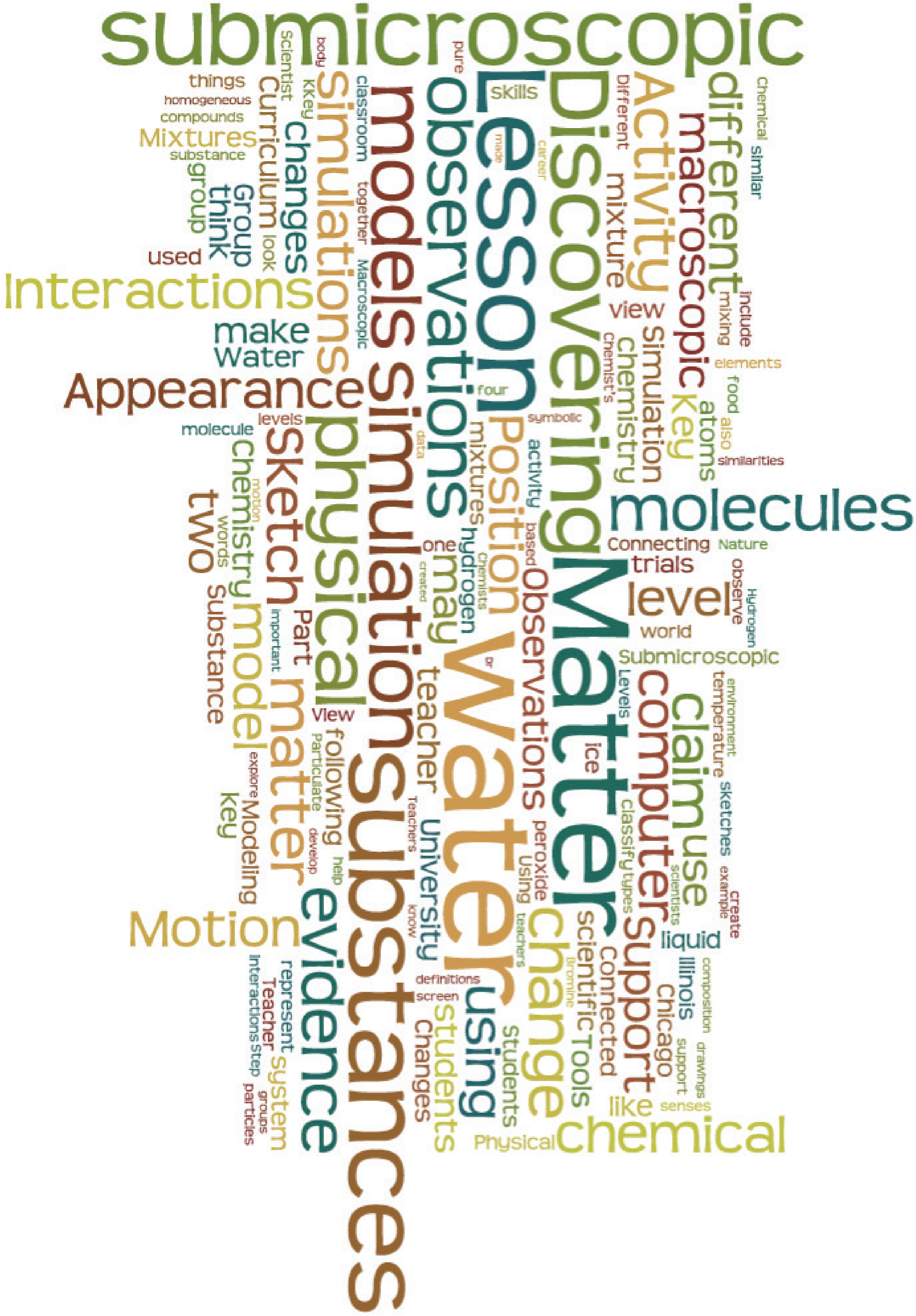
submicroscopic
Lesson
Discovering
Matter
Water
substances
simulations
models
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Activity
different
macroscopic
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physical
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matter
evidence
molecules
Interactions
Appearance
Motion
chemical
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Support
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Position
Observations
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chemistry
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Substance
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Changes
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also
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Nature
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Hydrogen
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peroxide
Using
example
create
scientists
composition
support
drawings
senses
Interactions
Step
particles
groups
definitions
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Bromine
teachers
know
help
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include
mixing
Macroscopic
together
look
body
pure
made
career
Different
Chemical
similar

The Connected Chemistry Curriculum

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Please direct all questions or concerns regarding The Connected Chemistry Curriculum to Dr. Mike Stieff at mstieff@uic.edu.

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U1S v2.1 23 May 2012

The Connected Chemistry Curriculum

Technology

System Requirements

The Connected Chemistry Curriculum has a software component (a set of *Simulations*) which is available at The Connected Chemistry Curriculum website, connchem.org. This software is necessary to use the curriculum, and is open-source and free of charge.

Besides the CCC software, you will need:

- **A personal computer of recent vintage, with an OpenGL-enabled graphics card.**
- **A 13" screen (or larger), with at least 1280 × 800 (WXGA) pixel resolution**
  For most computer monitors this is not a problem. Projectors, on the other hand, sometimes only manage VGA resolution (640 x 480), which will not allow sufficient room for our Simulations.
- **The latest Java runtime environment (JRE)**
  As of this writing, the latest JRE is Java 6, version 29. Java is free of charge: http://www .java.com/en/download/
- **Macintosh OS X 10.6 (Snow Leopard) or later, or Windows 7 or later**
  Earlier versions of the Macintosh OS or Windows may run, but may suffer performance issues. The software should also run on Linux. None of these options have been tested, however, so make sure you run all simulations before using them live in the classroom.

Troubleshooting

Please consult The Connected Chemistry Curriculum website (connchem.org) for up-to-date troubleshooting information, and to download software

Connected Chemistry
Modeling Matter Unit
Contents

The Connected Chemistry Curriculum

Welcome

Welcome to *The Connected Chemistry Curriculum*! The Connected Chemistry Curriculum, or CCC, is designed to help students learn about chemistry by directly exploring the submicroscopic level of matter and phenomena that form the basis of study in chemistry. Educators designed CCC using direct feedback from teachers, students and researchers. CCC uses computer-based simulations to provide a unique submicroscopic perspective of the chemical world for students.

Activity Icons

These icons will be found throughout the teacher and student manuals.
The icons designate the purpose/theme of the activity or section.

Connecting

Hands-On Activity

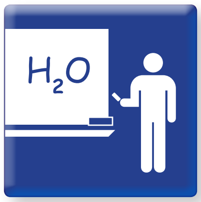
Student Simulations

Putting It All Together

Questions

Lab Safety

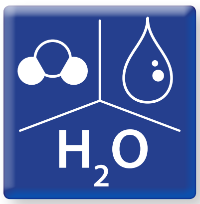
Sketching (without simulations)



Teacher Demon-stration

Wet Lab

Teacher Facilitated Discussion



Chemistry Levels

Introductory Reading

Student's Lesson at a Glance

Lesson Summary

Students are introduced to what chemistry is and what transferable skills are necessary for a student to have and develop in the class. Students begin their exploration of levels in chemistry: macroscopic, microscopic, submicroscopic, and symbolic. Students are asked to make predictions to represent water at each of these levels. In the final decoding activity, students are introduced to formula writing using molecules that they will see throughout the unit.

SWBAT (Students Will Be Able To)

Understand what skills scientist use, understand how to make scientific observations, and define macroscopic, microscopic, submicroscopic, and symbolic levels.

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- Students and teachers from many different schools helped designed CCC so that the lessons are more helpful and meaningful for all classroom participants.
- Many questions will ask you "what you think" or "to make predictions." The only wrong answer is the answer that is left blank..
- Prefixes and suffixes on words can help you discover the meaning of a word.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.
- There is a periodic table and list of common elements used in the back of this book. You will need to refer to the periodic table often.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

There are many careers a student can pursue after graduating from high school. Every career has a unique skill set. Skills are tools that people use to do their jobs. Some skills require education and training to develop. Developing strong work skills related to a career allows a person to increase his or her earnings, which will affect their lifestyle in a positive way. Science is one area that offers a wide range of career opportunities.

