Sample Lesson
Big Ideas
Unit Summary

Lesson 5: Changing Motion: Starting Things Moving and Changing Direction
Teacher Background Information
My Science Notebook
Mi Libreta de Apuntes de Ciencias
Assessments
Teacher Masters
Visual Pack
ExploraGear
I Wonder Circle

More about Science Companion
Module Components
Full Curriculum List
Science Companion Unique Features.
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Science Companion
The Teacher Lesson Manual engages and guides teachers to implement hands-on science lessons with their students. Lesson by lesson, students develop strong process skills and in-depth understanding of specific concepts.

The book brings teachers up to speed for the science content through “Teacher Background Information” and in-context lesson notes. Teachers can feel comfortable with leading the class—whether they have a long history of teaching science or not.

Each Teacher Lesson Manual focuses on a set of Big Ideas for a science topic. Each lesson focuses on a Big Idea. Groups of lessons (called clusters) develop a Big Idea through a series of different experiences and discussions.

Lessons Follow a Consistent Sequence

- Engage – In this section of a lesson, the teacher introduces the topic. The goal is to briefly generate interest, activate prior knowledge, or link the day’s activities to what has come before.

- Explore – This is often (but not always) a hands-on exploration conducted in small groups. Students record their work in their Science Notebooks. Collaboration with peers is encouraged. Key materials are provided in the ExploraGear kit.

- Reflect and Discuss – In this important section, the teacher and students discuss what they observed, share ideas and data, and reflect on the day’s activities. This portion of the lesson brings the class back to the Big Idea.

You’ll find that while the lesson format is very consistent, students explore science content and the process of “doing science” in a large variety of ways.

You’ll also find that students LOVE the mix of active, hands-on, minds-on science.
Lessons at a Glance

Science Content: Big Ideas

The Motion Unit concentrates on the following “big ideas.” These concepts, along with the scientific Habits of Mind discussed on page 6, should be reinforced throughout the unit. The lessons in which each big idea is introduced or is a major focus are indicated in parentheses.

Lessons

• Motion is movement. You can describe an object’s motion by how long it takes, how far the object travels, how fast the object goes, and what path it follows. (Lessons 1-4 and 13)

• The way to change how something moves is to give it a push or a pull. (Lessons 5-13)

• Collisions cause pushes that may change the motion of all the colliding objects. (Lessons 7 and 8)

• Friction is a force (a pull) that slows down moving objects. (Lessons 9 and 10)

• On Earth, gravity is a force that pulls everything down all the time. (Lesson 11 and 12)

Skill Building Activities

• Observation is a powerful tool for learning about something. Detailed and accurate descriptions of your observations help you communicate them to others. (Observing and Describing)

• Measuring how much something weighs is a basic scientific skill. (Using Balances and Scales)
# Unit Summary

## Cluster 1: Describing Motion (Lessons 1-4)

### Overview
Children heighten their awareness of motion in their surroundings by going on a Motion Search. They practice describing an object’s motion with words and drawings and learn to incorporate aspects of distance, time, speed, change of speed, and path into their descriptions. Children use their bodies and balls to experience different paths of motion; they investigate speed by comparing how far they can move in a fixed amount of time using different motions.

### Science Content
- Motion is movement.
- Motion always follows a path.
- Motion has speed, which is related to how far something goes (distance) and how long it takes (time).
- You can describe an object’s motion by how long it takes, how far the object travels, how fast the object moves, and what path it follows.

### Science Center
- Explore various objects to find and describe interesting ways to make them move.
- Use drawings to document observations and discoveries about motion.
- Make and fly paper airplanes to explore and describe motion.
- Look for pictures that depict motion in interesting ways.
- Use measuring devices and stopwatches to measure distance and time.
- Set up “races” between objects and document the results.
- Investigate an exercise pedometer or bicycle speedometer.

### Family Links
- Go on a motion search at home to look for and document examples of motion.
- Bring in objects that move in interesting ways, such as yo-yos, Slinkys™, springs, and Frisbees™.

### Further Science Explorations
- Examine and try to create flipbooks.
- Learn about cartoon animation.
- Collect, record, and analyze data about how long it takes to complete a frequently traveled route in the school.
- Conduct additional speed trials for different motions.

### Cross-Curricular Extensions
**Language Arts:** Categorize motion words as verbs or adverbs. Play a motion verb and adverb game. Make a class book about the motion search. Write a story to accompany a motion mural.

**Mathematics:** Practice using mathematical language to describe distance, time, speed, and path of motion. Use meter sticks and stopwatches to measure distance and time for races and speed trials. Collect, display, and analyze speed data.

**Art:** Collaborate to create a motion mural. Make marble art to depict different paths. Incorporate these paths into pictorial representations.
### Cluster 2: Changing Motion (Lessons 5-8 and 13)

Children explore how forces (pushes and pulls) cause starts, stops, and changes in speed or direction of motion. As they think of ways to get a toy car to start moving and a rolling ball to change direction, children discover that successful tries involve either a push or a pull. They explore the effect of big and little forces on toy cars, and they perform controlled collisions with marbles along a track to see the results.

- **Overview**
  - The way to change how something moves is to give it a push or a pull.
  - Starting, speeding up, slowing down, and changing direction all represent changes in motion.
  - There are many sources of pushes and pulls.
  - There are different sizes of pushes and pulls. Bigger pushes and pulls (forces) cause bigger changes in motion than smaller forces do.
  - Collisions cause pushes that may change the motion of all the colliding objects.

- **Science Content**
  - Use penny launchers on different surfaces.
  - Play sliding games with coins or paper “footballs.”
  - Conduct additional shoe slide trials.
  - Use balance scales to explore the relationship between weight and gravity.
  - Repeat and vary marble drop experiments.
  - Use marbles and inclined tracks to explore gravity.

- **Science Center**
  - Measure hand and arm strength using a bathroom or spring scale.
  - Design and conduct collision experiments using ramps, tracks, and marbles.
  - Play with steel “collision balls.”
  - Set up marble “races.”

