IQWST

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IQWST LEADERSHIP AND DEVELOPMENT TEAM

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About the Publisher

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IQWST OVERVIEW

IQWST is a carefully sequenced, 12-unit middle school science curriculum, developed with support from the National Science Foundation. As designed, each academic year includes four units, one in each discipline: Physics, Chemistry, Life Science, and Earth Science. IQWST's foundation is the latest research on how students learn and how they learn science in particular. At its core, IQWST engages students in scientific practices as they experience, investigate, and explain phenomena while learning core ideas. Rather than memorizing facts, students build understanding by connecting ideas across disciplines and across the middle grades. The following are core tenets of IQWST, important whether following NGSS, the Framework, or individual state standards.

Phenomena: Experience phenomena first-hand where possible, second-hand where not possible, but always so that the goal of science learning is to be able to explain phenomena—to explain how and why things in the natural world happen as they do.

Coherence: Build understanding through a progression within each grade level and across grade levels. Learning critical concepts and practices across content areas and grades provides students with opportunities to develop, reinforce, and use their understandings on an ongoing basis throughout their middle school years.

Core Ideas: Focus on a limited number of core science ideas, aiming for depth of understanding rather than the superficial coverage inherent when aiming for breadth.

Scientific Practices: Engage meaningfully in the work of scientists through eight practices, used singly or in combination to explore and learn core ideas in each lesson.

Crosscutting Concepts: Thread throughout the curriculum the seven cross-disciplinary concepts, repeatedly revisited such that students construct deep understanding of the ideas as they apply to each science discipline.

Learning Performances: Address lesson-level learning goals that engage students with a single practice as they focus on a specific core idea, and build increasing understanding of a crosscutting concept. Learning Performances describe small steps on the way to meeting a Performance Expectation standard.

Science for All: Engage all students in common investigations, then in reading, writing, and talking about their experiences, enabling every student to have an entry point into constructing meaning.

THE IQWST UNIT SEQUENCE: BUILDING COHERENCE

Although IQWST units can be enacted in a manner that meets district needs, they are designed based on research that shows the importance of coherent curriculum, structured such that students build understanding as they revisit ideas across disciplinary strands, content, and grade levels and deepen their understanding across time. The *Framework* indicates, "Standards should be organized as progressions that support students' learning over multiple grades. They should take into account how students' command of concepts, core ideas, and practices becomes more sophisticated over time with appropriate instructional experiences" (NRC 2011).

The role of coherence in materials and instruction is well documented: Most science programs (textbooks and instruction) do not support deep, integrated student learning because they lack coherence (Kesidou & Roseman, 2002; National Research Council, 2007). Yet presenting interrelated ideas and making connections between and among them explicit (Roseman, Linn, & Koppal, 2008) was found to be the strongest predictor of student outcomes in the Trends in International Mathematics and Science Study (TIMSS) (Schmidt, Wang, & McKnight, 2005).

Curricular coherence is best accomplished through teaching the ideas in IQWST units in a recommended sequence. That sequence aligns with NGSS, which treats a core idea such as "energy," for example, as both a Crosscutting Concept and a Core Idea. In IQWST, students engage with ideas about energy in the first physical science unit of the sequence and then revisit energy concepts in life science, chemistry, and Earth and space science—and in later physical science units—so that as students apply energy ideas to new content and contexts, their understanding of one of the most challenging concepts in science education deepens across middle school.

The following chart illustrates the recommended sequence for optimum curriculum coherence, enabling students to build on and revise their understanding of core content and to strengthen their ability to successfully engage in scientific practices over multiple years.

IQWST MIDDLE SCHOOL CURRICULUM

Level 1	Physical Science	Introduction to Chemistry	Life Science	Earth Science
	Can I Believe My Eyes? Light Waves, Their Role in Sight, and Interaction with Matter	*How Can I Smell Things from a Distance?* Particle Nature of Matter, Phase Changes	*Where Have All the Creatures Gone?* Organisms and Ecosystems	*How Does Water Shape Our World?* Water and Rock Cycles
Level 2	Introduction to Chemistry	Physical Science	Earth Science	Life Science
	How Can I Make New Stuff from Old Stuff? Chemical Reactions, Conservation of Matter	*Why Do Some Things Stop While Others Keep Going?* Transformation and Conservation of Energy	*What Makes the Weather Change?* Atmospheric Processes in Weather and Climate	*What Is Going on Inside Me?* Body Systems and Cellular Processes
Level 3	Earth Science	Life Science	Physical Science	Introduction to Chemistry
	How Is the Earth Changing? Geological Processes, Plate Tectonics	*Why Do Organisms Look the Way They Do?* Heredity and Natural Selection	*How Will It Move?* Force and Motion	*How Does Food Provide My Body with Energy?* Chemical Reactions in Living Things

UNIT STRUCTURE

Driving Questions

Each IQWST unit focuses on a Driving Question, which is also the unit's title. A Driving Question is a rich, open-ended question that uses everyday language to situate science content in contexts that are meaningful to middle school students. As each unit progresses, the phenomena, investigations, discussions, readings, and writing activities support students in learning content that moves them closer to being able to answer the Driving Question in a grade-appropriate manner.

Learning Sets

IQWST lessons are grouped into three to five learning sets per unit, each guided by a sub-question that addresses content essential for answering the Driving Question. This structure unifies lessons and enables students to meet larger learning goals by first addressing constituent pieces of which they are comprised.

IQWST lessons support research-based instructional routines with several components designed and structured to meet teacher needs. Each lesson comprises multiple activities (i.e., Activity 1.1, Activity 1.2) that altogether address one to four Performance Expectations (as described in NGSS). Each lesson is preceded by lesson preparation pages—Preparing the Lesson—as described in the following Lesson Structure section.

LESSON STRUCTURE

Each IQWST lesson contains common components to support teachers as they progress through the unit's activities.

Preparing the Lesson

The information on the first pages of each lesson supports the teacher in previewing and preparing for the lesson.

Teacher Background Knowledge

This section describes content to be addressed in the lesson, specifics about use of language or measurement tools, and prerequisite knowledge students are expected to have. If IQWST units are taught in the designed sequence, prerequisite knowledge is that which is expected from elementary school or prior IQWST units. If IQWST units are taught in an alternative sequence, this section alerts teachers about what students will need to understand in order to make sense of activities in a unit and to achieve its learning goals. This section also supports teachers in working with less-familiar content by providing information that contextualizes the learning, even as it goes beyond what students need to know.

Sometimes, a Common Student Ideas heading describes ideas from research on misconceptions or describes other difficulties students have been shown to have with the content of a particular lesson. The section may describe prior knowledge that does not align with accepted science and that may be a stumbling block to understanding.

Setup

Setup is noted on the preparation page when the teacher needs to prepare materials ahead of time, such as mixing solutions, premeasuring materials for student groups, or setting up stations.

Safety Guidelines

A section on safety is included in the IQWST Overview. Within units, safety guidelines specific to a lesson are sometimes described separately so as to call attention to them. For additional information about handling chemicals, Materials Safety Sheets are available on the teacher portal.

Differentiation and Other Strategies

This section suggests ways to modify lessons—to either go beyond the learning performances, or to support students who need additional help with content. Differentiation ideas highlighted prior to a lesson specify ways to either go beyond the performance expectations for the lesson or to support students who need additional help with content. Differentiation and other strategies that can be applied across lessons are described elsewhere in this Overview.

Building Coherence

This section briefly situates the lesson in those that precede and follow it and often references content students will have encountered in previous IQWST units, if units have been enacted in the recommended sequence.

Timeframe (Pacing)

This note estimates the number of class periods the lesson will take to complete based on widespread classroom experience. Richer discussions, more time spent on reading or writing skills, enacting demonstrations as group activities or vice versa, and other teacher-chosen adaptations require adjusting the timeframe. Most lessons require two or more class periods, as most are composed of multiple activities. Pacing is based on 50-minute class periods. Longer or shorter periods, or block schedules, require adjustment so that each class session is a coherent whole. Suggested pacing is also noted on the Unit Calendar located in the front matter.

Overview

A succinct list provides a snapshot of primary activities within a lesson, identified by activity number (i.e., Activity 1.1, Activity 1.2).

Learning Performances

Learning Performances describe what students should *know* and *be able to do* in a given lesson. Learning Performances describe one or more scientific practices in which students will engage in order to learn a disciplinary core idea, often also addressing a crosscutting concept, such that teachers can effectively plan, focus, and assess students' understanding.

Materials

These sections list the supplies required to carry out each activity within a lesson. They are quantified and grouped based on teacher needs, group needs, and individual needs. Materials provided in the kits depend on what districts elect to purchase.

Introducing the Lesson

This feature is included when activities are specifically designed to launch a lesson, often including integration of the previous reading or homework assignment.

Discussion Types

Types of discussion are identified within each activity: Brainstorming, Synthesizing, or Pressing for Understanding. Each discussion has a stated purpose, followed by suggested prompts to guide conversation. Prompts are not intended as a script but provide teachers with alternatives they can use or from which they can shape their own questions—both closed and open-ended—to encourage thinking, challenging, explaining, and arguing from evidence.