A chemist is a scientist who specializes in the field of chemistry. **Chemistry** is the study of matter and energy. Chemists make observations of *phenomena* in the world around them and gather *qualitative* and *quantitative data* through research. The data they gather may include information about the mass, density, size, shape, and composition of different substances. Chemists use this data to better understand the known and unknown substances they work with in their labs and in the field. Chemists can be found working for the Federal Bureau of Investigation (FBI) analyzing evidence from a crime scene. Some chemists work for pharmaceutical companies developing new drug treatments for diseases from the common cold to cancer. Chemists can even be found working for car companies to develop new materials and fuels to make cars faster, lighter, stronger, and more fuel efficient.

In the chemistry classroom, you are doing the work of a scientist as you make qualitative and quantitative observations about demonstrations, labs and computer simulations. These observations will help you better understand how the world around you works. Many students might not be interested in becoming a chemist. A student might ask, “Why bother taking chemistry classes? I am not going to be a chemist.” You do not have to be a chemist to use the knowledge and skills gained in chemistry classes. Hair stylists, nurses, doctors, engineers, chefs, biologists, agriculturalists, teachers, jewelry makers, mechanics, psychologists, cosmetologists, forest rangers, computer technicians, and military personnel are just some of the professionals that use skills gained in the chemistry classroom.

1. What specific skills do you think scientists need to do their job?

____

____

2. What do you think scientists use to gather observations?

____

____

3. Should initial scientific observations contain statements trying to explain why phenomena happen?

   You are a scientist when in a chemistry classroom. Yes or no is not a scientific answer. Instead, provide evidence to support your claim.

4. What happens when claims are made without using evidence to support them?

Activity 2: Exploring the Levels of Observations

Part 1

1. What does the prefix ***macro*** mean?

2. What does the prefix ***micro*** mean?

3. What does the prefix ***submicro*** mean?

4. Imagine the following situations:

   - Smelling your favorite food cooking
   - Wrapping up in a blanket on a chilly evening
   - Biting into a slice of sour fruit
   - Scratching your nails down a chalkboard
   - Watching the sun set on a summer evening

Qualitative observations are often made using personal experience from the five senses. All these experiences are on the **macroscopic level.** They can be observed and experienced without the use of special scientific equipment. Imagine if you were shrunk down in size, would the world appear different?

A world surrounds us that cannot be seen with the naked eye; a world that requires the use of a microscope. For example, a tiny cell taken from inside of your cheek or from the root of an onion can be seen using a microscope. These observations are on the **microscopic level**. A cell cannot be seen unless you have a microscope.

Many scientists, study smaller things that cannot be seen with a microscope. Some objects, such as molecules and atoms, are found only at the **submicroscopic level**. We cannot see the submicroscopic level without sophisticated technology. Scientists make models of the submicroscopic objects in the world. Chemists have helped the rest of the world learn about the submicroscopic level using symbolic representations, such as chemical formulas. In chemistry, scientists attempt to connect the macroscopic, microscopic, and submicroscopic levels. Specifically in CCC, simulations show how events on the submicroscopic level explain observations on the macroscopic level that can be observed with the five senses. Chemists can then communicate such observations using symbolic representations.

Based on the paragraph you have just read, define the following terms:

5. Macroscopic

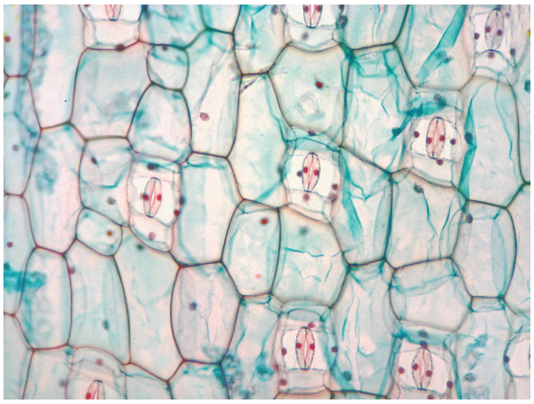
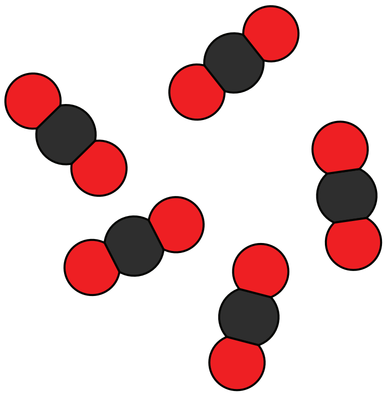
6. Microscopic

7. Submicroscopic

8. Symbolic

Check your definitions for macroscopic, microscopic, submicroscopic, and symbolic against definitions your teacher provides. If your definition is different than your teacher's, record your teacher's definition in the vocabulary section of the Lesson-At-A-Glance found at the beginning of the Lesson.

Part 2

Figure 1	Figure 2
	
Figure 3	**Figure 4**
	**Common Name** Elm **Scientific Name** Ulmus carpinifolia **Family** Ulmaceae

9. In the series of pictures above, at what level would you classify Figure 1? Why?

10. In the series of pictures above, at what level would you classify Figure 2? Why?

11. In the series of pictures above what level would you classify Figure 3? Why?

12. In the series of pictures above what level would you classify Figure 4? Why?

Activity 3: Representing Different Levels of Water

Consult the definitions you gave in the previous activity. Using these definitions as a guide, sketch what you think water looks like at each of the four levels.

Sketch water at the macroscopic level	Sketch water at the microscopic level	Sketch water at the submicroscopic level	Sketch water at the symbolic level
Key	Key	Key	Key

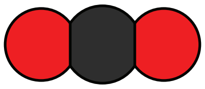
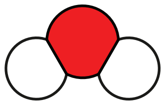
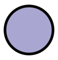
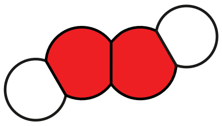
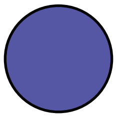
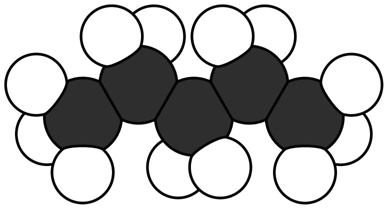
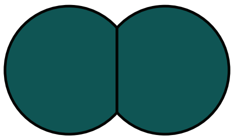
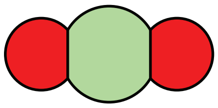
1. Revisit your initial definitions of macroscopic, microscopic and submicroscopic. How has your understanding about these three levels changed?

Activity 4: Putting It All Together - Decoding Scientific Representations Using a Key

What does the key on a map tell the reader? A key is a list of symbols and their meanings. It is important to make a key when using the simulations for CCC lessons. This will help you to clarify your drawings of substances so that you can communicate your ideas clearly. The **periodic table** that is included can be used to make future keys, but in this activity a key has been provided. Each color represents a specific element on the periodic table. From these colored models, you can create **chemical formulas**. For example, the chemical formula for carbon dioxide, a gas exhaled while breathing, is CO_2.

1. Is the order you write out the elements in the formula important?

Using the key, provide the chemical formula for the following substances.

Key	Formula	Key	Formula
Ex/ Carbon Dioxide 	CO_2	Water 	
Silver 		Hydrogen Peroxide 	
Mercury 		Pentane 	
Bromine 		Silicon Dioxide 	
Key			

Student's Lesson at a Glance

Lesson Summary

Students are introduced to scientific models and should be allowed to explore CCC simulations that they will be using for subsequent units. Through comparing and contrasting the models, students will discover when models are used and the benefits and limitations that are associated with models. This lesson also serves as a time when teachers introduce protocols about making observations with CCC models. Teachers will also introduce the importance of using and developing keys that describe models. Your teacher will spend some time with scientific writing with specific attention to claims and evidence. Supporting claims with evidence is an essential element of all lessons in CCC.

SWBAT (Students Will Be Able To)

Identify different types of models used in chemistry, compare contrast different models, identify benefits and limitations of different models

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- In this lesson you will learn how to make good scientific observations. Follow the sketching and observation protocol; the more you practice these skills the more accurate your will become.
- Develop your own language to help define words so that you can use scientific language with confidence in your writing.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier.
- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.
- Pause the sims when you are creating sketches.
- Support the claims with evidence.

