THE ARCTIC, CLIMATE CHANGE AND CONTAMINANTS: PERSPECTIVES FROM ECCC SCIENCE

To bridge between your life and environmental science, ask yourself and others these questions. Talk with your class and community about what you think of, and how you feel when you say these aloud.

What is simultaneously inescapably present and also alarmingly absent?

What is this thing that is all around us, that can tickle the hair on your arm, or make papers flutter off a table?

How does the smell of this AIR evoke a vivid mental image of another time or place?

Your eyes cannot see the AIR. How do you know AIR is REAL?

What does AIR mean to you?
Do you have an AIR story?

How is AIR good?
How is AIR bad?

How is AIR related to your breathing?

Do you make connections among AIR, atmosphere, wind?

Are you a KEEPER of the AIR?

Without your internal wind, you could not speak, you would not live.

Lose AIR = Lose LIFE.

What are some of the gifts of AIR--like temperature? Sunlight?

How can you celebrate AIR?

How do scientists investigate the AIR?
How can you investigate the AIR?

Airborne Aerosols

Question: How do aerosols and dusts travel through the air?

Learning Outcome: This activity is designed to bring awareness to the issues of aerosol and spray pollutants, and how they spread through the air over time.

Background

Aerosols and sprays are used around the world in many households for a variety of purposes, such as paint or hairspray. Aerosols and sprays are some of the main contributors to pollution in the air, as they remain in the air for a long period of time. Air circulates around the globe, so when pollution enters the air in other regions of the world, it drifts towards the low-pollution arctic regions and becomes easier to detect. By using a scented spray in a classroom, we can observe how aerosol pollution travels through the air over time and impacts global air quality.

Time Required

20 minutes setup, 20 minutes observation, 30 minutes discussion

Safety: Do not inhale aerosol directly. Avoid contact with eyes. Ensure that no students have allergies to the spray. Ensure that you are following COVID-19 safety guidelines.

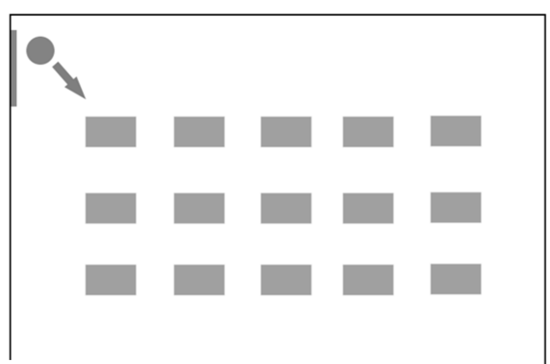
Materials

- Tape Measure
- Scented Aerosol Spray
- Stopwatch or clock
- Projector or digital screen (optional)

Procedure

All students of the class participate in the set-up, observation, and clean up of this activity.

1. Make sure that the scented aerosol spray has a scent that is easily smelled in the air, such as citrus or pine.
2. Decide (as a class) on a starting point to spray the aerosol. A good starting point might be at the front door to the classroom.
3. Use the tape measure to measure and record the distance in centimeters (cm) from your desk or seat to the chosen starting point.
4. Choose a person to stand at the chosen starting point. Have the chosen student spray the aerosol towards the rest of the students. Make sure to use enough aerosol



An Example Classroom
The aerosol is sprayed from the chosen location (circle) towards the rest of the students' desks.

spray so that the scent is noticeable. Start the stopwatch or use the clock to record the time once the aerosol is initially sprayed. If a digital screen or projector is available, the time can be projected to the class for everyone to easily see.

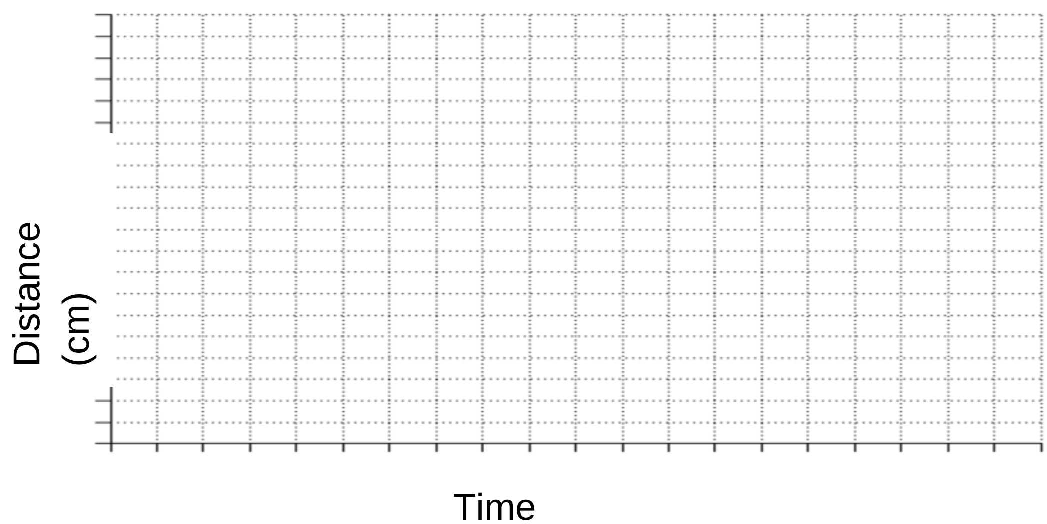
5. When you can smell the spray from your location, record the time that has passed since the aerosol was sprayed, and raise your hand to indicate to the other students that you can smell the scent. You will notice a pattern forming from the aerosol spray starting point spreading throughout the class. Observe and record how the pattern changes over time.
6. Wait 15 minutes from when the aerosol was initially sprayed, or until all students have smelled the aerosol. If you are far from the chosen starting point, you may be unable to smell the spray before the time has passed. Record if this is the case.
7. Gather seven other students' distance and time from the activity and record it in your table.
8. Plot the gathered data on the graph provided and draw a line of best fit through the points. The plot may not be a straight line.

Results

Distance to starting point (cm):

Time from start to smelling spray (min:sec):

Student							
Distance (cm)							
Time (min:sec)							



Discussion

1. What is the shape of your graph? Why does the graph have this shape? What could this show about how aerosol pollution travels?
2. Why might you not be able to smell the aerosol spray if you are sitting further away from it?
3. What sort of pattern or shape formed (as shown by students raising their hands) over time from the aerosol spray starting point? Why might this be?
4. What issues may arise when aerosol pollution “hangs” in the air? How might this affect the environment?
5. Think about how aerosol and spray cans are used. What are some other options you could use to cut down on aerosol usage?

Visibly Invisible

Question: How can you see or visualize air pollution?

Learning Outcome: This activity is designed to bring awareness to the issues of air pollution by allowing dust in the to turn visible to the human eye.

Background

Although it may look clear in most places around the world, the air you breathe is often full of invisible dust. However, this dust can become visible when gathered in one place, like how it builds up on surfaces over time. By priming a surface with an oily material, dust will gather in a large-enough collection to become visible. By observing the oiled paper, we can see how air pollution gathers in the air around us.

Time Required

30 minutes setup, 10 minutes observation for 5 days, 30 minutes discussion

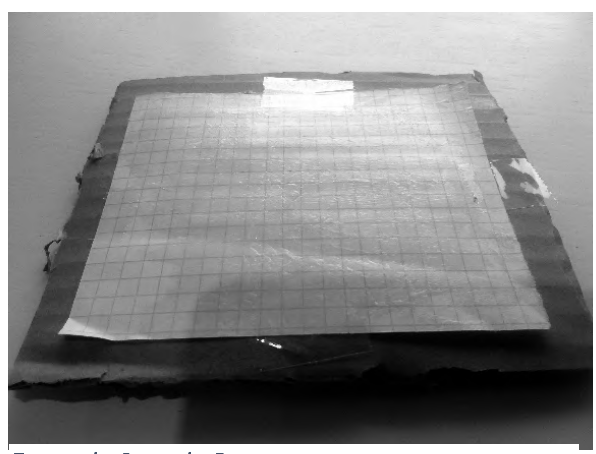
Safety: Do not breathe in dust and pollution on sample. Make sure to dispose of materials properly when finished with the activity. Ensure that you are following COVID-19 safety guidelines.

