Name:

What is Particulate Matter – Vocabulary

Use web resources to define the terms below; provide an example of each.

particulate matter:

$PM_{2.5}$:

PM_{10}:

coarse particles:

fine particles:

aerosols:

primary particles:

secondary particles:

Teacher Comments:

Name

LAB 1: Exploring Particulate Matter

In this activity, you will be exploring a variety of possible air pollution sources, including ones that generate particulate matter. Using the Dylos monitor, observe the particle numbers created as different substances are released in the air. Remember that there are two particle readings, $PM_{2.5}$ and $PM_{2.5\text{-}10}$ - be sure to record both. Using the table below, record your observations.

"Resting" PM Levels $PM_{2.5}$	$PM_{2.5\text{-}10}$	**Sample/Substance**	**$PM_{2.5}$ Particle Count**	**$PM_{2.5\text{-}10}$ Particle Count**

Drawing Conclusions:

1. Which samples did <u>not</u> increase particle count?

2. Do these samples have anything in common?

3. Using the table below, fill in which samples increased $PM_{2.5}$ particle counts and which increased $PM_{2.5\text{-}10}$ particle counts.

$PM_{2.5}$ Particle Count	**$PM_{2.5\text{-}10}$ Particle Count**

4. Looking at your lists above, what observations can you make about the characteristics of $PM_{2.5}$ vs. $PM_{2.5\text{-}10}$ particles?

5. Which of the samples would be found indoors, outdoors, or both?

Indoors	Outdoors	Both

6. What other possible sources of particulate matter can you think of?

Indoor	Outdoor

7. Now that you are more aware of some of the sources of particulate matter, identify the sources of PM within *your own home.*

8. What other indoor environments do you frequently find yourself in and what sources of PM might exist in these environments?

9. Indoor air quality is a rapidly growing branch of scientific research. Why do you think this is?

10. As a class, take a 24-hour Dylos sample in your classroom. Once the data has been collected, again as a class, download the data to a computer. Copy the data to a thumb drive and use the conversion Excel spreadsheet to convert the data from number of particles to microgram/cubic meter, and to generate a graph. Print graph and attach it here. What trends do you see over the 24-hour period? What do you think may have caused these trends?

Teacher Comments:

LAB 2: How do Secondary Particles Form?
Student Lab Sheet

In this lab you will be exploring how emissions can affect air quality by simulating chemical reactions that occur in the atmosphere. You will be synthesizing nitric oxide (NO) gas, a by-product of fossil fuel combustion. Nitric oxide, though a gas, can contribute to particle pollution, particularly in the winter months. In this lab, you will explore how and why NO forms and the potential impact(s) that occur from this reaction. You will be using a lidded petri dish as a contained environmental chamber.

Complete the following steps:

1. Place a clean, dry petri dish onto the circular grid of the lab top.
2. Put drop one drop of distilled water into the petri dish in the positions shown in the diagram. Then drop a single drop of bromocresol green (BCG) solution into each drop of distilled water. (See diagram on next page for a visual of this.) BCG is an indicator for acids and bases; any color changes indicate chemical changes in the petri dish. Observing these changes will help you understand what is produced in the following chemical reactions.
3. Now it's time to simulate the burning of fossil fuels!
    - Measure 1 ml of 0.5 M potassium nitrite (KNO_2). Using a pipette, place it onto the center of the dish.
    - Get the lid of the petri dish ready (Note: you'll want to cap the petri dish right away after the next step).
    - Add 2 ml of 2 M sulfuric acid (H_2SO_4) to the KNO_2. Immediately place the lid on the dish.
    - Watch carefully and record your observations:

    - Though the fluids never touched, the acidity changed. How is this possible? (Hint: consider the phases of matter)

    - What gas is in your chamber at the moment (use the introduction paragraph to answer this)?