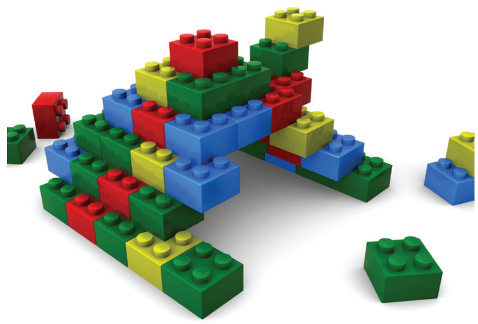
Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

Many students play with Lego® building blocks while growing up. With these blocks and their imaginations, children can build houses, skyscrapers, forts, or other designs. From this kind of play, children develop important skills to help them throughout the rest of their lives.



1. What skills did you gain by playing as a child?

____

One of the many skills children gain through play is modeling. Modeling is a skill used by scientists every day. Consider the following list:

- A picture showing the parts of an atom
- A volcano built as a science project
- A teacher demonstrating a formula on the chalk board
- A recipe
- A map of the United States
- A diagram to hook up a car's sound system

2. What do all of these things have in common?

____

____

3. In your own words, what is a **model**?

____

____

4. Think about the examples of models in the reading above and how they are used. Why would we use models in chemistry?

Models can be used to represent complex or simple systems. A **system** is a part of a larger whole chosen for analysis in which all variables are defined, but independent of the **environment** (everything outside of the system). During analysis, the environment is ignored except for its effects on the system. The system may be separated from the environment by a boundary, such as a the walls of a container.

For example, when studying the human body, teachers may introduce one system at a time - skeletal, nervous, respiratory, etc. These systems are separated by tissues. All parts of each body system are defined as well as how environmental factors such as disease and nutrition can affect them.

In CCC, closed and open systems will be explored. A **closed system** is like a container with a lid: it cannot exchange matter with the outside environment. An **open system** is like a jar without a lid: it can exchange matter with the outside environment.

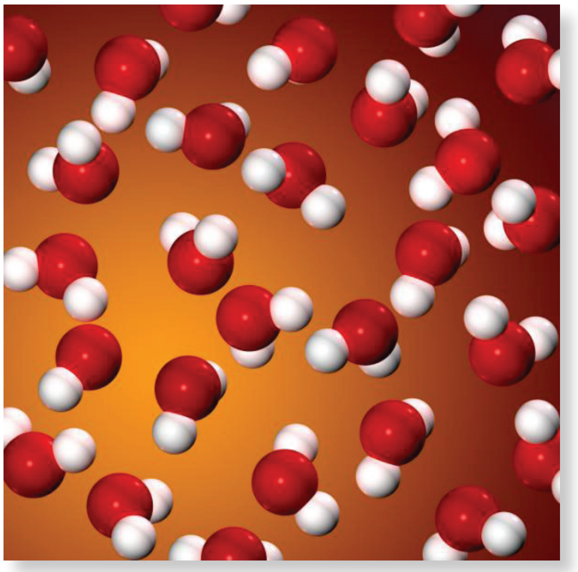
5. What are the benefits of studying a system as opposed to looking at the whole environment?

6. A sealed room is a system. Define the variables, boundaries, and the environmental factors that may affect it. Would you classify a sealed room as an open or closed system?

   Support your claim with evidence.

Activity 2: Facilitated Discussion: Are All Models the Same?

Models are helpful tools for understanding concepts in chemistry. In this activity, your teacher will show you several images. You will compare and contrast types of models.



Part 1

Use Simulation 1, ***Set 1***

Your teacher will project a simulation of water molecules.

1. Compare the simulation to the molecular picture of water molecules on the right. What are similarities between the two models?

2. What are differences between the two models?

3. When might it be helpful to use a simulation over a picture in a textbook?

Part 2

Use Simulation 1, ***Set 1***

Your teacher will project two simulations.

The CCC Simulation vs. Kral Visualization can be found on the ConnChem.org website.

4. Compare the two simulations. What are similarities between the two models?

5. What are differences between the two models?

6. Which model would be more useful for a scientist working a lab?

   Support your claim with evidence.

7. Which model would be more useful for someone who is taking an introductory science class?

   Support your claim with evidence.

Part 3

Use Simulation 1, ***Set 1***

Your teacher will project a simulation of water molecules and a physical model of water molecules.

8. Compare the simulation to the physical models. What are similarities between the two models?

9. What are differences between the two models?

10. When would using a physical model be more beneficial than using a simulation?

Activity 3: Making Scientific Observations

Part 1

Use Simulation 1, ***Set 1***

In CCC you will be using simulations to explore substances and chemical reactions. It is important that you make detailed scientific observations of the simulations. Using the simulation provided by your teacher, complete the following questions. Your sketches are also a way to communicate like a scientist. Using shading or colored pencils as well as symbols (such as arrows) in your sketches will help you and others who look at your sketches to understand your observations.

Sketch what you see in the simulation.	Observations

1. In your observations, you may have noticed the *appearance* of the molecules. How would you define appearance based on your experience with the simulation?

2. In your observations, you may have noticed the *location* of the molecules. How would you define location based on your experience with the simulation?

3. In your observations, you may have noticed the *interactions* of the molecules. How would you define interactions based on your experience with the simulation?

4. In your observations, you may have noticed the *motion* of the molecules. How would you define motion based on your experience with the simulation?

Part 2

As a class, share your observations with each other. Your teacher will write all the ideas on the board. Classify any observations that are different from your observations into the four categories in the chart below using the definitions for guidance.

Appearance	Location	Interactions	Motion

Each time you use the simulations you will need to make observations of four characteristics:

- Appearance
- Location
- Interactions
- Motion

Chemists are able to classify, identify, and make predictions about substances using these four characteristics. Describing these four characteristics in the simulations is a form of qualitative scientific observations.

5. What problems could arise if you are not consistent in the way you make scientific observations?

6. Having good observational skills can be useful for many other careers. What other careers can you think of that might use observation as a skill? Explain why it would be important for that career.

7. How could your five senses limit your ability to make observations ?

8. What safety considerations are there when using your five senses to make scientific observations?

Part 3

Use Simulation 1 ***Set 1***

Your teacher will give you a few minutes to explore the simulation.

Once you are familiar with the controls, begin the activity.

The simulation allows you to adjust the size of your molecule by zooming in and out. Give it a try. Pay special attention to the functions of all the buttons, sliders, and data recorders. You will need to make your own key. Make sure to include all symbols and colors you use.

9. Can you adjust the size of molecules, without adding more atoms, in the real world?

   Support your claim with evidence.

10. How could the ability to adjust the size on the simulation help or hinder you as a student?

11. Do you think that the observations you made about the model would hold true for a real molecule of water?

    Support your claim with evidence.

12. Do real molecules have color?

    Support your claim with evidence.

Some simulations will allow you to work with substances such as concentrated acids and bases, such as hydrochloric acid and lithium hydroxide, as well as toxic gases and liquids, such as bromine and mercury.

13. Why is this a helpful feature of this kind of model?

Add one more water molecule to the screen.

14. Is adding one molecule the same as adding one milliliter of water?

    Support your claim with evidence.

You can control the velocity of the molecules in the simulation using the speed slider. Practice with your simulation.

15. Can you control the speed of molecules ***directly*** in real life?

    Support your claim with evidence.

16. How might you change the velocity of the molecules in a laboratory experiment?

    Hint: Look at some of the other options provided by the simulation's interface.

Add more molecules of water and observe any changes to the data measurement tools (for example, plots and monitors) on the screen.

17. What does the simulation allow you to do with data that a real experiment may not?

18. What are some of the benefits of using a simulation to model chemical interactions?

Student's Lesson at a Glance

Lesson Summary

In this lesson, students learn about matter. They will make connections between matter, atoms, elements and compounds. Students are shown the six key substances that will be used throughout the unit in a demonstration by the teacher. Students are then asked to represent each of the key substances on both the macroscopic and submicroscopic levels. Using simulations, students will investigate similarities and differences in the following substances: water, hydrogen peroxide, mercury, bromine, phosphorous, and oil (pentane).

