STANDARDS ADDRESSED IN THIS LESSON

Building toward Performance Expectation MS-LS1-8
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.

Building toward Performance Expectation MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.

Preparation

Background Knowledge
“Special Instrument” View and Models Used in this Unit
This unit frequently asks students to imagine viewing a material though a “special instrument” that allows them to see “a tiny spot” in that material. Because no classroom instrument will enable students to see at the molecular level, this language is used to help students think in a what-if situation. Scientists use this technique as well and refer to it as a “thought experiment.” Scientists now have instruments that provide evidence for the particle model of matter, but such instruments still do not enable the user to see atoms or molecules in the same way they can see cells using a light microscope.
Each time such a representation is used, be sure students understand what is being represented (or what they are representing) in the models. Students should understand that models show relationships between entities (in this unit, between the source, the nose, the odor in the air, and how it travels between them). Dots, circles, stars, letters of the alphabet, and different colors for each may be used to represent particles, atoms, or molecules of odor, air, and later in the unit, the substances that make up air. The representation does not matter as long as the key is clear as to what symbol is being used to represent what.

Students are repeatedly asked to draw and to describe their models, either orally or in writing, so you can be sure understanding is developing across the unit. It is possible for students to draw an appropriate model but not be able to explain it accurately, thus both the representation and the explanation are important for assessing student understanding.

**Modeling**

Students may or may not have experience with the scientific practice of modeling as they approach this unit. Students who had IQWST PS 1 have developed and used models, and a discussion to connect that unit with this one will be helpful for them.

In general, emphasize that the reason to develop models is to try to explain a phenomenon. For the purposes of this class, a model should show how and why something happened (e.g., how the odor traveled across the room). A model represents the student's best ideas about what happened and why it happened. It is not important that a model show every detail about a phenomenon, just the details that show how and why something happened.

An important difference between what is needed to see and what is needed to smell has to do with the path. Students learned that between the eye and the object there needs to be an unobstructed path. This is not the case with smelling odors, and students will learn more about why as the unit progresses (as they learn about the movement of particles in the air). You might ask, “If I put a piece of cardboard between the container and your nose, will you still smell the odor?” (If there is debate about this, have students think about a restaurant in which there is a wall between them and the food, but they can smell the food outdoors.) Ask about different positions in the room (e.g., back turned, standing on a chair, squatting) and whether they could still smell the odor. You could prepare a container with another substance, block its straight path to students, and observe what happens.

**Sharing Models/Critiquing/Revising Models**

Students will need guidance as to how they should listen to each other talk and respond to each other’s models. Eventually you want students to ask critical questions and make constructive suggestions to one another. But that takes time. Stress the following from the beginning:

Having different ideas is fine; that is how people figure things out. Developing models and using them to explain a phenomenon gives us an opportunity to talk to each other and to share ideas that are in our heads so we can come up with the best model we can as a class.
Work with students to generate guidelines or criteria for good models (much as you generated scientific principles) in appropriate student language. You will keep in mind a few target ideas and nudge students toward them, as needed, but ideally, ideas come from the students and are phrased in their language. Key ideas include:

1. Models need to explain. Can you use the model [or your model] to show and to explain how and why the phenomenon happened?
2. Models need to fit the evidence. Does this model fit what we observed?
3. Models need to help other people understand and be persuaded that your explanation makes sense. Is the model easy to understand? Are there ways to clarify what it shows?

The Particle Nature of Matter
Some students may indicate on the first day of this unit that “air is made of molecules.” Two cautions are in order. First, take care not to assume that because they utter this statement, they deeply understand molecular structure or what happens at the molecular level during phase changes. Second, take care not to have such an idea become the “accepted” language of the class if some students are not yet at the place that they understand the concept that all matter is particulate. Most students will not, and it may be that no students in your class will begin with the knowledge that air is made of particles. To many students, air is “nothing”—not matter—not a something with mass and volume. Let understanding develop over time, through the activities, so that students’ knowledge is based on evidence and not on memorization of science rules, definitions, and facts.