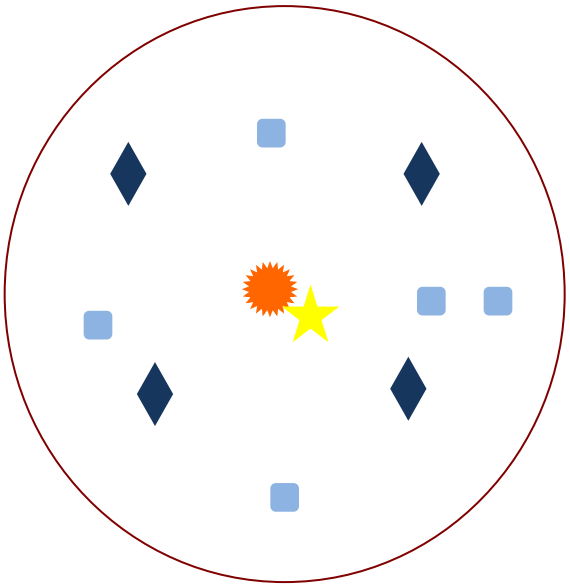
4. You will now simulate another reaction:
    - Lift the lid slightly at an angle. Add a couple of drops of 2 M ammonia (NH_3) in four or five places around the petri dish and replace the lid.
    - Carefully slide the petri dish off the grid and onto an all-black background. Watch carefully and record your observations.

    - You can now test the substance in your petri dish by releasing it near the Dylos. To do this, set the dish 6 inches *behind* the machine. Be sure to record the particle levels before you open the lid to the petri dish, as well as after.
      Before: $PM_{2.5}$- $PM_{2.5\text{-}10}$- **After:** $PM_{2.5}$- $PM_{2.5\text{-}10}$-

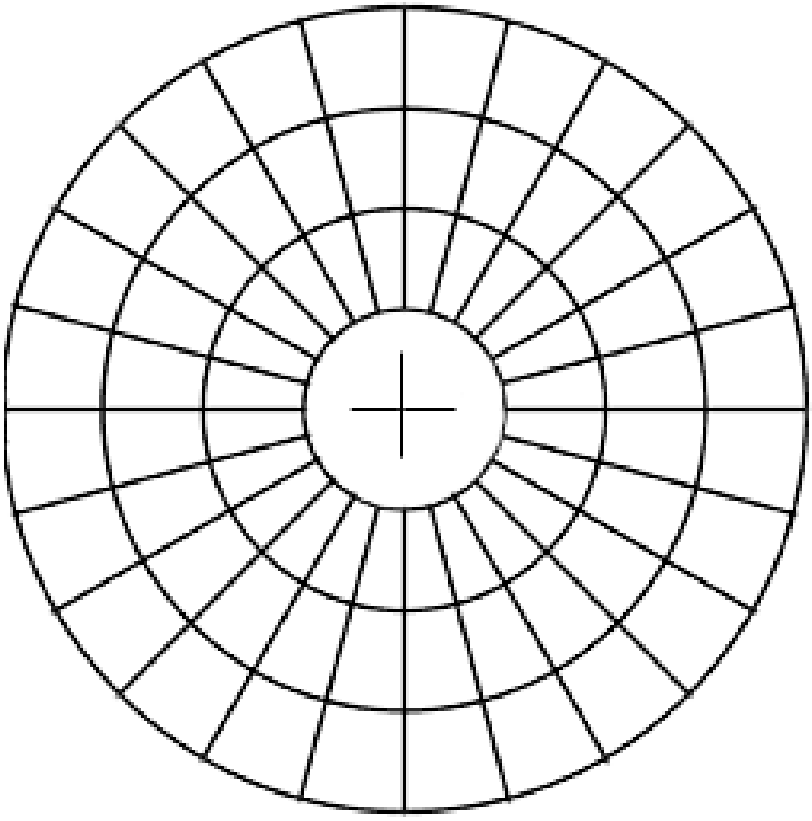
5. Did each particle count change after opening the lid? Using what you know about particulate matter formation, explain why or why not.

