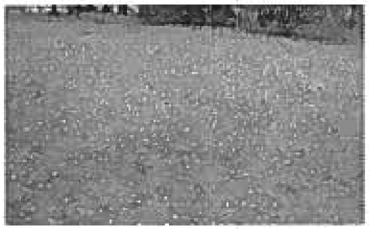
LESSON 1: What causes this kind of precipitation event to occur?

PREVIOUS LESSON *There is no previous lesson.*

THIS LESSON

ANCHORING PHENOMENON

3 days



We observe three video clips of hail falling in different areas of the United States on different days. We develop a model to try to explain what causes this to occur. We develop questions for our Driving Question Board (DQB) about the mechanisms that cause different kinds of precipitation events. We brainstorm investigations we could do and sources of data that could help us figure out answers to our questions.

NEXT LESSON *We will analyze data from hail-related weather events, including hailstone images, hail maps, and weather data.*

BUILDING TOWARD NGSS

MS-PS1-4, MS-ESS2-4, MS-ESS2-5, MS-ESS2-6

WHAT STUDENTS WILL DO

Develop an initial model to describe changes and mechanisms at both the observable and the particle level that cause hail to fall during a brief time period.

Ask questions that arise from careful observation of phenomena and gaps in our current models to clarify and seek additional information about how changes to the flow of matter and energy in the air above and around a location on Earth's surface could cause short-duration precipitation events and longer-duration precipitation events (scale).

WHAT STUDENTS WILL FIGURE OUT

- Rain and wind accompany some hail events.
- Some of the water that reaches the ground reached a low enough temperature to freeze, at some point, before it fell.
- Clouds can be seen moving into and out of the area where it hailed.
- Cloud movement in the sky, moving air (wind) at Earth's surface, and temperature may be related to why, where, and when different forms of precipitation fall.

Part	Duration	Summary	Slide	Materials
1	22 min	**EXPLORE SOME STORM-RELATED PHENOMENA** use chartpaper/notes or Jamboard Record and share noticings and wonderings from three video clips of hailstorms. Make predictions about what we might see going on in the sky before, during, and after these events.	A	chart paper, markers, computer and projector, https://youtu.be/9PeACgaLC4A, https://youtu.be/Lx4TUg3TD-s, https://youtu.be/wwPnb-1qRtQ
2	7 min	**CREATE INITIAL MODELS** Formative Assessment Create initial models to explain what caused the precipitation events seen in the videos.	B	*Initial Model* put up old Consensus Model from Thermal
3	8 min	**CONNECT TO PREVIOUS UNIT IDEAS** Review ideas developed in the Cup Design Unit that might be useful for representing particle-level differences in precipitation-related phenomena.	C	posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup systems
4	8 min	**DEVELOP INITIAL MODELS** Develop a particle-level representation for three places above the ground and identify places where energy may be getting transferred into, through, or out of the system.	D	*Initial Model*, *Representing Particle-Level Changes in the System*, colored pencil or highlighter
				End of day 1
5	3 min	**TARGET A NORM TO FOCUS ON** Review the classroom norms and pick one norm to focus on for today.	E	classroom norms handout (to tape into new notebooks if needed), classroom norms poster
6	10 min	**COMPARE MODELS** helps ALL to spark ideas Conduct a gallery walk to compare models.	F	*Initial Model*, *Representing Particle-Level Changes in the System*, Communicating in Scientific Ways poster or handouts
7	20 min	**DEVELOP AN INITIAL CONSENSUS MODEL** "talk moves" if st. struggle Convene a Scientists Circle to develop an initial consensus model.	G	Initial Consensus Model poster, markers, posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup system
8	5 min	**DEVELOP INITIAL QUESTIONS** Record initial questions for the DQB and save them for sharing next period.	H	markers, sticky notes
9	7 min	**IDENTIFY RELATED PHENOMENA AND REFLECT ON NORMS** Recall and record experiences with two different categories of related phenomena. Revisit individual focal norms. equity builder - how do st. connect/relate to phenomenon?	I, J	chart paper, markers, sticky notes
				End of day 2
10	13 min	**SHARE RELATED PHENOMENA AND RECORD ADDITIONAL QUESTIONS** Share experiences with two different types of related phenomena and generate additional questions for the Driving Question Board.	K-M	chart paper, markers, sticky notes, Related Phenomena poster
11	20 min	**BUILD THE DRIVING QUESTION BOARD** Develop the DQB with contributions from all students in the class.	N	chart paper, scissors, markers, DQB

ALL voices need to be heard

! see Unit overview for ideas on how to organize st. ?s.

Part	Duration	Summary	Slide	Materials
12	12 min	**DEVELOP IDEAS FOR FUTURE INVESTIGATIONS** Develop ideas for future investigations using contributions from all students in the class.	O	Ideas for Future Investigations and Data We Need poster, markers

End of day 3

	per student	per group	per class
Lesson materials	• science notebook • *Initial Model* • *Representing Particle-Level Changes in the System* • colored pencil or highlighter • classroom norms handout (to tape into new notebooks if needed)		• chart paper • markers • computer and projector • https://youtu.be/9PeACgaLC4A • https://youtu.be/Lx4TUg3TD-s • https://youtu.be/wwPnb-1qRtQ • posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup systems • classroom norms poster • Communicating in Scientific Ways poster or handouts • Initial Consensus Model poster • posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup system • sticky notes • Related Phenomena poster • scissors • DQB • Ideas for Future Investigations and Data We Need poster

Materials preparation (30 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

If students are working in new notebooks, you will want to provide them a new copy of the classroom norms (built together in previous units) to tape to the inside cover of their notebook.

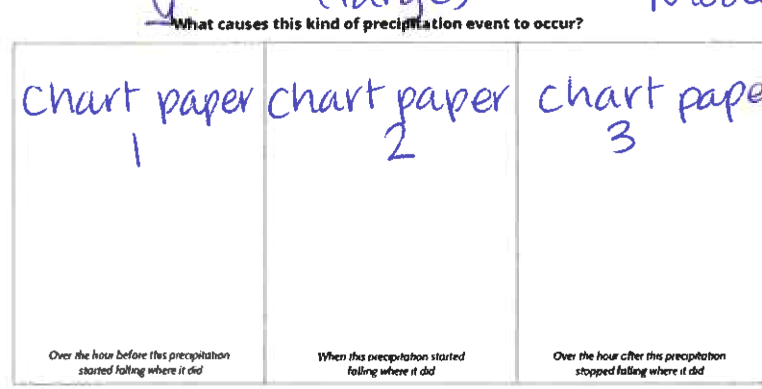
Test the three hail videos ahead of time: watch with "St. hat"

- https://youtu.be/9PeACgaLC4A
- https://youtu.be/Lx4TUg3TD-s
- https://youtu.be/wwPnb-1qRtQ

Prepare these posters ahead of time for each class: Related Phenomena, Ideas for Future Investigations and Data We Need, and Initial Consensus Model.

make ☆ Use three pieces of chart paper to set up the Initial Consensus Model poster. It should have the title **"What causes this kind of precipitation event to occur?"** written above them. Label each piece of chart paper with the time period it represents, as shown in the diagram here:

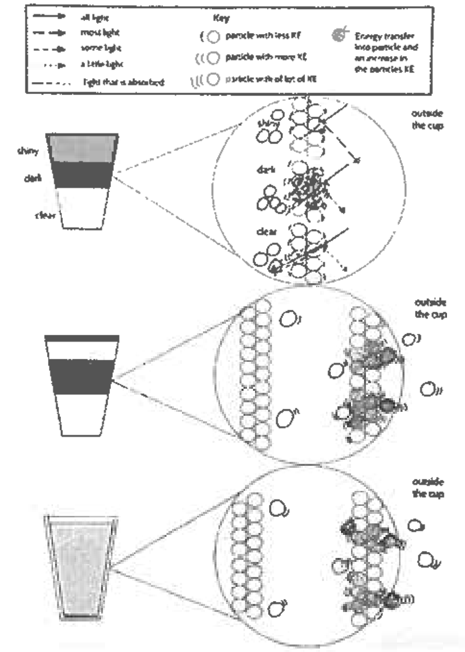
Chart for intial Consensus Model (large)



make DQB Prepare a driving question banner on a half-piece of poster paper with the driving question written on it, "Why does a lot of hail, rain, or snow fall at some times and not others?" This banner will be added over the DQB after it is completed.

Connect to prior learning – check for unfinished learning during discussion

Bring out any posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup system. An example is shown here.



1st unit of 7th

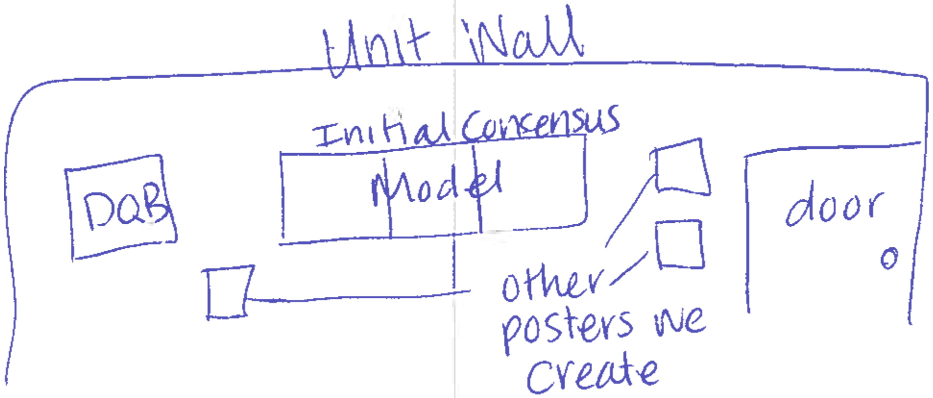
or check w/ co-teachers

If you do not have these records from that unit, develop a diagrammatic representation of the Cup Design Unit's main ideas for the class to refer to. Use the conventions you developed with your students for representing these ideas.

Download the Communicating in Scientific Ways file from the website and use it in your classroom as a poster or add it to students' science notebooks as a handout.

place on unit wall

Determine where to set up the DQB and other posters so students can gather around them. Near this space, post the classroom norms you developed with students in previous units.



overview of how st. develop understanding of a phenom

Where We Are Going

In the first 13 lessons of this unit, students use ideas about how light interacts with matter to explain why surfaces on Earth warm up over the course of a sunny day. They will develop ideas about how the composition and spacing of molecules in the air changes as it warms and cools, which can explain what causes the amount of water vapor in the air to change, what causes water to evaporate or condense to form precipitation, what causes some air to rise or sink, and what causes clouds to form. They will develop ideas to explain how differential heating of gases and liquids results in convection, which can explain what causes some surface winds, why precipitation doesn't fall from every cloud, and why some storms produce hail and others do not. The need to develop these ideas will be established through the development of students' questions at the end of this lesson and the investigation of these questions over the next twelve lessons.

In this first lesson, students identify potential causes for why hail forms, which likely include a location in the atmosphere (e.g., higher up) where the air is colder than the air near the ground. They will gather evidence for that idea in Lesson 2.

Students should come to this unit with prior knowledge from the Cup Design Unit related to these two NGSS performance expectations:

- MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

prior knowledge

Relevant ideas from previous work include these:

- Gases, liquids, and solids are made of particles.
- In a liquid, the particles are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. In a solid, the particles are closely spaced and may vibrate in position without changing relative locations.
- Temperature is a measure of the average kinetic energy of particles of matter.
- Thermal energy can be transferred through particle collisions within an object or between two objects in contact with each other (via conduction).

Students may come to this unit with prior knowledge that air tends to be cooler the higher up they travel, based on experiences related to mountains and air travel. Some may think that the air should get warmer higher up because it is closer to the sun.

competing ideas

Students may think that a cloud is all gas, rather than a combination of gas and droplets or crystals. Alternatively, they may think of a cloud as something similar to a sponge - a solid that can absorb only so much water before it becomes saturated and starts overflowing with water, leading to precipitation.

In Lesson 14 students will explore an additional anchor phenomenon, a severe winter storm forecast, to motivate adding new questions to the Driving Question Board. In the lessons that come after this, students will explain why larger-scale and longer-duration precipitation events occur by developing and using a model for how midlatitude, low-pressure weather systems form and produce precipitation, particularly along frontal boundaries.

Where We Are NOT Going

An intentional effort is made in Lesson 1 to not refer to the hail events or related phenomena as "weather events." This is to avoid having students generate questions about lightning and thunder, which will happen if the related phenomena conversation is framed too broadly. Instead, we use the terms "precipitation" and "other precipitation events" in this first lesson to help students generate relevant phenomena and questions about how precipitation forms, which is the goal of this unit. We anticipate students will generate many questions about how hail and thunderstorms form and a smaller set of questions about blizzards and hurricanes. Please avoid using the word "weather" until Lesson 2.

my st. will have lots of prior life experiences here

less experience here so consider guiding question: "What kind of precipitation events might people in the northern part of our country experience?"

don't use "weather" until lesson 2

LEARNING PLAN for LESSON 1

1 EXPLORE SOME STORM-RELATED PHENOMENA

22 min

MATERIALS: science notebook, chart paper, markers, computer and projector, https://youtu.be/9PeACgaLC4A, https://youtu.be/Lx4TUg3TD-s, https://youtu.be/wwPnb-1qRtQ

Introduce the phenomenon. Say, *I have some videos that show a kind of perplexing phenomenon occurring outdoors that I want to explore together. Some of you may have experienced this phenomenon before. Let's get ready to explore this phenomenon by preparing our science notebooks.*

Present slide A. After preparing space to organize a new section in their notebook for this unit, have students make a two-column chart on the next available page to record their noticings and wonderings from the videos.

Say that the first video clip was recorded on April 7, 2013, in Fort Scott, Kansas. Tell them to make notes on their chart during and/or after you show the video.

SCIENCE NOTEBOOK

This is the first use of the science notebook for this new unit. You may need time to organize a new section in the notebook. It is recommended to have students do the following:

- Reserve a blank page at the start of the unit, to be titled on day 3 of this lesson when students are given the unit question.
- After the title page, reserve 2 pages (4 pages front-to-back) for the table of contents (unless all tables of contents are at the front of the notebook).
- Reserve 8 pages (16 pages front-to-back) for the Progress Tracker.
- Number the pages so everyone begins the first investigation on the same page number (e.g., page 1 for the first page of the table of contents, page 5 for the first page of the Progress Tracker, and page 21 for the first Notice and Wonder chart they are making now).

Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking as well as a place to show how their thinking changes as they learn more.

Show the first hail video. Play https://youtu.be/9PeACgaLC4A . Give students an additional minute to record their notes on their charts. Take about 3 minutes to have a few students share a few of the things they noticed with the class. Start a public record of what they share, using chart paper, the board, or a digital document. Don't worry about generating a comprehensive list when students report out what they noticed, as you can emphasize that you will ask them to report out additional noticings and wonderings again in a few minutes.

Emphasize that this kind of event doesn't occur all that often, but ask for a show of hands of students who have seen something like this before. At this point, it is likely that students will identify this event as hail.

Say, *Share with your partner any experiences you've had with hail and how your experience compared to what you saw in the video.* Give students a couple of minutes to do this.

Bring students back together, emphasizing that you have another video from a different time and place that produced different-sized pieces of hail than this one did. Tell students that this next video clip is of golf ball-sized hail that fell on October 5, 2010, in Phoenix, Arizona. Remind them to record what they notice and wonder about this event during and/or after you show the video.

Show the second hail video. Play https://youtu.be/Lx4TUg3TD-s . Give students an additional minute to record their notes. Have a few students share these with the class. Add what they share to the public record you started after the first video.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY

At this point in the unit, it is important to emphasize the relatively brief duration of a typical hailstorm compared to other precipitation events students may have experienced. Helping students notice this sets the stage for thinking about longer-duration precipitation events later in this lesson and explaining them in the second half of this unit. In Lesson 2, students will see the relatively small area that a hailstorm impacts. In the second half of the unit, they will make explicit comparisons between explanations for small-scale precipitation events (like hailstorms) vs. larger-scale precipitation events (like what is happening along frontal boundaries between mesoscale air masses).

ALTERNATE ACTIVITY

To make this type of phenomenon even more locally relevant, you could search the internet for videos of hail in your state or region. It is recommended to only use video that foregrounds the falling of hail rather than the damage or impact after the event. The latter will generate questions that are better raised and addressed in the later OpenSciEd Unit 6.5. If you find a video you want to add, show it after https://youtu.be/Lx4TUg3TD-s and then end with the timelapse video https://youtu.be/wwPnb-1qRtQ .

local connection

Before starting the next video clip, tell students it is a time-lapse video from before, during, and after a hailstorm that produced smaller hail than the other two videos. Explain that this video was recorded on June 10, 2013, in Winnipeg, Manitoba, Canada, and is sped up 60 times, so each second in the video is equal to 1 minute of real time; therefore, though the video is only 99 seconds long, it represents 99 minutes of real time.

Show the third hail video. Play https://youtu.be/wwPnb-1qRtQ . Give students an additional minute to record what they notice and wonder. Have students share these observations with the class, and add them to your public record.
Don't worry about generating a comprehensive list when students report out what they noticed. Here are some anticipated student observations:

- *It looked like big pieces of ice or snow were falling in all the videos, but the size of them looked different in each of the three cases.*
- *When it hit the ground, it bounced really high in the first and second videos. It made noise when it hit things in those videos.*
- *The plants in the area had green leaves (e.g., grass, flowers, trees).*
- *There was wind at some point in all of them. It was very strong in the second one (Arizona), and there was some in the first one (Kansas).*
- *There was rain at one point along with the hail in the second one (Arizona), and there was rain before the hail in the third one (Canada), and it looked like the ground was wet in the first one—maybe from previous rain.*
- *It seemed windy in the second video. And there was a moment in the third video when the tarp on the ground seemed to flap a lot.*
- *It didn't seem to last very long in all three cases.*

"listen fors" possible student connections/notices

ADDITIONAL GUIDANCE

You may find that while they share what they noticed, some students will suggest initial explanations for why the hailstorm happened. As they do, say things like, *It sounds like you have some initial ideas about how or why this happened. This is a really interesting and strange phenomenon to try to explain. What you shared is helping me think of new questions. Remember, if something somebody says makes you think of a new question, jot it down in your notebook so you can look back at it later when we start building our DQB.* This helps transition the class back to focusing on what students noticed and the experiences they shared, rather than following up on any initial explanations that arose. It will help generate a sense of wonder and curiosity around what is happening and what might be causing it.

keep focus on notices, not explanations at this point

Define *precipitation*. Once students notice that it was both raining and hailing during the second video, introduce the word ***precipitation*** as a way to refer to any liquid or solid forms of water that fall to the ground from above, which can include hail, rain, sleet, or snow. Add the word to your word wall along with those examples.

ADDITIONAL GUIDANCE

Precipitation is a key reference word that you will use to help students think of certain kinds of related phenomena in later steps. That is why it is introduced here by the teacher, as a word that students "find out" rather than "earn" at this point in the unit.

If students don't bring up what they noticed happening in the sky before and after the hail fell in the third video, use these suggested prompts to help elicit that line of observations.

T questions to ask if st. struggle w/ notices (see listen fors)

Suggested prompt	Sample student response
Did you notice any changes in the sky before the hail fell in the third video?	*It was partly cloudy at first, and then it became completely overcast right before it rained and hailed.*
How were you able to see what was happening in the sky when the camera was pointed toward the front yard?	*You could see the clouds overhead in the reflection on the car windows.*
What patterns could you see in the movement of the clouds?	*It looked like they came in from one direction.*
Was anything happening in the sky after the hail fell?	*It cleared up afterwards (it became sunny).*
	The clouds overhead kept moving in the direction they were moving before the storm.

Students may want to watch the third video again to check observations that they didn't notice but others reported; if so, show the video again.

ADDITIONAL GUIDANCE

Seeing a reflected image in a window is another strange phenomenon. A window is typically thought of as something you can see through, rather than something that can also act like mirror under certain conditions. Students investigated this as part of OpenSciEd Unit 6.1: *Why do we sometimes see different things when looking at the same object?* (One-way Mirror Unit). If your students have completed this unit, you may want to point out that a part of the phenomenon in the video (the reflection in the car windows) is something they have already investigated and explained. If students have not completed this unit, don't take time to make that connection.

Connection to 6th grade unit

Describe the duration of hail events. Emphasize that the sky appeared to remain cloud covered the entire length of the first two videos, but each video clip was also really short—the first was under a minute and the second was under 2 minutes. Tell students, *Though most hail events are quite brief and last just 5 to 10 minutes, the first two video clips didn't help us see what was happening before and after the hail fell.*✱

Emphasize that in the third video, however, we were able to use the reflected image in the car windows to see changes in the sky over a longer time before, during, and after the hail fell (99 minutes total).

2 · CREATE INITIAL MODELS

← 1st attempt to explain or "Make Sense"

7 min

MATERIALS: science notebook, *Initial Model*

Cue students to create their initial models. Present slide B. Read the directions on the slide aloud. Distribute a copy of *Initial Model* to each student. Ask students to wait before taping it into their notebooks. You will collect their models at the end of this class period for review and return them at the start of the next period, which is when they can add the handout to their notebooks.

ADDITIONAL GUIDANCE

Students may ask what kind of precipitation the handout is referring to. If they do, reference the definition and examples of precipitation on the word wall, and ask what types they saw in the videos. Emphasize that their model should account for each type they observed. Though hail is the most perplexing part of the precipitation event in the videos, students may have noticed other types of precipitation at the same time, such as rain.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY

this type of scale is new

In the next few lessons, students will uncover data that will help them determine the relative scale of this weather event. This will include how big an area hail typically falls over, how big the clouds that produce hail grow, and how fast those clouds move over

Cue students to create their initial models by first representing what type of changes they saw happening outside before, during, and after the precipitation event.

Emphasize that the handout divides the event into three time points. Say something like, *Use the middle box to show what was happening above and around the place where the precipitation fell at the time that it started falling. The box on the left is for showing what was happening above and around the place where the precipitation fell, but an hour beforehand. The box to the right is for showing what was happening an hour afterward.*

Provide additional guidance. The handout doesn't provide a scale for distance. Help students include their ideas about the scale in their model through prompts such as, *One thing to consider in your model is how big of a space you are trying to represent. So include labels and notes to show the distance between the place where things in the air are happening and the place where the precipitation fell (How high are the clouds? How high did this precipitation fall from?).*✱

Lastly, remind students that even though they are drawing what was happening at different points of time in each box, they can use arrows, symbols, and annotations to connect things between the boxes, to help show how things that happened an hour in the past caused the hail to form and fall when it did.

Emphasize that identifying what is causing the observed changes in their models can be the most challenging part, because we need to consider things that may be happening even though we can't see them. Remind students that a combination of written descriptions, labels, and diagrams helps make their thinking visible, both for themselves and for others. Ask them to write down any questions that come to mind as they work. Encourage students to use different-colored writing implements if it is helpful.

While students construct their models, walk around the room and quietly ask probing questions of students who have no written labels or descriptions on their models, to help them represent their thinking more clearly and elaborate upon their ideas.✱

After giving students 8 minutes to do this, ask them to pause their individual work on this part of the model.

an area. This initial model provides an opportunity to get a sense of students' intuitions about the height of storm clouds. Students are unlikely to indicate that they picture those clouds having started elsewhere and moved from relatively far away (e.g., many miles) over the course of an hour.

✱ SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

Here are some additional prompts to help students create their initial models or make their ideas more explicit:

- *What did you draw in the air here? Can you label what that is? Can you explain how it got there?*
- *Where did this water come from? Can you label and explain that?*
- *What do these lines or arrows represent? Can you label them?*
- *It looks like you included the Sun in this box. How is it connected to the changes you're showing?*
- *It looks like you're showing something happening in the clouds. Can you describe what you think is happening to cause that?*
- *How far up do you picture this happening? Can you include a description or a scale to show that?*
- *How far away do you picture this happening an hour beforehand? Can you include a description or a scale to show that?*

3 · CONNECT TO PREVIOUS UNIT IDEAS

8 min

MATERIALS: posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup systems

Connect to ideas developed in the Cup Design Unit. Say something like, *Today we explored a phenomenon where relatively big pieces of hail somehow formed and ended up falling from the sky. We also saw rain falling during the storm, and other interesting things were happening in the air, including changes in the wind and clouds overhead. So this phenomenon included things happening with both water and air. Those were two important parts of the systems we modeled and explained in our previous Cup Design Unit too. In that unit, we developed some useful ways to represent what was happening to the matter and energy in a system. Let's review those, so we can figure out whether they might be useful in explaining changes that would cause hail to form and fall.*

✱ STRATEGIES FOR THIS CONSENSUS DISCUSSION

This is considered a Consensus Discussion because the ideas being articulated were already developed in the Cup Design Unit. Since that unit would have been completed recently, reviewing these ideas should be

ADDITIONAL GUIDANCE If your students didn't complete the Cup Design Unit but did complete one or more other units of study that covered the particle nature of matter, temperature, thermal energy, conduction, and light's interaction with matter, modify this framing in slide C to reflect those experiences.

Present **slide C**. Give students 3 minutes to discuss these questions with a partner. Then facilitate a short Consensus Discussion around the ideas students developed in that previous unit.✱

KEY IDEAS

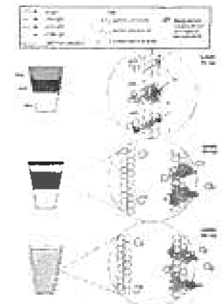
Purpose of this discussion:

- Summarize the conventions the class developed for representing the particles that make up different states of matter: in a gas, a liquid, and a solid.
- Summarize the different ways that energy can be transferred into and out of a system like a cup with liquid in it, how the class represented this in the past, and what happens to the particles in the system when this occurs.

Listen for these ideas:

- The particles in a gas, like air, are spread far apart, and the particles in a solid and a liquid are packed close together.
- Energy can be transferred through collisions between neighboring particles (conduction).
- Energy can enter a system when matter absorbs light shining on it (radiation).
- The particles of a substance move faster, on average, at higher temperatures and slower, on average, at lower temperatures.

easy. It is useful to have a public record of the ideas students are sharing to refer to throughout this lesson and later lessons. If you have these records from that unit, bring them out now. If not, develop a diagrammatic representation of the Cup Design Unit's main ideas for the class to refer to. A set of sample diagrams from that unit's teacher's guides is provided here as a reference. Use the conventions you developed with your students for representing ideas in this discussion.



4 · DEVELOP INITIAL MODELS

8 min

MATERIALS: science notebook, *Initial Model*, *Representing Particle-Level Changes in the System*, colored pencil or highlighter

Develop a particle-level representation for the initial models. Say something like, *Let's try to use those ideas about particles and energy to represent what we think is happening in the air and water above and around where the precipitation event occurred.*

Present **slide D**. Distribute a copy of *Representing Particle-Level Changes in the System* to each student. Take a minute to review the directions and answer any questions.

Have students complete their models on *Representing Particle-Level Changes in the System* and add annotations to *Initial Model* in a colored pencil or highlighter. During this time, walk around the room and quietly ask probing questions of students who have no written labels or descriptions representing energy on *Initial Model*, to help them make their thinking more visible on their papers.✱

Collect students' copies of *Initial Model* and *Representing Particle-Level Changes in the System* to review before the next period.

ASSESSMENT OPPORTUNITY This initial model collection will help you (1) get a sense of commonalities and differences across models and (2) plan for the consensus model discussion during day 2 by serving as an individual pre-assessment of student understanding.

✱ SUPPORTING STUDENTS IN DEVELOPING AND USING ENERGY AND MATTER

Here are some additional prompts to help students develop their initial models or make their ideas about matter and energy more explicit:

- *Are you showing the particles in a gas here or in a solid or a liquid? Or in more than one state of matter? Can you label that?*
- *What do these arrows represent? Can you label them?*
- *Where in your model are you showing energy moving into, through, or out of the system? Can you explain the process or mechanism for how that might be happening?*

End of day 1

5 · TARGET A NORM TO FOCUS ON

3 min

MATERIALS: classroom norms handout (to tape into new notebooks if needed), science notebook, classroom norms poster

Choose a focal norm. Display **slide E**. Direct students to look over the classroom norms once more. If students are working in new science notebooks, provide them with a new copy of the norms to tape to the inside cover. If not, they can refer to the copy already in their notebook from the previous unit and/or the copy posted on the wall. Ask students to choose a norm to practice in class today.

As students are doing this, give back their copies of *Initial Model* and *Representing Particle-Level Changes in the System* that you collected last time.

ADDITIONAL GUIDANCE

Evaluate how well your students did with the classroom norms in the previous unit. If they did well with some norms, celebrate that now. If they need additional work on others, focus their attention to those. As needed, spend additional time discussing the norms again and having students share (1) what a given norm would look like if everyone were following it and (2) what it would sound like.

6 · COMPARE MODELS ← helps in sense making

10 min

MATERIALS: science notebook, *Initial Model*, *Representing Particle-Level Changes in the System*, Communicating in Scientific Ways poster or handouts

Prepare for a silent gallery walk. Show **slide F**. Read the slide aloud. Emphasize that everyone should be prepared to compare their own ideas to those they see other people using. Encourage students to linger on the models they see to read the written explanations on them fully. This may mean that each student only gets to a couple of models in the gallery walk, but that is OK.

Ask if there are any questions. Set the timer for 4 minutes and cue students to begin the gallery walk.

Discuss similarities and differences. When the timer goes off, have students pause where they are in the gallery walk. Instruct them to find one or two people nearest them to talk to. Have each student share an interesting similarity and difference they noticed across the models with their new shoulder partners.

may get good info. here to help in facilitating a Scientist Circle

7 · DEVELOP AN INITIAL CONSENSUS MODEL

20 min

MATERIALS: science notebook, Initial Consensus Model poster, markers, posters from the previous Cup Design Unit that summarize ways to represent what was happening to the matter and energy in the cup system

Gather in a Scientists Circle. Present slide G. Tell students to bring their science notebooks and their handouts with them, along with chairs, to form a Scientists Circle.

Move the posters from the previous Cup Design Unit to be next to the Initial Consensus Model poster.

SCIENTISTS CIRCLE

Your students may be familiar with the Scientists Circle from the previous unit. A Scientists Circle includes these important features:

- students sitting so they face one another to build a sense of shared mission and a community of learners working together
- celebrating progress toward answering students' questions and developing more complete explanations of phenomena
- focusing on where students need to go next and how they might go about the next steps in their work

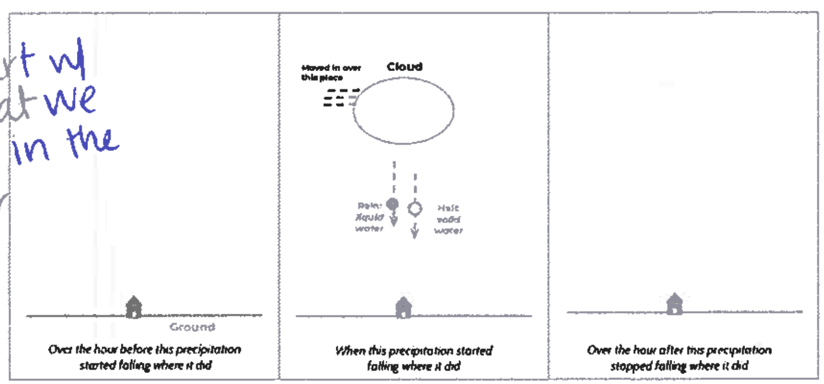
Tell students, *Remember that the goal of this discussion is to figure out areas of agreement and disagreement between our initial models. Knowing where we agree and disagree will help us figure out more about what might be happening in this kind of phenomenon. We also want to use this time to practice using our classroom norms.*✱

Remind students of the sentence starters. Make certain a *Communicating in Scientific Ways* poster or handout is conveniently located for students to see.

Develop and record the consensus model. It is useful to develop a visual representation of areas of agreement and disagreement at this point. This is what you will capture in the initial consensus model, a public record of the parts or pathways of the system that students are certain about as well as those they are less certain about. A suggested plan for developing this model, along with example images showing its incremental co-construction, is provided below. Ensure that the model you develop with your students represents their shared thinking. Different classes may develop this model in a different order or way.

It will be easiest to start with establishing agreement around what we all saw in the air outside when the precipitation fell as well as what we saw during the hour beforehand and the hour afterward. Almost all student models will include these elements:

- a cloud or clouds moving over the place where the precipitation fell
- rain (liquid water) and hail (solid water) falling from above
- relatively clear skies overhead (and sunlight reaching the ground) before and after the hailstorm (seen in video 3)



✱ ATTENDING TO EQUITY

This is an important opportunity to emphasize that each individual has contributions to make to their community of learners. It is through differences in thinking that the class will grow their knowledge together. Throughout this unit, students will be asked to be open to sharing knowledge products that depict their current thinking and to be open to learning from classmates who share their knowledge too.

✱ STRATEGIES FOR THIS CONSENSUS DISCUSSION

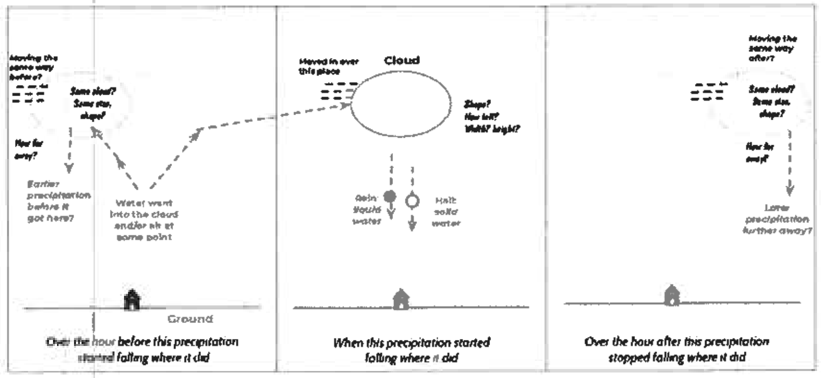
There are two goals of this discussion: (1) to continue to help students build the habit of sharing their initial ideas publicly and (2) to generate a variety of initial ideas about what is causing these precipitation events. As such, it is important to accept all student responses and encourage students to share their ideas. Further, it is important to highlight any areas of disagreement and help students clearly explicate their thinking. Be careful not to favorably respond to any one idea over others so as not to "give away" what might be going on.

next to include in model

Since the cloud is now a primary shared feature, focus on what we know about it and where it came from. Record these areas of controversy as they emerge:

impt. for model

- *Though we all showed a cloud, we aren't in agreement about its shape or size.*
- *We aren't in agreement (or aren't sure) about whether precipitation fell out of the cloud at a different location before it started falling over the location we saw in the videos.*
- *Though we know the cloud moved in over the place where it hailed, we don't know how far away it came from, nor whether it was the same shape or size before and after it arrived*
- *Some of us showed water going into the cloud at some point before it fell out as precipitation. Others didn't. But, we all agree now that all that water must have gotten up into the cloud at some point.*

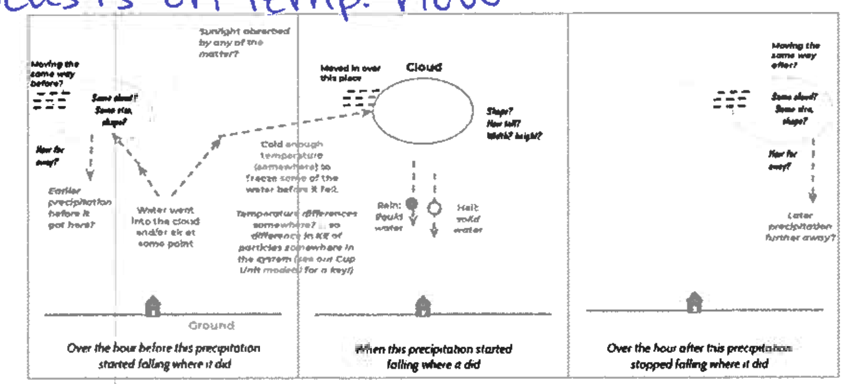


focus is on temp. now

Help the class recognize and record areas of agreement and uncertainty around temperature in the system, including these:

impt. for model

- *The temperature got cold enough somewhere in the system to freeze some of the water that fell.*
- *There must be temperature differences somewhere in the system because some of the water that fell was frozen and some wasn't.*



pull representation idea from Thermal

Emphasize that we have a way to represent temperature differences between a gas, liquid, or solid as differences in the average kinetic energy of the particles, based on our work in the Cup Design Unit. Post those representations from that unit next to this consensus model as a reference. They should include ideas identified earlier: the particles in a gas (like air) are spread far apart; the particles in a solid and a liquid are packed close together; and the particles of a substance move faster, on average, at higher temperatures and slower, on average, at lower temperatures.

focus on energy

Ask students about any places in their model where they thought energy might be getting transferred into, through, or out of the system. Remind students that this is what they added in a new color to their ~~original~~ model. Areas of agreement and uncertainty will likely include these:

- *We agree that light can be absorbed by matter (as in some systems in the Cup Design Unit), but we aren't in agreement about whether (or where) that was happening in this system.*
- *We aren't sure (or aren't in agreement) whether there were other ways energy was moving through or out of the system (e.g., conduction, wind, and so forth).*

possible competing ideas

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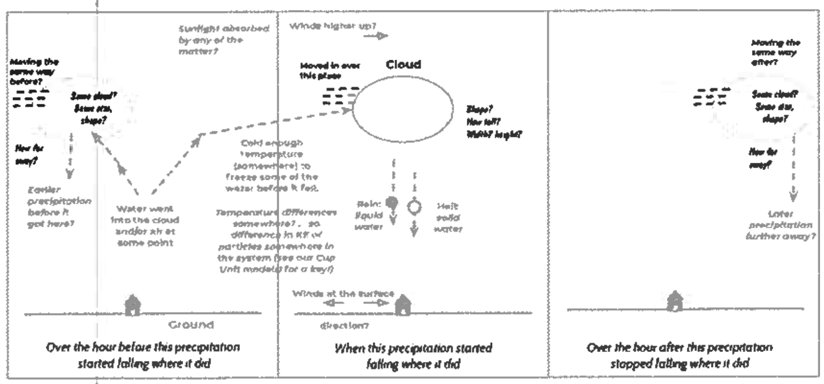
focus on wind

If students noticed winds at the surface and agree on this, add ~~that too~~.

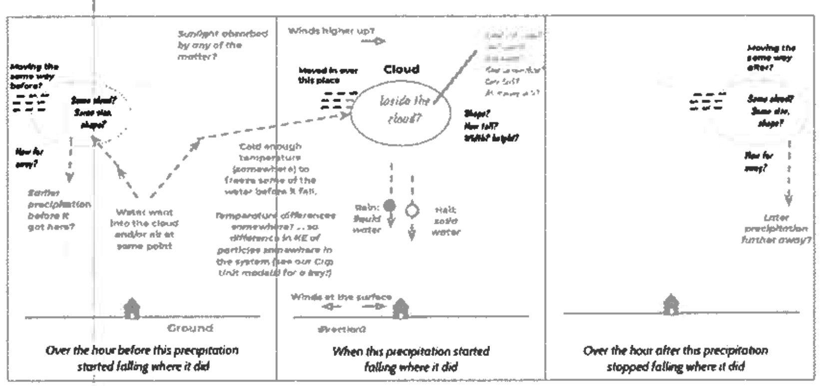
Help the class recognize areas of disagreement or controversy around these issues:

- which direction the winds are going and whether that changes over time
- whether there is wind at the height of the clouds (or above them) and whether it is the same as wind at the surface

possible competing ideas



Lastly, emphasize that a cloud seems to be at the center of all the action in this system. Ask about what students showed happening in the cloud at the particle level. It is likely that some models did not show anything happening in the cloud, and there may be different ideas or controversy around models that did. Help the class recognize those areas we didn't all show or didn't all agree on.



get st. thinking about clouds at the particle level - may see competing ideas

Cloud-related areas of controversy that you may hear students raise at this point will include things like these:

- *Does it fill up with water as it gets darker?*
- *Is there ice or liquid water in it?*
- *Is there water vapor in it?*
- *Does part of the cloud get heavier before the precipitation falls out?*
- *Is part of the cloud held up somehow?*
- *Is there air or wind moving inside the cloud?*

possible competing ideas

Record these areas of uncertainty as well. Include any additional ideas your class raises or is collectively unsure about, such as ideas related to humidity or pressure.

Save the Initial Consensus Model Poster to use as part of the background for the DQB on day 3.

will need Consensus Model posters on day 3

8 · DEVELOP INITIAL QUESTIONS

5 min

MATERIALS: markers, sticky notes

Record initial questions. Make sure extra markers and sticky notes are provided for this part. Say, *Let's try to capture some of the questions we have about what is happening in this type of phenomenon.*

Present **slide H**. Read the directions on the slide aloud. Give students sticky notes and at least 4 minutes to generate questions. Encourage students to write more than one question, but only one per sticky note. Have students put their initials in pencil on the back of their questions and save them in the back of their science notebooks until next time.

9 · IDENTIFY RELATED PHENOMENA AND REFLECT ON NORMS

7 min

MATERIALS: science notebook, chart paper, markers, sticky notes

Identify and record related experiences. Present **slide I**. If needed, refer back to the meaning of *precipitation* posted earlier ("liquid or solid forms of water that fall to the ground from above").
Give students 3 minutes to record their related phenomena in their science notebooks. As students are doing this prepare a two-sheet Related Phenomena poster, with these titles:

- Times when a lot of precipitation fell **in one place in a relatively short time** (minutes)
- Times when a lot of precipitation fell **continuously in one place over a much longer time**

prep before

helps to build st. experiences w/ scale

Check in on the classroom norms. Ask a few students to share how they the class did overall on it as a learning community on their norms. If time allows, use **slide J** to prompt collecting their thoughts on how each student feels they did on their chosen focal norm on a sticky note as an exit ticket.

End of day 2

10 · SHARE RELATED PHENOMENA AND RECORD ADDITIONAL QUESTIONS

13 min

MATERIALS: science notebook, chart paper, markers, sticky notes, Related Phenomena poster

Share and record related experiences. Post the Related Phenomena poster Present **slide K**. Take 6 minutes to have all students share out related phenomena from their notebooks and assign them to one of the two sheets on the chart.

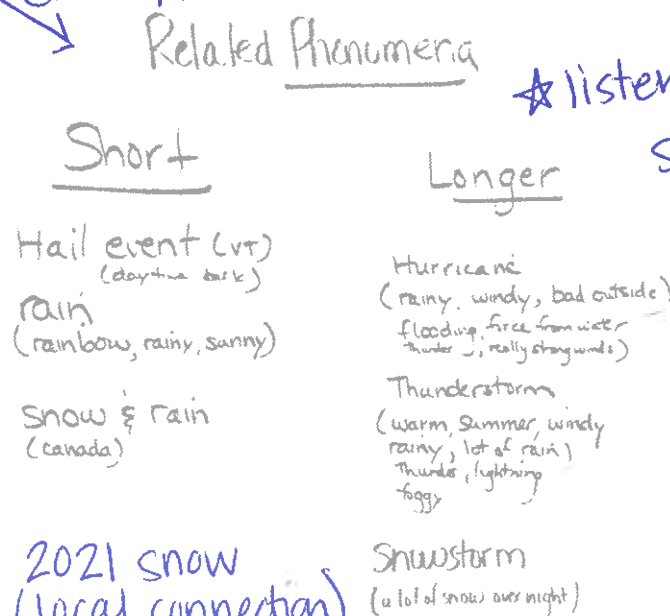
→ provides access to ALL st.

Start off with the phenomenon everyone experienced—the hail events in the videos—and ask students where it should go. Students should assign it to the first poster (relatively short time). Write "The 3 hail events in the videos" on that poster.

As students share their examples, record them on the corresponding posters according to students' suggestions. Related phenomena that students will likely share as "short" include severe thunderstorms. Related phenomena that students will share as "longer" include things like multi-hour or -day hurricanes, northeasters, blizzards, and drizzle.

If students aren't sure where an example goes, you could add it between both posters with a question mark or with arrows pointing to both posters to indicate the uncertainty. Alternatively, you could write it on another sheet of chart paper.

create/put on Unit Wall



★ listen for connections and st. assets

With each example shared, ask for a show of hands of students who described a similar event in their science notebooks. Put tally marks showing the number of students next to that event on the poster, and have students put a check mark next to their own similar event if it gets written up on the poster. This will ensure everyone's example is represented on the posters and consolidate the overlapping examples. A sample poster from one class of students is shown here.

builds equity

2021 snow (local connection)

2016 Flood - local connection
★ be prepared for tough emotions/memories

Connect mechanisms across related phenomena. Present **slide L**. Give students 3 minutes to discuss the question on this slide with a partner.

Record additional individual questions. Make sure extra markers and sticky notes are provided. Say, *Let's try to capture any additional questions we have about what is happening in these different precipitation events too, before we form our Driving Question Board.*

Present **slide M**. Give students at least 3 minutes to generate their questions on sticky notes. To prompt an array of questions, remind students to think carefully about the hail events in the videos in addition to other related phenomena. Encourage students to write more than one question, but only one question per sticky note, and put their initials in pencil on the back of each.

While students write questions, move the Related Phenomena poster to hang next to the Initial Consensus Model poster where all students can see it from a Scientists Circle. These posters together will serve as the space where students can add their questions to build their DQB, and will be referred to as the DQB in subsequent activities and lessons.

1 · BUILD THE DRIVING QUESTION BOARD

20 min

MATERIALS: chart paper, scissors, markers, DQB

Gather in a Scientists Circle around the DQB. Present slide N. Have students bring their science notebooks and all of their sticky notes questions, including those from the last class period, along with a chair.

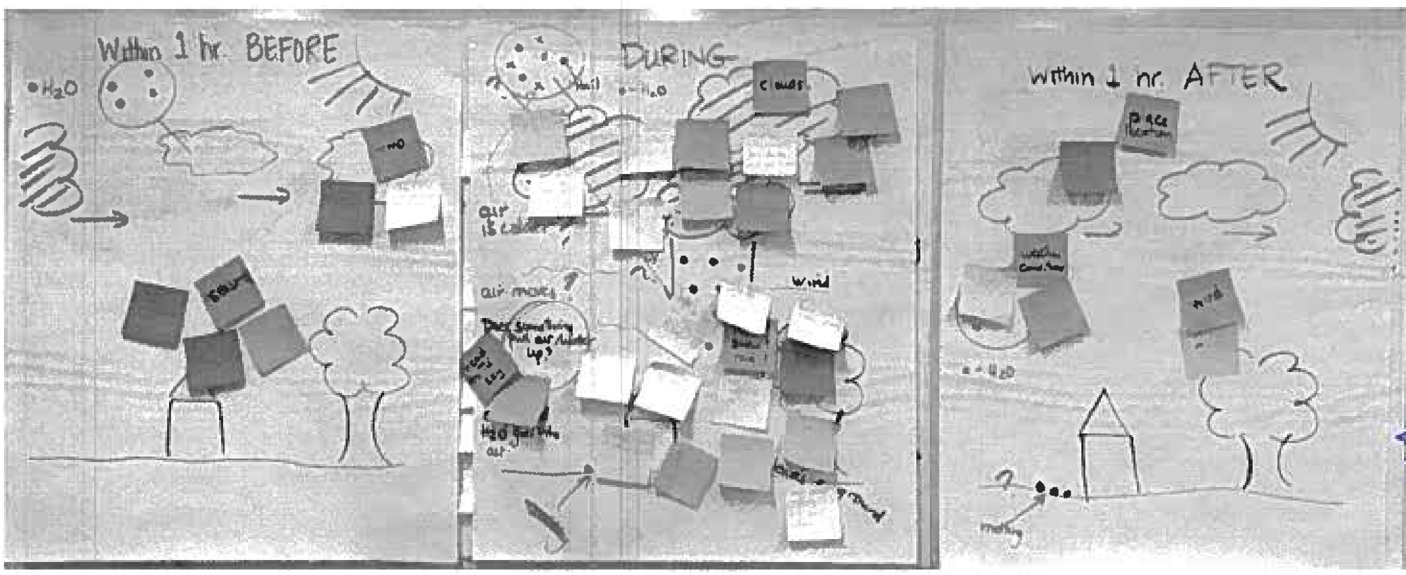
Remind students that our goal is to capture all our questions to build a DQB. Say something like, *It looks like you have a lot of really good questions about the hail storms in the videos and about other precipitation-related phenomena. It is important that we hear everybody's questions, and we might find that we have similar questions. To help us group similar questions, let's try to post each question on a spot on the Initial Consensus Model poster or on the Related Phenomena poster, or in between them.*

Review these steps for forming the DQB:

- The first student comes up to the DQB with a sticky note, faces the class, and remains standing.
- The student reads their question off the note and then posts it on the DQB near the section of the consensus model or related phenomena it is most related to.
- The student selects the next student whose hand is raised.
- The next student reads their question and posts it on the DQB. This student also says what other posted questions it relates to and explains why or how it relates.*
- The student then selects the next student whose hand is raised.*
- This process continues until everyone has had a chance to post a question.
- Remind students to keep track of whether their question was already asked, put a checkmark on that sticky note if it was, and then select a different question to share.