Setup
Activity 1.1 requires a “strong smelling odor,” such as an ointment, a pine- or orange-scented cleaning product, Vicks VapoRub, or nail polish remover. Other suggestions are peppermint oil, vinegar, crushed cinnamon, or popcorn. Prepare containers in advance so the odor will not already be recognizable as students walk into the room but can gradually be smelled after class begins. Keep ventilation after the activity (and before the next class period) in mind and use a fan, if needed. Avoid using perfume because of allergies and asthma.

Differentiation and Other Strategies
1. Students will develop (draw) original models throughout this unit, revise and refine those models over time, and eventually develop a consensus model they will use to explain states of matter and phase change. Students with artistic ability may create renderings to post on the Driving Questions Board (DQB) of the consensus model; or of atoms and molecules in a solid, liquid, and gas; or of equipment or activities in which they engage in this unit. Students’ original visual representations, added to the DQB, become part of the classroom work. Such efforts can contribute to the artist’s own understanding, as well as to the understanding of peers for whom a visual representation is especially helpful. This will often include English-language learners, students with learning disabilities, and students who have difficulty with the kind of abstract thinking that this unit calls upon them to do.
SAFETY GUIDELINES

Wafting
When smelling substances in close proximity, instruct students to waft (wave) the aroma toward their noses rather than sniffing the material directly. Many substances can be irritants if inhaled deeply. Wafting will be important many times in this unit.

Tasting
Instruct students never to taste any object in the science lab. Even when a substance is familiar and edible (e.g., gumdrops, water), the equipment, surfaces, and the substance itself may have become contaminated.

Chemicals
You will demonstrate, or students will handle, several substances in this unit that require goggles as good science safety practice. Specific items are described in activities, but the general rule is for students to learn to be careful around the materials they handle, never to mix them together, and not to assume that colorless, odorless liquids must be water.

2. The modeling activities in this unit provide many opportunities for individual work, pair work, group work, and collaborative work. Students discuss, draw, and write about models many times. You may invite students to work in one of these configurations of their choice or you might assign students to work in a particular manner, or you might have all students work individually first, then in pairs, and then share with another group or with the whole class. You might also decide on which strategy is best for individual students after you see how they manage this task in the first and second lesson. In general, talking about ideas before committing them to paper is especially helpful for students with any kind of expressive language or processing difficulty. Articulating ideas using oral language enables them to think as they express their ideas, and to think and use language before they are required to represent ideas in writing or in a model (drawing).

3. Throughout the unit, original student questions on the DQB may be used in a variety of ways (see IQWST Overview for ideas). Gifted students may be assigned independent exploration, such as internet research on questions that will not be addressed in class or that are of particular interest to them, in order to maintain engagement with and interest in the material. It is important that all students, however, are encouraged to pursue questions that interest them and to use internet resources to learn more about their interests.
Teaching Lesson One

Learning Performances
Students will develop and use models to explain their initial ideas about (a) what an odor is made up of and (b) how an odor moves from a source to their noses.

Overview
Activity 1.1
Smell strong odors to contextualize the learning goals for the unit.

Activity 1.2
Develop a model to represent what students think is happening when they smell an odor.

Building Coherence
This lesson generates interest as it draws on students’ everyday experience of smelling odors as the context for the Driving Question. Students may have experience developing and using models to explain and predict phenomena (IQWST PS1); modeling ideas will be taught throughout the unit (see IQWST Overview). Students develop a particle model for the structure of matter, a model that is referenced in subsequent IQWST units.

Timeframe
Two 50-minute class periods

SAFETY GUIDELINES
See Preparation section.
Activity 1.1: Can You Smell What I Smell?

Building toward Performance Expectation MS-LS1-8
Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Disciplinary Core Idea LS1.D Information Processing
- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Building toward Performance Expectation MS-PS1-4
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

Science and Engineering Practices: Asking Questions and Defining Problems; Developing and Using Models; Obtaining, Evaluating, and Communicating Information

Crosscutting Concept: Patterns

Materials

For the Teacher
- (1) handheld electric fan
- (2) opaque containers with lids, each with a strong-smelling material inside (see Setup in Teacher Prep section)

For Each Student
- SE Activity 1.1 & 1.2
- Lesson 1 Reading One
- sticky notes
Introducing the Activity

Inconspicuously open a prepared container. As the odor moves through the room and students begin to comment on it, incorporate that odor’s presence into the discussion. If students do not detect the odor, walk around with the open container, so students can smell the substance as it gets closer to them.

