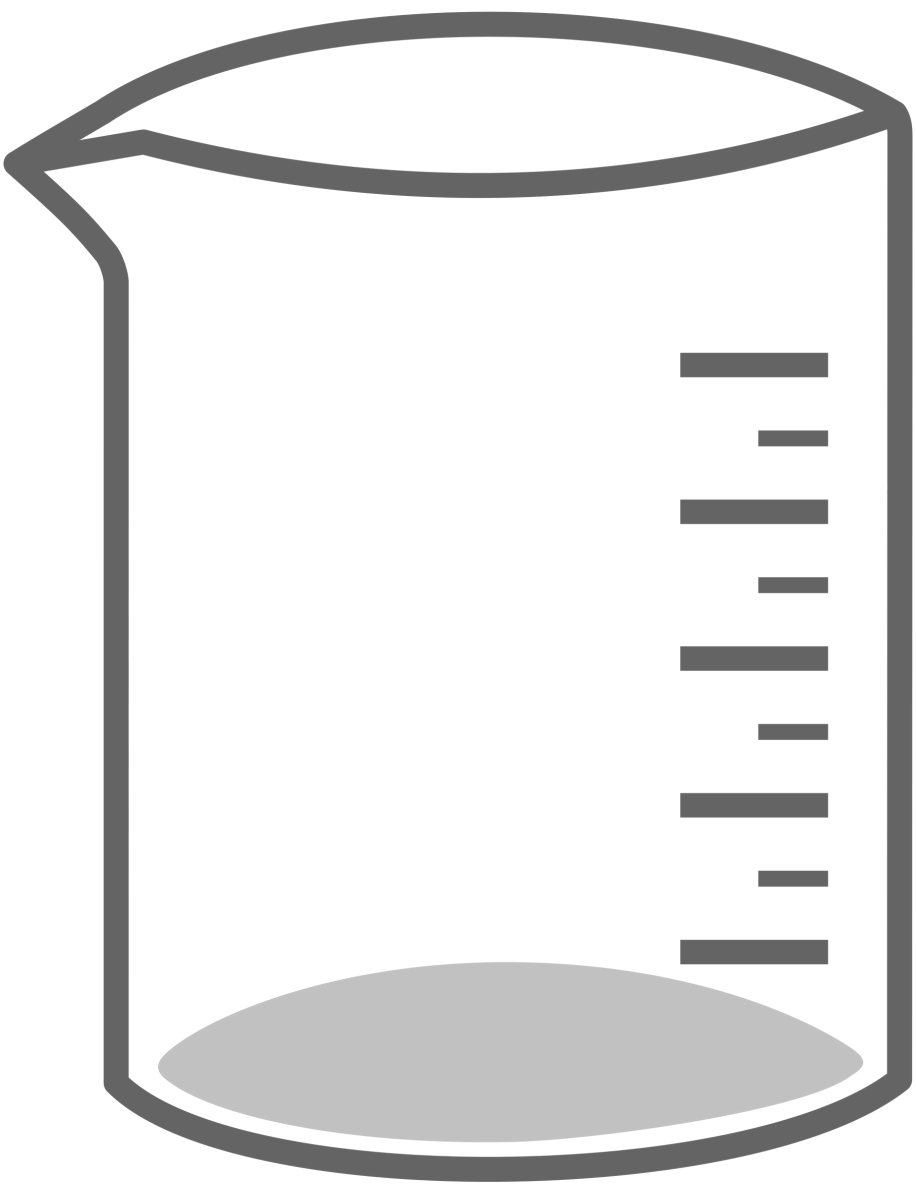
- Lesson 1 Card Sort & “Should Dr. Queen Drink Water Out of the Yellowstone River” Student Response Sheet
- Lesson 2 “Ask a Biomedical Professional” Student Response Sheet
- Lesson 3 Initial Filter Creation Student Sheet
- Lesson 4 Super Filter Student Lab Sheet & Engineering a Filter Rubric
- Lesson 5 Student Presentation Rubric

NAME: ________________________

SHOULD DR. QUEEN DRINK WATER OUT OF THE YELLOWSTONE RIVER?

CIRCLE ONE: YES NO

Draw what the water Dr. Queen is about to drink might look like.
Label or draw arrows to at least one thing in your drawing that is macroscopic, microscopic, or atomic.



