Grade 5 Implementation Workshop Guide

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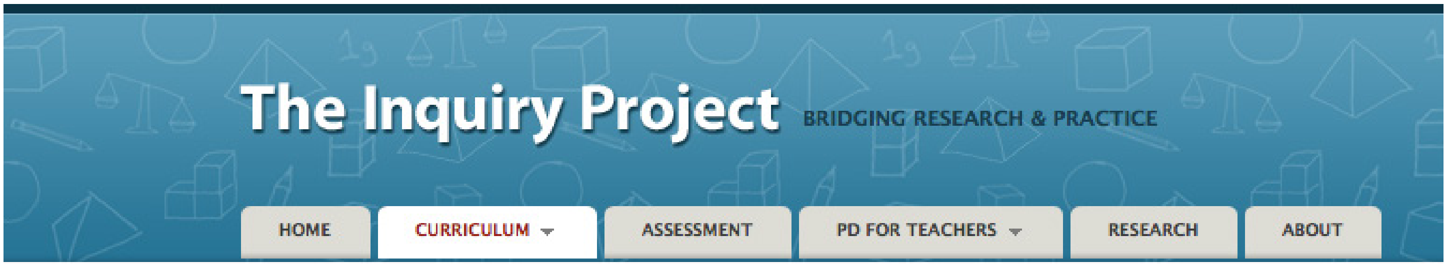
Transformations, Keeping Track of Matter



Grade 5: Investigating Water Transformations

Keeping Track of Matter

Dear Workshop Leader

6-HOUR IMPLEMENTATION WORKSHOP

These materials will help you get ready to lead an Implementation Workshop for the *Grade 5 Inquiry curriculum*. This curriculum is a carefully crafted, research-based progression about Matter for grades 3-5. The curriculum includes a detailed *Teacher's Guide* and additional resources for teachers. Why hold an implementation workshop? A teacher who is about to use the Inquiry curriculum for the first time has a lot to think about and will have many questions:

FIRST TIME QUESTIONS

- big picture questions about the core science ideas;
- logistical questions about managing materials;
- pedagogical questions about how to help students work with data or learn to reason scientifically.

WORKSHOP EXPERIENCE

This workshop

- helps teachers answer some of these questions.
- illustrates the "architecture" of The Inquiry Project website.
- facilitates teachers' own firsthand experience of some of the key investigations, using materials from the kit.
- models ways to answer questions, work with data, and lead discussions.
- highlights resources available for teachers when they want to know more about specific science con- tent or children's ideas about these same topics.

In our experience, teachers like the invitation to be active explorers. They like experiencing some of the investigations firsthand. They like the combination of theoretical and practical information and the tight connection between the workshop content and what they are about to teach.

The workshop requires 6-hours. The time could be organized as a full day workshop, two three-hour, or three two-hour workshops.

MODIFY AS NECESSARY

You can use these materials as is or modify them to meet the needs of your group of participants. It is essential that you become very familiar with the curriculum, the organization and contents of the *Teacher's Guide*, *The Child and the Scientist* essays, and video cases.

TRY ACTIVITIES BEFOREHAND

Be sure to try the firsthand activities yourself before you ask participants to experience them in the workshop.

As you begin your planning, print out (in color if possible) this *Grade 5 Implementation Workshop Guide* (pdf)

1 Workshop Goals

By the end of the workshop, participants will:

1. **be familiar with the conceptual flow of *The Inquiry Project* curriculum** Grades 3-5 and see where the Grade 5 curriculum fits in the progression;
2. **know their way around *The Inquiry Project* curriculum website,** the Grade 5 curriculum, and resources for teachers;
3. **have firsthand experience with some key science investigations**;
4. **know how to find resources** they can use to deepen their understanding of the science content of the curriculum and children's ideas about these topics.

2 Before the Workshop

This workshop leader guide is based on the assumption that you are familiar with *The Inquiry Project* materials and have specific knowledge and understanding of the investigations in the Grade 5 *Investigating Water Transformations* curriculum. If the curriculum is new to you, it is critical that you read the teacher guide carefully, try the firsthand investigations that are part of the workshop yourself, review the video classroom and scientist cases, and follow the links that are provided in these workshop notes.

1. **Workshop space.** Arrange for a workshop space where participants can work in groups around a table or cluster of desks and everyone can see a screen or SMART board.
2. **Laptop or tablet for everyone.** Check to be sure everyone – you and participants – can connect to the Internet and there's a screen or SMARTboard where you can project *The Inquiry Project* website. You will want to encourage participants to bring a laptop or tablet to the workshop and to follow along as you work through the curriculum and professional development resources on the website.
3. **Materials.** Gather and organize materials (see *Master Workshop Materials List* at the end of this document). Materials are also listed where they are called for in the workshop.

   Provide a scale and set of materials for every 2, 3, or 4 participants.

> **TIP** *Working with materials for groups of 4 will model what happens in the classroom; having materials for every pair will allow more firsthand experience in a shorter amount of time.*

4. **Agenda and Goals.** Post an agenda and a list of workshop goals (above) so that they will be visible throughout the workshop. Your agenda will depend on how your organize the 6 hours, e.g., full-day workshop, two 3-hour or three 2-hour workshops.
5. **Prepare ahead.**

a. **For *Investigations 7-9*.** Set up one 2-bottle system. Do this several days before the workshop if possible, otherwise as early as you can the day of the workshop. See *Setting up a 2-bottle system* in *Investigation 7, Materials and Preparation*.

Put 30cc of water and a few drops of food coloring in the lower (smaller) bottle and turn on the lamp.

b. **For *Investigations 10-12*.** To prepare for *3. Water to Ice,*

- Freeze several trays of mini-ice cubes (*Investigation 10*)
- Prepare several 8 oz. plastic capped water bottles from the kit ¾ filled with water. Record the volume by marking the water level with a Sharpie and record the weight of each bottle. Place the bottles in a freezer at least 24 hours before you will need them. (*Investigations 10 and 12*)

HANDOUTS

c. **Handouts.** Prepare the handouts.

	Handout Title
1	*Science Concepts Grades 3-5 Chart*
2	*Directions for Making the Mini-lake and Recording Measurements*
3	*Mini-lakes: a Long-term Investigation*
4	*Data Table: Weight of Mini-lakes*
5	*Weight of Mini-lakes Over Time Graph*
6	*Student sample Mini-lake Graph*

3 The Workshop

Set the Stage and Welcome

Show the video introduction to the Inquiry Curriculum to situate the grade 5 curriculum.

Tailor your welcome to your group of participants and particular setting. Workshop leader and participants introduce themselves - briefly.

Project the Home Page and click the Grade 5 curriculum.

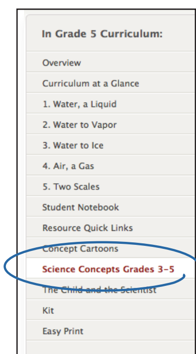
Time: 10 Mins

Small Group Activity

What are the core ideas and science concepts in this curriculum? (~10 min.)

Click *Science Concepts Grades 3-5* (sidebar menu).

Ask participants to use a copy of this chart found in the Handout packet.



Science Concepts

	Weight	Volume	Material	Matter
Grade 3	The weight of objects can be compared using a pan balance and standard (gram) units.	Two solid objects cannot occupy the same space. The amount of 3D space that objects occupy can be compared.	Objects can be described in terms of their weight and volume and the materials they are made of (clay, cloth, paper, etc.). Materials have observable physical properties such as color, size, texture, flexibility, etc. Same size objects can have different weights when they are made of different materials.	Materials can be subdivided into small pieces and the pieces still have weight.
Grade 4	The weight of solids and/or liquids can be compared using a digital scale and can be represented on a weight line or a table. Weight is conserved during crushing and reshaping	Liquid and solid volumes can be measured in cubic centimeters. When immersed, a solid displaces a liquid volume equal to the solid volume.	The relationship between weight and volume (i.e. density) is a property of solid and liquid materials.	Matter can be divided into tiny pieces, and even the tiniest pieces have weight and take up space.
Grade 5	Weight is conserved during dissolving, freezing, melting, evaporation and condensation.	Volume may not be conserved in phase change.	Air is a mixture of gaseous materials composed of particles too small and spread apart to see. Melting, freezing, evaporation and condensation change the form of matter but do not change the material.	Matter is composed of particles that have weight, occupy space, and are too small to see. Gases, liquids and solids are all forms of matter and have weight and take up space.

Handout
Science Concepts Grades 3-5 Chart

And take 5 minutes to discuss the question below:

What can we expect our students to understand about the nature of matter as they begin the Grade 5 Transformations of Matter curriculum?

Take a few minutes to find out what participants noticed and what questions they have.

Emphasize that students learn about matter through a coherent sequence of investigations across the three grades.

Learning science includes eight practices described in *A Framework for K-8 Science Education (2012)*.

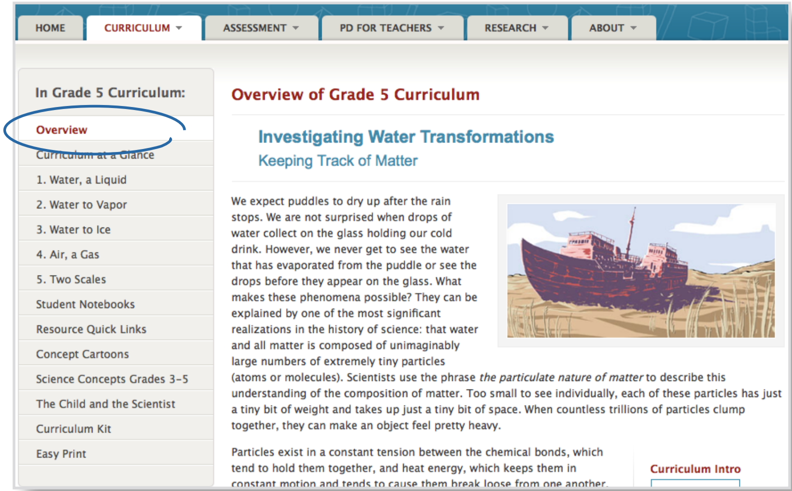
1. Asking questions
2. Designing and using models
3. Planning and carrying out investigation
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Time:
10 Mins

Overview of the Grade 5 Curriculum

Explain that you'll now look more closely at the Grade 5 curriculum.

Click *Overview* on the sidebar menu and make the points below.



This curriculum is called Investigation Water Transformations, Keeping Track of Matter. There are 18 Investigations grouped in 5 clusters called "Sections." The curriculum in Grades 3 and 4 focused on solid and liquid materials. In Grade 5, the focus is on transformations of liquids, on gases - particularly water vapor and air, on invisible processes such as dissolving and evaporation, and on the crosscutting concepts of systems, scale, and flows, cycles and conservation of matter.

Time:
10 Mins

Get to Know the Grade 5 Website

Tell participants that *The Inquiry Project* includes a detailed *Teacher's Guide* to the curriculum plus a rich set of resources for teachers that are all closely tied to the classroom investigations. Links to resources are embedded in the online Teacher's Guide and also can be accessed from the sidebar menu on the left. These materials can be used online or printed out.

Explain that to become familiar with the navigation and resources of the Grade 5 website, you'll take them on a website tour of what they'll find when they use the sidebar menu.

Encourage participants to follow the tour on their own laptops or tablets and explain that you want them to continue to explore the website throughout the workshop.

Play the Website Tour video on the Grade 5 Overview page. You can pause the video tour at any point.

Grade 5 Curriculum Sidebar Tour

In Grade 5 Curriculum:

- Overview
- Curriculum at a Glance
- 1. Water, a Liquid
- 2. Water to Vapor
- 3. Water to Ice
- 4. Air, a Gas
- 5. Two Scales
- Student Notebook
- Resource Quick Links
- Concept Cartoons
- Science Concepts Grades 3–5
- The Child and the Scientist
- Kit
- Easy Print

Investigations

1. Water, a Liquid
- Investigation 1
- Investigation 2
- Investigation 3
- Investigation 4
- Investigation 5

2. Water to Vapor
- Investigation 6
- Investigation 7
- Investigation 8
- Investigation 9

3. Water to Ice
- Investigation 10
- Investigation 11
- Investigation 12

4. Air, a Gas
- Investigation 13
- Investigation 14
- Investigation 15
- Investigation 16

5. Two Scales
- Investigation 17
- Investigation 18

Resource Quick Links
- Aral Sea
- Annotated Drawing
- 315 Dots per Page
- Particle Magnifier

Concept Cartoons
- Air Has Weight
- Condensation
- Evaporation

Grade 5 Curriculum at a Glance

Water Transformations: What Changes and What Stays the Same?

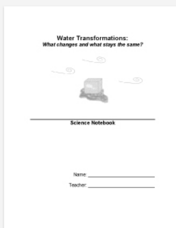
1. WATER, A LIQUID	2. WATER TO VAPOR	3. WATER TO ICE	4. AIR, A GAS	5. TWO SCALES
1. Why are these ships in a field? A PowerPoint presentation poses a mystery and presents a real-world example of a dramatic water transformation. Students start to build class-room-sized mini-lakes to investigate.	**6. What happens to the water?** As students watch with magnifiers, water droplets shrink and disappear. Does evaporation destroy water, or has it gone somewhere else? This question launches a search for the answer.	**10. How are ice and water the same and different?** Students launch this 3-session investigation by contrasting and comparing the properties of ice and water. They also revisit condensation in a different context.	**13. Is air matter?** An exploration with syringes provides evidence that air takes up space. A demonstration comparing air-filled and empty balloons establishes that air has weight. Air is determined to be *matter*.	**17. What's the story behind th graph?** Students annotate their graphs. Their observations include their new understandings of the relationship between macroscopic change and microscopic processes.
2. How can we keep track of our mini-lake materials? Students are reintroduced to the concepts of volume and *heavy for size*, and finish building their mini-lakes. They learn that everything that has weight and takes up space is *matter*.	**7. What happened to the water?** The class assembles a set of three small closed systems in order to study evaporation. Can this tiny system help us investigate processes that happen in the larger world?	**11. What happens to weight and volume when water freezes?** Students discover that while the volume of a water sample changes as it is frozen, the weight remains the same. Has the material also changed?	**14. What are some properties of air? (1)** Further exploration reveals that air is compressible while water is not. Students develop an annotated drawing (an explanatory model) to explain this difference in properties.	**18. How have our understandings changed?** Students reflect on how the 2-bottle system and other investigation materials have helped them develop new understandings about real-world transformations of water.
3.How does water compare with sand? As they compare the weights and volumes of materials used in their mini-lakes, students discover the unit weight of water and have additional experience with the concept of *heavy for size*	**8. What is happening in the 2-bottle system?** Students learn about the elements of a system: the boundaries, components, and interactions. They also record the transfor-mations underway in the 2-bottle systems.	**12. What changes and what stays the same as ice melts?** Reasoning suggests that the material itself does not change as ice melts to water. A computer model that highlights water and ice particles reinforces the reasoning.	**15. What are some properties of air? (2)** A demonstration highlights the response of air to heating and cooling. Students develop another annotated drawing to explain this response.	
4. What does a drop of water weigh? In working with single drops of water, students see that very sm things can take up space and ha weight, even when that weight does not register on a classroom scale.	**9. Why do the water drops form?** Through a study of water drop patterns in the 2-bottle systems, students begin to understand the relationship between condensation and temperature.		**16. What are some properties of air? (3)** Students again view a computer model that helps them under-stand the relationship between temperature, particle motion, and the volume of gas.	
5.What changes and what stays the same when salt dissolves in water? Dissolving salt in a cup of water highlights the fact that even particles too small to see can have weight and take up space.				