- **Family Links**
  - Measure the hand strength of family members using a bathroom scale.
  - Experience forces through different muscles and movements.
  - Discuss which muscles are used during different activities.
  - Play “Tug of War.”
  - Investigate head-on collisions and chain reactions using marbles and tracks.
  - Experience and discuss the forces involved in T-Ball, kickball, bowling, and Four-Square.
  - Analyze the forces involved in one of the motions observed on the Motion Search.

- **Language Arts**: Write about the forces involved in favorite activities. Write about favorite “Motion Madness” activity. Narrate a sports event.
- **Mathematics**: Collect, record, and analyze data about collision experiments.
- **Art**: Create and analyze marble art to explore the effects of forces on the path of motion.

### Cluster 3: Friction and Gravity (Lessons 9-12)

Children learn about two ubiquitous, but often overlooked or misunderstood, forces that affect motion: friction and gravity. They explore friction by comparing the motion of pennies sliding across different surfaces and the traction of different shoes on smooth surfaces. They learn about gravity by investigating its effects on their bodies and on falling objects. They also imagine and draw what the classroom would look like without the force of gravity.

- **Overview**
  - Friction is a force (a pull) that slows down moving objects.
  - If there is a lot of friction between surfaces, a moving object slows down quickly. If there is not much friction between surfaces, a moving object slows down more gradually.
  - On Earth, gravity is a force that pulls everything down all the time.

- **Science Content**
  - Experiment with overcoming friction using blocks, shoes, rubber bands, various surfaces, and other props.
  - Roll balls on different surfaces to compare how far they travel before stopping.
  - Resurface the indoor “shoe slide” with different materials and compare the results.
  - Observe a helium-filled balloon and discuss why it doesn’t fall to the ground.
  - Analyze the pushes and pulls involved in jumping.
  - Explore the effects of air resistance by dropping various items and comparing the results.
  - Devise parachutes to slow the descent of falling marbles and test how well they work.
  - Research gravity and outer space.

- **Science Center**
  - Use penny launchers on different surfaces.
  - Play sliding games with coins or paper “footballs.”
  - Conduct additional shoe slide trials.
  - Use balance scales to explore the relationship between weight and gravity.
  - Repeat and vary marble drop experiments.
  - Use marbles and inclined tracks to explore gravity.

- **Family Links**
  - Measure the hand strength of family members using a bathroom scale.
  - Experience forces through different muscles and movements.
  - Discuss which muscles are used during different activities.
  - Play “Tug of War.”
  - Investigate head-on collisions and chain reactions using marbles and tracks.
  - Experience and discuss the forces involved in T-Ball, kickball, bowling, and Four-Square.
  - Analyze the forces involved in one of the motions observed on the Motion Search.

- **Further Science Explorations**
  - Experiment with overcoming friction using blocks, shoes, rubber bands, various surfaces, and other props.
  - Roll balls on different surfaces to compare how far they travel before stopping.
  - Resurface the indoor “shoe slide” with different materials and compare the results.
  - Observe a helium-filled balloon and discuss why it doesn’t fall to the ground.
  - Analyze the pushes and pulls involved in jumping.
  - Explore the effects of air resistance by dropping various items and comparing the results.
  - Devise parachutes to slow the descent of falling marbles and test how well they work.
  - Research gravity and outer space.

- **Language Arts**: Write about the outdoor slide climb.
- **Mathematics**: Collect the data from the penny launching experiments, find a way to depict the results in a graph, and analyze the data.
- **Art**: Make shoe sole prints with flour and black paper. Predict whether or not a shoe would be a good slider, based on its sole print.
Changing Motion: Starting Things Moving and Changing Direction

A QUICK LOOK

Overview
Children begin an extended study of how forces (pushes and pulls) change an object’s motion. They use toy cars and other props to discover that pushes and pulls are needed to get a still object to start moving. They also learn that pushes and pulls are required to change the direction of an object’s motion, and they contemplate other changes in motion, such as slowing down and speeding up.

Key Note
- Consider teaching this lesson in two sessions. It would work well to teach the introductory discussion and exploration in one session and conduct the sharing and synthesizing discussion during a second session.
- Locate or prepare a flat, smooth surface to roll the toy cars on. If you have a smooth floor in your classroom, you can use that. If your classroom floor is carpeted, experiment with the cars to see how well they move when pushed or pulled on it. If they don’t move well, try putting sheets of poster board over the carpet, or do the activities in another area (such as the gymnasium, hallway, or playground) or on a different surface (tables or desks).
- For more information about the science content in this lesson, see the “Forces” section of the Teacher Background Information.
Standards and Benchmarks

As children plan, try, and observe different ways of making their toy cars start moving, they develop their understanding of all aspects of Science as Inquiry Standard A (Abilities to do scientific inquiry), especially the following:

- “Plan and conduct a simple investigation.”
- “Employ simple equipment and tools to gather data and extend the senses.”

They also begin to explore Physical Science Standard B (Position and motion of objects) and The Physical Setting Benchmark 4F (Motion): “The way to change how something moves is to give it a push or a pull.”

Lesson Goals

1. Use experimentation to identify many different ways to start things moving.
2. Discover that a force (a push or a pull) is always involved when something starts to move.
3. Learn that forces are involved in other changes in motion, such as changing direction, too.

Assessment Options

This is the first of a series of lessons on the role of forces (pushes and pulls) in changing motion. Today you may want to assess your class's early thinking about this concept using Rubric 2. Plan to revisit this assessment to see how children's understanding of force develops during subsequent lessons.