Reading Follow Up and Introducing Reading

Suggestions for introducing and following up reading aid comprehension, retention, and integration of reading into science lessons. Readings are designed to be done independently, as homework, providing students with opportunities to revisit class activities, to connect science to their everyday lives, to deepen their understanding of content, and to apply their understanding to new examples and contexts. The pacing of lessons, as described, presumes that reading is not an in-class activity but is an at-home activity to extend student learning. Reading is addressed more fully elsewhere in this Overview.

Teacher Supports

Icons

Apple – Signals an "aside" to the teacher, often a strategy or a hint about student thinking likely to arise during an activity. Strategies and hints are embedded at points in the lessons that are most helpful to the teacher. It may signal a point at which the teacher should stop and check students' understanding before moving forward in the lesson or unit. Often, the ideas accompanied by this icon can be used as assessment opportunities.

Open Book – Signals either a reading assignment or a follow-up homework activity at the point in a lesson that it is best assigned. Typically the book icon is at the end of an activity and indicates work that is to be done in preparation for the activity that follows.

Safety – Signals precautions important to ensure safety in a lesson. Many lessons do not have specific safety precautions; instead, the lesson directs the teacher to the Overview, where general precautions, to be followed across IQWST lessons, are outlined.

Key – Signals smaller-scale learning goals that may be components of a larger disciplinary core idea. Key ideas might also include scientific principles derived from class activities, important definitions, or a new type of X to be added to a list of "types of X" students have been compiling in the unit. Key ideas might include main ideas at which students should arrive after an activity, reading, or class discussion.

Probe – Signals that technology is used in a particular lesson either for modeling (e.g., a computer simulation) or for quantitative measurement (e.g., probes and data loggers).

Pencil (only in Student Edition) – Signals places in which a written response is expected. Because questions are used as headers and are also woven throughout readings to engage students as active readers, an icon is used to indicate when a written response, rather than simply "thinking about," is required.

Projected Images (PI)

The value for students of seeing images in science cannot be overestimated. Projected Images (PI) are to be displayed for the class. Selected images may be printed for display on the Driving Question Board and perhaps laminated for reuse.

Each IQWST lesson includes projected images, charts, and graphs to expand students' understanding of science concepts. These colorful images are most effective for instruction if they are displayed in the front of the room on the white board. The images are located on the IQWST Portal in each unit folder, and all are named clearly.

The IQWST Portal

The IQWST Portal is an online resource for educators and students to access IQWST curriculum resources, including teacher editions of IQWST textbooks, student lab books, unit materials lists, assessments, and more. The IQWST Portal also provides access to digital resources including lesson-specific videos and audio files with narration of every student reading. Interactive resources and simulations like NetLogo are also located on the IQWST Portal.

The IQWST Portal is organized with each of the 12 units listed as a course. Within each course the content is divided into learning sets that are composed of multiple lessons. Within the lessons, educators can access digital versions of IQWST print materials, digital resources, and interactive resources. Each unit also contains a news section with up-to-date links to articles and research relevant to physical science, chemistry, life science, and Earth science.

DIFFERENTIATION IN IQWST

Range of Student Learners

Strategies built into IQWST lessons acknowledge students' differing capabilities, expectations, experiences, preferred learning styles, language proficiency, reading strategy use, and science background knowledge, among others. Materials address diverse needs by connecting classroom science to students' everyday, real-world interests and experiences. Each activity provides opportunities for teacher guidance, for independent work as well as small-group and whole-group interaction, for investigation, for discussion, and for reading, writing, and talking science. Opportunities for differentiation abound in each of these areas and in each lesson, so all students can work at their appropriate level of challenge.

Phenomenon-based lessons enable students to share common experiences from which to build understanding. Students with kinesthetic preferences can use their strengths as doers and problem solvers. Those with verbal preferences can talk and write about processes and practices and can contribute ideas from readings to the discussion. Those with tactile preferences can manipulate materials. Those with visual preferences observe rather than only read about science. IQWST does not require memorizing definitions, writing paragraphs using vocabulary, or writing lab reports. Students with a range of learning preferences, language abilities, and other strengths and weak areas as learners can contribute to, engage in, and learn from each investigation—independently and collaboratively.

Specific differentiation opportunities are described in the Preparing the Lesson pages that precede each lesson. The following general strategies apply across IQWST.

Differentiation and Other Strategies

- Students begin each unit with an activity to generate original questions that will form the Driving Question Board (DQB) for the unit. Some of their questions will not fit into any of the categories used to organize the DQB and will not be addressed in the unit. Such questions may be assigned to students as an ongoing, individual project that they complete using various resources.

    o Such projects enable students who benefit from "going beyond" the unit to do so independently. With the teacher's discretion, projects for advanced students might come from such work, requiring use of multiple resources with varied text complexity.
    o Passionate interest has been shown to motivate students who struggle with reading to nonetheless read texts well beyond their Lexile level or presumed "ability" in a quest to learn more about something they are invested in. English Learners, students with learning disabilities, and struggling readers should thus be encouraged to investigate topics in which they are keenly interested. Some students will need support with resources (e.g., Internet search terms or suggested websites), but it is important to encourage all students to pursue areas of interest.

- Two follow-up questions that students cannot get wrong, simply by virtue of having read are (1) What did you find most interesting about the reading? and (2) What is one new thing you learned as you read the assignment? Some variation of either of these questions can be used for accountability purposes (i.e., Did the student read?) and for encouragement purposes (i.e., There are no wrong answers).

- Discussion is important to allow exchange of ideas and examination of one's own ideas. Many students, especially English-language learners, students with learning disabilities, or students with auditory processing difficulties, struggle to make sense of a question and formulate a response in time to raise their hands and articulate their ideas orally. For such students, consider a think-pair-share strategy. Pose a question and provide students with time to *think* about their response (or to write their ideas). Then, *pair* students with partners to *share* ideas. The teacher can then call on a pair, who can give a response they have had time to rehearse. This activity can be taken a step further to *square* the response by having two pairs talk together.

- Some students participate more fluently and comfortably if they are sometimes told ahead of time which question they are going to be asked to share their ideas about. Preparation time allows them to jot notes, to practice orally, or to reread a written response and be confident about sharing aloud. A teacher can prepare a sticky note such as "Be ready to talk about your answer to Question 3," and can place that note on a student's book in the course of teaching a lesson. This enables students with a range of language proficiencies, background knowledge, memory, or ability to process information time to think through their ideas and thus to be more confident and successful sharing in whole-class contexts.

Reading-Focused Strategies

- Readings are designed based on research indicating that when students are passionate about a topic, they often read well beyond their determined "reading level." Thus, IQWST readings emphasize engaging students in science. In many programs, reading level is simplified by shortening sentences and using easier vocabulary. However, doing so shortchanges students in two ways. First, shorter sentences require removal of connecting words (therefore, so, then) that actually support comprehension. Second, simplifying text by limiting multisyllabic words shortchanges students by ensuring that weaker readers remain unable to engage with texts that use the vocabulary of science. Therefore, IQWST does not differentiate with simplified materials but with strategies that support all students to learn all they can from the texts provided.

- IQWST lessons provide strategies for introducing reading, monitoring student comprehension, and following up on reading assignments. A Getting Ready section begins each reading as a research-based strategy for improving comprehension—the sections generate interest and engage students, activate prior knowledge, and provide a purpose for reading. Although these strategies support all students, struggling readers can be explicitly taught the value of each of these components as strategies successful readers use to improve comprehension. Strong readers, often unknowingly, "wonder" about what they are about to read, thus providing a purpose for reading that improves their comprehension and retention.

- Reading in science requires organizing both main ideas and important details. Some IQWST readings employ methods for students who need to continue to work on reading strategies with built-in prereading strategies and advance organizers to help students with both text structure and content. Teachers may create additional advance organizers, as desired, for particular readings.

- Encourage students to read all of the written material, as it is designed to support learning of key concepts, and to extend the application of key ideas into the real world thus to generate interest in science. However, many options enable the teacher to support struggling readers, students with learning disabilities, English Language Learners, and advanced students.

  o If students find an assignment overwhelming, let them know what to focus on as they read, perhaps indicating (or marking) two or three sections of the reading that they should read carefully. Doing so gives them freedom to read all of the material but focuses their reading so that they are more likely to experience success when they can participate in follow-up class discussion because they focused on the "right" section of the reading.
  o When a reading has multiple examples (e.g., a reading about how the eyes of three types of animals work), invite students to prepare to talk about any one of the three. Doing so does not erase the opportunity to read all but enables students to make choices and to focus their reading, providing encouragement and small steps toward success.
  o Many opportunities exist for advanced students to conduct Internet searches and read more complex texts as they either pursue areas of interest or are assigned such work by the teacher.

