# Investigation 2a: What Do Particles Look Like?

## Goals and Objectives

Students will understand that particles in the air can be collected in various ways and observed.

- Students will use the engineering design process to design a method for collecting particle pollution data.
- Students will calculate the rate of particle collection.

### Time Required

**Two 50-minute periods.**

**You will need a minimum of one class period to design the collectors and a second class period to analyze the results.**

## Standards

**Grade 6, ACCRS, Mathematics, 6.RP.A.3**

Use ratio and rate reasoning to solve real-world and mathematical problems.

**Grade 7, ACCRS, Mathematics, 7.NS.A.3**

Solve real-world and mathematical problems involving the four operations with rational numbers.

**Grade 6-8, ELA, 6.W.1, 7.W.1, 8.W.1**

Write arguments to support claims with clear reasons and relevant evidence.

**Grades 9-12, ELA, 9-10.W.1,11-12.W.1**

Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

## Materials

- Class set of Investigation 2a: Lab Sheet
- Class set of Investigation 2a: Planning Sheet (Option 1 or Option 2)
- Filter paper, one 12 inch piece for each group
- 3X5 index cards
- Graph paper
- Hole punches, one per group
- Scissors, one per group
- String
- Pipe cleaners
- Craft sticks
- Clear transparent tape (not the invisible kind)
- Glue sticks
- 40X Magnifiers or hand lens, one per group
- Microscopes and glass slides (optional)
- Science journals or notebooks

### Essential Question

What is in the air we breathe?

# Particle Pollution

## Teacher Preparation

- Copy a class set of Investigation 2a: Lab Sheet
- Copy a class set of Investigation 2a: Planning Sheet
- Assemble materials for students to use as they design their particle pollution collectors
- Set up microscopes, if available

## Key Vocabulary

**Air Quality Index (AQI):** An index for reporting daily air quality that indicates how clean or polluted the air is, and what associated health effects might be a concern

**Cubic meter:** A unit of volume equal to a cube one meter long on each side

**Concentration:** The amount of an ingredient in a mixture

**Dust:** Fine powder made up of very small particles of earth or sand

**Filter:** A device that is used to remove something unwanted from a liquid or gas that passes through it

**High volume sampler:** An instrument used to collect samples of air particles

**Micrograms:** A weight equal to one millionth of a gram

**Milligrams:** A weight equal to one thousandth of a gram

**Particle pollution:** A complex mixture of extremely small solid and liquid components

## Potential Sources of Error

- When counting particles, it may be helpful to use a grid so that students don't lose track of what they have counted. Pre-made dust particle collectors with a grid pattern are available for purchase from science lab supply companies.
- Many students will realize that air sampling is often about being in the right place at the right time, so be sure to lead a discussion about random sampling and how to minimize error. Good suggestions would include using lots of samples, using larger samples, or samples taken over a long period of time. In addition, ask students to identify potential sources of particles that might affect their measurements, a construction site or unpaved lot, for example.
- If using microscopes, students may need instruction on how to use a microscope.
- If students use a hand lens, they will only see the large, coarse particles; a microscope will allow them to see more detail.

## Accommodations & Modifications

- This investigation is best done in small groups of three to four students. Students may be grouped by ability level to accommodate special populations.
- This investigation may be extended as a homework assignment. Two sets of cards can be made at school. Students will put one set of cards in a re-sealable plastic bag with the sticky side up to take home. This will give students two sets of data to compare.
- If you send the particle collectors home for sampling, caution students not to do anything dangerous; for example, standing in the road.

## Assessment

Students are assessed informally on their contributions to small group and class discussions. Students are assessed on their written expression in science journals and lab sheets.

## Additional Resources

Kids Making Sense: KidsMakingSense.org

Website created to support the Kids Making Sense curriculum.

“A Simple Method for Measuring Air Pollution, Suitable for Schools”, courtesy of Berkeley Lab, a presentation which describes how to make a simple particle pollution collector using an aquarium pump and plastic container:

http://go3project.com/network2/pdf/Hansen_School_BC_Measurement.pdf

Link to PBS kids video: Kid Engineer, The Design Process

http://pbskids.org/designsquad/video/kid-engineer-design-process

Link to information on the engineering design process:

https://www.teachengineering.org/k12engineering/designprocess

# Investigation 2a: Lesson Plan

## Pre-Lab Guiding Questions

Begin the lesson by asking students the following questions:

1. What gases are in the air we breathe? Oxygen, nitrogen, water vapor, carbon dioxide methane, ozone, etc.
2. What else is in the air we breathe? Water droplets, dust, soot, particles, volatile organic compounds, etc.

## Introduction

1. Divide students into cooperative learning groups. Pass out samples of filter paper to each group. Ask them to discuss what they think the papers might be, what the different colored circles represent and how the circles got onto the paper, etc. Students record their ideas in a science journal or notebook.
2. Tell students: Particles in the air can have harmful effects on people's health. So, it makes sense that scientists want to better understand what kind of particles are floating around the different spaces in which people spend time. Collect the filter papers. Students will return to these in Investigation 3b.

## Procedure

Students will work in groups to complete an engineering design project. Their challenge is to design and build an instrument that will collect airborne particles.

Explain: One way scientists collect particles in the air is to use something called a **high-volume sampler**. This sampler uses a pump to pull air through a filter that traps particles of a certain size. The longer the pump is run, the greater the number of particles that will get trapped.

Another way to collect particles is to wait for them to settle onto a sticky surface, like a piece of tape. This method works well with coarse particles, since they settle out of the air quickly. Because coarse particles are larger, you can view them using a classroom microscope or hand lens.

There are two options for this investigation.

# Particle Pollution

## Procedure Continued...

**Option #1**: Students follow the step-by-step directions for building a particle pollution collector using an index card and tape. (See Planning Sheet-Option #1)

**Option #2**: Students design their own particle pollution collectors following the engineering design process outlined on Planning Sheet-Option #2. Students first identify the problem, brainstorm a list of possible solutions, and choose the best one. Then, they draw a diagram of their proposed collector, listing all needed materials. They create a prototype and test it outside. Finally, they evaluate the effectiveness of their collector and revise the design to improve upon it. Option #2 may require additional class time for students to design and refine their collectors.

Regardless of which option is chosen, students will need to give some thought to selecting a location for their collectors, identifying potential sources of particle pollution, as well as any variables that might affect the results of the investigation. It is recommended that students sample the air for a minimum of 24 hours. Students will complete Investigation 2a: Lab Sheet after they have retrieved their particle pollution collectors.

## Data and Observations

- Students will record quantitative data by completing the data table on their lab sheet. Remind them to record the location of the card and the number of small, medium, and large particles they see using either a magnifier or microscope.
- Students will record qualitative data by describing the particles. They may include diagrams or sketches. Students should write a claim statement about the source of the particles and cite specific evidence to support their claim.

## Calculations

Tell students: When a scientist measures particles, he/she uses an air pump to measure the volume of air that passes through a filter. Then, after weighing the particles on a filter, the scientist reports data in µg/L, or micrograms (mass) of particles per liter of air. Since you can't weigh your particles, and we didn't measure how much air touched your card, we'll have to use another measure: rate of particle collection.

Students follow the steps under the calculations section of their lab sheet to determine the particle collection rate.

## Making Sense of Your Results

Working in cooperative groups, students complete the Making Sense of Your Results section of the lab sheet.

## Post-Lab Discussion

Ask students to report their results to the class during a whole group discussion. Other post -lab discussion questions may include the following:

- What are some indoor particle sources? ***Wood smoke, household chemicals, hair, pet hair, carpet fibers, cooking***
- What are some outdoor particle sources? ***Vehicles (from both combustion and tire and brake wear), power plants, fires, pollen, construction dust, volcanoes***
- Do cars make particles? ***Yes, especially if they have black smoke in their exhaust. Particles also come from the rubber bits that rub off of tires.***
- What kinds of vehicles make the most particles? ***Vehicles with unregulated diesel engines, such as old trucks or construction equipment.***

At the conclusion of the lab, students store their particle collectors in a re-sealable plastic bag. They will be needed in Investigation 3a.

## Going Further

A scientist used a filter weighing 4.020 grams to collect particles. After pumping 750 mL of air through the filter, it weighed 4.031 grams. What was the concentration of particle mass in the processed air, in milligrams per liter (mg/L)?

***4.031 g - 4.020 g = 0.011g or 11mg***

***750 mL = 0.75 L volume***

***11mg/0.75 L = 14.7 mg/L***

# Particle Pollution

## Going Further Continued...

The concentration of particles in the air is really small, so the mass units need to be really small as well. We commonly use micrograms instead of milligrams when measuring particle pollution concentrations. We also need a lot of air, so we use a cubic meter instead of a liter of air. Imagine a box of air that is one meter on each side. If my filter paper weighs 2.011 milligrams when clean and 2.023 mg after I pump one cubic meter of air through it, what would the concentration of particles be in $\mu g/m^3$?

***2.023 mg - 2.011 mg = 0.012 mg and there are 1000 micrograms in a milligram, so 12 micrograms of particles per cubic meter of air (12 $\mu g/m^3$). This concentration is well below the current 24-hour standard of 35 $\mu g/m^3$.***

## On a Personal Note

After seeing all the coarse particles collected in this lab, you decide to wear a dust mask from now on. Will that protect you from the most dangerous particles? Why or why not?