Student Science Notebooks

Individual notebook pages can be viewed within the curriculum. To print the entire student notebook, use the file on the right. It is recommended that the notebook is printed or copied in two-sided format.

The notebook file is in pdf format and can be read using Adobe reader. To get the latest copy of Adobe reader click here: Download Adobe Reader.

See Teacher Resources for more information about using student science notebooks in your classroom.



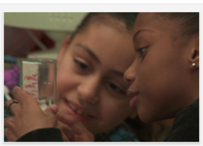
Open Student Science Notebook [pdf]

Science Concepts

	Weight	Volume	Material	Matter
Grade 3	The weight of objects can be compared using a pan balance and standard (gram) units.	Two solid objects cannot occupy the same space. The amount of 3D space that objects occupy can be compared.	Objects can be described in terms of their weight and volume and the materials they are made of (clay, cloth, paper, etc.). Materials have observable physical properties such as color, size, texture, flexibility, etc. Same size objects can have different weights when they are made of different materials.	Materials can be subdivided into small pieces and the pieces still have weight.
Grade 4	The weight of solids and/or liquids can be compared using a digital scale and can be represented on a weight line or a table. Weight is conserved during crushing and reshaping	Liquid and solid volumes can be measured in cubic centimeters. When immersed, a solid displaces a liquid volume equal to the solid volume.	The relationship between weight and volume (i.e. density) is a property of solid and liquid materials.	Matter can be divided into tiny pieces, and even the tiniest pieces have weight and take up space.
Grade 5	Weight is conserved during dissolving, freezing, melting, evaporation and condensation.	Volume may not be conserved in phase change.	Air is a mixture of gaseous materials composed of particles too small and spread apart to see. Melting, freezing, evaporation and condensation change the form of matter but do not change the material.	Matter is composed of particles that have weight, occupy space, and are too small to see. Gases, liquids and solids are all forms of matter and have weight and take up space.

The Child and the Scientist

A child and a scientist often have very different ideas about the world around us. Our challenge is to identify the difference between how the child and the scientist think about matter, and then to bridge that gap.



Dr. Roger Tobin

Two essays appear at the beginning of each section of the Inquiry Project curriculum. The first essay, by Professor Roger Tobin, presents the scientist's perspective about the science content that is introduced in the section. The second essay, by Professor Carol Smith, presents the child's perspective, and explains why the science concepts may be hard for students to understand. As a group, these thirteen pairs of essays cover a network of concepts relevant to understanding matter. This network of concepts is developed throughout the learning progression (across grades 3–5), using language and concepts that children can understand. The essays are collected here to be easily accessed at any point in the curriculum. We encourage you to refer to them prior to teaching, as they bring forward the nuances of the concepts and how children perceive them.

The Scientist	The Child
Water, a Liquid What are materials made of?	**Water, a Liquid** What makes the particulate model of matter so challenging for students?
Water to Vapor What's important about evaporation and condensation?	**Water to Vapor** The Challenges of Learning about Evaporation and Condensation
Water to Ice What's important about freezing and melting?	**Water to Ice** The Challenges of Learning about

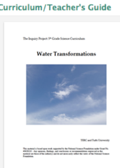
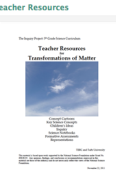
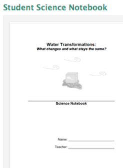
Curriculum Kit

Materials are listed for a classoom of 24 students split into 6 groups of 4. Your classroom may require modifications of this list.

- 1 spray mister
- 1 pitcher
- 1 double pan balance
- 1 balloon pump
- 1lb salt
- 4lb sand
- 2 1/2-inch mini ice cube trays
- 2 1gal buckets
- 6 digital scales
- 6 trays
- 16 balloons
- 24 conical paper cups
- 24 magnifiers
- 24 plastic spoons
- 3 aluminum reflector lamps
- 3 100 watt incandescent bulbs
- 3 2-liter plastic bottles
- 1 rubber stopper
- 1 bottle glycerin
- 1 bottle Joy dishwashing liquid
- 1 bottle blue food coloring
- 4lb gravel
- 1/2-liter small rocks
- 20ft of clear plastic 14-inch tubing
- 200 centimeter cubes
- 12 100ml graduated cylinders
- 12 8oz plastic capped water bottles
- 14 sandwich boxes with covers
- 24 1cc small syringe
- 32 12cc syringes (10 with caps)
- 48 185ml capped vials
- 60 12oz clear plastic cups
- 4 1-liter plastic bottles
- 3 bottle system bases
- 3 plastic bottle connectors (bored out to 2.5cm in diameter)

Grade 5 Easy Print

Easy print versions of the curriculum, teacher resources and science notebook in pdf format are available to simplify printing the Inquiry Project materials.

Curriculum/Teacher's Guide	Teacher Resources	Student Science Notebook
		
The Curriculum/Teacher's Guide Easy Print (pdf) is formatted for double-sided printing. It includes the overview of the Grade 5 Curriculum, the Sessions at a Glance chart, the Curriculum Kit, the Core Science Concepts chart and all the section overviews and investigations	The Teacher Resources Easy Print (pdf) is not formatted for double-sided printing (most of the resources are single pages). It includes the Concept Cartoons, Key Science Concepts, Children's Ideas, and information about Inquiry, Science Notebooks, Formative Assessment and Representations.	The Student Science Notebook (pdf) is formatted for double-sided printing.

A Closer Look at the Curriculum

This workshop looks at the Inquiry curriculum through two lenses: the overarching organization and goals or big picture on one hand, and step-by-step details on the other. Teachers need both perspectives, how learning experiences connect and contribute to understanding core science ideas, concepts, and scientific practices and the specifics of how to carry out investigations.

A critical part of the workshop is the time participants experience student investigations firsthand, discuss them and raise quesitons.

The rest of this guide is organized by clusters of investigations we call "sections."

Section 1: Water, a Liquid, Investigations 1-5

I. To the Workshop Leader (orientation, materials/preparation, *Framework* connections)

II. Overview of Section 1(the big picture for this group of investigations)

III. Experience the Investigations (the specifics)

Section 2: Water to Vapor, Investigations 6-9

I. To the Workshop Leader

II. Overview of Section 2

III. Experience the Investigations

Section 3: Water to Ice, Investigations 10-12

I. To the Workshop Leader

II. Overview of Section 3

III. Experience the Investigations

Section 4: Air, a Gas, Investigations 13-16

I. To the Workshop Leader

II. Overview of Section 4

III. Experience the Investigations

Section 5: Two Scales, Investigations 17-18

I. To the Workshop Leader

II. Overview of Section 5

III. Experience the Investigations

Section 1: Water, a Liquid, Investigations 1-5

I: To the Workshop Leader

Introducing Investigations 1-5

The unit begins with a mystery, *Why are these ships in a field?* The investigations that follow provide evidence that helps resolve the dilemma. Participants experience a condensed version of a mini-lake investigation in which weight is used to keep track of matter. In the next investigation, knowing that weight can be used to track matter in mini-lakes helps answer questions about the disappearance of salt when it dissolves. Evidence from weight data suggests the now-invisible salt is still there and that gets us wondering about the nature of matter we can no longer see! These investigations play an essential role in students' understanding of materials and matter, as well as two crosscutting concepts, scale and systems.

Materials and Preparation for this part of the Workshop

A critical part of the workshop is the opportunity for participants to experience student investigations first-hand and raise questions about materials management and logistics. In addition to a materials list for each Section of the curriculum, *Appendix A* contains a *Master Materials List*.

Handout packet for each participant

Investigations 1-3

For each group of 2-4 participants

- 1-6" strip of masking tape
- 1 index card "120 grams"

  Note to leader: In the classroom students are assigned 120g, 130g, 140g, or 150g. We suggest all participants measure 120g of sand, gravel, and water in this workshop.

- 2 plastic spoons
- 1 sandwich box with covers
- 1-12 oz. cups 2/3 full of sand
- 1-12 oz. cups 2/3 full of gravel
- 1-12 oz. cups 2/3 full of water
- 1-12 oz. cups each holding 8 small rocks
- 4 plastic vials with covers
- 1 digital scale
- 1-12 oz. cup holding 30 centimeter cubes
- 1-12 oz. cup
- 1-100ml graduated cylinder
- 1 funnel: conical paper cup with ½" snipped of the end
- 1-12 oz. cup 1/3 full of kosher salt

Investigation 4

For each pair of participants

- 1 cc syringe
- 1-12 oz. cup of water
- 1 paper towel

Investigation 5

For each pair of participants

- 1 small square of black paper (~2”x 2”)
- 1 plastic spoon
- 1 pinch of kosher salt
- 1 hand lens

For Workshop Leader

- 1 set of Dot Sheets
- 1-12oz cup of water
- 1 plastic spoon
- small cup of kosher salt

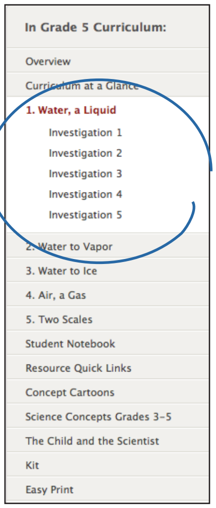
Time: 50 Mins

How Investigations 1-5 reflect the Science Framework

Component Ideas about Matter and Its Interactions	*The focus*: Weight is an indicator of the *amount of matter in a system* and can be used to account for and explain transformations of matter. Even *small bits of matter* such as a drop of water or a grain of sand have *weight and volume*.
Scientific Practices	*Planning and carrying out investigations** *Analyzing and interpreting data*: students use data to compare the weight: volume ratios of water and sand; they interpret data to find evidence of what happens to dissolved salt. *Engaging in argument from evidence*: students use weight data as evi-dence to explain what happens to the dissolved salt they can no longer see; weight data serves as evidence to explain what happens when the mini-lake is changed from a closed to an open system. *Developing and using models*: students create a change of weight over time graph to represent transformations in their mini-lakes.
Crosscutting Concepts	*Systems and system models*: studying a mini-lake system helps students under¬stand open and closed systems and transformations of matter in real lakes.

* *Planning and carrying out investigations*. Each investigation in this curriculum is framed as an investigation. Guided by an investigation question, students explore phenomena and/or collect observational or measurement data. They use evidence from the data to support claim or response to the investigation question. In addition, they are expected to explain their reasoning. As they broaden their experience and build a body of evidence, students learn to construct explanations.

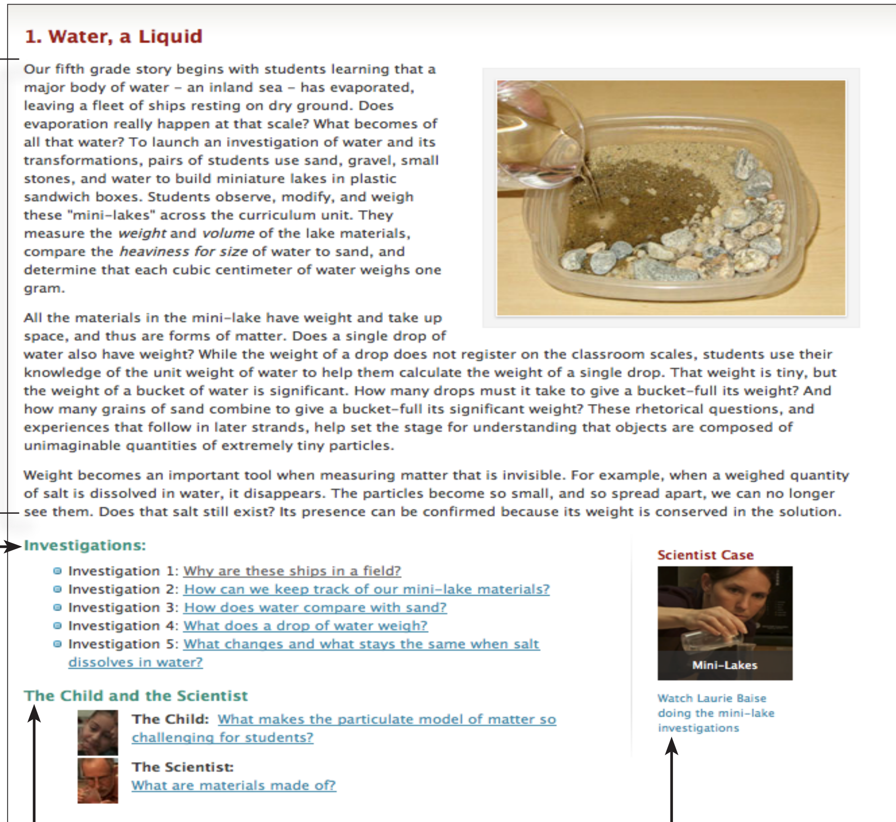
II. Overview of Section 1: Water, a Liquid, Investigations 1-5



Click *1. Water, a Liquid* (sidebar menu).