- Support readers by pre-identifying challenging language in the readings. On the board, write 2-3 words likely to be stumbling blocks, pronounce them, and provide connections (if possible) to everyday use of such words or to cognates for English-language learners (e.g., consulting an English/Spanish science glossary). IQWST is built on a strong research base showing that the best way to learn vocabulary is to encounter and use words in context. Use an interactive Word Wall to display words so that they may be referred to often. Pre-identifying and pronouncing words that might cause difficulty is not meant as a strategy for teaching vocabulary but only as a way to ensure that when students encounter Leonardo da Vinci's name or see "optical illusion" in print, they will not experience unfamiliar words as roadblocks.

- Readings should be previewed and followed up in class, and soon most students, even struggling readers, will attempt at least portions of the reading. Even if they do not read the entire assignment, or do not read well, students will make sense of whatever they do accomplish in ways that will help them learn. IQWST is not a textbook-driven curriculum, so using class time to read the materials does not align with a project- and inquiry-based philosophy in which students experience phenomena and then think about, write about, talk about, and read about science to learn content in meaningful ways. Encourage reluctant readers by asking follow-up questions that draw on examples from the reading, making the focus not on details, but on sense making, so that all can feel successful and encouraged to read independently.

Writing-Focused Strategies

- Writing in science must be clear and accurate. For students with motor skills difficulties, provide ample writing space by using the margins, the back of the page in the student book, or additional paper. Students can also write on a computer, print, and paste the page into the student book.

- To support students with learning disabilities, who may omit words in writing, suggest that they read their own writing aloud, as they can often "hear" omissions when they do so. Alternatively, a peer or family member can read a written response aloud to allow students to self-correct as they hear errors in their writing. Another person may also scribe while students who struggle with writing provide oral responses, allowing students to express their understanding of science ideas and to communicate more successfully.

Mathematics-Focused Strategies

- Measurements in science are precise, and measuring using science equipment can be difficult. Collaborative investigations enable students with varied strengths to work together. Although all students should learn how to use the tools of science, students who have difficulties with motor skills or vision impairments, for example, do not need to physically measure or be the person solely responsible for reading the thermometer. Instead, students work together to carry out investigations.

- Procedures in science require a sequencing of steps that can be difficult for some students if instructions are given only orally or only in print. To support all students, review written instructions orally, step-by-step, as needed. Have students reread procedures even after they have been reviewed. Demonstrate procedures for investigations that are anticipated to cause confusion or frustration. Many students are more successful if they check off steps as each is completed.

SCIENTIFIC AND ENGINEERING PRACTICES

The *Framework* and NGSS identify eight practices that build and refine scientific knowledge and thus are central to the scientific enterprise. Rather than separate content knowledge and inquiry skills, as in previous versions of national standards, newer standards move toward combining core content and scientific practices in tandem. IQWST is based on the same extensive research that forms the foundation of science education for the 21st century and the basis for the *Framework* and NGSS. Thus, IQWST lessons integrate and continually reinforce practices such that students develop greater facility with and deeper understanding of these practices and of the content they address, whether NGSS, the Framework, or state standards guide learning.

Engaging in scientific practices enables students to experience how it is that scientists come to particular understandings, rather than to experience science as a set of complete, discrete, isolated facts. In addition, a focus on practices, as an extension of previous approaches to inquiry, expands students' understanding of science beyond viewing it as a limited set of procedures or as a single approach typically characterized as "the scientific method."

Scientific practices require both knowledge and skill, and IQWST approaches scientific practices in that manner; practices are always contextualized. Rather than a lesson about "how to construct a good scientific explanation," explanations are taught in the context of a lesson about core content, using the construction of an evidence-based explanation as a way to think about, make sense of, and communicate one's understanding of phenomena. All eight practices are reflected throughout IQWST. However, each unit's learning goals emphasize particular practices, emphasizing those best taught (and practiced) in the context of a given unit's learning goals and investigative activities.

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics, Information and Computer Technology, and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Each of these is addressed individually in sections that follow.

Scientific Practice 1: Asking Questions and Defining Problems

A key IQWST instructional component is each unit's Driving Question (DQ). A DQ is a rich, open-ended question that uses everyday language to situate scientific principles in contexts that are meaningful to middle school students. The discussions, investigations, science readings, and writing activities all relate to the DQ. IQWST involves students in constructing, evaluating, communicating, and reaching consensus on scientific explanations of how and why phenomena happen. In order to engage in this practice, students must make sense of phenomena they study and then articulate and defend their understandings to themselves, each other, the teacher, and other audiences. As each unit progresses, students learn content that moves them closer to being able to answer the DQ in a grade-appropriate manner. As important, each unit purposefully solicits students' original questions and provides the teacher with guidance about posting those questions on a Driving Question Board in the classroom and integrates them into the lessons. Thus science becomes "what I wonder about" rather than only "what I am told I should think about."

In addition, in the process of exploring phenomena and wondering how and why things happen, students question one another about what they observe and the conclusions they draw. They question one another about the texts they read. They learn about questioning in this manner, as well as asking testable questions that students can answer by designing, planning, and carrying out an investigation. In some IQWST units, students work together to define a problem, determine how to find a solution, and compare ideas with others in the process of solving the problem. Extending this practice, support students in developing testable how and why questions that move them closer to authentic scientific practice.

Driving Question Board (DQB)

To organize each IQWST unit, the DQ is displayed on a Driving Question Board (a bulletin board or large area on a wall). The Driving Question Board (DQB) is a tool used throughout IQWST to focus students' attention, record what they have learned, and show students where they have been and the direction they are going. The DQB serves as a visual reference that remains in place throughout a unit. Lesson plans typically guide the teacher in their use. Although the teacher maintains the DQB, because it functions as a shared space to represent learning, students might also contribute regularly to the display.

Each IQWST lesson addresses a component of the unit's DQ, supporting students in making sense of science content and determining which part of a question they can answer and which they still need to investigate. Thus, new lessons are motivated, in part, by what questions still need to be addressed. The visual display supports teachers and students in tracking and organizing ideas along the way.

Each unit invites students to post their own original questions on the DQB to encourage active engagement in a participatory classroom culture. As they think of new questions at any time during the unit, students write those questions on sticky notes and add them to the class DQB. Across a unit, the DQB will come to include the unit-specified question and subquestions, as well as student questions, drawings, photographs, artifacts, objects, and sample student work. The DQB will serve as a focal reference helpful to all but especially important for students for whom visual representations aid in their learning, such as connecting new ideas to previous

understandings. Revisit the DQB with students in each lesson. Refer to it often. Point to artifacts displayed on it as a reminder of previous activities or understandings. Post on it summaries of scientific principles, as well as artifacts students create that relate to specific questions. Any projected image used in IQWST could be printed, laminated, or inserted into a plastic sleeve and displayed on the Driving Question Board. This includes models or data tables developed as a class or any other visual representation of concepts students have studied.

Space on the Driving Question Board may be limited, but it is important that aesthetics and the neatness of the DQB do not outweigh the support provided to students when they can frequently refer to the visual representations as a reminder of activities done and content learned throughout a unit.

Scientific Practice 2: Developing and Using Models

The *Framework* describes the central role of constructing and using models to explain: "Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observations and imagine a world not yet seen. Models enable predictions . . . to be made in order to test hypothetical explanations." NGSS specifies that models can include "diagrams, physical replicas, mathematical representations, analogies, and computer simulations," all of which contain "approximations and assumptions" that students need to learn to recognize as a given model's limitations. In science, models are used to help people understand, describe, predict, and explain phenomena in the real world.

Scientific modeling consists of several core practices: constructing models, using models to explain or predict, evaluating models, and revising models. IQWST engages students in all of these, supporting learners as they develop models, use models to explain, use models to predict, critique one another's models, and revise models as they learn new information—engaging in modeling as real scientists do. Because modeling is often connected with other aspects of scientific practice, students' experiences with modeling are embedded in the broader context of investigating, understanding, and explaining phenomena. Students create and use models to understand and apply scientific ideas, to illustrate and defend ideas, and to evaluate interpretations.

Engaging Students in Modeling

Students need to understand the purpose of models and modeling in science in order to effectively engage in the practice of developing and using models. As a real-world application with which students may be familiar, have them think about the models scientists use to explain and predict the path of hurricanes, tornadoes, thunderstorms, or snowstorms.

Before Students Develop Models

1. It is helpful to emphasize that the point of developing models is to try to explain the phenomenon just investigated in class. Students' models should demonstrate their best ideas about how to show how and why X happened, so that the model can be used to explain what happened to someone else.
2. Begin to develop criteria for good models, which can be posted in the classroom and used throughout IQWST as students develop their own models and critique one

another's models. These ideas should come from class discussion and should be written in students' own language. Important ideas include the following:

    a. Models need to explain. Does the model show *how* and *why* the phenomena happened the way they did? Is there anything in the model that does not need to be here? Are there steps we are leaving out?

    b. Models need to fit the evidence. Does this model fit what was seen about the phenomenon?

    c. Models need to help others understand a phenomenon. Is the model easy to understand? Are there ways to clarify what it shows?

    d. As lessons lead to the need for model revision to account for a new phenomenon, address the idea that models also can be used to predict. Probe students with the following questions: What does our model predict about what will happen in situation X? Was that what actually happened? What does that mean about our model? What do we need to revise based on our new evidence?