The lessons in this unit feature a variety of interesting experiments, so children will have many opportunities to develop their approach to conducting experiments as the unit progresses. Use the Conducting Experiments checklist to check their current skills and understanding.
Materials

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ExploraGear</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marbles</td>
<td>Several</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Straws, plastic</strong></td>
<td>1 per child</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>String</strong></td>
<td>Several pieces</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Toy cars</strong></td>
<td>1 per pair</td>
<td>To experiment with.</td>
</tr>
<tr>
<td><strong>Classroom Supplies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balls</td>
<td>2</td>
<td>To demonstrate changes in direction.</td>
</tr>
<tr>
<td><strong>Cardboard tubes</strong></td>
<td>Several</td>
<td>To try moving toy cars. Toilet paper or paper towel tubes work well.</td>
</tr>
<tr>
<td><strong>Chart paper</strong></td>
<td>1 sheet</td>
<td>To record ideas and observations.</td>
</tr>
<tr>
<td><strong>Rubber bands</strong></td>
<td>Several</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Rulers</strong></td>
<td>Several</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Stiff paper or cardboard</strong></td>
<td>Several strips</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Tape</strong></td>
<td>1 roll</td>
<td>To try moving toy cars.</td>
</tr>
<tr>
<td><strong>Curriculum Items</strong></td>
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</tr>
<tr>
<td><em>Motion Science Notebook, pages 6-7</em></td>
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<tr>
<td>Rubric 2: Pushes and Pulls (Forces) (optional)</td>
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<td></td>
</tr>
<tr>
<td>Checklist: Conducting Experiments (optional)</td>
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</tr>
</tbody>
</table>

**NOTES**

**Preparation**

- Gather materials children can use to try to get their toy cars to roll, including rulers, straws, string, tape, rubber bands, cardboard tubes, marbles, and strips of cardstock or poster board. Put these materials out in the classroom right before the lesson.
- Find two balls to use during the sharing and synthesizing discussion.
- Make a large chart, titled “What makes the cars start moving?” with columns labeled “Try” and “What Happened?”

**Vocabulary**

force ......................... A push or a pull.
Teaching the Lesson

Engage

Introductory Discussion

1. Place a toy car on a smooth surface where all the children can see it. Wait a few seconds and then look exasperated. Tell the class you are waiting for the car to start moving.

2. Wait a few more seconds and then order the car to start moving. Beg the car to start moving. Threaten the car. Bribe it with a piece of candy. Wave a wand over it and mutter incantations.

Teacher Note: There is a subtle distinction between “making the car start to move” and “making the car move.” When you include the word “start,” you emphasize the important idea that force is associated with changes in motion. Try to use the phrases “start to move” and “start moving” consistently throughout this lesson.

3. Ask the class how to make the toy car start to move. (The children will probably suggest that you push it.) Tell them to be more specific and to indicate what they would use to push it. (The most likely answer is their hands.) Have a child come forward and demonstrate how they’d push the car.

4. Have the children think of more ways to make the car start to move. Record their ideas on the chart under “Try.” Encourage them to be specific and detailed, so that each entry on the chart is different. If they say something vague like “push it,” have them explain what they would use to push the car and how they would do it.

5. Choose one of the suggested ideas and try it.

6. Ask the children what they observed. Again, tell them to elaborate. Refer back to the concepts and language introduced in the previous lessons. How did the car move? Did it move in a straight line or follow a different path? Did it change its speed? Did it go fast? How far did it go? Record their observations on the chart under “What Happened?”

7. Try a few more proposed methods until you see that the children are providing detailed descriptions under the “Try” and “What Happened?” columns.
Explore

Making Cars Start to Move

**MANAGEMENT NOTE:** To ensure that children are able to focus on the guidelines and goals of the experiment, you may want to give them a chance to play with the toy cars a bit before launching into the directions.

1. Divide the children into pairs, then direct the pairs to find many different ways to make the toy car start moving.

2. Go over science notebook pages 6 and 7. Explain that the children should use a picture and words to describe their favorite method of getting the car to start moving. They will use their entries when they report to the class.

3. Have one child from each pair get a toy car. Have the other child get the first item they want to use to try to push and pull the car. Tell them that these materials are there to give them ideas, but they are free to use other things around the room too. Encourage the children to be creative.

**SAFETY NOTE:** To minimize germ transmission, do not allow children to share straws. Instead, give each child their own straw to try as they see fit.

**MANAGEMENT NOTE:** Remind the children to share the items on the table and to put items back as soon as they are finished with them so others can have a turn. Discuss any other problems you anticipate, such as children being too rough, losing materials, or tripping on them. Have the children decide on a few rules that will keep everyone safe and able to learn.

4. Allow the class time to experiment with making the toy cars move. Circulate and talk with children about what they are trying, observing, and discovering. If any pairs are having difficulty, you may want to draw their attention to strategies you notice other children trying.
Reflect and Discuss

Sharing and Synthesizing

1. Bring the cars and other props to the meeting and have each pair demonstrate their favorite method for getting their car to start moving. As they share, record children’s descriptions of their experiments in the “Try” column of the chart and their observations in the “What Happened?” column.

Teacher Note: If children mention other things they’d like to try the next time they use these materials, add these ideas to the “Try” column as a way to remember them for later.

2. Ask whether any of the cars started to move by themselves. (No) Emphasize that in every case, the children needed to do something to make the cars start moving. (Some may have attached string or rubber bands to the car and used them to pull it, while others may have pushed it with a stick, pencil, or stiff piece of paper. Some may have used gravity, such as rolling the car down a ramp or dropping it. Still others might have had a collision start the car moving by sending another object to push it. If children blew through the straw to start the car moving, they pushed it with air.)

3. Introduce the term force. Explain that a force is simply a push or a pull, and that forces are needed to start something in motion or to change an object’s motion. Forces can be made by muscles and many other things, such as some of the ones they tried in the lesson. If you sense that the word “force” is too confusing or too abstract for some children, stick to the more concrete words “push” and “pull.”

4. Have the class look at the list of ways to make the car start moving classify each method as either a push or a pull. Talk about the following questions:
   - Did all the ways involve some push or pull? (Yes) (See the note below on less obvious examples of pushes or pulls.)
   - Can they think of any ways to get the cars moving that do not involve using a push or pull (a force)? (No, force is necessary to start things moving.)