Begin a discussion using the following questions:

- Did you ever walk into your house and you could tell what was cooking before you could see it? Tell about what happened.
- How is it that you can smell food even when you are outside a restaurant?
- How can you tell what an odor is without seeing it?

Guiding the Activity

If students have not yet commented on the odor from the container, ask: “Does anyone smell something you usually do not smell in the room?” Have students raise their hands when they can smell the odor.

Discussion: Brainstorming

Purpose: To engage students in thinking about why they are able to smell an odor from a distance.

- Describe the odor, even if you do not know what it is.
- From where is the odor coming?
- What do you notice about who could smell it first, second, third, and so on?
- How does the odor get from the container to your nose?

Turn to Activity 1.1. Hold up a second container containing a different odor. Walk around with the container, keeping its lid on. (Students should not be able to smell the material.) After all students have had a chance to smell the second container with the lid on, remove the lid. Have students raise hands as they can smell the odor. Again, walk around, if necessary, so all students can smell the odor. Have students answer Question 1 on Activity 1.1.

If you use an ointment, you may heat it by submerging the container in a hot water bath or by rubbing some on your skin. Rubbing alcohol can be used to clean the container of a material that is not soluble in water.

Always probe students’ ideas in discussion beyond their initial responses. Use questions like the following: Who agrees? Who has a different idea? How does [your idea] compare to [someone else’s] idea? What evidence do we have [for that idea]? Do we have any evidence that does not match [that idea]? Why do you think that? See IQWST Overview for more ideas for facilitating productive class discussions.
Discussion: Pressing for Understanding

Purpose: To realize that proximity matters, and that *something* is going from the container to their noses.

- Why does it make a difference whether the lid is on or off the container?
- What does it mean that the odor [moves or got out of the container]?
- How does it move? *(If students say that parts or pieces are moving, push that idea further by asking students if there are tiny pieces of [the substance] going up their noses.)*
- Why could [person A] smell it before [person B] smelled it?
- We smelled two different substances. How did two different odors get to your noses? How do you know? Do you think that all odors get to your nose the same way?
- What is odor made up of so that you can smell it?

The unit focuses on developing an appropriate model of the particle nature of matter over time. The purpose of this discussion is to share ideas and begin to make sense of personal experiences. It also helps you to assess students’ prior knowledge. This type of discussion establishes a classroom culture in which expressing ideas and comparing ideas is important. Thinking—rather than right answers—is the critical goal.

In order to explain phenomena, such as that odors are in the container and then you can smell them, scientists try to picture in their heads what happens. Then they develop a way to show what they think is happening so they can study it. Scientists call what they have in their heads and the representation of the idea a *model*. Students will now engage in the scientific practice of modeling.

Walk students through the following exercise so they can picture in their minds what is happening. This can help them better understand the modeling activity that will be used throughout the unit.

1. Close your eyes and picture one of the containers.
2. Picture me taking the lid off the container.
3. Picture [different people] in class smelling the odor from the container.
4. Imagine a tiny spot in the air between the container and your nose.
5. Imagine a very special instrument that could let you zoom in and see that tiny spot very close up.
6. Open your eyes, and in Activity 1.1, draw what you imagine you would see with that special instrument in that tiny spot between the container and your nose.

Do not expect students to draw a particle model at this time. Students will revisit these models throughout the unit as they experience new phenomena. At this point, students are likely to draw fog, clouds, lines, dots, circles, or any combination. They may show movement using wavy lines, arrows, or quotation marks, or they may not show movement at all. Challenge students to explain why they think what they do, but only so that they verbalize their thinking, not so that their thinking can be changed at this time.
When students finish their model, they are asked to describe (in writing) what they would see. Ask how their model can show what happened and help them explain how the odor moved from the source to their nose. Students may have difficulty deciding what to include in their models or what to write to describe their models. Assure them that these are first drafts, and they will have many opportunities to revise their models. (See sections on models and modeling in Lesson 1 Preparation.)

**Using the Driving Question Board**

In Lesson 1 students might ask questions about how the nose works, or why dogs can smell things that people cannot, or any one of a number of other odor-related questions. Record such questions on the Driving Question Board.

**Introducing the Driving Question**

At this point, students have created models about what makes up an odor. Introduce the Driving Question: How Can I Smell Things from a Distance?