Before Students Share Models

It is helpful to give students guidance about how they should listen to each other as they present their models. Eventually students will ask critical questions and make constructive suggestions to each other. Be sure to support that process until they understand this kind of classroom discourse. The following are ideas to address:

1. Different ideas will arise as we try to figure things out. This is our chance to put our heads together and come up with the best model we can come up with, as a group. But we need to agree on what we are looking for. As we listen to each other explain our models, remember what we created these models to try to do. Let's talk about what is important.

2. All scientific models have limitations. Not every aspect of a phenomenon can be explained using a single model. Models often simplify as they illustrate things that are too small, too large, too fast, or too slow to observe without a model as a representation. A static model cannot show movement. No model can sufficiently illustrate the number of molecules involved in a phenomenon nor the time required for others to take place.

3. More than one model can be used to explain the same phenomenon. Scientists judge how good a model is based on how well it helps to explain or predict phenomena—not by how similar it looks to the thing it aims to explain or describe. For example, a good model of gases can be used to explain all the behaviors of gases observed in the real world (e.g., what happens when air is cooled, heated, or compressed), but it will not be used to explain the behavior of solids. Different models have different advantages and disadvantages.

Constructing Models Depends on Scientific Argumentation

The practice of constructing models in IQWST draws critically on another scientific practice, Engaging in Argument from Evidence. In the practice of constructing models in IQWST, argumentation occurs when students defend their proposed models, showing how the model fits evidence and explains the phenomena. Argumentation occurs in classroom discourse when comparing and discussing competing models. IQWST lessons contain support for students

to critique one another's models and ultimately to reach consensus, both critical parts of the argumentation practice.

Scientific Practice 3: Planning and Carrying Out Investigations

IQWST is an activity-based, phenomena-rich, investigative curriculum. Students plan investigations that address the Driving Question for each unit and carry out investigations in each lesson. The investigations build understanding of core ideas throughout each unit, always directed at gaining more understanding toward being able to answer the Driving Question. In addition, students' original questions not answered in the unit can be used as a springboard for additional investigation. Some investigations arise out of previous ones in a process of figuring out "what we know as a class" and "what we need to figure out next," typically in learning the how and why of a process. Any such questions can motivate further investigation. Thus, besides those opportunities provided by the curriculum itself, the teacher can require or encourage the planning and carrying out of investigations that extend student learning beyond the performance expectations of a given unit.

Carrying out a multistep procedure is an important science literacy skill; thus teachers might have students plan investigations, write procedures, and share plans and procedures with other groups to read and critique.

Scientific Practice 4: Analyzing and Interpreting Data

IQWST units engage students in observation, data collection and organization, interpretation, and using data to make sense of phenomena they investigate. All lessons regularly use the language of "observation," "data," and "evidence." Teachers are encouraged to ask students to support their ideas with evidence (e.g., Why do you think that? How could that happen? What if . . . ? What evidence do you/we have for that?), requiring students to consider their data carefully. Teachers encourage students to question data provided by others. This creates a situation in which using data as evidence to defend a claim makes sense—students need evidence because they will be questioned about their data in discussion.

Students analyze both qualitative and quantitative data in IQWST. They learn that both are important and while observation with the unaided eye enables them to make some significant claims, instrumentation and scientific tools enable them to be much more precise. Students analyze data they have collected themselves as well as data collected by others (e.g., changes in a population over time, melting points of substances they are unable to investigate in the classroom). Charts and graphs require understanding of independent and dependent variables, and investigations require understanding of what it means to control variables. Throughout the units, IQWST provides students with multiple opportunities to analyze and interpret data through classroom discourse as a whole class, in small groups, in pairs, and independently, providing practice in multiple contexts that reinforce the development of this scientific practice.

Scientific Practice 5: Using Mathematics, Information and Technology, and Computational Thinking

NGSS specifies within this practice ideas such as "using digital tools," for example, "to analyze very large data sets for patterns and trends" and "to test and compare solutions to an engineering design problem." In addition, this practice specifies a need for students to "measure and compare quantitative attributes of different objects and display the data using simple graphs." Therefore, IQWST units include lessons that include probes, sensors, data loggers, and a sensor interface as digital tools that enable quantitative measurement and graphic display in a manner in which real scientists do their work.

IQWST uses the language of *probes*, *sensors*, *data loggers,* and *sensor interface* for illustrative purposes, given rapid changes and advancements in technology and the attempt to use generic terms where possible. IQWST materials show photographs of and reference Pasco brand probes for several activities, as Pasco makes high-quality equipment for middle school use. If your school uses another brand of technology, adjustments may be required in the instructions to students. If your school does not have probeware, and you elect not to purchase such equipment, then more significant adjustment to activities will be necessary, especially where measurements may not be made quantitatively without similar devices. It is recommended, in keeping with the NGSS call for the types of scientific practices considered integral to science education, that probeware be used as recommended in IQWST. More specific guidelines and instructions specific to brands of probeware may be found on the Teacher Portal with updates available to teachers in a timely manner.

Mathematics is used throughout the IQWST program as students take measurements using the tools of science, collect data, plot data on graphs or create data tables, and come to understand and work with dependent and independent variables. Students use scientific probes to calculate in the manner of scientists. Computers are used for simulations of models of phenomena, such as predator/prey relationships, or for observing a phenomenon in slow motion so that it can be more carefully examined.

Scientific Practice 6: Constructing Explanations and Designing Solutions

The *Framework* defines explanations as "accounts that link scientific theory with scientific observations or phenomena" and identifies the related engineering practice of designing solutions, in which students construct and defend solutions to problems that draw on scientific ideas. In IQWST, these two aspects of the practice are combined as constructing, evaluating, and defending evidence-based scientific explanations. The scientific practice of explanation goes beyond asking students to describe what they know about a particular idea. Instead, students develop a chain of reasoning that shows why the phenomenon occurs as it does.

For example, rather than asking students simply to "explain the process of cellular respiration," an IQWST Life Science Unit asks students to "explain why the air a human breathes out contains less oxygen than the air breathed in." Students not only describe the process of respiration but also construct a causal chain that fits the evidence. Drawing on prior ideas from chemistry and physical science, such a chain should specify where glucose goes in the body,

what materials can get into and out of cells, and conclude that a chemical reaction requiring both glucose and oxygen must be taking place in cells to convert energy to a form the organism can use.

What Does It Mean to Construct an Explanation?

In the practice of constructing explanations in IQWST, students make claims, use data as evidence to support their claims, and engage in reasoning that draws on scientific principles, or the "what we know" in science, to explain the "how" and "why" of phenomena they investigate in the classroom. Teachers pose questions that push students to think more deeply about what they have observed, read, and experienced, modeling this practice so that students learn to question one another. IQWST lessons support students in critiquing one another's explanations, providing students with opportunities to talk, to write, to discuss, to give and receive feedback, and to revise the explanations they have constructed. Many literacy standards are addressed as students cite evidence from sources; integrate information from observations and from text; write arguments that use a claim, use data as evidence, and use logical reasoning in an explanatory text; and engage in revision focused on writing clearly and coherently for a specific purpose and audience.

Supports are designed around a framework that divides scientific explanations into three smaller, manageable, and teachable components for middle school students: claim, evidence, and reasoning (referred to as the C,E,R framework). IQWST identifies these components in order to support students as they learn to write in a new way.

Claim

A claim is a statement of one's understanding about a phenomenon or about the results of an investigation. The claim is a testable statement about what happened. The claim expresses what the author is trying to help the audience understand and believe.

Claims may be made about data that students have been given or they have gathered themselves. If an investigation has independent and dependent variables, the claim describes the relationship between them.

In practice, teachers have found it useful to teach that a claim must be a complete sentence, cannot begin with "yes" or "no," and is typically the first sentence of an explanation. Although it is not necessary that a claim be the first sentence, experience has shown that freedom to vary the guidelines is best managed *after* the guidelines and their purpose have been learned.

The claim is often the part of an explanation that students find easiest to include and to identify as they critique others' explanations. One of the purposes of focusing on evidence-based scientific explanations is to help students include more than a claim (or "simple" answer to a question) in their writing.

Evidence

The evidence consists of the data used to support the claim. The evidence tells the audience the support the author has collected that makes the claim convincing.

An explanation must contain accurate and sufficient evidence in support of the claim. Evidence makes claims understandable and convincing. While "data" can refer to all the observations that students have collected or analyzed, data become "evidence" when used to support a claim. The evidence for explanations can come from investigations students conduct, from observations they make, or from reports of empirical research others have done. Where possible, explanations incorporate more than one piece of data as evidence.

A goal in IQWST is to help students understand that data must be marshaled as evidence in support of a particular claim. In complex situations, more than one claim might be made about a single data set. It might also be that more data are available than are necessary to support a particular claim. Students must determine which are the appropriate data to use in support of a claim they have made and what are sufficient data to support that claim. The idea that multiple claims might be made using the same data develops across the curriculum as the inquiry activities become more complex, and students' options for research questions (and resulting claims and evidence) become increasingly open ended.