Teacher Notes: Children may suggest that dropping the car or rolling it down a ramp is a way to get the car to start moving without using a push or a pull. Mention that the “pull of gravity” moved the car and let them know they will learn more about gravity in future lessons.

If none, or very few, of the pairs pulled the car, you may want to talk a bit more about pulling. Have the class think of ways to pull the toy car and try a few of their suggestions. You can also share other examples of pulling to get something to start moving, such as pulling a wagon, pulling a yo-yo up by its string, or a tow truck pulling a car.
5. Use a ball to demonstrate that pushes or pulls (forces) are also necessary to change an object’s direction.
   a. Roll a ball along a straight path and ask children to describe its motion. Be sure they describe its path: a straight line.
   b. Ask children how you might get the ball to turn or change direction and try some of their ideas. If no one suggests them, try the following methods: rolling the ball so it bounces off a wall; hitting it with a ruler; and rolling a second ball into it.
   c. Ask children if they can think of any ways to change the ball’s direction that do not involve a push or a pull.
   d. Confirm that, just as pushes and pulls are required to start an object moving, they are also required to change the direction an object is moving in. Have children think back to Lesson 3, when they moved along different paths. Help them realize that they used forces from their muscles to change their direction as they moved.
   e. Explain that a push or a pull is required to change any aspect of an object’s motion. Ask children to think about what other aspects of motion can be changed by pushes or pulls. (Objects can speed up, slow down, and stop, in addition to starting and changing direction.)

**Teacher Note:** Children will have additional experiences with the role of forces in changing various aspects of motion in later lessons, but take some time now to establish an understanding of the basic concept that forces are involved in all changes in an object’s motion.

**Maintenance**

Keep the “What makes the cars start moving?” chart for the next lesson.
Ongoing Learning

Science Center

- Put the cars and props in the Science Center and encourage children to continue to try different ways of making the cars start moving. Post the “What makes the cars start moving?” chart and help children record their results on it. Also encourage children to look for and document ways to change other aspects of the car’s motion, such as direction or speed.

- Put out small balls and encourage children to put them in motion and then try different ways to change their direction.

Materials: Cars, props to make cars move, “What makes the cars start moving?” chart, balls
Extending the Lesson

Further Science Explorations

*Experiencing Forces Through Our Muscles*

1. Direct the children to put their hands together and place the palms towards each other.
   a. Tell them to push hard with each palm. What do they feel? *(Each palm feels the other one pushing on it.)*
   b. Have the children push harder with their right hand. What happens? *(The left hand moves back as the right hand pushes it.)*
   c. Have them push harder with their left hand. What happens? *(The right hand moves back as the left hand pushes it.)*

2. Have the children link their fingers together and pull.
   a. What do they feel? *(The fingers of each hand feel the fingers of the other hand pulling on them.)*
   b. Have them pull harder with their right hand. What happens? *(The left hand moves forward as the right hand pulls it.)*
   c. Have them pull harder with their left hand. What happens? *(The right hand moves forward as the left hand pulls it.)*

![Image of a child performing an experiment]

![Image of another child performing an experiment]
3. Direct the children to stand up and place their hands on top of their chairs.
   a. Have the children stand in one place and use their arms to push their chairs away from themselves.
   b. Have them pull the chairs back to their original positions.
   c. Ask the children how they were able to move the chairs. *(By using their arm muscles)*

4. Direct the children to sit on the floor behind their chairs with their knees bent and one foot placed on each rear chair leg.
   a. Have the children stay seated on the floor and use their legs to slowly push their chairs away from themselves.
   b. Now have them use their legs to pull the chairs back to their original positions.
   c. Ask the children how they were able to move the chairs back to their original positions. *(By hooking their feet around the chair leg and using their leg muscles to pull)*

5. Direct the children to walk or run in a circle. Have them try to feel the muscles in their outside leg push to make them change direction.

**Thinking About Muscles, Forces, and Movement**

Solicit ideas about some of the many ways the children use their muscles in their daily lives to create forces that cause things (including themselves) to start to move, move faster, or change direction. Also encourage them to think about whether these changes in movements are created by a push, a pull, or a combination of both. Although there are often many muscles involved in creating movement, for this discussion simply concentrate on arms and legs. Use some of the following examples to stimulate thinking about the children’s use of forces to start movement:

- Bike riding (push with the legs, push and pull with the arms for steering)
- Skating and skateboarding (push with the legs, especially when starting)
- Running, walking, skipping, and jumping (push with the legs, especially when starting or stopping suddenly or turning)
- Tree climbing (pull with the arms, push with the legs)
- Swimming (push and pull with the arms, push with the legs)
Notes

- Basketball (push with the arms to shoot, push with the legs to run)
- Crossing monkey bars (pull with the arms)
- Jumping rope (push with the legs, push and pull with the arms)
- Kicking a soccer ball (push with the legs)
- Throwing a baseball or football (push with the arms)
- Hitting a tennis ball or baseball (push with the arms)

Language Arts Extension

**Writing About Forces**

Have the children write about some of the pushes and pulls they use during their favorite activities, such as doing sports, playing an instrument, or using playground equipment.

Art Extension

**More Marble Art**

If children did the Marble Art extension in Lesson 3, have them think about the forces that created the different paths they represented. You might put out the materials again and encourage further exploration.

Planning Ahead

**For Lesson 6**

Consider using part or all of the *Further Science Exploration “Experiencing Forces Through Our Muscles,”* above, as an introduction to the next lesson.
Teacher Background Information

Introduction

By the time children are in school, they already know a lot about motion. They seem to be in constant motion, and to constantly change their path of motion. They start and stop, speed up and slow down, move from place to place, jiggle and bounce, and, occasionally, sit perfectly still. In this unit, children get to examine motion closely by observing how their bodies move and by inventing ways to make other things move. They learn some things about motion—such as that a marble and a bowling ball fall at the same rate—that even surprise most adults. They experiment with many materials and activities and learn to repeat their experiments many times to verify their findings.

