Unit 1

Chemical Reactions and Matter:

How can we make something new that was not there before?

Student Procedure Guide

GRADE 7 Core Knowledge Science®

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Chemical Reactions and Matter

Table of Contents

Lesson 1: What happens when a bath bomb is added to water (and what causes it to happen)?

Exploring an Interesting Phenomenon

Turn and talk

1. Have you ever heard of bath bombs before? What is your experience with bath bombs?
2. What do you predict will happen when you place the bath bomb, which I got from the store, in a bowl of water?

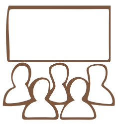
In your notebook

3. Make a Notice and Wonder chart on a blank page in your science notebook.

What I notice	What I wonder

4. Use this space to record what you notice and wonder about the store-bought bath bomb, before and after we add it to water.

With your class



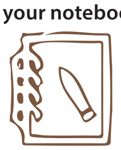
5. Share some of your noticings and wonderings about the store-bought bath bombs with the whole class.

Planning an Investigation

With your group

6. Your group will get the chance to investigate and look at some homemade bath bombs a little closer. Below are supplies available to you to use along with other measurement devices upon request.
   - Samples from the different homemade bath bombs, a different one per person, from 4 possible different recipes (A, B, C, or D).
   - Toothpicks or pipettes or eye dropper.
7. Discuss what types of data you want to collect about the homemade bath bombs to help you figure out what happens when bath bombs are added to water.

In your notebook



8. On the right-hand page of your notebook, write, “Homemade Bath Bomb Observations.” As a group, create a data table to use when you record your results from your investigations.

With your class

9. Share some things you noticed about the homemade bath bombs.

10. How did our results from the homemade bath bombs compare to our results from the store-bought bath bomb?

Modeling What Happens to Bath Bombs in Water

Your teacher will pass out handout: *What Happens to a Bath Bomb When Put in Water?*. Attach this handout to your notebook. You will use this handout to develop a model to explain what is happening when a bath bomb is added to water and explain why gas bubbles appear. We will also develop a model to explain the other changes we observe.

In your notebook

11. In your notebook where you attached *What Happens to a Bath Bomb When Put in Water?*, develop an initial model that explains what we noticed when we added the bath bomb to water. The model should include answers to the questions:

- What happened to the solid bath bomb?
- Why do gas bubbles appear?

12. Your model should include pictures, symbols, and words to help you represent and explain what you think caused the changes you observed.

13. Include a zoomed-in view to explain what happened. It should show any changes you think might be happening to matter in the system at a scale smaller than you can see.

14. Record any questions that come to mind as you are developing your model.

15. In the space next to your initial model in your notebook, write a detailed explanation addressing the bullet points below:

- What happened to the solid bath bomb?
- Why do gas bubbles appear?
- What caused the other changes you observed?

With your group

16. Share your initial models and explanations with the group. Together, keep track of the similarities in your models by placing a (✓) next to those items. In each other's models, mark the differences or areas where the group is less certain by placing a (?) next to those items.

Developing Shared Community Norms

With your class

17. With your class, you will form a Scientists Circle to set up some norms for how the class wants to work together and learn together in science class.

18. Silently pick one norm from the sheet *Initial Model-based Explanation* that you personally will work on the next time we meet.

19. Share with a partner the norm you plan to work on and why it is important to you.

Related Phenomena

In your notebook

20. Add "Related Phenomena" on a new page in your notebook and record any other experiences you had that either:

- Reminds you of what you saw happen to the bath bomb.
- Reminds you of other phenomena that might happen, due to the same sorts of things that the bath bomb did.

21. Share your related phenomena with the class and keep a record of class experiences.

Driving Question Board and Ideas for Investigations

With your class

22. Look back at

- your Notice-Wonder chart from the video,
- your initial models and our class consensus models, and
- our list of related phenomena.

23. Choose one or two questions to share with your class, and write each question on a sticky note. Write the question in dark marker and large enough for others to read.

24. Be prepared to post your questions to our Driving Question Board (DQB).

25. After the DQB is complete, think about investigations or data that could help answer the class's questions.

26. Share your ideas for investigations with the class and record them.

a. Identify a question to answer.
b. Describe how to investigate the question.
c. Share what you think we'll figure out in the investigation.

Revisiting our Shared Community Norms

Turn and talk

27. How did you do practicing the norm you selected to work on during the last class?

28. Silently pick another norm from the sheet that you will intentionally work on and monitor today to help our learning community grow stronger and more productive for everyone.

29. Share some of the things we did well as a class and things we can improve when it comes to our norms.

Exit Ticket

On your own

30. Think about the norm "Equitable." Then answer the following questions on the notecard provided by your teacher:

- Why is it important that we hear what other people say?
- How did this norm help us with hearing others?
- What did we do that helped you feel your ideas were heard?

Lesson 2: Where is the gas coming from?

Gather around the Driving Question Board (DQB).

With your class

1. What questions did we have about where the gas bubbles came from?
2. What ideas did we have about where the gas bubbles came from?

What is inside a bath bomb?

With a partner

3. Working with a partner, use a hand lens to look closely at the bath bomb.
4. Talk about what you see. Be ready to share what you noticed with the class.

With your class

5. Share what you noticed with your class.
    - What were you able to see inside of the bath bomb?
    - What do these observations make you think about where the gas bubbles come from?

Recall key model ideas.

With your class

6. Since we are trying to figure out the gas from this bath bomb, let's take a minute to remember some of the key model ideas we already have from other units. What else do you know about gases?
    - What sort of things did you figure out about gasses in the Cup Design Unit or the Storms Unit?
    - What sort of evidence did you collect to determine whether gas was escaping from a system like the cup?
    - What sort of thing did you do in the Storms Unit to see what air does in a closed system when you heat it or cool it?

We'll record what we know on a poster to come back to later.

Plan an investigation.

With your class

7. One of our claims is: The gas is part of the bath bomb itself, trapped inside it.
    - How can we investigate if the gas is trapped inside the bath bomb itself?
    - What do we need to measure? How could we use the idea that gases have mass to answer our question?

- What data should we record? How should we collect and organize that data?
- What would we observe if the gas is trapped in the bath bomb itself?
- What would we see if the gas does not come from inside the bath bomb?

8. Create a data table in your science notebook to use for this investigation.

Investigate the crushed bath bombs.

With your class

9. Participate as your class works together to plan a procedure and crush 8 mini bath bombs in a ziplock bag.

10. Discuss these questions with your class:

- What did you observe about the bag after we crushed the bath bombs in it?
- What did you notice about the mass of the system?
- Can we use any of this data as evidence to support the claim that the gas is trapped inside the bath bombs themselves?

Plan another investigation.

With your class

11. Another of our claims is: The gas is something new, made from the bath bomb.

- How can we investigate whether the gas is new matter or not?
- Should we test an open system, closed system, or both?
- What should we measure?
- How should we collect and organize that data?

12. Create or add to a data table in your science notebook to use for this investigation.

13. Work with your class to develop the procedure you'll follow to carry out this investigation.

14. Consider what evidence we might see that would support whether or not the gas is new matter.

Carry out this investigation with your group.

With your group

15. Gather materials. Your group will need:

- 100 mL of water in plastic bottle with cap
- long plastic test tube
- 8 mini bath bomb cubes
- digital scale

16. Carry out the investigation according to the procedure our class planned together. If needed, you may refer to *Investigating Gas from Bath Bombs in a Bottle*.

17. While everyone is finishing cleanup, record your group's data on the class-wide tables so we can compare results.

What did we figure out about the gas in bath bombs?

Scientists Circle

18. Discuss the following questions with your class:

- What did we observe during our investigation of the bath bombs in the bottle?
- Does this data provide evidence to support or refute either of our claims?

Arguing for or Against a Claim

With a partner

19. Discuss with a partner: How does our evidence support one of these claims? How does our evidence refute the other claim?

- Claim 1: The gas is new matter that was not there to start with.
- Claim 2: The gas is not new matter, but comes from what was already there.

With your class

20. Share the ideas you had about the claim our evidence best supports. Your teacher will record your ideas and ideas from the class. Your teacher will also underline and highlight certain words or phrases.

21. Look for patterns in what is underlined and what is highlighted in the notes your teacher wrote.

22. Consider how the arguments you're hearing in the class discussion include the key elements of a strong and convincing argument. These are:

- Make a claim that answers a question about a phenomenon.
- Support your claim with both:
- *Evidence*: <u>referencing data</u> that support or refute the claim and
- *Reasoning*: explaining what these data mean by connecting them to agreed-upon key model ideas.

Answer our lesson question.

On your own

23. Use what you've learned about arguing for or against a claim to write your answer to the lesson question: Where is the gas coming from? Write on a separate piece of paper so your teacher can collect your work and give you feedback.

On your own

24. On the bottom or back of the page where you wrote your argument, write your response to these questions:

- On a scale of 4 (totally independent) to 1 (need lots of help with this), how are you feeling right now about writing a well-supported argument?
- Briefly explain what makes you feel that way and what help you could use as you develop this practice.

Lesson 3: What's in a bath bomb that is producing the gas?

Navigation

In the last class, we investigated where we thought the gas bubbles could be coming from and figured out that the bubbles come from what is already there.

With your class

1. Can we make something new that was not there before?
2. How can we revise our driving question to make it better?

Turn and talk

3. What exactly do you think is in a bath bomb?
4. How can we find out?

In your notebook

5. Your teacher will give you *Bath Bomb Recipes*.
    - Attach the recipes to a clean page in your notebook.
6. Make a Notice and Wonder T-chart in your notebook and record your ideas about patterns you notice.

Plan and conduct an investigation.

Your team will receive a set of materials to observe. These materials are common ingredients in bath bombs.

With your class

7. Discuss these questions with your class to plan an investigation.
    - Now that we know the names of these ingredients what do we still want to know about them?
    - How can we use the ingredients to help us figure out how the bath bomb makes gas bubbles?
    - What could we investigate using these ingredients?

In your notebook

8. Prepare your notebook for the investigation.
    - Title the investigation "Observations of Bath Bomb Ingredients."
    - Create a data table to list each ingredient you will test.

With your group

9. Observe each ingredient and record the data in your data table. Focus on observations and data that will help us tell the ingredients apart.

With your class

10. What are some patterns you noticed in your data?

11. Did we find any evidence that would help us figure out why the bath bomb produced gas bubbles? Explain your answer.

Exit Ticket

Record your response on a note card or a scrap of paper your teacher provides. Turn it in as you leave class.

On your own

12. What else should we do to figure out what causes these gas bubbles to appear?

13. What should we measure when we do this?

Navigation

With your class

14. Recall your response from the exit ticket from the last class.
    - What else should we do next with these ingredients to try to figure out what causes the gas bubbles to appear?
    - Where do we go next?

Investigating Ingredients in Water

Your teacher will assign you and your partner to test two ingredients separately in water.

In your notebook

15. Prepare your notebook for the investigation.
    - Title the page "Investigating Ingredients Mixed in Water."
    - Record the two ingredients assigned to your team.
    - Draw the data table your class designs to record your observations and the data that the other teams present.

With your class

16. Plan your investigation.
    - What types of data in this investigation are important for us to keep track of?
    - What are some different ways we could keep track of this data?
    - What kinds of things have we kept track of in our other investigations?
        - Are those also important to keep track of here?

With your group

17. Obtain a copy of *Lab Procedure for Mixing the Ingredients in the Water* for your group, then conduct your investigation.

- Test each sample in water one at a time.

  Do not mix samples.
- Record the observations your class agreed upon and any others you feel are important.
- Be prepared to share your results with the class.

With your class

18. Make sense of your data and the class's data.

- What did you see happen to the substances you combined with water?
- How does that behavior compare with a bath bomb placed in water?

Interpreting Our Data

Your teacher will give you *Bath Bomb Ingredient Data*. Do not put it in your notebook. We will attach it to our notebooks later.

With your class

19. Many of you have used the word "dissolve." What does this word mean?

20. When something dissolves, we say it is soluble. What do insoluble and partially soluble mean?

With your class

21. Work with your class to understand the scientific vocabulary.

- soluble
- insoluble
- partially soluble
- solubility
- substance
- mixture
- matter
- states of matter

On your own

22. Enter the states of matter data for each ingredient at room temperature. Enter the data on the handout, *Bath Bomb Ingredient Data*.

23. Record the solubility of each ingredient in *Bath Bomb Ingredient Data*.

- Use the words "soluble," "insoluble," and "partially soluble."
- Title the first blank column "Solubility in water."

Adding to Your Progress Tracker

On your own

24. Add a new row in your Progress Tracker. Use two columns with the headings “Question” and “What I figured out.”

25. Record the lesson question, “What’s in a bath bomb?”

- Record the ideas you figured out related to this question and what you did to figure it out.

Exit Ticket

Use a note card or other paper to respond to the questions. Turn this in to your teacher as you leave class.

On your own

26. Respond to these three questions.

- What else should we investigate about these substances or try to do using these substances?
- What is one new question you have based on the investigation we did today?
- What was one new idea you heard from a classmate?

Lesson 4: Which combinations of the substances in a bath bomb produce a gas?

Choose a focal norm for today.

On your own

1. Silently choose a norm from the norms chart that you will intentionally work at and monitor today to help our learning community grow stronger and more productive for everyone.

Update our Progress Tracker.

Meet in a Scientists Circle with your notebook and be ready to share the discoveries we made in our last lesson.

Scientists Circle

2. Participate in the class discussion and work together to update your Progress Tracker with what the class has figured out.
3. We will also add to our Key Model Ideas list.

Turn and talk.

Turn and talk

4. What should we investigate next? Share your ideas with a partner. Be ready to share your ideas with the class, as well.

Planning and Preparing for an Investigation

With your group

5. Your group will get the chance to combine some of the ingredients from the homemade bath bombs and observe what happens. Discuss the following:
    - What are we hoping to figure out by testing combinations of these different ingredients?
    - What evidence are we looking for to help figure that out?
    - How many different possible combinations will we have if we combine them two at a time?
    - Which combinations are you most interested in testing?

Your teacher will pass out the handout *Combinations of Ingredients to Test*. Do not attach this handout to your notebook until directed by your teacher. You will use this handout to record and organize your data while you investigate what happens when different combinations of bath bomb ingredients are added to water.

With your class

6. Highlight the one row of the table your teacher tells your group to test, so you know which combinations your group will be responsible for testing.

With your group

7. Discuss with your group which three other combinations you want to test, and highlight those boxes as well.

8. Write the combinations of ingredients you plan to test in the numbered grid at the bottom of the handout. This will be the key for your observations during the investigation, so make sure everyone in your group has identical grids.

In your notebook

9. Title the left side of your next clean notebook page "Testing Combinations of Bath Bomb Ingredients." Attach your handout *Combinations of Ingredients to Test* to this page.

10. On the right side of your notebook, opposite your handout, write the heading "Observations" and list the numbers 1–12. This is where you will record your observations of what happens when you combine each of the different ingredients (as listed in your key).

Exit Ticket: Focal Norm

On your own

11. Use a note card or other paper to respond to the questions. Turn this in to your teacher as you leave class.
    - How did you do with practicing the norm you selected to work on?
    - How did the class do as a learning community today?
        - What did we do well?
        - What could we improve on?

Carry out the combinations of ingredients lab.

Safety Precautions

12. Be sure you wear splash goggles the whole time your group is working with the ingredients.

With your group

13. Review the following lab procedures and clarify other specific details with your teacher.
    - Carry materials carefully to and from your work space in their bin.
    - Use the dropper that coordinates with each cup's letter—do not cross-contaminate pipettes.
    - Use only 5–6 drops of each solution for each section of your ice cube tray. Record detailed observations in your notebook.
    - When finished, clean your ice cube tray as directed.
    - Be sure all materials in your bin are neat and tidy when you return them.
14. Work with your group to carry out the investigation as directed.

In your notebook

15. Be sure you record your observations in your notebook.

Making Sense of the Data

With your class

16. Have one person from your group post your data on the class data table. Identify which, if any, of the combinations you tested resulted in bubbles by placing "Y" in the box for that combination.
17. Discuss the results of the investigation with your class.

Examine the lemonade mix.

Turn and talk

18. Turn and talk with a partner about these questions:
    - Lemonade is a mixture that contains more than one type of substance. What predictions do you have about the ingredients you will find in the two lemonade mixes?

On your own

19. Look at *Lemonade Mix Labels*. What patterns do you notice between the substances listed in the ingredients of these mixes and the substances that resulted in bubbles appearing during our investigation?

Update your Progress Tracker.

In your notebook

20. Add a new row to your Progress Tracker. Use two columns to record the lesson question, "What combinations of substances caused a gas to appear?" and to explain what you figured out in words and/or pictures.

Arguing for a Claim About the Bath Bomb Gas

With your class

21. Read through these questions and prepare to discuss your ideas with the whole class:

- What claim can you make about the key combination of substances that are interacting together to cause the gas bubbles to appear? Use evidence to support your claim.
- What claim can you make about the gas in the bubbles? Is it any of the substances we started with, or is it a new substance(s)? Use evidence and key model ideas in your reasoning.

22. During our discussion, work with your peers' ideas by responding to follow-up questions such as these:

- Can we restate what others said and explain why we agree or not? Do we agree or not?
- Can we identify the use of evidence and/or key model ideas in their reasoning?

Lesson 5: What gas(es) could be coming from the bath bomb?

What gas(es) could be coming from the bath bomb?

Turn and talk

1. Discuss the following from your investigations and work in the last lesson:

a. What evidence did we use to conclude that the gas in the bubbles was not one of the three substances we started with (baking soda, citric acid, or water)?

b. What kind of gas do you think it was? Feel free to brainstorm multiple predictions.

Scientists can identify different substances based on their properties. If we want to figure out what gas is in those bubbles, we also could try to identify the gas based on its properties.

In your notebook

2. Title a new page in your notebook “Gas-Related Phenomena”.

a. List any experiences you’ve had with gas(es) that were used in different systems to make different things happen.

b. What are some properties of the gas that make it good for the things you listed?

With a partner

3. Get *Some Common Gases* from your teacher.

a. Look over the list of gases and share your noticings and wonderings verbally with your partner.

b. What two properties would be good to use to find out what gas is coming from our bath bombs?

We will test for flammability first, and then we can test for density. In the past, we have used bags, bubbles, soda bottles, and flasks to trap a gas.

With your class

4. How might we trap the gas from a bath bomb so we can test its flammability?

With a partner

5. Make a prediction about what you think will happen to the flame on the match when your teacher puts it in the flask of room air and the flask of gas from the bath bomb. Share your ideas with a partner.

With your class

6. Watch and participate as your teacher demonstrates how a flame will interact with room air and the gas from a bath bomb.

a. Record the results of your two tests.

On your own

7. Use *Some Common Gases* and examine the flammability data for the gases.
    a. Think about which gases could be the gas from the bath bomb based on your class's tests.
    b. Mark off any gases that do not match the properties of the gas from the bath bomb that you tested.

In your notebook

8. Add the question "What gas(es) could be coming from the bath bomb?" to your two-column Progress Tracker.
    a. Record what you figured out from this flammability test.

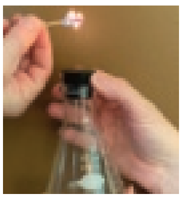
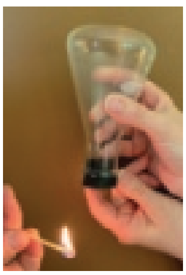
We have tested flammability, and that property helped us narrow down our list of possible gases that could come from a bath bomb. Now we can use a different property and continue to narrow the list down. We will use the property of density to help us get closer to identifying the gas that comes from a bath bomb.

With your class

9. Check the flammability data for helium. Make note of this property of helium.

In your notebook

10. Title a new page of your notebook "Predictions of Gas Behavior".
    a. Record your predictions about what will happen to the flame if the helium bottle lid is removed in the two different situations. Use a table like this below:.

	Helium gas	**Gas from a bath bomb**
Cap facing up 		
Cap facing down 		

With a partner

11. Discuss your predictions from #10 with a partner.

With your class

12. Watch and participate in a class demonstration.

a. Discuss what happened in the demonstration.

b. Why did the match go out in one situation and not the other?

On your own

13. Get *My Predictive Explanations for the Gas from a Bath Bomb* from your teacher, and make two different if-then statements that explain what could happen with the gas from a bath bomb.

a. Use the information in *Some Common Gases* as a reference as you record your predictions.

b. Attach your completed handout to your notebook.

With your group

14. Review the procedures displayed on the slide, paying extra attention to the safety considerations.

15. How might you alter the procedure for testing helium so that it works with the gas from a bath bomb? (You have to consider the liquid in the bottle.)

16. Work with your group to carry out the investigation. Follow the steps shown on the slide or that are printed here.

- Fill a bottle about 1/10 full with water. Add 8 mini bath bombs to it. Cap it.
- Light a match. Hold it 1 inch over the bottle as a partner removes the cap. Keep it there for 2 seconds. Make a note of whether the match goes out or not.
- Extinguish the match, and cap the bottle. Discard the match in a cup of water.
- Light a candle in a bread pan.
- Lean the edge of the bottle against the pan and remove the cap.
- Gently squeeze the bottle to push the gas out of it. Make a note of whether the candle in the pan goes out or not.

With a partner

17. Use *Some Common Gases* and examine the flammability and density data for the gases.

a. With the results of your test, you should be able to mark off more gases from the list that do not match the properties you have found from the bath bomb gas.

b. Work with your partner to mark off any gases that do not match the properties of the gas from the bath bomb.

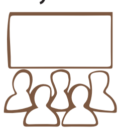
18. Update your Progress Tracker in your notebook by drawing a line under your last entry on the right column. You have the same question, so there is no need to write it again.

a. Record what you figured out by doing the investigations with the class and with your group.

b. Flag this page with a sticky note so that you and your teacher can locate it quickly.

You have gathered evidence that will be useful for identifying the gas that comes from a bath bomb. You may not know exactly what gas it is yet, but you do know the properties of the gas from a bath bomb. And, you have some ideas about the gases that it might be.

With your class



19. Work with your class to gather the resources you need for the next activity. You will need:

- your notebooks turned to their last entry in the Progress Tracker,
- the data table from *Some Common Gases*,
- your predictive explanations from *My Predictive Explanations for the Gas from a Bath Bomb*, and
- the new handout *Alternate: My Predictive Explanations for the Gas from a Bath Bomb.*

20. Review the discussion protocol with your class. Ask questions if you do not understand parts of the protocol.

With your group

21. Gather with your new group.

a. Sit with your group in a circle.

b. Decide who will be the first one to share in your group.

c. Follow the protocol until everyone has had a chance to share.

With your class

22. Determine if there is a main scientific principle that should be used in a written argument.

a. What other science ideas will be helpful in developing a strong argument about the gas that is produced from a bath bomb?

23. Review the Anchor Chart for key features to include in a strong argument.

The next task is an assessment. You will write an argument that includes the key features listed on the Anchor Chart. The question you will be answering is "What gas(es) could be produced by a bath bomb?" You have had multiple opportunities to practice this task and get feedback from your teacher and your classmates. Now it is time to show off what you have learned!

On your own

24. Work individually to construct your argument. Record your argument where your teacher directs.

We know some possible candidate substances for the gas bubbles produced from bath bombs. We also know that this gas is a different substance from the substances that make up a bath bomb.

With a partner

25. How is it possible that a new substance is produced that was not there before?

26. You found that mixing baking soda, citric acid, and water produced the gas bubbles from the bath bomb. What do you think is going on with the particles of these ingredients to make the gas?

Lesson 6: How can we explain another phenomenon where gas bubbles appear from combining different substances together?

Explain a related phenomenon.

With your class

1. Look back at our related phenomena poster from Lesson 1. Can we use what we have figured out so far to explain any of our related phenomena?

We have a related phenomenon that is sometimes referred to as "elephant's toothpaste." We will take some time today to see if we can use what we have figured out to explain this related phenomenon. In a moment you will have a chance to explain what is happening to the substance.

On your own

2. Watch as your teacher plays a video of the phenomenon. Record your observations from the video.

Develop related arguments.

On your own

3. Look at *Explaining another phenomenon* as your teacher goes over it with your class. This individual assessment will help gauge you progress on analyzing data and making arguments using key model ideas and evidence for a related phenomena.
   a. Use what you observe in the videos and the information on the handout to help you explain the phenomenon.
   b. In addition to the handout, use your other resources to help you, such as:
      i. Your Progress Tracker
      ii. Some Common Gases Data Table
      iii. The classroom anchor chart
      iv. Key model ideas
4. As your teacher shows the video, record your observations on your paper under the first question.
5. Read through the prompts for questions 2-4 and think about how many resources you will need for each question. Be ready to share your ideas with the class.
6. Complete the remainder of the assessment on your own.

Revisit the Driving Question Board.

With your group

7. Work with your group to see what questions from the Driving Question Board (DQB) we have made progress on so far in our unit. On the handout your teacher provides you:

a. Place a ✓✓ next to any questions you feel we have made progress on **and** we have evidence for.

b. Place a ✓ next to any questions you feel we have made progress on, but we still need more evidence for.

c. Do nothing to any of the questions you feel we have made no progress on yet.

Be prepared to share with the class.

What could be happening at a particle level?

We still don't know what mechanism can explain how it is possible that we are able to produce different substances in each of these cases.

Turn and talk

8. What are some of your initial ideas about what is going on between the particles of matter in the system that could help explain this outcome?

Lesson 7: How can we revise our model to represent the differences in the matter that goes into and comes out of the bath bomb system?

How can particles for a new substance be formed from the old particles we started with?

The last lesson ended with the class returning to the questions that are on the Driving Question Board (DQB). We were trying to figure out what questions we have answered or made progress on and what questions still need to be answered. We then brainstormed some possible explanations to the questions "How is it possible that we have a new substance that was not there before?" and "What do you think is going on with the **particles** of the bath bomb ingredients to make the gas?" Think about your responses to those questions as you begin this lesson.

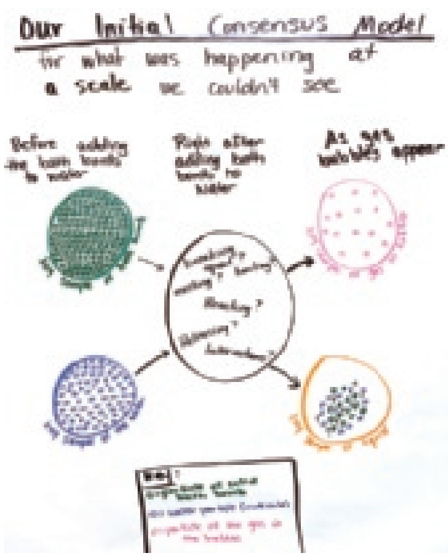
Scientists Circle

1. Gather in a Scientists Circle with your class.
2. Reflect on your ideas about the two questions from the last lesson. Think about what questions we still have about the gas bubbles that come from bath bombs.
3. Share your ideas about the two questions from the last lesson.
    a. What questions do we still have about the gas bubbles that come from bath bombs?

Review the initial Consensus Model with your class.

With your class

4. Participate as your class begins a new model of the interaction of a bath bomb and water. You will add to the model table new things you figured out from Lessons 2–5. Use your notebooks and your Progress Trackers to remind you of your learning.



Lesson 2: Where is the gas coming from?

In Lesson 2 the question we wanted to answer was "Where is the gas coming from?" In this lesson we crushed the bath bomb and put it in a baggy and a bottle and measured the mass of the system.

With your class

5. What did you figure out in this lesson?
6. Where was the gas coming from?
7. What should we add to our class consensus model to capture what we figured out?

Lesson 3: What's in a bath bomb?

In Lesson 3 the question we wanted to answer was "What's in the bath bomb that is producing bubbles?" In this lesson we looked at the ingredients of the bath bombs. Then we mixed individual ingredients in water. After gathering this data we added our observations to a property table of the ingredients of the bath bombs.

With your class

8. Use your Progress Tracker entries to review what you figured out in this lesson.
9. What important ideas did you figure out about how the substances interacted with water?
10. What should we add to our consensus model to capture these ideas?

Lesson 4: Which combinations of the substances in a bath bomb produce a gas?

In Lesson 4 the question we wanted to answer was "Which combination of substances in a bath bomb produces a gas?" In this lesson we did an investigation where we mixed pairs of ingredients in water.

With your class

11. What were some of the things you figured out by combining two substances at a time?
12. What substances are important to mix together to get gas bubbles from a bath bomb?
13. What should we add to our class consensus model to capture these ideas?

Lesson 5: What gas(es) could be coming from the bath bomb?

In Lesson 5 the question we wanted to answer was "What gas(es) could be coming from the bath bomb?" In this lesson we analyzed data from different gases and investigated the gas coming out of the bath bomb to see how it related to the data table.

With your class

14. What were some things you figured out about the **properties** of the gas that could be coming from the bath bomb?

a. Describe the property and how you figured out the property of the gas. You should describe two properties.

b. Name the gas(es) that could be coming from the bath bomb.

15. What should we add to our consensus model to capture these ideas?

Compare these ideas you figured out from the investigations in Lessons 2–5 to your ideas in the initial class consensus model.

On your own

16. Record the revisions you want to add to the particle models from the initial consensus model in your notebook. What part of the particle model would you want to keep the same and what parts would you want to change? Why?

Turn and talk

17. Share your ideas for revisions with a partner and listen as they share their ideas.

With your class

18. Work with your teacher and classmates to represent your new ideas with particles. This is at a scale you cannot see. Consider these parts of the model:

a. How will you represent particles in the bath bomb?

b. Where do we still have questions and need more evidence to revise?

c. How will you represent the gas from the bath bomb?

In your notebook

19. Turn to a clean page in your notebook. Title the page "My Ideas for How the New Gas was Formed."

You have made a lot of revisions to your model, and now we have a new way of representing what is going on with the bath bomb. We still have questions, though. How can you take certain types of particles to begin with and make them into new kinds of particles? You have evidence that the new particles have to come from the old substances because none of the matter disappears. But how can this happen?

With a partner

20. Discuss your ideas about these ideas and questions. Record your ideas in words and pictures in your notebook.

a. Flag this page so you can find it quickly for the next class.

Lesson 8: How can particles of a new substance be formed out of the particles of an old substance?

How can particles of a new substance be formed out of the particles of an old substance?

When we combine particles of different substances together, they sometimes end up forming particles of a new substance.

With a partner

1. With a partner, discuss:

a. What is happening at a particle level that could help explain how this is possible?

Scientists Circle

2. Work together with your class to:

a. Use the manipulatives to represent your ideas.

b. Label and use words to make your ideas clear on a poster.

c. Be ready to share with the class some ideas you and your partner had for ways to represent what happens to particles when new substances are made.

Use your Progress Tracker to record questions about how new substances are made.

John Dalton and his colleagues had some of the same questions you have had. What did they do to answer their questions? The reading you interact with next will provide you with some of the ideas they had. Maybe we can try out some of their ideas to answer our questions.

In your notebook

3. Record the questions you have about what happens to particles when new substances are made in your Progress Tracker.

4. Get *Reading: Dalton's Investigations* from your teacher.

a. As you read, keep track of ideas or questions you have by writing them on the handout. Use the margins or anywhere else there is room.

b. Underline questions that the scientists had that are similar to your own questions.

c. Circle any investigations you think we should try to answer our questions.

d. Respond to the questions at the end of the reading.

e. Record anything you figure out from the reading to help answer your question(s) in your Progress Tracker.

5. When all of your classmates are finished reading, participate in a class discussion.

What happens when energy is added to water through heating from a battery?

Turn and talk

6. Dalton and other scientists tried heating water and putting electricity through water and found both caused bubbles to form. Have you seen either of these phenomena before? Turn and talk with a partner:

a. What substances do you think are in the gas bubbles? Is it the same substance in each case?

b. If we could capture the gas, what are some tests we could do to help us answer these questions?

Lesson 9: Does heating liquid water produce a new substance in the gas bubbles that appear?

Heating Liquid Water to Produce Gas

Your teacher is heating some water to make it produce gas bubbles, like we did in the last lesson.

With your class

1. Discuss these questions as a class:
   - Why did we want to try to produce bubbles by adding energy to water using heat and electricity?
   - What were some of the properties of these gas bubbles we wanted to test?
   - What question(s) would those tests help us answer?

Property Tests on the Gas from the Heated Water

In your notebook

2. Make a new section in your notebook and title it "Property data from gas produced when water is heated."

With your class

3. Put on splash goggles.
4. Go to the area your teacher indicates and make and record observations of the heated water demonstration with your classmates.
5. Discuss how we might measure the grams and liters of a sample of liquid.

Problematizing, Planning, and Carrying Out a New Investigation

Water, glycerin, and rubbing alcohol are all different substances, made of different types of molecules. They are all clear liquids at room temperature.

With your class

6. Discuss this question as a class:
   - How might we be able to tell these substances apart from one another?

We saw different density values for different gases. These values ranged from as low as 0.09 g/L to as high as 2.0 g/L. Notice that the units used are the same for all of the different gas densities.

With your class

7. Discuss these questions as a class:
   - The g in these units stands for grams. How could we measure the number of grams of a liquid sample?
   - The L stands for liters. How could we measure the number of liters of a liquid sample?

Your teacher will show you a photograph of a clear liquid in a graduated cylinder to demonstrate why it can be tricky to get an accurate measurement for the volume of a liquid sample.

With your class

8. Discuss these questions as a class:

- What do you notice about the liquid level in this 25 mL graduated cylinder?
- If you measured the liquid to the lowest point on its curved surface, what would be the volume of the liquid?

On your own

9. Complete the "Predictions" section of *Density calculations of clear liquids*.

10. Record data for the substances you were assigned to test in the second table of this handout.

11. Make note of the estimated amount of liquid you will be measuring out, as assigned by your teacher.

With your group

12. Carry out this procedure:

A. Get a graduated cylinder for you and your partner. Dry off the outside and inside.

B. Complete columns A–D for rows 1 and 2 of your first data table on *Circles as Particles*. In the procedure below, let one partner start by measuring the water and then allow the second partner to measure the other substance (glycerin or alcohol):

- Determine the mass of the empty graduated cylinder and record it in column A.
- Put about ____ mL of water in the cylinder. Calculate its mass. Record its mass in column B and its volume in column C. Dump the water out in the drain.
- The partner who did not have a chance to measure should now have a chance to complete the next step, which is to put about ____ mL of glycerin or alcohol (whichever you were assigned) in the cylinder. Calculate the mass of the substance. Record its mass in column B and its volume in column C.
- Dump the liquid out in the drain. Wash your cylinder out in soapy water. Rinse it under water and return it. Do not fill out data table 3 yet.

Analyzing and Interpreting Data

With your class

13. One partner should copy the mass of the water that was measured on one sticky note and the volume of the water on another. The other partner should copy the mass of the other liquid that was measured on one sticky note and the volume of the liquid on another.

14. Form a line in front of the graph associated with the substance you measured.

15. Get a magnet and place it on the corresponding coordinate point (volume, mass) on the poster paper for your substance. Post your sticky notes in one of the rows in the table to the right of the graph and allow the next person to post their data.

In your notebook

16. Add a "Patterns in the mass vs. volume graphs" section to your notebook. Record the patterns you notice in a single graph. Record any patterns you notice between graphs.

With your class

17. Discuss the patterns you notice as a class.

With your group

18. Calculate the ratio of mass to volume for your row and record it in column E in *Circles as Particles*. This calculation is mass (C) divided by volume (D) = density, which is a unit rate (in grams per mL).

19. Record your calculation on a sticky note and post it on the third column of the table in the room.

With your class

20. Discuss the patterns you notice in these calculated ratios (unit rates) as a class.

With your group

21. Calculate the average density for each of the substances on the three posters. Record these averages in the first three rows of the last table on *Circles as Particles*.

Collecting Data on the Density of the Unknown Clear Liquid

Turn and talk

22. Discuss this question with a partner:

- What do you predict the density of the unknown clear liquid that we collected from the gas that came out of the heated water container will be?

On your own

23. Individual check-in. Answer these questions on an index card (or a half sheet of paper) with your name on it and turn the card in to your teacher:

- What is the density of the clear liquid (in grams per mL)?
- If we had a new sample of this same liquid that was double the volume of the sample we just measured, what would we expect the density to be?

Arguing from Evidence

Get a copy of *Evaluating and improving alternate arguments* from you teacher. Take out a sheet of blank paper to use with this handout.

Turn and talk

24. Another class came to conclusions similar to the conclusions of our class. Below are two students' arguments. Read through these with a partner:

- Student #1: The gas in the bubbles is made of water particles, because of its properties. Properties help prove whether two substances are the same or different.
- Student #2: The gas in the bubbles is made of water particles. If a sample of something is made of the same particles as another substance then it has the same properties.

25. Discuss what you think about these arguments with a partner.

- What do you agree with?
- What problems do you have with their arguments?

In your notebook

26. Identify elements to include to strengthen each argument. Use *Evaluating and improving alternate arguments* to list the observations we took that we could use to strengthen these arguments. What data did we collect? List the key pieces of data individually on part 2 of this handout.

27. Look back at the key model ideas we have that are relevant to this argument. Identify which ones are relevant and write those down on part 2 of *Evaluating and improving alternate arguments*.

28. Write a revised argument. Read the text on part 3 of *Evaluating and improving alternate arguments*. Use the remaining time to write a response to part 3 on a separate sheet of paper.

29. Attach your completed response to part 3 to *Evaluating and improving alternate arguments* and turn in both to your teacher.

Turn and talk

30. Discuss this question with a partner:

- Tomorrow we will try the other investigation we have on our “Adding Energy to Water Investigations” poster—putting electricity through water. Make a prediction:
- Today we added energy to water by heating it and found that this process did not produce a new substance. Do you think we will see anything similar or different happen by adding energy to water with electricity?

Lesson 10: When energy from a battery was added to water, were the gases produced made of the same particles as were produced from heating the water?

Looking Back at Lesson 8

Now, we will look back at the *Adding Energy to Water Investigation* poster from last lesson.

With your class

1. Discuss the following questions with the class.
    - Why did we want to try the two investigations we read about (adding energy to water using heat and electricity)?
    - What question(s) would that help us answer?
    - How will these investigations provide us data to help support or refute these ideas?

Property Tests on the Gas from the Electrified Water

2. Open up to a new page in your notebooks. Title the new page, "Adding Energy to Water with Electricity." We will use this page to make observations during the investigation.
3. Watch your teacher as they demonstrate the setups. Use the space under your title to record any observations of the different setups.

Comparing the Materials Used in Both Setups

With a partner

4. The test tubes labeled Gas A and Gas B were both captured using the same setup as Setup 2 and then corked. Turn and talk to a partner about the following question:
    - Do you think the gas we collected in each test tube from running electricity through the water is made of the same particles produced from heating the water?

Be ready to share your ideas with the class.

Flammability Test for Gases in Test Tubes

With your class

5. It is hard to tell if the gases in each test tube are the same. We will see if we can figure it out using the property of flammability. Work with your class to make a chart to record your observations.

Safety Precautions

6. Listen carefully to the safety instructions to follow as your class participates in a demonstration to test the flammability of the gas or gases that are produced.

    - Wear safety goggles during the demonstration.
    - If you assist your teacher in the demonstration, tie back long hair, remove dangling jewelry, and secure baggy sleeves.
    - Follow your teacher's instructions carefully.

With your class

7. Record your observations of the flammability test of the gas in tube A.

8. With your class, use your observations of the flammability test on the gas in test tube A to discuss the following questions:

    - How does this result compare to our test of the gas produced from boiling water?
    - How does this provide additional evidence that the particles that make up this gas are not water particles?
    - What could doing this test on the gas in test tube B tell us about the particles that make it up?

In your notebook

9. Do you think the gas in tube B will have the same or different properties from the gas in tube A? Record your observations for the flammability test of the gas in tube B.

    - How do these results compare to the flammability test for the gas in tube A?
    - How do these two flammability tests help tell us if the gases are different or if they are the same?

10. Look back at *Some Common Gases* and use the flammability data to see if you can tell what gas or gases might have been in tubes A and B. Record your ideas in your notebooks.

With your class

11. When scientists were first doing these types of investigations, one thing that they measured that we did not was the mass. They collected such measurements in a closed system. They found that the mass before adding electrical energy was the same as the mass after the gas was produced.

12. Discuss the following questions with your class:

    - How does that result compare to what we found in the bath bomb system in the soda bottle?
    - What does that tell us about where the matter that makes up the gas particles is coming from in all of these systems?

Construct an explanation.

On your own

13. Use a new sheet of paper to construct an explanation that answers our lesson question, “When energy from a battery was added to water, were the gases produced by this made of the same particles as those produced from heating the water?” Use the evidence we collected in your notebook and key science ideas to support your explanation.

Lesson 11: How do Dalton's models of the particles that change in a reaction compare to the ones we developed?

How do Dalton's models of the particles that change in a chemical reaction compare to the ones we developed?

In the last lesson, you worked on constructing an explanation that new types of particles were made from the water particles. Using the discoveries you have recorded in your explanations, let's revisit our particle models to evaluate whether any of them represent what we explained happens to the water particles when we added energy from a battery to them.

With your class

1. Look at this key model idea with your class:

a. When new substances are produced from old substances, some of the particles that make up the original substances break apart and/or join together to make different types of particles.

b. Is this idea represented on our poster?

With a partner

2. Talk with a partner:

a. How could we use the same manipulatives as before to show how two different kinds or particles come from this one water particle?

b. Be ready to share your ideas with the class.

Read a piece of text that summarizes some of the results and discoveries from other scientists who investigated this question. Whenever you start a non-fiction reading, it can be helpful to identify a particular question or questions you want to try to answer based on the reading. This helps you look for different things in the text than if you didn't have a framing question or questions. If you get a reading that it is OK to write or highlight on, it is also helpful to write the question or questions at the top of the text you are about to read. Write this question on the top of the handout you receive from your teacher: ***How do Dalton's models of the particles that change in a chemical reaction compare to the ones we developed?*** As you are reading, look for connections that help answer this question. Highlight and write on this text after you read it. You will turn this in when you are finished. First, start with a small part of the text to practice.

On your own

3. Follow this protocol when reading this article:

a. Read page 1 only.

b. Follow the directions in the boxes in the reading on this page.

c. Go back and highlight any piece(s) of the text that you think is connected to the question you recorded at the top of your paper.

d. Add annotations to your paper saying how it is connected.

Be ready to share any new connections you have discovered with the class.

4. Follow this reading protocol for the remaining part of the text:
    a. Read the remaining text.
    b. Go back and highlight any piece(s) of the text that you think is connected to the question above.
    c. Add annotations to your paper saying how it is connected.

Using information you read about in the text and the connections you made to the text, add to your individual Progress Tracker.

On your own

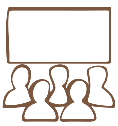
5. Draw a line under the last entry in the two column format for your Progress Tracker.
6. Record the question, "**How do Dalton's models of the particles that change in a chemical reaction compare to ours?**"

In your notebook

7. Record what you have figured out in your Progress Tracker.

With your notebook and annotated text, meet in a Scientists Circle as a whole class.

With your class



8. Bring your notebook with you to meet in a Scientists Circle.
9. The goal of this discussion is to share what we have figured out about the question, "**How do Dalton's models of the particles that change in a chemical reaction compared to ours?**"
10. Use *A summary of some historical investigations and discoveries into the particle nature of matter* to see if we can use Dalton's model of a molecule to represent what we think is happening to the particles when we add energy from a battery to water.

In Lesson 8, we started our own way of representing the structure of water particles with shapes during both physical and chemical changes. We also saw that Dalton came up with his own way to represent them. There are quite a few different ways to represent atoms and molecules that might be useful as we develop our final models and explanations of our bath bomb. Others may be less useful. Let's get ready to compare and evaluate some of these representations.

In math, you may have seen that when you use numbers to indicate how many of a variable there are, you might say things like 2x or 10x to represent 2 of x or 10 of x. But if there is only 1x, the convention is to drop the 1, as it is implied. That is the case in this model too—if no number is shown, then the implied number for that particle type is 1.

With your class

11. A different substance that has the same type of atoms in it as water, but different numbers of atoms, is hydrogen peroxide. Its molecules have two atoms of hydrogen and two atoms of oxygen in them. How would we write that in chemical formula notation?

12. What do you think the 3 represents in the following formula $3H_2O$?

13. How would we represent three molecules of hydrogen peroxide?

Turn and talk

14. Turn and talk with a partner about what patterns you see between the different models of water.

Be ready to share your ideas with the class.

In your notebook

15. In your notebook, add the following:
    a. Use chemical notation to represent seven molecules of water.
    b. Use chemical notation to represent ten molecules of hydrogen peroxide.

Now let's look at a new handout that has structures of substances other than water.

With your group

16. In your small group, use *Molecular Models of Different Substances* to compare the different molecular structures.
    a. What are some interesting patterns you notice between the different substances?

Be ready to share your ideas with the class.

With your class

17. Discuss your ideas with the class.
    a. Which combination of these substances do we know caused gas to form? After you decide on these, put a star next to them in your packet.
    b. Which of the three substances did we think the gas that was produced might have been (based on the property data we collected and analyzed)? After you decide, circle the substance.

Make an individual explanation.

Now you should be able to revise your explanation of the anchoring phenomena (bath bombs), in light of what we have figured out in the last couple of lessons. This is an assessment you will turn in when you are done. Use the models on the handout, the new scientific principles posted in the room, and anything in your science notebook in your response.

On your own

18. Use our new scientific principles to explain why the gas that was produced could only be one of the substances you circled and not the other two.
    a. Draw a model (at a particle level) showing where the matter came from to produce this particular kind of gas.
    b. Describe, in words, what happens to molecules of baking soda, citric acid, and water when this gas is produced.

Lesson 12: How can a new substance (a gas) be produced and the total mass of the closed system not change?

Compare and explain bath bomb models.

Last class we figured out that we could use different models to represent what was going on with our bath bombs, and use those explanations to explain what was happening to others.

With your group

1. Take time to compare and explain your models with others. Use the protocol below to discuss your models.

<u>Discussion Protocol</u>

a. Decide who will go first and move clockwise around your group.
b. Share your model with the group as you use it to explain where the new molecules of the new substance come from. Be sure to explain *how* the new substance was made.
c. Discuss how your model helped you understand and explain what you cannot see because it is too small.
d. Think about the questions you had about your model. Listen to others' ideas and see if you need to use some of their ideas to make your model better.
e. If you still have questions about how to show something in your model after everyone has shared, ask your teammates for help.

Revisiting the Consensus Model

Scientists Circle

Head to the Scientists Circle with your notebooks and explanations. We updated our consensus model several lessons ago.

2. Take a moment to look over our model from Lesson 7 and think about what details we could add or what we need to change.

3. Review the new vocabulary—reactants and products—that we put on the Word Wall. Use this new vocabulary as you talk about the molecules you start with in the reaction and the molecules you end with.

4. Participate with your class to discuss the revisions that we need to make on the class consensus model.

Individual Assessment

We still have more to figure out about what happens in the liquid. We will spend some time digging into the data on *Explaining New Aspects of the Anchoring Phenomena* to help us figure this out.

Another group of students in another class that investigated bath bombs wondered if the chemical reaction between citric acid, baking soda, and water produced other substances besides carbon dioxide.

On your own

5. On your own:

a. Explain why it could be possible that water is a product in this chemical reaction.

b. Analyze property data and use it to argue whether one of the solids found in the container after the water has been boiled off is a new substance.

c. Use molecular models to argue which substance is a possible product in the chemical reaction.

6. Before you leave class:

a. Separate questions 1 and 2 of your assessment and turn it in.

b. Tape the remaining pages of the assessment (question 3 and the related molecular models) into your science notebook to work on more with a partner next time.

Compare and develop models with a partner.

Question 2 on the individual assessment from yesterday asked you to analyze property data and use it to argue whether one the solids found in the container after the water has been boiled off is a new substance. **Question 3** asked you to consider what that substance could be that was made using different molecular models.

With a partner

7. Look at Part 3 of *Explaining New Aspects of the Anchoring Phenomena* with a partner.

a. Discuss what claims you can make about which substance could be produced from the bath bomb using the molecular models.

Update our Class Consensus Model.

Scientists Circle

Join your classmates in a Scientists Circle around the model revisions from yesterday.

8. Thinking about our work with our partners on question 3, what revisions should we make to this model?

Now, we will consider the number of molecules on our consensus model.

9. Do you think that there is only this number of molecules of these substances in the bath bomb?

Look at *Comparing Molecular Ratios in a Chemical Reaction* with a partner.

10. Which of these models is a stronger model for supporting an explanation for why the mass of the closed system didn't change during the reaction?

Be ready to share your ideas with the class.

11. Work with your class to update the consensus model with the class ideas.

Revisit the Driving Question Board (DQB).

With a partner

12. Look back at the DQB in your notebooks. With a partner, evaluate which questions we have answered on our DQB. Mark them on the handout in your notebook as follows:

    nothing = Our class did not answer any part of this question yet.

    ✓ = Our class answered some parts of this question, or the ideas we developed could help us answer some parts of it.

    ✓✓= Our class answered this question, or the ideas we developed could answer it. Be ready to share how much of the DQB we now think we can answer as a class.

Think about our odor questions.

With a partner

13. Consider the following questions with a partner:
    a. Do you think these store bought bath bombs have the same odor as ours?
    b. How is your body able to detect a different odor anyway?
    c. What could we do to investigate these questions?
14. Be ready to share your ideas with the class.

Lesson 13: Why do different substances have different odors and how do we detect them?

What do we still need to figure out?

Review questions on our Driving Question Board (DQB) about odors.

Turn and talk

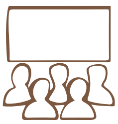
1. Turn and talk to a partner about these questions:
   a. What were some remaining questions we had about odor?
   b. What were some ideas we had for investigating those?

Be ready to share your ideas with the class.

Let's investigate odors.

We want to figure out: Why do different substances have different odors? And how do we detect an odor?

With your class



Think about these questions:

2. Are there times that you have smelled something without being able to see where the odor is coming from, but you could still identify what the smell was coming from?
3. How did you know what substance the odor was coming from?

In your notebook

Conduct an odor lab to determine if we can identify substances by their odor. Use your Progress Tracker to record what we figure out.

4. Draw a two-column tracker.
5. Draw a horizontal line halfway down the page.
6. Record the first question: "Why do different substances have different odors?" in the top section.
7. Write the second question: "How do we detect odors?" in the bottom section.

As you go through the lab, use this space to record what you figure out about each of the questions on this page.

Conducting Our Odor Lab

Using vials of different substances, smell it to identify the substance. Use the technique of **wafting** in order to determine if these substances have an odor and what the odor is.

Safety Precautions

8. How to smell odors safely by wafting:
   a. Hold the vial in one hand and make sure the top is open.
   b. Using your other hand wave it over the air above the top of the vial, as if you are scooping it toward your nose.

With your group

9. Use *Odor Lab* and your Progress Tracker to record your data.
   a. Take turns smelling each of the vials and recording your observations.
   b. Return the vials to the center of the table.
   c. Pick up *Molecular Models of Different Substances*.
   d. Compare the different molecules and record your noticings on your handout.

Reflect on our main questions about odor.

With your class

10. Now answer our two questions about odors:
    a. Why do different substances have different odors?
    b. How do we detect odors?
11. Why would these different molecules have different odors if they have the same type of atoms that make them up?

On your own

12. Read a short article, *Reading: How do we detect odors?*. Write the following question at the top of your reading: “How do we detect odors?”
13. As you read the article:
    a. Highlight any information that will help answer this question.
    b. Annotate any sections that contain information to help answer this question.
    c. Remember to fill in your Progress Tracker with anything you have figured out.

Develop an explanation.

On your own

14. Use the next blank page in your science notebook to explain what you have figured out to answer: What is an odor and how do we detect it?
    a. Use the resources you have in your Progress Tracker, on *Molecular Models of Different Substances*, *Odor Lab*, and *Reading: How do we detect odors?*.
    b. When you are finished, flag your explanation page with a sticky note.

Lesson 14: What is happening to the Taj Mahal?

Navigation

A few days ago we determined that we made a lot of progress on our Driving Question Board (DQB) and we identified one remaining area of questions related to odor that we wanted to make progress on.

With your class

Be ready to share your ideas with the class.

1. What was one of the most interesting things you discovered in the work you did in the last lesson related to odor?

Taj Mahal

Now, we will get oriented to the context together, before you start the individual portion of the assessment. In the assessment you will try to explain what is happening to this monument called the Taj Mahal, which is one of the seven wonders of the world.

With your class

2. Below is an image of the Taj Mahal. Have you seen or heard of this monument?

We will see more about what is happening to this monument to prepare you for planning an investigation, writing an argument, and using a model to explain what is happening to it.

3. Read through the first part of the *Part 1: Explaining Marble Changes in the Taj Mahal* together, up until "Plan an Investigation."
4. The rest of this packet are tasks that you will do individually this period and the next.

Taj Mahal Assessment Instructions

On your own

5. All students will do part 1, and then using what you did in part 1, you will have a choice for two different paths you will follow for part 2.
6. Part 2a is a challenging set of modeling and explanation tasks that revolve around trying to explain further what is happening to the marble that the Taj Mahal is made of and advising the Indian government on what pollutants might be responsible for this.
7. Part 2b is an even more challenging set of modeling and explanation tasks that revolve around trying to explain what is happening to the iron rods and clamps that are being used to hold this marble together.

Part 1 of the Assessment

On your own

8. Follow the steps on *Part 1: Explaining Marble Changes in the Taj Mahal*.
9. Follow the cleanup procedure when you are finished with the investigation.
10. Be sure to turn in Part 1 of your assessment before you leave.

Part 2 of the Assessment

On your own

11. You will have the next 30 minutes to complete part 2 of the *Part 1: Explaining Marble Changes in the Taj Mahal*.
12. Be sure to turn in part 2 of your assessment when you finish.

Reflection on Norms

On your own

13. Look back at the norms we have for our class. On your own, reflect on which ones you felt successful with.

With a partner

14. Share with a partner the norm(s) you felt successful with in this unit.

Reflection on End of Unit

On your own

On a notecard, answer the following questions:

15. What was most rewarding in this unit?
16. What was most challenging?
17. What might you want to do differently the next time you engage in making sense of phenomena in your next unit of study

Investigating Gas from Bath Bombs in a Bottle

Follow these procedures to help determine your answer to the question “Is the gas coming from the bath bombs already there to start with?”

1. Measure 100 mL (100 g) of water into the bottle.
2. Put 8 mini bath bombs (from Recipe B) into a small plastic test tube.

3. Carefully slide the test tube of bath bombs into the bottle so they don’t spill into the water.

4. Tighten the cap onto the bottle.
5. Obtain the mass for the whole system. Record the mass.

6. Turn the bottle over to mix the bath bombs into the water.
7. Wait for the bubbles to stop fizzing.

8. Obtain and record the mass of the whole system again.

9. Slowly remove the cap.
10. Obtain the mass of the whole system (including the bottle cap). Record the mass.
11. Rinse out the bottle for other students to use, and put away materials as directed.

Lab Procedure for Mixing the Ingredients in the Water

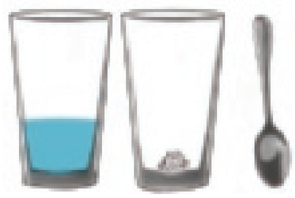
Follow these procedures to help determine your answer to the question "Will mixing the individual ingredients with water create gas bubbles?"

1. Obtain the materials from your teacher:

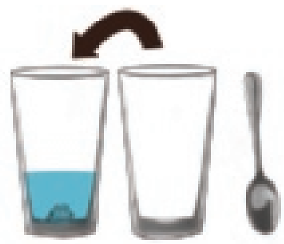
2 cups each containing each of the assigned ingredients

2 cups filled ¼ up with water

1 spoon for mixing

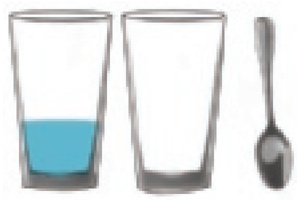


2. Add one of the ingredients to the water and record your observations.



3. Slowly mix the ingredient with the water using the spoon. Record your observations as you mix the ingredient with the water.

4. Remove the spoon, then obtain and record a final observation.



5. Repeat steps 2–4 for the other ingredient.

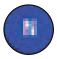
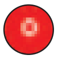
6. Rinse out the cups for future use, and put away materials as directed.

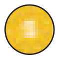
Lemonade Mix Labels

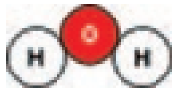
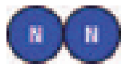
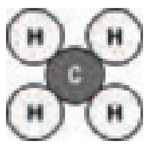
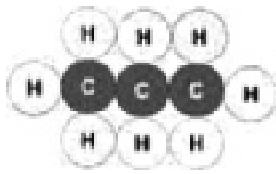
Sugar-free lemonade mix
INGREDIENTS: CITRIC ACID, POTASSIUM CIRATE, SODIUM CIRATE, ASPARTAME, MAGNESIUM OXIDE, MALTODEXTRIN, CONTAINS LESS THAN 2% OF NATURAL FLAVOR, ACESULFAME POTASSIUM, SOY LECITHIN, ARTIFICAL COLOR, YELLOW 5, BHA (PRESERVES FRESHNESS).

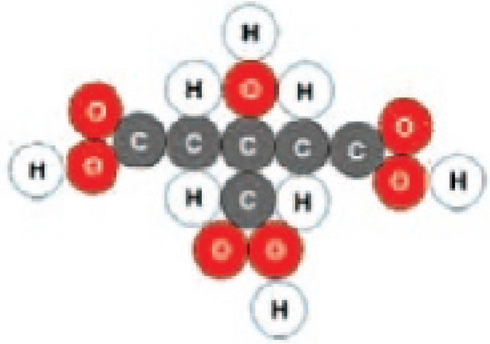
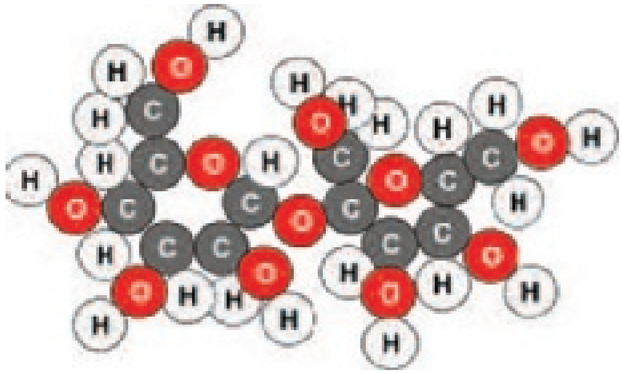
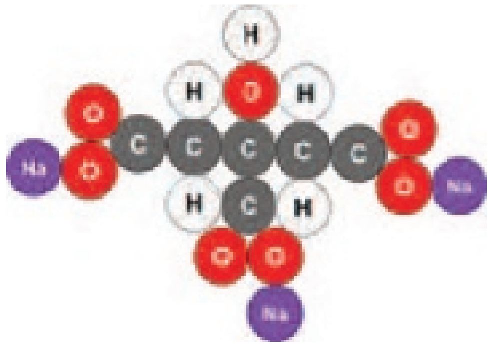
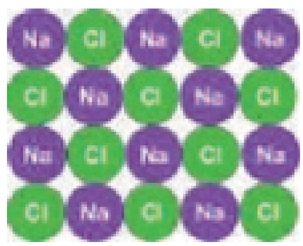
Lemonade mix
INGREDIENTS: SUGAR, FRUCTOSE, CITRIC ACID, CONTAINS LESS THAN 2% OF MALTODEXTRIN, SODIUM ACID PYROPHOSPHATE, MAGNESIUM OXIDE, SODIUM CITRATE, ASCORBIC ACID (VITAMIN C), NATURAL FLAVOR, ARTIFICAL COLOR, YELLOW 5 LAKE, SOY LECITHIN, TOCOPHEROL (PRESERVE FRESHNESS).

Molecular Models of Different Substances

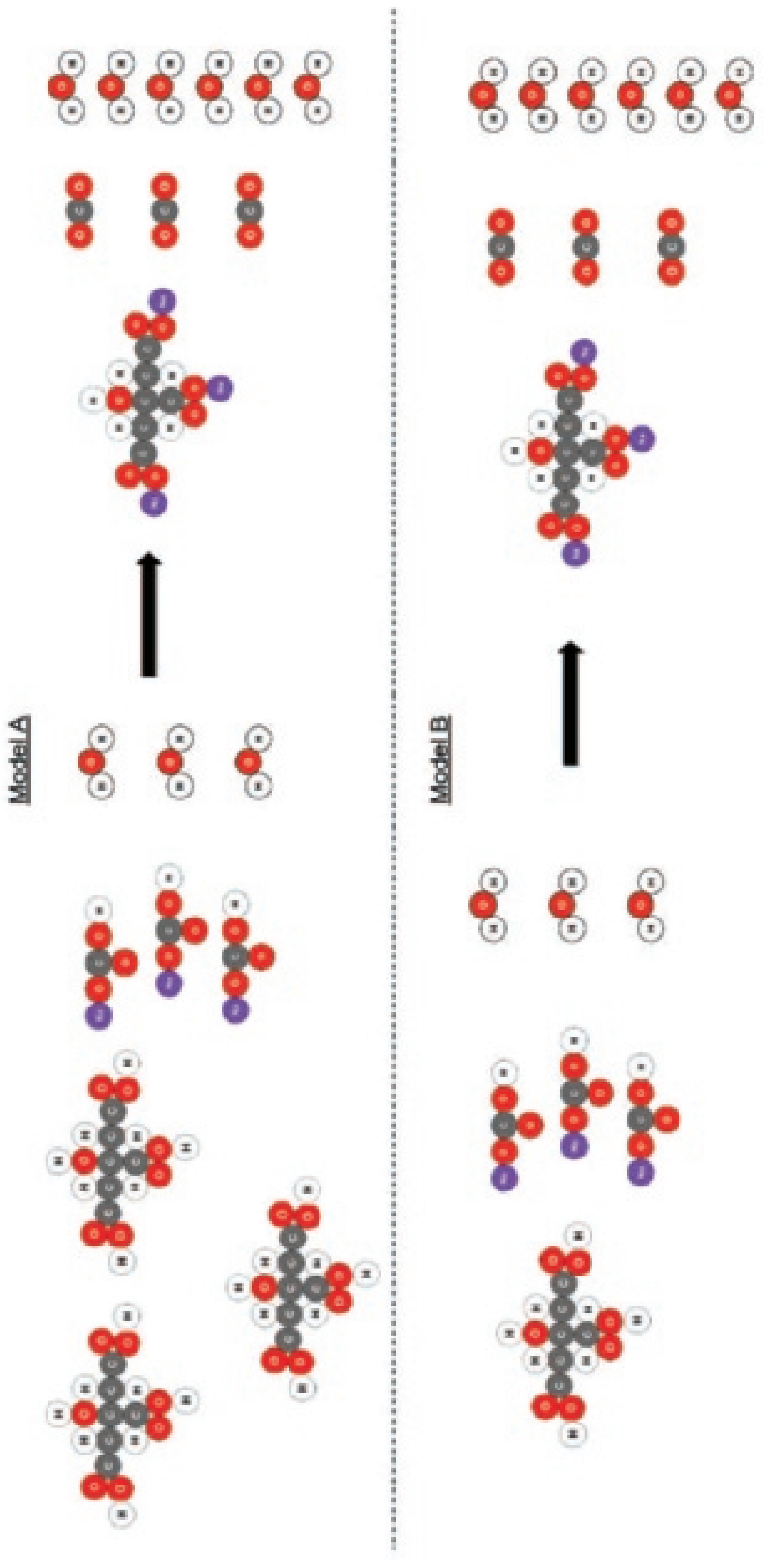
Atom Symbol	Atom Name
	Hydrogen
	Carbon
	Nitrogen
	Oxygen

Atom Symbol	Atom Name
	Sodium
	Magnesium
	Sulfur
	Chlorine
	Argon

Substance	Molecular Formula	2D Model
Water	H_2O	
Hydrogen gas	H_2	
Nitrogen gas	N_2	
Argon gas	Ar	
Oxygen gas	O_2	
Carbon dioxide	CO_2	
Carbon monoxide	CO	
Methane gas	CH_4	
Propane gas	C_3H_8	
Epsom salt magnesium sulfate *(Nonhydrous)*	$MgSO_4$	

Citric acid	$C_6H_8O_7$	
Sucrose *(one kind of sugar)*	$C_{12}H_{22}O_{11}$	
Sodium citrate	$Na_3C_6H_5O_7$	
Baking soda	$NaHCO_3$	
Table salt	NaCl	A single molecule of this substance is not well-defined. A salt crystal has a repeating structure similar to that shown to the right. 

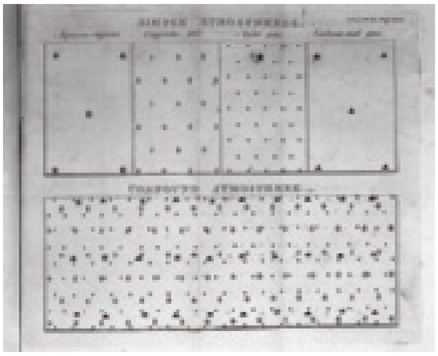
Comparing Molecular Ratios in a Chemical Reaction



Reading: Dalton’s Investigations

John Dalton was a retired school teacher in the early 1800s who was initially very interested in how different types of weather happened. In his attempts to figure out weather phenomena he took lots of measurements of the air where he lived. To study the air higher up, he climbed to the top of mountains and collected measurements of the air there and recorded them in his journal.

Dalton’s investigations into air helped him figure out that the air is made of more than one type of gas. At first, he assumed that air was made of the same type of particle throughout. But as he tested the air, he found he could isolate different gases that had different properties. He reasoned that the way each gas behaved (its properties), was due to the type of particle it was made of. He was able to isolate and identify four distinct gases in the air around us: water vapor, oxygen, nitrogen, and carbon dioxide.



The image to the left, shows a page out of Dalton’s journal where he tried to represent these gases at a particle level. The top portion of his journal shows how he pictured the gases as separate substances. The bottom image shows how he pictures the particles of those gases when they were mixed together in the air. Notice that Dalton used different shapes to represent the different particles rather than different colors. One reason for this may be because he was color blind (which was another phenomenon he also investigated and tried to explain).

These initial models worked with the ideas that different substances are made of different particles and that each individual substance is made of the same type of particle throughout. These models led Dalton to wonder how many different substances and therefore how many different types of particles there were in the world.

In order to figure out more about this, he tried heating and cooling different substances. Some were gases at room temperature, while others were liquids and solids at room temperature. Many of the investigations he conducted were on water. When he heated liquid water, he observed this caused gas bubbles to appear in the water, which then rose to the surface. You may have observed this too when heating liquid water.

As it turns out, Dalton was not the only scientist interested in what makes up substances. Around the same time that Dalton was heating different substances, other people were also experimenting with adding energy to water in a different way to see what would happen. They used a battery to run electricity through water. These scientists found that this also caused gas bubbles to appear in the water and rise to the surface.

In both cases, adding energy to water caused gas bubbles to appear. But what exactly was in those gas bubbles? Scientists had different ideas about that. They wondered:

- *Was the gas in the bubbles produced from both adding heat and adding electricity to the same substance?*
- *What substance was in those gas bubbles? Was it particles of water in gas form or was it particles of an entirely different substance?*

Reading: A Summary of Some Historical Investigations and Discoveries into the Particle Nature of Matter

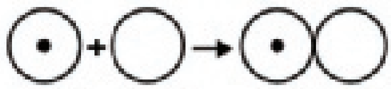
Let's revisit what John Dalton and his colleagues were investigating in the 1800s. Last we read, they carried out two different types of investigations with water, both involving adding energy to it. When they boiled water they argued that this did not produce a new substance. But when they added energy to water with a battery, they argued that this produced two new substances that weren't there before.

They conducted flammability tests and also measured the density of these gases. The one that exploded had a density of 0.09 g/L. This was much less dense than other flammable gases, like marsh gas (methane). The one that caused a match to burn brighter also caused a glowing ember to burst into flame. It had a density of 1.430 g/L.

> Pause here and take out your *Some Common Gases* and see if you can identify what these two gases are based on this property data.

Dalton developed a new idea to explain these results. He argued that water particles could be broken apart into the parts that make up each of the two gases. In his model, he assumed that each water particle was actually made of two smaller parts connected together. He called these smaller parts "atoms." The model of a water particle he developed contained one hydrogen atom and one oxygen atom.

He developed a way of representing this idea in a diagram, which is represented to the right.



> How does his model of a water particle compare to ones you developed and used in previous lessons?

In addition to making hydrogen gas and oxygen gas out of water, other scientists found you can also do the reverse. You can make water out of hydrogen gas and oxygen gas.

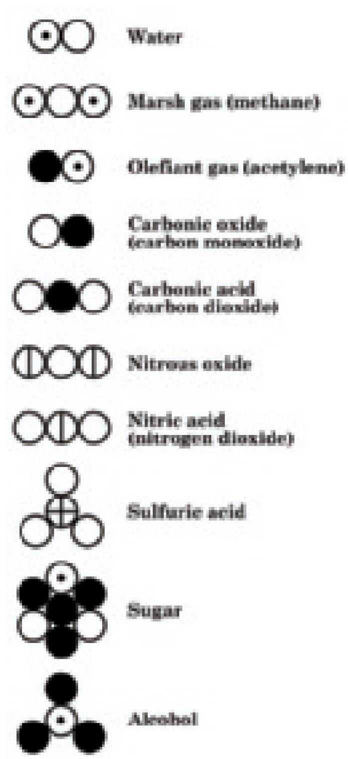
This happened when scientists combined both gases together and added a small bit of energy (e.g., a spark or a flame). This caused an explosion. When this was done in a container, water droplets appeared on the side of the container. When they did this in a closed system, the mass of the entire system did not change.

This showed scientists that you can also put atoms together to make a compound particle (water). This was the opposite of what happened when they broke water particles into hydrogen and oxygen atoms using energy from a battery. Scientists named the way that atoms can be rearranged to make new substances a "chemical reaction."

Over time, scientists started referring to compound particles, like water, as "molecules." Dalton did additional experiments on more substances to see if they were compound particles (molecules) that could be broken apart into smaller atoms. These experiments ended up producing the same type of gases over and over again, from the many different substances that he tested.

This led Dalton to suggest that all of these different substances were made of only a few different types of atoms. At first, he proposed that all of the substances he tested were made of only five different types of atoms. The diagrams here are replicas of those published by Dalton in 1803. Use these diagrams to see if you can explain how it is possible that just five types of atoms could make up these substances.

The compound particles (molecules) that these different substances are made of



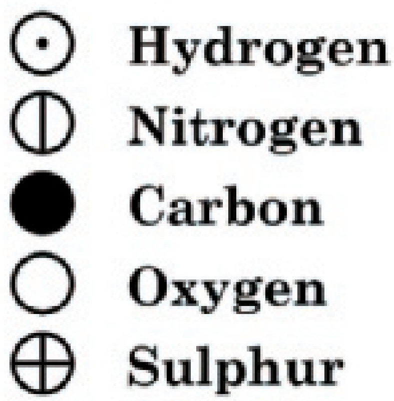
Only ten substances are listed in the diagram to the right. How many other substances do you think are made of the types of atoms shown below?

He found that molecules of both vinegar and sugar contained only three types of atoms—carbon, hydrogen, and oxygen. But sugar molecules were larger and had more carbon atoms in them than acetic acid (vinegar) molecules did.

One consistent piece of data Dalton collected when carrying out his investigations was the mass of the substances he started with as well as the mass of the new substances that were produced in his experiments. Because the mass of all of the substances in a closed system never changed in his experiments, regardless of what new substances were formed, it led him to propose the idea that atoms cannot be divided and cannot be destroyed, even in a chemical reaction.

As Dalton tested more substances, he discovered new types of atoms. He revised his model to include 20 different types of atoms. By the end of his life, the work of other scientists had contributed to the discovery of additional types of atoms bringing the total number of different types of atoms to 36 all together. These types of atoms included ones like iron, gold, copper, aluminum, and phosphorus.

Atoms are too small to see (an atom is a million times smaller than the thickest human hair). In spite of this, scientists found ways to determine exactly how many atoms made up different substances. Like us, they used investigations with water to figure this out. Dalton originally proposed that a single water molecule was made of one hydrogen atom and one oxygen atom. Later, scientists were able to show that a water molecule must be made of two hydrogen atoms and one oxygen atom.



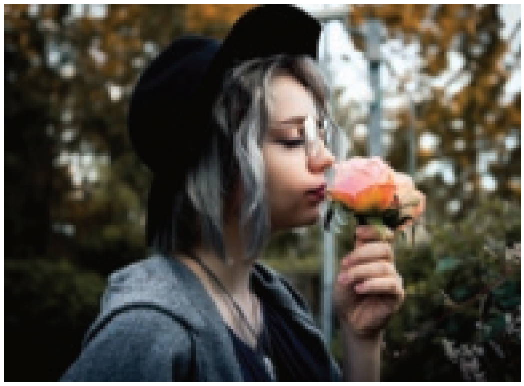
Types of Atoms

One piece of evidence that supported this was something you may have noticed when you used a battery to add energy to water and saw it produce gas bubbles. Think back to the investigation. What was something you noticed about the rate of bubble production in each of the test tubes?

The bubbles that contained hydrogen gas were produced at twice the rate and twice the volume as the bubbles that contained the oxygen gas. This was one line of evidence for supporting the idea that a water molecule is made of two hydrogen atoms and one oxygen atom.

Additional experiments since Dalton's time led other scientists to discover even more types of atoms. For example, in 1939 Marguerite Perey discovered a type of atom that she named Francium. This was one of the last types of atoms ever discovered in a natural source. There are now 94 types of atoms that we know of, all of which can be found in natural occuring sources. These few types of atoms make up all of the different substances found in our world today.

Reading: How do we detect odors?

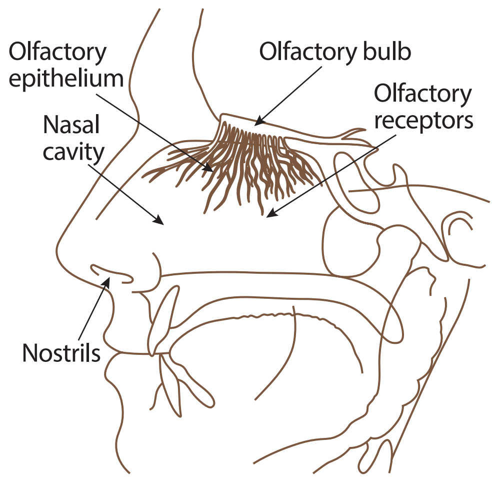


Imagine back to a time when you smelled something really pleasant, such as a type of flower, soap, or food. When you smelled these, how far away was the source from your nose? Was it right up against your nose? Or was it something you smelled from across the room or from something farther away?

Now imagine a time you smelled something that you did not like the odor of, such as burnt popcorn, hot asphalt, or a skunk. How close or far away were you from these things when you could smell them?

There are some odors that are very strong, such as lilacs, fresh baked cookies, burnt toast, or vinegar. Many times we can detect these smells even when we are not near the source they came from. How do you think we are able to smell something that is coming from something far away from our nose?

The way we smell something from far away is related to the movement of molecules from the source of the odor to our nose. This process is similar to what happens to water molecules when they evaporate. Have you ever left a glass of water out overnight? What have you noticed happening to the amount of water in the glass over time? Over time you probably noticed that the amount of water in the glass has decreased due to the water evaporating and becoming water vapor. This means molecules of water have separated from other molecules of water and are now in the air. The same thing happens to other substances—over time molecules of the substance can evaporate and the molecules then go into the air and move around. Eventually these molecules can reach our nose. This is what happens when we detect an odor. Our nose is detecting a certain type of molecule reaching it.



When these molecules reach our nose and we breathe them in, they enter the nasal cavity where there is mucus that these molecules dissolve in. Under this mucus is what is called the olfactory epithelium, where there are special receptors that can detect odors, called olfactory receptors. These receptors can detect many different odors. "The receptors are like locks and the keys to open these locks are the odor molecules that float past," explains Leslie Vosshall, a scientist who studies olfaction at Rockefeller University.

“Each receptor can be activated by many different types of molecules, and each molecule of an odor can activate several different types of receptors. Think of a lock that can be opened by 10 different keys. Two of the keys are a perfect fit and open the door easily. The other eight don’t fit as well, and it takes more jiggling to get the door open,” explains Vosshall. The molecules are like the keys that open these locks.

Once the odors make contact with a receptor they stick to it and are “locked” into the receptors. When this happens these types of receptor neurons relay a signal to the brain through other nerve cells that are part of a structure called the olfactory bulb that is located at the back of the nose. These signals are processed by our brain. Memories of other experiences with similar signals help us categorize and recognize times when we detected the same or very similar odor.

Similar odors tend to be caused by similar shaped molecules that reach these nerve cells. Different molecules have different atoms that make them up. Each different substance, therefore, is made of different kinds of molecules. When these different molecules enter our nose and nasal cavity, they might connect to one of the many different receptors that are able to accept their shape of molecule. Some molecules aren’t detected by our receptors, because their shape doesn’t fit into any of them. This explains why some molecules of substances that reach our noses seem odorless to us.

Most scents we recognize are composed of more than one type of odor molecule reaching our noses; a whiff of lavender, for example, is made up of 7 different types molecules and 2 of the main ones are linalool and linalyl acetate. When all 7 of those molecule types are received by the different receptors at the same time a signal is sent to the brain that we are smelling lavender.

There are scientists who study the sense of smell. These scientists estimate there to be around 1 trillion different scents that a human can potentially detect.

Adapted from the following sources:

1. Marin, A. (2015, Jan.). *Making sense of scents: Smell and the brain*. Retrieved from: www.brainfacts.org/thinking-sensing-and-behaving/smell/2015/making-sense-of-scents-smell-and-the-brain.
2. Williams, S.C.P. (2014, Mar.). Human Nose Can Detect a Trillion Smells. *Science*. www.sciencemag.org/news/2014/03/human-nose-can-detect-trillion-smells.
3. Morrison, J. (2014, Mar.). Human Nose Can Detect 1 Trillion Odours. *Nature News*. Retrieved from: www.nature.com/news/human-nose-can-detect-1-trillion-odours-1.14904.
4. Klein, J. (2018, Jan.) They Hunt. They Gather. They’re Very Good at Talking About Smells. *The New York Times*. Retrieved from: www.nytimes.com/2018/01/19/science/smells-descriptions-hunter-gatherers.html.
5. California Deaf and Blind Services (2004). The Sense of Smell: A Powerful Sense. Reprinted by: www.tsbvi.edu/seehear/summer05/smell.htm#:~:text=Vaporized%20odor%20molecules%20(chemicals)%20floating,receptor%20neurons%20detect%20the%20odor.

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