MIXTURES AND PHASE CHANGES

SCIENCE ACTIVITIES

SUPPLEMENTARY ACTIVITIES FOR OTHER CONTENT AREAS

FOCUS WORDS

Overview

Unit 8.5

This unit introduces students to mixtures and phase changes.

In this week's Reader's Theater, three friends are making pink lemonade and considering what happens to the drink as they add more powder. They use precise academic vocabulary such as *dissolve*, *dilute,* and *concentration* when talking about the sweetness of the lemonade. They then consider different kinds of drink mixtures like lemonade vs. smoothies and are introduced to the distinction between homogeneous and heterogeneous mixtures. One of the friends is inspired to use the information on homogeneous mixtures (also called *solutions*) for a science poster. To reinforce *concentration,* students consider how blood alcohol concentration (BAC) is determined by the relationship between a person's size and the amount of alcohol that they drink.

In *Speaking Scientifically*, students receive background information on mixtures and solutions and complete a chart that reinforces their understanding of *pure substances* and *mixtures.* Students then consider the kinds of mixtures that are present at a seaside scene and practice distinguishing between *homogeneous and heterogeneous mixtures.*

In *Going Through Phases,* students see how salt can be separated from seawater through a physical change process—*evaporation.* Likewise, students see how evaporated seawater can yield fresh water through another process called *condensation.* Students learn that these processes are examples of *phase changes* (as opposed to chemical reactions).

Students review physical changes at both the familiar and particulate scale and learn that heat causes macroscopic objects to expand, or increase in volume. This increase in volume results in a decrease in density. Here students review density = mass / volume and see the relationship between density and floating. This idea is reinforced through a tale of "The Three Little Chemists" who build a lab in a hot air balloon as a way of escaping the Big Bad Wolf.

Finally, students apply their understanding of this unit's information after learning about desalinization and the potential problems and solutions that communities may face when considering desalinization as a source for freshwater.

The word chart at the end of the unit should be used as a resource for students throughout the week.

Reader's Theater

The Science of Lemonade

Setting: Adam and Zena are at their Aunt Lucy's house after school with Olivia, mixing up some pink lemonade from a powder mix.

Olivia: Where's a pitcher? I'll fill it with water.

Zena: Nope, I make mine separately, because Adam makes it too sweet.

Adam: You don't make it sweet enough.

Zena: Yuck! Don't listen to him. Here's the right way to make it: Put four teaspoons of pink lemonade powder into a glass, like this, and then fill the glass with water. Perfect!

Olivia: Okay. How many teaspoons of powder do you use per glass, Adam?

Adam: Oh, I don't measure, exactly. I just eyeball it. I put water into the glass, like this... Then I shake some powder out of the package, like this...and stir it a bit. Look at the color. It's about as pink as Zena's, which means it's not as sweet as I like it.

Olivia: That's kind of interesting: You can "see" how sweet it is by looking at the color.

Adam: Right. The **concentration** of sugar and of food coloring in the lemonade go together. If you add more powder, the sugar **concentration** and the pink food coloring **concentration** both go up. So I add a bit more powder and stir again. There! It's a nice dark pink. That should be good... Yup! Tastes about right.

Zena: Suit yourself, Adam. Olivia, let's get you a drink.

Olivia: Thanks. I'm not sure how much of the powder to use. I guess I'll try four teaspoons, like Zena. It'll be easier to add more powder and make it sweeter than to take it out once it's mixed in. (*Olivia makes herself some lemonade and takes a sip.)* Hmm. Actually, even that is a little too sweet for me.

Zena: If you want it less sweet, you can just **dilute** it with a little more water.

Olivia: "**Dilute**"?

Zena: Yeah, **dilute**: Make it less **concentrated**.

Adam: Sure. You'll have the same amount of powder mix dissolved in your glass, but when you **dilute** it with more water it'll be less **concentrated**.

Olivia: There! It's not as pink now...and it's not as sweet. Good.

Zena: Hey, do you think that when we mix the pink lemonade powder in with the water, we get a chemical reaction, like we were learning about last week in Ms. Quintanilla's class? I mean, we're making a new substance, right?

Olivia: What new substance? Pink lemonade? That's just water with sugar, flavoring, and coloring mixed in, isn't it? I don't think we're making a chemical reaction and producing some kind of pink lemonade molecules...are we?

Zena: Why not? There's obviously some kind of change, and we learned in class that chemical reactions change matter. Maybe water reacts with the powder and makes a new compound.

Adam: Well, wait a minute. I don't think pink lemonade can be a compound. Look at our three glasses. Mine is the darkest pink and sweetest. Olivia's is the palest pink and the least sweet. And Zena's is in between. We learned that a compound combines different elements in *definite proportions*: all water has two atoms of hydrogen per one atom of oxygen, and so on. But we've got three samples of pink lemonade and each one combines its ingredients in different proportions. So if pink lemonade doesn't have definite proportions, I don't think it can be a compound.

Olivia: Yeah, I think it's just water with powder dissolved in it.

Zena: So is "dissolving" not a kind of chemical reaction? It's definitely a change. Is dissolving a kind of change that doesn't involve a chemical reaction?

Adam: I think it could be. We did learn that not all changes in matter are chemical reactions. Remember: When a nail rusts, that's a chemical reaction, but when it just bends, that's a physical change that's not a chemical reaction. So maybe dissolving is another kind of physical

Teacher Directions, Session 1

pages 2-7

Reader's Theater

There are several options for reading the Reader's Theater. You may want to have students read in small groups first and then assign parts for students to read in front of the class.

Prior to reading, explain to students that they will be introduced to new vocabulary terms and ideas that may not be familiar. Reassure them that this is okay. The reading is meant to introduce the ideas, not explain them completely. Look at the focus words at the top of the page. Show students the word chart at the back of the unit.

Consider previewing the Reader's Theater by asking students to look at the illustrations and consider what scientific topics might be covered in this unit based on these illustrations.

Reader's Theater

The Science of Lemonade

change that doesn't involve making new compounds. Maybe dissolving just mixes the molecules of different compounds together.

Olivia: The powder has sugar molecules, and I suppose the coloring and flavoring also come in the form of molecules. Maybe all those molecules just get mixed in with the water molecules. And if the molecules don't change, there's no chemical reaction.

Zena: Hmm. Okay, maybe mixing the molecules of the water and the pink lemonade mix is like mixing white rock gravel and black rock gravel. You could mix white and black gravel in different **concentrations** and get mixtures that would be different shades of gray when you looked at them from a distance. But there wouldn't actually be any grey rocks; the white and black rocks would all be the same as before. Maybe our glasses of lemonade are like that.

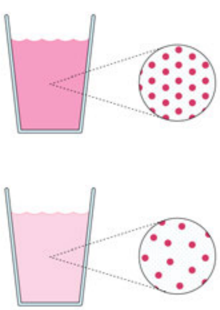
Adam: Well, I'm not sure. But I've got a **solution**. Hey, Aunt Lucy?

Aunt Lucy: (*coming into the kitchen)* Hi guys. What's up?

Adam: We were wondering whether you get a chemical reaction when you stir pink lemonade powder into water. We figured if there was a chemical reaction, there would have to be a new compound, and we weren't sure whether pink lemonade is a compound, because it isn't made with consistent proportions of ingredients. Some pink lemonade is **diluted**, like the weak stuff Zena likes...

Zena: And some is more **concentrated**, like that sickeningly sweet stuff Adam drinks.

Concentration is a **rate**: There are more food coloring, sugar, and flavoring molecules ***per unit of volume*** in highly **concentrated** pink lemonade than in less **concentrated**, more **dilute** pink lemonade.



Aunt Lucy: Um, okay. Well, when we talk about **concentration**, we're usually talking about a chemical **solution**, not a compound.

Oliva: A **solution** like the answer to a problem?

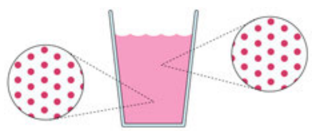
Aunt Lucy: No, I'm using the word **solution** in a different sense, related to the word "dissolve." A **solution** is what you get when you put compounds together and instead of a chemical reaction you get a **homogeneous** mixture. In a **homogeneous** mixture, the particles are evenly mixed together, the way the water molecules, sugar molecules, flavor molecules, and coloring molecules are in the pink lemonade. Samples taken from different parts of a **homogeneous** mixture will be exactly the same.

Adam: So are all mixtures **homogeneous**?

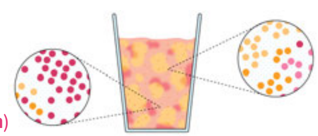
Olivia: No, I don't think that would make sense. If we made a smoothie in a blender and you took a sip, you might get a lump of banana. In another sip, you might get more strawberry, or more orange juice, or whatever ingredients you mixed into your smoothie.

Aunt Lucy: Right. A smoothie would be an example of an uneven, lumpy, **heterogeneous** mixture. Samples taken from different parts of a **heterogeneous** mixture may have different substances.

Homogeneous pink lemonade mixture (a **solution**)



Heterogeneous fruit smoothie mixture (not so smooth at a molecular level, so *not* a **solution**)



Zena: So when stuff dissolves and makes a **solution**, is that a kind of chemical reaction?

Aunt Lucy: No, dissolving is usually thought of as a physical change, not a chemical reaction. There are other physical changes, too, like when a substance changes from solid to liquid to gas—for example, water changing from ice to liquid water to steam. Those are called **phase** changes. A substance doesn't change its chemical composition just because it melts or evaporates. Water is still H_2O, whatever **phase** it's in.

Reader's Theater, continued

Ask students to think about other drinks. What are some other *solutions* or homogeneous mixtures?

Sports drinks are an example of heterogeneous mixtures. Sodas are too, but their carbonation makes them a more complicated case. A soda has sugar, flavoring, coloring, and carbon dioxide evenly dissolved in it. But when you shake and open a soda, and it becomes fizzy and foamy, is it still a homogeneous mixture? Well, the liquid part is still a solution of sugar, flavoring, and coloring in water; but some of the carbon dioxide comes out of solution to form gas bubbles, making a heterogeneous mixture of liquid and gas.

What are some other drinks that are heterogeneous mixtures? (Milkshakes, orange juice with pulp.)

(If students bring up milk, you may want to explain that it is actually a heterogeneous mixture of microscopic milk solids suspended in water.)

Reader's Theater

The Science of Lemonade

Olivia: And water is still H_2O even when it's got sugar molecules and other molecules from pink lemonade powder dissolved in it. It's still water, even though it's not pure water.

Aunt Lucy: Exactly. In fact, you can divide substances into pure and impure substances. Elements and compounds are pure substances. Another name for pure substances is "chemicals." Mixtures are impure substances, because they combine two or more pure substances. Within mixtures, you have **homogeneous** mixtures (also called **solutions**) and **heterogeneous** mixtures.

Zena: Wait, slow down. Let me grab some paper. Can you repeat that? We're supposed to make a poster about chemistry in Ms. Quintanilla's class for next Tuesday. If we use these categories, maybe we can make a kind of map for categorizing all kinds of matter.

Olivia: I think I'll do my poster on **concentration**. I can do the whole thing with pink lemonade!

Aunt Lucy: And I think I'll have a spoonful of this pink lemonade powder. I like it straight up, with no water!

Adam: Go Aunt Lucy! Now that's what I'm talkin' about!

Zena and Olivia: Eeeeeew!

Reader's Theater, continued

At the end of the Reader's Theater, Zena and Olivia remember that they need to make a poster about chemistry for a science project. Olivia thinks she can do the whole poster on *concentration* with pink lemonade.

Options for More Discussion

1. Without referring students to the word chart at the back of the unit, ask them to look at the focus words. Identify words that have multiple meanings. Discuss those multiple meanings with a partner.
    - *solution*: the answer to a problem
    - *concentration*: to be able to think about one thing for a long time
    - *phase*: a period in a person's life
2. Look at the photograph at the bottom of the page. Ask students what they think is happening. (lemonade stand) Ask students to think about how kids running a lemonade stand might increase profits by using some of the information in the Reader's Theater.

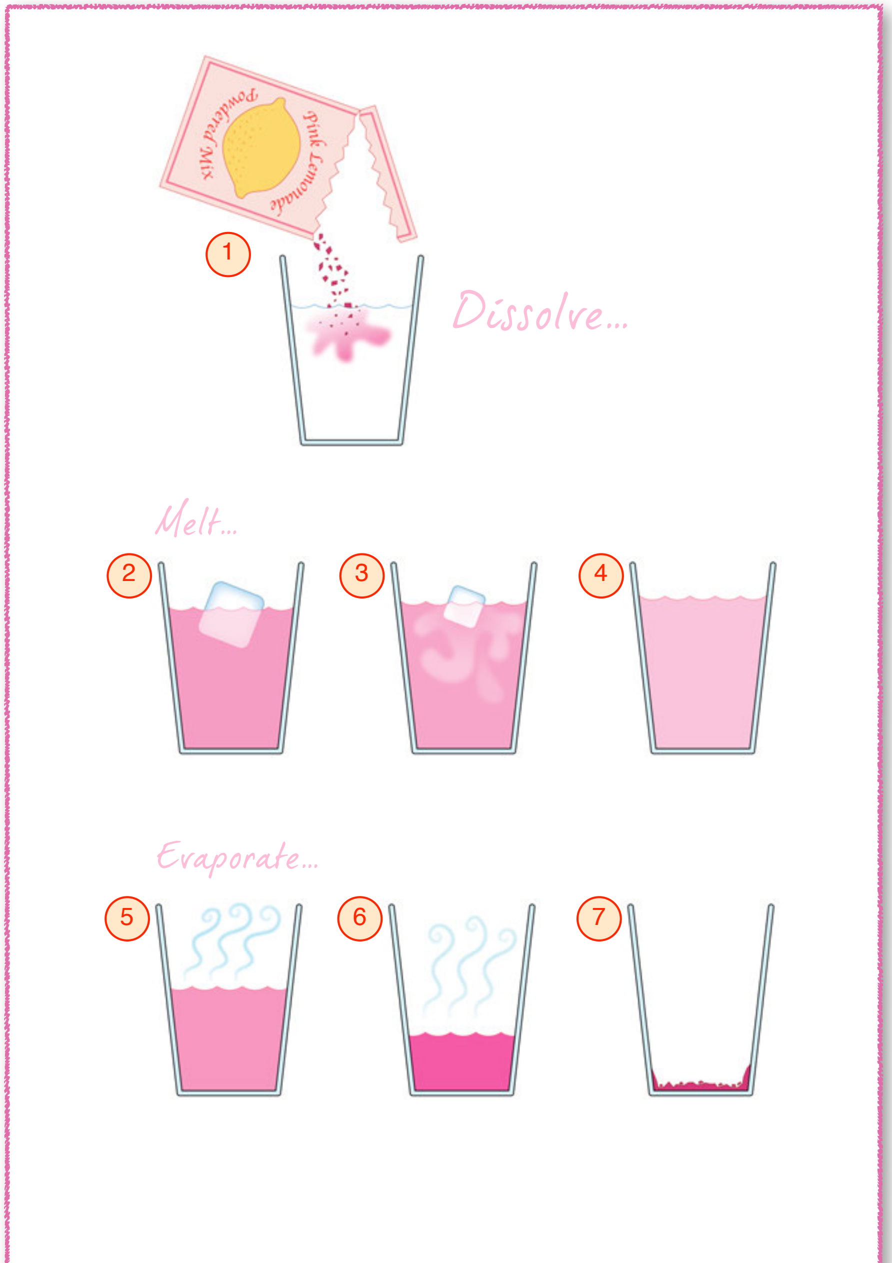
Sample response: *They could make the lemonade weaker by not using as much powder. This means that it will cost less money to make each glass of lemonade but they can still charge the same amount for each glass. Their profits will be higher because their costs will go down (unless, of course, customers stop buying the watered-down lemonade!).*

Ask students to fortify their response with more academic language by using the focus words.

More academic response: The proprietors could *dilute* the *solution* by reducing the amount of powder added to the mixture. While the lemonade will be less sweet, it will cost less to make each cup, thus making each sale more profitable.

A Closer Look at Concentration

Olivia's Poster



A Closer Look at Concentration

Olivia's Poster

Olivia's poster on **concentration** shows a simple story: Pink lemonade powder is poured into water to make a **solution**, and ice is added to cool it. But then the glass of lemonade gets left in a sunny spot for several days, with nobody drinking any of it. First the ice melts, and then eventually all the water evaporates, leaving the powdered mix re-solidified in the bottom of the glass.

TURN AND TALK

With a partner, help Olivia fill in some information to go along with the illustrations on her poster. (Thinking about how to fill in these blanks will help prepare you to consider a more serious **concentration** problem on the next page: drunk driving.)

As the ice melts into the solution…

What happens to the volume of the **solution**?

____

What happens to the amount of sugar, flavoring, and coloring molecules in the **solution**?

____

What happens to the **concentration** of the **solution**?

____

As the water evaporates from the solution…

What happens to the volume of the **solution**?

____

What happens to the amount of sugar, flavoring, and coloring molecules in the **solution**?

____

What happens to the **concentration** of the **solution**?

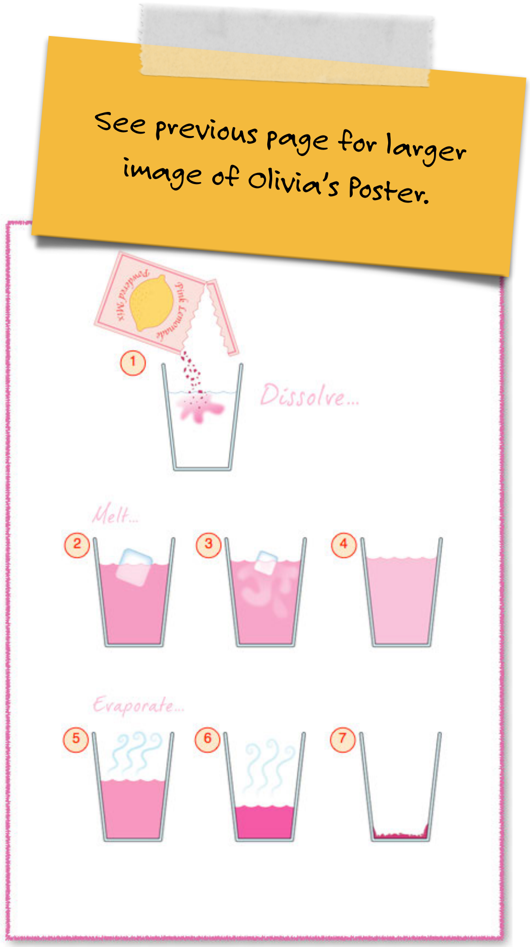
____

At which step are the contents of the glass *most **concentrated** and sweet?*

#____________________

At which step are the contents of the glass ***most dilute*** *and unsweet?*

#_________________________



A Closer Look at Concentration

Olivia's poster illustrates what happens to powder pink lemonade under a couple of different conditions. Read through the introductory text as a class and have students work in partners to answer the questions.

Answers (in order):

- The volume increases.
- They remain the same.
- The concentration of the solution goes down. (Or: The solution becomes more dilute).
- The volume decreases.
- They stay the same.
- The concentration goes up. (Or: The solution becomes more concentrated.)
- Step #7
- Step #4

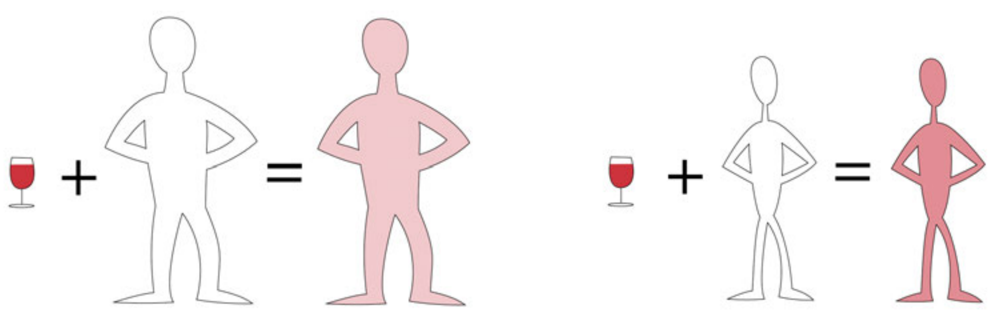
A Closer Look at Concentration

Blood Alcohol Concentration (BAC): A Matter of Life and Death

Blood is a **heterogeneous** mixture, with solid blood cells suspended in liquid blood plasma (made mostly of water). When people drink alcoholic beverages, the alcohol becomes dissolved in the blood plasma. The **concentration** of alcohol in the blood is one of the main factors in how drunk a person may become. To save lives, the law prohibits drivers from having too much alcohol in their bodies, even if they are of legal drinking age.

Laws restricting drunk driving generally set the legal limit for blood alcohol **concentration** (BAC) at 0.08% by volume for people who are old enough to drink.

Here's the question: Why do you think the legal drinking limit uses blood alcohol **concentration** instead of just setting a maximum number of drinks adults are allowed to drink before driving? Explain. (Hint: Think about Olivia's pink lemonade **concentration** poster, and look at the illustrations below.)



A Closer Look at Concentration, continued

If you have time, you can go ahead and complete the Blood Alcohol Concentration (BAC) activity today. Or you can stop here and continue tomorrow if you are able to extend this unit over an extra day or two at a slower pace. If neither of those options is viable, you can skip the BAC activity altogether.

Read the explanation on Blood Alcohol Concentration (BAC) and the question.

Before students write an explanation, ask them to discuss the topic with a partner. As students write, encourage them to use precise, academic words and phrases, including the focus words.

Less precise, more informal response:

Larger people have more blood in their bodies than smaller people. One drink in a small person is going to have a bigger effect than the same drink in a larger person. So to set a maximum number of drinks would not be the best way to tell if a person is getting too much alcohol or not.

More precise, academic response:

A person's Blood Alcohol **Concentration**, or BAC, depends on both the size of the person and the amount of alcohol that a person consumes. Since larger people have a greater volume of blood, they will have a lower BAC when drinking the same amount of alcohol as a smaller person. It's the concentration of alcohol that matters, not simply the total amount.

We can see the same idea with the medicine that we buy at the drug store. There are usually different dosages for children than adults because of body size and blood volume. Children taking the same amount of medicine as a person twice their size may actually be harmed by the medicine rather than helped.

Session 2

phase • homogeneous • heterogeneous • solution • dilute • density • concentration • fluid

Speaking Scientifically

A Map of Matter

Below is a diagram Zena made showing how different categories of matter fit into one another. In her diagram, more specific categories are nested inside of more general ones. Pretty much all the materials around you, and even in you, fit into one of the four categories in the diagram's white areas. In this section, we're focusing on the mixtures.


BRONZE HELMET


STEEL BEAM

CARBONATED WATER

Homogeneous mixtures (solutions)

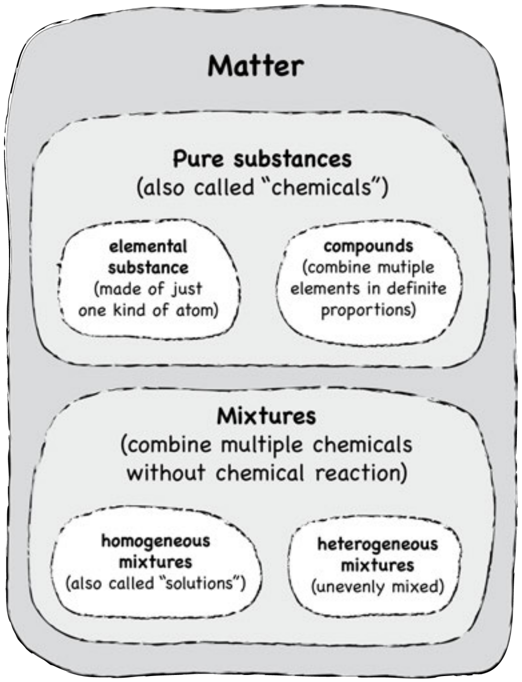
Mixtures with substances dissolved evenly into one another, like pink lemonade powder dissolved in water, are called **homogeneous** mixtures, or **solutions**.

It might surprise you to learn that **solutions** don't necessarily have to be made of a solid dissolved in a liquid. There can be solids dissolved in solids. For example, "alloys" are metals made by evenly mixing different metals together, or sometimes by mixing nonmetallic elements into metals. Alloys are mixed together while metals are melted, but they remain evenly mixed **solutions** when they cool and solidify. Bronze is a **homogeneous** mixture of copper (Cu) and tin (Sn). Steel is an alloy made by mixing a little carbon (C, a nonmetal), and sometimes other elements, into iron (Fe).

Gases can be dissolved in gases. For example, the air you breathe is a **solution** of oxygen gas (O_2), carbon dioxide gas (CO_2), and other gases dissolved in nitrogen gas (N_2). Apart from varying amounts of water vapor, "dry" air is about 78 percent nitrogen gas and 21 percent oxygen gas.

Gases can also be dissolved in liquid. For example, carbonated drinks have carbon dioxide (CO_2) dissolved in water (H_2O).

Liquids can be dissolved in liquids. Alcohol and water, for instance, will blend evenly into a **solution**.



Heterogeneous mixtures

Some substances, like oil and water, cannot dissolve into one another. Vinegar is made mostly of water (with acetic acid and various flavoring molecules), so oil and vinegar salad dressings are **heterogeneous** mixtures.

The world is full of **heterogeneous** mixtures. For example:

- concrete made with sand and other materials mixed together
- food with various ingredients stirred together but not perfectly dissolved
- dirt with tiny pieces of minerals and organic matter and pockets of air
- wood with solid fibers and tiny vessels carrying sap


OIL AND VINEGAR

Teacher Directions, Session 2

pages 8-14

Speaking Scientifically

The information on this page about classification of matter into pure substances and mixtures provides background information for the activity on the next page. Among other things, students learn that solutions are not always liquid: homogeneous mixtures can also take gaseous or solid forms. (In the case of a solid solution, like a metal alloy, the different chemicals typically become mixed in the liquid phase and later harden into a solid.)

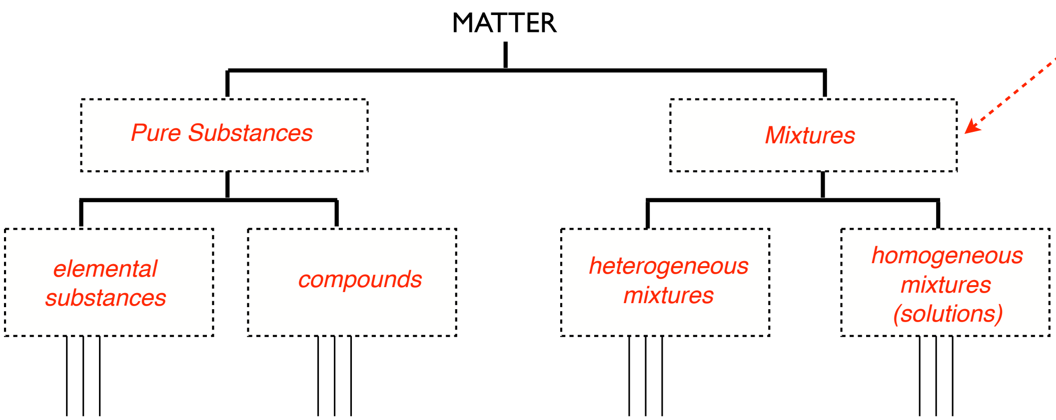
Speaking Scientifically

Name that Category

With a partner, examine the chart below. It represents the same categories as Zena's diagram, but most of the important labels are missing. This version is constructed like a flow chart or a family tree and has examples of each category of matter. Go over the examples at the bottom of the chart and work your way up, figuring out what label belongs in each blank box.

Here are the six terms to use to fill in the blanks:

heterogeneous mixtures
compounds
homogeneous mixtures (solutions)
pure substances (chemicals)
mixtures
elemental substances



- **Gold** (Au)
- **Helium** (He)
- **Oxygen gas** (O_2)
- **Ozone** (O_3)
- **Diamond** (carbon atoms arranged in a repeating three-dimensional structure)
- **Graphite** (carbon atoms arranged in two-dimensional sheets with a repeating hexagonal pattern)

- **Water** (H_2O)
- **Carbon dioxide** (CO_2)
- **Ammonia** (NH_3)
- **Glucose** ($C_6H_{12}O_6$)
- **Sodium chloride** (NaCl)
- **Silicon dioxide** (SiO_2)

- **Oil and vinegar dressing** (a mixture of small droplets of vinegar suspended in oil to make salad dressing)
- **Dirt** (mixture of minerals, organic matter, and air)
- **Mud** (mixture of dirt and water)
- **Fog** (water droplets suspended in air)
- **Granite** (a kind of rock made of grains of various mineral compounds; granite forms as molten rock cools gradually underground, with different minerals coming out of the **solution** to form solid crystals at different temperatures)
- **Lemonade with pulp**
- **Fruit smoothie**

- **Vinegar** (water with acetic acid dissolved in it, plus different molecules that give different flavoring to different kinds of vinegar)
- **Carbonated water** (carbon dioxide dissolved in water)
- **Metal alloys** (like bronze, brass, and steel)
- **Air** (nitrogen, oxygen, argon, carbon dioxide and other gases mixed evenly together, usually with water vapor as well)
- **Molten rock** (various minerals mixed together in liquid form at high temperatures underground; it is called lava when it is expelled by a volcano)
- **Pink lemonade from powdered mix**

Speaking Scientifically, continued

Students fill in the chart using the words at the top of this page. In these Teacher Directions, the correct answers have been filled in for you.

Speaking Scientifically

Seaside Mixtures

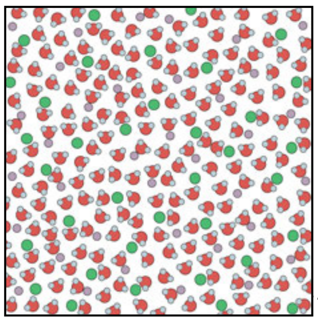
TURN AND TALK

Take a look at these particulate views of mixtures by the seashore. With a partner, talk about which mixtures you think are **homogeneous** and which you think are **heterogeneous**.

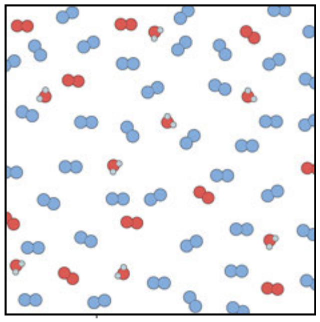
Elements shown

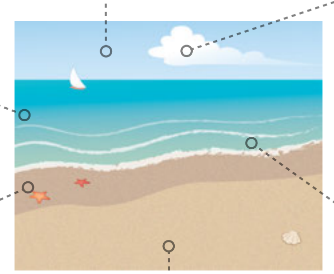
- chlorine (Cl)
- sodium (Na)
- hydrogen (H)
- oxygen (O)
- silicon (Si)
- nitrogen (N)

SALT WATER
Salts like sodium chlorine (NaCl, shown) dissolved in water. Sodium atoms are attracted to the oxygen atoms in water molecules, and chlorine atoms are attracted to the hydrogen atoms, pulling the sodium chloride apart.

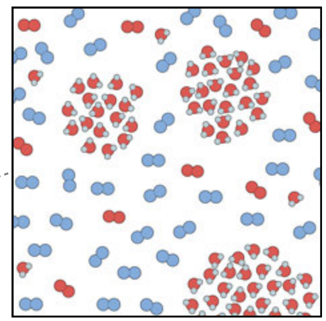


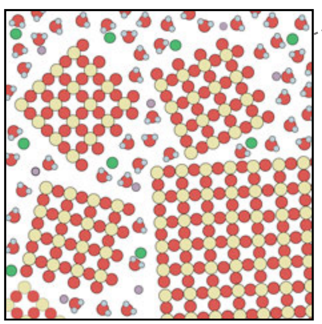
AIR
About 78% nitrogen gas (N_2) and 21% oxygen gas (O_2), with smaller amounts of other gases including water vapor, carbon dioxide, and argon.



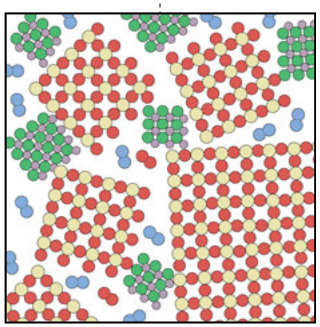


CLOUD
Microscopic droplets of liquid water suspended in **AIR**.

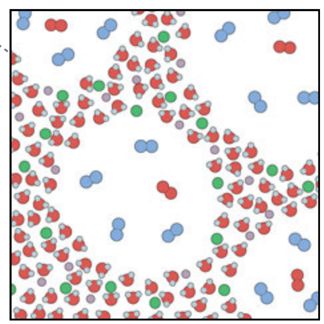




WET SAND
Pieces of solid silicon dioxide (SiO_2), mixed with **SALT WATER**.



DRY SAND
Pieces of solid silicon dioxide (SiO_2), mixed with salt crystals and **AIR**.



FOAM ON WAVES
Bubbles of **AIR** surrounded by **SALT WATER**.

Note: These illustrations are not drawn to scale: A water droplet in a cloud has many more water molecules than shown here, a grain of sand has many more oxygen and silicon atoms, etc.

Speaking Scientifically, continued

In this activity, students consider homogeneous and heterogeneous mixtures at a particulate level. The mixtures on this page could be found at a typical seaside scene—salt water, wet sand, air, dry sand, cloud, and foam on waves. Students determine whether each mixture is ***homogeneous*** or ***heterogeneous.***

Remind students about the examples of homogeneous pink lemonade and heterogeneous smoothies in the Reader's Theater. An illustration on page 3 compares particulate views of pink lemonade and smoothie.

More detailed descriptions of these mixtures follow on subsequent pages, but here is a quick rundown of which mixtures are homogeneous and which are heterogeneous:

Salt Water—homogeneous because the different atoms and molecules are evenly distributed

Air—homogeneous

Cloud—heterogeneous

Wet Sand—heterogeneous because the different atoms and molecules are grouped unevenly

Dry Sand—heterogeneous

Foam on waves—heterogeneous

Speaking Scientifically

Looking Through a Particulate Window

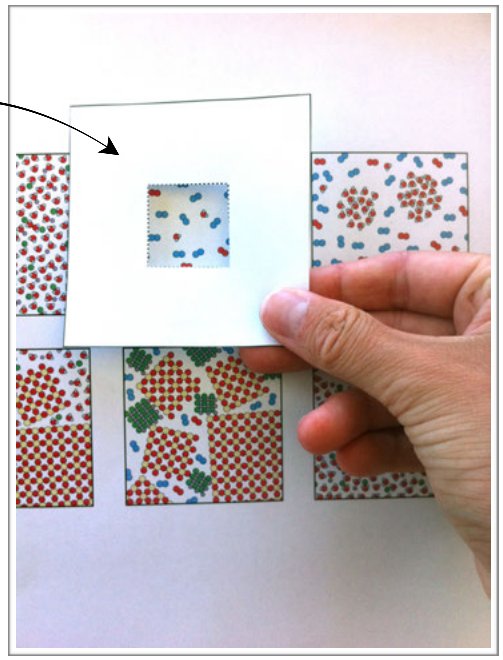
To help you decide which mixtures are **homogeneous** and which are **heterogeneous**, cut out the viewing frame below and move it over each picture on the pages that follow. Does the makeup of particles look about the same no matter which part of the image you sample? If so, the mixture is an even, **homogeneous** mixture (a **solution**). Does the mixture look different depending on which part you sample? If so, it is an uneven, **heterogeneous** mixture.

As you and a partner use the viewing frame to compare samples of the particles in each illustration, fill out the worksheet on the following pages. Say whether each mixture is **homogeneous** or **heterogeneous**. Explain your reasoning. Talk about what chemicals are found in each mixture and how they are mixed together in each case.

Cut out the viewing frame below and use it to look at the illustrations of the different seaside mixtures, as in the photograph.

cut here

cut here



Speaking Scientifically, continued

You can choose to either continue the lesson, break and continue tomorrow (if you are able to stretch this unit beyond one week), or stop here and proceed to the next lesson tomorrow if you do not have time to include this activity.

This activity is an opportunity for students to use a simple visual sampling device to check their perceptions from the previous activity.

Students should cut out the viewing frame and the small box within the frame. By moving the frame around over each drawing, students can determine if the substance is heterogeneous or homogeneous.

If the pattern appears consistent and repetitive regardless of where the frame is positioned, that means that the particles are evenly distributed throughout the substance, making it homogeneous. If placing the frame around different parts of an illustration shows distinctly different results, it's heterogeneous.

Have students use the frame to re-examine each of the seaside substances on the next few pages and explain if the mixture is heterogeneous or homogeneous.

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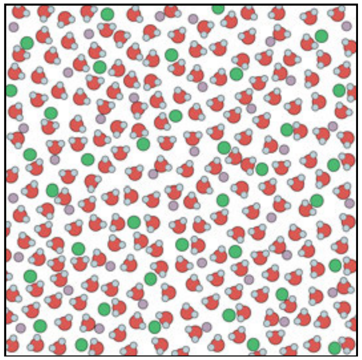
Speaking Scientifically

Looking Through a Particulate Window



SALT WATER

Salts like sodium chloride (NaCl) dissolved in water. When dissolved in water, the sodium and chlorine atoms are pulled apart from each other because of their attraction to different parts of the water molecules. The sodium atoms are attracted to the oxygen atoms in water molecules, and chlorine atoms are attracted to the hydrogen atoms.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

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____

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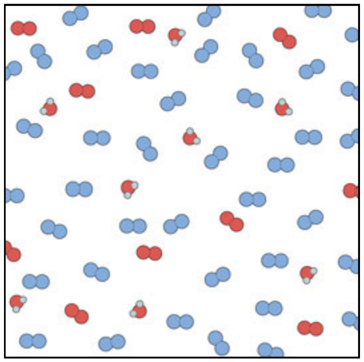

AIR

About 78% nitrogen gas (N_2) and 21% oxygen gas (O_2), with smaller amounts of other gases including water vapor, carbon dioxide, and argon.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

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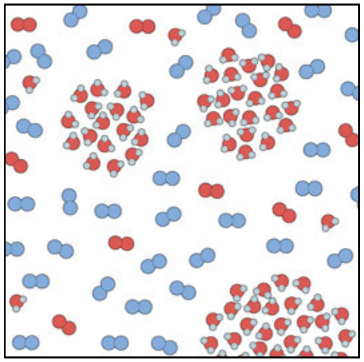

CLOUD

Microscopic droplets of liquid water suspended in **AIR**.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

____

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Speaking Scientifically, continued

Sample explanations:

Salt Water:

It's homogeneous because the sodium and chlorine atoms are spread evenly among the water molecules.

Air:

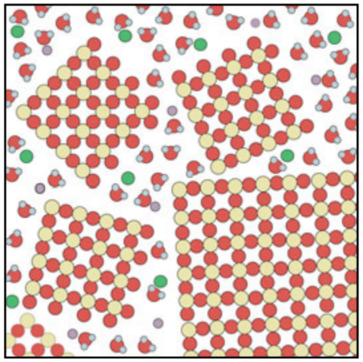
It's homogeneous because there is an even distribution of different kinds of molecules. The molecules are spaced equally.

Cloud:

It's heterogeneous because water molecules clump together in some places to form droplets, while other areas just have air.

Speaking Scientifically

Looking Through a Particulate Window



WET SAND
Pieces of solid silicon dioxide (SiO_2), mixed with **SALT WATER**.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

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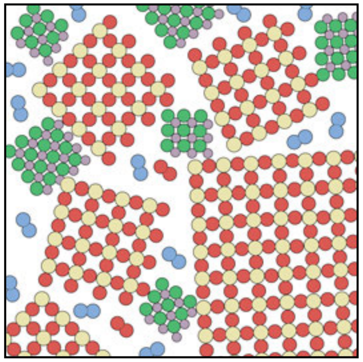

DRY SAND
Pieces of solid silicon dioxide (SiO_2), mixed with salt crystals and **AIR**.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

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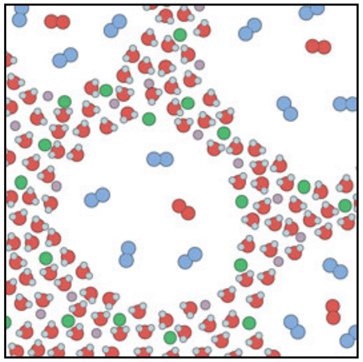


FOAM ON WAVES
Bubbles of **AIR** surrounded by **SALT WATER**.

Is this mixture **homogeneous** or **heterogeneous**? Explain:

___

___

___

___

Speaking Scientifically, continued

Sample explanations:

Wet Sand:
It's heterogeneous because in some places there are solid chunks of silicon dioxide, while in other places salt water fills the gaps between grains of sand.

Dry Sand:
It's heterogeneous because in some places there are solid grains of sand, in others there are solid salt crystals, and in the gaps between all these solids there is air.

Foam on Waves:
It's heterogeneous because some areas have salt water, but there are also bubbles of air separated by thin walls of salt water.

Going Through Phases

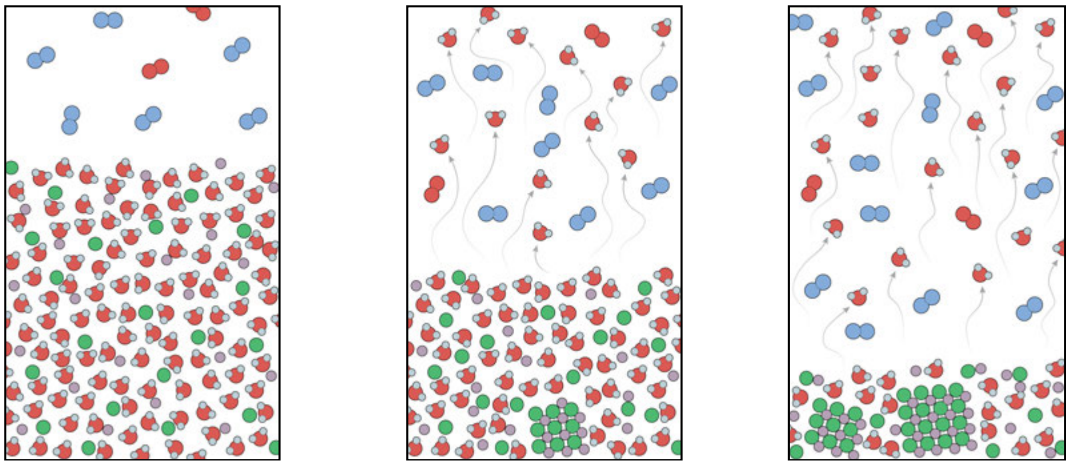
Concentrating on Evaporation

For chemists, one thing that distinguishes a mixture from a compound is that the ingredients in a mixture can be taken apart by a *physical process*, while the ingredients of a compound can only be taken apart by a *chemical reaction*. You can get solid salt out of a saltwater mixture by evaporating the water molecules away, a physical process requiring no chemical reaction. This evaporation might be caused by, for example, sunlight heating the water, so that many of the water molecules get enough energy to escape the salt water and fly into the air.

1 Salt water, with air above (mostly nitrogen & oxygen gas)

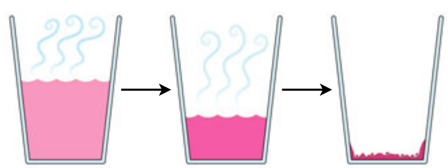
2 Some water molecules evaporate into the air...

3 More water molecules evaporate into the air...



Question: What happens to the saltwater **solution** as water molecules evaporate but sodium and chlorine atoms do not? Refer to the three pictures above, and use the words "**concentration**" and "**dilute**" in your explanation.

A salt pan worker in southern India harvests sea salt from evaporated seawater. **© 2012, Sandip Dey**



Hint: Remember what happened to the evaporating pink lemonade?

Teacher Directions, Session 3

pages 15-18

Going Through Phases

This session introduces students to phase changes—changes between solid, liquid, and gaseous states of matter. Building on the particulate views of mixtures from the previous session, this session starts by considering how salt can be separated from seawater by evaporating the water from the solution. Whether this evaporation happens naturally or is facilitated by humans, it increases the concentration of salt in seawater; if the salt concentration becomes high enough, solid salt crystals will come out of solution.

In the three particulate illustrations on this page, students consider what happens to the salt particles when seawater evaporates.

Ask students to think about their particulate window from yesterday. Ask if the illustrations show homogeneous or heterogeneous mixtures.

When seawater evaporates, only the water molecules evaporate into the air. The sodium and chlorine atoms do not; they remain in the seawater. As more water evaporates, students should notice that the sodium and chlorine form crystals of sodium chloride, just as the powder from pink lemonade recrystallizes when the water evaporates.

Students may write:

Before the evaporation, the salt water solution was more ***diluted****. But as a result of the evaporation of the water molecules, there is a higher* ***concentration*** *of sodium and chlorine in the seawater. As the* ***concentration*** *of salt increases, solid salt crystals start to form.*

Tell students to look at the photograph of the salt pan worker. This is how we get sea salt to put in our food. Ask them if this is a natural process, a human-engineered process, or both.

Going Through Phases

Fresh water from the sea?

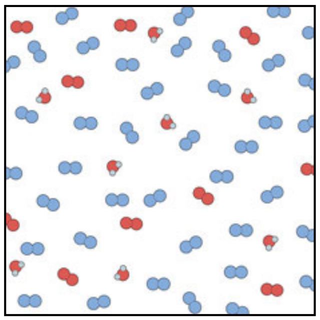
Water, water, every where,
Nor any drop to drink.

—Samuel Taylor Coleridge, *The Rime of the Ancient Mariner*

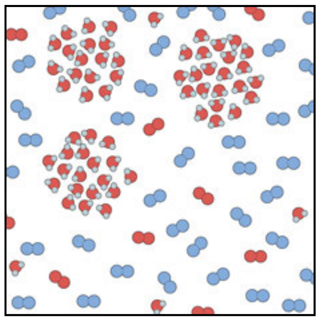
You can get salt out of seawater through evaporation. But what if what you really want is the *water* without the salt? The world has oceans full of salt water, but salt water isn't much use for drinking or agriculture. People need fresh water (that is, non-salty water), but fresh water is in short supply in many places. One possible **solution** is to get fresh water from seawater, leaving behind the salt. There are several ways to do this, one of which is a process called distillation.

Distilling seawater starts with the same process used for getting solid salt out of seawater: evaporation. Evaporation separates the water from the salt. But you can't drink water vapor directly out of the air. You also need to get the molecules of the water vapor to join back together into their drinkable, closely-packed liquid form, a process called condensation:

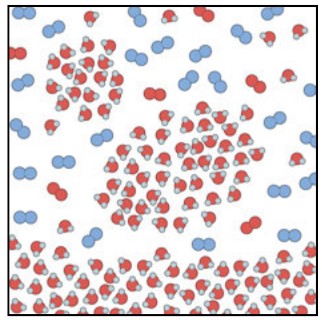
1 Water vapor in air...



2 condenses into cloud droplets...

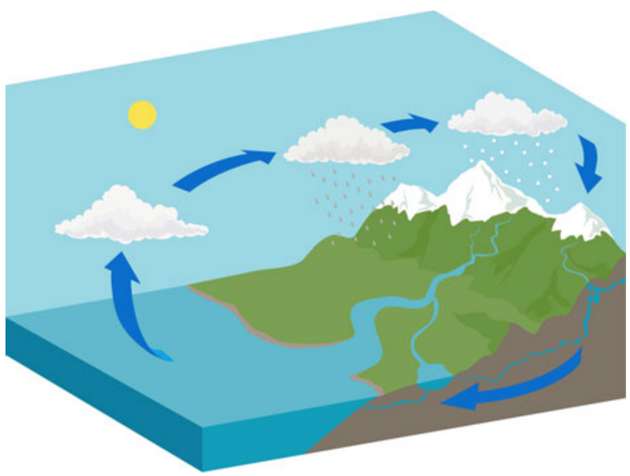


3 and falls down.



The higher the **concentration** of water vapor in the air, and the colder the air is, the easier it is for water molecules to clump together into a more dense liquid form. That's what puts the **density** in condensation!

So you get the salt water to evaporate by heating it, and then you get the water vapor to condense into liquid fresh water by cooling it. Nature runs this kind of distillation process all the time on a huge scale. The sun causes water to evaporate from the ocean, and then fresh water condenses into clouds and falls as rain or snow. That's where all the fresh water in rivers, lakes, and underground aquifers ultimately comes from.



Going Through Phases, continued

Ask students to read the lines from the Coleridge poem. Ask them if they've ever seen a movie or read a book where the character(s) were at sea and needed fresh water. What did the characters try to do to get freshwater? (Some students may have read the novel or seen the movie *Life of Pi*, in which the protagonist captures fresh water from evaporated seawater using a floating "solar still.")

The three particulate illustrations on this page pick up where the ones on the previous page left off. The previous illustrations showed water molecules evaporating from salt water, and so this new sequence starts with air that has lots of water vapor in it. When the concentration of water vapor in the air gets high enough (relative to the temperature—it has to be cold enough), the water molecules clump together into liquid droplets. This transition from gas to liquid is called condensation. As more water condenses, droplets join together into larger drops and can fall as rain.

The diagram at the bottom of the page shows the processes of evaporation and condensation at work on a massive scale, in the water cycle. Ask students to discuss the role that temperature plays in this process.

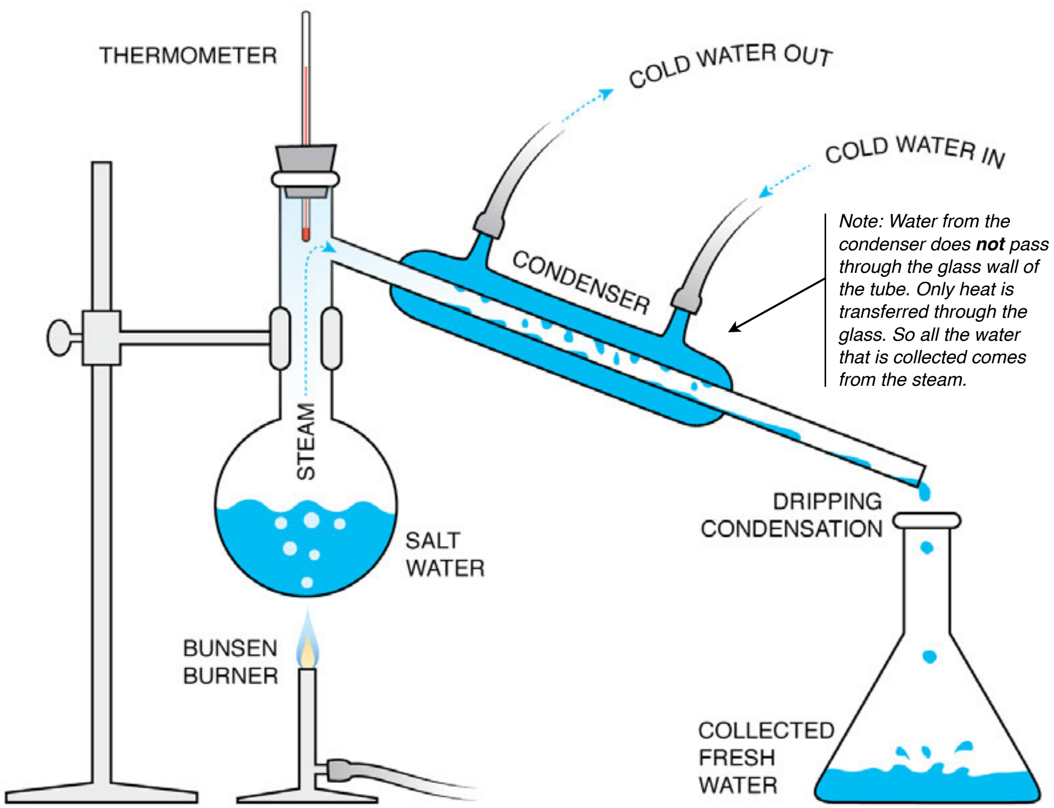
In general, colder temperatures with high water vapor concentration in the air promote condensation. Higher temperatures and lower water vapor concentration work against concentration.

Additional background information for teachers (you can choose how much detail to go into with students): The same concentration of water in the air may condense into rain or snow on a cold day but remain as vapor on a hot day. Conversely, the same air temperature may lead to rain on a very humid day or blue skies on a day with very low humidity.

Going Through Phases

Fresh water from the sea?

On a much smaller scale, a simpler distillation apparatus can be set up in a lab. The illustration below shows a beaker of salt water being heated with a bunsen burner. Steam (pure H_2O) rises, leaving the salt behind. When the steam gets into the glass pipe that is angled downward, it transfers its heat through the glass to cold water circulating in the surrounding condenser. Only heat passes between the pipe and the condenser, not water. In effect, the condenser is just a cold sleeve wrapped around the angled glass pipe. The cooled steam inside the pipe condenses and drips into a collection flask.



*Note: Water from the condenser does **not** pass through the glass wall of the tube. Only heat is transferred through the glass. So all the water that is collected comes from the steam.*

TURN AND TALK

How is the distillation apparatus illustrated above similar to the water cycle in nature? Specifically, which parts of the lab apparatus correspond to the sun, the ocean, cloud formation, rain, and rivers and lakes?

Going Through Phases, continued

This illustration shows how we can use laboratory equipment to replicate the distillation process seen in the water cycle illustration on the previous page.

Underscore for students that the cold water circulating in and out of the condenser is only there to transfer heat away from the steam. None of that cold water passes into the tube where the steam is. All of the water that drips into the collection flask is condensed steam from the original salt water.

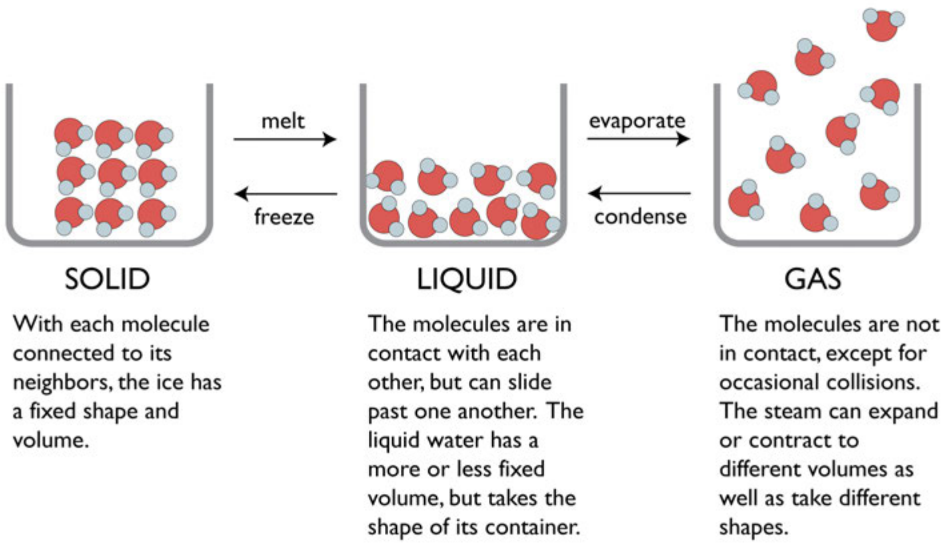
Ask students to label the equipment with the corresponding natural phenomena.

- bunsen burner—*sun*
- salt water—*the ocean*
- condenser—*cloud formation*
- dripping condensation—*rain*
- collected fresh water—*rivers and lakes*

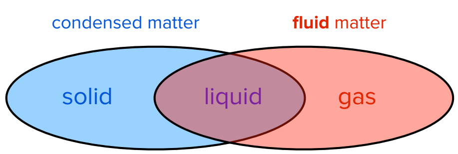
Going Through Phases

Phase Changes

Evaporation and condensation are both physical changes. More specifically, they are **phase** changes. **Phase** changes are changes between the solid, liquid, and gaseous forms of a substance. The most familiar example of **phase** changes is water:



Solids and liquids are both *condensed* ***phases*** of matter, with particles in continuous contact with each other. Liquids and gases are both ***fluid phases*** of matter, with particles able to change position relative to each other.



Notice that liquids are ***both*** condensed ***and*** **fluid**!

TURN AND TALK

When car mechanics talk about checking the **fluids** in a car, they generally mean the motor oil, transmission **fluid**, brake **fluid**, power steering **fluid**, coolant, and windshield washer **fluid**. How is this use of the word "**fluid**" different from the scientific definition of the word? What word could people use to be more scientifically precise about the "**fluids**" in cars? Should checking the air pressure in a car's tires be considered part of checking the car's **fluids**?

Going Through Phases, continued

The illustration on this page uses the familiar example of water to illustrate the three main phases of matter at a particulate level, and names most of the transitions between the phases. (Missing from this illustration are the less familiar transitions between the solid and gas phases: *sublimation*, in which a solid turns directly into a gas without passing through the liquid phase, and *deposition*, in which a gas turns directly into a solid.)

The captions for the illustration also characterize the phases in both macroscopic and particulate terms. At the ***macroscopic*** level, a solid has fixed shape and volume, a liquid has fixed volume and takes the shape of its container, and a gas assumes both the volume and shape of its container. At a ***particulate*** level, the particles in a solid remain connected to their neighbors in fixed positions (although they vibrate in place); the particles in a liquid slide past each other but remain in contact; and the particles in a gas lose contact with each other except for occasional collisions.

Ask students to turn and talk about more common words used to describe these phases of water.

- Solid—*ice*
- Liquid—*water*
- Gas—*steam*

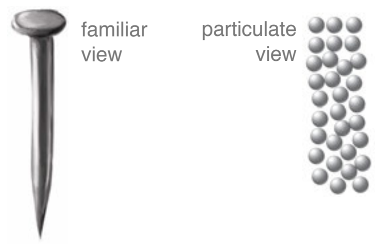
The scientific definitions of *condensed* and *fluid* matter may surprise students, but using these words more precisely may give students a more vivid understanding of matter at both the macroscopic and particulate levels.

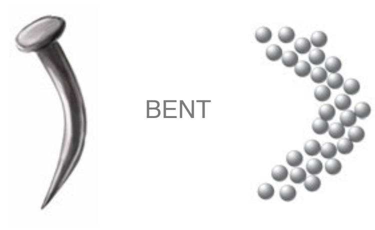
Turn and Talk: The items listed in the Turn and Talk fluid check are actually all *liquids*, so we could instead talk about checking a car's liquids. Colloquially, the word fluid is used to mean liquid. Technically speaking, the air in a car's tires is a fluid, although that's not the word most people would use.

Density

Heating Up and Spreading Out

When an iron nail rusts, it undergoes a chemical reaction. But when it bends, that's just a physical change, not a chemical reaction. There's no change in chemical composition: It's still just a bunch of iron atoms.



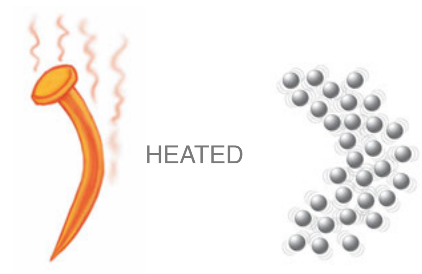


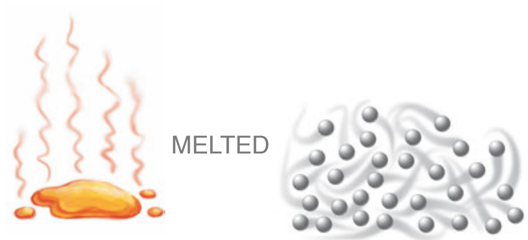
The iron nail can illustrate other physical changes. It can undergo expansion and even **phase** changes when its temperature is raised.

As the temperature climbs, the iron atoms move faster, bump into each other harder, and push each other away. They remain stuck in their relative positions, but their increased vibration causes the nail to expand slightly.

Suppose you heat the iron nail even more. At some point, the atoms have so much energy, and move so violently, that they're completely knocked out of position. They start to slide past each other. They are still in contact with each other (so they're in a condensed **phase**), but they can change position relative to each other (so they're in a **fluid phase**). The **phase** which is *both* condensed *and* **fluid** is the *liquid* **phase**.

If you could somehow heat the iron all the way up to 4982° F, the atoms would batter each other so hard that they would bounce off and lose direct contact with each other. You would have iron gas!





Teacher Directions, Session 4

pages 19-22

Density

This lesson discusses density (the ratio of mass to volume), using the previous discussion of phase change to come at density from a particulate perspective.

Students may remember the illustration of the straight and bent nails from unit 8.4. There, these images were paired with an image of a rusted nail (in both macroscopic and particulate views) to distinguish the chemical change of rusting from the physical change of bending. We return to these nail illustrations to further explore physical change.

Ask students if they've ever noticed how metal expands when heated. For example, a metal window sash might be harder to open or close during the hours when it receives direct sunlight and expands, making it bind in its track. Or if a metal lid on a glass jar is too tight to twist off, you can run hot tap water over the lid so that it expands slightly and is easier to remove.

The illustrations on this page show what happens at a particulate level to metal as it is heated. It's important that students see that as metal is heated, the particles are farther apart from teach other—but there are the same number of particles. (Students can count if they don't believe you! There are 31 iron atoms in each illustration.)

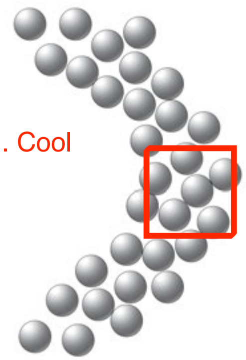
Notes on iconography:

In the particulate view of the "heated" nail, the small arcs that echo the shape of the atoms are intended to show that the atoms are vibrating in place. In the particulate view of the "melted" iron, long streaks or tails are intended to show the paths of the atoms as they tumble and swarm around each other.

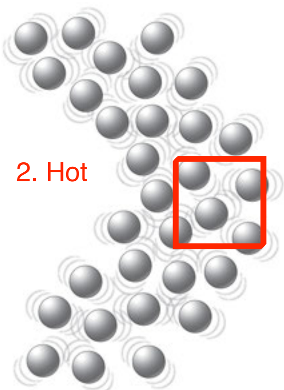
Density

Heating Up and Spreading Out

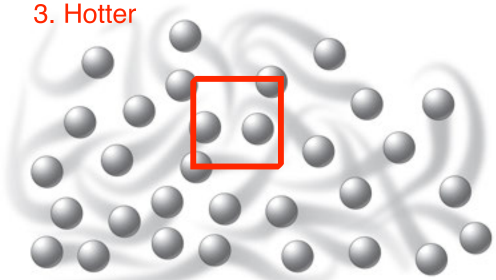
1. Cool



2. Hot



3. Hotter



Look again at the three illustrations of iron atoms at different temperatures. All the iron atoms are the same size, and there are 31 of them in each illustration. Those atoms take up more space as they heat up, move faster, and bounce off each other harder. There are the same number of atoms, just spread out more.

Each of the three illustrations has a square drawn over it. The three squares are the same size. What happens to the number of atoms inside the squares as you go from cooler to hotter?

____

____

____

____

As an iron nail heats up and expands its overall volume, one cubic centimeter of its substance has fewer atoms. With fewer atoms, one cubic centimeter of its substance has less mass, even though the overall mass of the expanded object is the same as before.

The ratio of mass to volume is called **density**. Put another way, **density** is mass divided by volume. So an iron nail becomes less dense as its temperature climbs.

Density = mass / volume

For example, ***density*** *is often measured in grams per cubic centimeter (g/cm^3).*

Iron at room temperature has a **density** of about 7.87 g/cm^3. For the following questions, assume the iron remains at room temperature.

What is the mass of three cubic centimeters of iron?

____

What is the volume of 15.74 grams of iron?

____

Density, continued

These illustrations again show the particulate view of iron at different temperatures. A square of the same size is overlaid on each of the three illustrations. The illustrations show the effect of temperature on density, as the wider spacing of atoms at higher temperatures reduces the number of atoms (and therefore the mass) in a same-size sample.

Students will see that there are fewer atoms in the square as heat is applied to the nail. Students may recognize that this means that the area is less dense.

Show students the formula for density:

- *Density = mass / volume*

Answers:

What happens to the number of atoms inside the squares as you go from cooler to hotter?

- *There are fewer iron atoms in the square as the temperature of the iron increases.*

What is the mass of three cubic centimeters of iron?

- *3 x 7.87 = 23.61 grams*

What is the volume of 15.74 grams of iron?

- *15.74 ÷ 7.87 = 2 cubic centimeters*

Density

Floating in Air

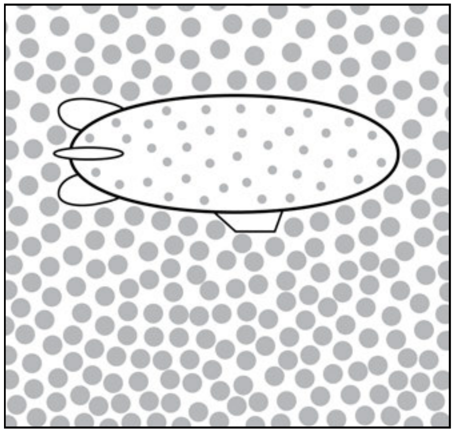
As you've seen with iron, the **density** of a substance can change with its temperature. But different materials at the same temperature also have different **densities**. If you have a cubic foot of lead, a cubic foot of water, and a cubic foot of Styrofoam all at the same temperature, they'll have very different masses, because they have very different **densities**.

Two ways to float in the air

An object placed in a **fluid** will float if it's less dense than the **fluid**, and sink if it's more dense than the **fluid**. Remember, a **fluid** can be either a liquid or a gas. The typical cases we see around us are things that float or sink in air, and things that float or sink in water. Iron is so dense that it sinks in water, whereas helium floats in air because it is less dense than air. Cork is less dense than water but more dense than air, so it floats on water but not in air.

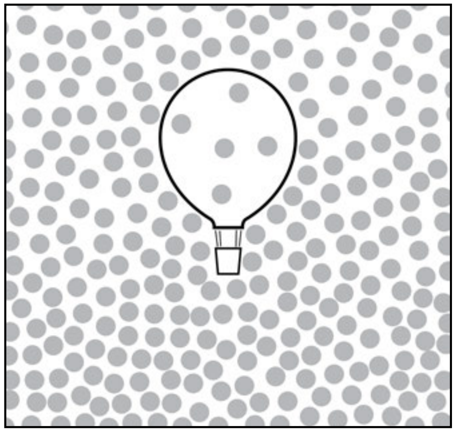
Remember, **density** is the ratio of mass to volume. So at a particulate level, the **density** of a substance is determined by two things: *how massive* the particles of the substance are, and *how closely packed or spread out* those particles are. These two aspects of **density** lead to two basic strategies for making lighter-than-air vehicles work.

Helium blimp



Helium-filled blimps and hot air balloons both float in the air by holding large volumes of low **density** gases. In a helium blimp, the gas is helium (He). At the same temperature and pressure as the surrounding air, helium has just as many atoms as the surrounding air has molecules. But the helium atoms are much less massive than the air molecules, so the helium is less dense.

Hot air balloon



In a hot air balloon, the air inside the balloon has pretty much the same kinds of molecules as the surrounding air. Compared to helium atoms, the nitrogen molecules (N_2) and oxygen molecules (O_2) that make up most of the air both inside and outside the balloon are pretty massive. But the molecules of heated air move fast and spread out more. Many of them are pushed out of the opening at the bottom of the hot air balloon, leaving the hot air inside the balloon less dense than the surrounding air.

Density, continued

The illustrations on this page show how density is related to floating.

Begin by asking students what they already know about items that float or sink in water. What about their own bodies when they try to swim? Students will know that wood floats and most will have learned that this is because wood is less dense than water.

Remind students that air is also a fluid. Anything that is less dense than air will float. Students will know that helium balloons float—but they may not know that this is because helium is less dense than air.

Illustrations:

Helium blimp

Helium is used in blimps to avoid such accidents. Draw students' attention to the different sizes of the molecules in the air and the helium atoms in the blimp. There are about the same number of air molecules and helium atoms per square centimeter of the illustration (which reflects the fact that a given volume of gas at a certain temperature and pressure will have the same number of molecules regardless of kind). However, the helium atoms are much smaller than most air molecules. Because of this difference in particle size, the helium filled blimp is less dense than the surrounding air. Therefore the blimp floats.

Hot air balloon

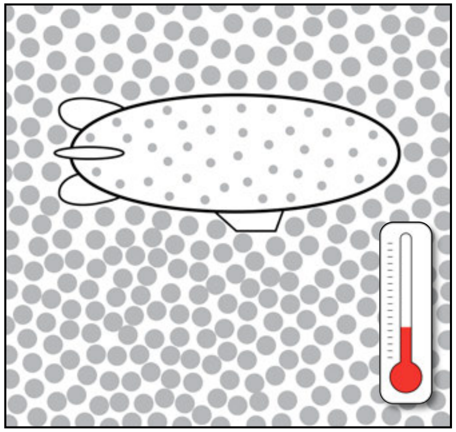
In a hot air balloon, the molecules inside the balloon and in the air are of the same kind, and therefore the same size. When the air in the balloon is heated, the molecules move and spread out. Excess molecules are forced out of the opening at the bottom of the balloon. This expansion due to heating makes the air inside less dense than the surrounding air, so the balloon floats.

Density

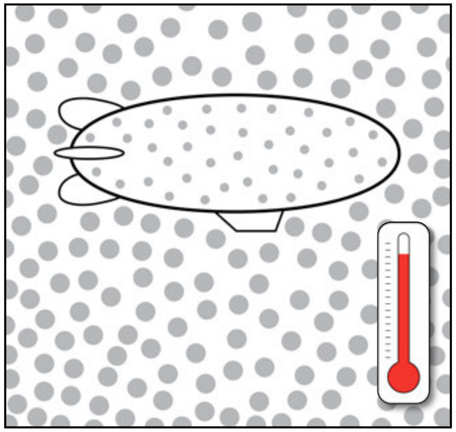
Floating in Air

It's not just what's inside the blimp or balloon that matters. The **density** of the air outside changes in different weather conditions. When the air is cold, it is denser because its molecules stay relatively close to each other. When the air heats up, its molecules move faster and spread out so that the air becomes less dense. Compare the two illustrations below. One shows the blimp in cooler, denser air, and the other shows the same blimp in warmer, less dense air.

Cooler, denser air



Warmer, less dense air



In both cases, the helium in the blimp is less dense than the surrounding air. But the blimp will rise more quickly and float more easily in one case than in the other. The air temperature might affect how much weight the blimp can lift—how many passengers or how much cargo it can carry.

TURN, TALK, AND WRITE

Do you think the blimp can carry more weight in cooler air or warmer air? Explain.

Density, continued

This activity asks students to consider the impact that air temperature has on the speed and ease with which a helium blimp will float.

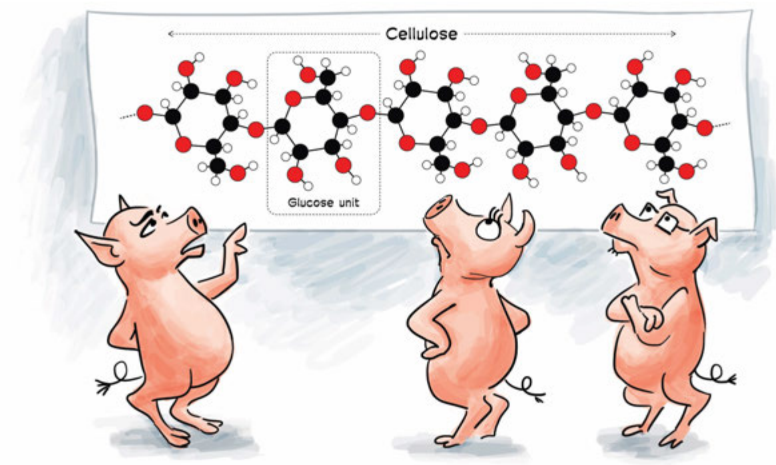
The particulate view of cooler and warmer air shows that cooler air is more dense. Assuming that the density of the blimp remains consistent in both situations, the greater contrast between its density and that of the cooler air will make it float more easily than it would in the warmer air. Because the blimp is more buoyant in colder air, it can carry more weight.

The following thought experiment may clarify how the contrast between the densities of a floating object and the medium in which it floats affects buoyancy. Students know that a helium balloon floats in air. Ask them to imagine pushing a helium balloon down through the air *and then down into water.* Assuming that the helium balloon does not burst and is not dramatically compressed (compression would change its density), will it be easier or harder to push the balloon down through water, compared with air? Many students will grasp intuitively that the balloon will be pushed upward more forcefully by the water than by the air. This contrast in "buoyant force" is caused by the different densities of water and air.

Technically (and this is probably too technical to go into with students at this point), buoyant force is equal to the weight of the displaced medium. (At constant gravity, weight is proportional to mass.) For example, if an iron anchor, a block of wood, and a helium balloon each displace ten pounds of water, each object will be pushed upward with a force of ten pounds. This will not be enough to lift the anchor (although it will reduce its perceived weight by ten pounds for someone in a boat dangling it under water on a rope); it will be enough to float the wood on the water's surface; and it will be enough to float the helium balloon. Unlike the wood, the helium balloon will also displace air with a mass, and therefore a weight, greater than its own; so the balloon will float in air.

Who's afraid of mixtures and density?

THE THREE LITTLE CHEMISTS AND THE BIG BAD WOLF



Once upon a time there were three little chemists who feared they would be eaten by the Big Bad Wolf. So they decided to move their laboratory out of the muddy end of the barnyard and into someplace safer.

"Let's build a high security laboratory," said Professor Bacon.

"What'll we make it out of?" asked Dr. Swineberg.

"Well," said Professor Bacon, "how about straw?"

"Sure," agreed Dr. Swineberg, shrugging her shoulders. "What could go wrong?"

"An intriguing suggestion," said Mr. Spork. "As an agricultural by-product from the growing of grain, straw should be plentiful around the farm. Straw is made of the dried, discarded stems of grain plants. More precisely, it is made mostly of cellulose, which is a long molecule made of many glucose molecules joined together. Glucose, of course, is a sugar molecule that plants produce through photosynthesis. It is made of carbon, hydrogen, and oxygen."

"Um… that's great, Spork," said Professor Bacon. "But enough chit-chat. We need to get the new lab built pronto, before the Big Bad Wolf comes and eats us."

Well, you know what happened, right? The Big Bad Wolf came along, and he huffed, and he puffed, and he blew the three little chemists' straw laboratory down! The three little chemists had to scramble to escape with their lives (and with their bunsen burners, test tubes, beakers, and other lab equipment).

Teacher Directions, Supplemental

pages 23-26

Who's afraid of mixtures and density?

There are several options for using this supplemental reading. It doesn't introduce new content, but it provides an entertaining review. If your class is finishing this unit in one week, you can either assign this reading as homework or skip it altogether. If you are able to stretch the unit over some additional days, this reading can become an in-class activity.

This short tale about the three little chemists and the big bad wolf reinforces the main ideas in this unit including:

- physical change (as opposed to chemical change, as treated in Unit 8.4)
- mixtures
- density

Suggested reading options (if done in class):

1. Turn into a Reader's Theater by assigning the following roles:
   a. Narrator (anything not in quotations)
   b. Professor Bacon
   c. Doctor Swineberg
   d. Mr. Spork
   e. Big Bad Wolf
2. Read in small groups of five. Assign same roles as above.
3. Read aloud to the class—changing voice for each character.

Who's afraid of mixtures and density?

When the Big Bad Wolf blew the straw lab down, was that a physical change or a chemical change? Explain. (Hint: Does the cellulose in the straw need to be transformed into another compound in order for the pieces of straw to separate from each other?)

"What a complete fail," said Professor Bacon. "We need to choose a more high-strength material for our next lab."

"Let's make it out of sticks," suggested Dr. Swineberg, waving her hoof at a nearby area of small trees.

"Interesting," said Mr. Spork. "Wood is composed largely of lignin. As with the cellulose in straw and other herbaceous plants, lignin is made of carbon, oxygen, and hydrogen. But lignin molecules are structured differently, and form networks with much greater rigidity, giving woody plants their characteristic strength."

"Spork," said Professor Bacon, "I can hardly understand a word you say, but let's get cracking on our wooden lab. I have a feeling that wolf will be along any minute."

Sure enough, the three little chemists had no sooner set up their new laboratory made of sticks than along came the Big Bad Wolf. "Yum, I smell ham," he thought to himself. And out loud he said, "Little chemists, little chemists, let me come in!"

But Professor Bacon answered, "Not by the hair of our chinny-chin-chins!"

Mr. Spork said, "Now are you going to huff and puff and blow our lab in?"

"Don't give him any ideas," hissed Dr. Swineberg.

But the Big Bad Wolf shook his head. "No," he said. "My asthma is acting up. I'm all huffed and puffed out after that last straw house of yours I blew down."

"It was a straw laboratory, not a house," Professor Bacon corrected him.

"Whatever," said the Big Bad Wolf. "I think I'll just burn you out this time. I've got some matches here somewhere…" So the Big Bad Wolf scratched his match and he burned the wooden lab down. Again the three little chemists fled, barely able to keep ahead of the wolf while they gathered up their glassware and safety goggles, their x-ray crystallography machine, the paperwork for their National Science Foundation grant proposals, and all their other stuff.

Was the burning of the wooden lab a physical or a chemical change? Explain.

"Back to the old drawing board," said Professor Bacon. "We need to build our next lab out of something strong that won't burn."

"How about bricks?" said Dr. Swineberg. "Somehow I feel like it should have been bricks all along."

"A brick laboratory would be a logical solution to our problem," agreed Mr. Spork. "And bricks are a fascinating material, from a chemical point of view."

"Oh, please stop him…" muttered Professor Bacon.

But Mr. Spork continued: "Bricks are made mostly of a combination of sand and clay, formed into blocks and then fired in an extremely hot

Who's afraid of mixtures and density?, continued

We interrupt this pig tale with a Question: #1 (blowing down the straw lab)

This is a physical change because the straw, which was arranged in the form of a laboratory, is now on the ground as a result of the wolf's strong exhalations. However, it is still straw; the chemical composition of the cellulose has not changed.

We interrupt this pig tale with a Question: #2 (burning down the wooden lab)

In this case, there was a chemical change: the wood reacted with oxygen in the air and literally went up in smoke, changing from lignin to soot, ash, water, and carbon dioxide. Without knowing details of reactants and products, students may recognize that burning changes the chemical identity of substances, not just their phase or (as with straw being blown down) their macroscopic arrangement.

Who's afraid of mixtures and density?

kiln until the different compounds stick together in a hard solid. Sand is made of silica, which is a compound of oxygen and silicon. Sand makes up at least half the mass of brick. Clay makes up a large part of the remaining mass. The clay in bricks is typically made of extremely fine particles of aluminum oxide (AlO_3). In addition, bricks contain lime—"

"Wait, lime? Like lemon and lime?" said Professor Bacon.

"No," said Dr. Swineberg. "Lime is the name for a group of materials high in calcium."

"Correct," said Mr. Spork. "The higher the calcium content of brick, the more yellow or white the bricks will appear. On the other hand, a high iron oxide content tends to give bricks a more pink color."

"Oh, by all means, let's use pink bricks," said Professor Bacon. "Much prettier. Only for heaven's sake, let's hurry and get this thing built, before the Big Bad Wolf eats us!"

We interrupt this pig tale with a Question

Is brick a pure substance or a mixture? Explain.

Well, you might be thinking that the brick lab was wolf-proof, and that the three little chemists lived happily ever after and patented all kinds of discoveries and got rich off of licensing fees, or all got university jobs with benefits like free parking and seats at the 50-yard line for the annual big game, or whatever it is little chemists want. But not so. To make a long story short, the Big Bad Wolf took a hydraulic jack hammer to their brick walls and the whole building came crumbling down.

We interrupt this pig tale with a Question

Is breaking bricks apart with a jack hammer a physical change or a chemical change? Explain.

"On the run again!" grumbled Dr. Swineberg, as she scurried along carrying a box of filter papers, tongs, binders full of lab notes, and a couple of laptop computers. "Will it ever end?"

"Now what?" grunted Professor Bacon when they finally stopped running.

"Yeah, what's left to try?" said Dr. Swineberg. "That wolf is a tough customer. So big and so bad!"

"Wicker," said Mr. Spork.

"What? Wicker? Like wicker basket?" said Dr. Swineberg. "Isn't that going backwards? Wicker is just weak, flammable plant fiber woven into baskets and light-weight furniture."

"Wicker is, like, halfway between straw and sticks," agreed Professor Bacon.

Who's afraid of mixtures and density?, continued

We interrupt this pig tale with a Question: #3 (is brick a pure substance?)

A brick is mixture. Even when you look at a brick without a microscope, you can see that its composition is gritting and uneven. It's more like a smoothie than pink lemonade! From the text, students can find that the mixture in bricks includes sand and clay.

We interrupt this pig tale with a Question: #4 (breaking apart bricks)

This is a physical change because the material after being jack hammered is still brick—it's just much smaller parts of the same mixture, not a new substance.

Who's afraid of mixtures and density?

"Wicker," insisted Mr. Spork, and he told them his plan.

The next day, the Big Bad Wolf set off following his nose in search of ham, as usual. He really had a thing for ham. Pretty soon he saw a sight that made him lick his chops. Up on a hilltop, the three little chemists had built a new laboratory entirely out of rattan wicker. "Ha!" laughed the Big Bad Wolf. "Do they seriously think wicker will save them? That'll happen when pigs fly. I'll be able to blow that down without any trouble." (His asthma was better.)

In the wicker lab on top of the hill, Dr. Swineberg was on wolf watch. She saw the wolf coming, checked once with binoculars to make sure it was him and not the mailman, and turned to her colleagues. "He's coming," she said. "The Big Bad Wolf, not the mailman."

"Time to go," said Professor Ham.

"Make it so," said Mr. Spork, taking a seat in a large wicker captain's chair and fastening his seat belt.

"Aye-aye, Mr. Spork," said Professor Ham, turning a valve on a nearby propane cylinder so that a jet of flame shot upwards from a jumbo quad burner above their heads. The giant, pink envelope of a hot air balloon quickly inflated above the wicker lab, which began to creak and quiver on top of the hill.

"Casting off!" shouted Dr. Swineberg, untying several ropes that held the wicker structure to the ground, and before the Big Bad Wolf's astonished eyes, the entire laboratory, with its cargo of lab equipment and delicious chemists, rose gracefully into the air.

"How is that possible?" cried the wolf. "That whole contraption must weigh a ton!"

"Even so, it all has less mass than the cooler air displaced by the balloon," explained Mr. Spork. But his voice was lost in the wind, leaving the confused, hungry wolf dancing with anger on the ground, unenlightened about density and the process of lighter-than-air travel.

We conclude this pig tale with a Question

Is the burning of the propane fuel a chemical reaction or a physical change? Is the expansion of the air in the balloon a chemical reaction or a physical change? Explain.

In your own words, how does the hot air balloon float?

Who's afraid of mixtures and density?, continued

We conclude this pig tale with a Question: #5 (burning propane, and expanding air)

The burning of the propane fuel is a chemical reaction. The molecules in the propane gas react with oxygen in the air to form new compounds. As a general rule, we can say that chemical reactions do not all involve fire, but all fire involves chemical reactions! However, the expansion of the air in the balloon is a physical change. The air molecules don't change or combine with other molecules; they just speed up and collide, creating more distance between them and changing the density of the air.

#6 (how does the hot air balloon float?)

(Responses will vary; the key idea to look for is density.) A hot air balloon floats because the air inside the balloon becomes less dense than the air outside the balloon. Even though air on the inside and the outside are comprised of same molecules, the heating of the molecules inside the balloon causes an expansion of the air. This expansion makes the inside air less dense and allows it to float.

Writing

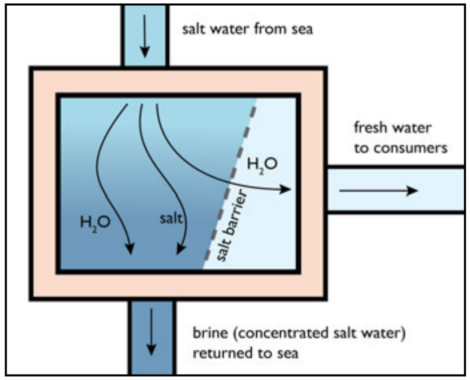
Water Shortage Solutions

Fresh water (water without salt) is a precious, life-giving resource, and in many parts of the world it's in terribly short supply. Desalinization—removing the salt from seawater—may be a great **solution** to the problem of scarce fresh water. But for desalinization to work on a large scale without causing environmental damage, people need to **concentrate** on the **concentration** of salt **solutions**!

Earlier we talked about getting the salt out of seawater through distillation: Water evaporates from salt water, and then the water vapor condenses into liquid fresh water. Most large-scale desalinization facilities now use a different process called "reverse osmosis." Basically this involves taking seawater and forcing some of it through a filter that will let water molecules through, but not salt particles.

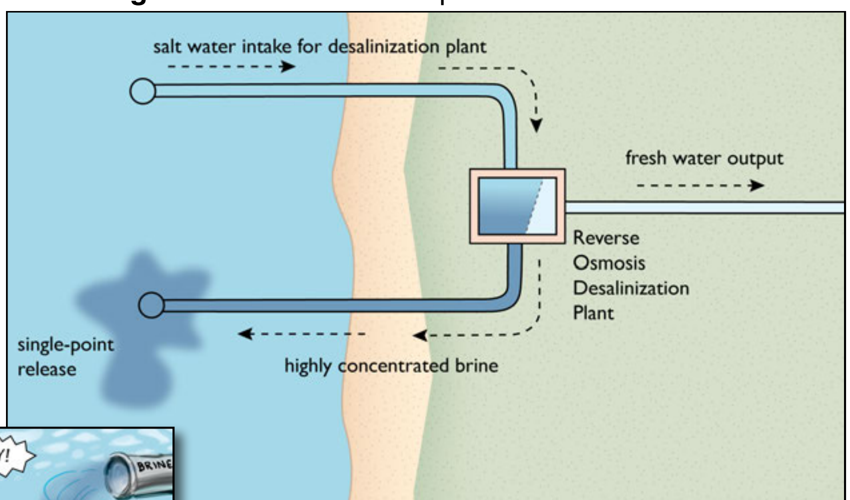
As fresh water is removed and sent to consumers to drink, irrigate farms, and so on, the **concentration** of the remaining saltwater mixture goes up. Highly **concentrated** salt water is called "brine." Brine from desalinization facilities is generally returned to the sea.

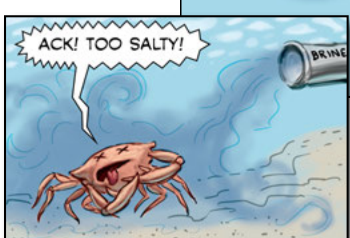
This waste brine discharge from a desalinization plant can cause problems. The extra-high **concentration** of salt can sometimes be too much even for plants and animals that live in the sea!



Schematic illustration of the reverse osmosis process.

Plant Diagram #1: desalinization plant alone





*Note: These illustrations visualize higher **concentrations** of salt in the water as darker, even though salt water and fresh water don't actually look that different.*

Teacher Directions, Session 5

pages 27-30

Writing

Today's writing activity builds on what students learned earlier in the week about salt water concentration. There, the focus was on phase changes—evaporation and condensation—as used in desalinization. Here, desalinization and concentration are considered without the phase changes.

The reading and diagrams provide background information that students will need when responding to this unit's writing prompt. The prompt asks them to try to convince their county supervisors to combine a desalinization plant and a power plant in order to mitigate a negative impact on the environment. In this way, the lesson makes a connection between basic science, engineering solutions, and social and environmental challenges.

The information on this page explains in a general way how desalinization by *reverse osmosis* works. Unlike the distillation process that students learned about earlier in the unit, reverse osmosis filters sodium chloride out of the water. As the fresh water is sent to consumers or farms, the leftover brine—highly concentrated salt water—is dumped back in the ocean. This can harm sea life.

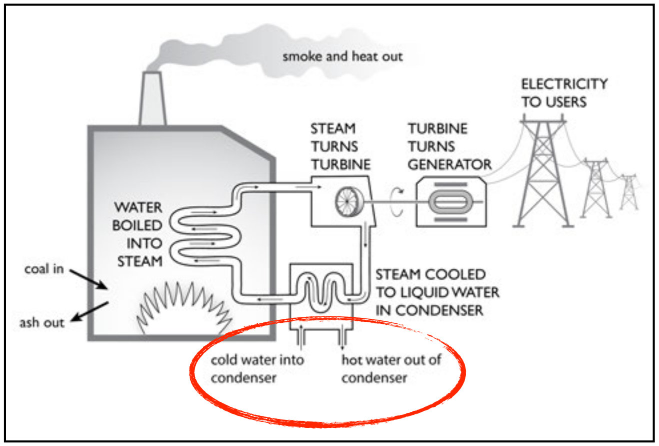
Writing

Water Shortage Solutions

How can you get fresh water out of seawater without hurting sea creatures that are sensitive to super-high salt **concentrations**? One method is to combine desalinization plants with power plants in a way that **dilutes** the brine before it is dumped back in the ocean. Before we look at how people combine power plants and desalinization plants, let's look at why some power plants use seawater.

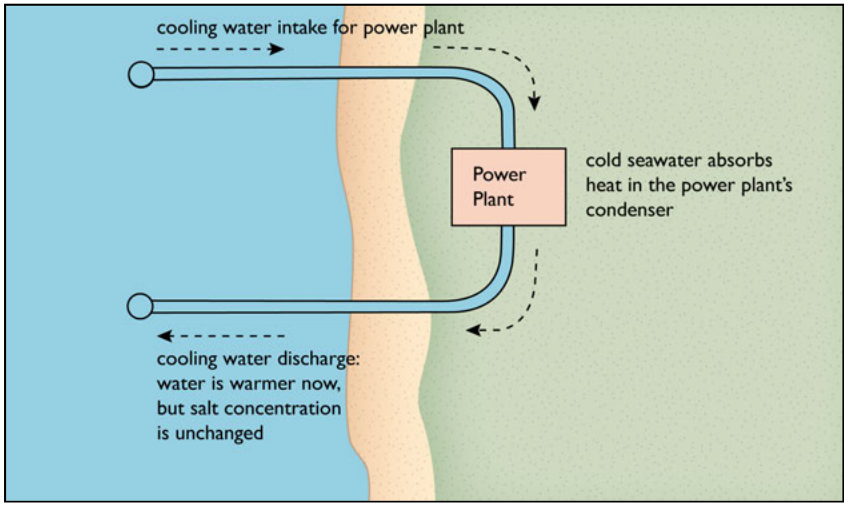
Many power plants generate electrical current using steam turbines. The steam that drives the turbines is part of a cycle: Fuel burns to boil water into steam; the steam turns the turbines; then the steam is cooled back into liquid water in a "condenser"; and that liquid water is reboiled to repeat the cycle. For power plants built near the ocean, cold seawater is often used in the condenser. The seawater is separate from the water that boils and turns the turbines. The seawater just absorbs heat in the condenser and carries it away. (Inland power plants typically use river water instead of seawater.)

To the **right** is a diagram of a coal-fired power plant. The part we're interested in right now is circled: That's where the seawater comes into the condenser, heats up, and then goes back out to the ocean.



Below is a diagram showing the intake and discharge of seawater for use in a power plant's condenser. The salt **concentration** of the seawater is not changed between intake and discharge.

Plant Diagram #2: power plant alone



Writing, continued

Students do not need to review the details of how a power plant works here, but the power plant diagram does provide several connections to other lessons they may remember. This diagram is taken from Unit 8.3, which you might point out to your students if they have recently studied that unit. The key thing to focus on is the circled part of the diagram, which shows coolant water going into and out of the power plant's condenser. This condenser works the same way as the condenser in the small distillation apparatus shown on page 17 of the present unit.

Now on to the connection between the power plant and our desalinization plant:

Coastal power plants often use seawater in their condensers. The coolant salt water (which is completely separate from the water/steam in the loop that drives the turbine) is returned to the ocean warmer than before, but with its salt concentration unchanged.

Writing

Water Shortage Solutions

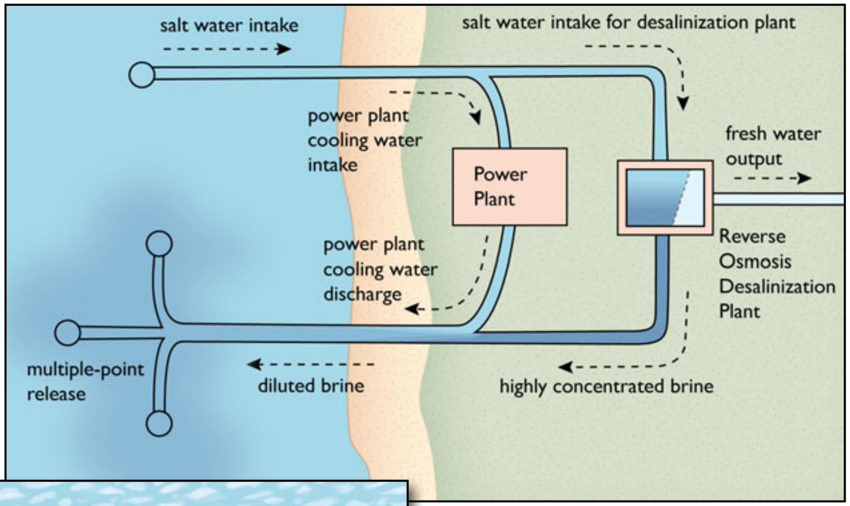
Okay, now we're ready to see how and why to put a desalinization plant and a power plant together.

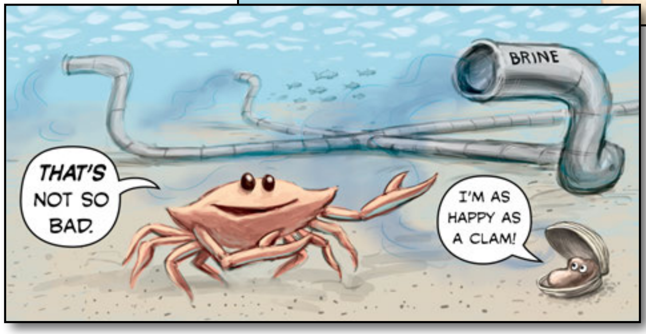
If you build a desalinization plant near an existing power plant, the two facilities can share the same water intake and discharge pipes. That way, the seawater discharge from the power plant can **dilute** the highly **concentrated** brine discharged from the desalinization plant.

Another way to **dilute** the brine discharge is to release smaller amounts of it at multiple points, instead of releasing it all in one place.

Plant Diagram #3 below shows a desalinization plant that uses both of these techniques for **diluting** brine: sharing discharge pipes with a power plant and spreading the discharge out over multiple points. Compare the dark area that represents the **concentrated** salt water in this diagram with the dark area in Plant Diagram #1.

Plant Diagram #3: plants combined





Writing, continued

The information on this page illustrates how combining the water intake and release for a power plant and a desalinization plant can dilute the salt concentration of the desalinization plant's waste.

Writing

Water Shortage Solutions

Suppose there is a plan to build a desalinization plant by itself on the coast, like the one in Plant Diagram #1. An environmental impact study reports that the highly **concentrated** brine discharged from the desalinization plant may harm the sea life in the area. The county board of supervisors must decide whether to approve the plan as is or require changes. The supervisors are torn between the community's need for drinking water and concerns about harming wildlife.

A mile down the coast, there is already a power plant like the one shown in Plant Diagram #2. Write a letter to the county board of supervisors to try to persuade them to consider combining the new desalinization plant with the existing power plant, as shown in Plant diagram #3. To help the supervisors understand the benefit of your plan, explain how the different plant designs affect the **concentration** of the salt water released into the ocean.

Writing, continued

Students write letters to their county board of supervisors trying to persuade them to combine a new desalinization plant with an existing power plant in order to minimize the environmental damage from the brine.

Encourage students to use the focus words in their responses.

Key points to look for in student responses:

The original desalinization plant (shown in Plant Diagram #1) removes seawater from the ocean and then removes pure water from the seawater. While the pure water is useful, it leaves behind a highly concentrated saltwater solution ("brine").

In the original desalinization plant design, the waste brine is returned to the ocean at full concentration, all in one place. This high salt concentration is harmful to some sea life.

This environmental impact could be reduced by diluting the concentration of the salt solution that is returned to the ocean from the plant. Plant Diagram #3 shows a couple ways of doing this.

First, the brine can be mixed with cooling water discharge from a power plant. This cooling water takes heat away from the power plant, but has the same salt concentration as the ocean from which it came. So the cooling water from the power plant can dilute the brine, making its salt concentration closer to that of regular ocean water.

Second, Plant Diagram #3 also shows how the diluted brine can be released in smaller amounts at multiple locations, instead of all in one place. This spreads out the extra salt, further diluting the salt concentration in any one place. All this dilution reduces the harm to sea life, while meeting the human need for fresh water.

(Some students may point out that this second technique—multiple release points—could be used even if the desalinization plant output was not mixed with the power plant output.)

Shorter, Please

In the play *Hamlet*, William Shakespeare has one of his characters say that **"brevity is the soul of wit."** Brevity means briefness, shortness of duration. Wit, in Shakespeare's time, meant intelligence, not just skill at making jokes. His phrase suggests that the best way to say something is often the briefest. Many writers and editors try to follow this ideal when revising prose. They boil down sentences to essential meaning, like chemists boiling seawater to get at the salt.

Making sentences clear and efficient takes effort, though. Maybe Shakespeare's early drafts looked something like these:

- *The thing of which brevity is the soul is wit.*
- *Wit-wise, brevity seems to be the soul of it.*
- *If wit could be said to possess something in the nature of a soul, I would venture to suggest that, all things considered, its soul-like essence might consist in keeping what one has to say as much as possible on the short side, rather than wandering off into a maze of tortured syntax, or puffing up one's discourse with florid and overblown diction, or being otherwise excessively and redundantly long-winded. Know what I mean?*

Thank goodness William was willing to revise!

"To be," or not?

Often the verb *to be*, assisted by prepositional phrases, **dilutes** a sentence's meaning. Underlining forms of to be (like *is* and *are*) and prepositions (like *by*, *in*, *of*, *to*, and *with*) can target your editing and help you strengthen a sentence. Is there a stronger verb than *is* or *are* that expresses the real action of the sentence? If so, use it!

Here's an example:

> **Your meaning is diluted by extra words.**

Underline any *to be* words and prepositions:

> **Your meaning <u>is</u> diluted <u>by</u> extra words.**

The real action in this sentence hides in the passive construction "is **diluted**." The real actor in the sentence is "extra words," related to the passive verb "**diluted**" by the preposition "by." Try this:

Extra words dilute your meaning.

continued on next page

Teacher Directions, Supplementary Activities

pages 31-36

ELA Activity

In their science class this week, students are learning about solutions and mixtures. In the Reader's Theater that introduced the unit, three friends were making pink lemonade from powder and discussing how some people like it sweet or "concentrated" and other prefer it more "diluted."

This week's ELA activity encourages students to edit their writing by looking for unnecessary words that "dilute" their message.

Shorter, Please

Here's another example:

A sentence that is good can be likened to a solution that is concentrated.

This one contains three *to be* words and one preposition:

A sentence that <u>is</u> good can <u>be</u> likened <u>to</u> a solution that <u>is</u> concentrated.

Can we boil down all this being? "A sentence *that is* good" just means "a good sentence." "A **solution** *that is* **concentrated**" just means "a **concentrated solution**." "Can *be* likened *to*" could be replaced with "resembles," so that the whole thing becomes:

A good sentence resembles a concentrated solution.

We don't necessarily have to go that far. This is also okay:

A good sentence is like a concentrated solution.

After all, there's no law against using forms of *to be*, and "is like" works well for making a comparison. At least now it's a direct "is like" and not a **diluted** "can be likened to."

Your turn. Underline the forms of *to be* and any prepositions:

The thing I want is to keep it brief.

Now try revising it into a more direct, powerful sentence:

____

Here's another. Underline the forms of *to be* and any prepositions. Then revise the sentence:

The thing her poetry is expressive of is her feelings.

____

Now for something a little different. We can take a clear, **concentrated** sentence like "Adam enjoys visiting Aunt Lucy because she serves pink lemonade" and **dilute** it with *to be* words, prepositional phrases, and all sorts of unnecessary clutter. Here's an example of how to mess up a perfectly good sentence:

The reason for Adam's enjoyment of his visits with Aunt Lucy is the pink lemonade that is served by her during these visits.

Or, pushing it farther:

The real reason for Adam's tremendous enjoyment of his visits with dear Aunt Lucy is the fantastic pink lemonade that is so graciously served by her during these treasured visits.

Now it's your turn. You can make up your own clear, **concentrated** sentence to start with, or you can use the following: "Zena likes her lemonade less sweet than Adam likes his." Try to make it grammatically correct, but stylistically puffed up and silly:

____

____

____

____

____

____

____

ELA Activity, continued

Revision #1

I want to keep it brief.

Revision #2

Her poetry expresses her feelings.

For the final writing activity, students can either start with the supplied sentence ("Zena likes her lemonade less sweet than Adam likes his") or write their own clear and concentrated sentence first. Then they should write a grammatically correct but silly sentence that is "diluted" with lots of extra words.

Allow students to share with partners, group members, or the whole class.

Here's an example of the kind of thing students might cook up:

"The lemonade for which Zena expresses a preference has less sweetener than the more concentrated beverage made to suit Adam's taste."

(Obviously, answers will vary!)

Density

Density is the ratio of mass to volume. Put another way, **density** equals mass divided by volume. **Density** can be measured in grams per cubic centimeter (g/cm^3), or in other units of mass and volume.

The **density** of a substance doesn't depend on the size of an object made of that substance any more than the color of the substance does. For example, the four blocks of gold below all have different masses, and they all have different volumes. But they all have the same **density** (not to mention the same color):

mass: 9.65g
volume: 0.5cm^3

mass: 19.3g
volume: 1cm^3

mass: 38.6g
volume: 2cm^3

mass: 154.4g
volume: 8cm^3

What is the **density** of gold? To find out, divide the mass of each block by its volume:

9.65g/0.5cm^3 = _______ g/cm^3

19.3g/cm^3 = _______ g/cm^3

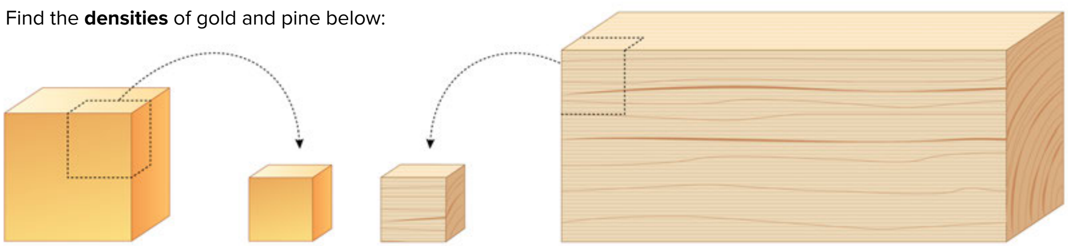
38.6g/2cm^3 = _______ g/cm^3

154.4g/8cm^3 = _______ g/cm^3

The second one, with no number in front of the cm^3, might have seemed either pretty obvious or pretty tricky to you. When you just have a unit like cm^3 in an expression like 19.3g/cm^3, it means **one** cm^3 (not zero cm^3!). This expression shows the "unit rate," which means it tells you how many grams there are per **one** cubic centimeter. That's what we use to describe the **density** of gold, and you can see by doing the math that it's the same for all four gold objects. They all have the same ratio of mass to volume.

Density helps us compare different substances—not just different *objects*, but the *substances* of which objects are made. Consider the block of gold on the left below, with a volume of 8cm^3 and a mass of 154.4g, and the block of pine wood on the right, with a volume of 160cm^3 and a mass of 64g. Just comparing the mass 154.4g to the mass 64g doesn't really get at the difference between these two substances, because the particular objects we're comparing are different sizes. But the **density** of the two substances tells us something essential about gold and pine wood, something that doesn't depend on the sizes of the objects. To compare the **density** of two materials, you consider pieces of each material with the same volume, and compare their masses. To do this without actually chopping pieces out of objects, you divide the mass of each object by its volume.

Find the **densities** of gold and pine below:



154.4g/8cm^3 _______g/cm^3 _______g/cm^3 64g/160cm^3

Math Activity

In their science class this week, students are learning about density—particularly what happens to density as heat is added to substances. Students learn that a helium balloon floats because the air inside the balloon is less dense than the air outside. The same principal applies to a hot air balloon—though the air molecules are the same size, the added heat to the air inside a hot air balloon makes it less dense than the surrounding air. This allows the hot air balloon to float.

This week's math activity reinforces how density is determined.

Answers:

All of the answers to the four questions are 19.3 grams per cubic centimeter

The density of gold is 19.3 g/cm3.

The density of pine is .4 g/cm3.

Density

Density plays a key role in determining whether objects will sink or float in **fluids**. Gold sinks in water because gold is denser than water, and pine floats in water because pine is less dense than water. In fact, the **densities** of different substances are often compared to that of liquid water.

density of gold > **density** of water > **density** of pine

TURN AND TALK

With a partner, figure out how you would explain to a second grader why gold sinks and pine wood floats:

____

____

____

The Densities of Liquid and Solid Water

Ice floats in liquid water, so ice must be less dense than liquid water.

The liquid water in this glass has a volume of 55 cubic centimeters and a mass of 55 grams. The ice cube floating in the water has a volume of 9.5 cubic centimeters and a mass of 8.74 grams.

Find the **density** of liquid water:

$55g/55cm^3$ = ________ g/cm^3.

The answer to the above question is no coincidence. A gram was originally *defined* as the mass of one cubic centimeter of pure water!

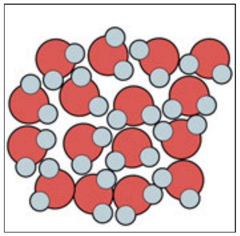
Now find the **density** of ice:

$8.74g/9.5cm^3$ = ________ g/cm^3

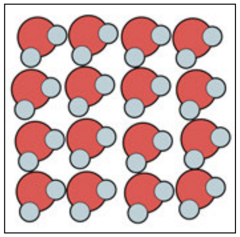
Ice is actually kind of a strange case. Usually, substances expand and become *less* dense when they are warmer, and shrink and become *more* dense when they are colder. Liquid water at room temperature, for example, is slightly more dense than hot water.

But when water freezes, it expands slightly and becomes less dense, as your calculation of the **density** of ice should show. Why? Well, when water molecules stop sliding past each other and form solid ice, they become organized in a way that actually spreads them apart slightly, so that there are fewer molecules per cubic centimeter. The white space in these illustrations represents empty space:

Liquid water



Ice



Math Activity, continued

Turn and Talk:

Allow students to think how they might explain this to a second grader. Have students share with the class. This is an opportunity for students to explain density and buoyancy in their own words. The key point is that objects that are more dense than water will sink in water, while objects that are less dense than water will float in water. If students are able to articulate the definition of density as the amount of mass per unit volume, or words to that effect, and to express the idea of water and objects pushing each other, so much the better. (If students seem to need an additional prompt, you can ask them whether—and why—a 100 kilogram pine log floats whereas a one gram piece of gold sinks.)

Remind students that what we commonly call water and ice are often called "liquid water" and "solid water" in scientific language.

Students discover that the *density of liquid water is 1*. Reinforce that this is intentional—the weight of a cubic centimeter of pure water was determined to be a gram. Water is the standard for measuring density.

The density of ice, or solid water, is 0.92 g/cm3.

The History of Salt

"Please pass the salt." An ordinary request that you might hear a couple of times when you sit down to a meal with family or friends, right? But the next time someone asks you to pass the salt, take a moment and consider this: Those little white grains inside your saltshaker represent a complex history that dates back to our earliest ancestors and spans our entire globe.

Sound like a trumped-up claim? How could simple table salt, which we take for granted, play such a significant role in human history? Well, for starters, humans and all other mammals need sodium chloride, or salt, as part of their diet. Sodium chloride is necessary for breathing and digestion. Without salt, mammals die.

Salt exists naturally in saltwater **solution** in the oceans and in underground springs, and in its solid **phase** in dry salt beds and in some rock. When early humans lived a nomadic life as hunters and gatherers, they got enough salt from the flesh of the wild animals that they ate. However, once people began to stay in one place and develop agriculture, salt became harder to get in their diet. In this new **phase** of social evolution, salt became an important and valued item. Farmers and the animals that they raised needed salt to survive. Farmers may have first domesticated wild animals by offering them salt.

A goat licking a block of salt.

Over time, farmers formed communities and engaged in trading and selling the food they produced. At some point, people discovered that salt could keep food from spoiling. Can you imagine how significant a discovery this was in a time before refrigeration? With the ability to preserve food came the freedom to travel far from home and benefit from a much wider market for trading and selling.

Salt became so valuable that in the ancient Roman empire, soldiers were often paid in salt. That's why the Latin word for salt, "sal," made its way into words like "salary" and "soldier." To say that people are "worth their salt" means that they earn their pay.

A connection was forged between a rich supply of salt, a thriving trade, and power. According to Mark Kurlansky, the author of *The Story of Salt*, "On every continent, in every century, the dominant people were the ones who controlled the salt trade." Today the United States is the largest producer of salt.

The Wieliczka salt mine in Poland.

In ancient China, rulers **concentrated** their power and wealth by keeping control of the production and sale of salt, raising prices whenever the government needed more money, despite the hardship it created for the citizens. In France, King Louis XIV taxed salt at such a high rate that some of his subjects began smuggling it at night to avoid paying the tax.

One of the most dramatic historical acts related to salt and power was carried out in 1930 by Mahatma Gandhi, an Indian leader. Yearning for independence from Britain's rule, Gandhi chose salt as a symbol of British imperialism. Britain's salt laws restricted India's production of salt, requiring Indians to buy salt shipped from Britain. To protest the salt laws, Gandhi set off on a 240 mile walk to the Arabian Sea.

Social Studies Activity

In their science class this week, students are learning about solutions and mixtures. They learned that seawater is a solution—and that during evaporation, only the water molecules go into the air. They saw how the salt molecules remain behind and how shallow salt beds are used for harvesting sea salt. They also learned about desalinization and the problems that can occur as large concentrations of salt water—or brine—can cause harm to the marine life as a result of filtering out the fresh water.

Students learn about the history of salt in this week's social studies passage.

The History of Salt

Supporters joined him along his walk, and when he arrived at the beach by the village of Dandi, 25 days later, the crowd was thousands strong and included journalists from around the world. Defying British law, Gandhi picked up a piece of salt that had dried along the beach. His gesture of "producing" salt struck a deep chord in the people of India, many of whom celebrated, demonstrated in the cities, and gathered salt of their own along the coastline. Gandhi's symbolic act sparked a movement that, 17 years later, resulted in Indian independence.

Are you familiar with the expression, "Take it with a grain of salt"? It means to avoid taking something too seriously, to retain your sense of doubt. But the next time that you reach for the saltshaker, maybe you should do something quite different. Consider the importance of what you're holding in your hand and give credit to those bunch of tiny rocks that have helped shape the course of human history.

An Indian postage stamp commemorating Gandhi's Salt March.

Debate activity:

Because salt was so important to preserving food supplies and ensuring health, some might argue that the old Chinese and British empires were justified in conserving stores of salt and taxing it heavily. On the other hand, it could be argued that it's important to keep salt cheap and widely available precisely because everyone needs it. Which position do you find most persuasive? Explain.

Social Studies Activity, continued

Debate activity: Students take a position on whether or not it was right for the British and Chinese empires to tax salt so heavily. You may want to compare salt to oil, and remind them that the U.S. government keeps reserves of oil and taxes gasoline because of its importance to our economy.

Examining the Focus Words Closely

SciGen Unit 8.5

→ Scientific or ✱ Everyday Use		Definition	Try using the word...
→	**phase** *noun*	a state of matter, usually solid, liquid, or gas	*What **phase** change takes place as snow melts?*
✱	**phase** *noun*	a step in a process	*What do parents mean when they say their child is "just going through a **phase**"?*
→	**homogeneous** *adjective*	(of mixtures) even, smooth, the same in every part	*Salt water contains evenly distributed sodium and chlorine atoms, making it a **homogeneous** mixture. Can you think of another?*
✱	**homogeneous** *adjective*	even, undifferentiated	*Is your taste in music **homogeneous**? Explain.*
→	**heterogeneous** *adjective*	(of mixtures) uneven, lumpy, different in different parts	*What foods do you eat that are **heterogeneous** mixtures?*
✱	**heterogeneous** *adjective*	uneven, made up of different things	*Is it good for a friend group to have **heterogeneous** interests? Why or why not?*
→	**solution** *noun*	a homogeneous mixture	*Many people who wear contacts clean them with saline **solution**. Name a **solution** that you use in your daily life.*
✱	**solution** *noun*	the answer to a problem	*Describe a time when you came up with a **solution** to a big problem.*
→	**dilute** *adjective*	having a low amount of one substance dissolved in another	*Which is more **dilute**, lemonade or tomato juice? How do you know?*
✱	**dilute** *adjective*	weakened in force, effect, or presence	*Think of a short story with a clear moral. If this story were longer and more complex, would the moral become **dilute**? Why or why not?*
→	**dilute** *verb*	to lower the strength of a solution by adding water (or other solvent)	*Can you think of a substance that you would **dilute** by adding something other than water?*
✱	**dilute** *verb*	to weaken the force, effect, or presence of something, especially by adding something else	*How do some people try to **dilute** the blame when they've done something wrong?*
→	**density** *noun*	the ratio of mass to volume	*How do differences in **density** help balloons float in the air?*
✱	**density** *noun*	the amount of something distributed in an area	*Name some reasons that a city's population **density** might increase.*
→	**concentration** *noun*	the rate of dissolved substance to solvent in a solution	*As the water in salt water evaporates, what happens to the **concentration** of salt?*
✱	**concentration** *noun*	mental focus, emphasis	*What helps your **concentration** when you study?*
✱	**concentrated** *adjective*	condensed in one area	*When have you made a **concentrated** effort to improve your skills in a certain area? Did it work?*

Teacher Directions, Focus Words

pages 37-38

Examining the Focus Words Closely

The chart includes the scientific definitions that are reinforced throughout the unit. Each of these words has an arrow next to it. Additionally, there are other forms of the words or polysemous meanings that sometimes cause confusion for students. These words are marked with an asterisk.

Have students discuss the questions next to each word to help them learn these distinctions. Make sure students answer the questions using the focus word.

Examining the Focus Words Closely

SciGen Unit 8.5

→ **Scientific** or ✱ **Everyday Use**	**Definition**	**Try using the word...**
→ **fluid** *noun*	a substance that is in a liquid or gaseous phase	*Compare and contrast the characteristics of liquid and gaseous **fluids**.*
✱ **fluid** *noun*	a liquid	*Is it more important to eat healthy foods or drink enough **fluids** each day? Why?*
→ **fluid** *adjective*	liquid or gaseous	*What causes a substance that is **fluid** to solidify?*
✱ **fluid** *adjective*	smooth, easily transitioning	*Which requires more **fluid** movements, dancing or playing sports? Explain.*