Reasoning

Students learn that the accepted scientific understanding or principles that underlie the explanation must be made explicit in a process IQWST calls reasoning. The reasoning presents the logic that leads from the evidence to the claim and, if possible, connects it with a scientific principle. The reasoning says why the claim makes sense, given what is understood so far about the phenomena. Reasoning ties in the scientific knowledge or theory that justifies the claim and helps determine the appropriate evidence. The reasoning may include a scientific principle that reflects the consensus students have developed so far about the phenomena they are investigating. It may also require a logical chain that shows how the principle and evidence work together to support the claim. For example, the reasoning for the effects of a competitor X on population Y may refer to a series of connected steps that start with the increase in population size of the competing species X, decrease of available food sources needed by both X and Y, and then drop in population size of Y due to lack of food.

The reasoning connects to the general knowledge of the scientific community and a chain of logic to explain how particular data support a claim, given what scientists know about the world. Reasoning is the most difficult aspect of explanation writing for students to understand and is the most difficult aspect for teachers to teach. Reasoning requires relating general scientific principles—what is already known in science—to the specific question being investigated and requires students to make explicit the steps of their thinking.

Scientific Practice 7: Engaging in Argument from Evidence

The *Framework* defines the central role of scientific argumentation in building scientific knowledge as "a process of reasoning that requires a scientist to make a justified claim

about the world. In response, other scientists attempt to identify the claim's weaknesses and limitations." In the practice of constructing explanations in IQWST, argumentation occurs when students defend their explanations both in written form, by providing supporting evidence and reasoning, and in classroom discourse, when comparing and discussing competing explanations. IQWST lessons contain support for students to critique one another's explanations and to reach consensus, both critical parts of argumentation. Students learn about criteria for critiquing explanations that also apply to arguments: both must fit the evidence, be logically coherent, fit what is known in science, and include important steps in reasoning.

Argumentation is key in IQWST thus significant attention is paid to evidence-based explanation and argumentation, and students engage in this practice in every IQWST unit.

Scientific Practice 8: Obtaining, Evaluating, and Communicating Information

Student readings provide additional information to support students' in-class investigations. Readings are designed to be integrated into each lesson such that students obtain, evaluate, and communicate information from multiple sources—their own work, others' work, and the science they read about—in all that they do. In addition, opportunities abound for additional research using the Internet, for example, so that students can pursue areas of individual interest that go beyond the performance expectations and grade-level standards. That is, a student who reads about solar sails, described in an IQWST reading as an example of the use of solar power, might wish to learn more about what solar sails are and how they work. Such reading might also trigger interest in alternative forms of energy and their advantages and disadvantages and lead to a written project as situated in the context of the science being studied. This can enable a student to apply his or her understanding to global concerns or to issues in the local community. Such projects, models, and written products that result can interest and motivate students, deepen content understanding, encourage engagement in scientific practices and literacy practices related to science, and provide application and extension opportunities beyond the classroom. In addition, deeper understanding will likely be fostered as the student encounters new ideas in science that fit with the knowledge gleaned from such a project as the core of learning—connecting new understandings with prior knowledge—is strengthened. IQWST does not require research paper types of projects; however, opportunities for teachers to collaborate across content areas such that students might explore science topics as a way to meet literacy learning goals is an option, given that students are likely to encounter many topics they wish to explore further as they investigate phenomenon and read, write, and talk science in every lesson.

Practices Across Time

IQWST students engage in all eight practices across 6th-8th grades; however, their facility with the practices becomes increasingly adept as students engage with the practices in increasingly sophisticated ways, across multiple contexts, and across all of middle school.

INSTRUCTIONAL SUPPORT FOR SCIENTIFIC PRACTICES

The following strategies support students in developing experience with scientific practices.

Use Data to Build Understanding

As designed, earlier IQWST units help students become familiar with observation and data collection and with using data to make sense of phenomena. Teachers are encouraged to ask students to support ideas with evidence (e.g., Why do you think that? How could that happen? What if . . . ? What evidence do you/we have for that?). Teachers allow students to question evidence provided by others. This creates a situation in which using data as evidence to defend a claim makes sense—students need evidence because they will be questioned about it in discussion.

Model the Practice

The teacher uses a think-aloud process to make thinking visible to students. This highlights the underlying aspects of scientific practices, making them explicit as the teacher "talks through" his or her thinking, modeling how good writers, modelers, thinkers, observers, or questioners think as they engage in the practice.

Identify the Audience

All written tasks should be constructed with an audience in mind. This helps students shape their writing, so that the audience can make sense of a written explanation, a model, or a representation of data. In IQWST, students may be asked to think about convincing someone from another class of the validity of the claim in an explanation, to share with someone at home and get feedback, or to explain to an absentee student, someone new the school, or an elementary student.

Motivate the Practice

As teachers incorporate explanation construction and modeling into lessons, they must help students move back and forth between the components of the practice (e.g., claim, evidence, reasoning) and the overall purpose of the practice. Otherwise, focusing on the components becomes formulaic, and students lose sight of the purpose of explanations and modeling in science. To help students see a need for this work, they are placed in situations in which they must engage in argumentation as a way to "convince" someone that their conclusions make sense and can be supported with data.

Generate Criteria

When students are asked to convince one another and to determine whether they are convinced by someone's claim, they need criteria on which to base decisions. Although teachers begin with criteria in mind (described in each unit), they guide students to develop criteria in their own words. The framework can be given to students at the outset; however, students have a deeper understanding of the components and more buy-in when they work cooperatively as a class to generate criteria or the framework for an explanation.

Critique Examples

Students are accustomed to process writing in ELA, but they tend to think that once something is written in other content areas it is finished. Whole-class, teacher-led, and small-group critique of explanations and models helps students see that explanations can be revisited, rethought, and revised. A teacher can create sample explanations for critique purposes. Once students have written explanations, their work can be used anonymously for whole-class critique. Teacher-guided critique, in which the teacher asks probing questions in a discussion, is a useful next step. Once students have practiced in teacher-led sessions, they are ready to critique one another's work. In any critique, strengths and weaknesses should be highlighted and suggestions for improvement offered. It is small-group or paired sharing, in which students compare ideas and justify their use of evidence, that IQWST emphasizes. It is in those comparison and justification activities that deep conceptual understanding takes place, and it is these activities that motivate the use of explanations and models in science.

Explanation and Modeling Criteria

The following criteria can be adapted, as needed, for your students and for the specific task in which they are engaging. A list of this type supports students in developing a sense of how to critique a written explanation, argument, or model.

Explanation and Argumentation

- Does the claim clearly state a conclusion?

- Does the explanation include appropriate evidence? (Think about what type of evidence would not be appropriate.)

- Does the explanation include sufficient evidence? (Is all of the important data included?)

- Is there reasoning that helps you understand how the evidence connects to the claim? (Think about what you have learned that makes a particular type of data important to this claim.)

- Does the explanation include one or more scientific principles that are appropriate?

- Is the argument presented in a way that is convincing?

Modeling

- Does the model include all the key components and show how they are related to each other?

- Does the model accurately represent the phenomenon?

- Is the model consistent with all of the evidence?

- Can the model be used to represent and to explain the phenomenon? (Can it be used to predict other phenomena?)

- Does the model include only necessary information, and no extra details?

LITERACY IN THE IQWST CLASSROOM

IQWST supports literacy for diverse learners as students transition from *learning to read and write* in elementary school to *reading and writing to learn* in middle school. Lessons draw on the most recent research in literacy learning, with emphasis on reading comprehension and on the role that reading and writing—in tandem—play in learning. In IQWST, students learn by engaging with the tools, materials, ideas, and principles of science and by thinking, reading, writing, and talking science.

Literacy practices are integrated into every IQWST lesson. The curriculum encourages students to be reflective and critical thinkers, to ask questions of the teacher and each other, to share in small- and whole-group discussion, to read texts that connect science to their everyday lives and prior knowledge, to write responses to embedded questions, to construct models and written explanations and to revise them, to engage in argumentation to defend their ideas and to challenge one another's thinking.

Student books are consumable, functioning as portfolios; the lab activity pages, models and diagrams students draw, readings, and all writing are in one place. Books can be used to teach additional skills by a specialist, support person, or teacher who chooses to teach annotation or highlighting, for example, as students write directly in their books.

Reading in Science

IQWST materials are designed to meet expectations for reading and include strategies to guide teachers in addressing literacy requirements with additional depth or to differentiate for diverse students.

LITERACY GOALS	AS ADDRESSED IN IQWST
Cite specific textual evidence to support analysis of science and technical texts.	Discussion prompts and strategies for teachers and responses to questions embedded in readings ask students to refer to text for evidence.
Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	Summarizing or referencing central ideas from text in discussion is often done in the "Reading Follow Up" section that begins most lessons.
Follow precisely a multistep procedure when carrying out an experiment taking measurements or performing technical tasks.	Activity sheets that accompany investigations and homework activities provide extensive practice in reading and following procedures.
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to Grades 6–8 texts and topics.	The language of science is key to science learning. Thus readings address vocabulary in a manner that is context rich, and use of an interactive Word Wall reinforces the reading and the use of science language.

Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.	Readings provide opportunities for teacher-led analysis of structure.
Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	Readings provide an opportunity for teacher-led analysis of purpose.
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	Readings support students in moving back and forth between text and visual information (e.g., "notice the shaded area in the diagram"), and some readings suggest that teachers reinforce this practice when previewing or reviewing readings.
Distinguish among facts, reasoned judgment based on research findings and speculation in a text.	This is best accomplished through suggested projects in which students pursue individual interests or go into more depth studying a topic related to class.
Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	Questions such as "How does what you read help you think about yesterday's investigation?" support students in integrating multiple sources of information. Videos and simulations, as well, are interwoven with reading and with hands-on investigations.

RANGE OF READING IN IQWST

As students transition from learning-to-read to reading-to-learn, IQWST supports them with built-in strategies for students and teachers. IQWST does not provide texts at multiple Lexile levels, based on research that indicates (1) that students who are interested in a topic will choose to read well beyond their test-determined reading level, and (2) that reducing word length and shortening sentences (key strategies for decreasing reading level) can impair comprehension.

Rather than confine students who read below level to reading lesser content, materials suggest strategies for teachers to differentiate instruction so all students have opportunities to use the materials to develop as readers capable of using a range of written materials. Suggestions for students at the top of the grade level reading band encourage independent reading of texts beyond curriculum requirements, so no ceiling suppresses what IQWST students can achieve as readers and critical thinkers.

IQWST readings are integral to students' understanding of science concepts and enable teachers to simultaneously address reading- and writing-related concepts.

Using IQWST Readings Effectively

Given that the ability to "read and comprehend complex informational texts independently and proficiently" is a lifelong literacy skill, IQWST materials are designed such that readings are intended to be done independently, outside of class time. The few exceptions, in which class time is specifically devoted to addressing some portion of a reading assignment, are clearly indicated in the materials. Readings:

- Extend classroom learning by providing additional examples of principles and con- cepts encountered in class

- Review in-class activities to help students understand and retain main ideas and to sup- port absent students with content they missed

- Elicit students' prior knowledge and draw on it in engaging ways

- Provide real-world connections that illustrate the value of science outside the classroom

- Use examples with which middle school students are likely to have personal experience or at least be familiar

- Embed questions, to which students write responses, supporting integration of reading and writing in the service of learning, as well as support students' active engagement as readers

The Teacher Edition provides two primary ways of supporting students as readers in science by taking a brief amount of time to introduce the readings and consistently following up on readings in class discussion, as bell work at the beginning of class, or in a quiz-type format.

Introducing Reading

Introducing Reading sections in the teacher materials often suggest that the teacher review the Getting Ready section of the student materials as a whole-class, oral activity, thus eliciting whole-class prior knowledge, engaging students in brief discussion, and setting a purpose for the homework reading. Reading setup could take as few as 2 to 3 minutes of class time, or as much as 10, depending on the teacher's purpose, students' abilities, and the nature of the individual activity, but in general, teachers should plan on three to five minutes to introduce the reading.

Reading Follow Up

It is important to follow up the readings or other homework. Use the embedded assessments for grades or points or use them to generate follow-up discussion to begin a class period. Students held accountable for reading either through assessments or through in- class questions that require having read the materials in order to participate in discussion are more likely to read as homework. As they enter class, a simple way to do this is to have on the board an opening question that draws on what they read.

The Student Edition

Annotated versions of the student pages—in the Teacher Resource Book—provide the teacher with likely student responses or expected responses (including correct answers, where appropriate) as well as ideas for using those responses as formative or summative assessments.

Driving Question Notes and Scientific Principles Pages

The first few pages of every student edition are provided as note-taking space in which students can record both their own individual ideas that connect with the Driving Question, and those big ideas generated by the class. Students should record their own original questions and can add information about those as they progress through the unit. Scientific principles are big ideas that the entire class "arrives at" by the end of many lessons and that students record for ongoing reference. The teacher materials often suggest ideas to be recorded on these pages, but they can be used to record any information the teacher or students deem appropriate. Tracking of scientific principles is a way to ensure that the class articulates "what we know so far" as students progress through the unit; it has common language to draw on when constructing explanations or arguments that draw on these big ideas.

Below are some ways to talk with students about how it is that their own note-taking and recording of scientific principles in IQWST is similar to what scientists actually do.

- When scientists figure out something important from their data, they record (write down) what they have learned.

- When scientists want to let other people know what they have done, their written notes and explanations help other scientists to benefit from their work.

- Writing information down helps scientists keep track of what they understand and their evidence for why they believe something to be true.

- When scientists want to convince other people about what they have learned, their evidence is especially important to support their claims.

- When scientists figure something out, and other people test their ideas, ideas sometimes become "what we know" in science. Those ideas can be stated as Scientific Principles. Principles (or sometimes "laws") are called that because scientists have evidence that they happen now, happened in the past, and will happen in the same way in the future.

Activity Sheets

IQWST students experience phenomena in a problem-based, investigative context, typically guided by activity sheets for each lesson. These pages support students as they plan and carry out investigations, follow procedures, make predictions and compare them with what happened, organize and analyze data, and make sense of science. Activity sheets often include an opportunity for students to explain the *how* or *why* of a phenomenon, deepening students' understanding as they engage in scientific practices.

Having a student read the "What will we do?" section aloud is one strategy to provide students with an overview of activities in which they are about to engage. Read through the procedure with students, demonstrate it, highlight key components, or summarize briefly so that students conceptualize the big picture of what they are going to do. For example, tell students "You are going to observe two materials separately, and then observe them again after you put them together. It is important that you describe your observations in the table on your activity sheet. Then, you will write some questions about what you observed." Such review frames the activity for all students but is especially important for students who need to hear and not just read the procedure or who need to understand the big picture before making sense of the individual steps.

Homework

Some take-home assignments are designed as extension activities, typically requiring students to apply what they have learned to new contexts. These assignments reinforce in-class activities, providing independent practice focused on key ideas in each unit.

Writing in Science

LITERACY GOALS	AS ADDRESSED IN IQWST
Write arguments focused on discipline-specific content. (a) Introduce claims, distinguish from opposing claims, and organize reasons and evidence logically. (b) Support claims with logical reasoning and relevant, accurate data, and evidence. (c) Clarify relationships among claims, counterclaims, reasons, and evidence. (d) Maintain a formal style. (e) Provide a concluding statement that supports the argument.	One pervasive opportunity in IQWST is for students to construct evidence-based explanations of phenomena they investigate and to analyze and give feedback on the written explanations of their peers. In some units, this is taken a step further into argumentation, with written and oral defense of arguments: a key scientific practice supported when the unit content is conducive to argumentation. Reading and discussing writing can help students deepen their own understanding, hone their critical thinking skills, and support consensus-building or argumentation skills in a group.
Write informative/explanatory texts, including scientific procedures/experiments. (a) Introduce the topic clearly and organize ideas, concepts, and information as appropriate to achieving purpose. (b) Develop the topic with relevant facts, details, or other information. (c) Clarify the relationships among ideas and concepts. (d) Use precise language and domain-specific vocabulary to explain the topic. (e) Maintain a formal style and objective tone. (f) Provide a concluding statement that supports the explanation presented.	In addition to the information in the previous box, students write explanations in response to questions embedded in their reading materials and on activity sheets to conclude and make sense of investigations. Additional opportunities to write explanatory texts are often provided in the Differentiation Opportunities sections that precede each lesson.
Narrative skills—for example, write precise enough descriptions of step-by-step procedures they use in investigations that others can replicate them and (possibly) reach the same results.	Students write step-by-step procedures when they design investigations, engaging in an important scientific practice.
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	All explanations and arguments in IQWST are designed for a specific purpose and audience, and many other writing tasks define a purpose and audience so that students learn to write for different purposes.
With some guidance and support from peers and adults, students develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.	Process writing, as learned in ELA, is used throughout IQWST as students compose evidence-based scientific explanations and arguments, share them with peers, give and receive feedback, and revise.

Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	Opportunities to use the Internet to search for information and to inform writing are provided as Differentiation Opportunities to enable students to pursue curriculum-related topics in which they are keenly interested or for the teacher to assign topics to advanced students so that they might "go beyond" the curriculum's learning goals.
Conduct short research projects to answer a question (including a self-generation question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.	Self-generated questions are at the core of IQWST, generated in the initial lesson in each unit, and then questions are continually encouraged throughout. Students write their questions on sticky notes, post them on a Driving Question Board, and are advised (or can be required) to investigate them independently.
Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.	In order to engage in the previously mentioned activity, students draw on multiple resources, including in-class activities and readings and Internet searches for other resources.
Draw evidence from informational texts to support analysis, reflection, and research.	Students draw on multiple resources including in-class activities and readings and Internet searches for other resources.