***No. The smallest particles are the most dangerous and a dust mask might not stop them. Students might say "Yes, if you buy a dust mask good enough to stop the fine and ultrafine particles that pose a health risk."***

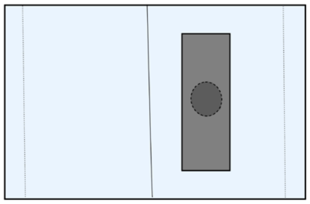
## Enhancements

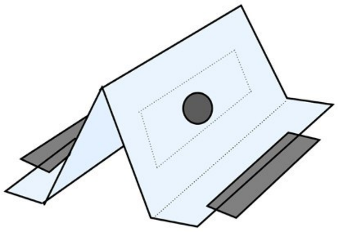
Collect particles from specific sources, such as near a construction site, a busy road, a house with smoke coming out of the chimney, or a farm. Examine the samples under a magnifier or microscope.

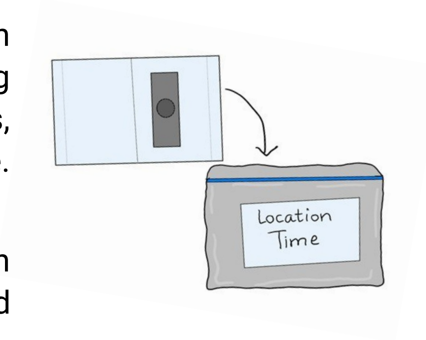
Name: ____________________

# Investigation 2a: Planning Sheet-Option 1

## Procedure








1. Take two 3x5 index cards and fold each one in half.
2. Punch a hole in the middle of one side of each card. Be sure the holes are no bigger than the width of your tape, so that the tape will cover the entire hole.
3. Fold over ½ inch on each end of the index cards to make the cards stand.
4. Place your tape over the hole on each card, with the sticky side of the tape facing outside the fold. Clear tape works best.
5. Put each of your cards in different locations for a measured amount of time. Secure the card to the location with tape. Record on your cards where you put them and how many minutes they sat there. Think carefully about where to put your cards and what type of particles you expect to collect.
6. Take note of the surroundings that might produce particles such as wood stoves, barbeques, cars, lawn mowers, air conditioning units, street sweepers, trains, buses, trees with pollen, animals, dusty fields, pet fur, and evaporating liquids such as gasoline. Draw a sketch of what is near each of your cards.
7. If you are collecting particles away from the classroom, put each of your cards in its own plastic bag to keep them protected between your sampling time and your class period.

### Sketch of Location

Name:

# Investigation 2a: Planning Sheet-Option 2

## Procedure

1. Identify the Problem

2. Brainstorm Your Ideas

3. Choose the Best Solution - Draw a Diagram

List all Needed Materials

4. Test Your Collector! Sketch the Location

5. Improve - How can you refine your design?

Name: ____________________

# Investigation 2a: Lab Sheet

## Data

Examine a clean piece of tape first. This is your control. Now examine your exposed tape. Count the number of particles you see by size and record the numbers in the table below.

If you are using a microscope, gently peel the exposed tape off of the card and stick it to a microscope slide. If you're using a hand lens, be sure to keep your card *sticky side up!*

| Location | Small Particles | Medium Particles | Large Particles |
|---|---|---|---|
| | | | |
| | | | |

## Observations

1. Describe some of your largest particles here, including drawings.

2. Can you tell where they came from? How do you know? Cite specific evidence to support your claim.

**Name:** ____________________

# Investigation 2a: Lab Sheet *(Answer Key)*

## Data

Examine a clean piece of tape first. This is your control. Now examine your exposed tape. Count the number of particles you see by size and record the numbers in the table below.

If you are using a microscope, gently peel the exposed tape off of the card and stick it to a microscope slide. If you're using a hand lens, be sure to keep your card *sticky side up!*

| Location | Small Particles | Medium Particles | Large Particles |
|---|---|---|---|
| *[Answers will vary]* | | | |
| | | | |

## Observations

1. Describe some of your largest particles here, including drawings.

2. Can you tell where they came from? How do you know? Cite specific evidence to support your claim.

***Students will only be able to see large particles and will observe string-like shapes, round pollen, or dark soot-like particles. They should be encouraged to guess what sources produced the particles.***

Kids Making Sense (KMS) is a global environmental educational program that unites science, technology, engineering, and math education to empower youth to change the environment in their communities and to improve public health. KMS teaches youth how to measure particle pollution using air quality sensors and how to interpret the data they collect.

Curriculum and program materials are available to schools in Maricopa County, Arizona at no cost. Please contact the Maricopa County Air Quality Department for details:

**Education Outreach Coordinator**
AQDEducationOutreach@maricopa.gov

Schools outside of Maricopa County, Arizona please contact Sonoma Technology, Inc.:

**Kids Making Sense**
kms@sonomatech.com
707.665.9900

STi | Sonoma Technology

MARICOPA COUNTY AIR QUALITY