Point out that the Grade 5 curriculum has five sections and explain that each section, or group of investigations, opens with an overview page containing important information for teachers. You are looking at the opening page for *1. Water, a Liquid*, a typical example.

Point out the elements of every opening page.



1. Water, a Liquid

Our fifth grade story begins with students learning that a major body of water – an inland sea – has evaporated, leaving a fleet of ships resting on dry ground. Does evaporation really happen at that scale? What becomes of all that water? To launch an investigation of water and its transformations, pairs of students use sand, gravel, small stones, and water to build miniature lakes in plastic sandwich boxes. Students observe, modify, and weigh these "mini-lakes" across the curriculum unit. They measure the *weight* and *volume* of the lake materials, compare the *heaviness for size* of water to sand, and determine that each cubic centimeter of water weighs one gram.

All the materials in the mini-lake have weight and take up space, and thus are forms of matter. Does a single drop of water also have weight? While the weight of a drop does not register on the classroom scales, students use their knowledge of the unit weight of water to help them calculate the weight of a single drop. That weight is tiny, but the weight of a bucket of water is significant. How many drops must it take to give a bucket-full its weight? And how many grains of sand combine to give a bucket-full its significant weight? These rhetorical questions, and experiences that follow in later strands, help set the stage for understanding that objects are composed of unimaginable quantities of extremely tiny particles.

Weight becomes an important tool when measuring matter that is invisible. For example, when a weighed quantity of salt is dissolved in water, it disappears. The particles become so small, and so spread apart, we can no longer see them. Does that salt still exist? Its presence can be confirmed because its weight is conserved in the solution.

Investigations:

- Investigation 1: Why are these ships in a field?
- Investigation 2: How can we keep track of our mini-lake materials?
- Investigation 3: How does water compare with sand?
- Investigation 4: What does a drop of water weigh?
- Investigation 5: What changes and what stays the same when salt dissolved in water?

The Child and the Scientist

The Child: What makes the particulate model of matter so challenging for students?

The Scientist: What are materials made of?

Scientist Case

Mini-Lakes

Watch Laurie Baise doing the mini-lake investigations

A summary of the major ideas and activities in this set of investigations

5 investigations that focus on weight and volume, a small system called a mini-lake, the weight of a single drop of water, and the importance of weight when the matter we're studying is invisible, for example, dissolved salt

The Child and the Scientist
This link takes you to a pair of essays. Here you can find out how students' ideas about matter differ from scientists' so you can help your students use evidence they collect to move closer to a scientific understanding.

Scientist Video Case, Mini-lakes (the icon is on the first page of this section). The *Scientist Video Cases* help teachers learn more about the science concepts and practices in each section. These cases are designed for teachers and are not part of the curriculum for students.

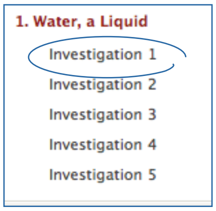
Show Scientist Video Case: Mini-Lakes, clip 1, *Through the Eyes of a Scientist* (2:02 min). This clip provides a preview of *Investigations 1-5*.

Allow a few minutes for comments, questions, or discussion about the content and concepts in this section.

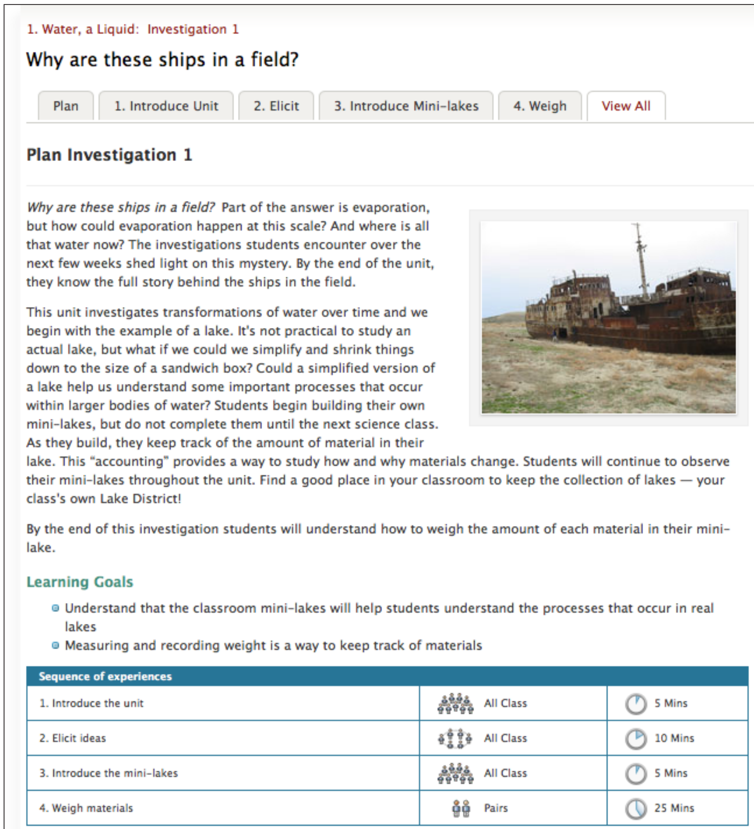
III. Experience the Investigations

Explain that participants are going to experience some – but not all – of the investigations in this section firsthand. Emphasize how important it is for teachers to actually try out materials and activities before they teach a lesson.

A. Investigation 1 and Investigation 2, Why are the ships in a field? and Mini-lakes



Click *Investigation 1: Why are these ships in a field?*



1. Water, a Liquid: Investigation 1

Why are these ships in a field?

Plan | 1. Introduce Unit | 2. Elicit | 3. Introduce Mini-lakes | 4. Weigh | View All

Plan Investigation 1

Why are these ships in a field? Part of the answer is evaporation, but how could evaporation happen at this scale? And where is all that water now? The investigations students encounter over the next few weeks shed light on this mystery. By the end of the unit, they know the full story behind the ships in the field.

This unit investigates transformations of water over time and we begin with the example of a lake. It's not practical to study an actual lake, but what if we could we simplify and shrink things down to the size of a sandwich box? Could a simplified version of a lake help us understand some important processes that occur within larger bodies of water? Students begin building their own mini-lakes, but do not complete them until the next science class. As they build, they keep track of the amount of material in their lake. This "accounting" provides a way to study how and why materials change. Students will continue to observe their mini-lakes throughout the unit. Find a good place in your classroom to keep the collection of lakes — your class's own Lake District!

By the end of this investigation students will understand how to weigh the amount of each material in their mini-lake.

Learning Goals

- Understand that the classroom mini-lakes will help students understand the processes that occur in real lakes
- Measuring and recording weight is a way to keep track of materials

Sequence of experiences		
1. Introduce the unit	All Class	5 Mins
2. Elicit ideas	All Class	10 Mins
3. Introduce the mini-lakes	All Class	5 Mins
4. Weigh materials	Pairs	25 Mins

1. Explain why Investigation 1 begins with a discussion

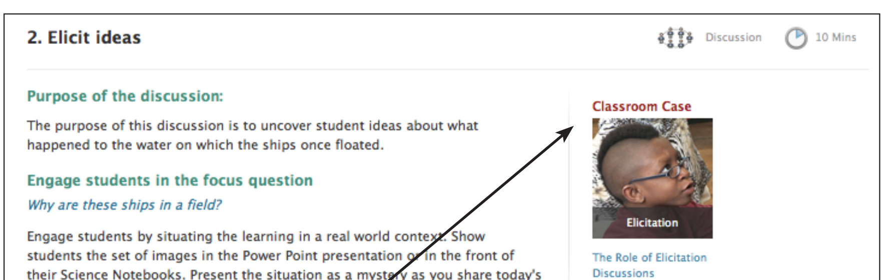
a. Point out that the title of each lesson (called an investigation) is also the investigation question. Asking questions is a fundamental scientific practice and the investigation question organizes each lesson or learning experience.

b. Explain that in this case the investigation question (*Why are these ships in a field?*) and the discussion that kick off the unit are designed to pique students' curiosity about the new unit and elicit students' initial ideas about evaporation. They will come back to this question in *Investigation 17* after they have gathered more evidence and information.

c. Move the cursor to *2. Elicit ideas* by scrolling.

Point to the *Classroom Case* icon. Explain that by clicking the *Classroom Case* icon we can take a look at how this first discussion unfolded in one classroom .

TIP *Encourage participants to follow along on their own laptops or tablets as you click, scroll, or move about the web site. Explain that you want them to explore the website throughout the workshop.*



2. Elicit ideas — Discussion — 10 Mins

Purpose of the discussion:

The purpose of this discussion is to uncover student ideas about what happened to the water on which the ships once floated.

Engage students in the focus question

Why are these ships in a field?

Engage students by situating the learning in a real world context. Show students the set of images in the Power Point presentation or in the front of their Science Notebooks. Present the situation as a mystery as you share today's

Classroom Case

Elicitation

The Role of Elicitation Discussions

Click the Classroom Case icon, *the Role of an Elicitation Discussion*.

Play clip 2. *What are Students' Initial Ideas?* (3:54 min).

Encourage participants to look at clip 1 (that describes the hallmarks of an Elicitation Discussion) and clip 3 as they prepare to introduce the unit.

2. Mini-lakes

Explain that after discussing ideas about why the ships are in a field, *Investigation 1* shifts to the **mini-lake investigation**. This key investigation extends over many lessons and helps wrap-up the entire unit.

a. Meet the scales and know their limitations

Distribute the digital scales. Explain that these are the same scales students use to measure **weight** and participants need to know how to use them and their limitations.

- Before weighing, make sure to "zero" the scale and be sure it is reading grams (not ounces).
- Scales weigh to the nearest whole gram (they do not measure parts or fractions of grams).
- Each measured weight can differ from the actual weight by plus or minus half a gram.
- Students need to understand the limitations of these scales: this is something teachers need to tell them - they can't discover it for themselves.

Explain that teachers need to check out the quality and accuracy of any measuring tool before their students use them. We have found that graduated cylinders used to measure volume are sometimes not calibrated accurately.

TIP *Provide an example. The scale says my cell phone weighs 95g. The actual weight could be any number between 94.5 and 95.4g*

b. Measure materials, assemble mini-lake, and record data.

- Distribute mini-lake materials. (*Materials List*)
- Ask participants to follow the steps listed in Handout 2, *Measuring and Assembling Mini-lake Materials.*
- Call attention to Handout 3, *Mini-lakes, a long-term investigation,* where participants can see how the mini-lake study unfolds over time.
The time you spend discussing logistics of the mini-lake investigation – and the rationale for each step – will be time well spent.

TIP *Review tare weight. Sand, gravel, or water must be weighed in a container. To find the weight of the material alone, they subtract the weight of the container and cap-tare weight.*

c. Facilitate a short discussion.

- Project an actual example of mini-lake data from a classroom.

(*PD for teachers/implementation workshops/Grade 5 workshop/Weight of mini-lakes class data table*)

Why aren't the weights of my mini-lake the same?

Group #	Sum of Weights (g)	Completed Mini-lake (g)
1	478	476
2	643	646
3	571	568
4	538	535
5	605	605
6	485	478

- Ask the focus question:

“ ” *How do you explain the difference between the weight of the completed mini-lake and the weight of the sum of its parts?*

[Scale is inaccurate: each measurement can be between ½ g more or less than the actual weight. The weight of the completed mini-lake – one measurement – is likely to be more accurate than the sum of a six measurements.]

- Ask the follow-up question:

“ ” *If we want to track changes in our mini-lakes over time, which of these weights is more reliable? Why do you think so?*

3. Discussions are opportunities to make meaning

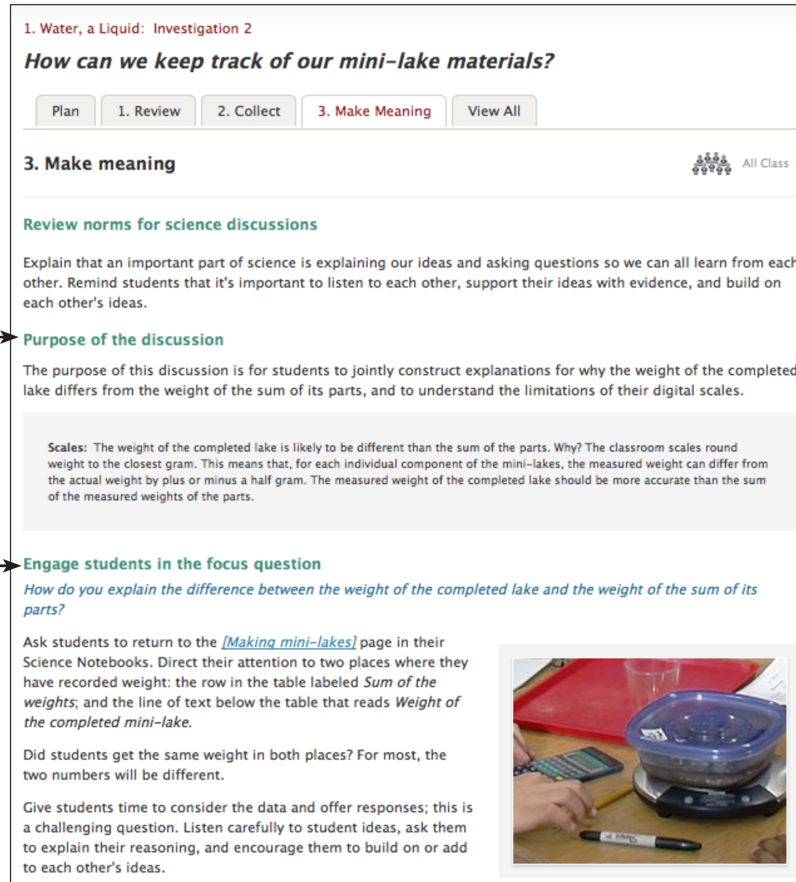
a. Emphasize that discussions are essential for learning and are critical parts of every investigations – do not skip them.

b. Use *Investigation 2*, step 3, to describe how the *Teacher's Guide* helps teachers plan for and lead discussions.