By observing submicroscopic interactions between the substances, students will create groups that categorize them.

SWBAT (Students Will Be Able To)

- Define what matter is and what composes it
- Understand the relationship between matter, elements, atoms, and compounds
- Sketch substances on macroscopic level
- Sketch substances on submicroscopic level
- Classify different types of matter

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- CCC simulations are models that represent the submicroscopic level.
- Follow the CCC sketching and observation protocol; the more you practice these skills, the more accurate you will become.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier. You will also need clear definitions to make your concept map.
- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.
- Memorizing the symbols of the most common elements you are using will be helpful. Keep using your periodic table in the back of the book to help decode molecules.

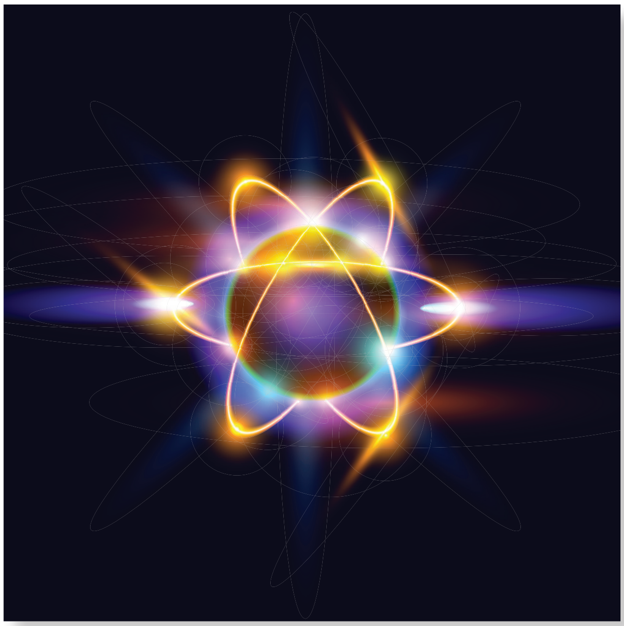
Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

1. Based on your experiences, what do you think matter is?



Chemistry is the study of interactions and changes in **matter** and **energy**. Chemists often construct explanations to everyday events by examining the **particles** of matter at the submicroscopic level. Although chemists have identified and classified millions of particles, they have organized them into a small number of categories. These categories include **atoms** and **molecules**.

Atoms are the building blocks of matter. Different combinations of atoms yield different substances. If two atoms of hydrogen and one atom of oxygen are combined, a water molecule is produced. Water, in all its forms, is matter. Take a deep breath in, then breathe out. Whether you know it or not, you just inhaled and exhaled a few kinds of matter made up of many types of atoms. This matter may include some particles that are healthy for your body and maybe some that are not so healthy.

In these lessons, you will explore the interactions between submicroscopic particles of matter to identify the categories that chemists use routinely to classify matter.

	List 6 things in the room that are matter	List 6 things in the room that are NOT matter
1		
2		
3		
4		
5		
6		

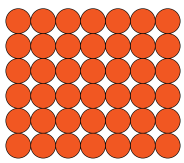
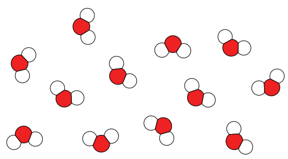
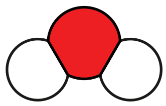
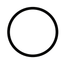
Activity 2: How Atoms, Molecules, Elements, and Compounds All Fit Together

A student wants to develop a simple model to explain the relationships that exist between four things:

- Atoms
- Molecules
- Elements
- Compounds

The student has been given some drawings and connecting words to use to develop their understanding of the relationships between these things.

Figures

Element (e.g., gold)	Compound (e.g., water)	Molecule (e.g., water)	Atom (e.g., hydrogen)
			

2. Using the connecting words *made of* and *forms*, draw a concept map showing the relationship between the terms: **element**, **compound**, **molecule**, and **atom**.

Activity 3: Sketching Macroscopic Representations

Before using the Classifying Matter simulation, draw ***macroscopic*** *pictures of each of the substances your teacher shows you. Write down your observations.*

Sketch macroscopic view of hydrogen peroxide	Observations
	Appearance
	Interactions
	Location
	Motion

Sketch macroscopic view of mercury	Observations
	Appearance
	Interactions
	Location
	Motion

Sketch macroscopic view of pentane	Observations
	Appearance
	Interactions
	Location
	Motion

Sketch macroscopic view of bromine	Observations
	Appearance
	Interactions
	Location
	Motion

Sketch macroscopic view of silver	Observations
	Appearance
	Interactions
	Location
	Motion

Sketch macroscopic view of silicon dioxide	Observations
	Appearance
	Interactions
	Location
	Motion

1. What symbols can you use to represent any of the substances?

2. What senses did you use to make your observations?

3. Safety is very important in the science classroom. What senses could be affected by failure to follow safety procedures in the classroom?

4. Would your macroscopic observations change if you used different senses?

   Support your claim with evidence.

5. What properties of the substances can you observe on the macroscopic level?

6. Why is a key not necessary for macroscopic representations?

Activity 4: Predicting Submicroscopic Representation

Select three of the six substances that you drew before (hydrogen peroxide, pentane, mercury, silver, silicon dioxide, and bromine). Sketch what you think they might look like on a submicroscopic level.

Remember, this is an educated guess based on what you already know. The only wrong answer is one that is left blank.

Submicroscopic view of Substance 1	Submicroscopic view of Substance 2	Submicroscopic view of Substance 3
Name of substance	Name of substance	Name of substance
Key		

Briefly explain why you drew each of the substances like you did.

Gravity affects all matter regardless of its size. CCC simulations take gravity into account for all states of matter.

1. When sketching a liquid like water, explain how you would represent the pull of gravity on the molecules.

2. If a computer showed a representation of a solid suspended in the middle of the screen, is this accurately representing the pull of gravity?

   Support your claim with evidence.

Activity 5: Classifying Matter

The following simulations contain the following substances:

- Water
- Silver
- Mercury
- Hydrogen peroxide
- Pentane
- Bromine
- Silicon dioxide

You may be familiar with some of these substances on the macroscopic level in your everyday life, and you may have noticed similarities and differences between their macroscopic properties. In this activity, you will characterize these substances on both the macroscopic and submicroscopic levels. You will also discover how chemists formally classify each of them according to their submicroscopic similarities.

Many of the physical things around you are matter. Matter is anything that has mass and takes up space. By drawing substances at the submicroscopic level first, we can classify the substances into groups later.

Part 1

Use Simulation 2, ***Sets 1-7***

Draw submicroscopic pictures from the simulations. Do not forget to include a key. Record observations about each of the substances including appearance, interactions, location and motion.

	Sketch submicroscopic view	Observations
Water		Appearance
		Interactions
		Location
	Key	Motion

	Sketch submicroscopic view	Observations
Hydrogen Peroxide		Appearance
		Interactions
		Location
	Key	Motion
Pentane		Appearance
		Interactions
		Location
	Key	Motion
Mercury		Appearance
		Interactions
		Location
	Key	Motion

	Sketch submicroscopic view	Observations
Bromine		Appearance
		Interactions
		Location
	Key	Motion
Silver		Appearance
		Interactions
		Location
	Key	Motion
Silicon dioxide		Appearance
		Interactions
		Location
	Key	Motion

3. Compare your submicroscopic drawings after viewing the simulation to your submicroscopic drawings on page 29. How did they change?

Part 2

Working with your teacher, use your sketches from page 30-32 *to classify the seven substances into two groups.*

Group 1: Solids

Substances

- Silver
- Silicon dioxide

4. How are these substances similar to one another?

Group 2: Liquids

Substances

- Water
- Hydrogen peroxide
- Mercury
- Bromine
- Pentane

5. How are the substances in Group 2 similar to one another?

6. How are the substances in Group 1 different from the substances in Group 2?

Part 3

Working with your small group, use the sketches from page 30-32 *to classify the six substances into two different groups different from the groups you constructed in Part 2 above. Have students work in small groups to complete this part independently.*

Group 1: Elements

- Mercury
- Bromine
- Silver

7. How are these substances similar to one another?

Group 2: Compounds

- Water
- Hydrogen peroxide
- Pentane
- Silicon dioxide

8. How are these substances similar to one another?

9. How do these substances differ from the previous group?

10. Recall that you made sketches predicting how these substances would look submicroscopically on page 30-32. How did your sketches change after viewing the substances with the simulation?