MACROSCOPIC

MICROSCOPIC

ATOMIC

Step 1

Billings Water Treatment Facility

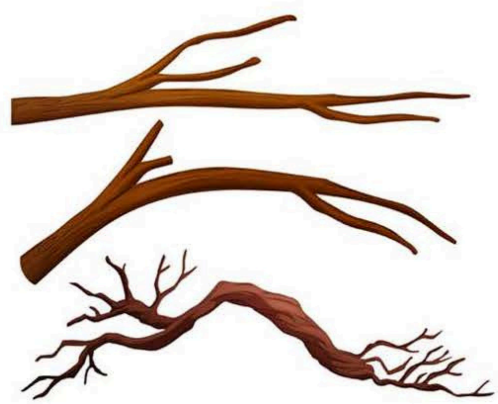
Step 2

Billings Water Treatment Facility

Step 3

Billings Water Treatment Facility

Water Sample



Sticks and Tree Branches

Image by brgfx on Freepik

Water Sample

Mud & Dirt

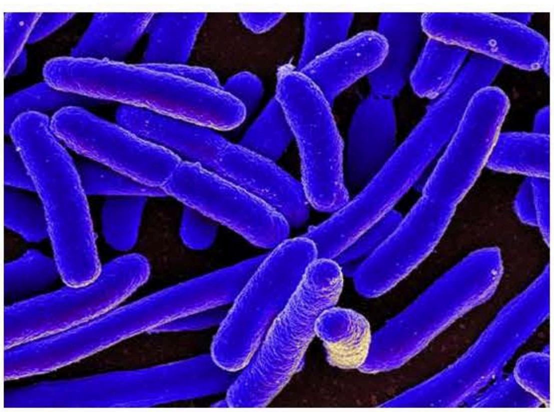
Image by Freepik

Water Sample

Microorganisms
(Small living organisms)

Image by picryl

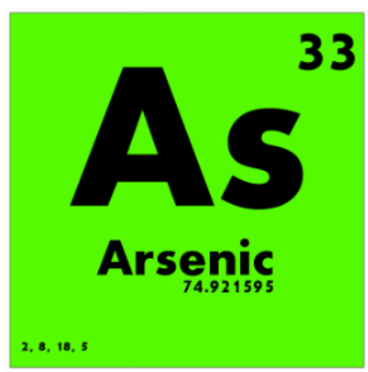
Water Sample



E. Coli Bacteria

Image by Wikipedia commons

Water Sample



Chemicals
(Arsenic)

Creator: Science Activism

NAME: ________________________

ASK A BIOMEDICAL PROFESSIONAL:
WHAT WOULD HAPPEN IF I DRANK BAD WATER?

From the videos, share what the biomedical professionals said would happen:

Physician's Assistant, Billings Clinic	Chemist, Energy Labs	Medical Lab Scientist, Billings Clinic
Stop and Talk Question: What would happen if I drank a lot of muddy water?	Stop and Talk Question: What other chemical contaminants could end up in drinking water?	Stop and Talk Question: What would happen if I drank water contaminated with microscopic life?
Can we see mud with just our eyes? **Circle One. Yes / No**	Can we see chemicals with just our eyes? **Circle One. Yes / No**	Can we see microscopic life with just our eyes? **Circle One. Yes / No**
What was the Physician Assistant's biggest concern?	**How did the Chemist know it was there?**	**How did the Medical Lab Scientist know it was there?**

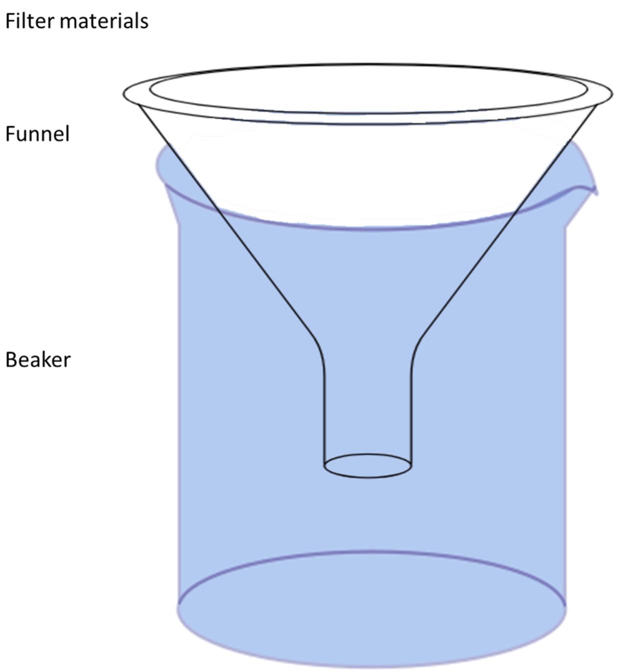
NAME: ________________________

Initial Filter Creation Student Sheet

Pre-lab Questions:

1. Predict what material is going to filter the water best?

2. Why do you think it will filter the best?



Lab: Data Table

Type of filter material	Observations

Post-lab questions:

Which filter material worked best to meet the criteria of clear water?

Consider the constraints of the materials including the cost and the time it took to filter the water listed in the table.

Which material would you suggest being used to start the process of creating drinking water?

Material	Cost	Time to Filter	Clarity
Cheese Cloth	$5	1 minute	4th place
Coffee Filter	$4	10 minutes	1st place
Cotton	$10	5 minutes	2nd place
Paper Towel	$4	3 minutes	3rd place

Why might using more than one filter material help make the water cleaner?

What two (2) filter materials would you put together to make a “Super-filter”? Why?

NAME: _________________________

Super Filter Student Sheet

Pre-lab questions

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