The purpose of this unit is to provide children with a rich exploration of motion. The lessons direct each child’s whole person, including his or her intuitive knowledge and physical body, into a sense of how motion works. This unit also develops the concept of force (a push or a pull), and explores the role that forces play in changing motion—starting, speeding up, slowing down, stopping, and changing direction. This exploration of motion is an excellent introduction to Newton’s laws of motion and other related topics that the children will encounter in later grades.

The Motion Unit was designed to address the standards on motion for this age group from both the National Research Council’s National Science Education Standards and Project 2061’s Benchmarks for Science Literacy. Many of the activities in the unit relate directly to these standards.

The relevant standards from the National Science Education Standards include:

• An object’s motion can be described by tracing and measuring its position over time.
• The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.
The relevant benchmarks from the *Benchmarks for Scientific Literacy* include:

- Things move in many different ways, including straight, zigzag, round and round, back and forth, and fast and slow.
- The way to change how something is moving is to give it a push or a pull.

Several basic concepts, such as those used to describe motion and those that help children understand forces (pushes and pulls) and their effects on a moving object, recur and are revisited throughout the unit. This structure allows and invites learners to make connections and relationships among the concepts as they explore them over the course of the unit. The goal is to give children multiple and varied, but connected, experiences to help them make sense of the fundamental concepts of motion and how they relate to the world around them.

### What is Motion?

Motion is the movement of objects from one location to another. Whenever anything moves from one location to another, motion is involved. Even when something moves in a circle or a cycle and comes back to where it started, there is motion because the object moves to intermediate points before returning to its starting position.

Motion always occurs along a continuous path. Continuous means that there are no gaps. Moving objects don’t jump from one place to another without traveling through all of the intermediate points. Teleportation may work in a Star Trek episode, but it doesn’t happen in the real world.

Motion always takes time. No matter how fast an object moves, it takes some time to travel from one location to another. Instantaneous travel is a popular theme in the realm of science fiction but, unfortunately, it is physically impossible.
Describing Motion

Swift, bumpy, languid, jerky, sluggish, rapid, smooth, and slow—these are just a few of the many adjectives that can describe motion. Describing motion can be complex. However, some pieces of information are commonly used. For example, imagine describing a car trip. Each sentence about the car trip describes an aspect of the car’s motion that lends rich and complex detail to the description, for example:

- I took a trip from Northfield to Milltown. (Motions have a starting point and an ending point.)
- I traveled west. (Motions have direction.)
- I traveled through Black Pond and Summit. (Motions follow a path.)
- Between Northfield and Black Pond the road was flat and straight, but between Summit and Milltown the road wound its way down the mountainside. (The path of motion can be straight or curved.)
- I traveled 261 kilometers. (Motions cover a distance.)
- The trip took 3 hours. (Motions have a duration.)
- My average speed was 87 kilometers per hour. (Motions have an average speed.)
- I slowed down while driving through the town of Black Pond, but sped up when I got on the highway outside of town. (Motions have an instantaneous speed that may be different from the average speed.)

The Benchmarks for Science Literacy identify several obstacles children often face in relating their personal view of how objects move to the formal ideas taught in school. One obstacle identifies how children usually describe motion.

“Limitations in describing motion may keep students from learning about the effect of force. Students of all ages tend to think in terms of motion or no motion. So the first task may be to help students divide the category of motion into steady motion, speeding up, and slowing down.”

Accordingly, the Motion Unit begins with a series of activities designed to sharpen a child’s skill at observing and describing motion. For example, Lesson 1 helps children compile and use a broad range of adjectives and adverbs to describe motion. Lesson 2 provides children with a repertoire of nonverbal techniques for describing motion.
Forces (Pushes and Pulls)

Everything—anything—that pushes, pulls, squeezes, stretches, or twists is a **force**. Forces are responsible for all changes in the motion of objects. Whenever an object speeds up, slows down, or changes direction, a force must have been involved. (However, no force is needed to produce a constant motion—a motion that proceeds at a constant speed and in a constant direction. This concept is discussed more thoroughly in the section on Newton’s first law of motion.)

There are a bewildering variety of forces in our daily world. Things are pulled down by gravity, pushed ahead by bulldozers, lifted up by rockets, knocked down by wind, swept aside by snowplows, attracted by magnets, sucked up by vacuum cleaners, propelled forward by engines, and slowed down by brakes.

In Lesson 5, the children try to think of as many ways as they can to start a toy car moving and to change a rolling ball’s direction. The variety of methods the children invent illustrates the many types of forces. Yet, every method the children think of involves either a push or a pull.

The forces that children are most familiar with are the forces their own muscles exert. Consequently, the introduction to force also includes experiences and discussions related to how children use their muscles to move themselves and to push and pull other objects. Later lessons discuss other types of forces, especially the forces involved in collisions, the force of friction, and the force of gravity.

Collisions

When one object collides with another object, it provides a push that can get the second object to move, or, if it is already moving in the same direction, to make it move faster. **Collisions** can also be used to slow down an object. If an object was moving toward you and you threw rocks at it, with each collision, the object would slow down. If you threw enough rocks, or threw them hard enough, or if you threw a heavy enough rock, you could even get the object coming at you to reverse direction. As this example illustrates, the force that a colliding object can impart depends both on its **weight** and on its speed. Collisions are investigated in Lessons 7 and 8.
The Science Notebook is a student’s ongoing record of his or her work as a scientist. Each Science Companion module for grades 1-6 has a Student Science Notebook tailored for that module.

Student Science Notebooks are age-appropriate. Notebooks for younger grades contain minimal text and opportunities to draw instead of write, so all students can participate and shine as scientists. For older grades, Student Science Notebooks utilize students’ developing skills: they contain procedures for students to follow, and provide support for controlling variables as students develop their own experiments—all leading to increased independence.

All the Student Science Notebooks develop literacy and support mathematics skills. Students apply these disciplines in the highly motivating process of doing science.
Hello, Scientist,

All scientists like to study things carefully. They like to think and ask questions. They try things out and then see what happens. They count and measure things. They look closely at things and draw them carefully.

Scientists use science notebooks to write and draw their ideas and their observations about the things they study.

Use this science notebook to write and draw some of your ideas and your observations.

Enjoy it!
Starting Things Moving

Draw your favorite way to start the car moving.
Describe your favorite way to start the car moving.
Hola Científicos,

Bienvenidos a la unidad llamada ‘Materia’. Esta libreta de apuntes de ciencias es el lugar donde registrarás tus descubrimientos sobre los materiales que en el mundo te rodean. Como todo científico, dudarás, pensarás, intentarás, observarás registrarás, y descubrirás. Conforme lo hagas es importante guardar un registro de tu trabajo. Tus preguntas, investigaciones, respuestas, y reflexiones podrán ser compartidas y regresar a ellas en cualquier momento.

Nosotros conocemos mucho sobre ciencias, pero hay mucho más por aprender. Tu contribución empieza aquí.

Disfrútalo, enorgullécete, y comparte tus descubrimientos—la ciencia depende de científicos como tu!
Empezando el Movimiento de Objetos

Dibuja tu manera favorita de empezar el movimiento de un carro.
Empezando el Movimiento de Objetos

Describe tu manera favorita de empezar el movimiento de un carro.
Assessments

Science Companion supplies a variety of tools to assess children “in-the-act” of doing science, as well as evaluate their understanding and proficiency as they finish clusters of lessons.

In the Teacher Lesson Manual:
- Big Ideas and lesson goals are clearly outlined on each lesson’s Quick Look pages.
- Assessment Options in each lesson suggest where pre-assessment and formative assessment can occur in the context of a lesson.

In the Assessment Book:
- Rubrics are supplied to score understanding of science content. The criteria in each rubric are derived from a module’s Big Ideas and lesson goals.
- Opportunities Overviews show where each criteria can be evaluated during pre-assessment, formative assessment and summative assessment.
- Checklists and Self-Assessments list criteria that are related to science process skills.
- Performance Tasks are used for summative assessment to evaluate students’ understanding of Big Ideas and lesson goals. The Assessment Book supplies evaluation guidelines and blank masters for each Performance Task.
- Quick Checks—another summative assessment tool—employ a multiple-choice format.

The Science Notebook Teacher Guide:
A final assessment tool is the Science Notebook Teacher Guide. This teacher edition of the Student Science Notebook is annotated to help teachers know what to expect in from children in their Student Science Notebooks.
### Rubric 2: Pushes and Pulls (Forces)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>The way to change how something moves is to give it a push or a pull.</td>
<td>There are many sources of pushes and pulls.</td>
<td>There are different sizes of pushes and pulls. Bigger pushes and pulls (forces) cause bigger changes in motion than smaller forces do.</td>
<td>Friction and gravity are pulling forces that affect an object’s motion.</td>
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</table>

<table>
<thead>
<tr>
<th>4 - Exceeds Expectations</th>
<th>3 - Secure (Meets Expectations)</th>
<th>2 - Developing (Approaches Expectations)</th>
<th>1 - Beginning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explores content beyond the level presented in the lessons.</td>
<td>Understands all changes in motion are caused by pushes and pulls.</td>
<td>Understands that pushes and pulls can cause changes in motion, but does not recognize that ALL changes in motion are caused by pushes or pulls.</td>
<td>Has no previous knowledge of lesson content.</td>
</tr>
<tr>
<td>Understands at a secure level (see box below) and thinks about the interaction between various pushes and pulls in particular changes in motion.</td>
<td>Understands that there are many sources of pushes and pulls including those that cannot be seen (such as friction and gravity).</td>
<td>Understands that there are different sizes of pushes and pulls (forces) but may only recognize pushes and pulls that are easily seen.</td>
<td>Does not understand that changes in motion are caused by pushes or pulls.</td>
</tr>
<tr>
<td>Understands at a secure level (see box below) and wonders about non-obvious sources of pushes and pulls, such as those from magnets.</td>
<td>Understands that friction and gravity are pulling forces that affect an object’s motion.</td>
<td>Understands that friction and gravity are pulling forces that affect an object’s motion.</td>
<td>Does not understand that pushes and pulls (forces) can have different strengths.</td>
</tr>
<tr>
<td>Understands at a secure level (see box below) and explores the sizes of various forces involved in everyday motions.</td>
<td>Knows a little bit about friction and gravity, but does not understand that they are pulling forces that affect an object’s motion.</td>
<td></td>
<td>Is very confused by the concepts of friction and gravity.</td>
</tr>
</tbody>
</table>
Opportunities Overview: Pushes and Pulls (Forces)

This table highlights opportunities to assess the criteria on Rubric 2: Pushes and Pulls (Forces). It does not include every assessment opportunity; feel free to select or devise other ways to assess various criteria.

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<tbody>
<tr>
<td>Lesson 5:</td>
<td>Lesson 5:</td>
<td>Lesson 6:</td>
<td>Lesson 9:</td>
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<td>- Reflective discussion</td>
<td>- Reflective discussion</td>
<td>- Reflective discussion</td>
<td>- Exploration</td>
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<tr>
<td>- Science notebook pages 6-7</td>
<td>- Engage Lessons 7-11</td>
<td>- Science notebook pages 8-9</td>
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<tr>
<td>Lessons 7-11:</td>
<td>- Reflective discussion</td>
<td>Lesson 7:</td>
<td>- Science notebook pages 14-15</td>
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<tr>
<td>- Reflective discussion</td>
<td>- Exploration</td>
<td>Lesson 8:</td>
<td>- Science Talk</td>
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<td>Lesson 9:</td>
<td></td>
<td>- Exploration</td>
<td>Lesson 10:</td>
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<tr>
<td>- Exploration</td>
<td></td>
<td></td>
<td>- Reflective discussion</td>
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<tr>
<td>Lesson 13:</td>
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<td>Lesson 11:</td>
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<tr>
<td>- Exploration</td>
<td></td>
<td></td>
<td>- Science notebook pages 28</td>
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<tr>
<td>Lesson 13:</td>
<td></td>
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<td>Lesson 12:</td>
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<tr>
<td>- Exploration</td>
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Performance Tasks

- Changing Motion Cluster and Friction and Gravity Cluster Bowling, page 28
- Lesson 13: Motion Madness, page 30

Summative Opportunities

- Changing Motion Cluster and Friction and Gravity Cluster Bowling, page 28
- Lesson 13: Motion Madness, page 30

Quick Check Items

- Changing Motion Cluster Page 33: item 1
- Changing Motion Cluster Page 33: items 2, 3
- Changing Motion Cluster Page 34: item 4
- Friction and Gravity Cluster Page 35: items 1-4
Checklist: Conducting Experiments
Teacher Assessment
(Lessons 5, 8-10, 12)

**TEACHER NOTE:** This unit offers early and informal exposure to these elements of scientific experimentation. They are revisited more formally in later grades.

Determine whether the following elements are evident in the child’s approach to conducting experiments. You might want to assign one point for each criterion that the child demonstrates. You can add specific observations or comments in the space below each criterion.

Name __________________________ Date__________

**Criteria:**

_______ A. Understands the purpose of a particular experiment.

_______ B. Distinguishes between predictions and observations.

_______ C. Recognizes the value of repeating an experiment several times.

_______ D. Understands the reason for changing only one thing at a time when doing experiments.

_______ E. Records results for future reference.

_______ F. Offers plausible interpretations of results.
Teacher Masters may be reproduced and used during lessons. Their uses vary—they may be used by individuals, in groups, or as reference sheets for teachers or adult helpers in the classroom.

Family Letters (introductions to the module) and Family Links (homework or optional activities) are also in the Teacher Masters.

Visuals include posters and pictures that may be displayed or projected in the classroom during lessons. In some cases, Visuals may also include cardstock games that are used during lessons.
Bowling
Changing Motion Cluster and Friction and Gravity Cluster (Lessons 5-13)

TEACHER NOTES:
Use this assessment after Lesson 12.
Give each child a copy of the Bowling Scene Assessment Master (page 40) to use to answer the questions.
You can administer this task orally, individually, or in small groups.

Look at the bowling pictures to answer these questions.

1. Name at least two objects in the pictures whose motion changed.
   Possible answers include the ball, one or more of the pins, or the bowler.

2. What do you think caused the objects you listed to change their motion?
   Look for responses such as the following, depending on which objects the children chose:
   - The change in the motion of the ball was caused by a push from the bowler, the bowler’s arm, or the bowler’s muscles.
   - The change in the motion of the pins was caused by a collision with the ball or with another pin.
   - The change in the motion of the bowler was caused by pushes from his arms, legs, or muscles.

3. If the bowler rolled the ball more gently, what might be different in the last picture? Why?
   Most children will probably say that fewer pins will fall down, since gentler forces produce smaller changes in motion. A few children might say that more pins will fall down, since stronger forces are sometimes harder to control than gentler forces. When evaluating children’s responses, consider whether the reasons they provide are consistent with their prediction about how the motion might change.
Changing Motion Cluster
Quick Check Items

TEACHER NOTE:
You might administer this assessment orally, individually, or in groups.
The following questions relate to the Changing Motion cluster. Use them after teaching
the entire cluster, or select the applicable questions immediately following each lesson.
You can also compile Quick Check items into an end-of-unit assessment.

1. (Lesson 5) Yes or No?
The way to change how something moves is to give it a push or a pull.

__________ yes

2. (Lesson 5) Circle two examples of changes in motion.

starting to move
standing still
turning

3. (Lesson 6) Wind can create a pushing or pulling force that moves leaves and trees.

Draw lines to match the strength of the wind with the motion it produces.

WIND STRENGTH          MOTION

Gentle breeze          Trees fall down
Strong wind            Leaves sway on trees
Very strong wind       Leaves fall off trees (hurricane or tornado)
4. (Lesson 5-8) Circle the picture that is NOT an example of a push or a pull.

a. a collision

b. blowing

c. looking

d. tugging
ExploraGear® Items

The ExploraGear® provides all of the hard-to-find, hands-on materials needed to effectively implement a Science Companion module. This kit of non-consumable and consumable items is your go-to place for the tools needed to teach inquiry science. The authors of Science Companion carefully developed the curriculum so that the ExploraGear® items are not overwhelming and unfamiliar, but filled with the most essential, high quality items needed to engage students in a rich, interactive, inquiry science experience.
“I Wonder” Circle®
Doing Science

I Wonder: notice, ask questions, state problems

I Think: consider, gather information, predict

I Try: experiment, model, test ideas, repeat

I Observe: watch, examine, measure

I Record: record data, organize, describe, classify, graph, draw

I Discover: look for patterns, interpret, reflect, conclude, communicate discoveries
I Discover...
What’s in Science Companion?

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Student Reference Book
(Levels 4-6)

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(Levels K-3)

Curriculum now available in print and digital!
Collecting and Examining Life
From collecting animal tracks to dissecting flowers, children deepen their understanding of what makes something alive as well as exploring the similarities and differences among living things.

Rainbows, Color, and Light
Through experiments with prisms, mirrors, bubbles, water, sunlight, and flashlights, children bring rainbow effects into their classroom and onto the playground. They also mix colors to observe that colored light produces different results than mixing pigmented paints, dough, or water.

Solids, Liquids, and Gases
While deciding what makes a solid a solid, watching water disappear from an open cup, or comparing various liquids, children find the value in asking questions and probing the world around them for meaningful answers.

Motion
Through activities that engage children’s bodies and minds, children move their own bodies in various ways to learn about motion, as well as build ramps, roll toy cars, drop and crash marbles, slide pennies and shoes, and even fly paper airplanes.

Life Cycles
From watching a pea sprout to feeding apples to butterflies, children closely study four organisms, including humans, to observe the remarkable growth and change that living things experience during their life spans.

Early Science Explorations
From making a collage of the leaves and seeds they find to constructing a lever from rocks and wood, children are introduced to the wonders of science and scientific exploration. Contains 7 studies in one book: Growing and Changing; Class Pet; Collections from Nature; Constructions; Dirt, Sand and Water; Sky and Weather; and My Body.

Weather
One day students learn to use a thermometer to record temperature, another day they measure rainfall or investigate the nature of ice. Throughout the year, students use their senses as well as scientific tools to discover that weather is a dynamic part of nature.

Magnets
From testing what sort of everyday objects are attracted to magnets to comparing the strength of different magnets, children deepen their observation skills while learning about the nature of magnets.

Rocks
One day children examine fossils, another day they might test minerals. As children collect, examine, describe, and experiment with rocks, minerals and fossils, they hone their observation skills and begin to unravel the puzzle of what rocks are and how they are formed.

Soils
From closely observing soil components and their properties to discovering the importance of earthworms, children use their senses of sight, smell, and touch to explore the wonders of soil.
Habitats
From going on a nature walk to dissecting owl pellets, children are asked to think about how organisms (plants, animals, fungi, and microscopic living things) survive in the places they live, and how they interact with other living things.

Light
Whether watching light “bend” a pencil in water or building a periscope, the combination of hands-on, multi-sensory learning enables children to understand what light is, how it behaves, and why it makes sight possible.

Our Solar System
One day children chart the moon’s cycles, another day they might make a scale model of our solar system. By observing the world around them, they address questions such as “Why are there seasons?” and “Why does the moon appear to change shape?”

Watery Earth
Whether following a drop of water through the water cycle, measuring their own water usage, or exploring how filters clean dirty water, students are encouraged to use what they learn to have a positive impact on water resources.

Matter
With challenges like exploring what they can learn about an unknown substance called “Whatzit,” students experience the excitement of scientific discovery and gain an appreciation of the scientific method used by professional scientists.

Energy
Whether testing the efficiency of light bulbs, exploring heat conduction, or designing an imaginary invention demonstrating the transfer of energy, students discover that energy is at the root of all change occurring in the world around them.

Design Projects

The design project series was developed to support compatible modules by allowing students to design and/or build animal homes, tools, machines, and designs of their own creation. Taking between 4-6 sessions, the projects strengthen skills and ideas about choosing materials, using tools, working with the limitations of materials, solving problems, and overall project design.
## Unique Features...

<table>
<thead>
<tr>
<th>Program Features</th>
<th>FOSS</th>
<th>Science Companion</th>
<th>STC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepares students to do inquiry-based science</td>
<td>✓</td>
<td>Lesson O introduces students to the scientific method through the “I Wonder” Circle</td>
<td></td>
</tr>
<tr>
<td>Hardback, colorful, content-rich student reference materials for upper elementary students</td>
<td>✓</td>
<td>Student Reference Books</td>
<td></td>
</tr>
<tr>
<td>Bound student science notebooks to foster student literacy and reading skills</td>
<td>✓</td>
<td>The original Student Science Notebooks</td>
<td></td>
</tr>
<tr>
<td>Parallels in instructional design to <em>Everyday Mathematics</em>®</td>
<td>✓</td>
<td>Developed by the creators of <em>Everyday Mathematics</em>®</td>
<td></td>
</tr>
<tr>
<td>Variety of assessment strategies</td>
<td>✓</td>
<td>Teacher-friendly formative and summative assessment strategies</td>
<td>✓</td>
</tr>
<tr>
<td>A variety of pilot options to fit the interests and needs of districts</td>
<td>✓</td>
<td>Several no-cost pilot options, including an innovative online pilot program</td>
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<tr>
<td>Correlations to local and state science standards</td>
<td>✓</td>
<td>Correlated to state standards with customized local standard correlations available upon request</td>
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</tr>
<tr>
<td>Teacher must gather minimal teacher supplied items</td>
<td>✓</td>
<td>ExploraGear and Supplemental Classroom Supplies available</td>
<td>✓</td>
</tr>
<tr>
<td>Early Childhood activity-based modules available</td>
<td>✓ (K Only)</td>
<td>Modules developed specifically for PreK-K available</td>
<td></td>
</tr>
<tr>
<td>Unique content offered to meet standards</td>
<td>✓</td>
<td><em>Light and Rainbows, Color, and Light</em> modules available</td>
<td></td>
</tr>
<tr>
<td>Children develop science habits of mind in addition to content knowledge</td>
<td>✓</td>
<td>“I Wonder” Circle integrates modules as tool for student reflection</td>
<td></td>
</tr>
<tr>
<td>Engaging activities nourish children’s curiosity</td>
<td>✓</td>
<td>Engaging, hands-on activities focused on Big Ideas</td>
<td>✓</td>
</tr>
<tr>
<td>Supports teachers in reaching Big Ideas</td>
<td>✓</td>
<td>Reflective Discussions help children integrate their experience and build science knowledge</td>
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<tr>
<td>Full curriculum available digitally</td>
<td>✓</td>
<td>Hyperlinked teacher materials (iTLM’s) &amp; digital student materials build affordable access</td>
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</tbody>
</table>

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Building from specific modules your district is using, a hands-on exploration of how to best implement Science Companion in your classrooms.

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Formative and summative assessment can work together to strengthen teaching and test scores!

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Science Companion was developed by the same researchers who developed Everyday Mathematics, and many of the same pedagogical tools are used. Making the jump to Science Companion is easy!

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Build a community of Science Companion experts in your district or intermediate unit.

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Fully customizable workshops to meet your needs. Contact us to learn how we can best help you!

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