5 E Model of Instruction

The information in this evidence-based practice is adapted from BSCS and Rodger Bybee.

> "The 5E Model of Instruction includes five phases: Engage, Explore, Explain, Elaborate, and Evaluate. It provides a carefully planned sequence of instruction that places students at the center of learning. It encourages all students to explore, construct understanding of scientific concepts, and relate those understandings to phenomena or engineering problems."
> – Rodger Bybee

Key Ideas

- Teachers use the 5E Model of Instruction to sequence lessons and activities which provide best first instruction for all students. Through this process they emphasize opportunities to personalize learning.
- In each phase of the 5E Model of Instruction, teachers carefully consider how the evidence collected or information obtained builds student understanding of a phenomenon or a solution to a design problem.
- The optimal use of the 5E Model is a learning sequence of two to three weeks where each phase is used as the basis for one or more lessons.
- Using the 5E Model as the basis for a single lesson reduces the effectiveness of individual phases due to the shortening of the time and opportunities for meaningful and deep learning across a learning sequence.
- According to research, there is the greatest impact on learning when phases are not omitted or their position shifted (e.g., Explain before Explore).
- Phases can be repeated or looped as needed to create time or experiences to learn a concept or develop an ability (e.g., Engage, Explore, Explain, Explore, Explain, Elaborate, Evaluate).
- Activities in a 5E learning sequence should be designed to integrate the Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas.

"The 5E Model of Instruction promotes active learning. Students are involved in more than listening and reading. They learn to ask questions, observe, model, analyze, explain, draw conclusions, argue from evidence, and talk about their own understanding. Students work collaboratively with peers to construct explanations, solve problems, and plan and carry out investigations." – Rodger Bybee

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ENGAGE

The first phase of the 5E Model engages students by having them mentally focus on a phenomenon, object, problem, situation, or event. The activities in the Engage phase are designed to help students make connections between past and present learning experiences, expose prior conceptions, and organize thinking toward the essential questions and learning outcomes of the learning sequence.

The role of the teacher in the Engage phase is to present a situation, identify the instructional task, and set the rules and procedures for the activities. The teacher also structures initial discussions to reveal the range of ideas, experiences, and language that students use which become resources for upcoming lessons.

Student Behaviors

- Asks questions such as, "Why did this happen?" "What do I already know about this?" "What can I find out about this?" "How can this problem be solved?"
- Shows interest in the topic through curiosity and expression of wonderings
- Demonstrates engagement by expressing ideas, sharing observations, and creating initial models
- Expresses current understanding of a concept or idea

Teaching Strategies

- Raises questions or poses problems
- Elicits responses that uncover students' current knowledge
- Helps students make connections to previous work
- Posts learning outcomes and explicitly references them in the lesson
- Invites students to express what they think
- Invites students to raise their own questions

EXPLORE

Once students have engaged in activities, they need time to explore ideas. Explore activities are designed so all students have common, concrete experiences which can be used later when formally introducing and discussing scientific and technological concepts and explanations. Students have time to investigate objects, events, or situations. As a result of their mental and physical involvement in these activities, students question events, observe patterns, identify and test variables, and establish causal relationships.

The teacher's role in the Explore phase is to facilitate learning. They initiate activities and allow time and opportunity for students to investigate objects, materials, and situations. The teacher coaches and guides students as they record and analyze observations or data and begin constructing models or initial explanations.

Student Behaviors

- Tests predictions and hypotheses; Forms new predictions and hypotheses
- Discusses problems with others
- Plans and conducts investigations in which they observe, describe, and record data
- Tries different ways to solve a problem or answer a question
- Creates initial models
- Compares ideas with those of others

Teaching Strategies

- Provides or clarifies questions or problems
- Provides common experiences
- Observes and listens to students as they interact
- Acts as a consultant for students
- Encourages student-to-student interaction
- Asks probing questions to help students make sense of their experiences and redirect them when necessary
- Provides time for students to puzzle through problems

EXPLAIN

The Explain phase consists of two parts. First, the teacher asks students to share their initial models and explanations from experiences in the Engage and Explore phases. Second, the teacher provides resources and information to support student learning and introduces scientific or technological concepts. Students use these resources and information, as well as ideas of other students, to construct or revise their evidence-based models and explanations. In engineering, students design solutions to problems based on established criteria.

Student Behaviors

- Shows models, explanations, answers, or possible solutions, to other students
- Listens critically to and questions explanations offered by others
- Explains using evidence from investigations
- Uses labels, terminology, and formal scientific language
- Compares current thinking with former thinking
- Records ideas and current understanding
- Adjusts ideas, models, and explanations as new evidence or reasoning is presented

Teaching Strategies

- Encourages students to explain concepts and definitions in their own words
- Asks for justification (evidence) and clarification from students
- Formally provides definitions, explanations, and information through mini-lecture, text, internet, or other resources
- Builds on student explanations
- Provides time for students to compare their ideas with others and if desired revise their ideas

ELABORATE

Once students have constructed explanations of a phenomenon or design solutions for a problem, it is important to involve them in further experiences that apply, extend, or elaborate the concepts, processes, or skills they are learning. Some students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaborate activities provide time for students to apply their understanding of concepts and skills. They might apply their understanding to similar phenomena or problems.

Student Behaviors

- Applies new labels, definitions, explanations, and skills in new, but similar, situations
- Uses previous information to ask questions, propose solutions, make decisions, design experiments, or complete a challenge
- Draws reasonable conclusions from evidence
- Critiques the models, explanations, or arguments made by others using evidence and reasoning
- Makes conceptual connections between new and previous experiences
- Communicates understanding to others

Teaching Strategies

- Expects students to use vocabulary, definitions, and explanations provided previously in new contexts
- Encourages students to apply the concepts and skills in new situations
- Provides additional evidence, explanations, or reasoning
- Reinforces students' use of scientific terms and descriptions previously introduced
- Asks questions that help students draw reasonable conclusions from evidence and data

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EVALUATE

It is important that students receive feedback on the quality of their explanations. Informally, this may happen throughout the learning sequence. Formally, the teacher can also administer a summative evaluation at the end of the learning sequence. The Evaluate phase encourages students to assess their understanding and abilities and allows teachers to evaluate individual student progress toward achieving learning goals and outcomes.

Student Behaviors

- Gives feedback to other students
- Evaluates progress or knowledge
- Checks work with a rubric or against established criteria
- Assesses progress by comparing current understanding with prior knowledge
- Asks additional questions that go deeper into a concept or leads to additional learning
- Demonstrates understanding of Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices
- Answers open-ended questions by using observations, evidence, and previously accepted explanations

Teaching Strategies

- Ask open-ended questions such as, "Why do you think…?" "What evidence do you have?" "How would you answer the question?"
- Observes and records notes as students demonstrate individual understanding of concepts learned and performance of skills
- Uses a variety of assessments to gather evidence of student understanding
- Provides opportunities for students to assess their own progress.

1st Grade Science Example for Developing 5E Learning Lesson Sequence

Prior to building a 5E learning sequence, teachers should consider Learning Intentions and Success Criteria, select the phenomenon/problem, and identify the essential question(s) that will drive learning.

Unit Phenomenon/Problem: The sky looks different during different times of the day and when seen from different parts of the world when viewed at the same time.

Investigative Phenomenon: Different things (e.g., the sun, the Moon, stars, black sky, blue sky, clouds) are visible in the sky at different times.

Essential Question(s):

1. Why doesn't the sky always look the same?
    a. Why does the sky look different to people who are in different locations?
        i. **What can we see in the sky at different times?**

5E Phase	Activity	What the Students Do	What the Teacher Does	Concept(s) Learned	Evidence Gathered/Connection to Phenomena
Engage	The teacher leads a conversation about how things in the sky are different during the daytime and nighttime when seen by a boy and his grandma. (15 minutes) The teacher introduces students to their role as sky scientists who will	• Think about ideas they already have about things in the sky. • Make observations of photographs of the sky and share observations and explanations. • Compare daytime and nighttime images. • Discuss what the	• Facilitates discussion of observations and explanations. • Facilitates a discussion about students' prior knowledge and experiences. • Introduces the little boy and his grandma and shows what they see in the sy	• The sky looks different at different times. •	• Formative data of students' previous experience and knowledge. • Student response on "Our Experiences Chart"

	help a boy named Sai and his grandma figure out a problem. (15 minutes)	sky looks like at different times.	when talking on the phone. • Introduces the role of Sky Scientist.		
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					
Explore	Students go outside to record observations of the sky. (20 minutes) Students discuss the sky observations. (first with partners then with the class) (10 minutes)	• Students will record what they safely observe in the sky.	• Model how to make and record observations. • Set a purpose for making observations (What can we see in the sky at different times?) • Circulate to provide support as needed. Encourage students to discuss the observations they recorded with a partner. • Facilitates discussion of sky observations among partners, then the class.	• During the school day, you can see the sun in the sky. • Scientists make observations to answer their questions. • Scientists record their observations so they can remember them later.	• Data records in science notebook. • Student discussion.
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					

Explore	Students compare the sky observations they made during the school day with what the boy and his grandma observed in the sky.(5 min) Students go outside to make and record new observations of the sky during the school day in their Investigation Notebooks.(15 min) The teacher uses the Sky Observations chart to records students' observations of the sky during the school day.(10 min)	• Identify similarities and differences in what students observed compared to what the boy and his grandma saw in the sky. •	• Facilitate comparison discussion. • Set the purpose for making new observations (at a different time). • Circulate to provide support as needed. Encourage students to discuss the observations they recorded with a partner. • The teacher uses a chart to record students' observations of the sky during the school day.	• Daytime is the part of the day when the sky is bright. •	• Formative data from comparison of the sky from different places. • Chart data of new observations from a different time of day.
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					

Explore	The teacher reads aloud the *After Sunset* big book and introduces the strategy of making and checking predictions.(20 min) Students share observations of the sky from *After Sunset*. The teacher introduces daytime and nighttime.(10 min)	• Listen carefully as a book is read. • Make predictions about what may happen. • Reflect on predictions. • Share observations from the reading and predictions made.	• Introduce the book. • Introduce making predictions. • Model making a prediction. • Actively read allowing students to make and check predictions. • Facilitate additional discussion.	• Nighttime is the part of the day when the sky is dark. • Scientists read to answer their questions, especially when something they are figuring out is difficult to observe.	• Accuracy of predictions of differences in the sky.
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					
Explain	Partners sort their Sky Observations data, classifying objects observed during the daytime, the nighttime, and both.(20 min) Students engage in a role-play to demonstrate actions representing what can be seen in the daytime or nighttime sky.(10 min)	• Students learn to organize observation data into a chart. • Develop a kinesthetic model in the form of a role play.	• Teacher circulates as students work to listen to their discussions and make note of where students place their cards. • Lead discussion on model development. • Use the role play kinesthetic model multiple times for daytime and	• Scientists organize their data to answer questions. • We can see the sun in the sky during the daytime and the stars in the sky during the nighttime.	• Student organization of data regarding night and day. • Accuracy of role modeling in night and day settings.

			nighttime.		
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					
Explain	The teacher introduces the idea of patterns.(15 min) Reflecting on *Daytime and Nighttime Patterns* - the teacher introduces the What We Know About Daytime and Nighttime chart.(15 min)	• Observe different real life patterns. • Share prior experiences of patterns they have experienced. • Identify the pattern from the kinesthetic role play model. • Organize data about daytime and nighttime on a chart.	• Sets a purpose for reading. • discusses what a pattern is and asks for examples from the students. • Have students reflect on the pattern in the kinesthetic role play model. • Record data provided by students about daytime and nighttime.	• A pattern is something that we observe to be similar over and over again. • Many events in the world are repeated. • You can see the sun in the sky during the daytime and the stars in the sky during the nighttime	• Identification of authentic patterns. • Organization of daytime and nighttime observation data.
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					

Essential Question(s):

1. Why doesn't the sky always look the same?
   a. Why does the sky look different to people who are in different locations?
      i. What can we see in the sky at different times?
      ii. What does the sky look like to people in different places on Earth right now?

Explore	Students observe webcams from different places on Earth and record their observations.(20 min) Role-Play by demonstrating actions to represent varied practices that scientists use to investigate the sky.(10 min)	• Students make observations of webcams showing the sky from different places to collect and record data about how the sky looks from different places on Earth at the same time. • Students engage in a role-play to reflect on what scientists do to investigate the sky. This role-play provides them with a kinesthetic opportunity to reflect on key scientific practices and vocabulary.	• The teacher introduces a new Investigation Question to frame the work that students will do in this lesson. Students make observations of webcams showing the sky from different places to support their developing understanding that the sky looks different from different places on Earth at the same time. • Facilitate development of role playing movement to reinforce scientific practices and vocabulary.	• Scientists organize data to make sense of what they observe and to answer their questions. • In some places on Earth, it is daytime right now. In other places on Earth, it is nighttime right now.	• Recorded observation data from webcams. • Use of science & engineering practices and vocabulary in role play.

Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					
Evaluate	Use an Interpretation Language Frame that students use to discuss daytime and nighttime based on their observations.(15 min) The class constructs a chart to organize the data from their webcam observations.(15 min)	• Students use the webcam observations they recorded to support their decisions about daytime or nighttime. (This activity provides a formative opportunity to assess students' understanding of what can be seen in the sky during the daytime and the nighttime.) • Students construct a chart or table to organize the data from their webcam observations.	• The teacher introduces an Interpretation Language Frame that students use to discuss daytime and nighttime based on their observations. • Facilitate organization of data to prepare to look for patterns.	• What can be seen in the sky during the daytime and the nighttime.	• Completed Interpretation Language Frame. • Student discussions. • Completed organizational chart/ table
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					

Elaborate	Students discuss the question "What does the sky look like to people in different places on Earth right now?" (15 min)	• Understand why scientists communicate. • Use a Shared Listening routine to discuss the appearance of the sky in different places on Earth at the same time.	• Set a purpose for using the Shared Listening routine. • Model the routine. • Facilitate student discussions. •	• Right now, the sky looks different to people in different places on Earth. • Scientists communicate their ideas about how and why things happen.	• Evidence from student discussions.
Evaluate	Students draw and write about what two friends see in the sky and use that information to determine if the friends live in the same place. (15 min)	• Draw and write about what two friends see in the sky and use that information to determine if the friends live in the same place. • Students talk with their partners and use their drawings to explain their thinking.	• Introduce how to use word rings. • Facilitate students drawing of sky descriptions. • Facilitate student discussions.	• Right now, the sky looks different to people in different places on Earth. • Scientists communicate their ideas about how and why things happen.	• Student drawings and explanations made using the drawings.
Assuming a 30 minute science block of instructional time, the lesson would conclude here for the day.					

Elaborate	Shared Writing about why the sky looks different to a boy than to his grandma when they talk on the phone.(20 min)	• Draw and write about what two friends see in the sky and use that information to determine if the friends live in the same place. • Students talk with their partners and use their drawings to explain their thinking.	• Introduce the Shared Writing routine. • Leads students in Shared Writing about why the sky looks different to a boy than to his grandma when they talk on the phone. • Facilitate class discussion of student responses.	• Right now, the sky looks different to people in different places on Earth.	• Shared writing • Student discussion..
Evaluate	Self-assessment of their learning.(10 min)	• Students answer the question "How did we communicate like scientists today?" • Summarize the ideas learned about what they see in the sky. • Share with their partner one thing they have learned	• Facilitate discussion for communicating like scientists. • Summarize ideas of things learned by students. • Facilitate partner discussion. •	• Scientists communicate their ideas about how and why things happen. • Right now, the sky looks different to people in different places on Earth.	• Student explanation of scientist communication. • Summarized list of things learned.

*Note: Depending on the number of learning events, additional rows for a 5E phase may be added

Evaluating a 5E Learning Sequence

Carefully evaluate a 5E learning sequence to ensure the three dimensions are integrated and related to the phenomenon or problem by answering the following questions:

1. How does the 5E instructional sequence provide students the opportunity to explore, investigate, and explain the phenomenon or identify the design solution to a problem?
2. How does the learning sequence help students demonstrate their understanding of the learning goals and outcomes?
3. How does the 5E learning sequence ask for students to demonstrate the use of the Science and Engineering Practices and Crosscutting Concepts to explain a phenomenon or design solution using Disciplinary Core Ideas?
4. How does the 5E learning sequence ensure access to learning for all students through universal design and best first instruction?

Chapter 1, Lesson 2: Molecules in Motion

Key Concepts

- Heating a liquid increases the speed of the molecules.
- An increase in the speed of the molecules competes with the attraction between molecules and causes molecules to move a little further apart.
- Cooling a liquid decreases the speed of the molecules.
- A decrease in the speed of the molecules allows the attractions between molecules to bring them a little closer together.

Summary

Students add food coloring to hot and cold water to see whether heating or cooling affects the speed of water molecules. Students watch molecular model animations to see the effect of heating and cooling on the molecules of a liquid. Students will also draw their own molecular model.

Objective

Students will be able to explain, on the molecular level, that heating and cooling affect molecular motion.

Evaluation

The activity sheet will serve as the "Evaluate" component of each 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding. A more formal summative assessment is included at the end of each chapter.

Safety

Be sure you and the students wear properly fitting goggles.

Materials for Each Group

- Hot water (about 50 °C) in a clear plastic cup
- Cold water in a clear plastic cup
- Yellow food coloring in a small cup
- Blue food coloring in a small cup
- 4 droppers

ENGAGE

1. Ask students to help you design an experiment to see if the speed of water molecules is different in hot water compared to cold water.

Ask students questions such as the following:

- **Is the speed of water molecules different in hot and cold water? What can we do to find out?**

Students may guess that molecules in hot water move faster. There are several possible experiments that students might suggest to find out if this is true. One of the more obvious ones is to heat water a lot so that it boils. Then you can see the water moving. You could do that but it requires a hot plate, takes a fair amount of time, and may have to be done as a demonstration instead of being an activity the students can do.

Tell students that one possible method is to use hot water and cold water and add food coloring to the water. If the water molecules move faster at one temperature than another, the food coloring should move faster too and make the movement easy to see.

Ask students:

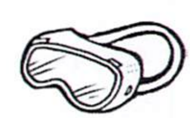
- **Should we use the same amount of hot and cold water in our experiment?** Yes
- **Should we use the same type of cup for the hot and cold water?** Yes
- **Should we use the same number of drops of food coloring in each cup?** Yes
- **Should we put the coloring in at the same time?** Yes

Explain that the different things like the amount of water, type of cup, and number of drops of food coloring are called *variables*. It is important to keep all the variables the same except for the one you are testing. Because we are trying to find out if *temperature* affects the motion of water molecules, we should keep everything else about the experiment the same. Temperature should be the only variable. This way, if we notice something different between the two samples of water, we will know that the difference in temperature is causing it.

Give each student an activity sheet.
Students will record their observations and answer questions about the activity on the activity sheet. The *Explain It with Atoms & Molecules* and *Take It Further* sections of the activity sheet will either be completed as a class, in groups, or individually depending on your instructions. Look at the teacher version of the activity sheet to find the questions and answers.

EXPLORE

2. Do an activity to compare the speed of water molecules in hot and cold water.



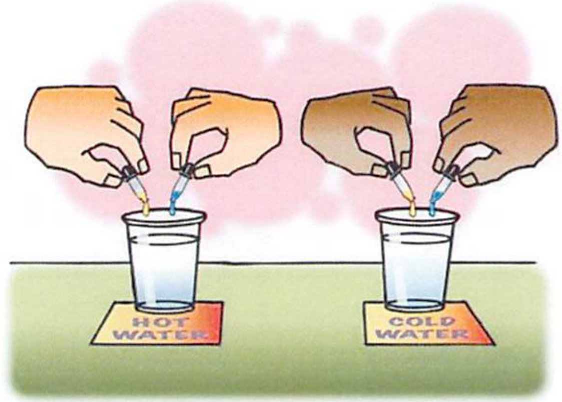
Question to investigate
Is the speed of water molecules different in hot and cold water?

Teacher preparation

This activity works best if there is a big difference between the temperatures of the hot and cold water.

1. Squirt 4–5 drops of blue food coloring into a small cup for each group.
2. Squirt 4–5 drops of yellow food coloring into another small cup for each group.
3. Add ice to about 6 cups of tap water to make it sufficiently cold.
4. Pour about ¾ cup of cold water (no ice) into a cup for each group.
5. Pour about ¾ cup of hot water into a cup for each group.

Materials for each group



- Hot water (about 50 °C) in a clear plastic cup
- Cold water in a clear plastic cup
- Yellow food coloring in a small cup
- Blue food coloring in a small cup
- 4 droppers

Procedure

1. With the help of your partners, use droppers to carefully place 1 drop of yellow and 1 drop of blue food coloring into the hot and cold water at the same time.
2. Allow the colors to mix on their own as you watch them for a couple of minutes.

3. Record and discuss student observations.

Give students time after the activity to record their observations by answering the following questions on their activity sheet. Once they have answered the questions, discuss their observations as a whole group.

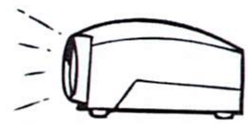
- **Describe what the colors looked like and how they moved and mixed in the cold water.**
- **Describe what the colors looked like and how they moved and mixed in the hot water.**
- **What does the speed of the mixing colors tell you about the speed of the molecules in hot and cold water?**

Expected results

The yellow and blue food coloring will spread faster in hot water than in cold. The colors will combine and turn green in the hot water while the colors will remain separate longer in the cold water. Students should agree that the colors mix faster in the hot water because the molecules of both the water and food coloring move faster in hot water than they do in cold water.

EXPLAIN

4. Show an animation of water molecules at different temperatures.



Show the molecular model animation *Heating and Cooling a Liquid*.

www.middleschoolchemistry.com/multimedia/chapter1/lesson2#heating_and_cooling

Move the slider at the bottom of the window all the way to the right to show that the water molecules are moving faster and are a little farther apart in hot water.

Explain that the little balls represent the particles of a liquid, in this case water molecules. Let students know that for now, they will use circles or spheres to represent atoms and molecules, but eventually they will use a more detailed model. For now, students should focus on the motion of the molecules, how they interact, and their distance from one another.

Ask students:

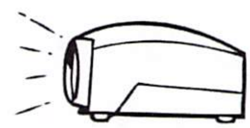
- **Are the molecules moving faster in cold or hot water?**
  Students should realize that the molecules of hot water are moving faster. The molecules of cold water are moving slower.
- **How does this match with your observations with the food coloring?**
  The food coloring in the hot water mixed faster than the coloring in the cold water did.
- **Look closely at the space between the molecules in cold and hot water. Is there more space in between the molecules in hot water or in cold water? Is it a lot of space?**
  Point out to students that molecules of hot water are moving faster and are slightly further apart. The molecules of cold water are moving slower and are a little closer together. If students do not notice a difference, move the slider all the way to the left again and then quickly to the right. Show the animation a few times to give students a chance to notice the differences.

5. Have students answer questions about the animation and draw a model of water molecules on their activity sheet.

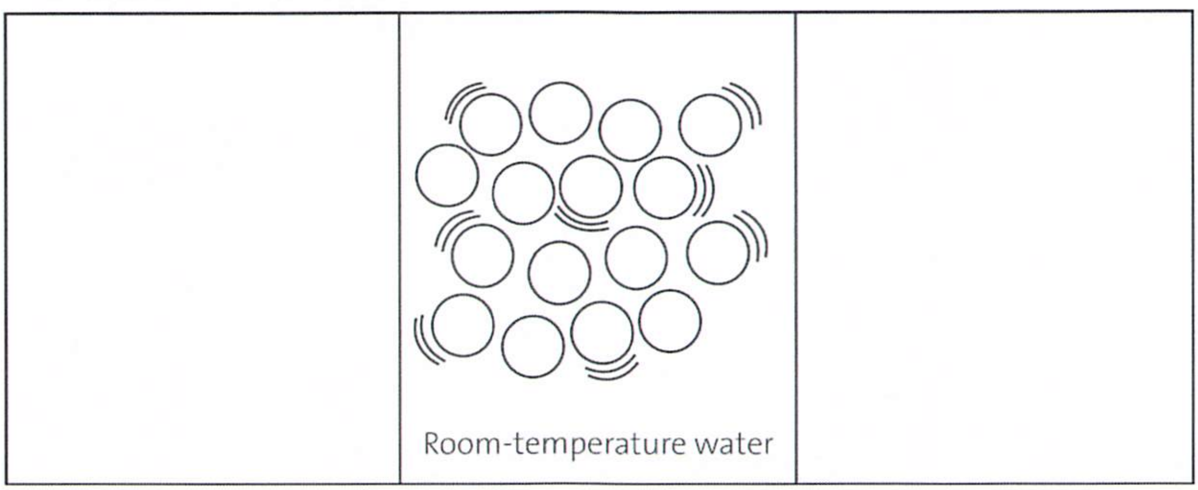
Have students fill in the blank with the word *increases* or *decreases* on their activity sheet as you read each sentence.

- Heating a substance *increases* molecular motion.
- Cooling a substance *decreases* molecular motion.
- As molecular motion increases, the space between molecules *increases.*
- As molecular motion decreases, the space between molecules *decreases.*

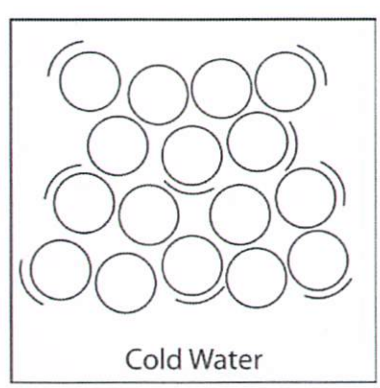
Project the image *Water Molecules at Different Temperatures.*
www.middleschoolchemistry.com/multimiedia/chapter1/lesson2#water_molecules_at_different_temperatures



Have students refer to the drawing of room-temperature water on their activity sheet and discuss how they should represent the molecules in cold and hot water.



Cold water
Ask students:

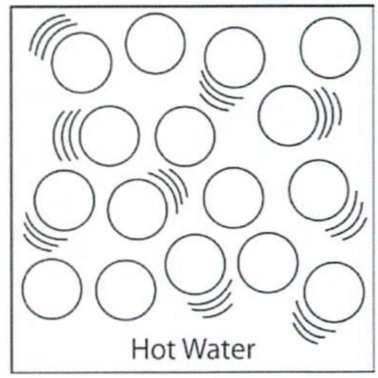


- **Would the water molecules be closer together or further apart?** Students should draw the circles a little closer together than the circles in the room-temperature water. The water molecules are closer together because the slower motion allows the attractions to bring the molecules a little closer together.
- **Would there be more or fewer motion lines?** Students should realize that since the molecules in the cold water are moving slower, they should have fewer motion lines than the molecules in room-temperature water.

Hot water

Ask students:

- **Would the water molecules be closer together or further apart?**
  Students should draw the circles a little further apart than the circles in the room-temperature water. The faster motion competes with the attractions water molecules have for each other and causes the molecules to move a little further apart.
- **Would there be more or fewer motion lines?**
  Students should realize that since the molecules in hot water are moving faster than in cold or room-temperature water, they should draw more motion lines.

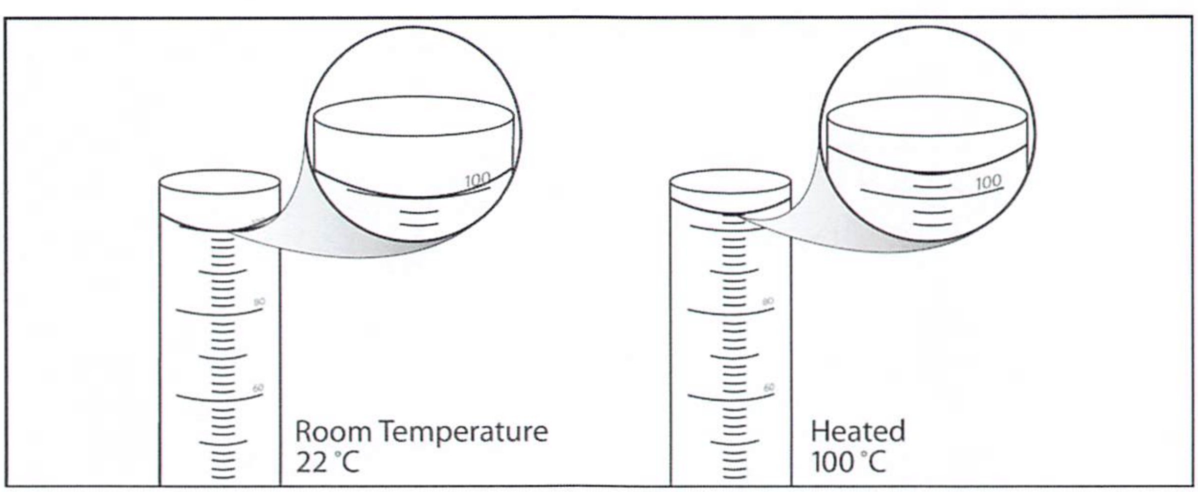


EXTEND

6. Have students explain why hot water takes up more space than room-temperature water.

Have students read and discuss the *Take It Further* question on the activity sheet. After the class discussion, have students write their own response to the following question in the space provided on the activity sheet.

- **Let's say that you measure exactly 100 milliliters of water in a graduated cylinder. You heat the water to 100 °C and notice that the volume increases to 104 milliliters. Using what you know about the attractions between water molecules and the way heating affects molecular motion, explain why the volume of water in the cylinder increases when it is heated.**
  Students should realize that the molecules in hot water move slightly further apart, accounting for the increased volume.



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NEXT: INVASIVE SPECIES 5E >

5E Instructional Model Plan:

Ecosystem Disruption & Recovery

Regents Skills/Content: ecological succession, interdependence of organisms, ecosystems
NGSS Performance Expectation Cluster

Lab Minutes: 0

Time: 5-8 Days

5Es - CONCEPTUAL FLOW

Engage: ***What do students know about the stability of an ecosystem over time?***
The teacher learns what students know and care about related to **ecosystem disturbances** by surfacing and **categorizing** their ideas. Students become invested in the content and in their own learning.

Explore: ***How do ecosystems naturally change over time?***
Students learn about **ecological succession** by exploring case studies on different **types of disturbances and how ecosystems recover** from those events. The teacher's role is to confer with students around their learning, but not offer formal explanations yet.

Explain: ***Developing an understanding of how ecosystems respond to disturbances over time***
Students collaboratively **interpret a complex diagram** on **ecological succession** in order to discuss how **ecosystems respond and return to stability** after different types of disturbances. Students return to the case study text to justify their response.

Elaborate: ***Extending conceptual understanding by applying their thinking to the reintroduction of a predator.***
Students test out their ideas and misconceptions about **ecosystem dynamics and recovery** by applying their thinking to task exploring the reintroduction of wolves, an important **predator,** to Yellowstone. This task connects to prior learning and extends students' thinking.

Evaluate: ***How does this connect to the Hudson River Ecology task?***
Students **use evidence** from **observed patterns** noted while studying **ecosystem disruption and recovery** to revise their Performance task.

Science and Engineering Practices | Crosscutting Concepts | Disciplinary Core Ideas

This 5E Instructional Sequence Demonstrates Partial Alignment to the Following Performance Expectations:

HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

HS-LS2-2.Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-6.Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Aspects of Three-Dimensional Learning in This Plan:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Analyzing and Interpreting Data

- Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable

New Visions for Public Schools

Please Read: We encourage all teachers to **modify** the materials to meet the needs of their students. To create a version of these document that you can edit:

1. Make sure you are signed into a Google account when you are on the resource.
2. Go to the "File" pull down menu in the upper left hand corner and select "Make a Copy." This will give you a version of the document that you own and can modify.

Ecosystem Disruption & Recovery Teacher Notes

ENGAGE Teacher Notes

What do students know about the stability of an ecosystem over time?

The teacher learns what students know and care about related to ecosystem disturbances, in order to make the explore phase more relevant and effective. Students become invested in the content and in their own learning.

Pre-Work	**Student Grouping** None	**Group Learning Routine** ❑ Student directions for Rumors
Materials	**Resources** ❑ Example class-wide chart	

Instructional Sequence

1 Use the group learning routine, **Rumors,** to elicit student ideas on the types of occurrences (both human caused and natural) that can disrupt ecosystems.

Note: this could be modified so that students also indicate one impact this change could have on an ecosystem.

2 Sort student ideas, creating a **chart** for the class

Plan forward based on misconceptions and categorize

EXPLORE Teacher Notes

How do ecosystems naturally change over time?

Students learn about ecological succession by exploring case studies on different types of disturbances and how ecosystems recover from those events. The teacher's role is to confer with students around their learning, but not offer formal explanations yet.

Materials

Handouts
- ❑ Case Study 1 - Surtsey Island
- ❑ Case Study 2 - Mount St Helens
- ❑ Case Study 3 - Yellowstone Fire

Resources
- ❑ Sequence charts

Pre-Work

Student Grouping
- ❑ Lab groups of 3-4 students

Group Learning Routine
- ❑ Idea Carousel student directions

Instructional Sequence

1 Launch students into working on a task to explore ecological succession using case studies. Jigsaw the 3 case studies, with 2-3 students working together on one example. As students read the case study, they will synthesize the most important events, creating a sequence chart. It is important that the sequence charts include no more than 4 boxes -- as student should identify / synthesize the most important events.

- Case Study 1 - Surtsey Island
- Case Study 2 - Mount St Helens

- Case Study 3 - Yellowstone Fire

Note: Case study #2 is longer and more challenging to synthesize than the other two

2 Confer with students as they work in collaborative group.
Suggested conferring questions (these should push students' thinking around establishing relationships, observing patterns, identifying variables, and questioning events):

- Why is the sequence of events important? In other words, can the order of the events change with the same outcome?
- How are biotic factors causing changes in abiotic ones?
- What is a pioneer/climax? Where have you heard those words used in other contexts? Is their meaning the same or different than in this process?

3 Use, the group learning routine, **Idea Carousel,** to help students articulate their ideas so far. Prompt students to draw their sequence charts from their case study on chart paper, with 1-2 sentences of explanation provided between each event. For the idea carousel, organize groups of students so that a larger 'group' includes all three case studies. As students move to a new poster (and new case study) they should annotate the poster demonstrating commonalities and differences between their own example and the one presented on the poster. After students have had the opportunity to view all three cases, facilitate a share out of their findings.

4 Plan forward based on the various understandings that students or student groups have articulated. It is appropriate to go on to the next phase once students have had a chance to make sense of the commonalities and difference between succession in different ecosystems.

EXPLAIN Teacher Notes

Developing an understanding of how ecosystems respond to disturbances over time

Students collaboratively interpret a complex diagram on ecological succession in order to identify the type of succession discussed in each case study from the Explore phase. Students return to the case study text to justify their response.

Materials

Handouts

- ❑ KWLS Chart
- ❑ Primary succession diagram
- ❑ Secondary succession diagram

Pre-Work

Group Learning Routine

- ❑ Student directions for Think-Talk-Open Exchange

Instructional Sequence

1 ***Note: Steps 1-3 can be done in any order that makes sense.***

Put students into groups (homogeneous or heterogeneous) to interpret two diagrams on ecological succession using a KWLS chart.
Guiding prompt:
How do ecosystems respond to disturbances?

Students should refer to their experiences with the case studies in the Explore phase in the 'K' and 'W' portions of the graphic organizer, before they read the diagrams. After collaboratively interpreting the diagram, they should fill in the 'L' and 'S' portions.

- Primary succession diagram
- Secondary succession diagram

2 Lead direct instruction around formal terms for the concepts students have been exploring.

- dynamic equilibrium
- primary vs secondary succession
- pioneer & climax species / communities
- review the importance of biodiversity in ecosystem recovery after disturbances

3 Use the group learning routine, **Talk-Think-Open Exchange**, to help students articulate their ideas so far

How do ecosystems respond to disturbances?

Note: the idea of human caused disturbance will be discussed again in unit 8, Human Impact

4 Confer with students as they return to their original case study. Prompt students to identify each example as either primary or secondary succession, providing a justification for their response.

Note: Although it is important for students to understand the difference between primary and secondary succession, the emphasis of this writing task should be placed on students returning to the text and justifying their response based on evidence.

5 Assess students' work using.
peer assessment OR
teacher assessment

ELABORATE Teacher Notes

Extending conceptual understanding by applying their thinking to consider the reintroduction of predators.

Students test out their ideas and misconceptions about ecosystem dynamics and recovery by applying their thinking to a task exploring the reintroduction of wolves to Yellowstone. This task connects to prior learning and extends students' thinking.

Materials	**Resources** ❑ Predicting & Confirming strategy ❑ Video- *How wolves change rivers*	**Handouts** ❑ Simple Yellowstone food chain
Pre-Work	**Student Grouping** ❑ Small groups of 3-4	

Instructional Sequence

1 Use a **predicting and confirming activity** to have students apply their understanding of ecosystems to the following prompt:

How can reintroducing wolves to Yellowstone National Park change the flow of a river?!

2 Students first make predictions (written or in a sequence chart) using their background knowledge on ecosystems and the interdependence of biotic and abiotic variables.

3 Then, provide the **simple food web** for wolves in Yellowstone to provide more context and revised predictions.

4 Finally, students watch the **video - How wolves change rivers**
Students may revise, confirm, or reject their initial predictions.

EVALUATE Teacher Notes

How have our ideas on ecosystem disruption and recovery changed?

Students return to their performance task response. Students review their original ideas, and confirm-modify- or add on to their original responses based the learning from the 5E sequence.

Materials	Handouts	Supplies	Lab Materials
	❑ Hudson River Ecology PT student packet	None for this phase	None for this phase

Pre-Work

Classroom Set-Up
- ❑ Driving Question Bank poster from the start of the unit should be available

New Visions for Public Schools

Instructional Sequence

1 Prompt students to return to their original anticipation guide. Students can work individually or in pairs to revise their responses.

Additional Resources

Resource	Stage for which it may be useful
• National Geographic resources on coral reef succession	All phases
• Back yard succession activity	Explore/Explain

Sample Template for Developing 5E Learning Lesson

Prior to building a 5E learning sequence, teachers should consider Learning Intentions and Success Criteria, select the phenomenon/problem, and identify the essential question(s) that will drive learning.

Phenomenon/Problem:					
Essential Question(s):					
5E Phase	**Activity**	**What the Students Do**	**What the Teacher Does**	**Concept(s) Learned**	**Evidence Gathered / Connection to Phenomena**
Engage					
Explore					
Explain					
Elaborate					
Evaluate					

*Note: Depending on the number of learning events, additional rows for a 5E phase may be added

Evaluating a 5E Learning Sequence

Carefully evaluate a 5E learning sequence to ensure the three dimensions are integrated and related to the phenomenon or problem by answering the following questions:

1. How does the 5E instructional sequence provide students the opportunity to explore, investigate, and explain the phenomenon or identify the design solution to a problem?
2. How does the learning sequence help students demonstrate their understanding of the learning goals and outcomes?
3. How does the 5E learning sequence ask for students to demonstrate the use of the Science and Engineering Practices and Crosscutting Concepts to explain a phenomenon or design solution using Disciplinary Core Ideas?
4. How does the 5E learning sequence ensure access to learning for all students through universal design and best first instruction?