Summarizing is another valuable way to use writing. Summarizing requires determining and restating main ideas and findings. To support students in summarizing key ideas, provide practice for them to verbalize their thinking before writing or time to write about their ideas before sharing orally. For instance, before writing a summary of a reading, students could be asked the following: *How would you summarize this reading for students who were absent yesterday? What did they miss that they need to know?* After discussing, students will be better prepared to write summaries. Writing before sharing orally enables students to think and to process what they have learned before they are called upon to share ideas in class. These and other strategies support students as readers, writers, speakers, and listeners in the context of the science classroom.

In addition to the multiple opportunities provided for students to write to learn in IQWST lessons, activity sheets, readings, and home assignments, teachers can provide additional opportunities to meet the needs of individual students, many of which are suggested in the Differentiation Opportunities section that precedes each lesson.

Speaking and Listening

LITERACY GOALS	AS ADDRESSED IN IQWST
Engage effectively in a range of collaborative discussions (one-on-one, in-group, and teacher-led) with diverse partners . . . building on others' ideas and expressing their own clearly, (a) come to discussions prepared, having read required material, (b) follow rules for collegial discussions, (c) pose and respond to questions with elaboration and detail . . . connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas; and (d) acknowledge new information expressed by others and, when warranted, qualify, justify, or modify their own views in light of the evidence presented.	These behaviors are addressed in daily discussion, often as a follow-up to reading, to make sense of science during and after investigations and as a precursor to writing. Students given opportunities to talk about their ideas and those of others; to use talk as a way to think more deeply; and to critique claims, evidence, and reasoning orally are then better positioned to be able to write convincingly about their ideas. In addition, talking through ideas in this manner enables students to make sense of reading they have done or can set up reading as students read purposefully to determine whether their ideas were right, wrong, or somewhere in between.
Interpret and analyze information, main ideas, and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue.	As students engage with phenomena during investigations, their work requires interpreting and analyzing information that is visual/observational, verbal as expressed in both oral and written texts, and both qualitative and quantitative, requiring students to synthesize information from multiple sources.
Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.	Activities throughout IQWST that call for explanation or argumentation also call for students to share and to critique one another's ideas.
Present claims and findings, sequencing ideas logically and emphasizing salient points in a focused, coherent manner; use appropriate eye contact, adequate volume, and clear pronunciation.	Activities throughout IQWST that call for explanation or argumentation, as well as modeling, also call for students to present their ideas to a partner, a small group, or to the whole class.
Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.	Visual displays, especially models that accompany explanations and arguments, are constructed and shared in every IQWST unit.
Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.	The primary manner of speaking and listening in IQWST is presenting ideas for comparison with others' ideas and both giving and receiving oral feedback.

Classroom Culture

Establishing a culture in which students actively participate in "talking science" is at the core of IQWST, but it is challenging for both teachers and students. By the time students have reached the middle grades, they know a great deal about what it means to "do school." They raise their hands, do so only when they think they have the right answer, and respond to teacher-posed questions rather than to peers' ideas. In an IQWST classroom, students ask questions that arise out of individual interests or concepts about which they are confused. They ask questions of other students, as well as the teacher. Science discussions promote active engagement in science learning such that everybody expresses their understanding and learns from each other. The goal is for students to develop as thinkers and problem solvers through participating in thoughtful talk about core content.

Sharing ideas openly, asking questions of one another, defending one's ideas, and not having right answers challenges many students, as well. Students who are successful when reading and answering questions may not be comfortable discussing and exploring alternative ways to explore concepts. Students may be uncomfortable participating in discussions if they are unsure of the correct answer or may be uncomfortable with the idea that multiple responses may be considered correct at a given time in the process of learning. Students who are successful doing activities and discussing their reasoning may struggle when they are required to write about their ideas. Students who have looked to the teacher for answers and guidance may find it unusual that they need to question another student or provide rationale for their responses.

Establishing a classroom culture wherein students feel comfortable sharing and discussing with each other and feel confident about participating actively begins on the first day of class. Since IQWST may introduce a new manner of discussion for students, the teacher will need to model sharing, listening, and learning with students by demonstrating the value of contributions, not just correct answers. The primary goal of oral discourse is for students to articulate their own understanding and to listen and respond to each other. This goal is assisted when the following occurs:

- All students are provided opportunities to participate.
- All students are encouraged to participate.
- Students are encouraged to think together, rather than only speak, if they think they have the correct answer.
- Students see the value in wrong answers for figuring things out.
- Students are provided opportunities to write their responses before sharing aloud.
- Students use information in readings as a springboard for discussion.
- Students listen carefully to others and respond to others' ideas.

Small-group discussions are an integral part of the inquiry process in IQWST. They provide the best opportunity for students to learn from each other and interact with their peers as well as with the teacher. It is important that all students have an opportunity to participate, express their ideas, listen to one another, and respect others' ideas. Developing a classroom culture in which this is the norm may take time, especially if this is not what students are accustomed to in other classroom settings.

Teacher Supports

IQWST lessons support teachers by providing scaffolding to help facilitate conversation. Teacher supports include a list of possible questions or prompts a teacher may use or adapt, as needed, possible student responses, information about what student responses might suggest about their understanding, and ideas about how to address those ideas. The lessons support the teacher in creating a culture of science discourse by providing question stems such as these:

- What can you add to make this idea clearer?
- How does this idea compare to the idea of the previous speaker?
- What can you add to expand on what was just said?
- How can you summarize our conclusions?

Three Types of Discussion

IQWST lessons identify discussions by type to assist teachers in recognizing the structure of the discussion and conducting the discussion according to the guidelines for each.

In IQWST, brainstorming is any discussion with the purpose of generating and sharing ideas without evaluating their validity. Prompts provided for all brainstorming discussions are suggestions meant to encourage students to express their ideas. It may be useful to record ideas on the board, on a computer, or on **chart paper** so that students can see what has been said and can build on others' ideas. A photograph of notes recorded on the board, a printout, or **student book** can be attached to the Driving Question Board as a reminder of the activity.

1. Discussion: Brainstorming
   Purpose: To articulate and share ideas without evaluating their validity.
   - All ideas are accepted in brainstorming.
   - Ideas are captured and recorded as they are generated.
   - Brainstorming prompts include the following:
     - o What have you observed or experienced?
     - o What do you think about when you hear the word . . . ?
     - o What do you know about . . . ?
     - o Who has a different way of thinking about this topic?
   - Follow-up can include, as appropriate, such questions as the following: Where does that idea come from? How do you know? Where have you heard/seen/ experienced that before?
2. Discussion: Synthesizing
   Purpose: To put ideas together or assemble them from multiple activities into a coherent whole.
   - Discussions may include making connections to personal experiences, to the Driving Question, and to other lessons or content areas.
   - Synthesizing prompts include the following ones:
     - o How does this connect to . . . ?
     - o How does this support the Driving Question?
     - o How does this help us think about the activity we did yesterday?
     - o What do we know about this topic so far?

In IQWST, the purpose of a Pressing for Understanding discussion is to get students to think more deeply and to make sense of their experiences. Some questions can lead to a simple answer, others to a deeper, more thoughtful answer. Learning through inquiry encourages students to think more deeply but only if their thinking is scaffolded until they learn to think in terms of how and why, to make connections, to analyze, and to synthesize. Probing questions such as *Why do you say that?*, *What makes you think that?*, and *How do you think that works?* invite students to think more deeply and, over time, establish a culture in which doing so is the norm in science class.

3. Discussion: Pressing for Understanding
   Purpose: To figure things out or make sense of readings or activities while going deeper and beyond surface answers.
   - Discussions may involve respectful challenge, debate, or arguments in which students justify their ideas.
   - When pressed, students may revise their previous ideas as they learn new information that shows the limitations of their previous understandings.
   - Pressing for Understanding prompts include the following:
     o How do you know? What evidence supports that idea?
     o Why does our old model not work to explain this new phenomenon?
     o How could we figure this out?
     o How does . . . compare to . . . ?
     o What new questions do you have?

THE LANGUAGE OF SCIENCE: VOCABULARY

New Meanings, Familiar Words

Science as a discipline is known for its challenging vocabulary; thus IQWST lessons contain supports to help students develop deeper understanding of science concepts, including how, when, and why particular language is used. Students are engaged in thinking about the language of science in multiple ways.

IQWST takes a research-based, contextual approach to science language, stressing the repeated, ongoing, pervasive use of new words in oral and written discourse, acknowledging that language and conceptual understanding develop hand-in-hand. Science words are taught as they are needed. Typically, after a concept has been encountered, it is then given a label (the vocabulary word). A primary support for students occurs when teachers use science vocabulary frequently and appropriately and guide students to do so as well.

One of the hallmarks of successful readers is their ability to understand word meanings as they occur in varied contexts. When the teacher uses science vocabulary in context and calls attention to similarities and distinctions between words, all students are supported in building their science vocabularies. Students' everyday understanding can help or hinder their understanding of the uses of many words in science. Words like *absorb* and *reflect* have everyday uses that are consistent with their meanings in science, so linking the everyday to the scientific is likely to be helpful. However, words like *volume* and *mass* or words that name scientific practices such as *modeling* or *explanation,* have everyday meanings that may not help students understand the meaning in science. In those cases, making differences explicit supports students in learning multiple uses of words, including specific uses in science.

Simple routines used before students read new text can help students recognize and use science language as they read, write, and discuss their developing understandings.

Prereading

Before asking students to read independently, the teacher can identify words that will be difficult for the class. Words the teacher anticipates will be difficult can be rehearsed by displaying them (on the board or on a Word Wall), pronouncing them, and providing a snapshot definitions aimed only to help students recognize the words when they encounter them in the context of written text. This scaffolding helps students move words from listening and speaking vocabulary to their reading and writing vocabulary.

Building Vocabulary

Many science words have common prefixes, suffixes, or root words. Building a list of words with similar word parts allows students to see, define, and make connections between words such as *biology* and *ecology*, especially when connected to biosphere, ecosystem, eco-friendly, biochemical, and biography, among others.

For teachers required to do more intense vocabulary study at the middle school level, strategies should support students in developing deeper understanding of science concepts, rather

than simply memorizing textbook-style definitions. Although writing vocabulary words in sentences is common school practice, it has not been shown to promote science vocabulary learning. Thus time is better spent engaged in tasks that use science vocabulary: constructing oral and written explanations and arguments, composing brief summaries, and answering questions that require both critical thinking and the use of appropriate vocabulary.

Interactive Word Wall

Keeping a space in the classroom to post new science language, as new words are encountered, provides students with multiple exposures to new words and allows them to refer to the Word Wall when communicating ideas, formulating questions, or writing (and learning to spell science vocabulary). Having words posted allows the teacher to gesture to the Word Wall during discussion to support students in using science language in their talk. Words written on sentence strips can easily be moved to increase opportunities for connecting words in various ways, grouping them or creating concept maps. Word Walls may be enhanced by short definitions or by visual representations, as well. Students with artistic ability or who like to draw, or who learn by the act of creating representations may create visuals to post on the Word Wall along with new words. Most important is that the classroom is language rich, providing students with ongoing exposure to discipline-specific vocabulary, which supports them as readers, writers, and critical thinkers in science.

Embedded/Formative Assessments

Formative assessment opportunities are embedded within IQWST lessons. They occur during discussions, activities, and readings and can be used to gauge students' understandings and developing science ideas in the moment. Formative assessments used regularly during the learning process enable the teacher to determine whether concepts need to be revisited, whether an optional activity would be beneficial for student learning, whether discussion should be extended or guided differently in order to support student learning, or whether some or all students would benefit from additional support. Formative assessments also enable teachers to provide explicit feedback to students on their ideas, so students can know in what ways they are on track toward meeting learning goals. Formative assessments also enable teachers to differentiate instruction in response to students' current understandings. Questions embedded in readings and as suggested prompts for discussion include possible student responses and, where appropriate, correct answers. When using embedded assessments to gauge students' understanding, analyze responses by listening for students'

- the ability to connect previous ideas with new content;
- the ability to summarize ideas accurately;
- current content understanding, as it will lead to meeting learning goals; and
- developing use of appropriate science language.

Summative Assessments

Many of the embedded assessments, while designed for formative use, may be assigned points or letter grades. Any written response in the student books may be seen as a summative opportunity. An option is to invite students to submit their one "best response" to questions in a lesson or their best evidence-based explanation or other revised response for a grade. This practice acknowledges that motivation, interest, and understanding vary from day to day and recognizes that assessing one's best work helps students be more aware of their own performance and what constitutes "good work" in science. IQWST also provides a bank of questions, available electronically, and in Word format, that teachers may draw from to customize quizzes and tests. Questions may be used as they are or adapted to best match instruction or to meet students' needs (i.e., differentiation).

Test Bank

A collection of multiple-choice and constructed-response questions is also available on the teacher portal, providing teachers with assessment item options that can be used for either formative or summative purposes.

SAFETY PRACTICES

Laboratory investigations excite students about the practice of science and lead to reflective discussions about investigation design and the real work of scientists. With investigations comes the need to teach laboratory safety and practice safety precautions with middle school students who may be new to lab experiences.

Science teachers are expected to take all possible actions to avoid accidents in the laboratory setting and to monitor labs for hazardous chemicals or flammable materials. This includes standard safety practices that include housekeeping to keep the laboratory areas clear of clutter and prohibiting unsupervised access to areas where electricity, chemicals, or heat sources are used.

Teachers should provide information about, and practice, laboratory evacuation drills. Gas and electricity should be shut off during any drills or whenever the class is leaving the lab. All exits must be kept free from obstructions, and no materials should be stored outside of the lab storage room. Safety rules should be posted in the room and reviewed with students prior to lab work. If the teacher, school, or district has specific science rules, those should be posted.

IQWST lessons contain specific safety information at the start of each lesson and throughout the lessons for easy reference for teacher and student. MSDS sheets should be consulted for appropriate use of all chemicals.

Science Lab Rules

There are many science rules to ensure safety in the laboratory. IQWST lessons have specific science cautions through each lesson to guide teachers and students, but middle school students, because of their inexperience with science labs, may need to be aware of certain safety procedures that include the following:

1. Clothing and Hair—Loose or baggy clothing, dangling jewelry, and long hair are safety hazards in the laboratory.
2. Cold and Heat Protection—Cold or hot materials should only be touched with hands protected by items such as safety tongs, safety mittens, or rubber gloves. In some instances, only the teacher should handle materials at extreme temperatures (e.g., dry ice).
3. Food—No eating, drinking, or use of cosmetics should occur during lab time. Even familiar substances used in activities (e.g., marshmallows for molecules) should not be consumed, as they may be contaminated in the lab setting.
4. Glass Caution—Glass should be used cautiously, and students should report any chipped, cracked, or scratched glassware should such occur during a lab activity.
5. Housekeeping—Work areas should be kept clean at all times, with backpacks, books, purses, and jackets placed away from lab tables.
6. Washup—Hands should be washed with soap and water before and after laboratory work. Students should not touch their faces or hair with either bare or gloved hands that have handled lab materials.

7. Safety Equipment—Personal protective equipment such as goggles, gloves, and aprons should be used as appropriate for the activity.
8. Allergies—All allergies should be noted for students and a plan put in place if peanuts, peanut oil, latex, or other known allergenic items are used in the lab. For example, although gloves and goggles provided in IQWST materials are latex-free, some units use balloons, which students with latex allergies should not handle.
9. Sniffing—When directed to "sniff" in the lab, students should be taught to follow the teacher's directions for "wafting" odor to the nose.

These rules are general and should always be followed in a lab situation. IQWST provides a letter to parents that discusses science safety rules. If a school or district has another science letter, and/or additional safety rules, teachers should use the district letter and follow all school or district guidelines for safety in the science lab. For additional safety information, consult the NSTA safety portal at http://www.nsta.org/portals/safety.aspx.

SAFETY LETTER

Dear Students, Parents, and Guardians:

Middle school science consists of engaging topics for students to investigate in a lab setting. However, any science activity may have potential safety issues if not conducted properly. Safety in the science classroom is an important part of the scientific process. To ensure a safe learning environment, a list of rules has been developed and discussed with all students because science rules must be followed at all times. Additional safety instructions will be given for each activity. Please discuss the safety rules with your child and return the bottom of this letter.

No science student will be allowed to participate in science activities until the student and a parent or guardian have acknowledged their understanding of these safety rules by signing this document.

Science Safety Rules
1. Conduct yourself in a responsible manner at all times in the science room.
2. Follow instructions carefully. Ask questions if you do not understand the instructions.
3. Use equipment (e.g., scissors and sharp items) only as directed by the teacher.
4. Perform only approved experiments.
5. Never eat, drink, chew gum, or taste anything in the science lab.
6. Keep hands away from face, eyes, and mouth while using science materials. Wash your hands with soap and water after the activity.
7. Wear safety goggles when instructed. Never remove safety goggles during an experiment. There are no exceptions to this rule!
8. Clean all work areas and equipment, and dispose properly of any waste materials.
9. Report any accident (spill, breakage, and so on), injury, or broken equipment to the teacher immediately.
10. If you have allergies, it is important that your teacher knows about them and that you avoid handling materials that could cause problems. For example, if you are allergic to latex, you can participate in activities that use balloons, but you should not be the one to handle the balloons.

SAFETY AGREEMENT

Dear Students, Parents, and Guardians:

We are providing the Science Safety Rules to keep you informed of the school's effort to create and maintain a safe science classroom/laboratory environment for all students.

Your signature on this letter indicates that you have read the Science Safety Rules, have reviewed them with your child, and are aware of the measures taken to ensure the safety of your son/daughter in the science classroom.

Parent/Guardian Signature: _____

Student Signature: _____

Date: _____

Important question – Does your child have any health issues or allergies? If yes, please list them here.