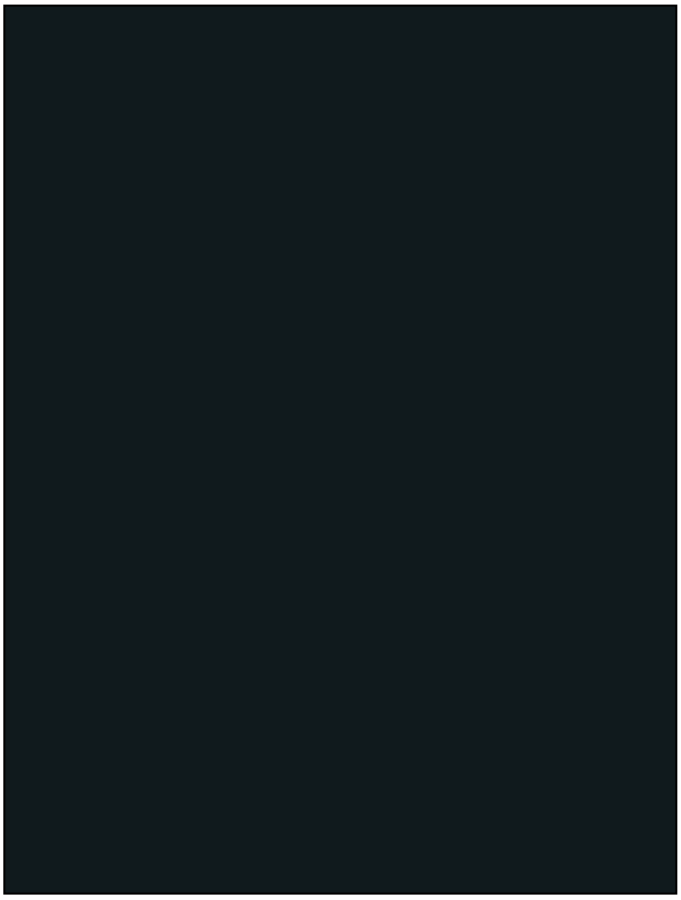
6. In research studies done on seasonal levels of particle pollution, it has been found that secondary particles have much higher concentrations in the summer months. Consider factors that affect the rates of chemical reactions. Why do you think there are more secondary particles in the summer months? Be sure to *explain* your answer.

7. Finish the experiment by rinsing your petri dish in a lab sink, washing it with soap and water, and dabbing dry with a cotton cloth (to avoid scratching).



Lab top





Teacher Comments:

There are many informational resources available for particulate matter. Start by exploring the EPAs website:

http://1.usa.gov/1DOeqph

COMPREHENSION 1

What are the Sources of Particulate Matter?

WHAT IS PARTICULATE MATTER?

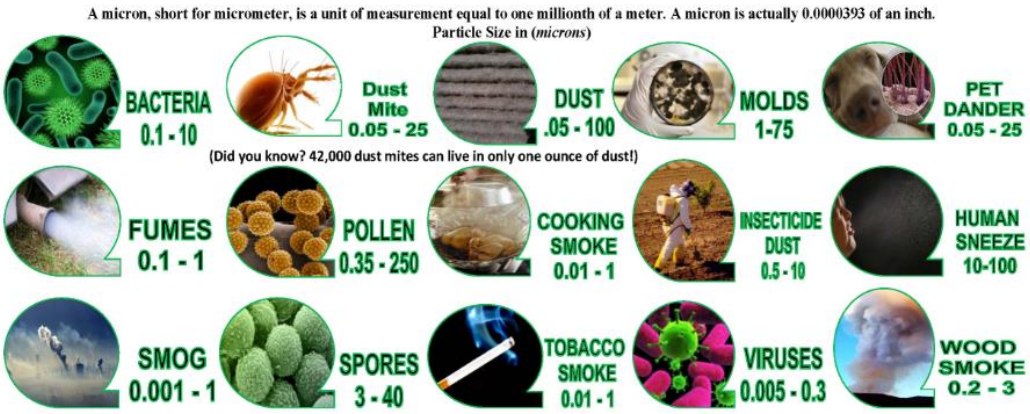
The term "particulate matter" (PM) includes both solid particles and liquid droplets found in air. Many manmade and natural sources emit PM, both indoors and out, including wildland fires, fossil fuel emissions, road dust, wood stove and fireplace emissions, volcanoes, cigarette smoke, and cooking. All forms of particulate matter belong to one of two groups: primary (emitted directly from a source) or secondary (formed through chemical reactions in the air). Secondary particles make up most of the fine particle pollution in the country! Particles can be further categorized based on their chemical composition. For instance, the composition of diesel PM would contain more elemental carbons while PM from wood smoke would have more organic carbons.