Click 3. *Make meaning*

Use the cursor to point out text that describes:

- Purpose for the discussion – in this case the purpose is to facilitate students' construction of explanations for any differences in the two weights for the mini-lakes. (this type of discussion is called an Explanation Discussion).
- Engage students in the focus question. It takes time to craft a productive question focused on the learning goal. The *Teacher's Guide* provides focus questions for make meaning discussions.
- Other information relevant to the specific content



c. Remind participants there are resources to support them as they plan and lead discussions. These include: (i) the *Teacher's Guide* that describes a structure and vision for each discussion as you have just illustrated; (ii) four classroom video case studies; and (iii) *Talk Science*, a professional development pathway to more productive science discussions that includes valuable tools and video resources. (Briefly, return to the Home page and point to the *Talk Science* website.)

Explain that there are four types of discussion that are built into the curriculum: Elicitation, Data, Explanation, and Consolidation. There is a *Classroom Case* that describes and illustrates each type.

Time:
10 Mins

4. Record mini-lake weight data in a table and a line graph

   a. Explain that participants will be now be working with *Handouts 2, 3,* and *4.*

   Ask them to record their mini-lake weight data (Weight of completed mini-lake) in two places, the *Handout 4. Data Table: Weight of mini-lakes* and *Handout 5. Weight of mini-lakes over time* graph.

   (The date is today's date and the Day # is 1.)

   Note that students may need quite a bit of time and help as they learn how to enter their data in the table and especially the graph.

   b. Extend experience with mini-lake graphs

   - Ask participants to imagine that they weigh their mini-lakes one week later.

     What will be the date?

     What will be the Day # [Day 8]

     What do you predict your mini-lake will weigh? [the same, it is a closed system]

     Where will you put a mark (data point) on your graph?

     What is the "shape" of the line when you connect the data points? [a flat line]

   - Explain that the graph tells a story about weight: a flat line says that the weight stayed the same.

     Explanation: the weight didn't change because the mini-lake is a closed system, no matter was added and no matter was taken away.

TIP *It typically takes about 50 minutes to get to this point in a workshop.*

B. Investigation 3, How does water compare with sand?

Move quickly through *Investigation 3*. (10 minutes)

Time:
10 Mins

1. Introduce the investigation question *How does water compare with sand?* and student activity. Explain that by the end of this investigation, students will have evidence that, in the case of water, 1cc = 1g.
2. Teachers help students interpret their data

   a. Click *Investigation 3* and scroll to *2. Share the data* and look at a sample data table.

Weight and Volume of Water and Sand

Team	Weight	Water Volume	Sand Volume
Team 1	150g	150cc	94cc
Team 2	150g	149cc	94cc
Team 3	150g	150cc	92cc
Team 4	140g	141cc	87cc
Team 5	140g	140cc	88cc
Team 6	140g	140cc	87cc
Team 7	130g	128cc	82cc
Team 8	130g	130cc	81cc
Team 9	130g	130cc	81cc
Team10	120g	120cc	75cc
Team 11	120g	120cc	76cc
Team 12	120g	122cc	75cc

b. Point out that students are typically confused by a table full of numerical data. The *Teacher's Guide* describes strategies to help the class analyze and interpret data. Demonstrate the following strategies:

- organize the data table by descending amounts of weight
- use different colors for water and sand data
- look at water data first (cover up the sand data)
- highlight cases where the weight and volume of a water sample are the same number

Check to see if participants think the data provide sufficient evidence to claim that, in the case of water, 1g=1cc or 1cc=1g. (Hide the sand data.)

c. What about sand? 150g = ~92cc, etc.

Ask participants how water and sand compare.

[1 gram of sand takes up less space than 1 gram of water; if the volumes are equal, sand will weigh more than water, i.e., sand is "heavier for size" than water.]

d. Explain that classroom data isn't always as "neat" as the example provided. What if it isn't?

We've found that some graduated cylinders are not calibrated accurately and this is likely to be the cause of very inaccurate data.

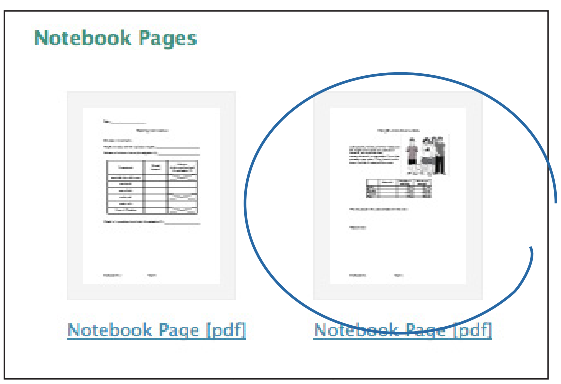
One solution: A teacher doesn't want to undermine students' work. In one classroom, the teacher explained that she had seen how carefully her students measured weight and volume and was surprised by the degree of variation in the data. She gave the class some additional information: when scientists created the metric system, they decided that the weight of one cubic centimeter of water would be called a gram. Each gram of water takes up exactly one cubic centimeter of space. Her class decided to investigate the accuracy of their cylinders and scales.

A second solution: Compare your class data to the sample from the *Teacher's Guide* and discuss why the patterns are not the same in both.

3. Formative assessment: Do students understand that for water, 1g=1cc?

Click the right hand *Notebook* page icon. *Weight and Volume Data.*

This *Concept Cartoon* on *Student Notebook* page 13 can be used as a quick formative assessment.



C. Investigation 4, What does a drop of water weigh?

1. Distribute 1cc syringes and some cups of water and have participants practice drawing up 1cc of water into a syringe.
2. Ask

How much does the 1cc of water in the syringe weigh?

Check participants' understanding that 1cc of water weighs 1g. They can use this information to calculate the weight of a drop of water from the syringe.

Imagine the water in your syringe is divided into two same-sized drops, how much would each drop weigh? [1/2g]

3. Demonstrate how to squeeze the syringe so the water comes out in separate drops that form a line on a paper towel or the edge of the table. Count the drops.

How much does each drop weigh?

4. Explain the purpose of *Investigation 4*

Students use the evidence they collect to build an argument that tiny bits of matter have weight (for example, a drop of water weighs only ~ 1/29th gram). When many tiny drops of water combine to fill a bucket or a lake, the individual weights add up to something very heavy.

A vial of sand is made of tiny grains of sand; the weight of a grain is imperceptible. However, the sand in the mini-lakes weighs 120g so we can reason that each grain of sand contributes some weight.

This idea is a precursor to a model of matter made of tiny particles too small to see but each one having an almost unimaginably small amount of weight.

D. Investigation 5, What changes and what stays the same when salt dissolves in water?

1. Introduce the *Dot Sheets.*

(*Materials List* or *Resource Quick Links/315 Dots per Page*)

a. Explain that these are introduced some time between Investigations 2 and 5, preferably at a time other than science class, e.g., morning meeting.

b. Model language to explain why one Dot Sheet appears empty

The dots are too small and too spread out to see.

c. Provide the following background.

Investigation 5 establishes the idea that weight can provide evidence for the presence of matter that we can't see. The "Dot Sheets" introduce the idea that when very small particles are spread out, they are "too small and too spread out to see." This is a foundation for the idea that we can't see water in the vapor phase because the material is made up of extremely small particles with a great deal of space between them: the particles are too small and too spread out to see.

2. Explore crushing salt

a. Distribute black paper, kosher salt, plastic spoons and hand lenses

(*Materials List*)

For each pair or group

- Small squares of black paper
- Hand lens (one per participant)
- Plastic spoon

b. Ask participants to observe a small pinch of salt on the black paper, crush the salt and observe the results. What do they notice?

- the total amount of salt has not changed
- the *size* of the grains has decreased
- the *number* of grains has increased
- it's still salt

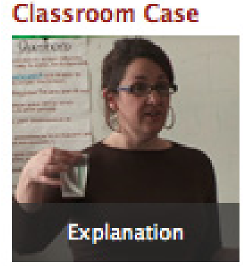
3. Summarize the steps in dissolving salt investigation

[find the weight of a water sample, a salt sample, dissolve the salt in the water and find the weight of the combined water and salt]

4. Introduce Explanation Discussions

a . Scroll to and project the *Make Meaning* section and click the *Classroom Case, The Role of an Explanation Discussions* icon.

Classroom Case



The Role of Explanation Discussions

b. Show clip 1, *What Happens in an Explanation Discussion* (2:57 min) and hear about the role of this investigation as students learn about matter at observable (macroscopic) and invisible (microscopic) scales.

c. Encourage participants to study the other clips when they plan their *Investigation 5* discussions.

5. Add salt to mini-lakes

a. Point out that students add salt to their mini-lakes after they finish *Investigation 5*.

b. Ask participants to add two spoonsful of salt to their mini-lakes (without stirring), put the top back on, and weigh the mini-lake.

6. Continue working with Handout 5, *Mini-Lake Graph*.

a. Have participants put the two new data points (weight before adding salt and after adding salt) on their graphs.

b. Ask participants to use a colored pencil and show what they predict will happen to the weight of the mini-lake over the next 3 days.

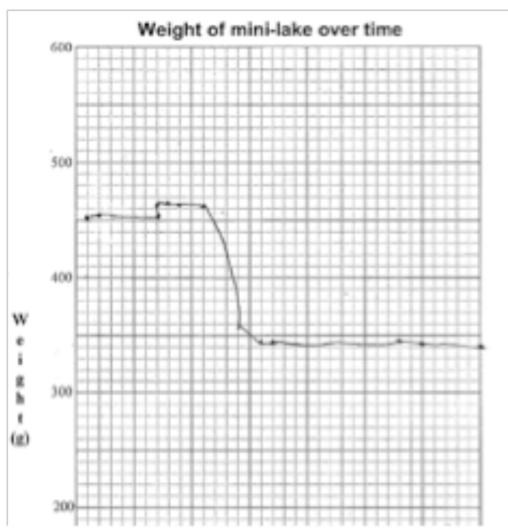
c. Ask participants to add a "prediction line" to their graphs

Imagine that 3 days after you add salt, you remove the cover of your mini-lake.

Use the colored pencil to draw a line that shows what you predict will happen to the weight of the mini-lake during the 10 days after you remove the cover.

What ideas about weight, material, and matter did you have to think about as you made your prediction?

d. Ask participants to annotate an example of a student's mini-lake graph Handout 6, *Mini-Lake Graph, Student Example.*



(*PD for teachers/Implementation Workshops/Grade 5 workshop/Handouts*)

In Investigation 17, students annotate their mini-lake Weight of mini-lake over time graphs. When they "annotate," students use words, arrows, brackets, etc. to explain how weight "tells the story" of changes in the mini-lake over time. Talk with your colleagues and reflect on your mini-lake experiences today as you annotate the sample graph.

Section 2: Water to Vapor, Investigations 6-9

I. To the Workshop Leader:

Introducing Investigations 6-9

These investigations focus on evaporation and condensation. Students in 5th grade often use these scientific terms but how well do they understand these phenomena? These investigations provide evidence that will help students better understand and reason about water transformations.

The investigations are straightforward. Participants will benefit from learning how experiencing the disappearance of a water droplet is a starting point for helping children think deeply about processes we cannot see. And how making an annotated drawing to describe an idea about what happens to water after it disappears from the surface of a cup is a starting point for developing a model to explain the behavior of matter.

To introduce investigations of the 2-bottle system, you can turn to a *Scientist Video Case*. Teachers also like seeing an actual 2-bottle system set up and running. If at all possible, set up a sample system with the light on the day before the workshop or early the day of the workshop.

To prepare to facilitate this section of the workshop, we recommend that you read *The Child and the Scientist* essays.

Materials and Preparation for this part of the Workshop

For Leader *(Investigation 6)*

- Spray bottle to mist the outside of plastic cups

For each participant *(Investigation 6)*

- A clear plastic cup
- Hand lens
- One paper towel
- Dropper
- Small amount of water

For the group *(Investigations 7-9)*

- Sample 2-bottle system

Preparation:

- Assemble three empty 2-bottle systems by connecting a 1-liter bottle and a 2-liter bottle using the special connector. Place each 2-bottle system in a base.
- Establish a location in the workshop space where you can leave the sample 2-bottle system under its lamp.
- Set up the 2-bottle system the day before the workshop or as early as possible before the workshop begins.

For one 2-bottle system to use as a sample

- 2 rubber bands
- 1-1-liter plastic bottles
- 1-2-liter plastic bottles
- 1 plastic bottle connectors
- 1 bottle system bases
- 1 assembled aluminum reflector lamps (Use only incandescent 100 watt bulbs)
- extension cords as needed (not included in kit)
- 1-12 oz. cup holding 30g of water
- blue food coloring

Time: about 20 minutes

Time:
20 Mins

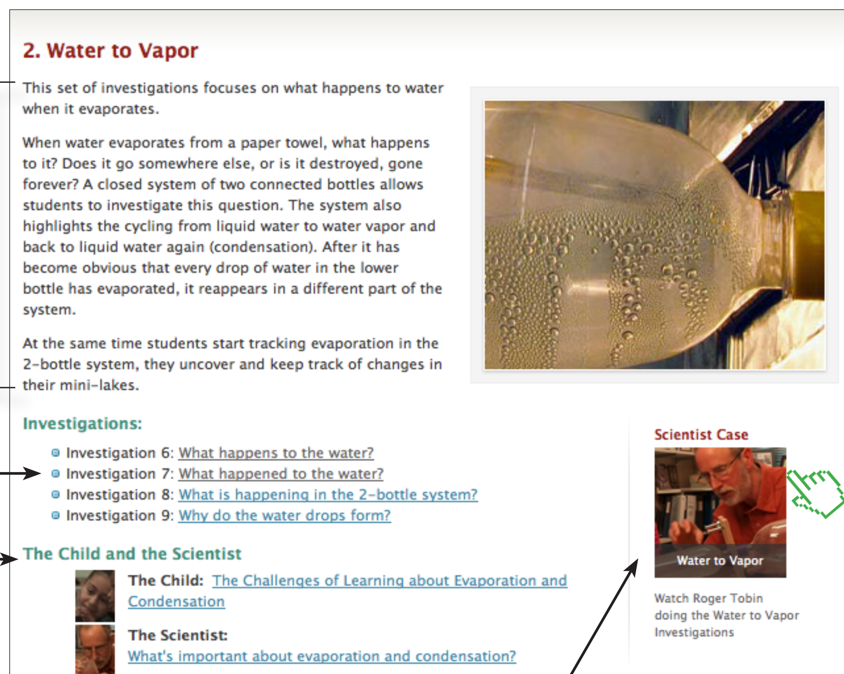
How Investigations 6-9 reflect the Science Framework

Component Ideas about Matter and Its Interactions	*The focus*: The process of *evaporation* involves a transformation: water particles that are too small to see break away from the surface of liquid water and spread out among other components of air, becoming a gas. The process of condensation also involves a transformation: water vapor particles lose enough energy to recon¬nect with other particles to form a liquid; this process depends on temperature differences between air and cooler surfaces of a 2-bottle system.
Scientific Practices	*Planning and carrying out investigations* *Developing and using models*: students use the closed two-bottle systems to study the transformations of water and collect evidence to build the case that when it evapo-rates, water is transformed to vapor that is part of air in the system. *Analyzing and interpreting data*: students use observational data as they investi¬gate the questions What happened to the water? Why do water drops form? *Constructing Explanations*: students explain changes in the two-bottle system, the dis-appearance of water in the lower bottle and appearance of water in the upper bottle.
Crosscutting Concepts	*Systems and system models*: changing the mini-lake to an open system allows evaporation to occur; a two-bottle system allows students to investigate evaporation and condensation in a closed system.