11. How has your understanding of matter changed?

Student's Lesson at a Glance

Lesson Summary

Students will make macroscopic and submicroscopic observations as water freezes into ice or evaporates into vapor. By observing this phenomenon through the simulation, students should be able to gain more insight into the nature of physical changes. Teachers may select an optional activity that requires the building of physical models of ice and liquid water so students have a hands on approach to the states of matter.

SWBAT (Students Will Be Able To)

- Describe how water differs submicroscopically in the different phases
- Define what a physical change is
- Create physical models of water in ice and liquid stage
- Identify the difference in structure of solid and liquid

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- Follow the sketching and observation protocol; the more you practice these skills, the more accurate you will become. Remember to draw a key when you are sketching.
- Pause the sims when you are creating sketches.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier.
- Supporting your claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- In the simulations in this lesson you adjust the heat to change the temperature. This will allow you to freeze or liquify substances. The temperature of a system is changed by adding or removing heat energy. In later units, you will learn more about why temperature and heat are not the same thing.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

1. What do you think is the difference between a physical and chemical change?

Water becomes steam when heated and ice when cooled. As the water is heated and cooled, water undergoes a **physical change**. How do these changes look on the macroscopic level? How do the water molecules look on the submicroscopic level when they are heated? How do water molecules look on the submicroscopic level when they are cooled?

Use what you know about steam and ice to predict how you will draw below.

Sketch a macroscopic view of water in a cold freezer	Sketch a macroscopic view of water on a hot stove
Key	

Sketch a submicroscopic view of water in a cold freezer	Sketch a submicroscopic view of water on a hot stove
Key	

Activity 2: Physical Changes

Simulation

Use Simulation 3, ***Set 1***

Use the simulation to generate each of the three conditions below.

Step 1

Modify the simulation to generate liquid water. Record your observations..

Sketch submicroscopic view of liquid water	Observations
	Simulation Temperature
	Appearance
	Interactions
	Location
	Motion
Key	

Step 2

Modify the simulation to generate solid ice. Record your observations.

Sketch submicroscopic view of ice	Observations
	Simulation Temperature
	Appearance
	Interactions
	Location
	Motion
Key	

Step 3

Modify the simulation to generate vaporous water. Record your observations.

Sketch submicroscopic view of water vapor	Observations
	Simulation Temperature
	Appearance
	Interactions
	Location
	Motion
Key	

1. What did you observe about the motion of the water molecules as you manipulated the heat to increase the temperature of the simulation?

2. What did you observe about the motion of the water molecules as the simulation moved from a higher temperature to a lower temperature?

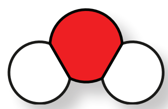
3. On the submicroscopic level, did the shape and location of each water molecule change after you generated ice or water vapor?

4. Did you change the location of the water molecules when you increased or decreased the heat added?

   Support your claim with evidence.

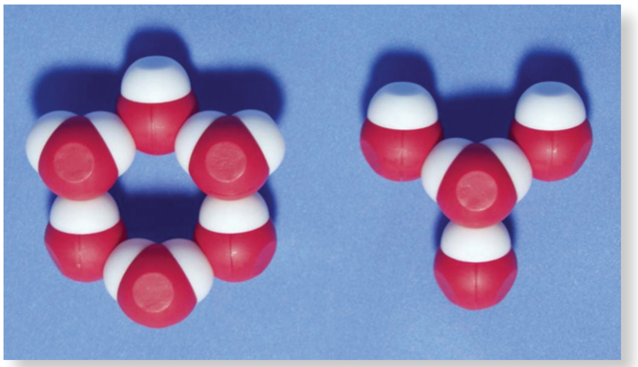
Activity 3: Physical Modeling of Water

The previous activity using the simulation introduced one way of representing water. Another way to represent water is through the use of physical models that can be manipulated by hand. In this activity you will compare and contrast physical models and simulations.



To start, create physical models of solid ice and liquid water. Follow the steps below to create the two models.

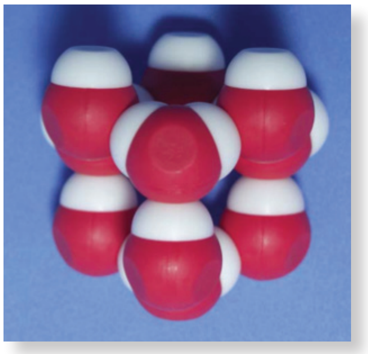
Part 1: Creating Ice



1. Create a Y formation and a ring formation using the pattern to the right. Hint: Three white hydrogen should be flat on the table for both structures

2. Without rotating the Y, place it on top of the ring that your created. Make sure magnets click together so the whole structure can be picked up.

Part 2: Creating Liquid Water



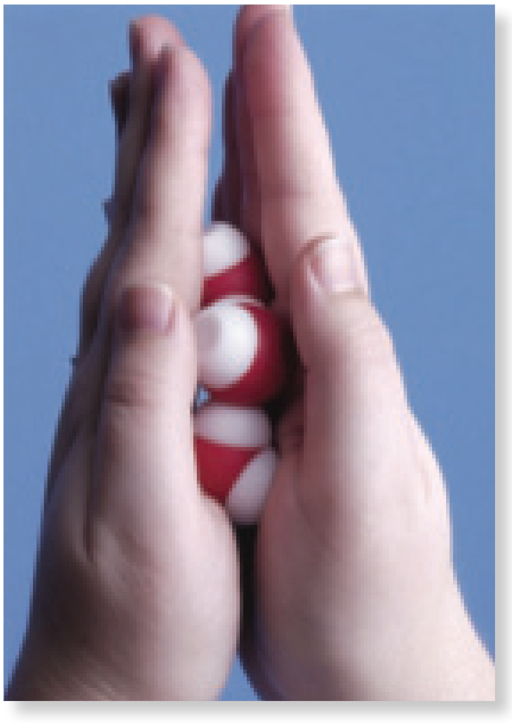
3. Take the ice model you created and "squish" it together with your hands as shown.

4. Are any of the atoms attracted to one another? If so, describe which.

____

____

5. Are any atoms repelled by one another? If so, describe which.



____

____

____

____

6. How would you describe the shape of your ice structure?

____

____

____

____

7. Are actual water molecules magnetic like the physical model?

Support your claim with evidence.

8. How are the physical models similar to the liquid water simulation?

9. How are the physical models different from the simulation and from real molecules?

Part 3: Comparing Ice and Water

10. What is noticeably different about how the molecules are arranged when you compare the model of solid ice to the model of liquid water?

11. Using what you learned with physical models, describe what you think happens on the submicroscopic level to liquid in a soda can when it is placed in the freezer overnight.

Consider the following claim

"The best model to explain how a liquid becomes a vapor is the CCC simulation."

12. Provide evidence from your observations and drawings of both the physical and simulations to either support or reject the claim above.

13. The models you created were for water. Do you think other substances have similar submicroscopic arrangements of atoms as solid and liquid forms of water?

    Support your claim with evidence.

The teacher will show you a model of sodium chloride, a solid salt, compared to ice.

14. Which solid, ice or sodium chloride, do you think is more representative of the submicroscopic structure of other solids, such as gold?

    Support your claim with evidence.

15. What makes ice different than other solids?

Connected Chemistry
Modeling Matter Unit
Lesson 5: Chemical Changes

Student's Lesson at a Glance

Lesson Summary

Students begin the exploration of chemical changes by discussing what changes occur when a candle burns. Teachers may briefly extend the opening to explore the products of the reaction. Students investigate macroscopic and submicroscopic observations as hydrogen peroxide is cooled or heated. Students should be able to gain more insight into chemical changes by observing this phenomenon through the simulation.

SWBAT (Students Will Be Able To):

Define what a chemical change is

Distinguish between a chemical and physical change

Describe what happens at the submicroscopic level during chemical change.

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- Follow the sketching and observation protocol; the more you practice these skills, the more accurate you will become.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier.
- Supporting your claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.
- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.
- In the simulations in this lesson you adjust the heat to change the temperature. The temperature of a system is changed by adding or removing heat energy. In later units, you will learn more about why temperature and heat are not the same thing.