**Introducing Lesson 1 Reading One: Can You Smell What I Smell?**

The Getting Ready section of Lesson 1 Reading One could be started in class as a quick preparation activity. Make a T-chart on the board or simply share and compare ideas. Students then complete their own individual charts in the reading as homework. The final task in the reading asks students to generate a list of questions about odors based on their observations or of items on their lists. These questions should be used to develop the DQB in class as the follow up to this reading.

**Reading Follow Up**

Ask students to write their questions on sticky notes. They should physically add their notes to the DQB, one person at a time [see IQWST Overview for ideas about the DQB]. Students will do investigations throughout the unit to aim to answer their questions.

Let students know that to determine answers to their questions, they need to learn more about odors. Point to the Driving Question and its three subquestions:

1. How does an odor get from the source to my nose?
2. What makes one odor different from another?
3. How can a material change so you can smell it?

Students can work in small groups to compare their models. For sharing models as a class, each group can draw their respective model.
Activity 1.2: Developing an Initial Model

**Building toward Performance Expectation MS-PS1-4**
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

**Disciplinary Core Idea PS1.A:** Structure and Properties of Matter
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

**Science and Engineering Practices:** Asking Questions and Defining Problems; Developing and Using Models; Constructing Explanations and Designing Solutions; Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information

**Crosscutting Concepts:** Scale, Proportion, and Quantity; Systems and System Models

**Materials**

**For Each Student**
- Lesson 1 Reading Two  
  - SE Activity 1.1 & 1.2

Have a student show and describe his or her model and tell how the model helps him or her explain the phenomena. Ask the class and the presenter the following questions.

- Does this model show the odor? The air?
- Does it show how the odor got from the source to your nose? Can you use this model to explain what happened?
- What questions do you have that would help you understand this model better?
- Is there something you might change in this model?
Ask another student or two to share models with the class and compare each to the previous models.

- **How is this model similar? How is it different?** (Use language like, *This one is like the other model in this way, but it is different from the other model in this way.*)

The purpose of this activity is for students to see and hear about other models and to become increasingly comfortable sharing ideas and discussing what they think. Reinforce the idea that in a community of learners, people discuss ideas—whether they agree or disagree—when they are working to figure something out. It is important that students be encouraged to share ideas in a constructive manner to develop a sense of how the scientific community shares ideas.

Students will tend to “like” one model better than another. Aim to create a discourse community in which the talk is not about liking but about representing and explaining the phenomena. When asked how they would revise their model, students often indicate that they would “add more color.” If color is helpful to distinguish “air” from “the odor,” that makes sense, but ask probing questions about why color would be helpful. How would it make the model explain something better?

**Wrapping Up**

Aim for students to understand that a scientific model represents objects or events that are too large, too small, too fast, or too slow to see unaided, and that models are used to explain phenomena.

**Introducing Lesson 1 Reading Two: How Can Models Help Me Understand Odors?**

Have students look back at their own T-charts and create a model of any one of those odors. Assess students’ models to see that they included an odor, air, a source, and a nose.

**Reading Follow Up**

Review what students know so far. Refer to models in the reading and focus on how students represented air and odor. You may also have them compare in-class models (Activity 1.1) and reading models (Lesson 1 Reading Two)—both should represent odors in the air.

- How does an odor get from a source to your nose? (*We smell it in the air.*)
- Why does it make a difference if the lid is on or off the container? (*The lid kept it from moving.*)
- What does it mean that an odor got out of the container? (*It had to move in some way.*)

Later, students will be able to further explain air as a mixture of different gases, of which odor is one. For now, “odor is in the air” is enough.
Candidate words include: odor, source

DQB

The questions from Activity 1.1 and Lesson 1 Reading One should be used to develop the DQB. Before beginning Lesson 2, choose from the DQB any questions that can serve as a bridge to the next lesson. Do this as often as possible to keep students’ questions the driver of their investigations; look ahead for questions that bridge to the next lesson.

Assessing Learning

No assessment is needed at the end of Lesson 1, but do encourage any students who struggle to come up with questions, so that all students have at least one question to post. If needed, ask additional questions or suggest topics in a vague enough manner that students can construct their own questions after you have prompted their thinking.