II. Overview of Section 2. Water to Vapor, Investigations 6-9

Begin by introducing participants to the Section 2 overview and investigations.

Use the cursor to call attention to



- The summary of the major ideas and activities in this set of investigations
- 4 investigations that focus on the evaporation and evidence to explain what happens to the water
- *The Child and the Scientist* This link takes you to a pair of essays. Here you can find out how students' ideas about evaporation and condensation differ from scientists' so you can help your students use evidence to bridge the gap.
- *Scientist Video Case* Water to Vapor (icon on first page of this section)

  The *Scientist Video Cases* help teachers learn more about the science concepts and practices we want students to develop.

Show Scientist Video Case: *The Water to Vapor Investigations*, clip 3, Water Vapor (3:11 min) and hear Roger Tobin explain the difference between water and water vapor.

Allow a few minutes for comments, questions, or discussion.

III. Experience the Investigations

Time: 25 Mins

A. Investigation 6, What happens to the water? (~25 min)

1. How is an investigation organized? (~10 min)

a. Take a few minutes to explore the structure of an investigation using *Investigation 6* as a model.

Click *Investigation 6*.

Quickly review how the tabs at the top of the screen reflect the parts of a typical Investigation.

Note that the View All tab is the default – that's where you land when you select an Investigation from the sidebar menu. Scroll down through the steps in the Investigation and point out the main features.

b. Describe the contents of "*Plan*"

- This is also the Investigation Question that frames the activities that follow.
- Plan *Investigation 6*

  Background information on the science content, connections to prior investigations, and what students are about to experience.

TIP *The last paragraph of this section always begins* "By the end of this investigation students will…" and describes the learning goals.

- *Learning Goals* - essential reading for everyone!
- The *Sequence of Experiences* – and guidelines for planning how long to spend on each part of the lesson and how to group students
- Materials and Preparation

  A list of materials for the class and each group of 4

TIP *In some classrooms, student volunteers use the Materials and Preparation section to prepare the trays of materials for the class. They also put away materials after the lesson.*

Explain that you'll be returning to this *Notebook* page later.

---

2. Water to Vapor: Investigation 6

What happens to the water?

Plan | 1. Ask | 2. Explore | 3. Make drawing | 4. Make meaning | View All

Plan Investigation 6

Evaporation happens before our very eyes – the fog on the bathroom mirror clears, our clothing dries, the puddle on the sidewalk shrinks. What happened to the water? And *how* does evaporation happen anyway? What makes it possible?

There are some connections between evaporation and the salt that students dissolved in the previous investigation. In both processes, matter separates itself into particles that are too small to see. Also, in both processes, weight can be used to track the presence (or absence) of these particles.

Students will not arrive at definitive answers about the evaporation process today, but after they observe the evaporation of water from a paper towel and from the surface of a plastic cup, they start to propose explanations based on their observations, prior experiences, and reasoning.

By the end of this investigation students will have formulated their initial ideas through an annotated drawing about what happens to water when it evaporates.

Formative Assessment

What do your students' think happens to water drops when they disappear from the outside of a cup?

Learning Goals

- To express initial ideas about the process of evaporation

Sequence of experiences		
1. Ask the question	All Class	10 Mins
2. Explore	Individual	10 Mins
3. Make annotated drawing	Individual	15 Mins
4. Make meaning	All Class	10 Mins

Materials and Preparation

Preparation:

- Read Annotated Drawings (See References). Create an Annotated Drawings poster. Save poster for reuse in later investigations.

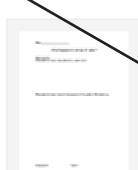
For the class:

- Post the investigation question in a place where all students can see it.
- 1 spray mister filled with water
- 1 paper towel

For each group:

- 1 12oz cup approximately 1/4 full of water
- 1 6in strip of masking tape
- 4 1cc droppers (1cc small syringe)
- 4 paper towels
- 4 magnifiers
- 4 12oz clear plastic cups

Notebook Pages



Notebook Page [pdf]

Notebook Page [pdf]

c. Describe the general structure of an investigation

Ask participants to use their laptops or tablets to follow along as you travel through the site.

Explain that each investigation has three ingredients: (1) ask a question; (2) exploration, data gathering, or modeling activities (some investigations have several more than one activity); and (3) a discussion to make meaning

Explain that the *"Ask"* section of the *Teacher's Guide* will help you

- set the stage and focus for today's work
- connect today's investigation to previous ones
- introduce the Investigation Question so that students understand that this is the organizing theme for the day's learning and that they will return to it throughout the lesson. Don't forget to post the question!

Emphasize that in our experience, teachers tend to spend too much time on the *"Ask"* step and end up running short on time for making meaning. Urge participants to stick to the time suggested for *Ask*, or take less time perhaps, but not more!

TIP *From time to time, check to be sure participants are referring to the appropriate pages as they follow the sequence of workshop activities on their laptops or tablets.*

The *Investigation 6* question is *What happens to the water?*

Explain that *2. Explore activities* are usually firsthand experiences with phenomena such as investigating evaporation, or teacher demonstrations. These common experiences help establish equitable classrooms where everyone has relevant experiences to draw upon. In other investigations tabs may refer to data activities, e.g., *Collect, Use Data, Share.*

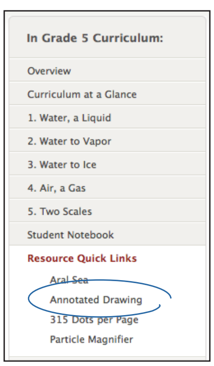
Explain that *Make Meaning* describes how to lead a discussion where students pull their ideas together.

The *Teacher's Guide* provides step-by-step instructions, photographs, and classroom examples to support teachers.

2. Experience Investigation 6 activities. (~10 min)

Time: 10 Mins

Click *2. Explore*. In *Investigation 6* students see a demonstration and explore two phenomena – *Drops on a paper towel* and *Mist of a plastic cup.*



a. Demonstrate weighing a wet paper towel.

Saturate a paper towel with water. Weigh the wet paper towel and record the weight. Open up the towel and hang it so the water can evaporate freely. You will weigh it again later.

b. Facilitate the two firsthand explorations.

Distribute materials and ask participants to follow the *Teacher's Guide* as they try out *Drops on a paper towel* and *Mist on a plastic cup*.

c. Click the right-hand *Notebook* page icon from the overview page.

What happens to drops of water.

Explain that

In this investigation, students make a drawing to show what they think has happened to water that has evaporated – a process they cannot see. This drawing is the beginning of the development of a model of matter that they will continue to elaborate in later investigations. Notice that the practice of modeling is blended with learning the core idea Matter.

Click *Resource Quick Links* (sidebar menu)/*Annotated Drawings* to learn more about annotated drawings. There is also a description at the back of the *Student Notebook*.

Suggest that participants make their own annotated drawing before they teach this investigation.

d. Before proceeding, weigh the towel you hung up to dry.

It will weigh less (how much less depends on how long it has been drying and the humidity and temperature of the room).

Ask participants to figure out how much water was lost through evaporation and think about where that water is now.

Time:
10 Mins

e. *4. Make Meaning* (~10 min)

Click or scroll to 4. Make Meaning and ask participants to find the focus question for the discussion:

What happened to the drops of water you put on the paper towels, or that I sprayed on the plastic cups? Does water still exist after it disappears, or has it been destroyed?

Ask participants to turn and talk with a colleague about the following question.

How do you think students might answer this question? What evidence can they draw upon?

Ask participants to take a few minutes to share some responses with the group.

TIP *Encourage teachers to read Challenges of learning about evaporation and condensation.*

Possible responses might be (1) water droplets are gone – they have been destroyed, (2) the wet paper towel lost weight and so the water might have gone into the surrounding air, (3) salt disappears in water but weight data tells us it's still there so the water could be in the air, (4) 315 extremely small dots on a piece of paper are visible when they are close together and invisible when they are spread out (the dots are too small and too spread out to see) so maybe the water is in the air even if we can't see it, (5) water drops have soaked into the plastic or paper.

Point out that the wet paper towel and mist on a cup can be considered part of an open system. The covered mini-lakes are a closed system.

In the next investigation the mini-lakes become open systems and students investigate evaporation and condensation in a closed system!

B. Investigations 7-9 (~15 min)

1. Return to the mini-lakes.

Explain that students remove the cover from their mini-lakes in *Investigation 7*, thus changing them from closed to open systems.

2. The two-bottle system (Investigations 7-9)

Explain that investigating the 2-bottle system will provide evidence to answer the questions What happens to the water? and Why do water drops form?

Show participants the sample 2-bottle system you set up prior to the workshop. (*Investigation 7, Plan* describes how to set up a 2-bottle system.)

As your students observe the 2-bottle system (a closed system), they will gather evidence that when water evaporates, it is transformed from a liquid into water vapor, a gas. Water vapor is invisible because the particles are too small and too spread out to see.

Explain that the *Teacher's Guide* can help them make the most of this investigation, including detailed descriptions of

- how to set up the two-bottle systems *(Investigation 7, Plan)*
- learning goals
- what you can anticipate will happen over time
- suggestions of questions for facilitation

Click *Scientist Video Case, Water to Vapor, Clip 2,* observing the two-bottle system (4:23), to hear Roger Tobin describe the dynamics of the two-bottle system.

Look at this clip together and then have participants discuss it with a colleague.

Observe your sample 2-bottle system.

Make sure participants understand that when it was first set up, the only visible water was the "puddle" on the bottom of the lower (smaller) bottle.

This bottle represents Earth's surface with an atmosphere and a body of water, warmed by a lamp. The larger upper bottle contains only air and represents "a different place" to which water can travel in its vapor form, condense, and collect.

Ask participants to describe where they see water now and reason about where the water drops or puddles came from.

Lead a short discussion with an emphasis on claims and evidence.

What happens to water when it evaporates?

How do water drops form?

Point out that (like their students) they cannot observe what actually happens to the water once it disappears, so their explanations will have to depend on their *reasoning* about what they think happened.

IV. Formative Assessments (~10 min)

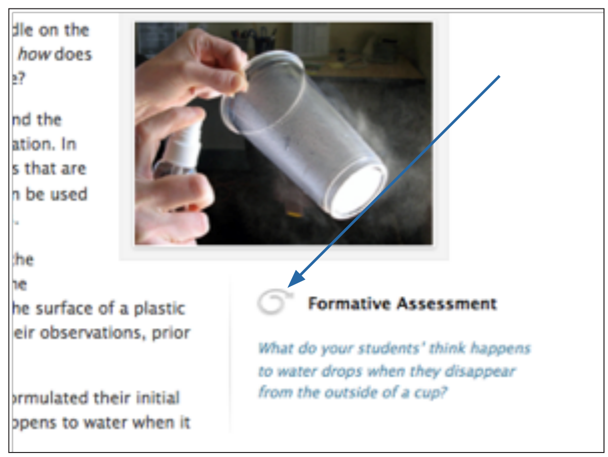
Time:
10 Mins

Explain that there are many sources of formative assessment data in this curriculum: what students write in their notebooks, what they say in small and large group discussions, and what they do as they use materials to investigate.

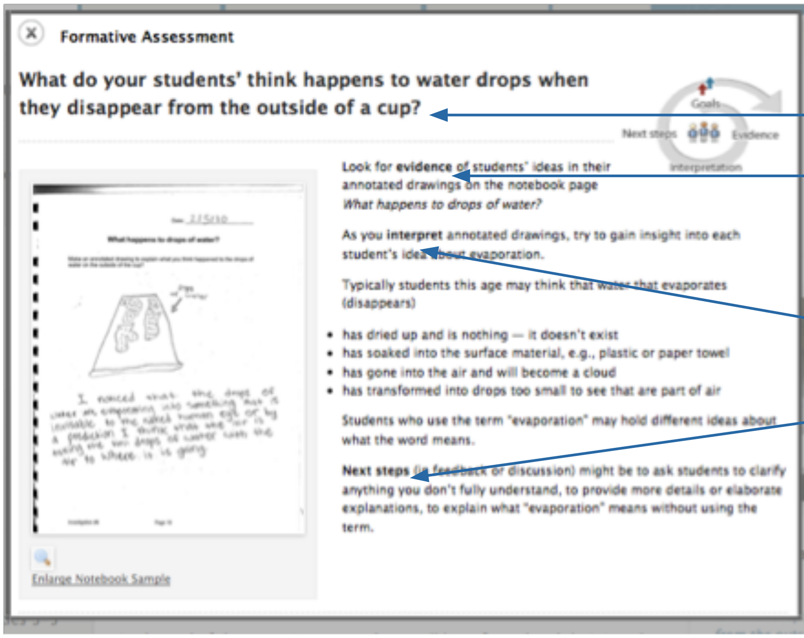
Call attention to two resources:

A. Embedded formative assessments (~5 min)

1. These examples of formative assessment are indicated by an icon and are found in the *Plan* part of the investigation.
2. Click the blue text below the icon and briefly describe the formative assessment cycle:



In this example, the teacher uses an annotated drawing to assess students' ideas about what happens to water drops that have disappeared from the outside of a cup.

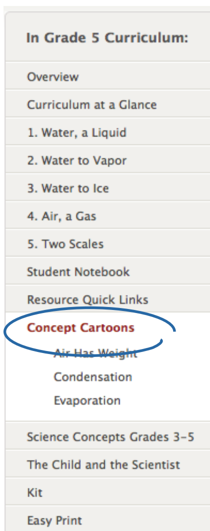


Assessment begins with a learning goal. In these examples, the learning goal is expressed in the *question*

writing, talk, or practices provide a source of *evidence* of understanding,

using criteria, the evidence is *interpreted*,

based on this interpretation, the teacher decides on *next steps* that will move students toward the learning goal.



Ask participants to keep an eye out for these assessment examples throughout the unit.

B. Concept Cartoons

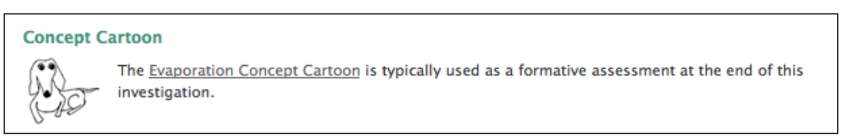
1. There are two *Concept Cartoons* in this section.

   Evaporation (used after *Investigation 7*)

   Condensation (used after *Investigation 9*)

2. These assessments are designed to probe students' ideas about a science concept they have been exploring or investigating. Cartoon style drawings show different characters arguing about the answer to a question or debating alternate explanations of scientific phenomena. Students respond to each cartoon character's idea, explaining their reasons for agreement or disagreement.

3. Darwin, the dog, is part of every concept cartoon, grades 3-5, and is the icon for these assessments.



If time permits, ask participants to take 5 minutes to explore one or both of these assessments and talk with a colleague about how they might be used in the classroom.

TIP *If you are presenting the curriculum in two workshop sessions, this is a good place to stop.*

Section 3: Water to Ice, Investigations 10-12

I. To the Workshop Leader

Introducing Investigations 10-12

Freezing and melting are the transformations of water featured in this section.

You'll need ice cubes to compare water and ice and a sample bottle (from the kit) of water after it has spend a night in the freezer. Think about how you'll prepare these chilly materials. At this point in the workshop you'll focus on two important scientific practices: analyzing and interpreting data and constructing explanations. A classroom example of the freezing and melting investigations provides the context for discussion of these practices.

So far, students have investigated transformations at the observable (macroscopic) scale. In Investigation 12 there's a shift to thinking about matter at a different, microscopic, scale. Meet the Particle Magnifier, a simulation that zooms in on the unimaginably tiny particles – and the spaces between them - that make up water and ice!

Materials and Preparation for this part of the Workshop

For every 4-5 participants

- 1 tray of 1/2-inch mini ice cubes
- 1-12 oz. clear plastic cup 1/3 full of water
- 1-12 o.z clear plastic cup each holding 15 ice cubes

For the Workshop Leader to demonstrate

- 1-8 oz. plastic capped water bottles, 3/4 filled with room temperature water with strip of masking tape to mark the water level
- 1-8 oz. plastic capped water bottles, 3/4 filled with room temperature water that has been frozen with strip of masking tape with the original water level marked
- 1 digital scale
- 1 fine-tip permanent marker or pen

Time:
20 Mins

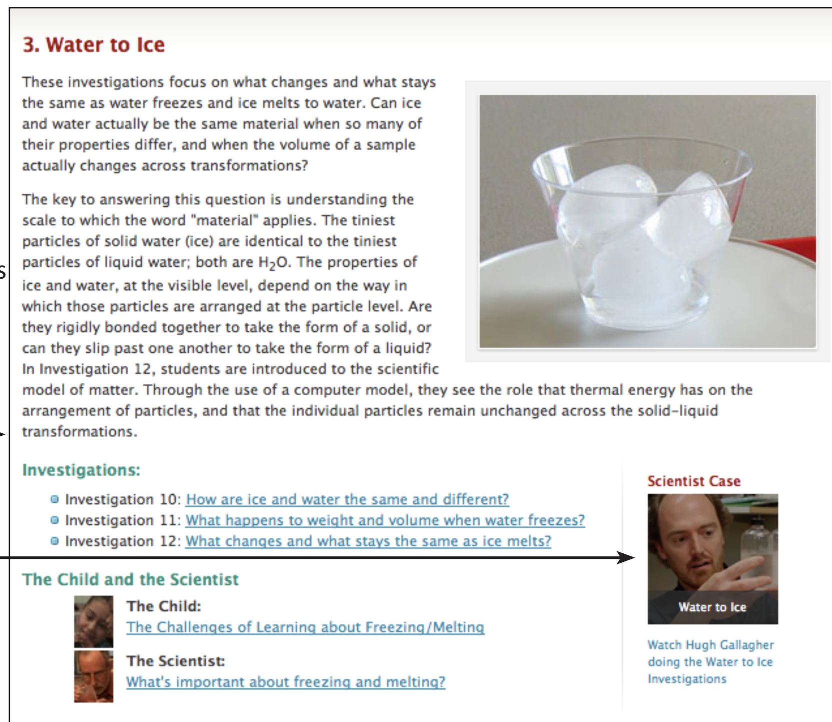
How Investigations 10-12 reflect the Science Framework

Component Ideas about Matter and Its Interactions	*The focus*: At the macroscopic scale, water and ice have different properties. At the microscopic scale, water and ice are made of identical particles that dif¬fer only in their motion and the spaces between them. Water particles have more space between them, on average, when they are fixed in position (ice) than when they can freely move about each other (water). The volume of a water sample increases when it freezes.
Scientific Practices	*Planning and carrying out investigations* *Developing and using models*: students use a computer simulation, the Particle Magnifier, to explore the behavior of water particles at different temperatures. *Analyzing and interpreting data*: students use weight and volume data to investigate the transformations of water by freezing and melting. *Engaging in argument from evidence*: students take a position on whether ice and water are the same material.
Crosscutting Concepts	*Scale, proportion and quantity*: students look at freezing and melting of water at two scales, the macroscopic and microscopic.

II. Overview of Section 3, Water to Ice, Investigations 10-12

Click *3. Water to ice* from the sidebar menu.

Explain that these three activities introduce students to the concept of scale. Use the Scientist Case to introduce teachers to the important science that is the focus of this section.



Click the *Scientist Case* icon and view clip 1, *The Eyes of a Scientist.*

III. Experience the Investigations

Explain that you will go through these activities quickly.

Remind participants that the *Teacher's Guide* is clear and specific about how to facilitate the investigations.

Properties of water and ice differ at the macroscopic scale. How different are water and ice when you switch to a microscopic or particle scale? These investigations provide evidence for students to answer this question.

A. Investigation 10, How are water and ice the same and different?

1. Distribute a cup of mini-ice cubes and a cup of water for every 4 participants.

   Ask participants to focus on observable differences between the water in the cup and the ice cubes and jot down their observations.

2. Partner activity

   Ask participants to take 2-3 minutes to discuss the question below with a neighbor or table group.

   If you wanted to convince someone that ice and water are the same material, what evidence would you use?

   Provide time for participants to share their ideas.

B. Investigations 10, 11 and 12, (Demonstration)

1. Introduce the investigation question: *What happens to weight and volume as water is transformed through freezing from a liquid to solid ice and through melting back to a liquid?*
2. Describe the materials and procedures for Investigations 10-12.
   - Show participants a bottle from the kit 2/3 full of water and point out that this is a closed system.
   - *Investigation 10*: Students (in groups) weigh a bottle filled 2/3 with water (prepared by the teacher) and show the volume by marking the water level. The teacher puts the bottles in the freezer overnight.
   - *Investigation 11*: students weigh the bottles and show the new volume by marking the level of the ice. The bottles are left in the classroom over night.
   - *Investigation 12:* Students gather weight and volume data of the melt water.

   Note: It's easy to keep track of a class set of water bottles if teachers number them as part of the preparation. Students record the number of "their" bottle in their notebooks.
3. Show participants a sample bottle that has been in the freezer overnight.

   a. Tell them what it weighed before freezing and point to the mark that shows the original water level. Weigh it again and mark the new volume. [the weight will stay the same; the volume will increase]

   b. If there is condensation on the outside of the bottle, have participants explain where the droplets came from and point out that this is another chance to revisit condensation. (Remind them of the essay *Children's Ideas About Evaporation and Condensation* found on the opening page of Section 2.)

   c. Tell participants that typically students complete the freezing and melting investigations quite independently and generate consistent and accurate data.
4. Introduce the *Classroom Case.*

   Click *Investigation 11*, scroll to *4. Make Meaning*

4. Make meaning Discussion 15 Mins

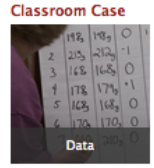
The class table now holds weight and volume data for (12) bottles. That data includes: weight before freezing; weight after freezing; and information about volume.

Purpose of the discussion

The purpose of this discussion is for students to connect the investigation question with the weight and volume data they have collected by making claims and describing the supporting evidence.

Engage students in the focus question

Classroom Case



The Role of Data Discussions

Click the classroom case icon and view Clip 1. *What happens in a data discussion.* (2:14 min.)

This case introduces the third type of discussion, a data discussion.

View the first 2:35 min of Clip 2 (*Predicting changes in Weight*).

Provide time for participants to discuss the few minutes of classroom discussion they have just seen.

As you watched the discussion, what did you notice about the teacher's facilitation and the students' ideas?

C. Investigation 12, Part 2: Switching scales: from macroscopic to microscopic

1. Explain that in *Investigation 12*, students imagine they have a magnifier that was so powerful they could look at the particles that make up water and ice. The *Particle Magnifier* simulates what they might see if they did have such a tool.

Show participants two ways to launch the *Particle Magnifier*

(1) in *Plan, Materials and Preparation*

Materials and Preparation

Preparation:

- Read The Particle Magnifier (See References)
- Explore the Particle Magnifier (Water)
  [Launch Particle Magnifer (Water) in a new window]

For the class:

- Post the investigation question in a place where all students can see it.
- Post the class chart, "Comparing Ice and Water"; created in Investigation 10.
- Post the class table, "Transforming Water to Ice and Ice to Water"; created in Investigation 11.
- The Particle Magnifier (Water), using a classroom computer and projector or Smart Board.

(2) the sidebar menu, *Resource Quick Links*

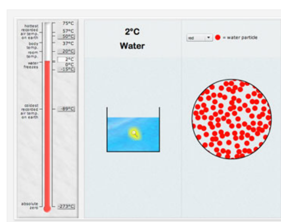
In Grade 5 Curriculum:

- Overview
- Curriculum at a Glance
- 1. Water, a Liquid
- 2. Water to Vapor
- 3. Water to Ice
- 4. Air, a Gas
- 5. Two Scales
- Student Notebook
- Resource Quick Links
  - Aral Sea
  - Annotated Drawing
  - 315 Dots per Page
  - Particle Magnifier
- Concept Cartoons
- Science Concepts Grades 3-5

Particle Magnifier

Use these links to launch the Particle Magnifier in a new window:

- Particle Magnifer (Water)
- Particle Magnifer (Water-Air)



The Particle Magnifier (Water) showing water at 2°C

At different points in this curriculum unit students have explained a process (e.g., salt dissolving in water; water evaporating) by making reference to particles too small to see. This explanation corresponds with scientists' understanding that all matter is composed of individual particles (atoms or molecules) too small to see. How small are these particles? It would take trillions of water molecules to form a drop of water with a diameter the same as the period at the end of this sentence.

The Particle Magnifier allows students to observe the arrangement and motion of water particles in their solid, liquid, and gaseous states, and supports the concept that, regardless of state, the particles themselves remain the same. A user can select one of six different temperatures on the thermometer to observe how particles respond to different amounts of heat energy.

Ask participants to explore the *Particle Magnifier* on their laptops or tablets for a few minutes.

2. Lead a tour of the *Particle Magnifier*

Take the role of a teacher presenting the *Particle Magnifier* to his or her class. Lead participants through an exploration of the characteristics of particles at different temperatures.

Or

Click the *Scientist Case* icon again and view Clip 3, *A Particle Model of Ice.*

Make the following points about using the *Particle Magnifier*:

- Learning how to introduce students to the *Particle Magnifier* can be challenging at first. The *Teacher's Guide* and *Scientist Case* are important resources for teachers.
- Teachers need to be explicit about what scale is being used to observe, describe, or compare properties of water or ice (and later, water vapor).
- Students benefit when they have time to explore the *Particle Magnifier* – with a classmate - in the classroom or computer lab.

Section 4: Air, a Gas, Investigations 13-16

I. To the Workshop Leader

Introducing Investigations 13-16

By 5th grade, students usually tell you air is a gas but they are not at all sure it's matter - at least not matter like liquids and solids. In the *Section 4* investigations, students collect evidence that air has weight and takes up space and are then ready to reason that air is matter. They investigate macroscopic properties of air compressibility and thermal expansion, and shift to the microscopic scale using the *Particle Magnifier* to explore these properties in another way.

But wait, this unit is about transformations of water! Where's the water in these investigations of properties of air? Remind participants that water vapor is a component of air, a gas, and consists of particles – in motion, with spaces between them. These ideas about water vapor, air, gases, particles, and models will be new to at least some participants in your workshop. They'll need time to raise questions about the science content and consider how to use the *Particle Magnifier* in their classrooms.

Materials and Preparation for this part of the Workshop

For Leader

(Investigation 13)

- 1 double pan balance, perfectly balanced with unfilled double balloons in each pan
- 1 balloon pump with rubber stopper inserted onto the tip
- 2 sets of 16 inch double balloons

(Investigation 14)

- 2-1gal buckets
- 2-12cc syringes with caps (to be filled with water during the workshop)
- 2-12cc syringes with caps (to be filled with air during the workshop)

(Investigation 16)

- Bubble mix (prepared earlier)
- 1-12 oz. plastic cup
- 1-1-liter plastic bottle
- 2-1gal buckets 1/2 filled with hot and cold water

For each pair of participants *(Investigation 13)*

- 1 16 inch lengths of clear plastic 1/4-inch tubing
- 2-12cc syringes
- (optional) Copy of *Air Has Weight Concept Cartoon*

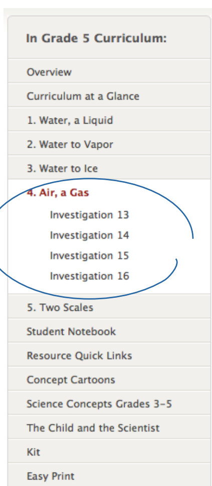
Time:
30 Mins

How Investigations 13-16 reflect the Science Framework

Component Ideas about Matter and Its Interactions	*The focus*: Air has weight, takes up space, and is composed of particles too small and too spread apart to see. Water vapor is a component of air, a gas. A particle model can explain macroscopic properties of air such as compress¬ibility and thermal phenomena.
Scientific Practices	*Planning and carrying out investigations* *Developing and using models*: students make annotated drawings and use the Particle Magnifier to test ideas about properties of gases. *Analyzing and interpreting data*: students use observational data as evidence to support claims about the properties of air. *Constructing explanations*: students use the Particle Magnifier to explain prop¬erties of air such as compressibility and thermal expansion.
Crosscutting Concepts	*Scale, proportion, and quantity*: students use centimeter cubes to estimate the volume of a rock by building a "replica," and use displacement of water to check the accuracy of their estimate.

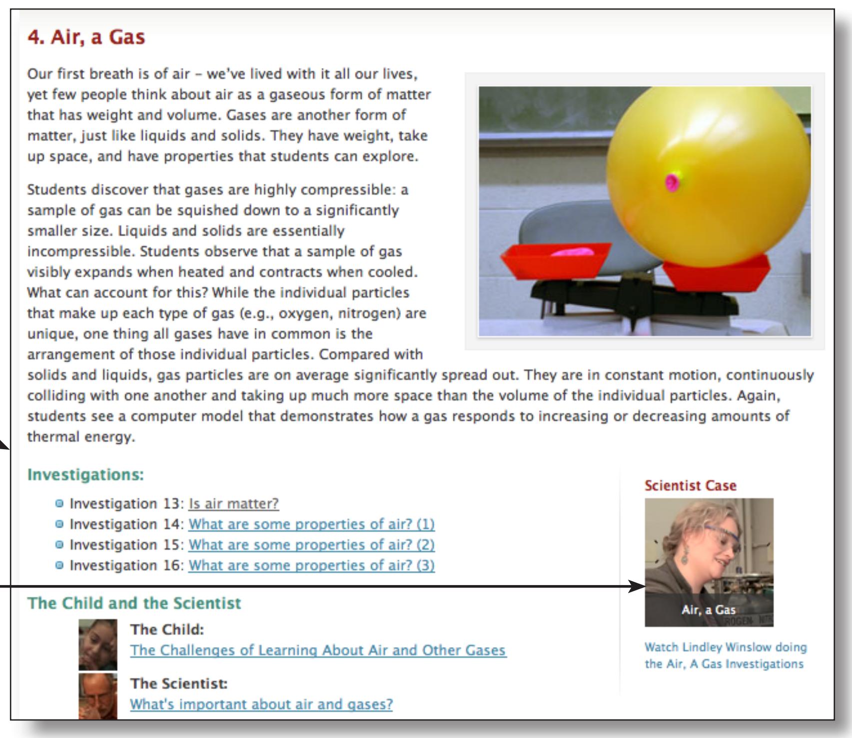
II. Overview of Section 4, Investigations 13-16

Click 4. *Air, a Gas.*



The 4 investigations in this section provide evidence to support the claim that air is matter and provide opportunity to explore compressibility and thermal expansion of air, at both macroscopic and particle scales.

The *Scientist Case* provides the scientist's perspective on the very same investigations students experience.



4. Air, a Gas

Our first breath is of air – we've lived with it all our lives, yet few people think about air as a gaseous form of matter that has weight and volume. Gases are another form of matter, just like liquids and solids. They have weight, take up space, and have properties that students can explore.

Students discover that gases are highly compressible: a sample of gas can be squished down to a significantly smaller size. Liquids and solids are essentially incompressible. Students observe that a sample of gas visibly expands when heated and contracts when cooled. What can account for this? While the individual particles that make up each type of gas (e.g., oxygen, nitrogen) are unique, one thing all gases have in common is the arrangement of those individual particles. Compared with solids and liquids, gas particles are on average significantly spread out. They are in constant motion, continuously colliding with one another and taking up much more space than the volume of the individual particles. Again, students see a computer model that demonstrates how a gas responds to increasing or decreasing amounts of thermal energy.

Investigations:

- Investigation 13: Is air matter?
- Investigation 14: What are some properties of air? (1)
- Investigation 15: What are some properties of air? (2)
- Investigation 16: What are some properties of air? (3)

The Child and the Scientist

The Child: The Challenges of Learning About Air and Other Gases

The Scientist: What's important about air and gases?

Scientist Case

Air, a Gas

Watch Lindley Winslow doing the Air, A Gas Investigations

Properties of gases are typically not well-understood by children or, in fact, many adults. Read these essays to learn more about these ideas and how the child's ideas differ from the scientist's understanding of air and other gases.

III. Experience the Investigations

A. Investigation 13. Is air matter?

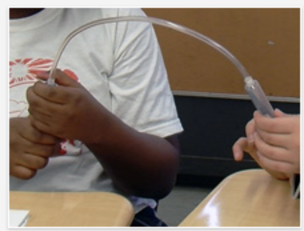
1. Look for evidence that air takes up space

- Click *Investigation 13*. This purpose of the investigation is to collect firsthand evidence that air is matter.
- Point out the photograph of two syringes connected by a piece of tubing.
- Scroll to *2. Explore air in a closed system*
- Distribute syringes connected by a piece of tubing (*Materials List*).
  Provide 1-2 minutes for participants to explore the double syringe system.
  Collect the syringes after 1-2 minutes (recommended in the *Teacher's Guide* as a classroom management strategy.)
- Point out how the *Teacher's Guide* supports the facilitator, with commentary and suggested questions.

Have students explore the system. *It takes no more than a minute or two* for students to explore how the system works. The point is to let them experience a situation in which air clearly takes up space.

> *What happens when you push one plunger very slowly while not touching the other plunger?*
>
> *What happens when you push one plunger very quickly while not touching the other plunger?*
>
> *Do you find evidence that air takes up space?*

Collect the syringes while students write a response to the [Does air takes up space?] page in their Science Notebooks.



Note: Students often take a lot of time drawing the details of the syringes. Suggest that the teacher provide an example of a simple outline drawing of a syringe.

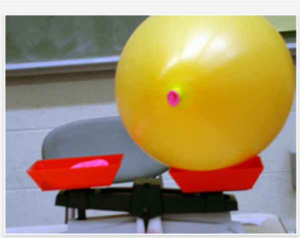
2. Look for evidence that air has weight

- Explain that students readily accept evidence that air takes up space but they are less ready to believe air has weight.
- Demonstrate the balloon activity. You will find detailed instructions in the *Teacher's Guide*, Investigation

Show students the uninflated double balloons placed on each side of the double pan balance. Point out that the two sides balance and so there are equal weights on both sides. Next, ask students to imagine that the balloons on one side of the balance are inflated.

> *What will we observe if air doesn't weigh anything?*
>
> *What will we observe if air does have weight?*

Use the balloon pump (with the rubber stopper) to inflate one set of doubled balloons to its full size. Using a balloon pump to inflate a balloon avoids adding moisture from your lungs into the balloon, which in turn helps to establish the fact that "dry" air has weight.



Tie off the opening of the inner balloon and return the inflated double balloon to the double pan balance. The pan with the inflated double balloon will move down.

> *Do we have evidence that air has weight?*

Students record their responses on the [Does air have weight?] page in their Science Notebooks.

13, step 3, *Weigh balloons (Materials List)*

- Explain why it is difficult to weigh a sample of air that is surrounded by the same "stuff." Inflating balloons allows us to cram a lot of air in a small space, thus increasing the density of the air in the balloon.

3. Weigh balloons All Class 15 Mins Notebook

The Weight of Air

If you scoop a cup of water out of a large pot you can feel its weight. If you pour that water back into the pot, you would not expect that weight to cause the water to sink to the bottom of the pot and stay there, as if it were a rock. The water from the cup will mix in with and drift through the rest of the water as if it were weightless, because it has the same density as the water in the pot.

For the same reason, any specific quantity of air in the atmosphere appears to be weightless. However, air does have weight. Air pressure, which we hear about in weather reports, results from air's weight. Since we live with air pressure all around us, and even inside of us (e.g., lungs) we do not sense it. Even scales do not sense the weight of air, because they are completely surrounded by air pressure.

One way to demonstrate that a sample of air has weight is to make it denser than the surrounding air. It that case, the sample will sink in the atmosphere. Cold air is denser than warm air; more particles are packed into each cubic centimeter. Open the freezer door and you'll feel the cold air spilling down towards the floor. Compressed air is denser than uncompressed air, with more particles packed into each cubic centimeter.

Why a double balloon?
A balloon resists being stretched, so as it is inflated it compresses air particles closer together, making that air more dense than the uncompressed air in the room. A double balloon offers even more resistance to being inflated, and compresses the air particles even closer together, making the enclosed air dense enough for a balloon-sized quantity to tip the pan balance.

Students may not need this much information. The demonstration speaks for itself.

- Call attention to the *Air has Weight Concept Cartoon*.
- If time permits, distribute copies of the cartoon and give participants about 5 minutes to write their responses.

  What could a teacher learn from this assessment?

  What are some possible follow-up steps she might take?

In Grade 5 Curriculum:

- Overview
- Curriculum at a Glance
- 1. Water, a Liquid
- 2. Water to Vapor
- 3. Water to Ice
- 4. Air, a Gas
- 5. Two Scales
- Student Notebook
- Resource Quick Links
- Concept Cartoons
  - Evaporation
  - Condensation
  - Air Has Weight
- Science Concepts Grades 3–5
- The Child and the Scientist
- Kit
- Easy Print

Air Has Weight Concept Cartoon

This cartoon was developed to assess students' ability to:

- Explain that air has weight and is matter and, therefore, makes the ball heavier; this requires that they distinguish the objective weight of materials from their felt weight (air weighs something because it is matter from air weighs nothing at all because I don't feel it in my hand) and the absolute weight of a object from its density or heaviness for size.

This cartoon is typically used after Investigation 13, *Is air matter?*

Write a response to each of the children. What you think of each of their ideas and why?

Tomas: ______

Leila: ______

Fern: ______

Things to look for in student responses

Do students realize that an object's weight increases when air is added?

- Some students may agree erroneously with Tomas that air may make objects feel lighter because they are less dense or less heavy for size or because air has intrinsic lightness (i.e., adding air makes things lighter). These students may be confusing weight with density. Those who disagree may point out that air is matter, matter has weight, so if you add air, you are adding weight to the deflated ball.
- Others may agree with Leila, who points out that if you add air to the leather the weight will increase, because air is matter and all matter has weight. Students who have observed that when air is added to a

B. Investigations 14, 15, and 16: What are some properties of air?

1. Explore compressibility of air and water

Trying to compress a cylinder of air and a cylinder of water is an uncomplicated yet vivid experience for students. In addition to learning more about properties of gases, students learn more about how to use a particle model to construct an explanation of the difference in compressibility of air and water.

a. compress syringes of air and water

- *Click Investigation 14*,

- Show participants how to fill the syringes.

  Fill 2 12cc syringes with water, eliminate air bubbles, and install caps to the open ends using finger pressure. Do not use a lot of force to tighten the caps.

  Fill 2 12cc syringes with air and install caps to the open ends using finger pressure.

- Ask participants to put the water-filled syringe in one hand and the air-filled syringe in the other and push on the plungers at the same time. (Model how to do this safely in the classroom: with the syringes are always pointing down into the empty bucket.)

b. Make an annotated drawing

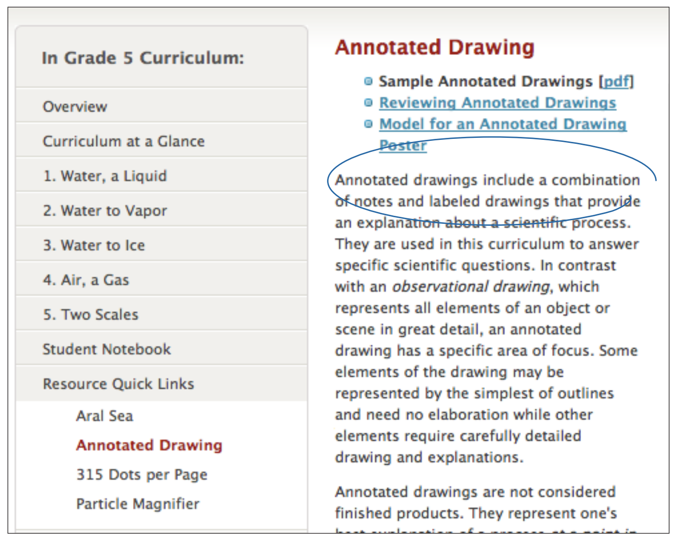
- Scroll to *3. Make an annotated drawing*
- Ask participants to make an annotated drawing that answers the questions

  How do you explain the difference in the compressibility of air and water?

  What would you see at the particle level to explain what is going on?

- Explain that when students create these drawings, they are trying to make sense of their observations that air is compressible and water is not. Drawings that depict an idea about something you cannot see is the beginning of an explanatory model.
- Explain that teachers are asked to review their students' annotated drawings and pick two for the class to critique in *Investigation 15*. Point to the resources teachers can use as they prepare for this part of the investigation.
- Click *Resource Quick Links/Annotated Drawings/*
- Click *Sample Annotated Drawings* [pdf]. Open the [pdf] file and display two drawings from a 5th grade classroom.

  A teacher may print out and use these drawings rather than select two pieces of student work from her own classroom.

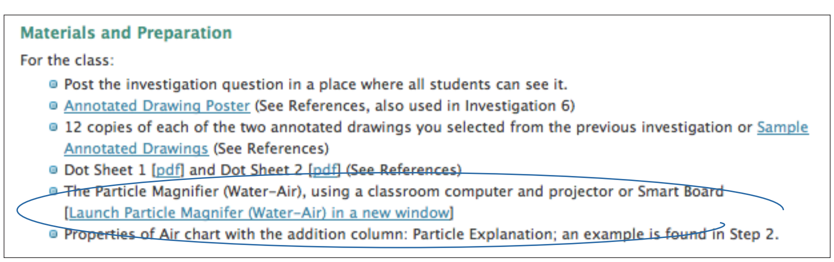


2. Use the Particle Magnifier to explain compressibility of water and air

- Click *Investigation 15*.
- Explain that this investigation begins with an explanation discussion. The *Teacher's Guide* provides detailed suggestions for facilitating this discussion and supplies the focus question:

  Why do you think air could be compressed and water could not?

- Explain that students once again shift from a phenomenon they can experience themselves to thinking about what's happening at a microscopic scale.
- Launch the *Particle Magnifier water-air* in a new window



- Provide time for participants to move back and forth between water and air at different temperatures and then hold a short discussion
- How can we explain compressibility in terms of particles that make up air and the spaces between them?

3. Explore thermal expansion of air

The purpose of this activity is to learn more about important properties of gases and to use a particle model to construct an explanation for the behavior of gases as they are warmed or cooled.

- Click *Investigation 16.*
- Explain that the lesson begins with prediction and a teacher demonstration.

- Carry out the demonstration using the procedure described in *1. Ask the question*. Remember to point out that the air in the bottle is part of a closed system: the soap film prevents air from entering or leaving thus the matter, or number of particles, remains constant as the bubble forms or soap film moves down the neck of the bottle.
- Check to be sure participants are familiar with the thermal properties of air. [The volume increases when air is heated and the volume decreases when it is cooled]
- Ask participants to shift scales.

  Launch the *Particle Magnifier Water-air* in a new window

Materials and Preparation

For the class:

- Post the investigation question in a place where all students can see it.
- Annotated Drawing Poster (See References, also used in Investigation 6)
- 12 copies of each of the two annotated drawings you selected from the previous investigation or Sample Annotated Drawings (See References)
- Dot Sheet 1 [pdf] and Dot Sheet 2 [pdf] (See References)
- The Particle Magnifier (Water-Air), using a classroom computer and projector or Smart Board [Launch Particle Magnifier (Water-Air) in a new window]
- Properties of Air chart with the addition column: Particle Explanation; an example is found in Step 2.

- Provide 3-4 minutes for participants to explore the model.

4. Make meaning

- Ask participants to scroll to step *4. Discuss annotated drawings.* This is an explanation discussion.
- Ask participants to locate the focus question

  How do warm air, cool air, and room temperature air differ?

- Scroll to diagram of three bottles of air. Ask participants (with one or two colleagues) to make a sketch similar to the one they can see on the screen and fill in each of the magnifier circles.

4. Discuss annotated drawings All Class 15 Mins

Purpose of the discussion

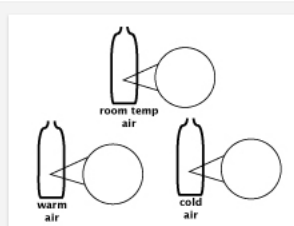
The purpose of the discussion is for students will understand that air expands when it is warmed and contracts when it is cooled and these phenomena can be explained in terms of the motion of particles.

Engage students in the focus question

How do warm air, cool air, and room temperature air differ?

Make a large sketch similar to the one in the Science Notebooks.

- Ask students how you should draw the soap film in all three bottles.



- Take a few minutes to discuss the challenges their students might face and what their drawings should convey.

5. Wrap up with the Properties of Air chart

- Point to the final *Properties of Air Chart* and remind participants that the class will be adding to the chart as they progress through *Investigations 13-16.*

I. To the Workshop Leader

The investigations in this last section consolidate learning from the 16 investigations that came before! Students' learning encompasses not only core ideas about matter and scientific practices but also crosscutting concepts of scale and systems. The question posed in *Investigation 17*, What's the story behind the graph? anchors the consolidation process. As they engage in these final workshop activities, teachers strengthen their understanding of how to think about matter and its transformations at different scales. They are introduced to one more type of discussion, a Consolidation Discussion. The *Investigation 17* discussion is designed to consolidate learning that took place over many weeks. The three questions that frame a consolidation discussion (What did we do? Why did we do it? What did we find out?) can be used productively at the end of any learning experience.

Preparation and Materials

One copy for each participant

Time: 15 Mins

- Handout 7, *Example of a student's mini-lake graph (Student sample Mini-Lake Graph)*

Time: 15 minutes

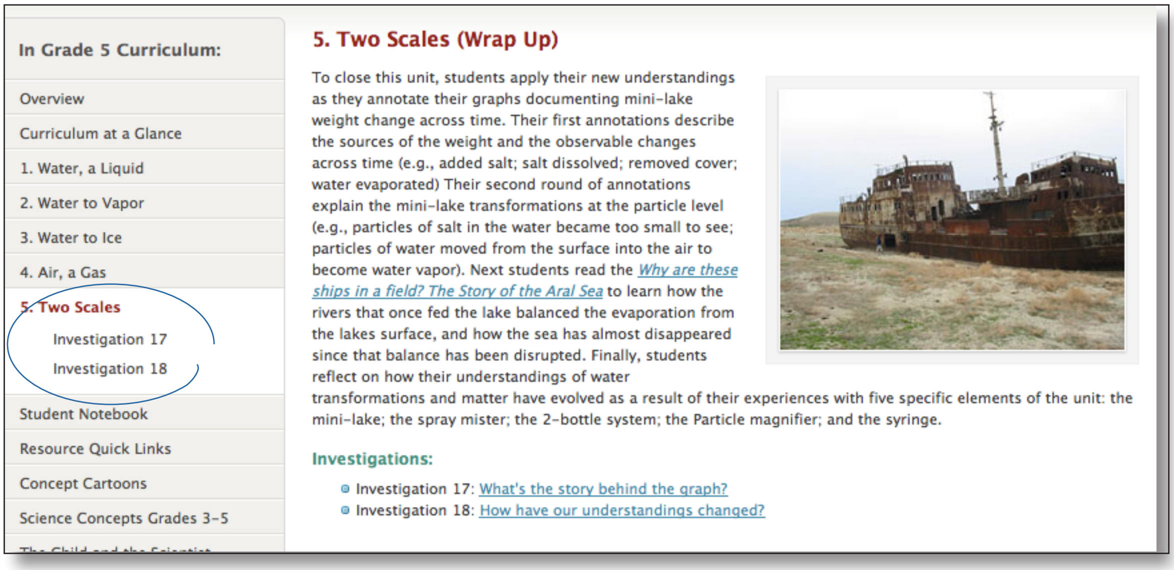
How Investigations 17-18 reflect the Science Framework

Component Ideas about Matter and Its Interactions	*The focus*: Students use a) observations from their investigations, b) their graph of weight measurements and c) a model of matter that is made of particles too small to be seen to explain matter transformations
Scientific Practices	*Analyzing and interpreting data*: students annotate their mini-lake graphs to tell the story of changes over time in their actual mini-lakes. *Constructing explanations*: students use their observations to explain how the shape of their mini-lake graphs changes over time. They use the particle model to explain what happened (e.g., dissolving salt, evaporation of water) at the particle level.
Crosscutting Concepts	*Scale, proportion, and quantity*: Students tell the story of transformation of water in both the mini-lake system on a macroscopic (visible) scale and on a microscopic (particle) scale. *Systems and system models*: Investigations of the mini-lake system allows students to explain transformations of the Aral Sea.

II. Overview of Section 5, Two Scales

There are just two investigations in this section. *Investigation 17* includes a new and final investigation question, What is the story behind the graph? To answer this, students pull together and apply all of their learning experiences. Finally, they revisit their ideas, elicited in *Investigation 1, Why are these ships in a field?*

Investigation 18 provides a framework for students to reflect on how five pivotal investigations influenced the development of their ideas about transformations of water. This can be used as a self-assessment tool.



III. Experience the Investigations

A. Investigation 17

The purpose of this investigation is to consolidate learning about transformations of water on two scales, the macroscopic and microscopic.

1. Annotate the mini-lake graph. (10 min)

   Explain that by annotating a mini-lake graph, participants will be better prepared to facilitate this activity in their classrooms.

   Distribute *Handout 7*, a graph that tracks weight change in a mini-lake across time. Ask participants to work in pairs.

   - On *one copy* of the graph, ask the pair add annotations that describe (a) the sources of the weight and (b) the observable changes across time (e.g., added salt; salt dissolved; removed cover; change from closed to open system; water evaporated).
   - On the *other copy* of the graph, ask them to add annotations that explain the mini-lake transformations at the particle level

     (Salt: when salt dissolves in the water, particles became too spread out to see; after the water evaporates, salt particles gather together and salt is visible.

     Water: particles of water in the mini-lake are close together and water is observable; during evaporation, water particles move into the air and spread apart and can no longer be seen and are now called water vapor, a gas).

     Provide a few minutes for participants to ask questions about the annotation activity. Explain that they are going to listen in on a class discussing how to annotate similar graphs.

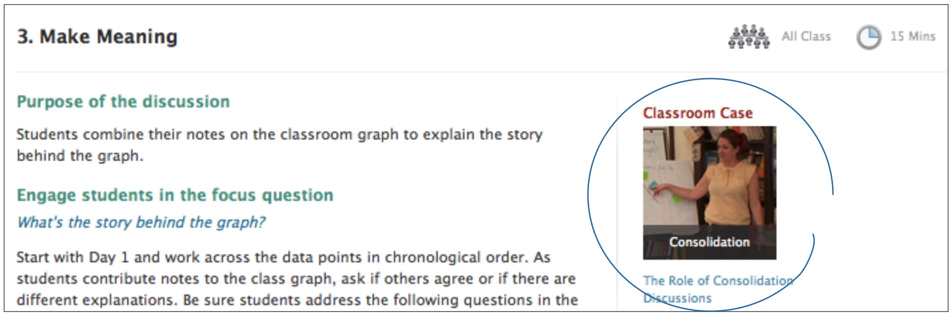
2. Listen in on a classroom consolidation discussion

This video looks in (via video) on a class doing the same activity participants have just experienced.

Explain that this is the fourth type of discussion, a Consolidation Discussion.

The purpose of a consolidation discussion is to make sure that, collectively, students can answer three questions about a learning activity: What did we do? Why did we do it? What did we find out?

Click the *Classroom Case icon*



Ask participants to note that this activity depends on *Notebook* entries to bring together many weeks of work. Students have been writing in their notebooks as part of every single investigation throughout the unit.

View Clip 3 *Consolidating Understanding*

Ask participants to comment on what they noticed in this clip. For example,

What did you notice about

students' discussion skills?

students' understanding of science content?

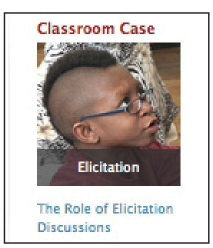
the role of the teacher?

What do you think about the strength of this activity a class discussion of how to annotate of the change in weight over time graph) and discussion as a wrap-up activity?

2. Why are these ships in a field? (3-4 min)

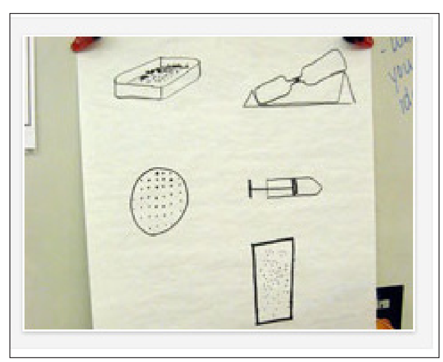
Explain that the class returns briefly to the question that kicked off the unit. A reading (*Resource Quick Links, Aral Sea: Why are these ships in a field?*) provides students with additional information. Armed with this new information and a deeper understanding of evaporation at the observable scale, they pick up the discussion they began in Investigation 1.

Return to *Investigation 1* and view the *Classroom Case Video, clip 3*, *Exploring How Ideas Have Changed.*



B. Investigation 18, time to reflect on their new ideas

Ask participants to roll over the *Notebook* pages icons in the *Plan* section.



Point out that students are provided with photographs or drawings of 5 important activities in the unit and are prompted to use their notebook entries to reflect on what they learned about transformations of water in each case. This is the final activity of the unit.

Encourage teachers to use notebook entries regularly to gain insight into students' thinking and to gauge their progress towards the learning goals.

C. Return to the Overview of the Grade 5 Curriculum

Encourage participants to return to this page and reread it. The information will have more meaning now that they have experienced the workshop.

TIP *Remind participants students get out their notebook at the beginning of every class and keep them open throughout. Notebook writing is a scientific practice and a core literacy skill. Their writing documents students' questions, ideas, data collections, claims, explanations, and models.*

In Grade 5 Curriculum:

- Overview
- Curriculum at a Glance
- 1. Water, a Liquid
- 2. Water to Vapor
- 3. Water to Ice
- 4. Air, a Gas
- 5. Two Scales
- Student Notebooks
- Resource Quick Links
- Concept Cartoons
- Science Concepts Grades 3–5
- The Child and the Scientist
- Curriculum Kit
- Easy Print

Overview of Grade 5 Curriculum

Investigating Water Transformations

Keeping Track of Matter

We expect puddles to dry up after the rain stops. We are not surprised when drops of water collect on the glass holding our cold drink. However, we never get to see the water that has evaporated from the puddle or see the drops before they appear on the glass. What makes these phenomena possible? They can be explained by one of the most significant realizations in the history of science: that water and all matter is composed of unimaginably large numbers of extremely tiny particles (atoms or molecules). Scientists use the phrase *the particulate nature of matter* to describe this understanding of the composition of matter. Too small to see individually, each of these particles has just a tiny bit of weight and takes up just a tiny bit of space. When countless trillions of particles clump together, they can make an object feel pretty heavy.

Particles exist in a constant tension between the chemical bonds, which tend to hold them together, and heat energy, which keeps them in constant motion and tends to cause them break loose from one another.

Curriculum Intro