Notes

Homework

Upcoming Quizzes/ Tests

Activity 1: Connecting

The human body takes food and converts it into energy to fuel all body systems. This biological process involves both **physical changes** and **chemical changes**. Biting and chewing food are considered physical changes. Like water changing between the states of liquid, ice, and steam, tearing off pieces of food does not change the composition of molecules in food. However, digesting food is a chemical change. The body uses unique enzymes and acids in the mouth and stomach to change the composition and structure of molecules in food to release **energy**, which helps to keep humans alive.

Digestion is a very complex process. In this activity you will look at a simpler example of a process that includes both a physical and chemical change. Your teacher will light a candle and let it burn for a few minutes. A candle burning is an example of both a physical and chemical change.

1. What aspects of a candle burning do you think are physical changes?

2. What aspects of a candle burning do you think are chemical changes?

3. What happens at the submicroscopic level to distinguish a physical change from a chemical change?

4. Fill in the chart below. List three or more things that you think are physical changes and three or more things that you think are chemical changes.

Physical change	Chemical change

Activity 2: Chemical Changes

Student Simulation

Use Simulation 4, Set 1

Step 1

Reset the simulation you were using for water with hydrogen peroxide.

Submicroscopic sketch of hydrogen peroxide	Observations
	Simulation Temperature
	Appearance
	Interactions
	Location
	Motion
Key	

Step 2

Heat the hydrogen peroxide.

Submicroscopic sketch of hydrogen peroxide after you increase temperature	Observations
	Simulation Temperature
	Appearance
	Interactions
	Location
	Motion
Key	

1. On the submicroscopic level, did the shape and composition of hydrogen peroxide molecules change after heating?

   Support your claim with evidence.

2. Is heating hydrogen peroxide a physical or chemical change? Support your claim with two pieces of evidence from the simulations.

3. Consider the following claim: "Heating a substance always produces new substances."

   Provide evidence from your observations or drawings to either support or reject your claim.

4. Recall that you were asked about what you thought the difference was between chemical and physical change. How have your ideas changed about what chemical and physical change are?

Activity 3: Putting it All Together

Applying what you know about models, matter, physical and chemical changes

You are asked to teach a 6th grade class using a model. The model can be of any type we use in class: simulations, physical models, or symbolic sketches.

1. Create a five- to seven-minute lesson that includes:

- How to use your model
- An explanation of the components of your model with correct scientific language
- An explanation of the benefits and limitations of your model
- A simple explanation of matter and the states we discussed
- How you know if matter undergoes physical or chemical changes
- Definitions for physical and chemical change

Connected Chemistry
Modeling Matter Unit
Lesson 6: Mixtures

Student's Lesson at a Glance

Lesson Summary

From the previous lessons, students may have learned that some types of matter are composed of pure substances and some are not. Through exploration, students identify how substances change and behave at the submicroscopic level when mixed together. Students then classify the types of mixtures as homogeneous or heterogeneous. Students assess their knowledge using a physical modeling activity and a final "putting it together" activity that requires them to draw on knowledge of all concepts learned in the unit.

SWBAT (Students Will Be Able To):

- Define and identify a pure substance
- Define what a mixture is
- Define and identify a heterogeneous mixture
- Define and identify a homogenous mixture

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.

CCC Reminder

- Refer back to your definitions for atoms, elements, and compounds to help with this lesson.
- Keep using your periodic table in the back of the book to help decode molecules.
- Follow the sketching and observation protocol; the more you practice these skills, the more accurate you will become. Remember to include a key.
- Pause the simulations when you are creating sketches.
- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes is easier.
- Supporting your claims with evidence.

Notes

Homework

Upcoming Quizzes/ Tests

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Please turn to the next page.

Activity 1: Connecting

Matter is composed of elements and compounds. Each of the simulations thus far have included **pure substances**, which are composed of only one type of element or compound. However, not all matter is composed of pure substances. For example, prepared Kool-Aid® contains a mixture of flavoring with food color, sugar, and water. Because a prepared Kool-Aid® drink is a combination of different substances, it is not a pure substance; it is a **mixture**.

A color change can be observed at the macroscopic level when Kool-Aid® powder is added to water. Likewise, when sugar is added to water, the mixture will taste sweet. But, what happens to the particles on the submicroscopic level when you add each substance to form the mixture? Are new substances formed or do the original substances remain the same? Does the motion of particles change when they are mixed?

In this investigation, you will examine what happens when elements and compounds are mixed and classify how substances change as well as the types of mixtures that exist. Sketch your prediction of the submicroscopic view of Kool-Aid® powder and water mixture. Do not forget to include a key.

Sketch a submicroscopic view of water and Kool-Aid® mixture	Explain why you think that this is an accurate representation of this mixture
	Appearance
	Interactions
	Composition
	Motion
Key	

Activity 2: Teacher Demonstrating Mixtures

Demonstration

Use Simulation 5, ***Set 1***

Your teacher will run the simulation of mixing bromine and water. Sketch a submicroscopic picture of the mixture after 30 seconds. Describe your sketches under the observations section of the table. Do not forget to include a key.

Sketch the submicroscopic view of the water and bromine after mixing	Observations
	Appearance
	Interactions
	Location
	Motion
Key	

Activity 3: Students Exploring Mixtures

Part 1

Use Simulation 5, ***Set 2-6***

*In the next exploration, you will add two or three substances together as your teacher did following the trials in the table below. Write down your observations **after 30 seconds**.*

Always start with water first, and include a key.

Set	Create a submicroscopic sketch of the mixture created by mixing:	Record Observations
2	Water, (H_2O) + Mercury, (Hg)	Appearance
		Interactions
		Location
		Motion
3	Water, (H_2O) + Hydrogen peroxide, (H_2O_2)	Appearance
		Interactions
		Location
		Motion

Set	Create a submicroscopic sketch of the mixture created by mixing:	Record Observations
4	Water, (H_2O) + Pentane (C_5H_{12})	Appearance
		Interactions
		Location
		Motion
5	Water, (H_2O) + Bromine, (Br_2) + Hydrogen peroxide, (H_2O_2)	Appearance
		Interactions
		Location
		Motion
	Key	

Set	Create a submicroscopic sketch of the mixture created by mixing:	Record Observations
6	Water, (H_2O) + Bromine, (Br_2) + Pentane, (C_5H_{12})	Appearance
		Interactions
		Location
		Motion
	Key	

Part 2

Use Simulation 5, ***Set 1-6***

Using your observations of sets 1-6 on pages 56-58, create two group descriptions of the mixtures and divide your trials into two separate groups.

Group 1: Layers

1. Which trials from page 56 belong in this group?

____

____

2. How are all the trials in this group similar?

____

____

3. How are the trials in this group different?

4. Are these trials pure substances or mixtures?

   Support your claim with evidence.

Group 2: No Layers

5. Which trials from pages 56-58 belong in this group?

6. How are all the trials in this group similar?

7. How are the trials in this group different?

8. Are these trials pure substances or mixtures?

   Support your claim with evidence.

9. How does group 2 differ from group 1?

Activity 4: Teacher Facilitated Discussion: Heterogeneous and Homogeneous Mixtures

In your small group or pairs, answer the following questions. Be ready to support your claims with evidence in the classroom group discussion.

1. What do the prefixes on the words **hetero**geneous and **homo**geneous mean?

2. Based on the prefixes and the simulations that you just completed, what is a **homogeneous mixture**?

3. Based on the prefixes and the simulations that you just completed, what is a heterogeneous mixture?

4. Which of your trials are heterogeneous mixtures? Which of your trials are homogeneous mixtures? Support your claims with evidence from the simulation.

Activity 5: Physical Modeling of Elements, Compounds and Mixtures

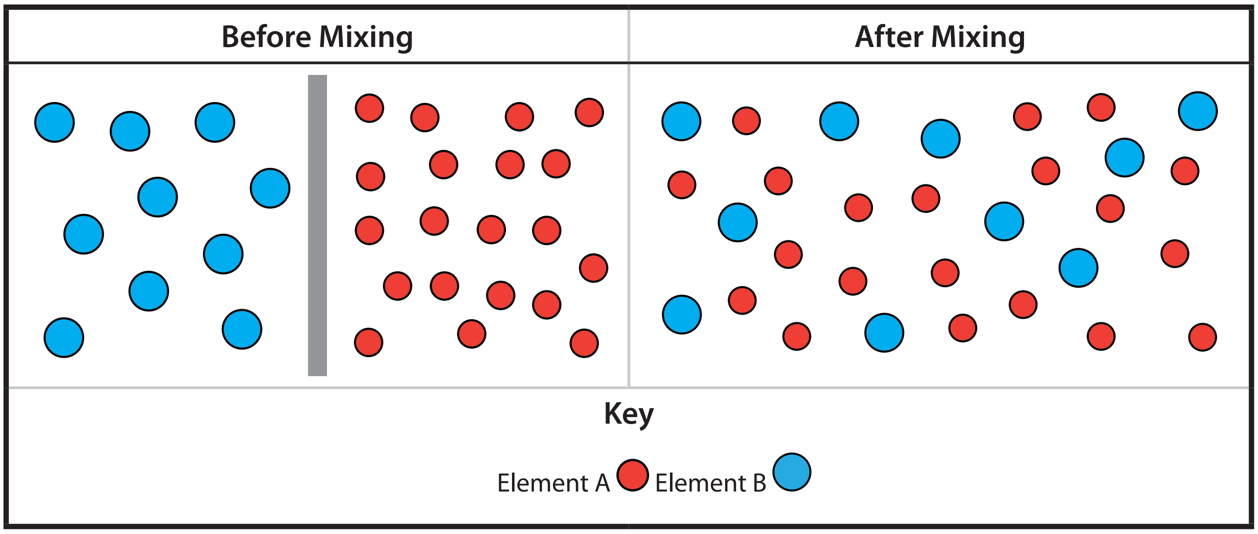
Students sometimes have trouble distinguishing between elements, compounds, and mixtures when larger amounts are present. This activity will help students learn how to distinguish between elements, compounds, and mixtures using hands-on models.

Activity 6: Putting It All Together - Mixtures Undergoing Physical and Chemical Changes

The following questions requires you to use all the knowledge you have gathered about mixtures, chemical changes and physical changes.

Part 1

Consider the two submicroscopic diagrams.



1. Before mixing classify the two elements as pure substances or mixtures.

   Support your claims with evidence.

2. Does mixing these two substances result in a physical change or chemical change?

   Support your claim with evidence.

   ____

   ____

3. If a mixture forms, state the type of mixture (homogeneous or heterogeneous).

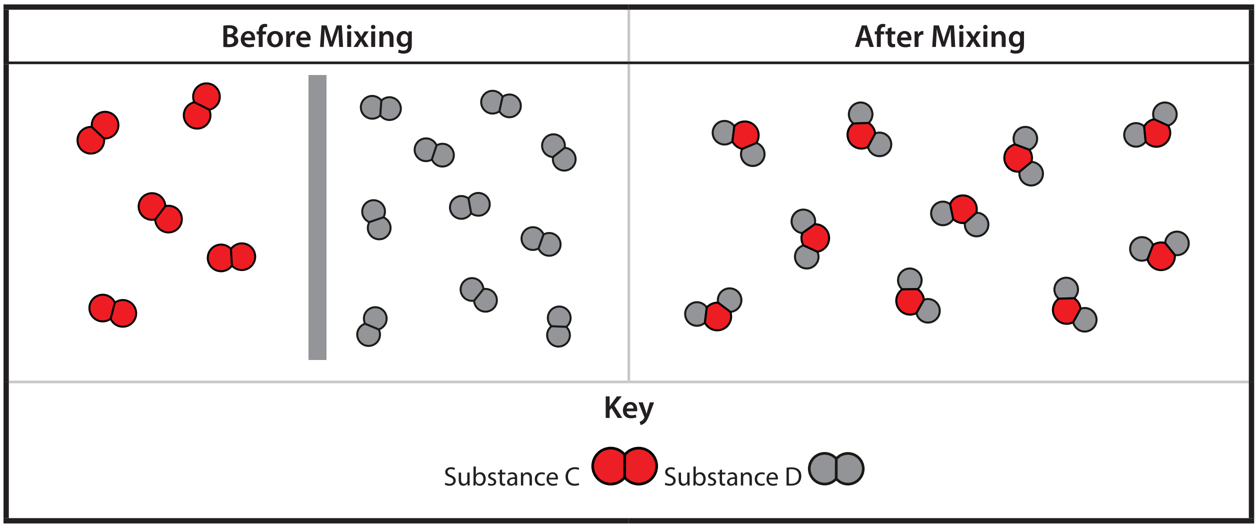
   Support your claim with evidence.

   ____

   ____

Part 2

Consider the two submicroscopic diagrams.



1. What is different about the substances before mixing in question 1 and 2?

2. Are substances C and D elements or compounds?

   Support your claim with evidence.

3. Does mixing these two substances result in a physical change or a chemical change?

   Support your claim with evidence.

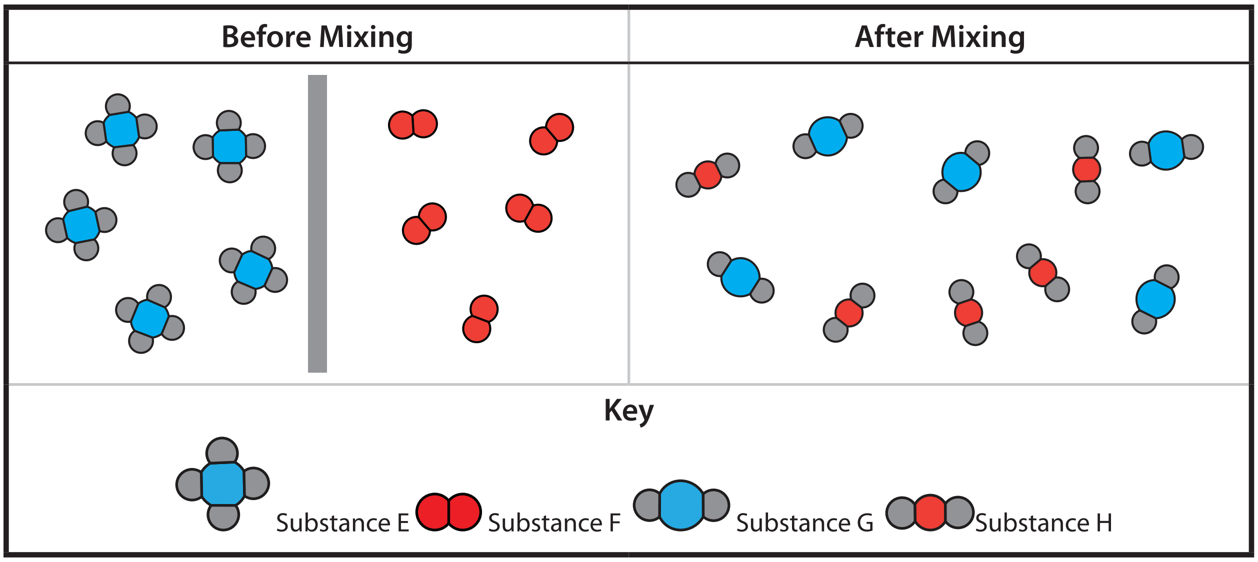
4. After mixing is the resulting product an element or compound?

   Support your claim with evidence.

5. Is a mixture formed based on the After Mixing diagram of Element C and D?

   Support your claim with evidence.

Part 3



Are substances E and F elements or compounds?

Support your claim with evidence.

6. Does mixing these two substances result in a physical change or a chemical change?

   Support your claim with evidence.

7. After mixing is the resulting product an element or compound?

   Support your claim with evidence.

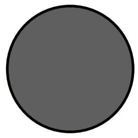
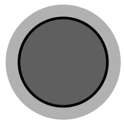
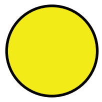
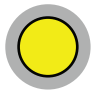
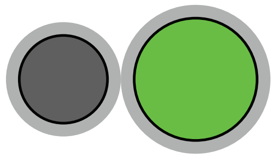
8. Is a mixture formed based on the After Mixing diagram?

   Support your claim with evidence.

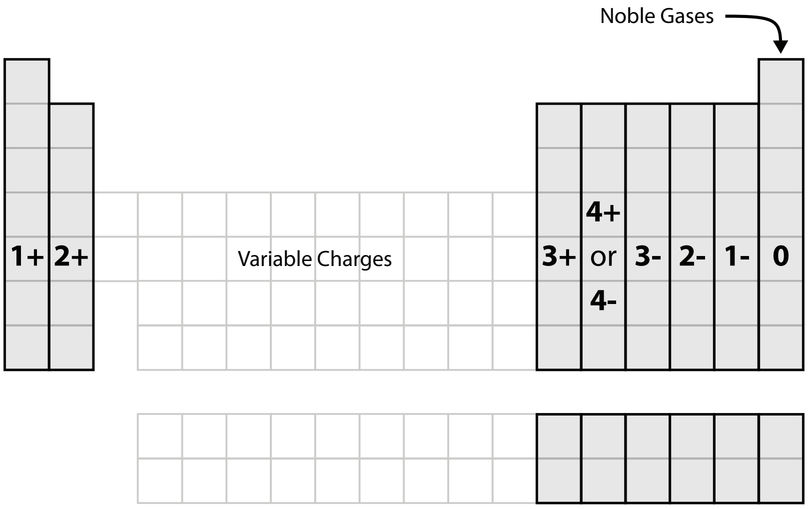
Activity 7: Looking Ahead: An Introduction to Ions

Many of the substances you have explored in this unit are known as molecular compounds, such as water, hydrogen peroxide, pentane, and carbon dioxide. These compounds are held together with covalent bonds. Covalent bonding involves the sharing of a pair of electrons between two atoms. In future units, you will explore another type of compound called an ionic compound. Ionic compounds are made up of ions with either a positive or a negative charge. Because opposite charges attract, a positive ion and a negative ion can come together to form an ionic bond. You will learn more about ionic and molecular compounds later, but it is important to learn to identify the difference between ions, regular atoms, or molecules in CCC simulations.

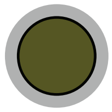
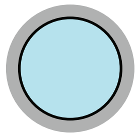
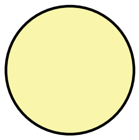
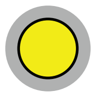
In all CCC simulations, a gray halo is used to identify ions and ionic compounds on the submicroscopic level. To indicate an ion with a symbol, the charge is indicated with a superscript number and a + or - sign after an element symbol:

Name	Symbol	CCC Model
Sodium	Na	
Sodium Ion	Na^{+}	
Sulfur	S	
Sulfur Ion	S^{2-}	
Sodium Chloride	NaCl	

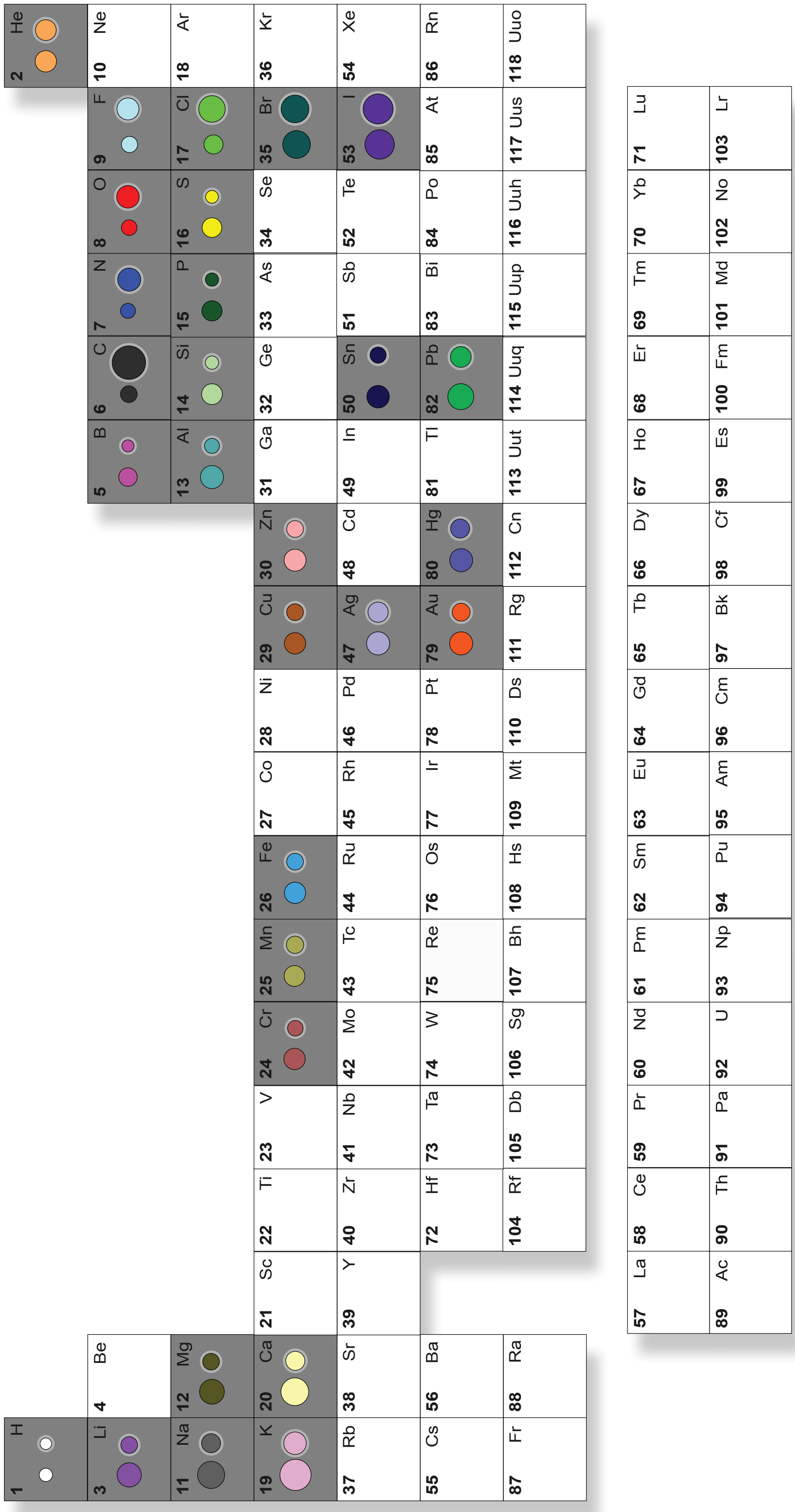
Although the halo in the submicroscopic view does not indicate whether an ion or ionic compound is positively or negatively charged, you can use a simple rule to identify an ion's charge using the periodic table. For example, using the chart on the right, you can identify that sodium, in the first column of the periodic table, forms an ion with a charge of +1. Similarly, sulfur forms an ion with a charge of -1, which can be determined from its location in the sixth column of the periodic table.



Use this periodic table and the one in the back of this workbook to fill in the missing information in the table below.

Name	Symbol	CCC Model
Magnesium Ion		
	F^-	
Chlorine		
	Ca	
	K^+	
		
	He	
Lithium Ion		

Elements Used in the Connected Chemistry Curriculum



Name	Symbol	Atomic Number	Atomic Weight
Hydrogen	H	1	1.00794
Helium	He	2	4.00260
Lithium	Li	3	6.941
Boron	B	5	10.811
Carbon	C	6	12.0107
Nitrogen	N	7	14.0067
Oxygen	O	8	15.9994
Fluorine	F	9	18.9984
Sodium	Na	11	22.9898
Magnesium	Mg	12	24.3050
Aluminum	Al	13	26.9815
Silicon	Si	14	28.0855
Phosphorus	P	15	30.9738
Sulfur	S	16	32.065
Chlorine	Cl	17	35.453
Potassium	K	19	39.0983
Calcium	Ca	20	40.078
Chromium	Cr	24	51.9961
Manganese	Mn	25	54.9380
Iron	Fe	26	55.845
Copper	Cu	29	63.54
Zinc	Zn	30	65.38
Bromine	Br	35	79.904
Silver	Ag	47	107.8682
Tin	Sn	50	118.710
Iodine	I	53	126.904
Gold	Au	79	196.967
Mercury	Hg	80	200.59
Lead	Pb	82	207.2