As students share, questions will naturally start clustering on certain parts of the DQB.

An example of one such DQB is shown here.



* SUPPORTING STUDENTS IN ENGAGING IN ASKING QUESTIONS AND DEFINING PROBLEMS

If students forget to explain how or why their questions are linked to someone else's question, press them to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off each other's ideas, and to help scaffold student thinking.

Don't worry if some questions raised are not part of topics in this unit. Over time, with practice in this type of activity, students will get better and better at forming testable questions in the scope of the DQB.

If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

If a question is similar to (or the same as) another one, have the student place it on top of that question so other students can visualize how many questions are identical or related. Emphasize that this provides us with evidence of where many people are thinking about similar things.

* ATTENDING TO EQUITY

Having the student who volunteered and posted a question pick the next student to share (from those whose hands are raised) is a great way to turn over the pacing and cadence of this group work to the students. Reuse this technique in future Scientists Circles to encourage increased student agency in the classroom learning community. When you do this, take a seat with the students in the circle to position yourself as an equal member of the learning community who is listening, making sense of questions, and trying to figure this out. If you have questions you want to share with the group, raise your hand and wait for someone to call on you.

Once students have completed their sharing, ask them to identify the categories of questions, if time permits. Here are some possible examples of categories that are likely to emerge and the kinds of questions you will hear students raise related to each.

- **Hail:** How does hail form, why do different things (hail, snow, or rain) sometimes form in clouds, and what keeps them up there?
- **Wind:** Why is there a lot of wind in some storms?
- **Clouds:** What is going on in the clouds?
- **Snow and blizzards:** Where does the water come from in a blizzard (when it seems to be freezing cold), and how do blizzards form?
- **Hurricanes:** What causes hurricanes?
- **Rain:** Why does it rain heavily sometimes in some places and not in others?
- **Elevation and temperature:** How does the temperature higher up in the air compare to the air closer to the ground?

Point out that many of the questions are connected to how and why different types and amounts of precipitation do or do not occur. Suggest that including these questions under a single driving question could remind us of how the work on any one question is in the service of all our questions. Propose that **"Why does a lot of hail, rain, or snow fall at some times and not others?"** could be a single driving question that most of our questions could fit under.

Once the class agrees to this, write it in large letters on a half-piece of chart paper and hang this banner over the top of the entire DQB. Remind students that we can revise this question as we continue to figure out new things in future lessons.

12 · DEVELOP IDEAS FOR FUTURE INVESTIGATIONS

12 min

MATERIALS: Ideas for Future Investigations and Data We Need poster, markers

Brainstorm ideas for future investigations and useful data sets. Present **slide O**. Read the slide aloud. Give students 3 minutes to talk with a shoulder partner to generate ideas. You may want to encourage students to stand or stretch while they talk.

As students are doing this, hang the Ideas for Future Investigations and Data We Need poster right next to the DQB.

In the remaining 9 minutes, have students reconvene standing in a semi-circle around the Ideas for Future Investigations and Data We Need poster so all can see it.

Build the poster with students' ideas. Tell students you want everyone's ideas to be shared and represented on the poster. Say something like, *To make sure we have your ideas up here, I will pass a marker to the first person on the edge of the circle. That student should share one idea. I will write it up and number it. Once I've almost finished writing it, that student should pass the marker to the student next to them. The second student then shares an idea. If that idea is on the poster already, the student should say which idea it is and how it is similar. I will put a tally mark next to it. The marker is then passed and we continue until we have heard once from everyone in the class. If you have additional ideas that don't end up on the poster, feel free to raise your hand after the marker makes it all the way around the circle. If we run out of time, we'll pick up here in the next class. And if you think of new ideas as we go, feel free to jot them down. We should always be thinking of ways we can add to this list.*

In large classes, you may run out of time before all students share out an idea. If needed, resuming this activity right where you left off is a natural point to launch Lesson 2.

A sample poster from one class of students is shown here. Notice that most of the ideas that students suggested map closely to the data presented in Lessons 2 and 3. A few additional ideas are related to cloud data and simulating a cloud, which is more aligned to the investigations in Lesson 6 and beyond. This is the typical pattern we have seen in other classrooms. Though the ideas for the investigations in Lessons 4 and 5 will not be apparent at this point, students will suggest something similar when they start those lessons, during the navigation portion.

Celebrate the formation of a joint enterprise. Once this poster is built, celebrate that they created a joint mission and proposed action plan to guide the work of our learning community for weeks to come. Say something like, *Wow. We have accomplished so much. We now have a mission to accomplish as a class, thanks to all the questions you shared and how you connected them. These questions really represent what we hope to figure out. And we have a lot of ideas for investigations and data sources we can work with. I am very excited for us to start investigating all of these. I have lots of additional data and equipment for us to use that are well matched to the things you've said we need. Let's plan to start exploring some of this in our next lesson.*

Prioritize one set of ideas for investigations. If time permits, say something like, *I noticed many of our questions were about how hail formed. Explaining that could help explain other precipitation events too. One thing you all said was weird was that it looked like the hail fell in places where green stuff was growing and it looked warm, so we weren't sure how the water got cold enough to freeze and form hail. We wanted to know more about what it was like outside on these days when it hailed. We also thought it would be useful to look at hail more closely, for clues about how it formed. Let's plan to look at that sort of data next time. Let's start making some predictions beforehand. If you could take observations of both things, what do you expect you might find?* Give students a minute or two to turn and talk with a partner.

Collect students' unposted sticky note questions before they leave.

Investigation Ideas:

- Dissect a piece of hail
- Temperature data → how it changes or stays same
- Wind data
  - ↳ direction, changes?
- Rain data
- Temperature data low and high
- Humidity data for winter
- Simulate how to make a cloud
- Cloud data → how high? → color, shape → how they change
- Collect rain and hail during a storm
- sizes of hail
- Average temperature data for US

Additional Lesson 1 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

While the class is building the Driving Question Board, if a student forgets to explain why or how their question is linked to someone else's, press that student to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off one another's ideas, and to help scaffold student thinking. If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

This lesson's activities rely on students communicating and articulating their thinking. One tool that supports classroom discussion is the Communicating in Scientific Ways sentence starters. This 1-page document can be enlarged and printed as a class poster, printed on 8.5-x-11 paper and posted near students' desks, and/or scaled down and taped into students' science notebooks. Reference the sentence starters and encourage students to use them. The sentence starters can be especially useful for helping students engage in scientific talk, particularly students who may feel reluctant to contribute.

have copies for St. notebooks & 1 large poster

can help