Materials

- Petroleum Jelly, Vaseline, or a similar oily substance
- 4 pieces of cardstock or cardboard
- 1 piece of grid paper (9” x 11”)
- Magnifying Lens

Procedure

1. Cut a sheet of grid paper into four equal sections. Tape each section to a piece of cardboard large enough to fit the paper.
2. Apply a thin, even layer of the oil to each of the grid papers. Coating the edges of each section is not necessary, as long as there is a thin layer of oil in the middle of the grid paper. You should now have 4 coated sample papers.
3. Place the sample papers in various locations inside the classroom or school. Make sure the sample papers are left in locations that will not be disrupted. Suggestions for possible locations could include:
    a. on a windowsill, shelf, or table
    b. in a closed drawer, cabinet, or locker



Example Sample Paper
Only a thin layer of oil required.

c. next to a wall or floor vent, or near a running heater or generator. Ensure that if placed near a heater, the sample papers will not catch fire.

NOTE: Make sure to place the sample papers in a bunch of different locations to see the effects of where they are.

4. Leave the samples for a week, checking on them and recording what you see each day.
5. To check the sample papers, use a magnifying glass to examine the square on the grid paper with the highest amount of visible dust. You may need to adjust your distance from the sample to properly focus the magnifying glass, as well as ensure that the sample is under good lighting. Count or estimate the amount of dust visible within the chosen square, as well as the shape and colour of the dust, and record what you see. Be careful when looking at the sample papers; if the papers are hit, or if the oil is dropped or touched, your results may be negatively affected.

Results

Observation Table

Locations	**Colour, Shape, and Amount of Dust**				
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Example: Desk	**No noticeable dust**	**4 dust spots, grey, round**	**6 dust spots, grey and brown, flat, and round**	**No change from Day 3**	**Lots of dust, grey/brown with some black, flat, and round**

Which locations had the lowest and highest amount of air pollution? Why?

Discussion

1. Why does the oil help with gathering dust?
2. What might the observed dust be made of? Where might they be from?
3. Why might the dust be different shapes and colours? What might the shapes and colours mean? How might this affect an environmental scientist?
4. What if you were to repeat the activity in a busy city, or in an area with lots of cars or gas heaters? How would this change the outcome of the activity?
5. Is there dust in the air that is still invisible? Why? Is it trapped in the oil too?

If I Could Make Clouds in a Bottle

Questions:
How are clouds formed?
What are the different types of clouds we can see?
How do you think clouds are classified?
Do you think pressure[1] and heat can be related?

Learning Outcome: The goal of this activity is to familiarize students with the different types of clouds and cloud formation.

Background:
In order for clouds to form, three things are required: moisture, the presence of tiny particles in the air called "condensation nuclei"[2], and cooling of air temperature. Without any of these three, clouds will not be able to form. In addition, there are several different types of clouds that can be formed, which can be identified by how high up they are and how they look. Being able to identify these clouds is important, as you can easily predict the weather for the day just by looking at them.

Time Required
5 minutes setup, 5 minutes observation, 20 minutes discussion

Safety: Be careful when using the air pump. Do not overpressurize the bottle. Do not look directly above the bottle when pumping air. Do not breathe in the fumes. Follow COVID-19 safety guidelines.

Materials
- Plastic bottle
- Isopropyl alcohol (not pure, works with 70%)
- Air pump
- Stopper (if necessary, block off bottle completely)

Procedure
1. Pour a small amount of isopropyl alcohol into the bottle.
2. Rotate the bottle around to cover the inside surface with the alcohol.
3. Pump air into the bottle. Use the stopper to prevent air from leaking out. There is a hole in the stopper for you to put the needle of the air pump through.

4. Keep pumping air in. The bottle should start to make stretching sounds. If you can't compress the bottle with your hand, the bottle should be ready.
5. Release the air pump.

Results

What happened when you released the pump?

Discussion

1. Explain why you think this experiment worked. Think about the three things that are needed for cloud formation and how they were satisfied.
2. Repeat the experiment again. This time, cap the bottle with the pump again after releasing it. Apply pressure into the bottle. What happens inside the bottle and why does it happen?
3. Looking at the tables attached, try to identify what type of cloud the one you made in the bottle resembles. Then list out the cloud's key features (height, shape, properties).

Discussion Wrap-Up

The goal of this experiment was to simulate the creation of a cloud to gain an understanding of cloud formation in the atmosphere. The isopropyl alcohol solution[3] contains the condensation nuclei in the form of molecules of isopropanol. The solution also contains water molecules, as the mixture isn't pure (is not only isopropanol), which provides the moisture necessary. The cooling may be somewhat harder to understand. When you pumped air into the bottle, since there was no place for the air to escape from, the bottle kept getting filled with air and increased in pressure[2]. This in turn increases the internal temperature of the bottle. When you released the pump, the rapid depressurization of the bottle quickly decreased the internal temperature of the bottle, providing the necessary cooling.

The tables attached are to help visualize the different types of clouds and show how to recognize them. Look outside. What kinds of clouds do you see?

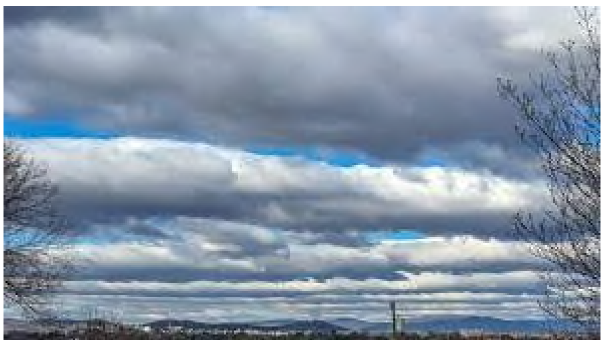
Glossary
[1]Pressure: the force exerted on an object by something in contact with it (air particles against plastic bottle).

[2]Condensation Nuclei: small particles in the atmosphere (eg. smog, smoke, pollen).

[3]Solution: a mixture which contains an evenly distributed part.

Cirro (high)	
Cirrus 	- Thin wispy appearance
Cirrocumulus 	- Thin and cotton-like
Cirrostratus 	- Thin sheet of cloud - If sun/moon visible, produces halo effect

Alto (mid)	
Altocumulus 	- Layers of round clouds in groups/lines
Altostratus 	- Gray or bluish-green sheet of cloud
Altocumulus Castellanus 	- Altocumulus that towers upwards

Strato (low)	
Stratus 	- Uniform layer of cloud
Stratocumulus 	- Layer of round clouds closer to ground
Nimbostratus 	- Low and dark layer of clouds - Nimbo indicates precipitation

Vertical Development	
Cumulus 	- Lumpy white cloud
Towering Cumulus 	- Cumulus cloud that builds upwards - Similar to Altocumulus Castellanus
Cumulonimbus 	- Development of Towering Cumulus - Anvil-shaped top

Float Like a Butterfly, Sink Like a Stone

Questions:
What are the fundamental principles of buoyancy?
Why do things sink and float?
What is Archimedes' principle?
What force keeps objects from sinking?

Learning Outcome: The goal of this activity is to introduce students to the concepts of buoyancy[1], density[2], and pressure.

Background:
You may have done a simple experiment where you pour oil onto water and observe that the oil will float on top of the water. This happens as a result of buoyancy. Buoyancy is an upward force exerted by a fluid that acts against the weight of an object in the fluid.

Archimedes, a Greek mathematician, stated that the volume of water displaced by an object is equal to the volume of an object immersed in water. If the object is denser than the water is, it has more mass than the water while having the same volume. The greater mass increases the force of gravity[3] on the object to the point where the buoyant force cannot keep it afloat. The opposite goes for less dense objects, which have less mass in the same volume, and therefore a weaker force of gravity acting on them.

The oil is less dense than the water, so it sits atop it. The principle of buoyancy can be applied to many real–world examples. Helium balloons will float upwards in the air, hot air rises and cool air falls, a boat will sink when too much water enters them. Density is how much of a substance can be found in a certain volume of that substance. Objects that are less dense have less mass in a certain volume while denser objects have a greater mass in the same volume.

Time Required
15 minutes setup, 5 minutes observation, 40 minutes discussion

Safety: Be careful when using the air pump. Do not overpressurize the bottle. Do not breathe in the fumes. Follow COVID-19 safety guidelines.

Materials
- Plastic bottle
- Bendable Plastic Straw
- Paper clips
- Water

Procedure

1. Fill the bottle with water. Not completely, but there shouldn't be much space remaining.
2. Take a bendable straw and bend it completely. Cut the straw so that the straw's lengths on each side of the bend are equal.
3. Take a paper clip and make a "V"-shape with it. Put both ends into the straw holes.


4. Attach more paper clips onto the V. Keep adding paper clips until the bend of the straw floats just above the water. (This step is extremely important. If the diver does not float or floats too high, the experiment won't work.) An image of a functional diver is shown below.

5. Put the finished diver into the water again.
6. Squeeze the bottle.

Results

What happened when you applied pressure onto the bottle? What about when you release the pressure?

Discussion

1. Why did the diver sink when you squeezed the bottle? Explain what is happening to the diver when you apply pressure to the bottle. What does the pressure do to the diver?
2. Why does the diver rise when pressure is released?
3. Do you think you could do this experiment without the paper clips? Why or why not?
4. What do you think would happen if you repeated this experiment with oil instead of water? How much pressure do you think you would need to apply to the bottle?

Discussion Wrap-Up

This activity allowed you to practice using the concept of buoyancy to help visualize how it works. When the diver was floating on the water, there was a small space above at the bend of the straw that kept it afloat. However, when you squeezed the bottle, the water flowed upwards into the straw due to its compressibility[4]. With nothing to keep it afloat, the diver sank. However, once you released the bottle, the water flowed out of the straw, and the diver surfaced again. Water is denser than air, so when it occupied the space inside the straw, the mass and density of the diver increased, so it sank below the water. However, when the air was in the space inside the straw, the mass and density were low enough such that the diver could float on top of the water. Hopefully, you now understand how buoyancy and density work in our daily lives!

Glossary

[1]Buoyancy: Upward force exerted by a fluid onto an object on/in the fluid. Counters gravity.

[2]Density: amount of an object (mass) in a given space (volume)

[3]Gravity: Force of attraction between any two objects that have mass. On Earth, downwards force that pulls us towards the planet.

[4]Compressibility: The ability for an object/fluid to be compressed.

Paint the Sky

Questions:
How can we visualize precipitation[1]?
How does rain fall to Earth?
How are rain droplets[2] formed?
How does the weight of a rain droplet affect how soon it will rain?

Learning Outcome: The goal of this activity is to simulate a nimbostratus cloud and allow students to visualize how precipitation works.

Background:
The formation of clouds is attributed to three factors: moisture content, the presence of small particles in the atmosphere called condensation nuclei, and cooling. Without any of these three, clouds will not be able to form. In addition, there are several different types of clouds that can be formed, each able to be identified by their altitude[3] and shape. Being able to identify these clouds is important, as you can easily predict the weather for the day just by looking at them.

Time Required
5 minutes setup, 10 minutes observation, 15 minutes discussion

Safety: Follow COVID-19 safety guidelines.

Materials
- Jar
- Water
- Shaving Cream
- Food Colouring
- Timer

Procedure
1. Fill a jar with water. Leave a little space at the top.
2. Spray a layer of shaving cream on top of the water. Don't close the jar.
3. Add a few drops of food colouring on top of the shaving cream. Pick a colour you like!
4. Watch what happens in the jar.

Results
Time to Rain: ___ s

What happened inside the jar? What kind of weather does this remind you of?

Discussion

1. Look at the shaving cream in the jar. What does it resemble? Think back to the table you were given in the previous cloud activity, and what kinds of clouds are usually associated with precipitation.
2. Try adding more drops of a different colour of food colouring onto the shaving cream. Track how long it takes for the new drops to fall into the water.

Discussion Wrap-Up

The purpose of this activity was to further expand your knowledge of clouds, and more specifically, how precipitation works. The shaving cream at the top of the jar resembles a nimbostratus cloud, although depending on the height and shape, could also resemble a cumulonimbus cloud. Notice that both cloud types contain a similar word in them. The prefix "nimbo-" and the suffix "-nimbus"[4] is used to signify that a cloud type is associated with precipitation. When you added the food colouring onto the shaving cream, it gradually sank because it was heavier than the cream. This closely resembles what happens in the atmosphere when it rains. In reality, water vapour in the clouds gradually condenses into heavier and heavier droplets until the droplet becomes heavy enough and falls down to Earth.

Glossary

[1]Precipitation: some form of water vapour that falls from clouds (snow, rain, hail)

[2]Droplets (Rain): small volumes of condensed water vapour

[3]Altitude: How high something is off of the ground.

[4]Nimbo-/-nimbus: pertaining to rain

Take Away Activity

Now that you know the different types of clouds, try to use this knowledge in your day to day life! Knowing different types of clouds and their associated weather can help you plan out your daily activities. Whenever you get the chance, take a quick break and look to the skies to see what you can find!

Battleship!

Questions:
How can you use buoyancy in your daily life?
What can you do to make something as buoyant as possible?

Learning Outcome: The goal of this activity is to give students time to explore the concepts of buoyancy in a friendly competitive setting.

Background:
To recap, buoyancy is an upwards force exerted by a fluid[1] that acts against the weight of an object on the fluid. Buoyancy helps keep objects afloat in a fluid, such as water or air. Boats don't sink because of buoyant forces acting upwards on the boat.

Time Required
1.5 hour setup, 30 minute observation, 30 minute discussion

Safety: Be careful when using the scissors. Follow COVID-19 safety guidelines.

Materials
- Styrofoam Boards (2 per group, 20" x 30")
- Plastic bottles (2 per group)
- Tape Roll
- Scissors (1 per group)
- Bin
- Water
- Timer
- Wooden blocks (6)

Procedure
1. Divide members into equal groups. Try to aim for 4-6 groups.
2. Provide each group with materials. Make a boat! Each boat will be judged in three categories: aesthetic, materials used, and max weight the boat can carry. Students are allowed to use any other materials they may have (stationary, empty food containers, etc). The boat must have a flat surface for blocks to be placed on. The boat must also fit inside the bin.
3. After the given time for construction passes, students should bring their boats forward and prepare for the competition.
4. Judge the boats in the following order: aesthetic[2], size, and max weight the boat carries.

Aesthetic: Class decision.
Size: Smallest boat is best.

Max Weight: Longest time remaining afloat in bin.

5. Add water into the bin and place a boat into the water. Start a timer.
6. Add in a block every 15 seconds.
7. Record how long the boat stays afloat for. Repeat for every boat.

Results

Boat Parameters
Length:
Width:
Height:

How many blocks did your boat carry?
How long did your boat stay afloat?

Which group won the aesthetic competition?
Which group had the smallest ship?
Which group's boat lasted the longest?

Discussion

1. Look at the boat that stayed afloat the longest. What kinds of features and structures does it have? If multiple groups lasted the whole minute, did they share any features or do they have differences?
2. How did your boat do? What would you have changed for next time to improve your boat's performance?
3. For this scenario, you were given a set of materials to use. If you were going to repeat this experiment on your own, what kinds of materials would you use?
4. Explain why the boat sinks as more blocks are added onto it.

Discussion Wrap-Up

The purpose of this activity was to provide students with a fun way of using the principles of buoyancy. The goal was to create a boat from given materials that would be able to continue floating while a weight was added on top of it. Depending on how your boat was designed, it may have held a certain amount of blocks, or maybe even all six. There's no specific rule that has to be followed to make a boat that floats, but generally, you should try to have more space for air inside the boat to help keep it afloat. Hopefully by now you have a good idea of how buoyancy works and how to use it in real-world scenarios!

Glossary

[1]Fluid: a substance that takes the shape of its container and can flow easily (eg liquids and gases)

[2]Aesthetic: visual appeal, concerned with beauty

Don't Fear the Atmosphere – The Sky Is Falling

Questions:
When you are outside and look up, what do you see? What do you imagine?
Where does the air that you breathe come from?
What happens if the air that you breathe is contaminated?
What is the atmosphere? Can you name the different layers of the atmosphere?

Learning outcome:
This activity is designed to bring awareness to the importance and structure of the atmosphere.

Background:
The atmosphere[1] is made up of many layers of gases that surround the Earth and are held around it by its gravity. The atmosphere is important for the survival of every species on Earth; it gives us the oxygen we need to breathe, it keeps our planet at habitable temperatures, it protects us from UV radiation,[2] and more. The atmosphere is made up of five major layers, listed in order of distance from the surface of the Earth: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. The troposphere is the layer closest to Earth's surface and is responsible for holding the oxygen we need to breathe, regulating temperature, the formation of clouds, and more. It is also the layer that is most directly affected by pollution: pollutants build up in this layer and contaminate[3] the air we breathe. In this activity, you will visualize the different layers of the atmosphere in a jar.

Safety:
Careful not to spill or drop the glass jar. If any allergies are known to any of the materials used, get the student to observe the experiment from a distance. Maintain social distancing.

Materials:
- Honey (¼ cup)
- Corn syrup (¼ cup)
- Clear dish soap (¼ cup)
- Water (¼ cup
- Vegetable oil (¼ cup)
- Transparent narrow jar
- Food colouring

Methods:
1. Mix 2-3 drops of food colouring in the ¼ cup of honey, and 2-3 drops of a different colour food colouring in the ¼ cup of water.
2. One by one, gently pour each substance in the transparent jar in order of decreasing density[4]: honey, corn syrup, dish soap, water, and vegetable oil. Be careful not to allow the denser substances (honey, corn syrup, and dish soap) to stick to the side of the jar; try to place them

directly on the bottom of the jar or on top of the previous layer. Pour as gently as possible to avoid mixing of the layers.

3. Allow the layers to clearly separate for about two minutes. In case any mixing occurred during the previous step, this time will allow the five substances of different densities to clearly separate into layers.
4. Observe the layers and record observations Table 1.
5. Wait two minutes, and record observations again. Has the colour from the honey layer or water layer moved to the surrounding layers?

Figure 1: The layers of the atmosphere are visualized above with honey, corn syrup, dish soap, water, and oil. This is an example of what this experiment may look like; your jar may look different!

Results

Record observations in the table below:

Names:	
What do you observe in the jar once all substances are added?	
Record your initial observations.	
Record your observations after 5 minutes. Has the colour moved to other layers?	

Table 1: Initial and final observations of the layers formed in the jar.

Discussion

1. Assuming the bottom of the jar is the Earth's surface and the substances are the layers of the atmosphere, which atmospheric layer corresponds to which substance?
2. What were the sizes of the layers in the jar? Is this reflective of the true size of the atmospheric layers? What would need to be changed to account for their true sizes?
3. Why do the substances form distinct layers? Is this physical property[5] what distinguishes one atmospheric layer from the next? If not, what physical property is used for this?
4. When adding the food colouring to the bottom layer (honey), what real life phenomenon do you think this was mimicking? In the atmosphere, which layer do you think is most affected by pollution?
5. Did the food colouring move to the other layers? Is this reflective of real life phenomenon (i.e. when pollution is generated in the troposphere, do you think it moves to other layers of the atmosphere)? Why or why not?

6. If aerosols (contaminants) are sprayed in Spain and blown by the wind across the Atlantic Ocean to Iqaluit, how long do you think it would take for you to smell it assuming that the scent remains? (Hint: look back at the results of the Airborne Aerosols activity).

Discussion Wrap-Up

This experiment was designed to provide a visual of the five main atmospheric layers. Honey, corn syrup, dish soap, water, and vegetable oil were stacked in a jar to form layers, meant to illustrate the troposphere, stratosphere, mesosphere, thermosphere, and exosphere, respectively. While the layers in the jar were all of equal sizes, the real atmospheric layers differ greatly in their thickness. Roughly, the troposphere is 12km, the stratosphere is 38km, the mesosphere is 30km, the thermosphere is 610km, and the exosphere is 300km. The topmost layer is roughly 25x thicker than the one closest to Earth! The topmost layer is also much less dense than the troposphere, as represented in this activity. However, in real life, scientists use temperature, not density, to distinguish between the atmospheric layers. Temperature differences between layers is also what often prevents mixing of air in the layers. At the top of the troposphere, there is a thin layer of cold air, and at the bottom of the layer just above it, the stratosphere, there is a thin layer of warm air. This stable arrangement (which is further explained in the activity discussing temperature inversions) prevents mixing of these layers, meaning that pollution in the troposphere most often remains there. As seen in this activity, the food colouring mimicking pollution in the honey and water layers did not travel elsewhere, just as is the case in the atmosphere. Throughout this activity, you have hopefully gained a greater appreciation of the air that surrounds you. If you go back to the questions at the start of the activity, are your answers now different?

Glossary

[1]Atmosphere: The layers of gases that surround a planet, in this case Earth. A strong gravitational force must exist to hold the atmosphere in place. Did you know that the Moon has no atmosphere because its gravitational force is too small?

[2]UV radiation: UV stands for ultraviolet. This is energy that is emitted from the sun and reaches the Earth. It can be harmful to humans, and the ozone layer in the stratosphere acts as a protective layer to block some of this radiation.

[3]Contaminate: The act of making something impure or unclean. In this case, we are talking about pollutants that are making the air we breathe impure. The substances that are responsible for the contamination are called contaminants.

[4]Density: A measure of the mass of a substance per unit volume (such as grams per millilitre). Substances with lower densities will stay on top of substances with greater densities (denser substances).

[5]Physical property: A quality of a substance that can be measured, such as density, temperature, boiling point, etc. In this case, we are asking which measurable quality is used by scientists to differentiate between the atmospheric layers.

When the Air Stops Moving – Visualizing a Temperature Inversion

Questions:
What is air?
What causes air to move? What do you think air looks like when it moves?
What would happen if air stopped moving?
Where do you think the air is the warmest? Where the air is the coolest?
What is a temperature inversion and how does it affect the movement of pollutants in the troposphere?

Learning objective:
This activity is designed to bring awareness to temperature inversions and the effect they have on the movement of pollutants.

Background:
As investigated in a previous activity, the atmosphere is made up of five layers, the closest to human life being the troposphere. In this layer, warm air is closer to the surface of the Earth, and cold air is above it. If you were to climb a tall mountain, you would find that the air at the top is much colder than the air at the bottom. Since warm air is less dense[1] than cold air, this creates a constant mixing as the warm air rises and the cold air falls. The cold air that has fallen is warmed up by the surface of the Earth, and the warm air that has risen is cooled down, continuing the cycle. This mixing is called a convection current[2]. However, a temperature inversion[3] may sometimes occur. This is when cold air is trapped at the bottom and warm air is at the top, which is an "inversion" of the usual arrangement. It often occurs in winter when the surface of the Earth is cold and cools the air above it. Since the denser air is now at the bottom and the lighter warm air is above it, there will be no convection current, and the air will not mix. The bottom layer of cold air will be "trapped" in place, and pollutants[4] emitted in it will also be trapped due to the lack of the usual mixing of air. The pollutants will build up and create unhealthy air conditions. This stable arrangement can often last days, or even weeks. In this activity, you will visualize the mixing of hot and cold fluids[5] during normal conditions, and observe the static nature of a temperature inversion.

Materials:

- Food colouring
- Water
- Four jars of equal size
- Funnel/tube/paper towel carton if doing the first option
- Thick plastic card/playing card if doing the second option
- Freezer (or fridge)
- Labels and pen OR Erasable marker
- Microwave/Stove/Hot Plate

Safety:

Careful not to drop the jars. Careful not to burn oneself with the hot water or hot plate. Maintain social distancing.

Methods:

Two options

Option 1 (easier, less visually interesting):

1. Fill all jars about half-way with water.
2. Label two jars “cold” and two jars “warm.”
3. Place the two “cold” jars in the freezer for about 20 minutes, or until very cold but not frozen.
4. Place the two hot jars one at a time in the microwave for 30-60 seconds one at a time – may need more or less time (use 15 second increments until hot to the touch). Make sure to do this when the cold jars are almost ready to be removed from the freezer as we do not want the hot water to reach room temperature while we wait for the cold jars to cool.
5. Add three drops of red food colouring to both “hot” jars, and three drops of blue food colouring to both “cool” jars once steps 3 and 4 have been successfully completed and a temperature difference is observable to the touch.
6. Place a funnel in one of the “cold” jars so it touches the bottom, and gently pour the contents of one of the “hot” jars in the funnel so it is placed below the cold water. Record observations.
7. Repeat step 6 in the opposite manner. Place the funnel in the remaining “hot” jar so it touches the bottom and gently pour the contents of the remaining “cold” jar in the funnel so it is placed below the hot water. Record observations.

Option 2 (harder because of placing one jar on top of the other, more visually interesting):

1. Fall all jars nearly all the way with water but leave a little room at the top.
2. Label two jars “cold” and two jars “warm.”
3. Place the two “cold” jars in the freezer for about 20 minutes or until very cold but not frozen.
4. Place the two “hot” jars in the microwave one at a time for 30-60 seconds one at a time. Make sure to do this when the cold jars are almost ready to be removed from the freezer as we do not want the hot water to reach room temperature while we wait for the cold jars to cool.
5. Add three drops of red food colouring to both “hot” jars, and three drops of blue food colouring to both “cool” jars once steps 3 and 4 have been successfully completed and a temperature difference is observable to the touch. Add a little bit of water to each jar to fill to the top.
6. Cover one of the “cold” jars with a playing card. Make sure it covers the whole jar.
7. Hold the playing card tightly over the jar, and very gently place the covered jar upside down over one of the hot jars. Make sure the two jar openings directly align.
8. Gently but quickly, pull the clear hard so the two jars are directly on top of each other. Record observations. Ensure the jars do not slip or fall.
9. Repeat steps 6 – 9 but with the remaining hot jar on top of the remaining cold jar.
10. Touch gently along the jar, and notice areas with temperature differences.
11. Record all observations immediately and after 10 minutes.

Figure 1: The cold water jar was placed on top of the warm water jar, causing a convection current where the lighter hot water rose as the heavier cold water sunk. This caused the two to mix, as visualized with the colours.

Figure 2: The warm water jar was placed on top of the cold water jar, creating a temperature inversion. The denser substance was on the bottom and the lighter substance was on the top, creating a stable arrangement where no mixing initially occurred.

Results:

Fill out the following table:

Names:	
What do you observe when you pour the warm water into the cold water/place the cold water jar on top of the warm water jar?	
What do you observe when you pour the cold water into the warm water/place the warm water jar on top of the cold water jar?	

Can temperature differences be felt along the jar? Explain.	
What do you observe in both jars after 10 minutes?	
After 10 minutes, can you still feel a temperature difference?	

Discussion:

1. Why are convection currents important? What events do they influence? Why are inversions problematic?
2. Which jar do you think mimicked the normal convection current in air and which do you think mimicked a temperature inversion? Explain.
3. After 10 minutes of waiting, you hopefully observed that the jar with a previous separation of cold and warm water was mixed to a greater degree. What do you think caused this? What do you think disrupts a temperature inversion in real life?
4. What would happen to pollution as a temperature inversion takes place? What could be the effects on human health and wildlife?
5. Think back to the previous activity, in which layer of the atmosphere do you think this phenomenon occurs?
6. Is it possible to see temperature inversions in real life? Do you think a temperature inversion would be more visible the longer it remains undisrupted?

Discussion Wrap-Up

Although water was used in this activity to make a temperature inversion, those in the atmosphere involve air. Convection currents happen in the troposphere during normal events. As mentioned earlier, they are created when the air just above the Earth's surface is warmed and rises as the cool air above it falls. This creates a continuous mixing of the air in the troposphere, which creates wind, helps clouds form, and allows pollution to disperse instead of staying concentrated[6] closer to Earth's surface. In this activity, the jar with the warm water at the bottom and the cold water at the top mimicked the normal convection current, since the cold water is denser and therefore falls below the warm water, causing them to mix. The jar with the warm water at the top and the cold water at the bottom showed an inversion and the layers formed remained still. However, as time passed, mixing started to occur as the cold water at the bottom of the jar warmed up to room temperature. In the troposphere, as temperatures rise, the cold air trapped at the bottom warms up and the convection current can be restored. However, depending on temperatures, inversions may remain for weeks. They can sometimes be seen as a smoky cloud. They are more visible the longer they remain undisturbed as more pollution is trapped in the cold bottom layer. Hopefully, you will never have to witness such an unhealthy event. Still, next time you are outside, try to imagine what a temperature inversion or normal convection currents look like. Although it cannot be seen as clearly as the blue and red water in this experiment, you can hopefully begin to picture what happens in the air around you!

Glossary:

[1]Dense: Density is a physical property which measures the mass of a substance per unit volume. When saying that warm air is less dense than cold air, we are saying that warm air is less "heavy" than cold air. You can hopefully imagine that the lighter warm air will float upwards as the heaver cold air falls.

[2]Convection current: In the atmosphere, this refers to the rising of warm air and falling of denser cool air. It allows for mixing of the air in the troposphere and is responsible for many natural events and dispersing pollution.

[3]Temperature inversion: In the atmosphere, this refers to the event in which heavier cold air is trapped below lighter warm air, preventing the usual mixing that takes place in the troposphere.

[4]Pollutants: These are substances that are responsible for pollution and have negative effects on the environment, wildlife, and human health.

[5]Fluids: In science, a fluid refers to either a liquid or a gas. It is any substance that is able to flow. We are using the term fluid here because inversions can happen both in liquids and gases. In this activity, we use water to visualize this, but in the atmosphere, air is the substance in which inversions occur.

[6]Concentrated: Concentration is a measure of the amount of a substance per unit volume. In this case, we are referring to the amount of pollutants per unit volume of air. If pollution becomes concentrated near Earth's surface, it means that there is more pollution per unit volume of air.

The Greenhouse Effect - Let's Get Heated!

Questions:

What is heat?
What does heat feel like to you?
How does heat affect your daily life?
What do you think heats the Earth?
How are heat and air related? Do you find that stuffy or airless rooms are generally different in temperature to open and well-ventilated rooms?
What would temperatures on Earth be without any air?
What are greenhouse gases? Are they good or bad?
What causes the greenhouse effect and what does it do to Earth's temperature?

Learning objective:

This activity is designed create an artificial greenhouse effect to bring awareness to its effect on temperature and its role in global warming.

Background:

The greenhouse effect[1] is the trapping of heat in the Earth's atmosphere by carbon dioxide, methane, water vapour, nitrous oxide, and other greenhouse gases.[2] The surface of the Earth absorbs UV radiation[3] from the sun, and releases this energy back into the atmosphere as heat, some of which escapes and some of which is trapped by greenhouse gases. The latter is important as it allows Earth to maintain temperatures high enough for our survival (by itself, the sun would not be able to heat up the Earth to habitable temperatures). However, an increase in greenhouse gasses due to human activity and pollution increases the amount of heat trapped, and thereby increases Earth's average temperatures. The greenhouse effect is one of the main causes of global warming,[4] which has many negative effects on wildlife, natural disasters, air pollution, and more. This activity will simulate the greenhouse effect and study the effect on temperature.

Safety:

Careful not to cut oneself with the scissors. Maintain social distancing.

Materials:

- Large clear soda plastic bottle (one for two pairs)
- Scissors
- Two glass jars
- Two thermometers

Procedure:

1. In pairs, cut the plastic soda bottle in half horizontally with the scissors. Both halves can be used; one soda bottle can be used for two groups. Ensure the thermometers can fit inside the glasses and soda bottles.
2. Place one thermometer in each glass jar.
3. Place one half of the plastic soda bottle over one of the glasses with thermometer.
4. Place the two jars in a sunny spot (ex: near a window).
5. Record the initial temperature in each jar, then after 5 minutes, 10 minutes, 30 minutes, 60 minutes, and 24 hours.

Results

Time Elapsed	**Temperature in Uncovered Cup (°C)**	**Temperature in Covered Cup (°C)**
0 minutes		
5 minutes		
10 minutes		
30 minutes		
60 minutes		
24 hours		

Table 1: Measured temperatures of uncovered and covered glasses at various intervals.

Discussion

1. Explain how the greenhouse effect is mimicked in this activity. What do you think was the role of the clear plastic bottle?
2. Hopefully you noticed a difference in temperature in the uncovered and covered cup. What is causing the greater temperature in the covered cup? Be specific.
3. Since greenhouse gasses are the main contributors to the greenhouse effect, what are three things you think you can do to reduce the emission of greenhouse gasses? What do you think should be done on a global scale?
4. As global temperatures increase, what negative consequences do you think the planet, wildlife, and humans will suffer?
5. Think back to the activity investigating the layers of the atmosphere. In which layer do you think the greenhouse effect occurs? Why?
6. Do you think the greenhouse effect is the same all over the world or varies between environments? Explain. (Hint: think back to Airborne Aerosols activity).

Discussion Wrap-Up

This activity used the plastic covered jar to create an artificial greenhouse effect, and compared the temperature inside to that in the uncovered jar. The plastic in this activity served as analogous to the greenhouse gases that cause the greenhouse effect on Earth. The clear plastic bottle is an insulator,[5] allowing UV radiation to pass through but preventing heat from escaping, resulting in increased temperatures. While the source of heat trapping was different in this activity and on Earth, the resulting effect on temperature was the same: the greenhouse effect causes an increase in temperature. This is needed to some extent on Earth, but the current amount of greenhouse gases is too large and temperatures are rising too high. To do your part in being more environmentally conscious, you can do your best to apply the three Rs (reduce, recycle, and reuse), turn off the tap when brushing your teeth, turn off the lights when you leave a room, and more. More importantly, more regulations are needed on a global scale to control the emissions of greenhouse gases by corporations. Agreements such as the Stockholm Convention ban certain pollutants and are helpful in reducing pollution. While certain countries are greater sources of greenhouse gas emissions, the whole world suffers the consequences. As seen in previous activities, the air in the troposphere is in constant movement and carries contaminants far and wide, resulting in a relatively even distribution of the greenhouse gases all over the world. A reduce in greenhouse gases is imperative as warmer temperatures on Earth cause more natural disasters, disrupt the food chain and migration patterns of certain species, cause the thawing of the permafrost and glaciers in the Arctic, and much more, which all have further dangerous consequences. Hopefully, you are realizing that the greenhouse effect is not isolated. It is related to many other environmental and natural processes, which are each research areas of their own. While you have hopefully gained insight into a small portion of this today, there remains a lot to learn. Do not be afraid to do your own research and ask questions!

Glossary

[1]Greenhouse effect: The warming of a planet, in this case Earth, by trapping the sun's radiation in the atmosphere in the form of heat. Greenhouse gases are responsible for this; a greater amount of greenhouse gases means a greater amount of heat trapped.

[2]Greenhouse gases: Gases that are able to trap energy in the form of heat. They include water vapour, carbon dioxide, nitrous oxide, methane, and more.

[3]UV radiation: Ultraviolet radiation, which is emitted from the sun and reaches the Earth. The Earth absorbs this energy and releases some of it as heat.

[4]Global warming: The increase in Earth's average temperature due to increases in human activity. Increases in greenhouse gases as a result of fossil fuel burning and other activities are a main source of global warming.

[5]Insulator: A substance which does not allow heat to travel through it. In this case, plastic is used as an insulator, which means that any heat cannot pass through it and is trapped inside the bottle as a result, causing an increase in temperature.

Thawing of the Permafrost – The Great Escape… of Pollutants

Questions:
What causes snow to melt?
What does snow become when it melts? How does it change?
How does snow melting affect you?
What happens to pollutants as snow melts? Can they move from snow to air?
How does global warming affect the concentration of pollutants in the atmosphere?
What is permafrost?
What effects does the thawing of the permafrost have on global warming and pollution?

Learning Objective:
This activity is designed to bring awareness to the effect of thawing permafrost on the contamination of surrounding land, bodies of water, and communities.

Background:
Permafrost[1] is a term to describe ground that is permanently frozen. As the planet warms, permafrost begins to thaw and releases greenhouse gasses,[2] mercury, and other contaminants in the atmosphere and freshwater watersheds.[3] Carbon dioxide and methane are released from the decomposition of plants and animals, which was previously halted in the frozen ground. Mercury can also find its way into the atmosphere, fresh water, and even food supplies as it is released from thawing[4] permafrost. In addition, other contaminants[5] that were stored in permafrost, such as persistent organic pollutants[6] are released to the atmosphere and freshwater watersheds, and contaminate wildlife. This activity provides an imagery of the contaminants released as permafrost thaws.

Safety:
Maintain social distancing as per COVID-19 regulations.

Materials:
- Food colouring
- Ice cube tray
- Water (to make ice cubes)
- Straw OR Coffee Stick OR Spoon (to mix food colouring into ice cubes)
- 2 Wide, shallow containers (a sandwich container works well)
- Paper towel
- Freezer

Procedure:

1. Fill the ice cube tray with water to make 4-6 ice cubes. Add 2-3 drops of food colouring to each ice cube. You may choose to use different colours of food colouring, provided that there are at least two ice cubes of each colour. You may also choose to mix the food colouring in the water before pouring into ice cube tray.
2. Place ice cube tray in the freezer and wait until the water freezes.
3. In the meantime, cover about half of the bottom surface of each container with paper towel. Rip the paper towel if need be, and make layers of about 2-3 towels.
4. Once the ice cubes are frozen, place 2-3 in each container. Make sure that there is the same amount of ice cubes of each colour in each container.
5. Place one container in the freezer, and place the other at room temperature.
6. Record observations after 30 minutes, 1 hour, and 2 hours. Note the melting or lack thereof of the ice cubes, as well as the colour depositing on the paper towel.

Figure 1: Set up of the experiment. Both samples should look as such, and one should be placed in the freezer, while another one should be placed at room temperature.

Results:

Time Elapsed	Fridge Container	Room Temperature Container
30 minutes		
1 hour		
2 hours		

Table 1: Observations of ice cubes and colour of paper towels in cold and warm samples.

Discussion:

1. What was the food colouring meant to represent? If you used different coloured food colouring, assign a class of contaminants to each colour.
2. Which container was meant to represent the thawing of the permafrost occurring on Earth? Which container was the control sample (representing what would happen in the absence of the permafrost thawing)? How do the observations differ? How does this represent what is happening on Earth?
3. Think back to the previous activity. What do you think is the relationship between the greenhouse effect and the thawing of the permafrost? (Hint: how does the greenhouse effect contribute to the thawing of the permafrost, and vice versa – think of the species released as permafrost thaws)?

4. In the Canadian Arctic, Arctic Char has shown increased concentrations of Persistent Organic Pollutants. Give a possible explanation for this. Do you think the contaminants released from thawing permafrost only affect wildlife in the surrounding environment? What about the atmosphere, do you think only the troposphere near thawing permafrost is affected by released chemicals? (Hint: think back to previous activities).

Discussion Wrap-Up

This activity simulated the effect of thawing permafrost on the release of pollutants. As the ice cubes melted, their colour stained the paper towel. This colouring was meant to show the contaminants that are released as the permafrost thaws. During warmer conditions, represented by the room temperature sample in this activity, the permafrost will rapidly thaw and contaminate the surrounding land, food crops, watersheds, and more. This is one of the many reasons why it is crucial for it to remain frozen, which can only happen at colder temperatures, shown by the frozen sample where no food colouring left the ice cubes. The species released from the permafrost cover a wide range of contaminants, including greenhouse gases. You hopefully remember that greenhouse gases trap heat and cause a rise in temperatures on Earth. Therefore, the thawing of the permafrost causes an increase in the concentration of greenhouse gases in the troposphere, which causes more heat to be trapped and temperatures to rise, and in turn causes the thawing of the permafrost and release of greenhouse gases to occur even more. This is a vicious cycle! Many other classes of pollutants have harmful consequences to the surrounding wildlife. As they are released from the permafrost, they can travel to bodies of water where they contaminate the populating wildlife both near and far from the source. As observed in previous activities, contaminants diffuse through the atmosphere. Therefore the troposphere everywhere is affected from the release of these contaminants. Overall, the thawing of the permafrost is an area of increasing concern as it has many adverse effects on the concentration of pollutants in oceans, air, wildlife, and more.

Glossary

[1]Permafrost: This refers to ground that stays at temperatures below 0°C for two years or more. It is important as it provides habitat for many Arctic species, it traps carbon so it is does not contribute to global warming, and more.

[2]Greenhouse gases: Hopefully you remember from previous activities that these are gases which are able to trap heat. They include water vapour, carbon dioxide, methane, nitrous oxide, and more. As the concentration of greenhouse gases increases, more heat is trapped in the troposphere and temperatures rise.

[3]Freshwater watersheds: These are areas of land which collect precipitation and melting snow and ice, and carry it to nearby bodies of water. If contaminants find their way in watersheds, they are easily brought to rivers, lakes, oceans, etc.

[4]Thawing: In this case, we are referring to the thawing of frozen ground (permafrost). The ice inside the frozen ground melts leaving behind liquid water and soil, and releasing previously trapped contaminants. When we are talking about permafrost, it would be incorrect to say that it melts! Snow and ice melt, but permafrost thaws.

[5]Contaminants: As investigated previously, this refers to molecules or substances that contaminate (make unclean) any body of water, air, land, etc. In this case, we are referring to species released from the permafrost that negatively impact wildlife and the environment.

[6]Persistent Organic Pollutants: Organic compounds which resist degradation. They are a class of contaminants or pollutants which "persist" in the environment, meaning that they remain a very long time and are almost impossible to get rid of.

Snow Pits Wait for Snow One

Questions:
What is snow?
What does snow feel like when you touch it?
What do you think of when you see snow? What does it mean to you?
What is snow made of? What else besides the main components can be found in snow?
Are there different types of snow?
What can we learn from digging a snow pit?

Learning Outcome:
This activity is designed to bring awareness to the information gathered from digging a snow pit,[1] as well as how natural processes affect snow layering ('stratigraphy'[2]), and vice versa. Students will dig a snow pit, analyze the different layers, and attempt to explain the observations and data.

Background:
What do you think of when we say "snow"? You may think of your favourite memories building a snowman, a storm that confines you to your home, or simply just white fluff falling from the sky. Scientists likely see snow differently from you; it is both a time capsule of many snowfall events piled up through the winter, as well as a body that will influence future chemical or physical processes. Digging a snow pit is crucial to gather this information. A snow pit is excavated from undisturbed snow cover, with a flat vertical face extending from the surface to the ground. By examining the snowpit face, different layers are visible. The layers result from the series of snowfall events that have accumulated and subsequently evolved over the season. They have differences in snow grain shape, snow grain, temperature, hardness, and more. These parameters inform scientists on the physical and chemical processes that have occurred during the season, such as number, size, and nature of snowfall events,[3] and how the resulting snow layers have changed ('metamorphosed'[4]). In mountain areas, understanding snow layering is essential to assess avalanche risks. Scientists can also learn about the insulation[5] of the soil, and how gases move between the snow and air. Try to think of other things a snow pit can tell us as you dig your own today!

Safety:
Wear weather appropriate clothing to prevent frostbite and hypothermia. This includes, but is not limited to, hats, gloves, scarves, coats, boots, warm socks, and snow pants. Ensure you clearly mark the snow pit and fill it when you are done to avoid leaving a hazard behind. Be careful when handling the knife and pencil to avoid cutting of puncturing skin. Ensure to maintain physical distancing as per COVID-19 regulations.

Materials
- Snow shovels
- Ruler or tape measurer

- Thermometer
- Pencil
- Kitchen knife
- Magnifying lens if you have one
- Snow crystal card
- Popsicle sticks (or something similar)

Procedure

Overview: Individually, you will dig a snow pit and measure only the depth and compare it to your classmates' snow pits. Then, in pairs, you will dig another snow pit and focus on analyzing the different layers.

Steps for individual snow pit:

1. Individually, use a snow shovel to dig a pit until you hit the ground. Make sure that your pit is flat along the vertical from the surface of the snow to the ground on one side (as in Figure 1) for ease and accuracy in measuring the depth. Take note of the location of the snow pit.
2. Using a tape measurer, measure the depth of the snow pit. Place one end at the top surface of the snow (where you started digging), and measure along the vertical edge to the ground. Report your answer in centimeters. Record the location of your snow pit.
3. Once you are done recording all information, fill the snow pit to ensure nobody is at risk of falling in.

Figure 1: Snow pit with flat wall for measuring depth.

Steps for snow pit as a group:

1. In pairs, use a snow shovel to dig a pit until you hit the ground, just as you did above. Make sure your pit has a flat vertical surface from the surface to the ground (this is important to see the different layers). This surface should not receive direct sunlight as this may affect temperature measurements. Take note of the location of the snow pit.
2. Once the pit is dug and one side has been cut with the shovel to appear flat, make observations on the appearance of the different layers. Make note of how many there are, how thick each layer is, any visible impurities in the snow, etc. Use descriptive words. Insert popsicle sticks or other device to mark the different layers (at the top and bottom of each layer).
3. Use your measuring tape to measure the size of each layer. Measure from the top edge of the layer to the bottom edge (or between the two popsicle sticks you placed in step 2). For the top-most layer, measure from the surface of the snow to the start of the next layer. For the bottom-most layer, measure from the end of the previous top layer to the ground. Record all measurements. If layers are ambiguous estimate the top and bottom of each layer as best you can. Describe the snow grain shape and size in each layer. Describe the snow grain shape in each layer.

4. Once all visual observations are made, take the temperature of each layer and record it. Using your thermometer, place the end perpendicular to the snow, in the middle of the layer. Wait for the temperature to stabilize (it should not change for about 20 seconds), and record the temperature, in degrees Celsius. Do this for each layer. If you are curious, you may also take the temperature at different places in the same layer and observe if it changes.
5. Perform a hardness test for each layer. Start with gently pressing your fist into the first layer. If it does not penetrate easily, gently press the tips of four fingers, the tip of one finger, the tip of a pencil, and the tip of a knife. Only move on to the next test if the previous object does not penetrate easily. As soon as a layer can easily be penetrated by an object, stop and record the estimated hardness according to the object easily pressed into it according to the table below.

Test	**Estimated Hardness**
Fist	Very soft
Four fingers (tips)	Soft
One finger (tips)	Medium
Tip of pencil	Hard
Tip of knife	Very hard
No test passed	Ice

Table 1: Classifying the estimated hardness of each layer according to the test it passes.

6. Once all measurements have been taken, fill back the snow pit.

Results

Individual snow pit:

Individually, when you are digging your snow pit, fill out the following table:

Name:	
Location of snow pit:	
Depth of snow pit:	
Did you fill the snow pit?	

Table 2: Recording data on individually dug snow pit.

As a class, fill out the following table once everyone has gathered data on their snow pit:

Total number of snow pits dug:	
Size of deepest snow pit and its location :	
Size of shallowest snow pit and its location:	
Average snow pit depth:	

Table 3: Class data on individually dug snow pits.

When digging your snow pits as a group, fill out the following table:

Names: Location of snow pit:								
Layer → ______________ Characteristic↓	Layer 1 (top)	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	Layer 8
Layer thickness								
Temperature (°C)								
Snow grain size (mm)								
Snow grain shape								
Estimated Hardness								

Table 4: Data for each layer of snow pit dug as a group.

Discussion

Individually dug snow pits:

1. Were all the snow pit depths the same? Ideally, you observed that there was a range in snow pit depth, as is usually the case. Why do you think the depth of snow varies between locations?
2. In which location was the depth greatest? In which location was it the smallest? Come up with a reasonable explanation for these results.

3. Do you think there is a general trend regarding the depth of snow pits and different locations? For example, how did snow depth relate to vegetation or the land's shape and texture (e.g. was the pit dug in a flat park, on a slope, etc.)?

Group snow pits:

1. Why do different layers occur in a snow pack? At which point in the season do you think there would be the most layers? Why do you think layers vary in their characteristics (appearance, temperature, size, hardness, etc.)?
2. What was the temperature range of the layers (i.e. what were the highest and lowest recorded temperatures)? Is there a trend in temperature as you move from the top layer to the bottom? Come up with a hypothesis to explain why or why not.
3. What was the snow grain size range of the layers? Is there a trend in size as you move from the top layer to the bottom? Come up with a hypothesis to explain why or why not.
4. What was the estimated hardness range of the layers? Is there a trend of hardness between layers when travelling from the top to the bottom layer? Come up with a hypothesis to explain why or why not.

General questions:

1. Why is measuring snow pits important from a scientific perspective? Name at least three physical, chemical, or natural processes snow affects and why measuring snow helps to monitor them.
2. Why do you think it is important to measure snow in different locations to get a real idea of physical and chemical processes? (Hint: think back to the results of the individual snow pit).
3. What other measurements do you think would be useful to characterize snow? Why do you think they would be important?

Discussion Wrap-Up

Hopefully, you had fun while learning a lot about snow! In digging your pits, you may have noticed that snow depth is highly dependent on the surrounding environment. For example, the depth of the snow pit will likely be greater in a flat land far away from a city, while a snow pit dug in a downtown yard will likely not be as deep due to the surrounding human activity. Snow depth is also affected by the surrounding vegetation and landscape. A pit dug on a steep slope will likely be smaller than one on flat land. When digging your snow pit, you hopefully saw many layers. These result from the accumulation of different snowfall events. The first snowfall of the season will change with time, likely becoming harder as it freezes, while newer snowfalls will accumulate on top of it, resulting in visible layers with different physical properties.[6] For example, the hardness likely increases as you move from the topmost to the bottommost layer, since the former is more fresh and the latter has had more time to freeze and harden. All of the measurements taken are of scientific significance as they can inform us on the risks of avalanche, insulation of the soil, gas exchange with the atmosphere, changes in weather, acidity levels, and more. On top of the measurements taken in this activity, scientists often measure the density, liquid water content, impurities, and other. All of these measurements give unique information on the snow pit and collectively inform scientists on physical, chemical, and natural processes. It is important to remember that, while snow holds memories, it also contains valuable scientific information. Now that you have learned about this perspective of snow, has your idea of it changed? What does snow now mean to you?

Glossary

[1]Snow pit: A hole that has been dug to expose a flat, vertical face from the surface to the ground in order to observe and take measurements of physical properties of the layers. They are crucial to draw information on physical and chemical processes taking place in the environment.

[2]Stratigraphy: The study of the different layers of snow. The measurable qualities of each snow layer (such as temperature, hardness, thickness, density, etc.) all together make up the stratigraphy of the snowpack.

[3]Snowfall events: Any precipitation event involving the accumulation of snow on the ground. In this case, snowfall events are important as each is likely to add a new measurable layer to the snow pit.

[4]Metamorphosed: Having changed from one state to another, now having different physical properties. In this case, snow layers that are said to have metamorphosed have changed over time to have different measurable qualities than they did when they initially formed.

[5]Insulation: In this case, we are concerned with the insulation of the soil, which is the degree to which the ground underneath the snow is protected or separated from the environment due to the snow. This may affect the temperature, contaminant level, and other properties of the soil.

[6]Physical properties: A quality of a substance that can be measured. In this case, we are concerned with the measurable qualities of snow, such as temperature, hardness, thickness, density, and more.

THE ARCTIC, CLIMATE CHANGE AND CONTAMINANTS: PERSPECTIVES FROM ECCC SCIENCE

Now that you have finished all the lab activities, use your experiences to further explore these topics. Talk with your class and community about what you think of, and how you feel when you say these aloud.

How do scientists investigate the AIR?
How can you investigate the AIR?

How is AIR in your FOOD?
How is AIR in your WATER?

What does FOOD and WATER mean to you?

How does WATER impact the environment?

You cannot have FOOD and WATER without AIR.

What is FOOD? Where is FOOD?

How does WATER change?

Where is WATER in your life?

How many forms of WATER are there?

How can you celebrate AIR? How can you protect AIR? How does AIR protect you?

Where does AIR, WATER, and FOOD combine?

FOOD travels through the environment, through the AIR and WATER.

Where do the WATER, FOOD, and AIR come from?

You are what you eat.