Below are the common components of PM and some of their sources:

- sulfates, often associated with emissions from industry
- nitrates, from fossil fuel emission and agriculture
- organic compounds, from all types of combustion, industry, agriculture
- water, vapor from the water cycle
- trace elements (including metals), some are naturally occurring from crustal sources (aka from the Earth's crust), others from industry and burning of fossil fuels

Particulate matter is also categorized by size. PM_{10} particles include those with a diameter of 10 microns and less. A micron is one millionth of a meter (1/1,000,000 m). Many of these can be seen with the naked eye, such as dust and pollen. $PM_{2.5}$ is 2.5 microns or less in diameter. You may equally hear people discuss "coarse" vs. "fine" particles. Fine particles are 2.5 microns or less in diameter. Coarse particles are those that measure between 2.5 microns and 10 microns. The distinction between PM_{10} and coarse particles is subtle but significant; PM_{10} includes all particles between 0.1 and 10 microns, while coarse particles only account for those between 2.5 and 10 microns. When looking at a PM_{10} reading, you are seeing the total number of coarse and fine particles. By subtracting the corresponding $PM_{2.5}$ reading, you get your "coarse particle fraction".

Below is a chart that shows common particulate matter pollutants and their respective size ranges:



WHAT ARE THE HEALTH EFFECTS OF PARTICULATE MATTER?

There are a number of known health concerns associated with particulate matter, though it is still not fully understood and it is the focus of many scientific studies. PM is known to aggravate respiratory and cardiovascular disease (as indicated by increased hospital admissions, emergency room visits, absences from school or work, and restricted activity days), decrease lung function, and trigger asthma attacks. Many scientists focus on $PM_{2.5}$ as it is so small that it can bypass the body's natural defenses – nose hairs and cilia – and make it down through the larynx into the respiratory system, and penetrate deep into the lungs. $PM_{2.5}$ is also linked to certain cardiovascular problems such as non-fatal heart attacks and cardiac arrhythmia (irregular heartbeat). For individuals with heart or lung disease it can even cause premature death. Other individuals who are particularly at risk to particle matter exposure include sensitive populations such as older adults, people with compromised immune systems, and children. It is important to consider that *length of exposure* to PM is a critical factor in what health effects are seen. Short-term exposure may result in respiratory difficulty, while long-term can cause more severe health issues such as cardiovascular disease and premature death.

Regulation of Particulate Matter

With the number of health concerns associated with particulate matter, as well as its broader environmental effects, the Environmental Protection Agency (EPA) enforces strict regulations on emissions as a part of the Clean Air Act. Acceptable levels are based on outdoor 24-hour averages measured in micrometers per m^3 (μ/m^3). The acceptable level for $PM_{2.5}$ is 35 μ/m^3. For PM_{10} it is 150 μ/m^3. Communities that exceed these levels are considered "non-attainment" areas and are required to create state implementation plans addressing how to improve pollutant levels.

Read the EPAs "Fast Facts" for more interesting facts on PM:

http://1.usa.gov/1KpvHJi

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PM LESSON 1: Guiding Questions

Read *What are the Sources of Particulate Matter?* and answer the following questions completely and concisely.

1. What is the difference between $PM_{2.5}$ and PM_{10}?

2. Why are scientists so concerned about $PM_{2.5}$?

3. What is the distinction between coarse particles and PM_{10}?

4. The EPA (Environmental Protection Agency) has set acceptable average levels of particulate matter pollution in a 24-hour period. What is the acceptable average 24-hour ambient (outdoor) level for $PM_{2.5}$? For PM_{10}?

5. What is the difference between primary and secondary particles? Provide at least one example of each.

6. What type of particles (primary or secondary) make up the majority of particle pollution in the US?

7. Match the $PM_{2.5}$ species with the sources in the second column. Note, more than one source may match a species, and sources can match multiple species:

_____ a) nitrate	1. dust
_____ b) carbon	2. car exhaust
_____ c) crustal	3. agriculture
_____ d) sulfate	4. ash
	5. smoke/fire
	6. industry

8. What are some of the possible health effects of exposure to particulate matter?

9. Select your state on the map at the following link. There you will be able to explore the primary sources of particulate matter pollution by county in your state. Select your own county first. Then explore at least 5 other counties in your state. Summarize and explain your findings. http://1.usa.gov/16AGO39

Teacher Comments: